SAE Aerospace
An SAE International Group

# AEROSPACE INFORMATION REPORT

AIR5697

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## Aerospace Landing Gear - FAA Regulatory History - Airplane Wheels, Tires, and Brakes

RATIONALE

In drafting new regulations, advisory circulars, and policy, Federal Aviation Administration (FAA) engineers need to know the previous Federal actions, policies, and organizational structures. Information is also requested on past safety issues and the evolution of aircraft manufacturing, commercial air transportation, and private flying. This brings together as a basic reference a broad range of data for airplane wheels, tires, and brakes. As a factual chronology, it includes only minimal analysis.

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## 1. SCOPE

This SAE Aerospace Information Report (AIR) contains regulatory and guidance information related to airplane wheels, tires, and brakes. It contains certain Civil Air Regulations (CAR) and Federal Aviation Regulations (formerly referred to as FARs) from Title 14 Code of Federal Regulations (CFR) in their current version as well as the historical versions. This gives the reader an ability to assemble certain CAR/CFR parts as they existed at any date in the past (referred to as a Regulatory Basis). A certain amount of preamble explanatory material is included, which led to the regulatory rule changes (Amendments to the CFR).

### 1.1 Purpose

The purpose of this document is to provide a basic reference for the FAA engineers and the public by bringing together a chronological regulatory data for airplane wheels, tires, and brakes. This includes Regulations, Policies, Advisory Circulars, and Technical Standard Orders (TSOs).

## 2. REFERENCES

### 2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

#### 2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

| | |
|---|---|
| AIR1064 | Brake Dynamics |
| AIR1739 | Information on Antiskid Systems |
| AIR1904 | Tire Spray Suppression – Airplane Design Considerations and Testing |
| AIR1934 | Use of Carbon Heat Sink Brakes on Aircraft |
| AIR4762 | Complication of Freezing Brake Experience and Suggested Designs |
| AIR4830 | Aircraft Tire Condition Monitoring System |
| AIR5372 | Information on Brake-By-Wire (BBW) Brake Control Systems |
| ARP597 | Wheels and Brakes, Supplementary Criteria for Design Endurance |
| ARP813 | Maintainability Recommendations for Aircraft Wheels and Brakes |
| ARP1070 | Design and Testing of Antiskid Brake Control Systems for Total Aircraft Compatibility |
| ARP1322 | Overpressurization Release Devices |
| ARP1619 | Replacement and Modified Brakes and Wheels |

ARP1786 Wheel Roll On Rim Criteria for Aircraft application

ARP1907 Automatic Braking Systems Requirements

ARP4102/2 Automatic Braking System (ABS)

ARP4102/3 Flight Deck Tire Pressure Monitoring System (TPMS)

ARP4834 Recommended Practice for Retreaded Aircraft Tires

ARP5257 Tire Overspeed Landing Test

AS227 Wheel and Brakes, Minimum Requirements for Civil Aircraft Applications (Cancelled May 91)

AS707 Thermal Sensitive Inflation Pressure Release Devices for Tubeless Aircraft Wheels

AS1145 Aircraft Brake Temperature Monitor System

AS4833 Aircraft New Tire Standard – Bias and Radial

AS8584 Brake Systems, Wheels, Aircraft Design Of

ARP5381 Minimum Performance Recommendations for Part 23, 27, and 29 Aircraft Wheels, Brakes, and Wheel and Brake Assemblies

2.1.2 U.S. Government Publications

Available from the Superintendent of Documents, Government Printing Office, Washington, DC 20402-0101, http://bookstore.gpo.gov/.

Title 14, Code of Federal Regulations (14 CFR) part 21 – Certification Procedures For Products and Parts

Title 14, Code of Federal Regulations (14 CFR) part 23—Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes

Title 14, Code of Federal Regulations (14 CFR) part 25—Airworthiness Standards: Transport Category Airplanes

Title 14, Code of Federal Regulations (14 CFR) part 27—Airworthiness Standards: Normal Category Rotorcraft

Title 14, Code of Federal Regulations (14 CFR) part 29—Airworthiness Standards: Transport Category Rotorcraft

2.2 Other Applicable References

2.2.1 Aeronautical Bulletin 7-F, Effective March 1, 1933

2.2.2 Aeronautical Bulletin 7-A, Effective October 1, 1934

2.2.3 Civil Air Regulations Part 04 Issued in 1937, 1938, 1941, 1942, 1943

2.2.4 Civil Air Regulations Part 15 issued in 1937, 1938, 1940, 1944, 1946, 1949, 1952 (Rescinded)

2.2.5 Civil Air Regulations Part 04 Airplane Airworthiness Transport Categories: Effective November 9, 1945

2.2.6 Civil Aeronautics Manual (CAM) o4 and CAM 04(T) July 1 and November 1, 1944

2.2.7 Civil Air Regulations Part 04b Airplane Airworthiness Transport Categories: Effective November 22, 1946

2.2.8 Civil Air Regulations Part 4b Airplane Airworthiness Transport Categories: Effective May 1, 1949

2.2.9 Civil Air Regulations Part 514 Technical Standard Orders, Effective October 12, 1951

2.2.10 Civil Aeronautics Manual (CAM) 4b Airworthiness Transport Categories: Effective January 1, 1958

2.2.11 CAR Part 514, Technical Standard Orders: TSO-C26, C26a, TSO-C62, C62a, and C62b

2.2.12 CAR Part 37, Technical Standard Orders: TSO-C26a, C26b, and C26c

2.2.13 Title 14, Code of Federal Regulations (14 CFR) Part 37 - TSO-C

2.2.14 Title 14, Code of Federal Regulations (14 CFR) Part 25 Airworthiness Standards: Transport Category Airplanes, Effective February 1, 1965

2.2.15 Amendment 25-23 - 14 CFR Part 25, Effective May 8, 1970

2.2.16 Amendment 25-38 - 14 CFR Part 25, Effective December

2.2.17 Amendment 25-48 - 14 CFR Part 25, Effective November 29, 1979

2.2.18 Amendment 25-49 -14 CFR Part 25, Effective December 31, 1979

2.2.19 Amendment 25-52 - 14 CFR Part 25, Effective June 9, 1980

2.2.20 Amendment 25-72 - 14 CFR Part 25, Effective August 20, 1990

2.2.21 Amendment 25-78 - 14 CFR Part 25, Effective March 29, 1993

2.2.22 Amendment 25-92 - 14 CFR Part 25, Effective February 18, 1998

2.2.23 Amendment 25-107 - 14 CFR Part 25, Effective April 24, 2002

2.2.24 FAA Advisory Circular AC 25.735-1, Effective April 10, 2002

2.2.25 TSO-C135 Transport Airplane Wheels and Brakes, Effective May 2, 2002

The following apply to N/U/A/R Small Airplanes Only

2.2.26 Civil Air Regulations (CAR) Part 03 Airplane Airworthiness Normal, Utility, Acrobatic, and Restricted (N/U/A/R) Purpose Categories, Effective November 13, 1945

2.2.27 CAR Part 03, Effective December 15, 1946

2.2.28 CAR Part 3, Effective November 1, 1949

2.2.29 Civil Aeronautics Manual (CAM) 3, Effective September 1, 1954

2.2.30 CAR Part 3, Effective May 15, 1956

2.2.31 Title 14, Code of Federal Regulations (14 CFR) Part 23 Airworthiness Standards: Normal, Utility, Acrobatic, and Restricted (N/U/A/R) Category Airplanes, Effective February 1, 1965 {Recodification of CAR Part 3 into 14 CFR, Part 23}

2.2.32 Amendment 23-7, Effective September 14, 1969

2.2.33 Amendment 23-17, Effective February 1, 1977

2.2.34 Amendment 23-24, Effective December 31, 1979

2.2.35 Amendment 23-42, Effective February 4, 1991

2.2.36 Amendment 23-45, Effective September 7, 1993

2.2.37 Amendment 23-49, Effective March 11, 1996

2.2.38 Advisory Circular (AC) 23-17B, Systems and Equipment Guide for Certification of Part 23 Airplanes and Airships, Dated April 12, 2005, Sections 23.731, 23.733 and 23.735

3. CHRONOLOGY

3.1 Air Commerce Act of 1926

a. The roots of the FAA go back to 1926 when the U.S., as the only industrial nation that did not regulate aviation and air commerce enacted the Air Commerce Act of 1926. In addition, the Act was established to foster air commerce, license pilots, certificate aircraft for airworthiness, designation, establish airways, and operate and maintain aids to air navigation. Driven in part by the need to assure the success of the Air Mail Act of 1925, the Air Commerce Act established the Bureau of Air Commerce to promote aviation safety and the development of aeronautics using its regulatory authority.

(1) On December 31, 1926, the first Air Commerce Regulations of the Aeronautics Branch became effective. The regulations prescribed licensing, operational, and air traffic safety rules.

(2) On March 29, 1927, Type Certificate No. 1 was issued by the newly formed Bureau of Air Commerce to the manufacturer of the Buhl-Verville J4 Airster CA-3, a 3-place open cockpit land biplane. It had an empty weight of 1,415 pounds and a gross weight of 2,300 pounds.

(3) On March 1, 1933, the Aeronautics Bulletin No. 7F, became effective. This bulletin prescribed Airworthiness Requirements for Aircraft Components and Accessories.

b. In 1934, after a reorganization, the Aeronautical Branch was renamed the Bureau of Air Commerce.

(1) Aeronautics Bulletin No. 7A, effective as amended October 1, 1934, prescribed Airworthiness Requirements for Aircraft.

(2) Aeronautics Bulletin No. 7-J, dated July 11, 1935, prescribed Special Requirements for Transport (or Airline) Aircraft.

(3) Aeronautics Bulletins 7-G and 7-H, respectively, prescribed requirements for engines and propellers, and alterations and repairs.

c. The main part of the Civil Air Regulations (CARs), representing a thorough revision and codification of the Air Commerce Regulations, went into effect on November 1, 1937. The CARs Part 04 - Airplane Airworthiness, and Part 15 - Aircraft Equipment Airworthiness, contained relevant requirements for mechanical systems. Aeronautics Bulletins 7A, etc., were canceled.

3.2 Civil Aeronautics Act of 1938

a. The Civil Aeronautics Act of 1938 abolished the Air Commerce Act of 1926. The Bureau of Air Commerce had come under criticism for not being effective, therefore, Congress created the Civil Aeronautics Authority (still under control of the Department of Commerce). It encompassed three unique features:

(1) An Administrator responsible for fostering air commerce, controlling air traffic, and establishing airways;

(2) An Authority (the only one in the Government), with a five-person board, responsible for promulgating safety (including design rules) and economic rules; and

(3) An independent three-person Air Safety Board responsible for determining the probable cause of accidents and recommending safety improvements.

b. The Reorganization Act of 1939-40 abolished the Air Safety Board, making it part of the five-person board renamed as Civil Aeronautics Board (CAB). The Administrator's collective functions were designated as Civil Aeronautics Administration (CAA). The CAB and CAA reported to the Secretary of Commerce.

(1) For the next 18 years, the CAB made the rules while the CAA carried out operational functions. The CAR Parts 04 and 15 were reprinted and amended several times between 1940 and March 15, 1952, when Part 15 was rescinded in favor of a new Technical Standard Order (TSO) system of equipment qualification.

(2) Effective June 30, 1945, the CAA drafted comprehensive proposals for revision of the CARs and submitted them to the CAB. The Board was engaged in revising safety regulations to reflect wartime advances in aviation.

3.3 The Federal Aviation Act of 1958

a. This Act was the culmination of long term effort to increase the effectiveness of the Government's effort to promote safety and develop aeronautics. In 1958, Congress created the Federal Aviation Agency by enacting the Federal Aviation Act.

b. The Federal Aviation Act of 1958 repealed the Air Commerce Act of 1926, as amended; the Civil Aeronautics Act of 1938, as amended; and the 1939-40 reorganization plans. This Act created two independent agencies:

(1) the CAB (for economic regulation of air carriers and for accident investigations) and

(2) the Federal Aviation Agency, responsible for safety regulations.

3.4 Title 14, Code of Federal Regulations (14 CFR)

a. Part 25, effective February 1, 1965, was added to replace part 4b of the Civil Air Regulations (CAR). The object of this recodification was to restate existing regulations. Part 23, effective February 1, 1965, was added to replace part 3 of the Civil Air Regulations (CAR). The object of this recodification was to restate existing regulations.

b. The pertinent provisions were freely reworded and re-arranged, subject to every precaution against disturbing existing rights, privileges, duties, or functions. In cases where well established administrative practice or construction had established authoritative interpretations, the revised rule language reflected the interpretations.

c. The sections titled “CAA Policies which apply to Sec. 4b.xxx” were determined as “not rule” and deleted from the Code of Federal Regulations. As CAR Part 4a “Airplane Airworthiness” had not been used for certification of new airplanes since 1947, it was deleted.

3.5 Department of Transportation Act of 1966

a. In 1966, the Department of Transportation (DOT) was created to consolidate the various governmental activities concerning transportation into one organization. The Federal Aviation Act of 1958 was amended to change the FAA, The Agency, to the FAA, the Administration. The FAA Administrator reports to the Secretary of Transportation as a result of this Act.

b. The CAB’s responsibilities for accident investigation were transferred to a new independent National Transportation Safety Board (NTSB). Although independent, the NTSB remained within the DOT for administrative purposes only until 1975, and then was separated entirely.

4. APPLICABILITY

a. The information provided in this document is directed to airplane manufacturers, modifiers, foreign regulatory authorities, and Federal Aviation Administration (FAA) airplane type certification engineers, and their designees.

b. This material does not change, create any additional, authorize changes in, or permit deviations from, regulatory requirements.

5. HISTORY OF REGULATIONS

5.1 Table 5-1 History of Regulations Index: All Airplanes [1933-1952]

| Date | Action | Wheels | **Tires** | Brakes |
|---|---|---|---|---|
| 03-01-33 | Aeronautical Bulletin 7-F: | 7(A) | **7(A)** | 7(B) |
| 10-01-34 | Aeronautical Bulletin 7-A: | 40(A) | **40(B)** | |
| 11-01-37 | Old Part 04: Airplane A/W | 04.442 | **04.443** | |
| 11-01-37 | Part 15: Equipment A/W | 15.10 | | 15.104 |
| 05-31-38 | Part 04 Reprinted | 04.442 | **04.443** | |
| 05-31-38 | Part 15 Reprinted | 15.10 | | 15.104 |
| 11-15-40 | Part 15 Reprinted | 15.10 | | 15.104 |
| 04-01-41 | Part 04 Reprinted | 04.442 | **04.443** | |
| 07-01-42 | Part 15/Amd't 15-1/-2 | | | 15.1040/1041T |
| 08-15-42 | Part 04 Reprinted | 04.442 | **04.443** | 04.445-T |
| 11-01-43 | Part 04 Reprinted | 04.442 | **04.443** | 04.445-T |
| 04-15-44 | Part 15 Reprinted | Consolidated 1937/38/40/& 42 versions | | |
| 07-01-44 | CAM 04 | 04.442 | **04.443** | 04.445-T |
| 11-01-44 | CAM 04-T | | | 04.445-T |
| 11-09-45 | Adopted an entirely New Part 04 for Transport Category only | | | |
| 11-13-45 | Adopted an entirely New Part 03 for Normal/Utility/Acrobatic/Restricted | | | |
| 05-31-46 | Part 15 Reprinted | 15.10 | | 15.1040/41T |
| 11-22-46 | Amd't 04-5 Old Part 04 became Part 04a: N,U,A,R categories | | | |
| 11-22-46 | Amd't 04-5 New Part 04 became Part 04b Transports only | | | |
| 11-01-47 | Part 04a Reprinted | 04a.442 | **04a.443** | 04a.445-T |
| 01-01-48 | Amd't 04a-1Approval by Administrator: Materials/Parts | | | |
| 05-01-49 | Parts 04a and 04b respectively designated as Parts 4a and 4b | | | |
| 11-01-49 | Part 15 reprinted | 15.11 | | 15.12 |
| 12-07-49 | Amd't 15-1 Identification Data/ | 15.11 | | 15.12 |
| 04-07-50 | Part 4a Reprinted | 4a.477-479 | **4a.480-481** | 4a.483-T |

03-05-52 Amd't 15-4 Part 15 Rescinded/Use TSO System

03-15-52 TSO-C26 is issued: Wheels and Brakes/AS-227A

12-15-52 Amd't 4a-1 Correction of References

5.2 Wheels, Tires, and Brakes: History of Regulations

5.2.1 Airworthiness Requirements for Aircraft
Aeronautics Bulletin No. 7-A, effective as amended October 1, 1934

Sec. 40. Wheels.

(A) Landing gear wheels shall be of a type and design approved by the Secretary [of Commerce] in accordance with the [design] requirements outlined in Aeronautics Bulletin No. 7-F and shall not be subjected to loading conditions in excess of those for which they are approved. The static working load of a landing gear wheel shall be taken as half the gross weight of the airplane upon which it is installed. The static working load for a tail wheel shall be taken as the maximum actual load which may be imposed on the tail wheel when the airplane is at rest on the ground.

(B) When the wheels installed on a specific airplane are of such a size as to require that a tire of special construction be used to support the airplane weight, the wheels shall be plainly and conspicuously marked to that effect. Such marking shall state the make and size of the proper tire and the number of plies required in its construction.

5.2.2 Aeronautical Bulletin No. 7-F, effective March 1, 1933.

Chapter I – General

Sec. 4. Data Required for an Approved Type Certificate or a Letter of Approval.

Data submitted in connection with a request for the approval of an accessory or component shall include:

(A) An application for approval in duplicate, on forms which will be furnished for that purpose by the Secretary. The data requested on these forms include the actual weight of the complete unit under consideration.

(B) A complete set of drawings which contain all the dimensions and material specifications of the particular item. These drawings shall be in duplicate.

(C) A list, in duplicate, of drawings submitted, giving the number and title of each drawing, preferably arranged numerically, or a complete parts list in duplicate if that system is standard practice with the manufacturer in question.

(D) The special data outlined in succeeding sections of these regulations for specific cases.

(E) In cases where such procedure is deemed advisable, or is specified in these regulations, one or more of the actual articles shall be submitted for examination and test.

(F) If the modifications to a previously approved component or accessory are not of sufficient extent to warrant a new model or type designation it is only necessary to submit revised drawings and drawing lists or parts lists for inclusion in the original approved file, and technical data substantiating the changes.



Chapter II – Landing Gear Wheels [and Tires, and Brakes]

Sec. 7. Design Conditions.

(A) Aircraft Landing-gear wheels will be approved for a maximum static load which will be determined from the strength of the wheel in accordance with Figure 1. The minimum load for which a wheel will be approved is the working load of the corresponding standard tire at the maximum recommended pressure. These values are given in Table 1 for high-pressure tires and low-pressure tires. Extra-ply and oversized tires may be used on approved wheels at the maximum working load of the tire provided the rated static load of the wheel is equal to, or greater than, the maximum working load of the tire. Standards for extra-low pressure tires are given in table 2. The values given in tables 1 and 2 are for front-wheel tires. Tail wheel tires may be inflated to higher pressures and carry correspondingly higher loads within reasonable and safe limits.

Figure 1 is derived from figure 2 of Aeronautics Bulletin 7-A. The required radial test load per wheel is equal to the product of the rated load of the wheel, which is assumed to be half the gross weight of the airplane, the load factor required for the corresponding airplane and a material factor of 1.25. The value given by the side load curve is 35 percent of the radial load values.

(B) In cases where brakes are incorporated in wheels the brake mechanism and its operation shall be satisfactory to the Secretary [of Commerce]. Brakes shall be free from any undue tendency to lock or jam.

Sec. 8. Technical Data Required.

The data submitted in substantiation of a request for approval of a wheel shall include the following in addition to the data specified in section 4:

(A) A report of static tests demonstrating compliance with the minimum wheel-strength requirements for each type or model wheel. Such tests shall demonstrate the strength of the wheel under radial loads and side loads. The radial and side loads shall be applied separately and the wheel shall be equipped with the correct size tire inflated to the proper pressure for the load for which approval is requested. The radial load shall be applied to the wheel in the plane of the tire and may be distributed over an arc of not more than $60^0$. When the side load is applied the wheel is to be restrained by the axle only. The report shall include complete details of the test, including a record of deflections and photographs of the test set-up, and shall be signed by the person making the test.

Sec. 9. Identification Data.

The identification data affixed to each wheel of an approved type shall contain the information specified in section 5(B) and shall also state the approved type certificate number under which the wheel has been manufactured and the maximum static load for which approval has been granted.



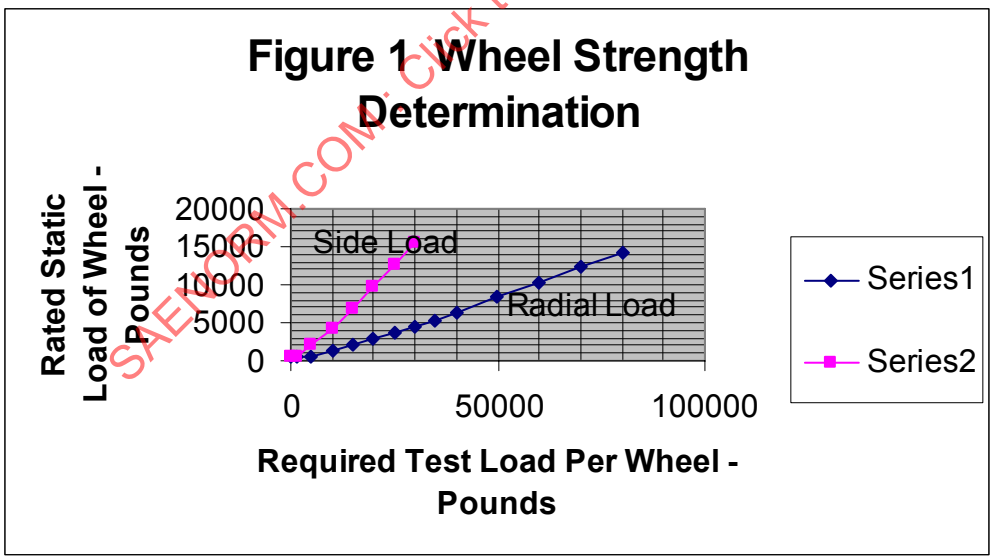


**Figure 1 - Wheel Strength Determination**

| (a) High Pressure Tires | | | (b) Low Pressure Tires | | |
|---|---|---|---|---|---|
| Tire Size | Recommended Inflation Pressure | Maximum Static Load | Tire Size | Recommended Inflation Pressure | Maximum Static Load |
| 10 by 3 | 55 | 400 pounds | 5.00-4 | 25 | 550 pounds |
| 12 by 4 | 55 | 600 | 7.00-4 | 25 | 950 |
| 14 by 3 | 55 | 500 | 7.00-5 | 25 | 1,050 |
| 16 by 4 | 55 | 750 | 8.00-5 | 20 | 1,200 |
| 18 by 3 | 55 | 550 | 9.00-6 | 20 | 1,600 |
| 20 by 4 | 55 | 825 | 6.00-8 | 25 | 1,150 |
| 24 by 4 | 50 | 850 | 6.50-10 | 25 | 1,200 |
| 26 by 5 | 50 | 1,350 | 7.50-10 | 25 | 1,500 |
| 28 by 4 | 50 | 1,000 | 8.50-10 | 25 | 1,950 |
| 30 by 5 | 50 | 1,600 | 9.50-12 | 25 | 2,500 |
| 32 by 6 | 55 | 2,200 | 11.00-12 | 25 | 3,400 |
| 36 by 8 | 60 | 4,000 | 12.50-14 | 25 | 4,700 |
| 40 by 10 | 65 | 5,500 | 15.00-16 | 28 | 7,000 |
| 44 by 10 | 65 | 6,300 | | | |
| 54 by 12 | 70 | 10,000 | | | |
| 58 by 14 | 70 | 13,000 | | | |

TABLE 1. RATED LOADS FOR HIGH-PRESSURE (and LOW-PRESSURE) TIRES

Source: Aeronautics Bulletin 7-F, dated March 1, 1933

Note: The tires listed in table 1 are standard tires. Extra-ply tires, with correspondingly larger rated loads, are made in several of these sizes and may be used on approved wheels in accordance with sec. 7.(A).

| Tire Size | Maximum Static | Highest Loads Tire loads for reduction in axle bending moment | | |
|---|---|---|---|---|
| | Load pounds | Inflation Pressure (psi) | Load pounds | Inflation Pressure (psi) |
| 16 by 7-3 | 600 | 12.5 | 600 | 12.5 |
| 18 by 8-3 | 775 | 12.5 | 775 | 12.5 |
| 19 by 9-3 | 1,025 | 12.5 | 1,025 | 12.5 |
| 22 by 10-4 | 1,500 | 15.0 | 1,500 | 15.0 |
| 25 by 11-4 | 1,900 | 15.0 | 1,900 | 15.0 |
| 27 by 12-5 | 2,300 | 15.0 | 2,600 | 17.5 |
| 29 by 13-5 | 2,700 | 15.0 | 3,350 | 20.0 |
| 35 by 15-6 | 3,700 | 15.0 | 4,600 | 20.0 |
| 40 by 18-7 | 5,550 | 15.0 | 7,000 | 20.0 |
| 44 by 20-8 | 6,900 | 15.0 | 8,700 | 20.0 |

TABLE 2. RATED LOADS FOR EXTRA-LOW-PRESSURE) TIRES
Source: Aeronautics Bulletin 7-F, dated March 1, 1933

Note: If no reduction in axle design bending moment is desired tires may be loaded to the amount shown in the last 2 columns. If no shock absorber strut is used in conjunction with tire the size of tire is limited by its shock absorption capacity.

5.2.3

## [old] Part 04: Airplane Airworthiness Effective November 1, 1937

04.442—Wheels. -- Main landing gear wheels shall be of a type or model certificated by the Secretary [of Commerce] in accordance with the [design] provisions of CAR 15 and shall not be subjected to static loads in excess of those for which they are certificated. Tail wheels may be of any type or model and are not certificated. Nose wheels are subject to special rulings to be made by the Secretary.

04.4420—For the purpose of these regulations main landing gear wheels are considered as those nearest the airplane center of gravity with respect to fore-and-aft location.

04.4421-- For the purpose of these regulations a tail wheel is considered as one which supports the tail of a conventional airplane in the three-point landing attitude. A nose wheel is considered to be a wheel supporting the nose of the airplane when the two main wheels are located behind the center of gravity.

04.443—Tires.—A landing gear wheel may be equipped with any make or type of tire, provided that the tire is a proper fit on the rim of the wheel and provided that the tire manufacturer's recommended load rating is not exceeded.

04.4430—When specially constructed tires are used to support an airplane, the wheels shall be plainly and conspicuously marked to that effect. Such markings shall include the make, size, number of plies and identification marking of the proper tire.

5.2.4

CAR 15 Aircraft Equipment Airworthiness effective November 1, 1937

15.1 LANDING GEAR EQUIPMENT

15.10 LANDING GEAR WHEELS.
15.100 Main landing gear wheels will be certificated for a maximum static load which will be determined from the strength of the wheel. Tail wheels will not be certificated.
15.1000 For the purpose of these regulations main landing gear wheels are considered as those nearest the airplane center of gravity with respect to fore-and-aft location.
15.1001 For the purpose of these regulations a tail wheel is considered as one which supports the tail of a conventional airplane in the three-point landing attitude.
15.101 For wheels other than main landing or tail wheels, application shall be made to the Secretary for special rulings particularly applicable to the cases in question.
15.102 The strength of a main landing gear wheel shall be substantiated by the following two static tests:
(a) Radial load test. (See CAR 15.1020)
(b) Side load test. (See CAR 15.1021)

15.1020 The required radial test load is equal to -

(P)x(n)x(1.5)x(1.25)
Where P is the maximum static load for which approval is requested, n is

2.80 + 9000/(2P+4000)
and is the applied landing load factor for the corresponding airplane, 1.5 is the factor of safety, and 1.25 is a strength test material factor.

15.1021 The required side test load is equal to -

(0.35)x(the radial test load).

15.1022 The radial and side loads shall be applied separately and the wheel shall be equipped with the correct size tire inflated to the proper pressure for the load for which certification is requested.
15.1023 The radial load shall be applied to the wheel in the place of the tire and may be distributed over a portion of the tire by allowing the tire to bear in a box of firm earth or sand.

15.1024 The side load shall be applied to the rim of the wheel at its maximum radius and may be distributed over an arc of not more than $60^0$. The wheel shall be restrained only by the axle.

15.1025 When it is impossible to apply sufficient side load to the tire due to its inability to stay on the rim of the wheel, the side load shall be applied directly to the rim of the wheel. In this case , the required test load shall be increased over that specified in CAR 15.1021 in the ratio of the distance from the center of the wheel to the point of maximum cross sectional width of the tire, to the distance from the center of the wheel to the point where the load actually is applied, thus obtaining a bending moment at the center of the wheel of the same value as would have been obtained had the load been applied at the maximum cross sectional width of the tire.

15.103 A main landing gear wheel shall support the required loads before failure.

15.104 When a brake is incorporated in a main landing gear wheel, the brake mechanism and its operation shall be satisfactory to the Secretary and the brake shall be free from any undue tendency to lock or jam.

15.105 The rim contour of a main landing gear wheel shall conform to the Tire and Rim Association's standards or recommendations unless the wheel is to be used in conjunction with a specially constructed tire.

15.106 A landing gear wheel may be equipped with any make or type of tire, provided that the tire is a proper fit on the rim of the wheel and provided that the tire manufacturer's load rating, which he uses and recommends as a basis for his guarantee, is not exceeded.

15.107 Each unit of a certificated model of main landing gear wheel shall bear the following additional identification data as prescribed in CAR 15.042(e): The maximum static load for which certificated.

15.108 A request for certification of a type or model or series of models of main landing gear wheels shall be supported by the following additional data as prescribed in CAR 15.0502:

15.1080 A report of the static tests prescribed in CAR 15.102. The report shall contain complete details of the tests, including records of wheel deflections and photographs of the test set-ups. If the side load is applied in accordance with CAR 15.1025, the report shall show clearly that the procedure prescribed in CAR 15.1024 was impossible. The report shall be signed by the person making the tests, and shall be supported by affidavit unless the tests were witnessed by a Bureau inspector, in which case such inspector also will sign the report as a witness.



**5.2.5**
**Part 04 – Airplane Airworthiness As Amended to May 31, 1938/Reprinted**

Same as item 3. above.

**5.2.6**
**CAR 15 – As Amended to May 15, 1938/Reprinted**

Same as item 4. above except as follows:

15.1020 Replace the strength test material factor of 1.25 with 1.15
15.1024 Replace "arc of not more than 60" with "arc of not more that 30"
15.105 Replace "tire manufacturer's load rating, which he uses and recommends as a basis for his guarantee, is not exceeded" with "tire rating of the Airplane Tire Committee of the Tire and Rim association is not exceeded".

**5.2.7**

**CAR 15 – As Amended to November 15, 1940** {Reprinted}

Same as item 3. above except as follows:

15.1080 Replace “a Bureau inspector” with “an inspector of the Administrator”.

**5.2.8**

**Part 04 – As Amended to April 1, 1941/Reprinted**

Same as item 6. above except as follows:

04.442 Replace “the Secretary” with “the Administrator”.

**5.2.9**

**Part 15.—As Amended to July 1, 1942—Amendment 15-1,-2**

Strike section 15.104 and insert in lieu thereof the following: [Sections 15.105, 15.106, 15.107, and 15.108/1080 remain unchanged]

15.1040 Testing of brakes for certification

a. A wheel-brake combination shall demonstrate satisfactory performance during 100 tests simulating the stopping of an airplane at an average deceleration of at least 10 feet per second per second, from a speed chosen by the applicant. The kinetic energy absorbed per stop shall be computed and the wheel-brake combination shall be certificated for a kinetic energy absorption not in excess of the amount so determined.

b. To be eligible for use on airplanes certificated in accordance with the transport category requirements of Part 04, a wheel-brake combination shall further demonstrate satisfactory performance during three tests identical with those specified in paragraph (a) except that the speed shall be increased to obtain a kinetic energy absorption of 125% of that determined under that paragraph.

15.1041T Adaptation of brakes to airplanes – Transport category

a. An airplane certificated in accordance with the transport category requirements of Part 04 shall make use of wheel-brake combinations for which the summation of the kinetic energy ratings of the brakes used in the main landing gear is at least equal to:

$$K.E. = .0334\ W\ V_S^2$$

Where K. E. = kinetic energy in foot-pounds

W = the maximum landing weight of the airplane

$V_S$ = the power off stalling speed of the airplane in miles per hour at sea level in standard air at maximum landing weight.

b. The wheel-brake combinations used in such airplane shall have been tested, in determining the kinetic energy absorption under 15.1040, from a speed lying between 80% and 100% of $V_S$.

15.1042 Design. Brakes shall be free from any undue tendency to lock or jam, and shall be suitably shielded from water, mud, and oil.

15.1043 Static torque. The maximum available static torque in reverse shall be at least 40% of the forward static torque when both are measured at the same applied pedal force.

15.1044 Adjustment. When necessary to insure satisfactory performance, the brake mechanism shall be equipped with suitable adjustment devices to compensate for disc or lining wear, heat, and other normal service effects.

15.1045 Strength. The brake and all of its attachments to the wheel shall be designed with an ultimate strength sufficient to withstand a torque which is 1.6WR/B, where R is the rolling radius of the tire and B is the number of brakes. A static test of the brake and wheel shall demonstrate that the assembly is capable of withstanding a torque which is 80% of the above without yielding to the

point of impairing service operation.

15.1046 Test log. A log of the test runs shall be submitted together with other calculations which are necessary to indicate compliance with the above brake regulations.

15.1047 Identification data. Each certificated brake shall bear the following identification as prescribed in section 15.042(e): "The foot-pounds of kinetic energy for which it is approved." _

**5.2.10**

**Part 04 – As Amended to August 15, 1942/Reprinted**

Same as item 3. above except added 04.445-T as follows:

04.445-T **Brakes.** Transport category airplanes shall be equipped with brakes certificated in accordance with the provisions of Part 15 for the maximum certificated landing weight at sea level and the power-off stalling speed, $V_{SO}$, as defined in

**§** 04.7511-T. The brake system for such airplanes shall be so designed and constructed that in the event of a single failure in any connection or transmitting element in the brake system, or the loss of any single source of hydraulic or other brake operating energy supply, it shall be possible, as shown by suitable test or other data, to bring the airplane to rest under the conditions specified in **§** 04.7533-T with a mean negative acceleration during the landing roll of at least 50 percent of that obtained in determining the landing distance under that section.

**5.2.11**

**Part 04: November 1, 1943 [Normal, Transport, and Acrobatic]/Reprinted**

04.442 **Wheels**. Main landing gear wheels shall be of a type or model certificated by the Administrator in accordance with the provisions of Part15 [created November 1, 1937] and shall not be subjected to static loads in excess of those for which they are certificated. Tail wheels may be of any type or model and are not certificated. Nose wheels are subject to special rulings to be made by the Administrator.

04.4420 For the purpose of these regulations main landing gear wheels are considered as those nearest the airplane center of gravity with respect to fore-and-aft location.

04.4421 For the purpose of these regulations a tail wheel is considered as one which supports the tail of a conventional airplane in the three-point landing attitude. A nose wheel is considered to be a wheel supporting the nose of the airplane when the two main wheels are located behind the center of gravity.

04.443 **Tires.** A landing gear wheel may be equipped with any make or type of tire, provided that the tire is a proper fit on the rim of the wheel and provided that the tire rating of the Airplane Tire Committee of the Tire and Rim Association is not exceeded.

04.4430 When specially constructed tires are used to support an airplane, the wheels shall be plainly and conspicuously marked to that effect. Such markings shall include the make, size, number of plies, and identification marking of the proper tire.

04.445-T **Brakes.** Transport category airplanes shall be equipped with brakes certificated in accordance with the provisions of Part 15 for the maximum certificated landing weight at sea level and the power-off stalling speed, $V_{SO}$, as defined in

**§** 04.7511-T. The brake system for such airplanes shall be so designed and constructed that in the event of a single failure in any connection or transmitting element in the brake system, or the loss of any single source of hydraulic or other brake operating energy supply, it shall be possible, as shown by suitable test or other data, to bring the airplane to rest under the conditions specified in **§** 04.7533-T with a mean negative acceleration during the landing roll of at least 50 percent of that obtained in determining the landing distance under that section.

**5.2.12**
**Part 15 Reprinted—As Amended to April 15, 1944**

Consolidated Part 15 versions of items 4.(1937), 6.(1938), 7.(1940), and 9.(1942).

**Part 15: Aircraft Equipment Airworthiness As Amended to April 15, 1944**

15.0 General

15.0 Provision for Rating. Pursuant to the provisions of the Civil Aeronautics Act of 1938, as amended, empowering and requiring the Civil Aeronautics Board to prescribe such minimum standards governing appliances, including instruments, equipment, apparatus, parts, appurtenances or accessories of whatever description, which are used, or are capable of being or intended to be used, in the navigation, operation, or control of aircraft in flight (including parachutes and communication equipment and any other mechanism installed in or attached to aircraft during flight), as may be required in the interest of safety, and to provide for the rating of aircraft and such appliances as to their airworthiness, the requirements hereinafter set forth shall be used as the minimum standards for establishing such rating of aircraft appliances for use in certificated aircraft.

15.10 (Wheels), and 15.104 (Brakes) thru 15.1080 remained unchanged.

**5.2.13**
**Civil Aeronautics Manual 04, Revised July 1, 1944**

**Introductory Note.** Through out this document, this note applies to any and all references made to the Civil Aeronautics Manual (CAM) 04.

The CAM 04 included for ease of reference the Civil Air Regulations (CAR) Part 04 immediately preceding the corresponding section of the manual. The manual material therein was not mandatory and was intended only to explain and to show acceptable methods of complying with the pertinent requirement. Alternate methods of showing compliance may be used at the option of the applicant. The function of the Civil Aeronautics Administration (CAA) was to examine such technical data and to conduct or witness such inspection and testing as may be necessary to demonstrate compliance with the Regulations.

04.442, 04.4420, 04.4421, 04.443, and 04.445-T: Same as under 5.2.11. except the following was added to 04.443 and 04.445-T:

04.443-Tires—A wheel appended to a previously approved tail skid installation will not be classes as a "landing gear wheel." See "Minor Changes," for an acceptable procedure of use in making such a change.__

04.445-T-Brakes This requirement is based upon the fact that compliance with the operating rules of CAR 61.712 will require great dependence upon the presence and proper functioning of brakes unless the runways involved are unusually long. *Its purpose is believed clearly indicated by the text of the regulation itself.[italicized text added by November 1, 1944 CAM 04]*

The nature and extent of the "test or other data" required to show compliance with this requirement will necessarily depend upon a great many things such as, for example, the general arrangement of the landing gear, the design of the brake system, the extent to which the capacity of the brakes is used in establishing the landing distance required by 04.7533-T, the amount of available performance data for the brakes, etc. The simplest possible procedure would appear to be to determine the average deceleration during a landing ground roll using no brakes and then to establish the landing distance required by 04.7533-T using the brakes to the extent necessary to double the mean deceleration so established. It appears likely, however, that this procedure would result in excessive landing distance and might seriously limit the use of the airplane in scheduled operation.

If it is desired by the applicant to make the maximum possible use of the brakes in establishing the landing distance, and if also the contribution of the brakes to the total deceleration is relatively large, it will be necessary so to design the brake system as to permit the application of slightly less than half the braking deceleration so developed under the conditions specified in this section. The following dual system is recommended: dual wheel elements (drums or disc units), transmitting elements, power sources, master cylinders, etc., connected to a single pedal on each rudder pedal, such that the failure of any single one of these would leave half the total braking capacity symmetrically disposed about the plane of symmetry of the airplane. With such a system it should be possible to show compliance with this section by means of calculation based upon the test data necessary to establish the landing distance plus those obtained as a part of the certification process for the brake (See CAR 15.104). *Such a braking system is recommended[11-1-44].*

If the system be so designed that under the conditions here specified appreciably less than half the total braking capacity remains or if the remaining capacity be asymmetrically disposed, it will almost certainly require tests to determine that half the mean deceleration may in fact be developed and/or that the airplane may be safely controlled directionally while doing so. *In the case of a conventional landing gear it appears unlikely that any appreciable braking effort might be safely applied on one side only of the airplane. [11-1-44].*

The decision, therefore, rests with the applicant. It is recommended however, that the question be considered well in advance of presenting the airplane and that, once the decision be taken, it be communicated to the Civil Aeronautics Administration, together with drawings of the installation, a proposal concerning the element or power source to be considered inoperative, and an outline of the method 9tests, calculations, etc.), by means of which it is proposed to show compliance. [11-1-44].

**5.2.14**
**Civil Aeronautics Manual 04-T, November 1, 1944**
See italicized text under 13. above {Italicized text was added to 04.445-T in this version of CAM 4-T}.

**5.2.15**
**Adoption of New Part 04 and New Part 03 – November 1945**

(i) A new Part 04 adopted on 11-09-45, applicable to Transport airplanes only.
(ii) A new Part 03 was adopted on 11-13-45, applicable to Normal, Utility, Acrobatic, and Restricted Categories [N, U, A, R]
(iii) The old Part 04 remained in effect for N, T, and A categories as well

**Part 04: November 9, 1945**

04.300 Approved Specifications and Parts. Where the word “Approved” or “acceptable” is used in this Part to describe specifications, materials, parts, methods and processes, such items shall be specifically approved by the Administrator upon a basis and in a manner found by him to be necessary to safety.
**Note:** 04.363 Wheels, and 04.365 Brakes , require that wheels and brakes be certificated in accordance with the provisions of Part 15.

**5.2.16**
**aPart 15 Reprinted—May 31, 1946.**
Same as Item 12. above.

**5.2.17**
**Re-designation of New and Old Parts 04—November 22, 1946**

(i) Old Part 04 designated as Part 04a:
(ii) New Part 04 designated as Part 04b Transports only

**5.2.18**
**Part 04a Reprinted: November 1, 1947**
04.442 to 04.445-T became 04a.442 to 04a.445-T
No change in content {Same as item 11. above.}
04a.442 **Wheels**. Main landing gear wheels shall be of a type or model certificated by the Administrator in

accordance with the provisions of Part15 and shall not be subjected to static loads in excess of those for which they are certificated. Tail wheels may be of any type or model and are not certificated. Nose wheels are subject to special rulings to be made by the Administrator.

04a.4420 For the purpose of these regulations main landing gear wheels are considered as those nearest the airplane center of gravity with respect to fore-and-aft location.

04a.4421 For the purpose of these regulations a tail wheel is considered as one which supports the tail of a conventional airplane in the three-point landing attitude. A nose wheel is considered to be a wheel supporting the nose of the airplane when the two main wheels are located behind the center of gravity.

04a.443 **Tires.** A landing gear wheel may be equipped with any make or type of tire, provided that the tire is a proper fit on the rim of the wheel and provided that the tire rating of the Airplane Tire Committee of the Tire and Rim Association is not exceeded.

04a.4430 When specially constructed tires are used to support an airplane, the wheels shall be plainly and conspicuously marked to that effect. Such markings shall include the make, size, number of plies, and identification marking of the proper tire.

04a.445-T **Brakes.** Transport category airplanes shall be equipped with brakes certificated in accordance with the provisions of Part 15 for the maximum certificated landing weight at sea level and the power-off stalling speed, $V_{SO}$, as defined in

**§** 04.7511-T. The brake system for such airplanes shall be so designed and constructed that in the event of a single failure in any connection or transmitting element in the brake system, or the loss of any single source of hydraulic or other brake operating energy supply, it shall be possible, as shown by suitable test or other data, to bring the airplane to rest under the conditions specified in **§** 04.7533-T with a mean negative acceleration during the landing roll of at least 50 percent of that obtained in determining the landing distance under that section.



### 5.2.19 Part 04a: Amendment 04a-1, Effective January 1, 1948

Prior to this amendment approval of certain specified appliances was required by type certification. This entailed submission of detailed data for each appliance or variation thereof, which had to be examined and approved by the Administrator of Civil Aeronautics. The purpose of this amendment was to simplify and expedite approval by permitting, in lieu of type certification, the establishment and publication of specifications, in the form of "Technical Standard Orders (TSOs)" by the Administrator for such appliances. The TSOs were established after collaboration with the industry and upon consideration of pertinent aviation industry, federal, and military specifications. An appliance for which a TSO had been so established was deemed approved by the Administrator when the manufacturer certified that the appliance meets the specifications included therein, and the appliance does in fact meet the specification. Section 04.300 was repealed and a new **§** 04a.07 was added to read as follows:

**§** 04a.07 *Approval of materials, parts, processes, and appliances.* Materials, parts, processes, and appliances shall be approved upon a basis and in a manner found necessary by the Administrator to implement the pertinent provisions of the Civil Air Regulations. The Administrator may adopt and publish such specifications as he finds necessary to administer this regulation, and shall incorporate therein such portions of the aviation industry, Federal, and military specifications respecting such materials, parts, processes, and appliances as he finds appropriate.
Any material, part, process, or appliance shall be deemed to have met the requirements for approval when it meets the pertinent specifications adopted by the Administrator, and the manufacturer so certifies in a manner prescribed by the Administrator.

### 5.2.20 Re-designation of Parts 04a and 04b as Parts 4a and 4b: effective. May 1, 1949

### 5.2.21 Part 15 Reprinted—As Amended to November 1, 1949

LANDING GEAR EQUIPMENT

15.11 *Landing gear wheels {Was 15.10 thru 15.103 and 15.105 thru 15.1080}*

(a) Main landing gear wheels will be certificated for a maximum static load which will be determined from the strength of the wheel. Tail wheels will not be certificated.

(1) For the purpose of these regulations main landing gear wheels are considered as those nearest the airplane center of gravity with respect to fore-and-aft location.

(2) For the purpose of these regulations a tail wheel is considered as one which supports the tail of a conventional airplane in the three-point landing attitude.

(b) For wheels other than main landing or tail wheels, application shall be made to the Secretary for special rulings particularly applicable to the cases in question.

(c) The strength of a main landing gear wheel shall be substantiated by the following two static tests:

(1) Radial load test. (See subparagraph (3) of this paragraph)

(2) Side load test. (See subparagraph (4) of this paragraph)

(3) The required radial test load is equal to -

(P)x(n)x(1.5)x(1.25)

Where P is the maximum static load for which approval is requested, n is

2.80 + 9000/(2P+4000)

and is the applied landing load factor for the corresponding airplane, 1.5 is the factor of safety, and 1.25 is a strength test material factor.

(4) The required side test load is equal to -

(0.35)x(the radial test load).

(5) The radial and side loads shall be applied separately and the wheel shall be equipped with the correct size tire inflated to the proper pressure for the load for which certification is requested.

(6) The radial load shall be applied to the wheel in the place of the tire and may be distributed over a portion of the tire by allowing the tire to bear in a box of firm earth or sand.

(7) The side load shall be applied to the rim of the wheel at its maximum radius and may be distributed over an arc of not more than $30^0$. In order to insure sufficient strength in the retaining flanges of the rim, all the side load shall be applied to the inner flange in a direction such as to bend it away from the tire. In such case , the load must be increased so that its side component is equal to the load specified in subparagraph (4) of this paragraph. The wheel shall be restrained only by the axle.

(d) A main landing gear wheel shall support the required loads before failure.

(e) The rim contour of a main landing gear wheel shall conform to the Tire and Rim Association's standards or recommendations unless the wheel is to be used in conjunction with a specially constructed tire.

(f) A landing gear wheel may be equipped with any make or type of tire, provided that the tire is a proper fit on the rim of the wheel and provided that the tire manufacturer's load rating, which he uses and recommends as a basis for his guarantee, is not exceeded.

(g) Each unit of a certificated model of main landing gear wheel shall bear the following additional identification data as prescribed in 15.5(c)(5): The maximum static load for which certificated.

(h) A request for certification of a type or model or series of models of main landing gear wheels shall be supported by the following additional data as prescribed in 15.6(a)(3):

(1) A report of the static tests prescribed in 15.11(c). The report shall contain complete details of the tests, including records of wheel deflections and photographs of the test set-ups. The report shall be signed by the person making the tests, and shall be certified to unless the tests were witnessed by an inspector of the

Administrator, in which case such inspector also will sign the report as a witness.

**§ 15.12** *Brakes* {was 15.1040 thru 15.1047}
**(a)** Testing of brakes for certification (1) A wheel-brake combination shall demonstrate satisfactory performance during 100 tests simulating the stopping of an airplane at an average deceleration of at least 10 feet per second per second, from a speed chosen by the applicant. The kinetic energy absorbed per stop shall be computed and the wheel-brake combination shall be certificated for a kinetic energy absorption not in excess of the amount so determined.

(2) To be eligible for use on airplanes certificated in accordance with the transport category requirements of Part 4a of this subchapter, a wheel-brake combination shall further demonstrate satisfactory performance during three tests identical with those specified in subparagraph (1) of this paragraph except that the speed shall be increased to obtain a kinetic energy absorption of 125% of that determined under that subparagraph.

(b) Adaptation of brakes to airplanes – Transport category

(1) An airplane certificated in accordance with the transport category requirements of Part 4a of this subchapter shall make use of wheel-brake combinations for which the summation of the kinetic energy ratings of the brakes used in the main landing gear is at least equal to:

$$K.E. = .0334\ W\ V_S^2$$

Where K. E. = kinetic energy in foot-pounds
W = the maximum landing weight of the airplane
$V_S$ = the power off stalling speed of the airplane in miles per hour at sea level in standard air at maximum landing weight.

(2) The wheel-brake combinations used in such airplane shall have been tested, in determining the kinetic energy absorption under § 15.12(a), from a speed lying between 80% and 100% of $V_S$.

(c) Design. Brakes shall be free from any undue tendency to lock or jam, and shall be suitably shielded from water, mud, and oil.

(d) Static torque. The maximum available static torque in reverse shall be at least 40% of the forward static torque when both are measured at the same applied pedal force.

(e) Adjustment. When necessary to insure satisfactory performance, the brake mechanism shall be equipped with suitable adjustment devices to compensate for disc or lining wear, heat, and other normal service effects.

(f) Strength. The brake and all of its attachments to the wheel shall be designed with an ultimate strength sufficient to withstand a torque which is 1.6WR/B, where R is the rolling radius of the tire and B is the number of brakes. A static test of the brake and wheel shall demonstrate that the assembly is capable of withstanding a torque which is 80% of the above without yielding to the point of impairing service operation.

(g) Test log. A log of the test runs shall be submitted together with other calculations which are necessary to indicate compliance with the above brake regulations in paragraphs (a) to (f) of this section.

(h) Identification data. Each certificated brake shall bear the following identification as prescribed in § 15.5(c)(5): "The foot-pounds of kinetic energy for which it is approved."

**5.2.22**
**Part 15, Amendment 15-1: Effective 12-07-49**

1. By amending 15.5 to read as follows:
15.5 Identification data. Each unit certificated or approved shall be marked with the identification data

required by § 2.36, unless otherwise specifically provided for in this part of the regulations. The identification data shall be displayed in a conspicuous place on the unit in a manner such that it cannot be easily erased, disfigured, or obscured.

2. By amending 15.11(g) to read as follows:
15.11(g) Each unit of a certificated model of main landing gear wheel shall bear the identification data as prescribed in 15.5.

3. By amending 15.12(h) to read as follows:
15.12(h) Identification data. See 15.5

**5.2.23**
**Part 4a Reprinted---April 7, 1950**

04a.442-04a.4421 became 4a.477-479; 04a.443-.4430 became 4a.480-481; and 04a.445-T became 4a.483-T

No change in content {Same as item 18. above.}

§ 4a.477 **Wheels**. Main landing gear wheels shall be of a type or model certificated by the Administrator in accordance with the provisions of Part15 of this subchapter and shall not be subjected to static loads in excess of those for which they are certificated. Tail wheels may be of any type or model and are not certificated. Nose wheels are subject to special rulings to be made by the Administrator.

§ 4a.478 *Main landing gear wheels.* For the purpose of these regulations main landing gear wheels are considered as those nearest the airplane center of gravity with respect to fore-and-aft location.

§ 4a.479 *Tail and nose wheels.* For the purpose of these regulations a tail wheel is considered as one which supports the tail of a conventional airplane in the three-point landing attitude. A nose wheel is considered to be a wheel supporting the nose of the airplane when the two main wheels are located behind the center of gravity.

§ 4a.480 **Tires.** A landing gear wheel may be equipped with any make or type of tire, provided that the tire is a proper fit on the rim of the wheel and provided that the tire rating of the Airplane Tire Committee of the Tire and Rim Association is not exceeded.

§ 4a.481 *Tire markings.* When specially constructed tires are used to support an airplane, the wheels shall be plainly and conspicuously marked to that effect. Such markings shall include the make, size, number of plies, and identification marking of the proper tire.

§ 4a.483-T **Brakes.** Transport category airplanes shall be equipped with brakes certificated in accordance with the provisions of Part 15 of this subchapter, for the maximum certificated landing weight at sea level and the power-off stalling speed, $V_{SO}$, as defined in § 4a.739. The brake system for such airplanes shall be so designed and constructed that in the event of a single failure in any connection or transmitting element in the brake system, or the loss of any single source of hydraulic or other brake operating energy supply, it shall be possible, as shown by suitable test or other data, to bring the airplane to rest under the conditions specified in § 4a.750-T with a mean negative acceleration during the landing roll of at least 50 percent of that obtained in determining the landing distance under that section.

**Note:** CAM 4a dated August 1959 has text identical to that shown above for §§ 4a.477, 4a.478, 4a.479, 4a.480, 4a.481, and 4a.483-T.

**5.2.24**
**Part 15 Rescinded, Amendment 15-4, effective March 5, 1952**

Present Part 15 of the Civil Air Regulations contains provisions for type certification of equipment used on aircraft. However, the adoption of the policy on Technical Standard Orders which sets up a procedure for approval of materials, parts, processes, and appliances without the necessity of type certification of such items has made unnecessary the retention of any of the provisions of Part 15. The Board therefore is rescinding

Part 15.

**5.2.25**
**TSO-C26 Wheels and Brakes/AS-227-A is issued, March 15, 1952**

UNITED STATES OF AMERICA
DEPARTMENT OF COMMERCE
OFFICE OF THE ADMINISTRATOR OF CIVIL AERONAUTICS
WASHINGTON 25, D.C.

TSO-C26 effective
March 15, 1952

TECHNICAL STANDARD ORDER

SUBJECT: AIRCRAFT WHEELS AND BRAKES

INTRODUCTION:

Under Section 601 of the Civil Aeronautics Act of 1938, as amended, and Parts 3, 4a, 4b and 6 of the Civil Air Regulations issued pursuant thereto, the Administrator of Civil Aeronautics is authorized to adopt standards for wheels intended for installation on civil aircraft. In adopting these standards, consideration has been given to existing Government and industry standards for the minimum strength and performance requirements for wheels intended for use on civil aircraft. This Technical Standard Order is intended to serve as a criterion by which the product manufacturer may produce wheels which will meet standards acceptable to the Civil Aeronautics Administration. In lieu of the above procedure, wheels may be approved as part of the aircraft design, in which case, the aircraft manufacturer should submit the pertinent wheel drawings and include them on the aircraft drawing list. Such wheels shall comply with the strength and performance requirements for wheels as stated in this Order, and the approval thereof will be recognized by all Civil Aeronautics Administration representatives.

The above is also applicable to wheel-brake combinations when the regulations require that a brake shall be rated on a basis of kinetic energy capacity in order to make it eligible for use on transport category aircraft.

DIRECTIVE:

Provision: The strength and performance requirements for wheels and brakes as set forth in Sections 4 and 5 of the Society of Automotive Engineers, Inc., Aeronautical Standard Specification AS-227A dated February 1, 1952*, with the exceptions hereinafter noted, are hereby established as minimum safety standards for wheels or wheel-brake combinations intended for use as main or nose wheels on civil aircraft.

EXCEPTION:

Wheels or wheel-brake combinations for non-transport category aircraft and rotorcraft need not comply with Sections 5.2(d), (e), (f) and (g), 5.4.3, 5.4.5, 5.4.6 and 5.4.7 of the above-mentioned specification. These sections pertain to brake tests and a wheel roll test.

* Copies may be obtained from the Society of Automotive Engineers, 29 West 69th Street, New York, New York.

Application: Wheels or wheel-brake combinations complying with the specifications appearing in this Order are hereby acceptable for use on civil aircraft.

Wheels or wheel-brake combinations already approved by the Administrator may continue to be installed by the aircraft manufacturer on production aircraft:---

1. for which an application for original type certificate is made prior to the effective date of this Order;

2. the prototype of which is flown within one year after the effective date of this Order; and

3. the prototype of which is not flown within one year after the effective date of this Order, if due to causes beyond the applicant's control.

If an alteration or replacement involving a change in type or model of wheels or wheel-brake combinations is made, or if an original installation on an individual airplane is made, previously type certificated wheels or wheel-brake combinations may be installed.

SPECIFIC INSTRUCTIONS

Marking. In addition to the identification information required in Section 3.2 of Specification AS-227A (except that "AS-227" is not required), each wheel and wheel-brake combination shall be permanently marked with the Technical Standard Order designation, CAA-TSO-C26, to identify the wheel as meeting the requirements of this Order in accordance with the manufacturer's statement of conformance described below. This identification will be accepted by the Civil Aeronautics Administration as evidence that the established minimum safety requirements for the wheel have been met. For wheel or wheel-brake combinations approved as part of the aircraft design, no identification marking other than the aircraft manufacturer's part or drawing number is required.

The above is also applicable to wheel-brake combinations when the regulations require that a brake shall be rated on a basis of kinetic energy capacity in order to make it eligible for use on transport category aircraft.

Data requirements: None.

Effective Date: After March 15, 1952, specifications contained in this Order will constitute the basis for Civil Aeronautics Administration approval of wheels or wheel-brake combinations for use on certificated aircraft.

Deviations: Requests for deviation from, or waiver of, the requirements of this Order, which affect the basic airworthiness of the component, should be submitted for the approval of the Chief, Aircraft Engineering Division, Office of Aviation Safety, Civil Aeronautics Administration. These requests should be addressed to the nearest Regional Office of the Civil Aeronautics Administration, Attention: Chief, Aircraft Engineering Branch.

Conformance: The manufacturer shall furnish to the CAA, Aircraft Engineering Division, Attention: W-298, Washington 25, D. C., a written statement of conformance signed by a responsible official of his company, setting forth that the designated wheel or wheel-brake assembly to be produced by him meets the minimum safety standards established in this Order. Immediately thereafter, distribution of the wheels or wheel-brake assemblies conforming with the terms of this Order may be started and continued. A statement of conformance is not required for wheel or wheel-brake assemblies approved as part of the aircraft design.

The prescribed identification on the wheels or wheel-brake assemblies does not relieve the aircraft manufacturer or owner of responsibility for the proper installation of the wheels or wheel-brake assemblies on his aircraft, nor waive any of the requirements concerning type certification of the aircraft in accordance with existing Civil Air Regulations.

If complaints of nonconformance with the requirements of this Order are brought to the attention of the Civil Aeronautics Administration, and investigation indicates that such complaints are justified, the Administrator will take appropriate action to restrict the use of the product involved.

Copies of this Technical Standard Order and other Technical Standard Orders may be obtained from the Civil Aeronautics Administration, Aviation Information Office, Washington 25, D. C.

Acting Administrator of Civil Aeronautics

**5.2.26**
**Part 4a, Amendment 4a-1, effective December 15, 1952.**

Correction of References By adding a note at the beginning of Part 4a immediately preceding the heading “GENERAL” to read as follows:

NOTE: Current applications for airworthiness and type certificate are not processed under this part, but are processed under other airworthiness parts. At present, this part primarily governs modification of aircraft which were originally certificated under Part 4a. Unless otherwise provided, all references to other parts of this subchapter are those provisions in effect on September 29, 1947.

5.3 Table 5-2 History of Regulations Index: 1945-2002: Transport Category Airplanes

**Wheels and Brakes**

| Date | Action | Wheels | Tires | Brakes |
|---|---|---|---|---|
| 11-09-45 | Adopted New Part 04 [T] | 04.363 | 04.364 | 04.365 |
| 05-31-46 | Part 15 Reprinted | 15.10 | | 15.1040/41T |
| 11-22-46 | Amd't 04-5Differentiation of ##: New Part 04 became Part 04b | | | |
| 01-01-48 | Amd't 04b-8Approval by the Administrator: Materials/Parts | | | |
| 05-01-49 | Part 04b designated as Part 4b | | | |
| 10-01-49 | Part 4b Reprinted | 4b.391 | 4b.392 | 4b.396-398 |
| 11-01-49 | Part 15 Reprinted | 15.11 | | 15.12 |
| 12-07-49 | Amd't 4b-1 | Identification Data/Amended 4b.931+15.11 and 15.12 | | |
| 07-20-50 | Part 4b Reprinted | 4b.335 | 4b.336 | 4b.337 |
| 10-12-51 | Part 514: The TSO System made available | | | |
| 03-05-52 | Amd't 4b-6 Changed: 4b.18 | 4b.335 | 4b.336 | 4b.337 |
| 03-05-52 | Amd't 15-4 Part 15 Rescinded/ TSO System to be used | | | |
| 03-15-52 | First TSO for Wheels & Brakes Issued: TSO-C26/Ref. AS-227A | | | |
| 12-31-53 | Part 4b Reprinted | 4b.335 | 4b.336 | 4b.337 |
| 09-01-54 | CAM 4b: added Policy 4b.337-1, -2, and –3 on Brakes | | | |
| 03-13-56 | Amd't 4b-3Misc. Amd'ts: including 4b.336-Tires & 4b.337-Brakes | | | |
| 05-01-56 | CAM 4b: added policy 4b.337-4 on Brakes | | | |
| 08-12-57 | Amd't 4b-6 Miscellaneous Amendments | | | |
| 01-01-58 | CAM 04b | 4b.335 | 4b.336 | 4b.337;-1-4 |
| 06-01-61 | TSO-C26a Issued: Aircraft Wheels & Brakes/§514.72/AS-227C | | | |
| 11-17-64 | TSO-C26a issued as FAR §37.172 [ref. Doc #5065, 29 F.R.15317] | | | |
| 02-01-65 | Recodified 4b into FAR §§ | 25.731 | 25.733 | 25.735 |
| 04-11-67 | TSO-C26a/§37.172 amended/Doc. # 8084, 32 F.R.5769/AS-227C | | | |
| 04-08-70 | Amd't 25-23 Revised §§ | | 25.733 | 25.735(e),(f) |
| 01-21-71 | Amd't 37-28 Issued TSO-C26b/Complete text/no ref. to AS-227C | | | |

11-29-79 Amd't 25-48 Revised § 25.735(b), (f)(2), (g) and TSO-C26b

12-31-79 TSO-C26c/§37.172 issued- Wheels & Brakes

06-09-80 Amd'ts 21-50/25-52/37-47: Part 37 revoked. TSOs became voluntary standards.

05-18-84 TSO-C26c with Addendum I issued: Wheels & Brakes

07-20-90 Amd't 25-72 Revised § 25.731 25.733 25.735(b)

02-18-98 Amd't 25-92 Added § 25.735(h)/requires worn brake accountability

04-24-02 Amd't 25-107 Revised §§ 25.731 25.735+AC

05-02-02 TSO-C135 issued: Brakes/Part 25 Only

11-26-02 Amd't 25-1081-g Stall speed method as acceptable MOC

## Transport Category Airplane Wheels and Brakes: History of Regulations

### 5.4.1 Part 04: November 9, 1945: adopted New Part 04[T]

04.363 Wheels. Main landing gear wheels (i.e., those nearest the airplane center of gravity) shall be of an approved type in accordance with Part 15. The rated static load of each main wheel shall not be less than the design take-off weight, divided by the number of main wheels. Nose wheels shall be tested in accordance with Part 15 for an ultimate radial load not less than the maximum nose wheel ultimate loads obtained in the ground loads requirements, and for the corresponding side and burst loads specified in Part 15.

04.365 Brakes. All airplanes shall be equipped with brakes certificated in accordance with the provisions of Part 15 for the maximum certificated landing weight at sea level and the power-off stalling speed, $V_{SO}$, as defined in § 04.121. The brake system shall be so designed and constructed that in the event of a single failure in any connection or transmitting element in the brake system (excluding the operating pedal or handle), or the loss of any single source of hydraulic or other brake operating energy supply, it shall be possible, as shown by suitable test or other data, to bring the airplane to rest under conditions specified in § 04.124 with a mean negative acceleration during the landing roll of at least 50% of that obtained in determining the landing distance under that section. In applying this requirement to hydraulic brakes, the brake drum, shoes, and actuators (or their equivalents) shall be considered as connecting or transmitting elements unless it is shown that the leakage of hydraulic fluid resulting from failure of the sealing elements in these units would not reduce the braking effectiveness below that specified above.

04.3650 Parking brake. A parking brake control shall also be provided which may be set by the pilot, and without further attention, maintain braking sufficient to prevent the airplane from rolling on a paved runway while applying take-off power on the most critical engine.

04.3651 Brake controls. Brake controls shall not require excessive control forces in their operation.

### 5.4.2 Part 15 Reprinted—As Amended to April 15, 1944
Consolidated Part 15 versions of 1937, 1938), 19401942

## Part 15: Aircraft Equipment Airworthiness

15.0 General
Provision for Rating. Pursuant to the provisions of the Civil Aeronautics Act of 1938, as amended, empowering and requiring the Civil Aeronautics Board to prescribe such minimum standards governing appliances, including instruments, equipment, apparatus, parts, appurtenances or accessories of whatever description, which are used, or are capable of being or intended to be used, in the navigation, operation, or control of aircraft in flight (including parachutes and communication equipment and any other mechanism installed in or attached to aircraft during flight), as may be required in the interest of safety, and to provide for the rating of aircraft and such appliances as to their airworthiness, the requirements hereinafter set forth shall be used as the minimum standards for establishing such rating of aircraft appliances for use in certificated aircraft.

15.1 LANDING GEAR EQUIPMENT
15.10 LANDING GEAR WHEELS.
15.100 Main landing gear wheels will be certificated for a maximum static load which will be determined from the strength of the wheel. Tail wheels will not be certificated.
15.1000 For the purpose of these regulations main landing gear wheels are considered as those nearest the airplane center of gravity with respect to fore-and-aft location.
15.1001 For the purpose of these regulations a tail wheel is considered as one which supports the tail of a conventional airplane in the three-point landing attitude.
15.101 For wheels other than main landing or tail wheels, application shall be made to the Secretary for

special rulings particularly applicable to the cases in question.
15.102 The strength of a main landing gear wheel shall be substantiated by the following two static tests:
(a) Radial load test. (See CAR 15.1020)
(b) Side load test. (See CAR 15.1021)

15.1020 The required radial test load is equal to -

(P)x(n)x(1.5)x(1.25)
Where P is the maximum static load for which approval is requested, n is

2.80 + 9000/(2P+4000)
and is the applied landing load factor for the corresponding airplane, 1.5 is the factor of safety, and 1.25 is a strength test material factor.

15.1021 The required side test load is equal to -

(0.35)x(the radial test load).

15.1022 The radial and side loads shall be applied separately and the wheel shall be equipped with the correct size tire inflated to the proper pressure for the load for which certification is requested.

15.1023 The radial load shall be applied to the wheel in the place of the tire and may be distributed over a portion of the tire by allowing the tire to bear in a box of firm earth or sand.

15.1026 The side load shall be applied to the rim of the wheel at its maximum radius and may be distributed over an arc of not more than $60^0$. The wheel shall be restrained only by the axle.

15.1027 When it is impossible to apply sufficient side load to the tire due to its inability to stay on the rim of the wheel, the side load shall be applied directly to the rim of the wheel. In this case , the required test load shall be increased over that specified in CAR 15.1021 in the ratio of the distance from the center of the wheel to the point of maximum cross sectional width of the tire, to the distance from the center of the wheel to the point where the load actually is applied, thus obtaining a bending moment at the center of the wheel of the same value as would have been obtained had the load been applied at the maximum cross sectional width of the tire.

15.103 A main landing gear wheel shall support the required loads before failure.

15.1041 Testing of brakes for certification

c. A wheel-brake combination shall demonstrate satisfactory performance during 100 tests simulating the stopping of an airplane at an average deceleration of at least 10 feet per second per second, from a speed chosen by the applicant. The kinetic energy absorbed per stop shall be computed and the wheel-brake combination shall be certificated for a kinetic energy absorption not in excess of the amount so determined.

d. To be eligible for use on airplanes certificated in accordance with the transport category requirements of Part 04, a wheel-brake combination shall further demonstrate satisfactory performance during three tests identical with those specified in paragraph (a) except that the speed shall be increased to obtain a kinetic energy absorption of 125% of that determined under that paragraph.

15.1041T Adaptation of brakes to airplanes – Transport category

b. An airplane certificated in accordance with the transport category requirements of Part 04 shall make use of wheel-brake combinations for which the summation of the kinetic energy ratings of the brakes used in the main landing gear is at least equal to:

$$K.E. = .0334\ W\ V_S^2$$

Where K. E. = kinetic energy in foot-pounds
W = the maximum landing weight of the airplane
$V_S$ = the power off stalling speed of the airplane

in miles per hour at sea level
in standard air at maximum landing weight.

b. The wheel-brake combinations used in such airplane shall have been tested, in determining the kinetic energy absorption under 15.1040, from a speed lying between 80% and 100% of $V_S$.

15.1048 Design. Brakes shall be free from any undue tendency to lock or jam, and shall be suitably shielded from water, mud, and oil.

15.1049 Static torque. The maximum available static torque in reverse shall be at least 40% of the forward static torque when both are measured at the same applied pedal force.

15.1050 Adjustment. When necessary to insure satisfactory performance, the brake mechanism shall be equipped with suitable adjustment devices to compensate for disc or lining wear, heat, and other normal service effects.

15.1051 Strength. The brake and all of its attachments to the wheel shall be designed with an ultimate strength sufficient to withstand a torque which is 1.6WR/B, where R is the rolling radius of the tire and B is the number of brakes. A static test of the brake and wheel shall demonstrate that the assembly is capable of withstanding a torque which is 80% of the above without yielding to the point of impairing service operation.

15.1052 Test log. A log of the test runs shall be submitted together with other calculations which are necessary to indicate compliance with the above brake regulations.

15.1053 Identification data. Each certificated brake shall bear the following identification as prescribed in section 15.042(e): "The foot-pounds of kinetic energy for which it is approved." _

15.105 The rim contour of a main landing gear wheel shall conform to the Tire and Rim Association's standards or recommendations unless the wheel is to be used in conjunction with a specially constructed tire.

15.106 A landing gear wheel may be equipped with any make or type of tire, provided that the tire is a proper fit on the rim of the wheel and provided that the tire manufacturer's load rating, which he uses and recommends as a basis for his guarantee, is not exceeded.
15.107 Each unit of a certificated model of main landing gear wheel shall bear the following additional identification data as prescribed in CAR 15.042(e): The maximum static load for which certificated.

15.108 A request for certification of a type or model or series of models of main landing gear wheels shall be supported by the following additional data as prescribed in CAR
15.0502:

15.1080 A report of the static tests prescribed in CAR 15.102. The report shall contain complete details of the tests, including records of wheel deflections and photographs of the test set-ups. If the side load is applied in accordance with CAR 15.1025, the report shall show clearly that the procedure prescribed in CAR 15.1024 was impossible. The report shall be signed by the person making the tests, and shall be supported by affidavit unless the tests were witnessed by a Bureau inspector, in which case such inspector also will sign the report as a witness.

**5.4.3. Amendment 04-5 effective 11-22-46 changed new part 04 to 04b {transports}**

**5.4.4. Amendment 04b-8 effective 01-01-48:** Added **§** 04b.05 and Established approval of parts and appliances by the Administrator via the TSO system. **Specific text** using the TSO system was not added to the regulation until 1952. The first TSO for Wheels and Brakes, TSO-C26 appeared in 1952.

Prior to this amendment approval of certain specified appliances was required by type certification. This entailed submission of detailed data for each appliance or variation thereof, which had to be examined and

approved by the Administrator of Civil Aeronautics. The purpose of this amendment was to simplify and expedite approval by permitting, in lieu of type certification, the establishment and publication of specifications, in the form of "Technical Standard Orders (TSOs)" by the Administrator for such appliances. The TSOs were established after collaboration with the industry and upon consideration of pertinent aviation industry, federal, and military specifications. An appliance for which a TSO had been so established was deemed approved by the Administrator when the manufacturer certified that the appliance meets the specifications included therein, and the appliance does in fact meet the specification. Section 04.300 was repealed and a new § 04b.05 was added to read as follows:

§ 04b.05 *Approval of materials, parts, processes, and appliances.* Materials, parts, processes, and appliances shall be approved upon a basis and in a manner found necessary by the Administrator to implement the pertinent provisions of the Civil Air Regulations. The Administrator may adopt and publish such specifications as he finds necessary to administer this regulation, and shall incorporate therein such portions of the aviation industry, Federal, and military specifications respecting such materials, parts, processes, and appliances as he finds appropriate.
Any material, part, process, or appliance shall be deemed to have met the requirements for approval when it meets the pertinent specifications adopted by the Administrator, and the manufacturer so certifies in a manner prescribed by the Administrator.

**5.4.5 Re-designation of Parts 04a and 04b as Parts 4a and 4b: effective May 1, 1949**

**5.4.6. Part 4b Reprinted---As Amended to October 1, 1949**

APPROVAL OF MATERIALS, PARTS, PROCESSES, AND APPLIANCES {was § 04b.05}

§ 4b.41 *Specifications*. (a) Materials, parts, processes, and appliances shall be approved upon a basis and in a manner found necessary by the Administrator to implement the pertinent provisions of the Civil Air Regulations. The Administrator may adopt and publish such specifications as he finds necessary to administer this section, and shall incorporate therein such portions of the aviation industry, Federal, and military specifications respecting such materials, parts, processes, and appliances as he finds appropriate.
(b) Any material, part, process, or appliance shall be deemed to have met the requirements for approval when it meets the pertinent specifications adopted by the Administrator, and the manufacturer so certifies in a manner prescribed by the Administrator.
[Amdt. 04b-8, 12 F. R. 7898, effective 11-48]

§ 4b.391 *Wheels.* Main landing gear wheels (i.e., those nearest the airplane center of gravity) shall be of an approved type in accordance with Part 15 of this subchapter. The rated static load of each main wheel shall not be less than the design take-off weight, divided by the number of main wheels. Nose wheels shall be tested in accordance with Part 15 of this subchapter for an ultimate radial load not less than the maximum nose wheel ultimate loads obtained in the ground loads requirements, and for the corresponding side and burst loads specified in Part 15 of this subchapter.

§ 4b.396 *Brakes-General*. All airplanes shall be equipped with brakes certificated in accordance with the provisions of Part 15 for the maximum certificated landing weight at sea level and the power-off stalling speed, $V_{SO}$, as defined in § 4b.93. The brake system shall be so designed and constructed that in the event of a single failure in any connection or transmitting element in the brake system (excluding the operating pedal or handle), or the loss of any single source of hydraulic or other brake operating energy supply, it shall be possible, as shown by suitable test or other data, to bring the airplane to rest under conditions specified in §§ 4b.111-4b.114 with a mean negative acceleration during the landing roll of at least 50% of that obtained in determining the landing distance under that section. In applying the requirements of §§ 4b.396-4b.398 to hydraulic brakes, the brake drum, shoes, and actuators (or their equivalents) shall be considered as connecting or transmitting elements unless it is shown that the leakage of hydraulic fluid resulting from failure of the sealing elements in these units would not reduce the braking effectiveness below that specified in this section.

§ 4b.397 *Parking brake*. A parking brake control shall also be provided which may be set by the pilot, and without further attention, maintain braking sufficient to prevent the airplane from rolling on a paved runway while applying take-off power on the most critical engine.

§ 4b.398 *Brake controls*. Brake controls shall not require excessive control forces in their operation.

**5.4.7. Part 15 Reprinted—As Amended to November 1, 1949**
LANDING GEAR EQUIPMENT

15.11 *Landing gear wheels {Was 15.10 thru 15.103 and 15.105 thru 15.1080}*
(a) Main landing gear wheels will be certificated for a maximum static load which will be determined from the strength of the wheel. Tail wheels will not be certificated.
(1) For the purpose of these regulations main landing gear wheels are considered as those nearest the airplane center of gravity with respect to fore-and-aft location.
(2) For the purpose of these regulations a tail wheel is considered as one which supports the tail of a conventional airplane in the three-point landing attitude.
(b) For wheels other than main landing or tail wheels, application shall be made to the Secretary for special rulings particularly applicable to the cases in question.
(c) The strength of a main landing gear wheel shall be substantiated by the following two static tests:
(1) Radial load test. (See subparagraph (3) of this paragraph)
(2) Side load test. (See subparagraph (4) of this paragraph)
(3) The required radial test load is equal to -

(P)x(n)x(1.5)x(1.25)
Where P is the maximum static load for which approval is requested, n is

2.80 + 9000/(2P+4000)
and is the applied landing load factor for the corresponding airplane, 1.5 is the factor of safety, and 1.25 is a strength test material factor.

(4) The required side test load is equal to -

(0.35)x(the radial test load).

(5) The radial and side loads shall be applied separately and the wheel shall be equipped with the correct size tire inflated to the proper pressure for the load for which certification is requested.
(6) The radial load shall be applied to the wheel in the place of the tire and may be distributed over a portion of the tire by allowing the tire to bear in a box of firm earth or sand.
(8) The side load shall be applied to the rim of the wheel at its maximum radius and may be distributed over an arc of not more than $30^0$. In order to insure sufficient strength in the retaining flanges of the rim, all the side load shall be applied to the inner flange in a direction such as to bend it away from the tire. In such case , the load must be increased so that its side component is equal to the load specified in subparagraph (4) of this paragraph. The wheel shall be restrained only by the axle.

(d) A main landing gear wheel shall support the required loads before failure.

(e) The rim contour of a main landing gear wheel shall conform to the Tire and Rim Association's standards or recommendations unless the wheel is to be used in conjunction with a specially constructed tire.

(f) A landing gear wheel may be equipped with any make or type of tire, provided that the tire is a proper fit on the rim of the wheel and provided that the tire manufacturer's load rating, which he uses and recommends as a basis for his guarantee, is not exceeded.

(g) Each unit of a certificated model of main landing gear wheel shall bear the following additional

identification data as prescribed in 15.5(c)(5): The maximum static load for which certificated.

(h) A request for certification of a type or model or series of models of main landing gear wheels shall be supported by the following additional data as prescribed in 15.6(a)(3):

(1) A report of the static tests prescribed in 15.11(c). The report shall contain complete details of the tests, including records of wheel deflections and photographs of the test set-ups. The report shall be signed by the person making the tests, and shall be certified to unless the tests were witnessed by an inspector of the Administrator, in which case such inspector also will sign the report as a witness.

**§ 15.12** *Brakes* {was 15.1040 thru 15.1047}

**(a)** Testing of brakes for certification (1) A wheel-brake combination shall demonstrate satisfactory performance during 100 tests simulating the stopping of an airplane at an average deceleration of at least 10 feet per second per second, from a speed chosen by the applicant. The kinetic energy absorbed per stop shall be computed and the wheel-brake combination shall be certificated for a kinetic energy absorption not in excess of the amount so determined.

(3) To be eligible for use on airplanes certificated in accordance with the transport category requirements of Part 4a of this subchapter, a wheel-brake combination shall further demonstrate satisfactory performance during three tests identical with those specified in subparagraph (1) of this paragraph except that the speed shall be increased to obtain a kinetic energy absorption of 125% of that determined under that subparagraph.

(b) Adaptation of brakes to airplanes – Transport category

(1) An airplane certificated in accordance with the transport category requirements of Part 4a of this subchapter shall make use of wheel-brake combinations for which the summation of the kinetic energy ratings of the brakes used in the main landing gear is at least equal to:

$$K.E. = .0334\ W\ V_S^2$$

Where K. E. = kinetic energy in foot-pounds

W = the maximum landing weight of the airplane

$V_S$ = the power off stalling speed of the airplane in miles per hour at sea level in standard air at maximum landing weight.

(2) The wheel-brake combinations used in such airplane shall have been tested, in determining the kinetic energy absorption under § 15.12(a), from a speed lying between 80% and 100% of $V_S$.

(c) Design. Brakes shall be free from any undue tendency to lock or jam, and shall be suitably shielded from water, mud, and oil.

(d) Static torque. The maximum available static torque in reverse shall be at least 40% of the forward static torque when both are measured at the same applied pedal force.

(e) Adjustment. When necessary to insure satisfactory performance, the brake mechanism shall be equipped with suitable adjustment devices to compensate for disc or lining wear, heat, and other normal service effects.

(f) Strength. The brake and all of its attachments to the wheel shall be designed with an ultimate strength sufficient to withstand a torque which is 1.6WR/B, where R is the rolling radius of the tire and B is the number of brakes. A static test of the brake and wheel shall demonstrate that the assembly is capable of withstanding a torque which is 80% of the above without yielding to the point of impairing service operation.

(g) Test log. A log of the test runs shall be submitted together with other calculations which are necessary to indicate compliance with the above brake regulations in paragraphs (a) to (f) of this section.

(h) Identification data. Each certificated brake shall bear the following identification as prescribed in § 15.5(c)(5): "The foot-pounds of kinetic energy for which it is approved."

**5.4.8 Part 15, Amendment 15-1: Effective 12-07-49**

1. By amending 15.5 to read as follows:
15.6 Identification data. Each unit certificated or approved shall be marked with the identification data required by § 2.36, unless otherwise specifically provided for in this part of the regulations. The identification data shall be displayed in a conspicuous place on the unit in a manner such that it cannot be easily erased, disfigured, or obscured.

2. By amending 15.11(g) to read as follows:
15.11(g) Each unit of a certificated model of main landing gear wheel shall bear the identification data as prescribed in 15.5.

4. By amending 15.12(h) to read as follows:
15.12(h) Identification data. See 15.5

**5.4.9. Part 4b Reprinted: July 20, 1950**

**§** 4b.335 *Wheels.* (a) Main landing gear wheels (i.e., those nearest the airplane center of gravity) shall be of an approved type in accordance with Part 15 of this chapter.
(b) The rated static load of each main wheel shall not be less than the design take-off weight, divided by the number of main wheels.
(c) Nose wheels shall be tested in accordance with Part 15 of this chapter for an ultimate radial load not less than the maximum nose wheel ultimate loads obtained in the ground loads requirements, and for the corresponding side loads.

**§** 4b.337 *Brakes-- (a) General*. (1) All airplanes shall be equipped with approved brakes.
(2) The brake system shall be so designed and constructed that in the event of a single failure in any connection or transmitting element in the brake system (excluding the operating pedal or handle), or the loss of any single source of hydraulic or other brake operating energy supply, it shall be possible, as shown by suitable test or other data, to bring the airplane to rest under conditions specified in **§** 4b.122 with a mean negative acceleration during the landing roll of at least 50% of that obtained in determining the landing distance as prescribed in that section.
(3) In applying the requirement of subparagraph (2) of this paragraph to hydraulic brakes, the brake drum, shoes, and actuators (or their equivalents) shall be considered as connecting or transmitting elements unless it is shown that the leakage of hydraulic fluid resulting from failure of the sealing elements in these units would not reduce the braking effectiveness below that specified in subparagraph (2) of this paragraph.

(b) *Brake controls*. Brake controls shall not require excessive control forces in their operation.

(c) *Parking brake controls*. A parking brake control shall be provided and installed so that it can be set by the pilot and, without further attention, will maintain sufficient braking to prevent the airplane from rolling on a paved runway while take-off power on the critical engine is being applied.

**5.4.10. Part 514, Technical Standard Order, effective 10-12-51:** Regulations of the Administrator, Part 514, was made available only through the Federal Register where it appeared on October 12, 1951, 16 FR 10403. Copies of Individual TSO's contained therein were available upon application to the Aviation Information Staff, Civil Aeronautics Administration, Department of Commerce, Washington 25, D. C.

**5.4.11. Amendment 4b-6, effective 3-5-52:** Added **§** 4b.18-Note in the regulatory text, allowing approval of equipment under the TSO system. The first TSO for wheels and brakes TSO-C26 was effective 3-15-52. Part 15 of the CAR was rescinded effective March 5, 1952.

**5.4.12. Part 15 Rescinded, Amendment 15-4, effective March 5, 1952**

Present Part 15 of the Civil Air Regulations contains provisions for type certification of equipment used on aircraft. However, the adoption of the policy on Technical Standard Orders which sets up a procedure for approval of materials, parts, processes, and appliances without the necessity of type certification of such items has made unnecessary the retention of any of the provisions of Part 15. The Board therefore is rescinding Part 15.

5.4.**13. TSO-C26 Wheels and Brakes/AS-227-A is issued, March 15, 1952**

Identical to item 5.2.25: TSO-C26

**5.4.14 Part 4b Reprinted: December 31, 1953**

**§** 4b.335 *Wheels.* Main wheels and nose wheels shall be of an approved type. The following provisions shall apply.
(a) The maximum static load rating of each main wheel and nose wheel shall not be less than the corresponding static ground reaction under the design take-off weight of the airplane and the critical center of gravity position.
(b) The maximum limit load rating of each main wheel and nose wheel shall be not less than the maximum radial limit load determined in accordance with the applicable ground load requirements of this part (see **§§** 4b.230 through 4b.236).
(c) The maximum kinetic energy capacity rating of each main wheel-brake assembly shall not be less than the kinetic energy absorption requirement determined as follows:
$KE = 0.0334\ WV_{SO}^{2}/N$
where:
KE=kinetic energy per wheel (ft.-lb.);
W=design landing weight (lb.);
$V_{SO}$= power-off stalling speed of the airplane (mph) at sea level at the design landing weight and in the landing configuration;
N=Number of main wheels.

NOTE: The expression for kinetic energy assumes an equal distribution of braking between main wheels. In cases of unequal distribution the expression requires appropriate modification.

(d) The minimum stalling speed rating of each main wheel-brake assembly i.e., the initial speed used in the dynamometer tests, shall not be greater than the $V_{SO}$ used in the determination of kinetic energy in accordance with paragraph (c) of this section.

NOTE: The provision of this paragraph is based upon the assumption that the testing procedures for wheel-brake assemblies involve a specified rate of deceleration, and, therefore, for the same amount of kinetic energy the rate of energy absorption (the power absorbing ability of the brake) varies inversely with the initial speed.

**§** 4b.337 *Brakes-- (a) General*. (1) The airplane shall be equipped with brakes of an approved type. The brake ratings shall be in accordance with **§** 4b.335 (c) and (d).
(2) The brake system shall be so designed and constructed that in the event of a single failure in any connection or transmitting element in the brake system (excluding the operating pedal or handle), or the loss of any single source of hydraulic or other brake operating energy supply, it shall be possible, as shown by suitable test or other data, to bring the airplane to rest under conditions specified in **§** 4b.122 with a mean deceleration during the landing roll of at least 50% of that obtained in determining the landing distance as prescribed in that section.
(3) In applying the requirement of subparagraph (2) of this paragraph to hydraulic brakes, the brake drum, shoes, and actuators (or their equivalents) shall be considered as connecting or transmitting elements unless

it is shown that the leakage of hydraulic fluid resulting from failure of the sealing elements in these units would not reduce the braking effectiveness below that specified in subparagraph (2) of this paragraph.

(b) *Brake controls*. Brake controls shall not require excessive control forces in their operation.
(c) *Parking brake controls*. A parking brake control shall be provided and installed so that it can be set by the pilot and, without further attention, will maintain sufficient braking to prevent the airplane from rolling on a paved runway while take-off power on the critical engine is being applied.

### 5.4.15 Civil Aeronautics Manual 4b: September 1, 1954

**Discussion of Policies Relating to Brake Tests in Section 4b.337-1**

The requirements of section 4b.337 are based upon the fact that compliance with the operating rules of section 40.70 of this subchapter will require great dependence upon the presence and proper functioning of brakes unless the runways involved are unusually long.

The nature and extent of the tests to show compliance with section 4b.337 (a) will necessarily depend upon a great many things such as the general arrangement of the landing gear, the design of the brake system, the extent to which the capacity of the brakes is used in establishing the landing distance required by section 4b.122, the amount of available performance data for the brakes, etc. The simplest possible procedure appears to be to determine the average deceleration during a landing ground roll without the use of brakes and then establish the landing distance required by section 4b.122 by using the brakes to the extent necessary to double the mean deceleration so established. It appears likely, however, that this procedure would result in excessive landing distance and might seriously limit the use of the airplane in operation.

4b.337-1 *Brake tests (CAA policies which apply* to *Sec.* 4b.337). If it is desired by the applicant to make the maximum possible use of the brakes in establishing the landing distance, and if also the contribution of the brakes to the total deceleration is relatively large, the brake system should be designed to permit the application of slightly less than half the braking deceleration developed under the conditions specified in this section. The following dual system is recommended: Dual wheel elements (drums or disc units), transmitting elements, power sources, master cylinders, etc., connected to a single pedal on each rudder pedal, such that the failure of any single one of these would leave half the total braking capacity symmetrically disposed about the plane of symmetry of the airplane. With such a system it should be possible to show compliance with section 4b.337 (a) by means of calculation based upon the test data necessary to establish the landing distance plus the brake data calculated by the aircraft manufacturer.

If the system is designed so that under the conditions here specified appreciably less than half the total braking capacity remains or if the remaining capacity is asymmetrically disposed, tests should be conducted to determine that half the mean deceleration may in fact be developed and/or that the airplane may be safely controlled directionally while doing so.

(a) [Rescinded.]

(b) *Brake controls, section 4b.337 (b).* General brake control force and operation should be noted throughout the flight test program to determine that they are satisfactory.

(c) *Parking brake controls, section 4b.337 (c).* During engine run-up prior to takeoff for other tests, the parking brake control should be set, and without further attention, a demonstration should be made to determine that sufficient braking is maintained to prevent the airplane from rolling on a paved runway while takeoff power is applied on the most critical engine.

(19 F. R. 4461, July 20,1954, effective Sept. 1, 1954; amended 22 F. R. 6963, Aug.

29,1957, effective Sept.15, 1957.)

4b.337-2 *Brake systems. (CAA policies which apply to sec. 4b.337.)* In order to obtain a minimum landing distance under section 4b.122 and at the same time meet the deceleration requirement of section 4b.337 (a) (2) in event of failure of the normal brake system, it is a common practice to provide an alternate brake system. When hydraulic (or pneumatic) brakes are used in the normal brake system, this alternate means usually consists of a duplicate hydraulic or pneumatic brake system and is commonly referred to as the "emergency brake system." The following items should be considered in the design of such systems:

(a) *Relationship between normal and emergency brake systems.* The systems for actuating the normal brake and the emergency brake should be so separated that a failure in, or the leakage of fluid from, one

system will not render the other system inoperative. A hydraulic brake assembly may be common to both the normal and emergency brake systems if it is shown that the leakage of hydraulic fluid resulting from failure of the sealing elements in the brake assembly would not reduce the braking effectiveness below that specified in section 4b.337 (a) (2).

(b) *Brake control valves.* In the normal brake system of all aircraft, the brake control valves should be of a type such that the pilots may exercise variable control of the pressure to the brakes. The foregoing provision need not necessarily apply to the emergency brake systems although obviously such a provision would be desirable. Flight tests should be conducted to determine that the normal and emergency brake systems fulfill the requirements of section 4b.170 (a) and (b).

In the normal brake systems of tail wheel type aircraft or of nose wheel type aircraft equipped with non-steerable nose wheels, provisions should be made for independently controlling the brakes on either side of the main landing gear in order that directional control of the aircraft can be maintained. (See sec. 4b.171 (c).) In the emergency brake systems of tail wheel type aircraft and in the normal and emergency brake systems of nose wheel type aircraft, it is desirable that independent control of the brakes on either side of the landing gear be provided although such control is optional.

(19 F. R. 4461, July 20,1954, effective Sept. 1,1954.)

4b.337-3 *Replacement or modified brakes (CAA policies which apply to sec. 4b.337).*

*(a) General.* Replacement or modified brake installations may be approved on the basis of dynamometer tests together with functional flight tests in lieu of measured accelerate-stop and landing distance flight tests if the decelerate performance based on dynamometer data is shown to be equal to or better than the original airplane flight test decelerate performance. Dynamometer tests which simulate actual airplane decelerate distance tests may incorporate variable kinetic energy absorption rates simulating flight test deceleration conditions, and may include an energy allowance for the aerodynamic drag of the airplane which occurs during the deceleration portion of the accelerate-stop and landing runs. However, if any improvement in decelerate performance over that shown in the original Airplane Flight manual is desired, then this policy is inapplicable and complete airplane flight tests will be required.

(1) The procedures of (c) through (g) may be used for substantiating replacement or modified brake installations and may be applied to approved brakes of any manufacturer. The replacement brake does not have to be manufactured by the maker of the original brake.

(2) Brakes which have been approved under TSO or preceding approval standards (whichever is pertinent) may be approved as a replacement brake on an existing airplane type upon the presentation of test reports and other pertinent computations showing:

(i) That, insofar as deceleration performance is concerned, the replacement or modified brakes are equal to or better than the original brake installation on the basis of dynamometer tests contained in this section, and

(ii) That, the replacement or modified brakes when installed on the airplane, comply with the ground handling requirements of section 4b.170.

(b) *Brake modifications.* Modifications to a previously approved wheel-brake installation involving changes to component parts which will involve variations in kinetic energy absorption characteristics should be subjected to the dynamometer tests contained in (b) (1) in addition to the dynamometer tests specified in (e) and (f) for the accelerate-stop and landing conditions and should also include a check of operating and ground handling characteristics. Typical modifications which vary the kinetic energy absorption characteristics are as follows: changes of brake lining material, changes in brake discs or brake drum material, reductions in friction surface plan dimensions (area), etc.

(1) The minimum reliability standards for brakes referenced in TSO-C26 and contained in Specification AS227A should be used as a guide for modified brakes. However, section 5.4.3 of AS227A may be applied as follows for evaluating such modifications:

(i) Thirty tests simulating the stopping of an airplane at 100 percent kinetic energy.[9]

(ii) One test simulating the stopping of an airplane at 125 percent kinetic energy.[9]

(c) *Determination Of kinetic energy requirements.*

(1) In the case of replacement brakes (that is, those brakes incorporating major design differences from those originally tested on the airplane) the kinetic energy (KE) to be absorbed on the dynamometer in compliance with provision (a) (2) of this section should be determined in accordance with the following

formula:

$$KE_{dyn} = KE_{wv} - 1/2\ KE_{ad}$$ where:

$KE_{wv}$=the maximum kinetic energy as determined from the most critical combination of weight and speed (in terms of ground speed). In determining the maximum speed, the effects of tailwind, altitude and flap setting should he taken into account.

$KE_{ad}$=the kinetic energy absorbed by aerodynamic drag of the airplane during the deceleration portion of the accelerate-stop and landing runs. This kinetic energy should be determined from available test data of the airplane or by other reliable calculations based on the basic parameters for the type of airplane involved.

(2) In the case of brakes modified as described in paragraph (b) the kinetic energy to be absorbed on the dynamometer should be determined in accordance with the following formula:

$$KE_{dyn} = KE_{wv} - KE_{ad}$$

(i) This formula should not apply to modifications of a replacement brake which has been approved in accordance with (1) of this paragraph. Such modifications of a replacement brake should meet the same dynamometer requirements as the replacement brake did when originally installed.

(d) *Dynamometer test method.*

(1) There should be no artificial cooling of the brakes during dynamometer tests. Ventilating air flowing normal to the tire tread is permissible.

(2) For wheel-brake installations where dual or duplex brakes are used, the dynamometer tests should be conducted on an entire wheel-brake unit.

(3) Brake lining should not be run-in to a degree which would be greater than the run-in for new lining when installed on an airplane prior to being put in regular airline service.

(4) Due to wing-lift acting on the airplane, the dynamometer tests should account for tire rolling friction due to the differential in braking effect resulting from the varying rolling radius of the tire on the runway as compared to the constant tire radius at constant tire deflection which occurs throughout the entire dynamometer run.

(5) The dynamometer mass should be corrected so that the selected inertia equivalent (I.E.) will result in a correct or conservative kinetic energy test value.

(6) During dynamometer testing a variable brake pressure, which does not exceed that pressure which is available from the airplane brake system intended for use with the replacement brake, should be used in duplicating as nearly as practicable the original airplane torque-speed and velocity-time flight test data corrected for aerodynamic drag and tire rolling friction.

(e) *Accelerate-stop distance test.* This condition is normally the most critical from a kinetic energy standpoint. The original flight test accelerate-stop deceleration camera data obtained during the type certification tests of the airplane should be obtained and corrected for aerodynamic drag and tire rolling friction.

(1) Continuous records of dynamometer torque-speed or velocity-time data for at least three of the runs, when absorbing the required kinetic energy for the critical combination of takeoff weight and $V_1$ speed, should duplicate, as nearly as practical, the original airplane brake deceleration data. These dynamometer records should be converted to corrected and faired velocity versus distance values and be plotted and superimposed on the curve for the original airplane velocity-distance data, and

[9] The modifier of the brake should substantiate the fact that the original brake approval tests and the tests specified in (i) and (ii) were conducted under similar conditions and that the modified brake assembly is at least the equal to that previously approved as an equipment item insofar as energy absorption and stopping time are concerned.

(2) The average of the above three corrected dynamometer velocity-distance curves should be superimposed on the curve for the original airplane velocity-distance data.

(3) The curves plotted in (1) and (2) of this paragraph should compare favorably with the original corrected flight data over the entire speed range and should indicate that, from any given speed, the airplane stopping distance would be equal to or less than the distance resulting from the original brake installation at the required kinetic energy level corresponding to the actual accelerate-stop conditions which prevailed during the airplane type certification tests.

(4) If, in compliance with (1) of this paragraph, velocity-time data are submitted in lieu of torque-speed data, then sufficient spot-check calculations of the velocity-time data should be made to insure an accuracy

comparable to the accuracy of torque-speed data. Inasmuch as torque-speed data are useful for airplane modification and design purposes, it is desirable that comparable and complete torque-speed data be included in the data submitted.

(5) Dynamometer time history recordings of brake pressure, torque, speed, and calculations for aerodynamic drag, tire rolling friction, and dynamometer mass correction, and all pertinent airplane data, should be submitted, together with an analysis showing the detailed calculations and charts necessary to establish the speed-distance relationship and comparison with the original airplane deceleration test data.

(f) *Landing distance test.* In order to substantiate landing distances, at least three dynamometer runs, using the critical combinations of landing weight and contact speed, should be conducted on the same brake unit. Landing distance data, compiled in accordance with the method described in (e) for accelerate-stop evaluation, should be submitted. The landing distance data, which are comparable to those of (e) for the accelerate-stop data, should compare favorably with the corrected airplane flight test results obtained with the original brakes in order to. substantiate the adequacy of the replacement brakes, insofar as landing distances are concerned.

*(g) Aircraft functional tests.* The brakes should be tested on the airplane to determine their functional characteristics as indicated in (a) (2). Functioning characteristics should be observed during taxi and engine run-up conditions and at least three normal takeoffs and landings, at the maximum landing weight, should be conducted. During these tests, the brakes should be checked for any undesirable characteristics such as "grabbing," "fading," etc., and should at least be visually inspected, without dismantling, at the completion of the test in order to determine any evidence of malfunction or failure. If no malfunctioning has occurred, this visual inspection is adequate, but if malfunctioning does occur, a thorough inspection should be conducted. If any characteristics arise which indicate that stopping distances would exceed the original values in the CAA Approved Airplane Flight Manual, then the Administrator may require actual camera recorded airplane deceleration tests or any other tests deemed necessary to establish the adequacy of the brakes.

(19 F. R. 4463, July 20,1954, effective Sept. 1, 1954.)



### 5.4.16 Amendment 4b-3, effective March 13, 1956

Amended § 4b.337(a)(2) – Brakes- by deleting the word “connection” and inserting in lieu thereof the word “connecting”.

### 5.4.17 Civil Aeronautics Manual 4b: May 1, 1956

4b.337-4 *Antiskid devices and installations (CAA policies which apply to sec. 4b.337).*

(a) *Eligibility.* Antiskid devices meeting the airworthiness portions of Military Specification MIL-B-8075 (ASG) and any amendments[10] thereto, are acceptable for installation on civil aircraft. Requests for deviations from these specifications should be submitted to the CAA Regional Office, Aircraft Engineering Division. The installation of the antiskid device should comply with the requirements specified in paragraph (b) of this section. The antiskid device and its installation will be approved for use on civil aircraft when the tests specified in paragraph (c) of this section have been satisfactorily demonstrated.

(b) *Installation*

(1)*Data required. An* engineering evaluation of the antiskid installation as installed on the airplane, including all necessary components, should be conducted. This analysis and complete descriptive data should be submitted to the CAA. The data should include hydraulic and electric schematic diagrams of the installation, assembly drawings of antiskid system units, test results or stress analysis substantiating structural strength of attachments and modification of the axle or other structural members, installation drawings, recommended instructions pertaining to installation, maintenance and operation and analysis of. flight test data and results. Schematic drawings should refer to all units in the normal and emergency brake systems. The engineering evaluation should also assure that the anti-skid system does not cause undesirable and adverse yaw characteristics.

(i)Engineering evaluation should account for a bounce condition wherein the wheels may leave the runway after the brakes have been applied, for a condition wherein the wheels stay on the runway but the oleos are extended (if the system utilizes landing gear oleo compression in its operation), and for a condition

in which the wheels of one main gear may not be in contact with the runway for a considerable time while the wheels of the other main gear are firmly on the runway. If the antiskid installation incorporates the "landing with brake pedals depressed" feature, then this type of operation should also be considered.

(ii) It should be shown that the brake cycling frequency imposed by the antiskid installation will not result in excessive loads on the landing gear because of proximity to resonant landing gear frequencies.

(2) *Systems.* The entire brake system (including both the basic brake system and the antiskid system) should conform to section 4b.337. The single failure criterion of section 4b.337 should be extended to include the anti-skid system.

(i)In the event of a probable malfunction within the antiskid system which would result in loss of the antiskid feature in one or more brake units, those brake units affected should automatically revert to normal braking.

[10]Proposed amendments may be obtained from the Civil Aeronautics Administration, Washington 25, D.C.

(ii)An indicating means should be provided to warn the pilot or copilot in the event of antiskid malfunction. For simple mechanical type antiskid installations wherein any single probable malfunction is considered remote and which will render only one braked wheel inoperative insofar as antiskid operation is concerned, the indicating means need not be located in the cockpit. *Note: This policy item (ii) was deleted effective May 5, 1958.*

(iii) A means should be provided so that the pilot or copilot can readily deactivate the antiskid system. For simple mechanical type antiskid installations wherein any single probable malfunction is considered remote and which will render only one braked wheel inoperative insofar as antiskid operation is concerned, the deactivating means need not be located in the cockpit.

(iv) Antiskid installations should not cause surge pressures in the brake hydraulic system which would be detrimental to either the normal or emergency brake system and components.

(v)The antiskid equipment should insure satisfactory operation on slippery runways as well as on dry hard surfaced runways without additional antiskid adjustments.

(c) *Tests and analyses.*

(1)When an antiskid system is included as original equipment on an airplane, it is not required that field length data,[11] with antiskid inoperative, be determined.

(2)Tests and analyses for the approval of an antiskid system to be used with a previously approved brake installation, without consideration for reduction of runway distances, should be conducted in accordance with this paragraph. When equivalent alternate procedures are developed and approved, they may be used in lieu of the method specified in this paragraph. If credit for shorter field lengths is requested on the basis of an antiskid installation, then complete flight tests should be conducted in accordance with sections 4b.115, 4b.122, 4b.123, 4b.170 and 4b.171.

(3)When an antiskid system is installed, the braking performance and airplane stopping distances should be at least equivalent to those obtained during the accelerate-stop and landing type certification tests. The tests to be conducted are based on the high speed condition as being critical, both for airplane braking as controlled by the antiskid system, and for the functional integrity of an acceptable antiskid device. However, should it become necessary for a particular type of installation, these tests may be modified as warranted.

(i)Conduct at least one accelerate-stop test at each of the following speeds: 80, 90, and 100 percent of the highest $V_1$ speed for which the airplane is certificated.[12] The maximum landing weight, or the lowest weight above maximum landing weight necessary to keep the airplane from leaving the runway at the highest $V_1$ speed, should be used in the above three tests. When appropriate, the decelerate portions of the accelerate-stop tests may be demonstrated by landings with wing flaps in takeoff position in lieu of accelerating the airplane to $V_1$ speed on the runway. (See also sec. 4b. 115-1.)

(ii)Conduct at least one landing deceleration test at each of the following weights: maximum landing weight, an intermediate landing weight and normal minimum landing weight.[13] All landings should be made from the highest corresponding contact speeds used in determining CAA Approved Airplane Flight Manual field lengths.

(4)Conduct controllability tests in accordance with sections 4b.170 and 4b.171 (except for the emergency braking condition) after the occurrence of any single malfunction within the antiskid system (excluding the device and those components which were determined to be satisfactory based on laboratory tests). Single probable malfunctions, which analysis indicates may be likely to occur, should be simulated

during landing or simulated landing deceleration tests. If analysis shows clearly that a particular malfunction would not adversely affect controllability, that malfunction need not be simulated in flight tests.

(5) Conduct taxi tests to demonstrate that repeated rapid full brake pedal application and release does not result in excessive delay in brake reapplications and that ground handling maneuvering characteristics and sensitivity of braking effect are satisfactory.

(6)Conduct tests and analyses to determine the effect of automatic cyclic brake action on the emergency brake system fluid supply. The fluid volume (reserved for emergency use in the reservoir or emergency accumulators of the basic brake system) may be adequate for manual braking but may be adversely affected by an antiskid installation. Hence, an engineering evaluation should be conducted to show that the antiskid system will not have an adverse effect on braking when the airplane is stopped by means of the emergency brake system, or to show that the antiskid system is automatically made inoperative when emergency braking is used.

(7)If, during the tests specified in this paragraph, adjustments or modifications to the antiskid device or its installation proved necessary and indicated the possibility of encountering unreliable operation due to maintenance difficulties or the need for frequent adjustments, then accelerated service functioning and reliability tests should be conducted as deemed necessary.

(21 F. R. 2558, Apr.18, 1956, effective May 15, 1956.)

[11] It is desirable to determine field length data with the antiskid inoperative in order that airplane operation may be conducted with antiskid inoperative if so desired by the operator.

[12] In order to assure stopping distances equivalent to those shown in the Airplane Flight Manual, camera recording, or equivalent recordation methods should he used. To ascertain that the measured stopping distances are equivalent to those in the Airplane Flight Manual it will be necessary to compare the measured antiskid data with the data obtained during the manufacturer's original certification test, for the weight used in the antiskid test, at the highest speed for that weight shown in the Airplane Flight Manual.

[13] If it can be shown by the accelerate-stop distance tests conducted and the data obtained in subdivision (i) of this subparagraph that the landing distances when using normal landing braking techniques, would not exceed the landing distances approved without antiskid devices, then the landing distance tests specified in subdivision (ii) of this subparagraph need not he conducted.



### 5.4.18 Amendment 4b-6, effective August 12, 1957

(1) A change was made to § 4b.335(c) to permit greater flexibility in determining the required energy capacity for wheel brakes. By amending § 4b.335(c) by deleting so much of the first sentence as precedes the formula and inserting in lieu thereof the following: “The brake kinetic energy capacity rating of each main wheel-brake assembly shall not be less than the kinetic energy absorption requirement determined in accordance with this paragraph. The brake kinetic energy absorption requirements shall be based on a rational analysis of the sequence of events which are expected to occur during operational landings at maximum landing weight. This analysis shall include conservative values of airplane speed at which the brakes are applied, braking coefficient of friction between tires and runway, aerodynamic drag, propeller drag or power plant forward thrust, and if more critical, the most adverse single engine or propeller malfunction. In lieu of a rational analysis it shall be acceptable to establish the kinetic energy absorption requirements for each main wheel brake assembly by the following formula:”

(2) By amending § 4b.337 by adding a new paragraph (d) to read as follows:
4b.337 Brakes. * * *

(d) Anti-skid devices. If anti-skid devices are installed, the devices and associated systems shall be such that no single probable malfunction will result in a hazardous loss of braking ability or directional control of the airplane.

### 5.4.19 Civil Aeronautics Manual 4b: January 1958

§ 4b.335 *Wheels.* Main wheels and nose wheels shall be of an approved type. The following provisions shall apply.

(a) The maximum static load rating of each main wheel and nose wheel shall not be less than the corresponding static ground reaction under the design take-off weight of the airplane and the critical center of gravity position.
(b) The maximum limit load rating of each main wheel and nose wheel shall be not less than the maximum radial limit load determined in accordance with the applicable ground load requirements of this part (see §§ 4b.230 through 4b.236).
(c) The brake kinetic energy capacity rating of each main wheel-brake assembly shall not be less than the kinetic energy absorption requirement determined in accordance with this paragraph. The brake kinetic energy absorption requirements shall be based on
a rational analysis of the sequence of events which are expected to occur during operational landings at maximum landing weight. This analysis shall include conservative values of airplane speed at which the brakes are applied, braking coefficient of friction between tires and runway, aerodynamic drag, propeller drag or power plant forward thrust, and if more critical, the most adverse single engine or propeller malfunction. In lieu of a rational analysis it shall be acceptable to establish the kinetic energy absorption requirements for each main wheel brake assembly by the following formula:

$KE = 0.0334\ WV_{SO}{}^2/N$
where:
KE=kinetic energy per wheel (ft.-lb.);
W=design landing weight (lb.);
$V_{SO}$= power-off stalling speed of the airplane (mph) at sea level at the design landing weight and in the landing configuration;
N=Number of main wheels.

NOTE: The expression for kinetic energy assumes an equal distribution of braking between main wheels. In cases of unequal distribution the expression requires appropriate modification.
(d) The minimum stalling speed rating of each main wheel-brake assembly i.e., the initial speed used in the dynamometer tests, shall not be greater than the $V_{SO}$ used in the determination of kinetic energy in accordance with paragraph (c) of this section.

NOTE: The provision of this paragraph is based upon the assumption that the testing procedures for wheel-brake assemblies involve a specified rate of deceleration, and, therefore, for the same amount of kinetic energy the rate of energy absorption (the power absorbing ability of the brake) varies inversely with the initial speed.

§ 4b.337 *Brakes*
*(a) General*.
(1) The airplane shall be equipped with brakes of an approved type. The brake ratings shall be in accordance with section 4b.335 (c) and (d).
(2) The brake system shall be so designed and constructed that in the event of a single failure in any connection or transmitting element in the brake system (excluding the operating pedal or handle), or the loss of any single source of hydraulic or other brake operating energy supply, it shall be possible, as shown by suitable test or other data, to bring the airplane to rest under conditions specified in § 4b.122 with a mean deceleration during the landing roll of at least 50% of that obtained in determining the landing distance as prescribed in that section.
(3) In applying the requirement of subparagraph (2) of this paragraph to hydraulic brakes, the brake drum, shoes, and actuators (or their equivalents) shall be considered as connecting or transmitting elements unless it is shown that the leakage of hydraulic fluid resulting from failure of the sealing elements in these units would not reduce the braking effectiveness below that specified in subparagraph (2) of this paragraph.

(b) *Brake controls*. Brake controls shall not require excessive control forces in their operation.
(c) *Parking brake controls*. A parking brake control shall be provided and installed so that it can be set by the pilot and, without further attention, will maintain sufficient braking to prevent the airplane from rolling on a paved runway while take-off power on the critical engine is being applied.

(d) *Anti-skid devices.* If anti-skid devices are installed, the devices and associated systems shall be such that no single probable malfunction will result in a hazardous loss of braking ability or directional control of the airplane.

Policies regarding 4b.337-1 through 4b.337-4 remained unchanged: See items 15. and 17.

5.4.**20 TSO-C26a is issued, effective June 1, 1961: § 514.72/AS-227C**

FEDERAL AVIATION AGENCY
Washington 25, D. C.

TECHNICAL STANDARD ORDER
Regulations of the Administrator
Part 514

SUBJECT:AIRCRAFT WHEELS AND BRAKES**TSO-C26a**

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Technical Standard Orders for Aircraft Materials,
Parts, Processes, and Appliances

Part 514 contains minimum performance standards and specifications of materials, parts, processes, and appliances used in aircraft and implements the provisions of sections 3.18, 4a.31, 4b.18, 6.18 and 7.18 of the Civil Air Regulations. The regulation uses the Technical Standard Order system which, in brief, provides for FAA-industry cooperation in the development of performance standards and specifications which are adopted by the Administrator as Technical Standard Orders, and a form of self-regulation by industry in demonstrating compliance with these orders.

Part 514 consists of two subparts. Subpart A contains the general requirements applicable to all Technical Standard Orders. These provisions are summarized below for the convenient reference of the public. Subpart B contains the technical standards and specifications to which a particular product must conform, and each Technical Standard Order is set forth in the appropriate section of Subpart B. The subject Technical Standard Order is printed below. ANY TECHNICAL STANDARD ORDER MAY BE OBTAINED BY SENDING A REQUEST TO FAA, WASHINGTON 25, D. C.

SUBPART A- -GENERAL

This subpart provides, in part, that a manufacturer of an aircraft material, part, process, or appliance for which standards are established in Subpart B, prior to its distribution for use on a civil aircraft of the United States, shall furnish a written statement of conformance certifying that the material, part, process, or appliance meets the applicable performance standards established in this part. The statement of conformance must be signed by a person duly authorized by the manufacturer, and furnished to the Chief, Engineering and Manufacturing Division, Bureau of Flight Standards, Federal Aviation Agency, Washington 25, D. C.

Subpart A also requires appropriate marking of materials, parts, processes, and appliances as follows:
(a) Name and address of the manufacturer responsible for compliance,
(b) Equipment name, or type or model designation,
(c) Weight to the nearest pound and fraction thereof,
(d) Serial number and/or date of manufacturer, and
(e) Applicable Technical Stand Order (TSO) number.

In addition, Subpart A provides that no deviation will be granted from the performance standards established in Subpart B, and that the Administrator may take appropriate action in the event of noncompliance with Part 514.

SUBPART B

§ 514.72Aircraft wheels and brakes - TSO-C26a--(a) Applicability - (1) Minimum performance standards. Minimum performance standards are hereby established for aircraft wheels and brakes which are to be used on United States civil aircraft of the following categories:

Wheels - Transport and non-transport category airplanes.
Wheels - Transport and non-transport category rotorcraft.
Brakes - Transport category airplanes.

New models of wheels and brakes manufactured for installation on the above aircraft on or after June 1, 1961, shall meet the standards of Aeronautical Standard AS 227-C revised February 1, 1959,[1/] with the

exceptions in subparagraph (2) of this paragraph.

(2)Exceptions.

(I) Unless determined to be unnecessary, means shall be provided to minimize the probability of wheel and tire explosions which result from elevated brake temperatures.

(ii) Reference paragraph 5.4.7.l of AS 227-C, Braking Capacity Calculations. The decelerating effects of propeller reverse pitch, drag parachutes and engine thrust reversers shall not be considered in determining brake kinetic energy ratings.

(iii) Taxi and Parking Test. At least one maximum weight landing test followed by a taxi roll, one taxi stop and parking test, which realistically simulate normal airplane operation, shall be conducted on the dynamometer. The taxi speed and distance shall be obtained from the airplane manufacturer.

(iv) Reference Table II of AS 227-C. Change 65 to 100 normal energy dynamometer stops in Method I and II.

(v) Reference Table II of AS 227-C. Change Note 2 to read as follows: One change of brake lining and attached discs is permissible in making the 100 normal energy stops. The remainder of the brake assembly parts shall withstand the 100 normal energy stops without failure or impairment of operation.

(vi) Reference Notes 3, 6, and 8 of Table II of AS 227-C. The most critical speeds used in the analysis shall include consideration for high ambient temperatures and airport elevations.

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1/Copies may be obtained from the Society of Automotive Engineers, Inc., 485 Lexington Avenue, New York 17, New York.

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(vii) ARP 586 “Wheel Castings" dated March 1, 1960. 1/

(a)Add the following sentence at the end of paragraph 2. “Acceptance of the provisions contained herein is predicated on the use of a casting factor of not less than 1.33 on ultimate radial and side loads."

(b)Add the words "in accordance with paragraph 4.1 or 4.2" to the end of paragraph 4.3.

(c)Paragraph 5.2.2. Replace the words "When at least five consecutive acceptable quality castings have been produced" by the following: “When quality control history is established, * * * ."

(d)Revise the end of paragraph 9.1 to read as follows " * * * in lieu of the procedures outlined above when authorized by the FAA."

(b)Marking. In lieu of the marking requirements of Subpart A, the aircraft wheels and brakes shall be legibly and permanently marked with the following information:

(1)Name of the manufacturer responsible for compliance.

(2)Serial number and drawing number.

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

(4)Size, (this marking applies to wheels only). All stamped, etched or embossed markings shall be located in non-critical areas.

(c)Data Requirements. (1) the manufacturer shall maintain a current file of complete data regarding all his inspection work and tests required to determine compliance with the standards specified herein. (See

paragraph (e) of this section.)

(2)Two copies of the following data shall be furnished to the Chief, Engineering and Manufacturing Division, Bureau of Flight Standards, Federal Aviation Agency, Washington 25, D. C., with the statement of conformance:

(i) Weight of brake assembly.

(ii) Maximum rejected takeoff kinetic energy in foot-pounds.

(iii) Normal kinetic energy in foot-pounds.

(iv) Maximum operating brake pressure.

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(v)Applicable speed specified in Note 1 or Note 5 of Table II of AS 227-C.

(vi) Type of hydraulic fluid used.

(vii) Weight of wheel assembly.

(viii) Maximum static load rating in pounds.

(ix) Maximum limit load rating in pounds.

(d) Previously Approved Equipment. Wheels and brakes approved prior to June 1, 1961, may continue to be manufactured under the provisions of their original approval.

(e) Quality control. Each wheel and brake shall be produced under a quality control system, established by the manufacturer, which will assure that each wheel and brake is in conformity with the requirements of this standard and is in an airworthy condition. This system shall be described in the data required under paragraph (c)(l) of this section. A representative of the Administrator shall be permitted to make such inspections and tests at the manufacturer's facility as may be necessary to determine compliance with the requirements of this standard.

(f) Effective date. June 1, 1961.



**5.4.21 TSO-C26a issued as § 37.172 {Doc # 5065, 29 FR 15317, effective 11-17-64} and issued again as § 37.172 {Doc # 8084, 32 FR 5769, effective 04-11-67}**

PART 37 -- TECHNICAL STANDARD ORDER AUTHORIZATIONS

Subpart B--- Technical Standard Orders

**§ 37.172 Aircraft wheels and brakes---TSO-C26a.**

(a) Applicability - (1) Minimum performance standards. Minimum performance standards are hereby established for aircraft wheels and brakes which are to be used on United States civil aircraft of the following categories:

Wheels - Transport and non-transport category airplanes.
Wheels - Transport and non-transport category rotorcraft.
Brakes - Transport category airplanes.

New models of wheels and brakes manufactured for installation on the above aircraft on or after June 1,

1961, shall meet the standards of Aeronautical Standard AS 227-C revised February 1, 1959,[1/] with the exceptions in subparagraph (2) of this paragraph.

(2)Exceptions.

(i) Unless determined to be unnecessary, means shall be provided to minimize the probability of wheel and tire explosions which result from elevated brake temperatures.

(ii) Reference paragraph 5.4.7.l of AS 227-C, Braking Capacity Calculations. The decelerating effects of propeller reverse pitch, drag parachutes and engine thrust reversers shall not be considered in determining brake kinetic energy ratings.

(iii) Taxi and Parking Test. At least one maximum weight landing test followed by a taxi roll, one taxi stop and parking test, which realistically simulate normal airplane operation, shall be conducted on the dynamometer. The taxi speed and distance shall be obtained from the airplane manufacturer.

(iv) Reference Table II of AS 227-C. Change 65 to 100 normal energy dynamometer stops in Method I and II.

(v) Reference Table II of AS 227-C. Change Note 2 to read as follows: One change of brake lining and attached discs is permissible in making the 100 normal energy stops. The remainder of the brake assembly parts shall withstand the 100 normal energy stops without failure or impairment of operation.

(vi) Reference Notes 3, 6, and 8 of Table II of AS 227-C. The most critical speeds used in the analysis shall include consideration for high ambient temperatures and airport elevations.

(vii) ARP 586 “Wheel Castings" dated March 1, 1960. [1/]

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1/Copies may be obtained from the Society of Automotive Engineers, Inc., 485 Lexington Avenue, New York 17, New York.

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(a)Add the following sentence at the end of paragraph 2. “Acceptance of the provisions contained herein is predicated on the use of a casting factor of not less than 1.33 on ultimate radial and side loads."

(b)Add the words "in accordance with paragraph 4.1 or 4.2" to the end of paragraph 4.3.

(c)Paragraph 5.2.2. Replace the words "When at least five consecutive acceptable quality castings have been produced" by the following: “When quality control history is established, * * * ."

(d)Revise the end of paragraph 9.1 to read as follows " * * * in lieu of the procedures outlined above when authorized by the FAA."

(b)Marking. In lieu of the marking requirements of § 37.7 {reads Subpart A in the 1967 version}, the aircraft wheels and brakes shall be legibly and permanently marked with the following information:

(1)Name of the manufacturer responsible for compliance.

(2)Serial number and drawing number.

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

(4)Size, (this marking applies to wheels only). All stamped, etched or embossed markings shall be located in non-critical areas.

(c)Data Requirements. (1) the manufacturer shall maintain a current file of complete data regarding all his inspection work and tests required to determine compliance with the standards specified herein. (See paragraph (e) of this section.)

(2)Two copies of the following data shall be furnished to the Chief, Engineering and Manufacturing Branch, Flight Standards Division, Federal Aviation Agency {reads Administration in the 1967 version}, in the region in which the manufacturer is located.

(i) Weight of brake assembly.

(ii) Maximum rejected takeoff kinetic energy in foot-pounds.

(iii) Normal kinetic energy in foot-pounds.

(iv) Maximum operating brake pressure.

(v)Applicable speed specified in Note 1 or Note 5 of Table II of AS 227-C.

(vi) Type of hydraulic fluid used.

(vii) Weight of wheel assembly.
(viii) Maximum static load rating in pounds.

(ix) Maximum limit load rating in pounds.

(d) *Previously Approved Equipment.* Wheels and brakes approved prior to June 1, 1961, may continue to be manufactured under the provisions of their original approval.

(e) *Quality control.* Each wheel and brake shall be produced under a quality control system, established by the manufacturer, which will assure that each wheel and brake is in conformity with the requirements of this standard and is in an airworthy condition. This system shall be described in the data required under paragraph (c)(l) of this section. A representative of the Administrator shall be permitted to make such inspections and tests at the manufacturer's facility as may be necessary to determine compliance with the requirements of this standard.

[Doc. No. 5065, 29 F.R. 15317, Nov. 17, 1964, as amended by Doc. No. 8084, 32 F.R. 5769, Apr. 11, 1967]

### 5.4.22 Re-codified CAR 4b into Federal Aviation Regulations Part 25, effective February 1, 1965

§ 25.731 Wheels.
(a) Each main and nose wheel must be approved.
(b) The maximum static load rating of each wheel may not be less than the corresponding static ground reaction with---
(1) Design takeoff weight; and
(2) Critical center of gravity.
(c) The maximum limit load rating of each wheel must equal or exceed the maximum radial limit load determined under the applicable ground load requirements of this part.

§ 25.735 Brakes.
(a) Each brake must be approved.
(b) The brake system must be designed and constructed so that, if any connecting or transmitting element (excluding the operating pedal or handle) fails, or if any single source of hydraulic or other brake operating energy supply is lost, it is possible to bring the airplane to rest under conditions specified in § 25.75, with a mean deceleration during the landing roll of at least 50 percent of that obtained in determining the landing distance as prescribed in that section. Unless the leakage of hydraulic fluid resulting from failure of the sealing elements in hydraulic brakes, the brake drum, shoes, and actuators, (or their equivalents) does not reduce the braking effectiveness below that required by this paragraph, these units are considered to be connecting or transmitting elements.
(c) Brake controls may not require excessive control force in their operation.
(d) The airplane must have a parking control that, when set by the pilot, will without further attention, prevent the airplane from rolling on a paved, level runway with takeoff power on the critical engine.
(e) If antiskid devices are installed, the devices and associated systems must be designed so that no single probable malfunction will result in a hazardous loss of braking ability or directional control of the airplane. Antiskid devices meeting the airworthiness portions of Military Specification MIL-B-8075 (ASG) and any amendments thereto, are acceptable.
(f) The brake kinetic energy capacity rating of each main wheel-brake assembly may not be less than the kinetic energy absorption requirements determined under either of the following methods:
(1) The brake kinetic energy absorption requirements must be based on a rational analysis of the sequence of events expected during operational landings at maximum landing weight. This analysis must include conservative values of airplane speed at which the brakes are applied, braking coefficient of friction between tires and runway, aerodynamic drag, propeller drag or power plant forward thrust, and (if more critical) the most adverse single engine or propeller malfunction.
(2) Instead of a rational analysis, the kinetic energy absorption requirements for each main wheel brake assembly may be derived from the following formula, which assumes an equal distribution of braking between main wheels:

$KE = 0.0444\ WV_{SO}^{2}/N$

where:
KE = kinetic energy per wheel (ft.-lb.);
W = design landing weight (lb.);
$V_{SO}$ = power-off stalling speed of the airplane at sea level, at the design landing weight, and in the landing configuration; and
N = number of main wheels.
The formula must be modified in cases of unequal braking distribution.
(g) The minimum stalling speed rating of each main wheel-brake assembly (that is, the initial speed used in the dynamometer tests) may not be more than the $V_{SO}$ used in the determination of kinetic energy in accordance with paragraph (f) of this section, assuming that the test procedures for wheel-brake assemblies involve a specified rate of deceleration, and, therefore, for the same amount of kinetic energy the rate of energy absorption (the power absorbing ability of the brake) varies inversely with the initial speed.

### 5.4.23 Amendment 25-23, effective May 8, 1970

a. *Change to Regulation.*

**§** 25.735 Brakes.
1. Section 25.735(e) was amended by deleting the last sentence of the paragraph referring to MIL-B-8075 etc.
**[** (e) If antiskid devices are installed, the devices and associated systems must be designed so that no single probable malfunction will result in a hazardous loss of braking ability or directional control of the airplane.**]**

2. Section 25.735(f)(2) was amended by inserting the words "(knots)" after the words "stalling speed".
(f)(2) * * * $V_{SO}$ = power-off stalling speed **[** (knots) **]** of the airplane at sea level, at the design landing weight, and in the landing configuration; and

b. *Explanation.* Currently, section 25.735(e) provides in part that compliance with the antiskid devices and associated systems design requirements may be shown by meeting the airworthiness portions of Military Specification MIL-B-8075 (ASG). Since this is not the only acceptable method of showing compliance, it was deleted from the rule. Section 25.735(f)(2) does not specify the unit of speed of "$V_{SO}$" and the correct unit of "knots" has been added to be compatible with the constant 0.0444. Note that the unit of speed in former CAR 4b.337 was miles per hour with the constant being 0.0334.

**5.4.24 TSO-C26b is issued, effective January 21, 1971: § 37.172**

PART 37 -- TECHNICAL STANDARD ORDER AUTHORIZATIONS

Subpart B--- Technical Standard Orders

**§ 37.172 Aircraft wheels and brakes---TSO-C26b.**

(a) *Applicability* The TSO prescribes the-minimum performance standards that aircraft landing wheels and wheel-brake assemblies must meet in order to be identified with the applicable TSO marking. New models of such equipment that are to be so identified and which are manufactured on or after the effective date of this standard must meet the requirement of the Federal Aviation Administration Standard for Aircraft Wheels and Brakes set forth at the end of this section.
(b) *Marking*. In lieu of the marking requirements of § 37.7, the aircraft wheels and brakes must be legibly and permanently marked with the following information:

(1) Name of the manufacturer responsible for compliance.

(2) Serial number and part number.

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

(4) Size (this marking applies to wheels only). All stamped, etched or embossed markings must be located in non-critical areas.

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

(1) One copy of the applicable limitations pertaining to installation of wheels and brakes on aircraft, including the weight of the brake assembly, maximum static load rating, a maximum limit load rating, maximum rejected takeoff kinetic energy in foot-pounds ($KE_{RT}$), design landing kinetic energy in foot-pounds ($KE_{DL}$), applicable speed as specified in paragraph 4.1(a)(1) of the FAA Standard for Aircraft Wheels and Brakes, type of hydraulic fluid used, and the weight of the wheel.

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

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

(d) *Previously Approved Equipment*. Wheels and wheel-brake assemblies approved prior to the effective date of this section may continue to be manufactured under the provisions of their original approval.

FEDERAL AVIATION ADMINISTRATION
STANDARD FOR AIRCRAFT WHEELS AND BRAKES

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

2. *Design and Construction* --- (a) *Design*--- (1) *Lubricant retainers*. Lubricant retainers must retain the lubricant under all operating conditions, prevent the lubricant from reaching braking surfaces, and prevent foreign matter from entering the bearings.
(2) *Removable flanges*. All removable flanges must be assembled onto the wheel in a manner that will prevent the removable flange and retaining device from leaving the wheel if a tire should deflate while the wheel is rolling.

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

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

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

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

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

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

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

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

(6)*Bolts and studs*. When bolts and studs are used for fastening together sections of a wheel, the length of the threads for the nut extending into and bearing against the sections must be held to a minimum and there must be sufficient unthreaded bearing area to carry the required load.

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

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

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

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

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

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

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

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

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

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

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

(a) *Maximum radial load test*. Test the wheel for yield and ultimate loads as follows:

(1) *Test method*. Mount the wheel with a suitable tire of proper fit installed on its axle, and position it against a flat nondeflecting surface. The wheel axle must have the same angular orientation to the nondeflecting surface that it will have to the runway when it is mounted on the aircraft and is under the maximum limit load. Inflate the tire to the pressure recommended for the S load with air or water. If water inflation is used, water

must be bled off to obtain the same tire deflection that would result if air inflation were used. Water pressure may not exceed the pressure which would develop if air inflation were used and the tire deflected to its maximum extent. Load the wheel through its axle perpendicular to the flat nondeflecting surface. Deflection readings must be taken at suitable points to indicate deflection and permanent set of the wheel rim at the bead seat.

(2) *Yield load*. Apply to the wheel a load, not less than 1.15 times the maximum radial limit load, determined under §§ 23.471 through 23.511, or §§ 25.471 through 25.511, or §§ 27.471 through 27.505, or §§ 29.471 through 29.511 of this chapter, as appropriate. Apply the load with the wheel positioned against the nondeflecting surface, and the valve hole positioned at $0^0$ with respect to the line between the center of the wheel and the point of contact, then with the valve hole positioned at $90^0$, $180^0$, and $270^0$ from the nondeflecting surface, and finally twice again with the valve hole positioned at $0^0$. The $90^0$ increments must be altered to other positions if the other positions are more critical. The successive loadings at the $0^0$ position must not cause permanent set increments of increasing magnitude. The permanent set increment caused by the last loading at the $0^0$ position may not exceed 5 percent of the deflection caused by that loading. The bearing cups, cones, and rollers used in operation must be used for these loadings. There must be no yielding of the wheel such as would result in loose bearing cups, air leakage through the wheel or past the wheel seal, or interference in any critical areas.

(3)*Ultimate load*. Apply to the wheel a load not less than 2 times the maximum radial limit load for castings and 1.5 times the maximum radial limit load for forgings, determined under §§ 23.471 through 23.511, or §§ 25.471 through 25.511, or §§ 27.471 through 27.505 or §§ 29.471 through 29.511 of this chapter, as appropriate. Apply the load with the same wheel positioned against the nondeflecting surface and the valve hole positioned at 0 degrees with respect to the line between the center of the wheel and the point of contact. The load must be sustained for 10 seconds. The bearing cones may be replaced with conical bushings, but the cups used in operation must be used for this loading. A tubeless tire may be replaced with a tire and tube.

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

(b) *Combined radial and side load test*. Test the wheel for the yield and ultimate loads as follows:

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

(2)*Yield load*. Apply to the wheel radial and side loads not less than 1.15 times the respective ground loads determined under § 23.485, or § 25.485, or § 27.485, or § 29.485 of This chapter, as appropriate. Apply these loads with wheel positioned against the nondeflecting surface and the valve hole positioned at 0 degrees with respect to the center of the wheel and the point of contact, then with the valve hole positioned 90 degrees, 180 degrees, and 270 degrees from the nondeflecting surface, and finally twice again with the valve hole positioned at 0 degree. The 90 degree increments must be altered to other positions if the other positions are more critical. The 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. The bearing cups, cones, and rollers used in operation must be used in this test. There must be no yielding of the wheel such as would result in loose bearing cups,, air leakage through the wheel or past the wheel seal, or interference in any critical areas. A tire and tube may be used when testing a tubeless wheel only when it has been demonstrated that pressure will

be lost due to the inability of a tire bead to remain properly positioned under the load. The wheel must be tested for the most critical inboard and outboard side loads.
(3)*Ultimate load*. Apply to the wheel radial and side loads not less than 2 times for castings and 1.5 times for forgings the respective ground loads determined under § 23.485, or § 25.485, or § 27.485, or § 29.485 of This chapter, as appropriate. Apply these loads with the same wheel positioned against the nondeflecting surface and the valve hole positioned-at 0 degrees with respect to the center of the wheel and the point of contact. The load must be sustained for 10 seconds. The bearing cones may be replaced with conical bushings, but the cups used in operation must be used for this loading. A tubeless tire may be replaced with a tire and tube. The wheel must be tested for the most critical inboard and outboard side loads.

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

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

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

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

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

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

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

4.2 *Wheel brake system test*. A sample of a wheel-brake system design must meet the following tests to qualify the design for its kinetic energy ratings. The wheel of a wheel-brake assembly must be separately tested under paragraph 4.1. The wheel-brake system must be tested with the recommended operating medium (e.g., air, or an oil meeting recommended specifications).

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

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

$KE = 0.0444WV^2$
where:

*KE*=Kinetic energy per wheel-brake system in ft.-lbs. For the design landing test, *KE* will be sub designated

$KE_{DL}$, and for the rejected takeoff, $KE_{RT}$.
*W*=Airplane weight per wheel-brake system in pounds. For the design landing test the design landing weight will be used.
*V*=Aircraft speed in knots. For the design landing test the speed will be $V_{SO}$, the power off stalling speed of the airplane at sea level at the design landing weight and in the landing configuration. For the rejected takeoff test, applicable only to airplanes certificated under Part 25 of this chapter, the manufacturer must determine the most critical combination of takeoff weight and $V_1$ speed.
For rotorcraft, the manufacturer must calculate the most critical combination of takeoff weight and brake application speed to be used in the above equation.

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

(2)The wheel-brake assembly must bring the inertial testing machine to a stop at the average deceleration rate, and for the number of repetitions specified in the following table without failure, impairment of operation or replacement of parts except as permitted in subparagraph (3) below:

| Category of the aircraft on which wheel-brake assembly will be used--*Tests* | |
|---|---|
| Federal Aviation Regulations Part 25 | $KE_{DL}$: 100 design landing stops at 10 ft/sec.$^2$ |
| | $KE_{RT}$: 1 rejected takeoff stop at 6 ft/sec.$^2$ |
| Federal Aviation Regulations Part 23 | $KE_{DL}$: 35 design landing stops at 10 ft/sec.$^2$ |
| Federal Aviation Regulations Parts 27 and 29 | $KE_{DL}$: 20 design landing stops at 6 ft./sec.$^2$ |

(3) *General Conditions*. (i) During landing stop tests ($KE_{DL}$), one change of brake lining and attached discs is permissible. The remainder of the brake assembly parts must withstand the 100 $KE_{DL}$ stops without failure or impairment of operation.
(ii) During the accelerate-stop tests ($KE_{RT}$), brake lining and bare disks may be new or used. No less than two landing stop tests must have been completed on the brake prior to this test. The brake must be usable to taxi the aircraft off the runway after the accelerate-stop test to $KE_{RT}$.
(iii) As used in this subparagraph, 'brake lining" is either individual blocks of wearing material or discs which have wearing material integrally bonded to them. "Bare discs" are plates or drums which do not have wearing material integrally bonded to them.

(b) *Brake structural torque test*. Apply the radial load *S* and a torque load specified in paragraphs (a)(1) or (2) of this section, as applicable, for at least 3 seconds. Rotation of the wheel must be resisted by a reaction force transmitted through the brake or brakes by an application of at least maximum brake line pressure or brake cable tension in the case of a non-hydraulic brake. If such pressure of tension is insufficient to prevent rotation,, the friction surface way be clamped, bolted, or otherwise restrained while applying above pressure or tension.
(1) For landing gears with only one wheel per landing gear strut, the torque load is 1.2 *SR* where *R* is the normal rolling radius of the tire under load *S*.
(2) For landing gears with multiple wheels per landing gear strut, the torque load is 1.44 *SR* where *R* is the normal rolling radius of the tire under load *S*.
NOTE: The 1.44 factor contains an additional factor of 1.2 to account for occasions when the load of a wheel truck is distributed as much as 10 percent above its design distribution.
(c) Burst *pressure-hydraulic brakes*. 'The brake with actuator piston extended to simulate a maximum worn condition must withstand hydraulic pressure equal to the greatest of the following:

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

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

(3) For airplanes, 2 times the pressure required to resist a static torque of 0.55 *SR* with the brake at $70^0$ where *S* is defined in paragraph (b) above.

(4) For rotorcraft, 2 times the pressure required to hold the rotorcraft on a $20^0$ slope at design takeoff weight.

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

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

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

(i) The hydraulic pressure that is required to hold a static torque of 0.55 *SR* at $70^0$ F, where *R* is the normal rolling radius;

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

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

(NOTE that paragraphs 4,2(c) and (d) of this section require fluid pressure observations to be made during the dynamic torque tests.)

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



### 5.4.25 Amendment 25-48, effective December 31, 1979

a. *Change to Regulation.*

**§** 25.735 Brakes.

(b) The brake system must be designed and constructed so that, if any connecting or transmitting element (excluding the operating pedal or handle) fails, or if any single source of hydraulic or other brake operating energy supply is lost, it is possible to bring the airplane to rest under conditions specified in **[§** 25.125**]** with a mean deceleration during the landing roll of at least 50 percent of that obtained in determining the landing distance as prescribed in that section. Unless the leakage of hydraulic fluid resulting from failure of the sealing elements in hydraulic brakes, the brake drum, shoes, and actuators, (or their equivalents) does not reduce the braking effectiveness below that required by this paragraph, these units are considered to be connecting or transmitting elements.

(f) **[** (2) Instead of a rational analysis, the kinetic energy absorption requirements for each main wheel brake assembly may be derived from the following formula, which assumes an equal distribution of braking between main wheels:

$KE = 0.0443\ WV^2/N$

where:

KE = Kinetic energy per wheel (ft.-lb.);

W = Design landing weight (lb.);

V = Airplane speed in knots. V must be not less than $V_{SO}$ , the power-off stalling speed of the airplane at sea

level, at the design landing weight, and in the landing configuration; and
N = number of main wheels with brakes.
The formula must be modified in cases of unequal braking distribution.**]**
(g) The minimum stalling speed rating of each main wheel-brake assembly (that is, the initial speed used in the dynamometer tests) may not be more than the **[** V **]** used in the determination of kinetic energy in accordance with paragraph (f) of this section, assuming that the test procedures for wheel-brake assemblies involve a specified rate of deceleration, and, therefore, for the same amount of kinetic energy the rate of energy absorption (the power absorbing ability of the brake) varies inversely with the initial speed.

**§** 37.172 Aircraft Wheels and Wheel-Brake Assemblies---**[** TSO-C26c.
TSO-C26b was revised to TSO-C26c by incorporating updates and improved minimum performance standards for the design and construction of aircraft wheels and brakes. To improve the overall strength of wheels and to reduce their susceptibility to fatigue, the standards for wheels were revised. This amendment would require more severe testing of wheels and wheel-brake assemblies to substantiate the load ratings of wheels and the kinetic energy capacity rating of brakes. **]**

b. *Explanation.* (1) The reference to **§** 25.75 in **§** 25.735(b) is replaced by a reference to **§** 25.125 which prescribes the landing requirements for all transport category airplanes; **§** 25.75 was revoked in an earlier amendment.
(2) The numerical constant 0.0444 in the formula for calculating the kinetic energy requirements for each main wheel brake assembly in **§** 25.735(f)(2) is replaced by 0.0443 for better accuracy of units conversion. The definition of "N" as it is used in the formula in **§** 25.735(f)(2) is changed from "number of main wheels" to "number of main wheels with brakes" to be consistent with the TSO and also recognizing that certain main gear wheel configurations may not use brakes, e.g., center main gear.
(3) The term "$V_{SO}$" in **§** 25.735(g) is replaced by the term "V" in order to be compatible with the terminology used in **§** 25.735(f)(2).
(4) TSO-C26c is provided as a separate section in this document. This amendment concerning aircraft wheels and wheel-brake assemblies was issued concurrently with the amendment which updated the minimum performance standards applicable to aircraft tires. The preamble to the tires amendment (25-49) explains the background which led to the need for revised standards for tires and for wheels and wheel-brake assemblies and their interaction.

**5.4.26 TSO-C26c is issued, effective 12-31-79 as § 37.172**

PART 37 -- TECHNICAL STANDARD ORDER AUTHORIZATIONS

Subpart B--- Technical Standard Orders

**§ 37.172 Aircraft wheels and brakes---TSO-C26c.**

(a) *Applicability.* This Technical Standard Order prescribes the minimum performance standards that aircraft wheels and wheel-brake assemblies must meet in order to be identified with the applicable TSO marking. New models of such equipment which are to be so identified and which are manufactured on or after December 31, 1979, must meet the requirement of the Federal Aviation Administration Standard for Aircraft Wheels and Wheel-Brake assemblies set forth at the end of this section.

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

(1) Name of the manufacturer responsible for compliance.

(2) Serial number, or date of manufacture, or both.

(3) Part number.

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

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

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

(c) *Data Requirements*. (1) In addition to the data specified in § 37.5, the manufacturer must furnish to the Chief, Engineering and Manufacturing Division, Federal Aviation administration, in the region in which manufacturer is located (or, in the case of the Western Region, the Chief, Aircraft Engineering Division), the following technical data:

(i) One copy of the applicable limitations pertaining to installation of wheels and brakes on aircraft, including the weight of the brakes on aircraft, including the weight of the brake assembly, maximum static load rating, a maximum limit load rating, maximum accelerate-stop kinetic energy in foot-pounds ($KE_{RT}$), design landing kinetic energy in foot-pounds ($KE_{DL}$), accelerate-stop deceleration in feet/second$^2$, design landing stop deceleration in feet/second$^2$, applicable speed as specified in paragraph 4.2.(a)(1) of the FAA Standard for Aircraft Wheels and Wheel-Brake Assemblies, type of hydraulic fluid used, and the weight of the wheel.

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

(2) Upon request of the regional office specified in paragraph (c)(1) of this section, the manufacturer must furnish the applicable maintenance instructions.

(d)*Previously Approved Equipment*. Wheels and wheel-brake assemblies approved prior to December 31, 1979 may continue to be manufactured under the provisions of their original approval.

FEDERAL AVIATION ADMINISTRATION STANDARD FOR AIRCRAFT WHEELS AND WHEEL-BRAKE ASSEMBLIES

1. *Purpose*.

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

2. *Design and Construction*.

(a) *Design*.

(1) *Lubricant retainers*. Lubricant retainers must retain the lubricant under all operating conditions, prevent

the lubricant from reaching braking surfaces, and prevent foreign matter from entering the bearings.

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

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

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

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

(b) *Construction*.

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

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

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

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

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

(6)*Bolts and studs*. When bolts and studs are used for fastening together sections of a wheel, the length of the threads for the nut extending into and bearing against the sections must be held to a minimum and there must be sufficient unthreaded bearing area to carry the required load.

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

(8) *Aluminum parts*. All aluminum alloy parts must be anodized or have equivalent protection from corrosion. This protection must include protection from fuse plug holes, valve stem holes, and other passages.

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

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

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

3. *Rating*.

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

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

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

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

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

(2) $KE_{RT}$=Kinetic energy capacity in foot-pounds per wheel-brake assembly at the maximum accelerate-stop rate of absorption for wheel-brake assemblies of airplanes certificated under Part 25 of this chapter only.

4. *Qualification Tests*. The aircraft wheels and wheel-brake assemblies required by the TSO must be tested as follows and the test data included in the applicant's test report required by the

§ 37.172(c)(1)(ii) of this part.

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

(a) *Maximum radial load test*. Test the wheel for yield and ultimate loads as follows:

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

(2) *Yield load*. Apply to the wheel a load not less than 1.15 times the maximum radial limit load, determined under §§ 23.471 through 23.511 or §§ 25.471 through 25.511, or §§ 27.471 through 27.505, or §§ 29.471 through 29.511 of Title 14 Chapter 1, as appropriate. Apply the load with the wheel positioned against the nondeflecting surface, and the valve hole positioned at 90 degrees with respect to the line between the center of the wheel and the point of contact, then with the valve hole positioned at 180 degrees, 270 degrees, and 0 degrees from the nondeflecting surface. The 90 degree increments must be altered to other positions if the other positions are more critical. Three successive loadings at the 0 degree position may not cause permanent set increments of increasing magnitude. The permanent-set increment caused by the last loading at the 0 degree position may not exceed 5 percent of the deflection caused by that loading or 0.005 inches, whichever is greater. The bearing cups, cones, and rollers used in operation must be used for these loadings. There must be no yielding of the wheel such as would result in loose bearing cups, air, or water leakage through the wheel or past the wheel seal, or interference in any critical areas.

(3) *Ultimate load*. Apply to the wheel a load not less than 2 times the maximum radial limit load for castings and 1.5 times the maximum radial limit load for forgings, determined under §§ 23.471 through 23.511, or §§ 25.471 through 25.511, or §§ 27.471 through 27.505 or §§ 29.471 through 29.511 of Title 14 Chapter 1, as appropriate. Apply the load with the same wheel positioned against the nondeflecting surface and the valve hole positioned at 0 degrees with respect to the line between the center of the wheel and the point of contact. The wheel must be able to support the load without failure for at least 3 seconds. The bearing cones may be replaced with conical bushings, but the cups used in operation must be used for this loading. If, at a point of loading during the test, it is shown that the tire will not successfully maintain pressure or if bottoming of the tire on the nondeflecting surface occurs, the tire pressure may-be increased to no more than 2 times the rated inflation pressure. If bottoming of the tire continues to occur with this 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 degrees.

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

(b) *Combined radial and side load test*. Test the wheel for the yield and ultimate loads as follows:

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

(2) *Yield load*. Apply to the wheel radial and side loads not less than 1.15 times the respective ground loads determined under §§ 23.485, 23.497, and 23.499, or §§ 25.485, 25.495, 25.497, and 25.499, or §§ 27.485 and 27.497, or §§ 29.485 and 29.497 of Title 14 Chapter 1, as appropriate. Apply these loads with the wheels

positioned against the nondeflecting surface and the valve hole positioned at 90 degrees with respect to the line between the center of the wheel and the point of contact, then with valve hole positioned at 180 degrees, 270 degrees, and 0 degrees from the nondeflecting surface. The 90 degree increments must be altered to other positions if the other positions are more critical. Three successive loadings at the 0 degree positions may not cause permanent set increments of increasing magnitude. The permanent set increment caused by the last loading at the 0 degree position may not exceed 5 percent of the deflection caused by that loading, or 0.005 inches, whichever is greater. The bearing cups, cones, and rollers used in operation must be used in this test. There must be no yielding of the wheel such as would result in loose bearing cups,, air or water leakage through the wheel or past the wheel seal, or interference in any critical areas. A tire and tube may be used when testing a tubeless wheel only when it has been demonstrated that pressure will be lost due to the inability of a tire bead to remain properly positioned under the load. The wheel must be tested for the most critical inboard and outboard side loads.

(3) *Ultimate load*. Apply to the wheel radial and side load not less than 2 times for castings and 1.5 times for forgings the respective ground loads determined under §§ 23.485, 23.497, and 23.499, or §§ 25.485, 25.495, 25.497, and 25.499, or §§ 27.485 and 27.497, or §§ 29.485 and 29.497 of Title 14 Chapter 1 as appropriate. Apply these loads with the same wheel positioned against the nondeflecting surface and the valve hole positioned-at 0 degrees with respect to the center of the wheel and the point of contact. The wheel must be able to support the load without failure for at least 3 seconds. The bearing cones *may* be replaced with conical bushings, but the cups used in operation must be used for this loading. If, at a point of loading during the test, it is shown that the tire will not successfully maintain pressure or if bottoming of the tire on the nondeflecting surface occurs, the tire pressure may be increased to no more than 2 times the rated inflated pressure. If bottoming of the tire continues to occur with this 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 degrees.

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

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

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

**TABLE I**

| Category of Aircraft | Load Conditions | Roll Distance (miles) |
|---|---|---|
| Part 25 | Maximum static load, "S" | 2000 |
| | Maximum static load, "S" plus 0.15 "S" side load applies in outboard direction. | 100 |
| | Maximum static load, "S" plus 0.15 "S" side load applied in inboard direction. | 100 |
| Part 23 | Maximum static load, "S" | 1000 |
| Parts 27 and 29 | Maximum static load, "S" | 250 |

(3) *Roll on Rim Test*. The wheel without a tire must be tested at a speed not less than 10 mph under the loads and distance shown in Table II. The test axle angular orientation with the load surface must approximate that of the airplane axle to the runway under maximum static load. At the end of the test there may be cracks but no fragmentation of the wheel. ($V_R$=takeoff speed in knots.)

TABLE II

| Category of Aircraft | Load Condition | Roll Distance (feet) |
|---|---|---|
| Part 25 | Maximum static load "S" | $V_R$2X 0.5 |

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

(1) *Overpressure test*. The wheel must be hydrostatically tested to withstand without failure for at least 3 seconds application of an overpressure factor not less than 4.0 for Part 25 airplanes, 3.5 for Part 23 airplanes, and 3.0 for rotorcraft, times the rated inflation pressure determined by the applicant.

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

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

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

(1) *Speed and weight values*. For airplanes, select either Method I or Method II below to calculate the kinetic energy level which a single wheel and wheel-brake assembly will be required to absorb. For rotorcraft, use Method I.

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

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

where:
KE=Kinetic energy per wheel-brake assembly (ft.-lbs.);
W=Design landing weight (lbs.);
V=Aircraft speed in knots. V must be not less than $V_{SO}$ the power off stalling speed of the aircraft at sea level, at the design landing weight, and the landing configuration. For the accelerate-stop tests applicable only to wheel-brake assemblies for airplanes certificated under Part 25, the manufacturer must determine the most critical combination of takeoff weight and speed;
N=Number of wheels with brakes. For rotorcraft, the manufacturer must calculate the most critical combination of takeoff weight and brake application speed to be used in the above equation.

(ii) *Method II*. The speed and weight values may be determined by other equations based on rational analysis of the sequence of events expected to occur during an accelerate-stop condition or an operational landing at maximum landing weight. The analysis must include rational or conservative values for braking coefficients of friction between the tire and runway, aerodynamic drag, propeller drag, power plant forward thrust, and if critical, loss of drag credit for the most adverse single engine or propeller due to malfunction. Do not consider the decelerating effects of propeller reverse pitch, drag parachutes, and power plant thrust reversers.

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

TABLE III

| Category of Aircraft | Test |
|---|---|
| Parts 23 and 25..... | $KE_{DL}$: 100 design landing stops at a deceleration .selected by manufacturer but not less than 10 ft/sec.$^2$ |
| Part 25..... .....| $KE_{RT}$: 1 accelerate stop at a deceleration selected by manufacturer but not less than 6 ft/sec.$^2$ |
| Parts 27 and 29..... | $KE_{DL}$: 20 design landing stops at a deceleration selected by manufacturer but not less than 6 ft./sec.$^2$ |

(3) *General Conditions*.

(i) During landing stop tests ($KE_{DL}$), one change of brake lining is permissible. The remainder of the brake assembly parts must withstand the 100 $KE_{DL}$ stops without failure or impairment of operations.

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

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

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

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

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

(c) *Overpressure-hydraulic brakes*. 'The brake with actuator piston extended to simulate a maximum worn condition must withstand hydraulic pressure for at least 3 seconds, equal to the following:

(1) For airplanes, 2 times the maximum brake line pressure available to the brakes.

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

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

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

(2) 5,000 cycles for airplanes, and 2,500 cycles for rotorcraft at the maximum system pressure available to the brakes.

(Secs. 313(a), 601, 603, Federal aviation Act of 1958, 49 U.S.C. 1354(a), 1421, 1423; sec. 6(c), Department of Transportation Act, 49 U.S.C. 1655(c))
[Amdt. 37-46, 44 F.R. 68743, Nov. 29, 1979]

**5.4.27 Amendments 21-50, 25-52, and 37-47, effective September 9, 1980**

a. *Change to Regulation.*

**§** 37.172 Aircraft Wheels and Wheel-Brake Assemblies-TSO-C26c.

**§** 37.172 Aircraft Wheels and Wheel-Brake Assemblies-TSO-C26c was eliminated from the regulations, previously published as Subpart B of 14 CFR Part 37, and was made available at FAA Headquarters in the Office of Airworthiness, Aircraft Engineering Division, Systems Branch (AWS-130) and at all regional flight Standards Engineering and Manufacturing offices. Part 37 was revoked. Subpart A of 14 CFR Part 37 became Subpart O of 14 CFR Part 21.

b. *Explanation.* Henceforth, a TSO is not a standard of general or particular applicability designed to implement or prescribe law or policy. It does not fall within the definition of "rule" contained in the Administrative Procedures Act (5 U.S.C. 551). There is no requirement that a TSO be published as a notice of proposed rulemaking in the Federal Register. A TSO thus becomes a voluntary standard. Future TSOs will, through incorporation by reference, make maximum use of "voluntary standards" as defined by the Office of Management and Budget (OMB) Circular A-119.

### 5.4.28 TSO-C26c with Addendum I issued, effective May 18, 1984

**TSO-C26c**
Date 5/18/84

**TECHNICAL STANDARD ORDER**

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**Subject**: TSO-C26c, AIRCRAFT WHEELS AND WHEEL-BRAKE ASSEMBLIES, WITH ADDENDUM I

This addendum provides clarifications and corrects certain omissions in TSO-C26c. These changes are considered non-substantive and do not affect technical standard order authorization or design approvals previously issued under TSO-C26c.

Addendum I changes to TSO-C26c Appendix 1 are as follows:

1. Paragraph 4.1(c)(3) Roll on Rim Test should read, "The main wheel (nose wheels are excluded from this test) without a tire must . . ... Table II. The test axle angular orientation with the load surface under maximum static load must be specified. At the end of the test . . "

2. Paragraph 4.1(c)(3) Table II under Roll Distance should read, "$V_R^2$ x 0.5 need not exceed 15,000 feet."

TSO-C26c, as amended by Addendum I, is set forth in its entirety below.

TSO-C26c, AIRCRAFT WHEELS AND WHEEL-BRAKE ASSEMBLIES

(a) Applicability.

(1) Minimum Performance Standard. This Technical Standard Order (TSO) prescribes the-minimum performance standard that aircraft wheels and wheel-brake assemblies must meet in order to be identified with the applicable TSO marking. This TSO has been prepared in accordance with the procedural rules set forth in Subpart O of the Federal Aviation Regulations, Part 21. New models of such equipment that are to be so identified and that are manufactured on or after December 31, 1979, must meet the requirements of Appendix 1 of the TSO titled, "Federal Aviation Administration Standard for Aircraft Wheels and Wheel-Brake Assemblies" dated December 31, 1979, or Appendix 1 dated May 18, 1984, as amended and supplemented by this Addendum I.

(b) Marking. In lieu of the marking requirements of § 21.607(d), aircraft wheels and wheel-brake assemblies must be legibly and permanently marked with the following information:

(1) Name of the manufacturer responsible for compliance.

(2) Serial number, or date of manufacture, or both.

(3) Part number.

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

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

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

(c) Data Requirements.

(1) In addition to the data specified in § 21.605 the manufacturer must furnish to the Chief, Aircraft Certification Office (ACO) having geographical purview of the manufacturer's facilities, one copy each of the following technical data:

(i) One copy of the applicable limitations pertaining to installation of wheels and brakes on aircraft, including the weight of the brakes on aircraft, including the weight of the brake assembly, maximum static load rating, a maximum limit load rating, maximum accelerate-stop kinetic energy in foot-pounds ($KE_{RT}$), design landing kinetic energy in foot-pounds ($KE_{DL}$), accelerate-stop deceleration in feet/second$^2$, design landing stop deceleration in feet/second$^2$, applicable speed as specified in paragraph 4.2.(a)(1) of the FAA Standard for Aircraft Wheels and Wheel-Brake Assemblies, type of hydraulic fluid used, and the weight of the wheel.

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

(2) Upon request of the regional office specified in paragraph (c)(1) of this section, the manufacturer must furnish the applicable maintenance instructions.

(d)Previously Approved Equipment. Wheels and wheel-brake assemblies approved prior to December 31, 1979 may continue to be manufactured under the provisions of their original approval.

(e) Availability of Reference Documents. Federal Aviation Regulations 21, Subpart 0 and Advisory Circular 20-110, "Index of Aviation Technical Standard Orders," way be reviewed at the FAA Headquarters in the office of Airworthiness, Aircraft Engineering Division (AWS-110), and at all ACO's.

Sd/ Joseph A. Pontecorvo
Acting Deputy Director of Airworthiness
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5/18/84 **TSO-C26c**

APPENDIX 1.

FEDERAL AVIATION ADMINISTRATION STANDARD FOR AIRCRAFT WHEELS AND WHEEL-BRAKE ASSEMBLIES DATED MAY 18, 1984

1. Purpose.

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

2. Design and Construction.

(a) Design.

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

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

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

(4) Water seal. Wheels intended for use on amphibious aircraft must be sealed to

prevent entrance of water into the wheel bearings or other portions of the wheel or brake, unless the design is such that brake action and service life will not be impaired by the presence of sea water or fresh water.

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

(b) Construction.

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

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

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

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

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

(6)Bolts and studs. When bolts and studs are used for fastening together sections of a wheel, the length of the threads for the nut extending into and bearing against the sections must be held to a minimum and there must be sufficient unthreaded bearing area to carry the required load.

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

(8) Aluminum parts. All aluminum alloy parts must be anodized or have equivalent protection from corrosion. This protection must include protection from fuse plug holes, valve stem holes, and other passages.

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

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

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

3. Rating.

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

(1) S=Maximum static load in pounds (ref. §§ 23.731(b), 25.731(b), 27.731(b), and 29.731(b) of Title 14 Chapter 1).

(2) L=Maximum limit load in pounds (ref. SS 23.731(c), 25.731(c), 27.731(c), and 29.731(c) of Title 14 Chapter 1).

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

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

(2) $KE_{RT}$=Kinetic energy capacity in foot-pounds per wheel-brake assembly at the maximum accelerate-stop rate of absorption for wheel-brake assemblies of airplanes certificated under Part 25 of Title 14 Chapter 1 only.:

4.Qualification Tests. The aircraft wheels and wheel-brake assemblies required by the TSO must be tested as follows and the test data included in the applicant's test report required by the TSO.

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

(a) Maximum radial load test. Test the wheel for yield and ultimate loads as follows:

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

(2) Yield load. Apply to the wheel a load not less than 1.15 times the maximum radial limit load, determined under §§ 23.471 through 23.511 or §§ 25.471 through 25.511, or §§ 27.471 through 27.505, or §§ 29.471 through 29.511 of Title 14 Chapter 1, as appropriate. Apply the load with the wheel positioned against the nondeflecting surface, and the valve hole positioned at 90 degrees with respect to the line between the center of the wheel and the point of contact, then with the valve hole positioned at 180 degrees, 270 degrees, and 0 degrees from the nondeflecting surface. The 90 degree increments must be altered to other positions if the other positions are more critical. Three successive loadings at the 0 degree position may not cause permanent set increments of increasing magnitude. The permanent-set increment caused by the last loading at the 0 degree position may not exceed 5 percent of the deflection caused by that loading or 0.005 inches, whichever is greater. The bearing cups, cones, and rollers used in operation must be used for these loadings. There must be no yielding of the wheel such as would result in loose bearing cups, air, or water leakage through the wheel or past the wheel seal, or interference in any critical areas.

(3)Ultimate load. Apply to the wheel a load not less than 2 times the maximum radial limit load for castings and 1.5 times the maximum radial limit load for forgings, determined under §§ 23.471 through 23.511, or §§ 25.471 through 25.511, or §§ 27.471 through 27.505 or §§ 29.471 through 29.511 of Title 14 Chapter 1, as appropriate. Apply the load with the same wheel positioned against the nondeflecting surface and the valve hole positioned at 0 degrees with respect to the line between the center of the wheel and the point of contact. The wheel must be able to support the load without failure for at least 3 seconds. The bearing cones may be replaced with conical bushings, but the cups used in operation must be used for this loading. If, at a point of loading during the test, it is shown that the tire will not successfully maintain pressure or if bottoming of the tire

on the nondeflecting surface occurs, the tire pressure may-be increased to no more than 2 times the rated inflation pressure. If bottoming of the tire continues to occur with this 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 degrees.

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

(b) Combined radial and side load test. Test the wheel for the yield and ultimate loads as follows:

(1) Test method. Mount the wheel, with a suitable tire of proper fit installed, on its axle, and position it against a flat nondeflecting surface. The wheel axle must have the same angular orientation to the nondeflecting surface that it will have to the runway when it is mounted on the aircraft and is under the combined radial and side load. Inflate the tire to the pressure recommended for the maximum static load with air or water. If water inflation is used, the water must be bled off to obtain the same tire deflection that would result if air inflation were used. Water pressure may not exceed the pressure which would develop if air inflation were used

and the tire deflected to its maximum extent. For the radial load component, load the wheel through its axle perpendicular to the flat nondeflecting surface. For the side load component, load the wheel through its axle parallel to the flat nondeflecting surface. The side load reaction must arise from the friction of the tire or the loading block on the nondeflecting surface. Apply the two loads simultaneously, increasing them either continuously or in increments no larger than 10 percent of the loads to be applied. Alternatively, a resultant load equivalent to the radial and side loads may be applied to the axle. Deflection readings must be taken at suitable points to indicate deflection and permanent set of the wheel rim at the bead seat.

(2) Yield load. Apply to the wheel radial and side loads not less than 1.15 times the respective ground loads determined under §§ 23.485, 23.497, and 23.499, or §§ 25.485, 25.495, 25.497, and 25.499, or §§ 27.485 and 27.497, or §§ 29.485 and 29.497 of Title 14 Chapter 1, as appropriate. Apply these loads with the wheels positioned against the nondeflecting surface and the valve hole positioned at 90 degrees with respect to the line between the center of the wheel and the point of contact, then with valve hole positioned at 180 degrees, 270 degrees, and 0 degrees from the nondeflecting surface.

The 90 degree increments must be altered to other positions if the other positions are more critical. Three successive loadings at the 0 degree positions may not cause permanent set increments of increasing magnitude. The permanent set increment caused by the last loading at the 0 degree position may not exceed 5 percent of the deflection caused by that loading, or 0.005 inches, whichever is greater. The bearing cups, cones, and rollers used in operation must be used in this test. There must be no yielding of the wheel such as would result in loose bearing cups,, air or water leakage through the wheel or past the wheel seal, or interference in any critical areas. A tire and tube may be used when testing a tubeless wheel only when it has been demonstrated that pressure will be lost due to the inability of a tire bead to remain properly positioned under the load. The wheel must be tested for the most critical inboard and outboard side loads.

(3) Ultimate load. Apply to the wheel radial and side load not less than 2 times for castings and 1.5 times for forgings the respective ground loads determined under §§ 23.485, 23.497, and 23.499, or §§ 25.485, 25.495, 25.497, and 25.499, or §§ 27.485 and 27.497, or §§ 29.485 and 29.497 of Title 14 Chapter 1 as appropriate. Apply these loads with the same wheel positioned against the nondeflecting surface and the valve hole positioned-at 0 degrees with respect to the center of the wheel and the point of contact. The wheel must be able to support the load without failure for at least 3 seconds. The bearing cones *may* be replaced with conical bushings, but the cups used in operation must be used for this loading. If, at a point of loading during the test, it is shown that the tire will not successfully maintain pressure or if bottoming of the tire on the nondeflecting surface occurs, the tire pressure may be increased to no more than 2 times the rated inflated pressure. If bottoming of the tire continues to occur with this 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 degrees.

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

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

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



**TABLE I**

| Category of Aircraft | Load Conditions | Roll Distance (miles) |
|---|---|---|
| Part 25 | Maximum static load, "S" | 2000 |
| | Maximum static load, "S" plus 0.15 "S" side load applies in outboard direction. | 100 |
| | Maximum static load, "S" plus 0.15 "S" side load applied in inboard direction. | 100 |
| Part 23 | Maximum static load, "S" | 1000 |
| Parts 27 and 29 | Maximum static load, "S" | 250 |

(3) Roll on Rim Test. The main wheel (nose wheels. are excluded from this test) without a tire must be tested at a speed not less than 10 mph under the loads and distance shown in Table II. The test axle angular orientation with the load surface under

maximum static load must be specified. At the end of the test there may be cracks but no fragmentation of the wheel. ($V_R$=takeoff speed in knots.)

TABLE II

| Category of Aircraft | Load Condition | Roll Distance (feet) |
|---|---|---|
| Part 25 | Maximum static load "S" | $V_R^2$ X 0.5<br>Need not exceed 15,000 feet |

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

(1) Overpressure test. The wheel must be hydrostatically tested to withstand without failure for at least 3 seconds application of an overpressure factor not less than 4.0 for Part 25 airplanes, 3.5 for Part 23 airplanes, and 3.0 for rotorcraft, times the rated inflation pressure determined by the applicant.

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

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

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

*(1)* Speed and weight values. For airplanes, select either Method I or Method II below to calculate the kinetic energy level which a single wheel and wheel-brake assembly will be required to absorb. For rotorcraft, use Method I.

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

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

where:
KE=Kinetic energy per wheel-brake assembly (ft.-lbs.);
W=Design landing weight (lbs.);
V=Aircraft speed in knots. V must be not less than $V_{SO}$ the power off stalling speed of the aircraft at sea level, at the design landing weight, and the landing configuration. For the accelerate-stop tests applicable only to wheel-brake assemblies for airplanes certificated under Part 25, the manufacturer must determine the most critical combination of takeoff weight and speed;
N=Number of wheels with brakes. For rotorcraft, the manufacturer must calculate the most critical combination of takeoff weight and brake application speed to be used in the above equation.

(ii) Method II. The speed and weight values may be determined by other equations based on rational analysis of the sequence of events expected to occur during an accelerate-stop condition or an operational landing at maximum landing weight. The analysis must include rational or conservative values for braking coefficients of friction between the tire and runway, aerodynamic drag, propeller drag, power plant forward thrust, and if critical, loss of drag credit for the most adverse single engine or propeller due to malfunction. Do not consider the decelerating effects of propeller reverse pitch, drag parachutes, and power plant thrust reversers.

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

TABLE III

| Category of Aircraft | Test |
|---|---|
| Parts 23 and 25..... | $KE_{DL}$: 100 design landing stops at a deceleration .selected by manufacturer but not less than 10 ft/sec.$^2$ |
| Part 25..... ..... | $KE_{RT}$: 1 accelerate stop at a deceleration selected by manufacturer but not less than 6 ft/sec.$^2$ |
| Parts 27 and 29..... | $KE_{DL}$: 20 design landing stops at a deceleration selected by manufacturer but not less than 6 ft./sec.$^2$ |

(3) General Conditions.

(i) During landing stop tests ($KE_{DL}$), one change of brake lining is permissible. The remainder of the brake assembly parts must withstand the 100 $KE_{DL}$ stops without failure or impairment of operations.

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

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

(b) Brake structural torque test. Apply load S and a torque load specified in paragraphs 4.2(b)(1) or (2), as applicable, for at least 3 seconds. Rotation of the wheel must be resisted by a reaction force transmitted through the brake or brakes by an application of at least maximum brake line pressure or brake cable tension in the case of a non-hydraulic brake. If such pressure of tension is insufficient to prevent rotation,, the friction surface way be clamped, bolted, or otherwise restrained while applying the pressure or tension.

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

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

(c) Overpressure-hydraulic brakes. 'The brake with actuator piston extended to simulate a maximum worn condition must withstand hydraulic pressure for at least 3 seconds, equal to the following:

(1) For airplanes, 2 times the maximum brake line pressure available to the brakes.

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

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

to:

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

(2) 5,000 cycles for airplanes, and 2,500 cycles for rotorcraft at the maximum system pressure available to the brakes.

### 5.4.29 Amendment 25-72, effective August 20, 1990

a. *Change to Regulation.*

**§** 25.735 Brakes.
(b) **[** The brake system must be designed and constructed so that, if any electrical, pneumatic, hydraulic, or mechanical connecting or transmitting element (excluding the operating pedal or handle) fails, or if any single source of hydraulic or other brake operating energy supply is lost, it is possible to bring the airplane to rest under conditions specified in **§** 25.125, with a mean deceleration during the landing roll of at least 50 percent of that obtained in determining the landing distance as prescribed in that section. Subcomponents within the brake assembly, such as brake drum, shoes, and actuators (or their equivalents), shall be considered as connecting or transmitting elements, unless it is shown that leakage of hydraulic fluid resulting from failure of the sealing elements in these subcomponents within the brake assembly would not reduce the braking effectiveness below that required by this paragraph. **]**

b. *Explanation.*

The change in text was to clarify the intent of the last sentence in existing **§** 25.735(b).

### 5.4.30 Amendment 25-92, effective March 20, 1998

a. *Change to Regulation.*
Section 25.735 is amended by revising paragraphs (f) introductory text and f(2) and adding a new paragraph (h) as follows:

**§ 25.735 Brakes**

*****
(f) The design landing brake kinetic energy capacity rating of each main wheel-brake assembly *shall be used during qualification testing of the brake to the applicable Technical Standard Order (TSO) or an acceptable equivalent. This kinetic energy rating* may not be less than the kinetic energy absorption requirements determined under either of the following methods:

(1) The brake kinetic energy absorption requirements must be based on a rational analysis of the sequence of events expected during operational landings at maximum landing weight. This analysis must include conservative values of airplane speed at which the brakes are applied, braking coefficient of friction between tires and runway, aerodynamic drag, propeller drag or power-plant forward thrust, and (if more critical) the most adverse single engine or propeller malfunction.

(2) Instead of a rational analysis, the kinetic energy absorption requirements for each main wheel brake assembly may be derived from the following formula, which must be modified in cases of designed unequal braking distributions:

$KE = 0.0443\ WV^2/N$
Where-
KE = kinetic energy per wheel (ft-lb);
W = design landing weight (lb);
V = airplane speed in knots. V must be not less than Vso, the power off stalling speed of the airplane at sea-level, at the design landing weight, and in the landing configuration; and
N = number of main wheels with brakes.

(g) The minimum stalling speed rating of each main wheel-brake assembly (that is, the initial speed used in the dynamometer tests) may not be more than the V used in the determination of kinetic energy in accordance with paragraph (f) of this section, assuming that the test procedures for wheel-brake assemblies involve a specified rate of deceleration, and, therefore, for the same amount of kinetic energy, the rate of energy

absorption (the power absorbing ability of the brake) varies inversely with the initial speed.

(h) The rejected takeoff brake kinetic energy capacity rating of each main wheel-brake assembly *that is at the fully worn limit of its allowable wear range shall be used during qualification testing of the brake to the applicable Technical Standard Order (TSO) or an acceptable equivalent. This kinetic energy rating* may not be less than the kinetic energy absorption requirements determined under either of the following methods:-

(1) The brake kinetic energy absorption requirements must be based on a rational analysis of the sequence of events expected during an accelerate-stop maneuver. This analysis must include conservative values of airplane speed at which the brakes are applied, braking coefficient of friction between tires and runway, aerodynamic drag, propeller drag or power-plant forward thrust and (if more critical) the most adverse single engine or propeller malfunction.

(2) Instead of a rational analysis, the kinetic energy absorption requirements for each main wheel brake assembly may be derived from the following formula, which must be modified in cases of designed unequal braking distributions.

$KE = 0.0443\ WV^2/N$

where-

KE = kinetic energy per wheel (ft-lb);
W = airplane weight (lb);
V = airplane speed (knots);
N = number of main wheels with brakes; and
W and V are the most critical combination of takeoff weight and ground speed obtained in a rejected takeoff.

b. *Explanation.* Added § 25.735(h) requiring that the maximum rejected takeoff kinetic energy capacity rating of the aircraft brakes be determined with the brakes at 100 percent of the allowable wear limit. The requirement evolved from an National Transportation Safety Board (NTSB) recommendation as follows: In 1988, a large transport category airplane experienced an 86% maximum kinetic energy (KE) rejected takeoff (RTO) in a dispatch configuration in which eight of the ten brakes were worn close to the maintenance limits. The eight brakes failed early in the braking run and the airplane overran the runway. As a result, the FAA reviewed the methodology used in the determination of allowable brake wear limits for transport category airplanes. It was determined that brake wear limits should be established during certification to ensure that fully worn brakes will function properly during a maximum KE RTO. A series of airplane specific airworthiness directives were issued between 1989 and 1994 to establish brake wear limits using the new criteria. These criteria were applied to transport category airplanes that exceeded a gross weight of 75000 pounds. The test criteria to establish brake wear limits were also defined in a separate Policy Memo . The regulation was updated to reflect this new criteria.



### 5.4.31 Amendment 25-107, effective May 24, 2002

**a. *Changes to Regulation.***

Amend § 25.731 to add new paragraphs (d) and (e) to read as follows:

**§ 25.731 Wheels.**

* * * * *

(d) Overpressure burst prevention. Means must be provided in each wheel to prevent wheel failure and tire burst that may result from excessive pressurization of the wheel and tire assembly.
(e) Braked wheels. Each braked wheel must meet the applicable requirements of

§ 25.735.

b. Explanation.
Discussion—25.731(d): Wheel failure and tire burst due to over-inflation present a hazard to ground personnel and the airplane. Certain airplane manufacturers require wheel pressure release devices that reduce this hazard. This is considered a safety issue requiring the incorporation of these devices. Incorporation of pressure release devices in tire inflation equipment is not considered adequate due to a history of misuse resulting in serious injuries or fatalities. Installation in the wheel reduces the potential for tampering or misuse and insures proper levels of protection. The adopted change would retain and potentially enhance the current level of safety. Applicable advisory information was included in AC 25.735-1.
Discussion--25.731(e): This section contains regulations applicable to all airplane wheels. If the wheel is braked, additional regulations apply, which are contained in Sec. 25.735. Section 25.731(e) was added to provide a cross-reference to those additional requirements. The adopted change would retain and potentially enhance the current level of safety.

Change to Regulation.

Revise § 25.735 to read as follows:

**§ 25.735 Brakes and braking systems.**
(a) Approval. Each assembly consisting of a wheel(s) and brake(s) must be approved.
(b) Brake system capability. The brake system, associated systems and components must be designed and constructed so that:
(1) If any electrical, pneumatic, hydraulic, or mechanical connecting or transmitting element fails, or if any single source of hydraulic or other brake operating energy supply is lost, it is possible to bring the airplane to rest with a braked roll stopping distance of not more than two times that obtained in determining the landing distance as prescribed in § 25.125.
(2) Fluid lost from a brake hydraulic system following a failure in, or in the vicinity of, the brakes is insufficient to cause or support a hazardous fire on the ground or in flight.
**Explanation. T**he term ``components'' was added to the terms ``brake system and associated systems'' in the first sentence to make it more comprehensive. (1) The parenthetical phrase ``(excluding the operating pedal or handle)'' was deleted because no justification could be found for such an exclusion. The words ``braked roll stopping distance'' was inserted in place of ``landing roll'' to clarify that the requirement refers only to the distance covered while the brakes are applied. The change in concept from at least 50 percent mean deceleration to not more than two times the landing distance was intended to eliminate any possible confusion between ``mean'' and ``average'' deceleration, and to state the requirement more clearly in terms of its real intent. The other changes in text were editorial and were made for clarity.
(2) The FAA added a new Sec. 25.735(b)(2) that would contain the intent and content of the ACJ 25.735(b) of JAR-25 regarding protection against fire resulting from hydraulic fluid leakage, spillage, or spraying on hot brakes.
Discussion: Although the adopted requirement was previously included in ACJ 25.735(b) as acceptable means of compliance and interpretative material, it was thought more appropriate that these practices should be considered as requirements as they have generally been treated as such in the past by both airplane manufacturers and regulatory authorities. The current level of safety would not be affected by this change as it would adopt an existing industry practice. Applicable advisory material was included in AC 25.735-1.

(c) Brake controls. The brake controls must be designed and constructed so that:
(1) Excessive control force is not required for their operation.
(2) If an automatic braking system is installed, means are provided to:
(i) Arm and disarm the system, and
(ii) Allow the pilot(s) to override the system by use of manual braking.
Explanation. The intent and content of the new requirement (2)(i)(ii) have generally been adopted in the design of current automatic braking systems and were included in FAA Order 8110.8, ``Engineering Flight Test Guide for Transport Category Airplanes,'' as interpretative and acceptable means of compliance. Consequently, both the airplane manufacturers and the regulatory authorities have generally considered them as standard practices; therefore, they did not impact the current level of safety. Applicable advisory material

was included in AC 25.735-1.

(d) Parking brake. The airplane must have a parking brake control that, when selected on, will, without further attention, prevent the airplane from rolling on a dry and level paved runway when the most adverse combination of maximum thrust on one engine and up to maximum ground idle thrust on any, or all, other engine(s) is applied. The control must be suitably located or be adequately protected to prevent inadvertent operation. There must be indication in the cockpit when the parking brake is not fully released.
Explanation: Introduction of the word ``brake" before ``control" clarified that the paragraph refers to the means provided to the flightcrew for the application of the wheel brakes in the airplane parking mode. By revising the text, the requirements were enhanced to cover not only the case of a single engine takeoff thrust check with all other engines stopped, but also cover an equally if not more probable case where any or all other engines are operating and producing up to a maximum ground idle thrust. The rule also clarified the extent of the takeoff thrust to be considered for the ``critical" engine as the maximum that can be achieved, and by implication also requires the relevant thrust cases for remaining engine(s) according to the environmental circumstances that are dictated for the achievement of the maximum takeoff thrust on the critical engine. The word ``dry" was added solely for clarification of the current understanding of this requirement.
The requirement for suitable location or protection against inadvertent operation of the parking brake control is derived from the current ACJ 25.735(d) of JAR-25 and was introduced because it is believed that such considerations should be regarded as requirements, and have generally been treated as such in the past by both airplane manufacturers and regulatory authorities. The additional requirement for cockpit indication when the parking brake is ``not fully released" is to caution the pilot against a takeoff with the parking brake set. The changes potentially enhanced the current level of safety by clarifying intent and addressing come critical cases. Applicable advisory material was included in AC 25.735-1.

(e) Antiskid system. If an antiskid system is installed:
(1) It must operate satisfactorily over the range of expected runway conditions, without external adjustment.
(2) It must, at all times, have priority over the automatic braking system, if installed.
Explanation: (1) and (2) The intent and content of these changes was included in FAA Order 8110.8, ``Engineering Flight Test Guide for Transport Category Airplanes," as interpretative material and acceptable means of compliance and was deemed appropriate to be adopted as requirements. Both the airplane manufacturers and the regulatory authorities have, in the past, considered it as a standard practice; therefore, it would not impact the current level of safety. Applicable advisory material was included in AC 25.735-1.

(f) Kinetic energy capacity.

(1) Design landing stop: The design landing stop is an operational landing stop at maximum landing weight. The design landing stop brake kinetic energy absorption requirement of each wheel, brake, and tire assembly must be determined. It must be substantiated by dynamometer testing that the wheel, brake and tire assembly is capable of absorbing not less than this level of kinetic energy throughout the defined wear range of the brake. The energy absorption rate derived from the airplane manufacturer's braking requirements must be achieved. The mean deceleration must not be less than 10 $fps^2$ .

(2) Maximum kinetic energy accelerate-stop: The maximum kinetic energy accelerate-stop is a rejected takeoff for the most critical combination of airplane takeoff weight and speed. The accelerate-stop brake kinetic energy absorption requirement of each wheel, brake, and tire assembly must be determined. It must be substantiated by dynamometer testing that the wheel, brake, and tire assemblies capable of absorbing not less than this level of kinetic energy throughout the defined wear range of the brake. The energy absorption rate derived from the airplane manufacturer's braking requirements must be achieved. The mean deceleration must not be less than 6 $fps^2$.

(3) Most severe landing stop: The most severe landing stop is a stop at the most critical combination of airplane landing weight and speed. The most severe landing stop brake kinetic energy absorption requirement of each wheel, brake, and tire assembly must be determined. It must be substantiated by dynamometer testing that, at the declared fully worn limit(s) of the brake heat sink, the wheel, brake and tire assembly is capable of absorbing not less than this level of kinetic energy. The most severe landing stop need not be considered for extremely improbable failure conditions or if the maximum kinetic energy accelerate-stop energy is more severe.
Explanation. The paragraph (f) would require the calculation of the necessary energy absorption capacity, and require dynamometer test substantiation of the capability of the wheel and brake assemblies to absorb the

energy at not less than specified rates. Usually, brakes are sized to exceed the calculated energy absorption requirements (i.e., their capacity exceeds the requirements, hence the heading ``Kinetic energy capacity'').
The term ``rating'' was deleted because it is more relevant to the TSO than to the regulation. The change encompassed the requirements of current paragraph (h) at amendment 25-92 without the need for complete duplication of text.
The term ``rejected takeoff'' used under current paragraph (h) was replaced with ``accelerate-stop'' for compatibility with Sec. 25.109 terminology; and the term ``most severe landing stop'' was added to address cases such as emergency return to land after takeoff, where the brake energy for a flaps up landing may exceed that corresponding to the accelerate-stop energy. For the accelerate-stop and the most severe landing stop, it is intended that the initial brake temperature resulting from previous brake use must be accounted for as specified in paragraphs 3.3.3.3 and 3.3.4.3 in the TSO-C135. It should be noted that the consideration for the initial temperature (in terms of residual energy) reflects an existing British Civil Aviation authority (CAA) Specification 17 requirement. Changing the term ``main wheel-brake assemblies'' to ``wheel and brake assemblies,'' ensures the paragraph's applicability to any wheels fitted with brakes (i.e., includes the possibility of nose wheel brakes, etc.) and further ensures the understanding that the absorption requirements apply to the wheel and brake assembly. The substantiation statement requires that the wheel and brake assemblies be capable of absorbing the calculated levels of kinetic energy at the fully worn limit and that the energy absorption capability substantiation testing be conducted on the dynamometer.
The current {amendment 25-92} §§ 25.735(f)(1) and (h)(1) were incorporated in AC 25.735-1, because their content is not strictly part of the requirement, but provides advice on the primary features that should be conservatively included in a rational analysis.
The current Secs. 25.735(f)(2) and (h)(2) are not strictly the requirement, but advice on the method of energy calculation to be used. Consequently, these were incorporated in AC 25.735-1.
Because the required energy capacity of each wheel and brake assembly must be determined, the need to refer to ``designed unequal braking distributions'' was no longer necessary and was deleted.
The current level of safety was retained and possibly enhanced by addressing the most severe landing stop condition. Applicable advisory material was included in AC 25.735-1.
(g) Brake condition after high kinetic energy dynamometer stop(s). Following the high kinetic energy stop demonstration(s) required by paragraph (f) of this section, with the parking brake promptly and fully applied for at least 3 minutes, it must be demonstrated that for at least 5 minutes from application of the parking brake, no condition occurs (or has occurred during the stop), including fire associated with the tire or wheel and brake assembly, that could prejudice the safe and complete evacuation of the airplane.
Explanation: Paragraph (g) requires that the parking brake be applied for a minimum of three minutes, which is considered to be the minimum period of time required to cover the brake's ability to maintain the airplane in a stationary condition to allow a safe evacuation.
The requirement also gives consideration to the fact that the flightcrew may not be aware of the condition of the brake assemblies at the commencement of the flight, nor of the condition of the brake and wheel assemblies following the braking maneuver. Furthermore, the reason for the severe braking could encompass both airplane system and engine failures or fires. It would therefore appear sensible that it should be demonstrated that neither during the stop, nor for a reasonable period of time after its completion, no condition(s) shall occur as a result of these maneuvers that could further prejudice the safe and complete evacuation of the airplane. On the basis that an evacuation may be determined as prudent or necessary, and that such an evacuation must be capable of completion, irrespective of the timely response of the emergency services, five minutes would appear to be a reasonable period of time for the associated brake systems and equipment to remain free from conditions that might prejudice or jeopardize the evacuation. This period should commence at the time of initial application of the parking brake, this being a time during which the possible need for evacuation and airport emergency services occurs following an accelerate-stop. The changes provide for the additional demonstration of a safe condition following high energy absorption by the wheels and brakes, which was not previously required. Although previously approved brakes may have been able to comply with the requirement, approval could not have been refused had this not been the case. It is therefore believed that the changes would provide a potential enhancement of the current level of safety. Applicable advisory material was included in AC 25.735-1.
(h) Stored energy systems. An indication to the flight-crew of the usable stored energy must be provided if a stored energy system is used to show compliance with paragraph (b)(1) of this section. The available stored energy must be sufficient for(1) At least 6 full applications of the brakes when an antiskid system is not operating; and

(2) Bringing the airplane to a complete stop when an antiskid system is operating, under all runway surface conditions for which the airplane is certificated.
Explanation: A full brake application is defined as an application from brakes fully released to brakes fully applied, and back to fully released. For those airplanes that may provide a number of independent braking systems, which are not ``reliant'' on a stored energy system for the demonstration of compliance with paragraph (b)(1) of this section, but which perhaps incorporate a stored energy device, this requirement is not applicable. It would be unreasonable that the requirement for a minimum energy capacity and the provision of means to indicate the level of stored energy to the flightcrew should be maintained, particularly if its failure would have a minimal consequence on airplane or passenger safety.
In the event that an hydraulic accumulator is used for energy storage and the gas pressurization depletes, a pressure indication alone as currently required in JAR 25.735(i) would be inadequate because it would not provide indication of such faults to the flightcrew. In fact, the current typical flight deck presentation could give a false sense of security to the crew because it would almost inevitably indicate a satisfactory pressure, regardless of the real situation. Consequently, the new rule would require a measure of the stored energy, rather than pressure, to be presented to the flightcrew.
The minimum level of stored energy required for the emergency/ standby braking means is presented as a requirement rather than as advisory material. In the majority of cases, this material has been used as a virtual requirement in the past by airplane manufacturers and regulatory authorities. The change would potentially enhance the current level of safety because the FAA is adopting a common but not universal industry practice and an improvement over the existing JAR rule. Applicable advisory material was included in the new AC 25.735-1.

(i) Brake wear indicators. Means must be provided for each brake assembly to indicate when the heat sink is worn to the permissible limit. The means must be reliable and readily visible.

Explanation: In order to ensure, as far as is practicable, that the brake heat sink is not worn beyond its allowable wear limits throughout its operational life, it is considered necessary to provide some device that can readily identify the fully worn limit of the heat sink. The proposal reflects a requirement included in a series of airworthiness directives issued between 1989 and 1994 to require establishment of brake wear limits and to provide means to indicate the same. The British Civil Aviation Authority (CAA) Specification No. 17 also specifies the provision of such an indicator, and the majority of wheel and brake assembly designs include such a device. The new rule would have no impact on the current level of safety, because the FAA is adopting an existing industry practice. Appropriate advisory information was included in AC 25.735-1.

(j) Over-temperature burst prevention. Means must be provided in each braked wheel to prevent a wheel failure, a tire burst, or both, that may result from elevated brake temperatures. Additionally, all wheels must meet the requirements of § 25.731(d).
Explanation: There is an existing requirement (Sec. 25.729(f)) related to the protection of equipment in wheel wells against the effects of bursting tires and a similar requirement is stated in TSO-C26c, Wheels and Wheel-Brake Assemblies. JAR 25.729(f) requires protection of equipment on the landing gear and in wheel wells against tire burst and elevated brake temperatures, and a similar requirement is stated in the ``Minimum Operational Performance Specification for Wheels and Brakes on JAR Part 25 Civil Aeroplanes'' (Document ED-69). However, there is no direct requirement in either part 25 or JAR-25 that means must be provided to prevent wheel failure and tire burst that could result from elevated brake temperatures. As a result, it has become an industry practice to incorporate pressure release device(s) that function as a result of elevated wheel temperatures to deflate the tires. Nevertheless, it is believed to be both reasonable and prudent that such a requirement should be clearly stated in the paragraph related to airplane brakes and braking systems. The added requirement for temperature activated devices would not impact the current level of safety. Applicable advisory information was included in AC 25.735-1.
(k) Compatibility. Compatibility of the wheel and brake assemblies with the airplane and its systems must be substantiated.

**b.** ***Explanation.*** Reliable and consistent brake system performance can be adversely affected by incompatibilities within the system and with the landing gear and the airplane. As part of the overall substantiation of safe and anomaly free operation, it is necessary to show that no unsafe conditions arise from incompatibilities between the brakes and brake system with other airplane systems and structures. Areas such as antiskid tuning, landing gear dynamics, tire type and size, brake combinations, brake characteristics, brake and landing gear vibrations, etc., need to be explored and corrected if necessary. Therefore, this requirement is introduced to address these

issues which are normally covered by airplane manufacturers during development of the airplane and must be addressed by modifiers of the equipment. Incorporation of this requirement would potentially enhance the current level of safety. Appropriate advisory information was included in AC 25.735-1.

***Overall Summary of Rule Changes:***

This amendment revises the braking systems design and test requirements of the airworthiness standards for transport category airplanes. The amendment moves some of the existing regulatory text, considered to be of an advisory nature, to an advisory circular and adds regulations addressing automatic brake systems, brake wear indicators, pressure release devices, and system compatibility. These revisions were developed in cooperation with the Joint Aviation Authorities (JAA) of Europe, Transport Canada, and the U.S. and European aviation industry through the Aviation Rulemaking Advisory Committee (ARAC). These changes benefit the public interest by standardizing certain requirements, concepts, and procedures contained in the airworthiness standards without reducing, but potentially enhancing, the current level of safety.

### 5.4.32 Harmonized Advisory Circular AC 25.735-1

U.S. Department of Transportation
**Federal Aviation Administration**

# Advisory Circular

| Subject | BRAKES AND BRAKING SYSTEMS CERTIFICATION TESTS AND ANALYSIS | Date: | 4/10/02 | AC No.: | 25.735-1 |
|---|---|---|---|---|---|
| | | Initiated by: | ANM-100 | Change | |

1. PURPOSE. This Advisory Circular (AC) provides guidance material for use as an acceptable means, although not the only means, of demonstrating compliance with the braking system requirements of Title 14, Code of Federal Regulations (14 CFR) part 25 for transport category airplanes. Like all AC material, this AC is not, in itself, mandatory and does not constitute a regulation. Terms used in this AC, such as "shall" or "must," are used only in the sense of ensuring applicability of this particular method of compliance when the acceptable method of compliance described herein is used. While these guidelines are not mandatory, they are derived from extensive Federal Aviation Administration (FAA) and industry experience in determining compliance with the pertinent CFR. This AC does not change, create any additional, authorize changes in, or permit deviations from, regulatory requirements.

2. RELATED DOCUMENTS.

a. Related Federal Aviation Regulations. Sections 25.731 and 25.735 of 14 CFR, as amended through Amendment 25-107, and other sections relating to brakes and braking system installations. Sections that prescribe requirements for the design, substantiation, and certification of braking systems include:

§ 21.303 Replacement and modification parts
§ 25.101 General
§ 25.109 Accelerate-stop distance
§ 25.125 Landing
§ 25.301 Loads
§ 25.303 Factor of safety
§ 25.729 Retracting mechanism
§ 25.733 Tires
§ 25.1301 Function and installation.
§ 25.1309 Equipment, systems and installations.
§ 25.1322 Warning, caution and advisory lights.
§ 25.1501 General: Systems and equipment limitations (JAR25x1524)
§ 25.1541 Markings and Placards
14 CFR part 21, Subpart O

b. Additional sections (and their associated advisory circulars where applicable) that prescribe requirements which can have a significant impact on the overall design and configuration of braking systems include, but are not limited to:

§ 21.101 Designation of applicable regulations

§ 25.863 Flammable fluid fire protection
§ 25.943 Negative acceleration (JAR 25x1315)
§ 25.1001 Fuel jettisoning system
§ 25.1183 Flammable fluid-carrying components
§ 25.1185 Flammable fluids

c. Advisory Circulars (AC's).

AC 25.1309-1A System Design and Analysis
AC 25-7A Flight Test Guide for Certification of Transport Category Airplanes
AC 91-6A Water, Slush, and Snow on the Runway (AMJ 25x1591 Supplementary Performance Information for Takeoff from Wet Runways and for Operation on Runways Contaminated by Standing Water, Slush, Loose Snow, Compacted Snow, or Ice)

d. Technical Standard Orders (TSO's).

TSO-C26c Aircraft Wheels and Wheel-Brake Assemblies with Addendum I
TSO-C135 Transport Airplane Wheel and Wheel and Brake Assemblies
TSO-C62d Tires
TSO-C75 Hydraulic Hose Assemblies

e. Federal Aviation Administration Orders.

Order 8110.4A Type Certification Process
Order 8110.8 Engineering Flight Test Guide For Transport Category Airplanes

f. Advisory Circulars, TSO's, and FAA Orders can be obtained from the U.S. Department of Transportation, Subsequent Distribution Office, SVC-121.23, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20785, or an electronic copy may be downloaded using the Internet at the following address: http://www.faa.gov/certification/aircraft/air_index.htm

g. Society of Automotive Engineers (SAE) Documents.

ARP 597C Wheels and Brakes, Supplementary Criteria for Design Endurance-– Civil Transport Aircraft
ARP 813A Maintainability Recommendations for Aircraft Wheels and Brakes
AIR 1064B Brake Dynamics
ARP 1070B Design and Testing of Antiskid Brake Control Systems for Total Aircraft Compatibility
AS 1145A Aircraft Brake Temperature Monitor System (BTMS)
ARP 1619 Replacement and Modified Brakes and Wheels
AIR 1739 Information on Antiskid Systems
ARP 1907 Automatic Braking System Requirements
AIR 1934 Use of Carbon Heat Sink Brakes on Aircraft
ARP 4102/2 Automatic Braking System (ABS)
ISO 7137 Environmental Conditions and Test Procedures for Airborne Equipment (not an SAE document but is available from the SAE)

h. These documents can be obtained from the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, Pennsylvania, 15096.

i. RTCA Documents.

RTCA/DO-160D Conditions and Test Procedures for Airborne equipment, Issued July 12, 1996.

RTCA/DO-178B Software Considerations in Airborne Systems and Equipment Certification, Issued December 1, 1992

j. Copies of RTCA documents may be purchased from the RTCA Inc., 1140 Connecticut Avenue NW, Suite 1020, Washington, D.C. 20036.

k. Military Documents.

MIL-STD-810 Environmental Test Methods and Engineering Guidelines

l. This document can be obtained from the Department of Defense, DODSSP, Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.

3. BACKGROUND.

a. Effective February 1, 1965, part 25 was added to 14 CFR to replace part 4b of the Civil Air Regulations (CAR). For wheels, CAR 4b.335(a) and (b), became §§ 25.731(a) and (b) respectively, of 14 CFR. For brakes/braking systems, CAR 4b.337 (a)(1), 4b.337(a)(2) and (a)(3), 4b.337(b), 4b.337(c), 4b.337(d), 4b.335(c), and 4b.335(d), became §§ 25.735(a), 25.735(b), 25.735(c), 25.735(d), 25.735(e), 25.735(f), and 25.735(g) respectively, of 14 CFR. Since then, § 25.735 has been revised by Amendment 25-23 (1970), Amendment 25-48 (1979), Amendment 25-52 (1980), Amendment 25-72 (1990), Amendment 25-92, Improved Standards for Determining Rejected Takeoff and Landing Performance (1998), and Amendment 25-107, Revision of Braking Systems Airworthiness Standards to Harmonize with European Airworthiness Standards for Transport Category Airplanes. These amendments were adopted to make the regulations more comprehensive and to delete redundancies.

(1) Amendment 25-23 deleted reference to military specification (MIL-B-8075) to show compliance for antiskid devices under § 25.735(e), and to allow any other acceptable means of compliance. In addition, proper units of "knots" were added to the stall speed under § 25.735(f)(2).

(2) Amendment 25-48 revised the technical standard order TSO-C26b for aircraft wheels and wheel-brake assemblies and related type certification requirements for airplane brakes (§ 25.735). The revised standard TSO-C26c incorporated updated and improved minimum performance standards for the design and construction of aircraft wheels and brakes. The amendment also changed § 25.735 as follows:

(a) Under § 25.735(b), the incorrect reference to § 25.75 was replaced by a correct reference to § 25.125.

(b) Under § 25.735(f)(2), the numerical constant 0.0442 was corrected as 0.0443, and the letter "N" was appropriately redefined as the Number of main wheels with brakes.

(c) Under § 25.735(f)(2), the term $V_{so}$ in the formula was replaced with "V" such that V must not be less than $V_{so}$ under definition.

(d) Under § 25.735(g), the term $V_{so}$ was replaced by V to be consistent with terminology used under § 25.735(f)(2).

(3) Under Amendment 25-52, § 37.172, Aircraft wheels and brakes, TSO-C26c was removed from the regulations, previously published as Subpart B of 14 CFR part 37, and made available to the public. The TSO-C26c is available through the FAA Office of Airworthiness, Aircraft Engineering Division, Systems Branch (AWS-130) at FAA Headquarters in Washington, D.C., and at all regional Flight Standards Engineering and Manufacturing Offices. Subpart A of 14 CFR part 37 was included in Subpart O of 14 CFR part 21. Part 37 of 14 CFR was revoked.

(4) Under Amendment 25-72, the text of the last sentence in existing § 25.735(b) was changed to clarify the intent. In addition, § 25.731 was amended to become compatible with § 25.25, which had been amended to provide for weights that are in excess of takeoff weight, such as ramp weights, provided that compliance with the applicable structural requirements, including wheel strength, is demonstrated at the

higher weights.

(5) Under Amendment 25-92, the regulations were updated to add the brake wear limits determination requirements. On May 21, 1988, an American Airlines DC-10 experienced an 86 percent maximum kinetic energy (KE) rejected takeoff (RTO) in a dispatch configuration in which eight of the ten brakes were worn close to the maintenance limits. The eight brakes failed in the early portion of the braking run and the airplane overran the runway. As a result, the FAA reviewed the methodology used in the determination of allowable brake wear limits for transport category airplanes. It was determined that brake wear limits should be established during certification to ensure that fully worn brakes will function properly during a maximum KE RTO. The FAA issued a series of airplane specific airworthiness directives between 1989 and 1994 to establish brake wear limits using the new criteria.

(6) Although part 25 and JAR-25 are very similar, they are not identical. Differences between part 25 and the JAR can result in substantial additional costs when airplanes are type certificated to both standards. Starting In 1992, the harmonization effort for various systems-related airworthiness requirements was undertaken by the Aviation Rulemaking Advisory Committee (ARAC). A working group of industry and government braking systems specialists from Europe, the United States, and Canada was chartered by notice in the Federal Register (59 FR 30080, June 10, 1994). The working group was tasked to develop harmonized standards and any collateral documents, such as advisory circulars, concerning new or revised requirements for braking systems, and the associated test conditions for braking systems, installed in transport category airplanes (§§ 25.731 and 25.735). The advisory material contained in this AC was developed by the Braking Systems Harmonization Working Group to ensure consistent application of the standards revised under Amendment 25-107, Revision of Braking Systems Airworthiness Standards to Harmonize with European Airworthiness Standards for Transport Category Airplanes, and the corresponding new TSO-C135.

4. DISCUSSION.

a. Approval.

(1) Section § 25.735(a) states that each assembly consisting of a wheel(s) and brake(s) must be approved. Each wheel and brake assembly fitted with each designated and approved tire type and size, where appropriate, should be shown to be capable of meeting the minimum standards and capabilities detailed in the applicable TSO, in combination with the type certification procedures for the airplane, or by any other means approved by the Administrator. This applies equally to replacement, modified, and refurbished wheel and brake assemblies or components, whether the changes are made by the Original Equipment Manufacturer (OEM) or others. Additionally, the components of the wheels, brakes, and braking systems should be designed to:

(a) Withstand all pressures and loads, applied separately and in conjunction, to which they may be subjected in all operating conditions for which the airplane is certificated.

(b) Withstand simultaneous applications of normal and emergency braking functions, unless adequate design measures have been taken to prevent such a contingency.

(c) Meet the energy absorption requirements without auxiliary cooling devices (such as cooling fans).

(d) Not induce unacceptable vibrations at any likely ground speed and condition or any operating condition (such as retraction or extension).

(e) Protect against the ingress or effects of foreign bodies or materials (water, mud, oil, and other products) that may adversely affect their satisfactory performance. Following initial airplane certification, any additional wheel and brake assemblies should meet the applicable airworthiness requirements specified in §§ 21.101(a) and (b) to eliminate situations that may have adverse consequences on airplane braking control and performance. This includes the possibility of the use of modified brakes either alone (i.e., as a ship set) or alongside the OEM's brakes and the mixing of separately approved assemblies.

(2) Refurbished and Overhauled Equipment. Refurbished and overhauled equipment is equipment overhauled and maintained by the applicable OEM or its designee in accordance with the OEM's Component Maintenance Manual (CMM) and associated documents. It is necessary to demonstrate compliance of all refurbished configurations with the applicable TSO and airplane manufacturer's specifications. It is also necessary to verify that performances are compatible for any combination of mixed brake configurations, including refurbished/overhauled and new brakes. It is essential to assure that Airplane Flight Manual braking performance and landing gear and airplane structural integrity are not adversely altered.

(3) Replacement and Modified Equipment. Replacement and modified equipment includes changes to any approved wheel and brake assemblies not addressed under paragraph 4a(2) of this AC. Consultation with the airplane manufacturer on the extent of testing is recommended. Particular attention should be paid to potential differences in the primary brake system parameters (e.g., brake torque, energy capacity, vibration, brake sensitivity, dynamic response, structural strength, and wear state). If comparisons are made to previously approved equipment, the test articles (other than the proposed parts to be changed) and conditions should be comparable, as well as the test procedures and equipment on which comparative tests are to be conducted. For wheel and brake assembly tests, the tire size, manufacturer, and ply rating used for the test should be the same and the tire condition should be comparable. For changes of any heat sink component parts, structural parts (including the wheel), and friction elements, it is necessary for the applicant to provide evidence of acceptable performance and compatibility with the airplane and its systems.

(a) Minor Changes. Changes to a brake might be considered as a minor change, as long as the changes are not to the friction elements. The proposed change cannot affect the airplane stopping performance, brake energy absorption characteristics, and/or continued airworthiness of the airplane or wheel and brake assembly (e.g., vibration and/or thermal control, and brake retraction integrity). It is incumbent on the applicant to provide technical evidence justifying a minor change.

(b) Major Changes. Changes to a wheel assembly outside the limits allowed by the OEM's CMM should be considered a major change due to potential airworthiness issues.

(c) Past history with friction elements has indicated the necessity of on-going monitoring (by dynamometer test) of frictional and energy absorption capabilities to assure that they are maintained over the life of the airplane program. These monitoring plans have complemented the detection and correction of unacceptable deviations. The applicant should submit a monitoring plan to the cognizant FAA Aircraft Certification Office to ensure continued airworthiness of the product.

(d) Intermixing of wheel and brake assemblies from different suppliers is generally not acceptable due to complexities experienced with different friction elements, specific brake control tuning, and other factors.

b. Brake System Capability.

(1) The system should be designed so that no single failure of the system degrades the airplane stopping performance beyond doubling the braked roll stopping distance (refer to § 25.735(b)(1)). Failures are considered to be fracture, leakage, or jamming of a component in the system, or loss of an energy source. Components of the system include all parts that contribute to transmitting the pilot's braking command to the actual generation of braking force. Multiple failures resulting from a single cause should be considered a single failure (e.g., fracture of two or more hydraulic lines as a result of a single tire failure). Sub-components within the brake assembly, such as brake discs and actuators (or their equivalents), should be considered as connecting or transmitting elements, unless it is shown that leakage of hydraulic fluid resulting from failure of the sealing elements in these sub-components within the brake assembly would not reduce the braking effectiveness below that specified in § 25.735(b)(1).

(a) In order to meet the stopping distance requirements of § 25.735(b)(1) in the event of failure of the normal brake system, it is common practice to provide an alternate brake system. The normal and alternate braking systems should be independent, being supplied by separate power sources. Following

a failure of the normal system, the changeover to a second system (whether manually or by automatic means) and the functioning of a secondary power source should be effected rapidly and safely. The changeover should not involve risk of wheel locking, whether the brakes are applied or not at the time of changeover.

(b) The brake systems and components should be separated or appropriately shielded so that complete failure of the braking system(s) as a result of a single cause is minimized.

(2) Compliance with § 25.735(b)(2) may be achieved by:

(a) Showing that fluid released would not impinge on the brake, or any part of the assembly that might cause the fluid to ignite;

(b) Showing that the fluid will not ignite; or

(c) Showing that the maximum amount of fluid released is not sufficient to sustain a fire.

(3) Additionally, in the case of a fire, the applicant may show that the fire is not hazardous, taking into consideration such factors as landing gear geometry, location of fire sensitive (susceptibility) equipment and installations, system status, flight mode, etc. If more than one fluid is allowed for the hydraulic system, compliance should be addressed for all fluids.

c. Brake Controls.

(1) The braking force should increase or decrease progressively as the force or movement applied to the brake control is increased or decreased (refer to § 25.735(c)(1)). The braking force should respond to the control as quickly as is necessary for safe and satisfactory operation. A brake control intended only for parking need not operate progressively. There should be no requirement to select the parking brake “off” in order to achieve a higher braking force with manual braking.

(2) When an automatic braking system is installed (refer to § 25.735(c)(2)) such that various levels of braking (e.g., low, medium, high) may be pre-selected to occur automatically following a touchdown, the pilot(s) should be provided with a means that is separate from other brake controls to arm and/or disarm the system prior to the touchdown.

(3) The automatic braking system design should be evaluated for integrity and non-hazard, including the probability and consequence of insidious failure of critical components, and noninterference with the non-automatic braking system. Single failures in the automatic braking system should not compromise non-automatic braking of the airplane. Automatic braking systems that are to be approved for use in the event of a rejected takeoff should have a single selector position, set prior to takeoff, enabling this operating mode.

d. Parking Brake. It should be demonstrated that the parking brake has sufficient capability in all allowable operating conditions (Master Minimum Equipment List (MMEL) to be able to prevent the rotation of braked wheels. This demonstration is to be accomplished with the stated engine power settings, and with the airplane configuration (i.e., ground weight, c.g., position and nose wheel (or tail wheel) angle) least likely to result in skidding on a dry, level runway surface (refer to § 25.735(d)). Use of ground idle thrust on the “other” engine is not mandatory, higher thrust levels may be used to prevent airplane motion due to the asymmetric engine thrust. Where reliable test data are available, substantiation by means other than airplane testing may be acceptable.

(1) For compliance with the requirement for indication that the parking brake is not fully released, the indication means should be associated, as closely as is practical, with actual application of the brake rather than the selector (control). The intent is to minimize the possibility of false indication due to failures between the brake and the point at which the parking brake state is sensed. This requirement is separate from, and in addition, to the parking brake requirements associated with JAR 25.703(a)(3), Take-off warning systems.

(2) The parking brake control, whether or not it is independent of the emergency brake control, should be marked with the words "Parking Brake" and should be constructed in such a way that, once operated, it can remain in the selected position without further flight crew attention. It should be located where inadvertent operation is unlikely, or be protected by suitable means against inadvertent operation.

e. Antiskid System.

(1) If an antiskid system is installed (refer to § 25.735(e)), then no single failure in the antiskid system should result in the brakes being applied, unless braking is being commanded by the pilot. In the event of an antiskid system failure, means should be available to allow continued braking without antiskid. These means may be automatic, pilot controlled, or both.

(2) Compliance with §§ 25.735(e)(1) and (e)(2)) may be achieved by:

(a) Failures that render the system ineffective should not prevent manual braking control by the pilot(s) and should normally be indicated. Failure of wheels, brakes, or tires should not inhibit the function of the antiskid system for unaffected wheel, brake, and tire assemblies.

(b) The antiskid system should be capable of giving a satisfactory braking performance over the full range of tire to runway friction coefficients and surface conditions, without the need for pre-flight or pre-landing adjustments or selections. The range of friction coefficients should encompass those appropriate to dry, wet, and contaminated surfaces and for both grooved and ungrooved runways.

(c) The use of the phrase “without external adjustment” is intended to imply that once the antiskid system has been optimized for operation over the full range of expected conditions for which the airplane is to be type certificated, pre-flight or pre-landing adjustments made to the equipment to enable the expected capabilities to
be achieved are not acceptable. For example, a specific pre-landing selection for a landing on a contaminated, low μ (friction level) runway, following a takeoff from a dry,
high μ runway, should not be necessary for satisfactory braking performance to be achieved.

(d) It should be shown that the brake cycling frequency imposed by the antiskid installation will not result in excessive loads on the landing gear. Antiskid installations should not cause surge pressures in the brake hydraulic system that would be detrimental to either the normal or emergency brake system and components.

(e) The system should be compatible with all tire sizes and type combinations permitted and for all allowable wear states of the brakes and tires. Where brakes of different types or manufacture are permitted, compatibility should be demonstrated or appropriate means should be employed to ensure that undesirable combinations are precluded.

(f) The antiskid function must be able to reduce braking for a wheel/tire that is going into a skid, whether the braking level is commanded by the pilot or an autobrake system if installed.

f. Kinetic Energy Capacity. The kinetic energy capacity of each tire, wheel, and brake assembly should be at least equal to that part of the total airplane energy that the assembly will absorb during a stop, with the heat sink at a defined condition at the commencement of the stop (Refer to § 25.735(f)).

(1) Calculation of Stop Kinetic Energy.

(a) The design landing stop, the maximum kinetic energy accelerate-stop, and the most severe landing stop brake kinetic energy absorption requirements of each wheel and brake assembly should be determined using either of the following methods:

(1) A conservative rational analysis of the sequence of events expected during the

braking maneuver; or

(2) A direct calculation based on the airplane kinetic energy at the commencement of the braking maneuver.

(b) When determining the tire, wheel, and brake assembly kinetic energy absorption requirement using the rational analysis method, the analysis should use conservative values of the airplane speed at which the brakes are first applied, the range of the expected coefficient of friction between the tires and runway, aerodynamic and propeller drag, power plant forward thrust, and, if more critical, the most adverse single engine or propeller malfunction.

(c) When determining the tire, wheel, and brake assembly energy absorption requirement using the direct calculation method, the following formula, which needs to be modified in cases of designed unequal braking distribution, should be used:

$KE = 0.0443\ WV^2/N$ (ft-lb.)

where KE = Kinetic Energy per wheel (ft-lb.)
N = Number of main wheels with brakes
W = Airplane Weight (lb.)
V = Airplane Speed (knots)

or if SI (Metric) units are used:

$KE = 1/2\ mV^2/N$ (Joule)

where KE = Kinetic Energy per wheel (J)
N = Number of main wheels with brakes
m = Airplane Mass (kg.)
V = Airplane Speed (m/s)

(d) For all cases, V is the ground speed and takes into account the prevailing operational conditions. All approved landing flap conditions should be considered when determining the design landing stop energy.

(e) These calculations should account for cases of designed unequal braking distributions. “Designed unequal braking distribution” refers to unequal braking loads between wheels that result directly from the design of the airplane. An example would be the use of both mainwheel and nose wheel brakes, or the use of brakes on a centerline landing gear supporting lower vertical loads per braked wheel than the main landing gear braked wheels. It is intended that this term should account for effects such as runway crown. Crosswind effects need not be considered.

(f) For the design landing case, the airplane speed should not be less than $V_{REF}/1.3$, where $V_{REF}$ is the airplane steady landing approach speed at the maximum design landing weight and in the landing configuration at sea level. Alternatively, the airplane speed should not be less than $V_{SO}$, the power off stall speed of the airplane at sea level, at the design landing weight, and in the landing configuration.

(g) For the most severe landing case, the applicant should address effects and consequences of typical single and multiple failure conditions that are foreseeable events and can necessitate landings at abnormal speeds and weights. The critical landing weight for this condition is the maximum takeoff weight, less fuel burned and jettisoned during a return to the departure airfield. A 30-minute flight should be assumed, with 15 minutes of active fuel jettisoning if equipped with a fuel jettisoning system.

(2) Heat Sink Condition at Commencement of the Stop.

(a) For the maximum kinetic energy accelerate-stop case, the calculation should account for

(b) The brake temperature following a previous typical landing,

(c ) The effects of braking during taxi-in, the temperature change while parked,

(d) The effects of braking during taxi-out, and

(e) The additional temperature change during the takeoff acceleration phase, up to the time of brake application.

(f) The analysis may not take account of auxiliary cooling devices. Assessment of ambient conditions within the operational limits established by the applicant and the typical time the airplane will be on the ground should be used.

(g) For the most severe landing stop case, the same temperature conditions and changes used for the maximum kinetic energy accelerate-stop case should be assumed, except that further temperature change during the additional flight phase may be considered.

(h) The brake temperature at the commencement of the braking maneuver should be determined using the rational analysis method. However, in the absence of such analysis, an arbitrary heat sink temperature should be used equal to the normal ambient temperature, increased by the amount that would result from a 10 percent maximum kinetic energy accelerate-stop for the accelerate-stop case and from a 5 percent maximum kinetic energy accelerate-stop for landing cases.

(3) Substantiation.

(a) Substantiation is required to show that the wheel and brake assembly is capable of absorbing the determined levels of kinetic energy at all permitted wear states up to and including the declared fully worn limits. The term “wear state" is used to clarify that consideration should be given to possible inconsistencies or irregularities in brake wear in some circumstances, such as greater wear at one end of the heat sink than the other end. Qualification related to equally distributed heat sink wear may not be considered adequate. If in-service wear distribution is significantly different from wear distribution used during qualification testing, additional substantiation and/or corrective action may be necessary.

(b) The minimum initial brakes-on speed used in the dynamometer tests should not be more than the velocity (V) used in the determination of the kinetic energy requirements of § 25.735(f). This assumes that the test procedure involved a specific rate of deceleration and, therefore, for the same amount of kinetic energy, a higher initial brakes-on speed would result in a lower rate of energy absorption. Such a situation is recognized and is similarly stated in TSO-C135, which provides an acceptable means for brake approval under § 25.735(a).

(c) For certification purposes, a brake having a higher initial brakes-on speed is acceptable if the dynamometer test showed that both the energy absorbed and the energy absorption rates required by § 25.735(f) had been achieved.

(d) Brake qualification tests are not intended as a means of determining expected airplane stopping performance, but may be used as an indicator for the most critical brake wear state for airplane braking performance measurements.

g. Brake condition after high kinetic energy dynamometer stop(s). (Reference § 25.735(g)).

(1) Following the high kinetic energy stop(s), the parking brake should be capable of restraining further movement of the airplane and should maintain this capability for the period during which the need for an evacuation of the airplane can be determined and then fully accomplished. It should be demonstrated that, with a parking brake application within a period not exceeding 20 seconds of achieving a full stop, or within 20 seconds from the time that the speed is retarded to 20 knots (or lower), in the event that the brakes are

released prior to achieving a full stop (as permitted by TSO-C135), the parking brake can be applied normally and that it remains functional for at least 3 minutes.

(2) Practical difficulties associated with dynamometer design may preclude directly demonstrating the effectiveness of the parking brake in the period immediately following the high energy dynamometer stop(s). Where such difficulties prevail, it should be shown that, for the 3-minute period, no structural failure or other condition of the brake components occurs that would significantly impair the parking brake function.

(3) Regarding the initiation of a fire, it should be demonstrated that no continuous or sustained fire, extending above the level of the highest point of the tire, occurs before the 5-minute period has elapsed. Neither should any other condition arise during this same period or during the stop, either separately or in conjunction with a fire, that could be reasonably judged to prejudice the safe and complete airplane evacuation. Fire of a limited extent and of a temporary nature (e.g., those involving wheel bearing lubricant or minor oil spillage) is acceptable. For this demonstration, neither firefighting means nor coolants may be applied.

h. Stored energy systems.

(1) Stored energy systems use a self-contained source of power, such as a pressurized hydraulic accumulator or a charged battery (refer to § 25.735(h)). This requirement is not applicable for those airplanes that provide a number of independent braking systems, including a stored energy system, but are not "reliant" on the stored energy system for the demonstration of compliance with § 25.735(b).

(2) The indication of usable stored energy should show:

(a) The minimum energy level necessary to meet the requirements of §§ 25.735 (b)(1) and (h) (i.e., the acceptable level for dispatch of the airplane);

(b) The remaining energy level; and

(c) The energy level below which further brake application may not be possible.

(3) If a gas pressurized hydraulic accumulator is to be used as the energy storage means, indication of accumulator pressure alone is not considered adequate means to indicate available stored energy, unless verification can be made of the correct precharge pressure with the hydraulic system pressure off and the correct fluid volume with the hydraulic system pressure on. Furthermore, additional safeguards may be necessary to ensure that sufficient energy will be available at the end of the flight. Similar considerations should be made if other stored energy systems are used.

(4) A full brake application cycle is defined as an application from brakes fully released to brakes fully applied, and back to fully released.

i. Brake wear indicators. The indication means should be located such that no special tool or illumination (except in darkness) is required. Expert interpretation of the indication should not be necessary (refer to § 25.735(i)).

j. Overtemperature and overpressure burst prevention. Generally, two separate types of protection should be provided: one specifically to release the tire pressure should the wheel temperature increase to an unacceptable level, and the other to release the tire pressure should the pressure become unacceptably high, particularly during the inflation process. The temperature sensitive devices are required in braked wheels only, but the pressure sensitive devices are required in all wheels (refer to §§ 25.735(j) and 25.731(d)).

(1) The temperature sensitive devices (e.g., fuse or fusible plugs) should be sufficient in number and appropriately located to reduce the tire pressure to a safe level before any part of the wheel becomes unacceptably hot, irrespective of the wheel orientation. The devices should be designed and installed so that once operated (or triggered) their continued operation is not impaired by the releasing gas. The effectiveness

of these devices in preventing hazardous tire blowout or wheel failure should be demonstrated. It should also be demonstrated that the devices will not release the tire pressure prematurely during takeoff and landing, including during “quick turnaround” types of operation.

(2) It should be shown that the overpressurization devices, or the devices in conjunction with the tire inflation means permanently installed in the wheel, would not permit the tire pressure to reach an unsafe level regardless of the capacity of the inflation source.

(3) Both types of devices should normally be located within the structure of the wheel in positions that minimize the risk of damage or tampering during normal maintenance.

k. Compatibility. Compliance with § 25.735(k) may be achieved by the following:

(1) As part of the overall substantiation of safe and anomaly free operation, it is necessary to show that no unsafe conditions arise from incompatibilities between the brakes and brake system with other airplane systems and structures. Areas that should be explored include antiskid tuning, landing gear dynamics, tire type and size, brake combinations, brake characteristics, brake and landing gear vibrations, etc. Similarly, wheel and tire compatibility should be addressed. These issues should be readdressed when the equipment is modified.

(2) During brake qualification testing, sufficient dynamometer testing over the ranges of permissible brake wear states, energy levels, brake pressures, brake temperatures, and speeds should be undertaken to provide information necessary for systems integration.

### 5.4.33 HARMONIZED TSO-C135 ISSUED, EFFECTIVE MAY 2, 2002

The material contained in this TSO was developed by the Braking Systems Harmonization Working Group of the Aviation Rulemaking Advisory Committee to ensure consistent application of the standards adopted under Amendment 25-107; "Revision of Braking Systems Airworthiness Standards to Harmonize with European Airworthiness Standards for Transport Category Airplanes," and a corresponding Advisory Circular AC 25.735-1, "Brakes and Braking Systems Certification Tests and Analysis" as documented under 5.4.31. The Appendix 1 requirements under sections 2.3.7 – Brake Piston Retention and 2.3.8 – Wear Indicator resulted from airworthiness directives issued per NTSB recommendations {ref. Worn Brake RTO issues}. Requirements under section 2.3.8, 2.3.9 – Wheel Bearings, and 2.3.10 – Wheel Fatigue Life were also stated un UK CAA Specification 17, dated 1986.

Department of Transportation
**Federal Aviation Administration**
Aircraft Certification Service
Washington, DC

**TSO-C135**

**DATE:**
May 2, 2002

# Technical Standard Order

**Subject:** 5.1 TSO-C135, Transport Airplane Wheels and Wheel and Brake Assemblies



**1. PURPOSE.** This Technical Standard Order (TSO) prescribes the minimum performance standards (MPS) that transport category airplane wheels, and wheel and brake assemblies must meet to 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 and replaces certain parts of TSO-C26c, "AIRCRAFT WHEELS AND WHEEL-BRAKE ASSEMBLIES," dated May 18, 1984, that are applicable to Title 14, Code of Federal Regulations (14 CFR) part 25 Transport Category Airplanes only. The TSO-C26c is still applicable for aircraft certified under 14 CFR parts 23, 27, or 29.

b. Previously Approved Equipment. Wheels and wheel-brake assemblies approved prior to the effective date of this TSO may continue to be manufactured under the provisions of their original approval, and labeled under the appropriate TSO.

**3. REQUIREMENTS.** Wheels, and wheel and 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 qualification and documentation requirements set forth in appendix 1 of this TSO titled "Minimum Performance Specification for Transport Airplane Wheels, Brakes, and Wheel and Brake Assemblies." Brakes and associated wheels are to be considered as an assembly for TSO authorization purposes.

**4. MARKING.**

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.

**5. DATA REQUIREMENTS.**

a. Application Data. In addition to the data specified in § 21.605, the manufacturer must furnish one copy each of the following to the Manager of the FAA Aircraft Certification Office (ACO) having geographical purview of the manufacturer's facilities:

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

(2) The manufacturer's TSO qualification test report.-

b. Data to be Furnished with Manufactured Articles.

(1) Prior to entry into service use, the manufacturer must make available the applicable maintenance instructions and data necessary for continued airworthiness. The manufacturer must send this information, upon request, to the ACO specified in paragraph 5(a) above (§ 21.50(b)).-

(2) The manufacturer must provide the applicable maintenance instructions and data necessary for continued airworthiness to each organization or person receiving one or more articles manufactured under this TSO. 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 airplane to determine that the airplane 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 installation is approved by the Administrator.
>
> Additional requirements may be imposed based on airplane 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 airplane requirements.

**6. AVAILABILITY OF REFERENCED DOCUMENTS.**

a. A copy of 14 CFR part 21, may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402-9325.

b. Advisory Circular No. 20-110, " Index of Aviation Technical Standard Orders," and this TSO (TSO-C135), "Minimum Performance Specification for Transport Airplane Wheel and Wheel and Brake Assemblies," may be obtained from the U.S. Department of Transportation, Subsequent Distribution Office, SVC-121.23,

Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20785.

c. An electronic copy of Advisory Circular No. 20-110 and this TSO (TSO-C135) may be downloaded using the Internet at the following address: http://www.faa.gov/certification/aircraft/air_index.htm or by submitting a request to the Federal Aviation Administration, Office of Rulemaking, ARM-1, 800 Independence Avenue SW., Washington, DC 20591, or be calling (202) 267-9680. Make sure to identify the TSO number.

## APPENDIX 1: MINIMUM PERFORMANCE SPECIFICATION FOR TRANSPORT AIRPLANE 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 airplanes certificated under Title 14 Code of Federal Regulations (14 CFR) part 25 . Compliance with this specification is not considered approval for installation on any transport airplane.

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 airplane operational characteristics and other external influences. Consequently, anticipated airplane braking performance should be verified by airplane 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 airplane 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 airplane 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 TSO.

1.4.7 D - Distance Averaged Deceleration.

$D = ( (\text{Initial brakes-on speed})^2 - (\text{Final brakes-on speed})^2)/(2\ (\text{braked flywheel distance}))$.

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 tire 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 tire 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 tire 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/tire 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/tire 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/tire 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 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.

1.4.17 S -Wheel Rated Static Load.

S is the maximum static load (Reference § 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 Tire Type(s) and Size(s).

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

1.4.20 $TS_{WR}$ - 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 by the airplane manufacturer for installation on the wheel.

1.4.21 $TT_{BT}$ - 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 ($TS_{WR}$). The suitable tire may be different for different tests.

1.4.22 $TT_{WT}$ - 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 ($TS_{WR}$). The suitable tire 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 $V_R$ - Airplane 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 § 25.1529, the continued airworthiness of the airplane on which the equipment is to be installed must be considered. See paragraph 5.b of this TSO, titled “Data to be Furnished with Manufactured Articles.”

2.2FIRE 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.

2.3DESIGN.

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

2.3.1Wheel 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.

2.3.2Removable 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.

2.3.3Adjustment.

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

2.3.4Water 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 tire burst that might result from overpressurization or from elevated brake temperatures. The means must take into account the pressure and the temperature gradients over the full operating range.

2.3.6Wheel Rim and Inflation Valve.

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

2.3.7Brake 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.

2.3.8Wear Indicator.

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

2.3.9Wheel Bearings.

Means should be incorporated to avoid misassembly 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 minimize the effects of the expected corrosion and temperature environment. The wheel must include design provisions to minimize 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 TSO minimum performance standard. The airplane 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 tire, $TT_{WT}$, and wheel loads must be applied through the tire. 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 tire 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 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 airplane 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 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 tire assembly a load not less than 1.15 times the maximum radial limit load, L, as determined under 14 CFR 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 tire 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 tire occurs, then the tire 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 tire 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 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, as determined under 14 CFR 25.471 through 25.511, as appropriate.

Apply the load with the tire 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 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 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 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.

3.2.2Combined 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 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 airplane 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.

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 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 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.

3.2.2.2 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, as determined under 14 CFR 25.485, 25.495, 25.497, and 25.499, 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 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 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 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 tire 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 14 CFR 25.485, 25.495, 25.497, and 25.499, as appropriate.

Apply these loads with a tire 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 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 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 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 airplane and is under the Wheel Rated Static Load, S. During the roll test, the tire 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 tire 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 3-1Load Conditions and Roll Distances for Roll Test

| Load Conditions | Roll Distance Miles (km) |
|---|---|
| Wheel Rated Static Load, S | 2000 (3220) |
| 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 tire 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 $0.5V_R^2$ but need not exceed 15,000 feet (4572 meters). The test axle angular orientation with the load surface must represent that of the airplane 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 tire, $TT_{WT}$, 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 overpressurization protection device(s) to conduct this test (§ 25.731(d)).

3.2.6 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 percent. This test must be performed after the tire growth has stabilized.

3.3 WHEEL AND BRAKE ASSEMBLY TESTS.

3.3.1 General.

3.3.1.1 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 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 airplane 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 airplane.

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 airplane manufacturer, but not less than 10 $ft/s^2$ (3.05 $m/s^2$). (See § 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 of 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 airplane manufacturer, but not less than 6 $ft/s^2$ (1.83 $m/s^2$). (See § 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 airplane's braking pressure limitations (e.g., tire/runway drag capability based on substantiated data).

3.3.3.2 For the accelerate-stop test, the tire, 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 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 airplane 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 tire, 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 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.

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 (§ 25.735(g)).

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 coolants may be applied.

The time of initiation of tire 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 airplane as defined by the airplane 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 airplane 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 airplane's braking pressure limitations (e.g., tire/runway drag capability based on substantiated data).

3.3.4.2 For the most severe landing stop test, the tire, 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 (§ 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 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 the airplane 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 tire, 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 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.

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 tire 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 tire 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 tire 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 airplane 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 airplane. 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, $BRP_{RET}$. 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 5000 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 1000 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 Tire Loaded Radius, R.

Wheel Rated Maximum Limit Load, L,
Wheel Rated Tire 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, $BRP_{MAX}$,
Brake Rated Retraction Pressure, $BRP_{RET}$,
Wheel/Brake Rated Structural Torque, $ST_R$,
Rated Design Landing Deceleration, $D_{DL}$,
Rated Accelerate-Stop Deceleration, $D_{RT}$,
Rated Most Severe Landing Stop Deceleration, $D_{SS}$ (if applicable),
Brake Rated Tire Size, $TS_{BR}$,
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.

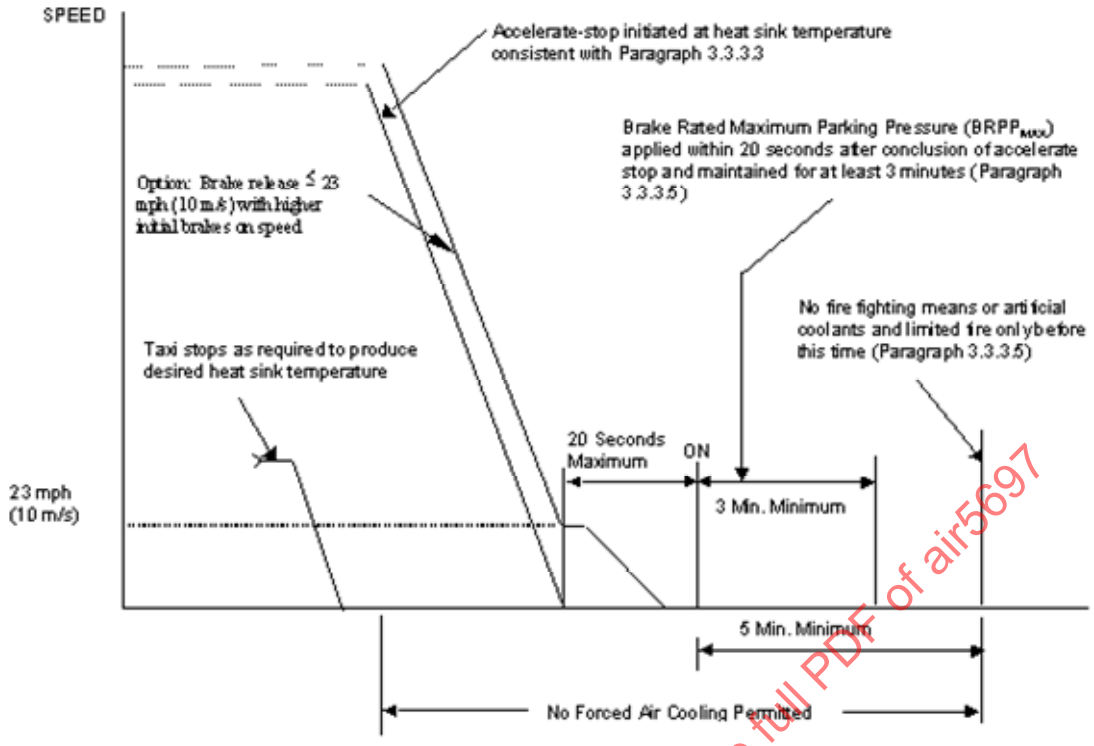


**Figure 3-1. Taxi, Accelerate-Stop, Park Test Sequence**

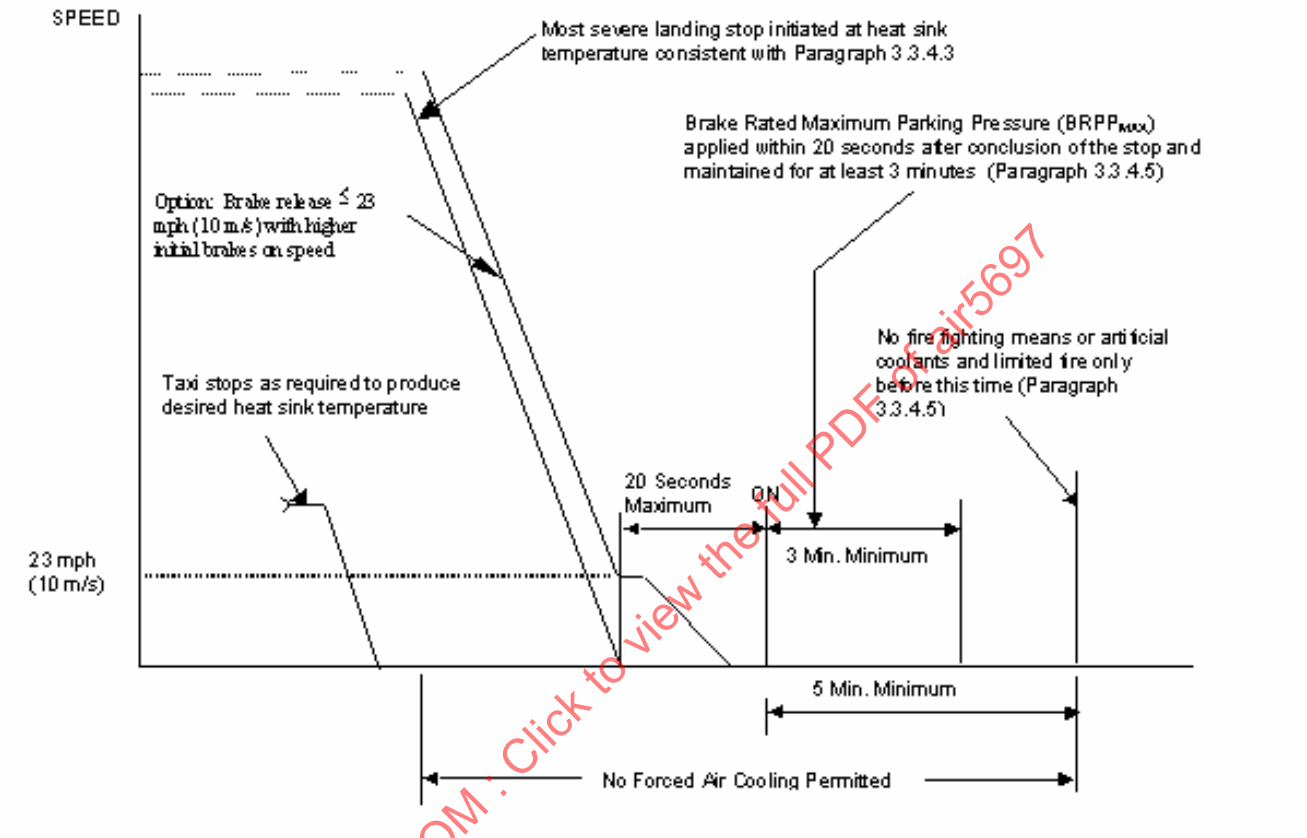


**Figure 3-2. Most Severe Landing-Stop, Park Test Sequence**

5.5 Table 5-3 History of Regulations Index: 1945-2004: Small Airplanes

**Wheels and Brakes**

| Date | Action | Wheels | Tires | Brakes |
|---|---|---|---|---|
| 11-13-45 | Adopted New Part 03 | 03.363 | 03.364 | 03.365 |
| 05-31-46 | Part 15 Reprinted | 15.10 | | 15.104 |
| 12-15-46 | Part 03 Reprinted + Index Reference to Part 15 under Wheels and Brakes was deleted. | 03.363 | 03.364 | 03.365 |
| 01-01-48 | Amd't 03-3 Approval by the Administrator: Materials/Parts added: § 03.06 | | | |
| 05-01-49 | Part 03 designated as Part 3 | | | |
| 11-01-49 | Part 3 Reprinted | 3.361 | 3.362 | 3.363 |
| 10-12-51 | Part 514 The TSO System made available | | | |
| 03-05-52 | Amd't 3-7 Miscell. Amendments/§3.361 – Wheels & §3.362 – Tires. Approval by TSO added to regulations/§3.18 | | | |
| 03-15-52 | First TSO for Wheels & Brakes TSO-C26 issued/AS 227A. | | | |
| 09-01-54 | Civil Aeronautics Manual (CAM) 3 issued | | 3.362 + 3.362-1 | |
| 05-15-56 | Part 3 Reprinted | 3.361 | 3.362 | 3.363 |
| 06-01-61 | TSO-C26a Issued: Aircraft Wheels & Brakes/§514.72/AS-227C | | | |
| 05-01-62 | CAM 3 | 3.361 | 3.362 | 3.363 |
| 11-17-64 | TSO-C26a issued as FAR §37.172 [ref. Doc # 5065, 29 F.R.15317] | | | |
| 02-01-65 | Recodify Part 3 as FAR § 23.731 | | 23.733 | 23.735 |
| 04-11-67 | TSO-C26a/§37.172 amended/Doc #8084, 32 FR 5769/AS-227C | | | |
| 09-14-69 | Amd't 23-7 Revised | | 23.733 | 23.735 |
| 01-21-71 | Amd't 37-28 issued TSO-C26b/Complete text/no ref. to AS-227C | | | |
| 12-31-79 | TSO-C26c/§37.172 issued – wheels & Brakes + Amd't 23-24 revised | | | 23.735 |
| 06-09-80 | Amd't 21-50/25-52/37-47: Part 37 Revoked/TSOs became Voluntary Standards | | | |
| 05-18-84 | TSO-C26c with Addendum I issued: Wheels & Brakes | | | |
| 02-04-91 | Amd't 23-42 Revised | | | 23.735 |
| 09-07-93 | Amd't 23-45 Revised | 23.731 | 23.733 | 23.735 |
| 03-11-96 | Amd't 23-49 Revised | | | 23.735 |
| 10-14-04 | TSO-C26d Issued: Applicable to Parts 23, 27, and 29: ARP 5381 | | | |

5.6 Small Airplanes Wheels and Brakes: History of Regulations Text

**Normal/Utility/Acrobatic/Restricted Category Airplane Wheels and Brakes: History of Regulations**

**5.6.1. Part 03: November 13, 1945: adopted New Part 03**

**03.363 Wheels**. Main landing gear wheels (i.e., those nearest the airplane center of gravity) shall be of an approved type in accordance with Part15. The rated static load of each main wheel shall not be less than the design weight for ground loads
(§ 03.240) divided by the number of main wheels. Nose wheels shall be tested in accordance with Part15 for an ultimate radial load not less than the maximum nose wheel ultimate loads obtained in the ground loads requirements, and for the corresponding side and burst loads specified in Part 15.

**03.365 Brakes.** Brakes shall be installed which are adequate to prevent the airplane from rolling on a paved runway while applying take-off power to the critical engine, and of sufficient capacity to provide adequate speed control during taxiing without the use of excessive pedal or hand forces.

**5.6.2. Part 15 Reprinted – as Amended to May 31, 1946**

PART 15 - AIRCRAFT EQUIPMENT AIRWORTHINESS

15.1 LANDING GEAR EQUIPMENT

15.10 LANDING GEAR WHEELS.
15.100 Main landing gear wheels will be certificated for a maximum static load which will be determined from the strength of the wheel. Tail wheels will not be certificated.
15.1000 For the purpose of these regulations main landing gear wheels are considered as those nearest the airplane center of gravity with respect to fore-and-aft location.
15.1001 For the purpose of these regulations a tail wheel is considered as one which supports the tail of a conventional airplane in the three-point landing attitude.
15.101 For wheels other than main landing or tail wheels, application shall be made to the Administrator for special rulings particularly applicable to the cases in question.
15.102 The strength of a main landing gear wheel shall be substantiated by the following two static tests:
(a) radial load test. (See § 15.1020)
(b) side load test. (See § 15.1021)
15.1020 The required radial test load is equal to -

(P)x(n)x(1.5)x(1.15)
Where P is the maximum static load for which approval is requested, n is

2.80 + 9000/(2P+4000)
and is the applied landing load factor for the corresponding airplane, 1.5 is the factor of safety, and 1.15 is a strength test material factor.
15.1021 The required side test load is equal to -

(0.35)x(the radial test load).

15.1022 The radial and side loads shall be applied separately and the wheel shall be equipped with the correct size tire inflated to the proper pressure for the load for which certification is requested.
15.1023 The radial load shall be applied to the wheel in the place of the tire and may be distributed over a portion of the tire by allowing the tire to bear in a box of firm earth or sand.
15.1024 The side load shall be applied to the rim of the wheel at its maximum radius and may be distributed over an arc of not more than $30^0$. In order to insure sufficient strength in the retaining flanges of the rim, all the side load shall be applied to the inner flange in a direction such as to bend it away from the tire. In such case, the load must be increased so that its side component is equal to the load specified in § 15.1021. The wheel

shall be restrained only by the axle.
15.103 A main landing gear wheel shall support the required loads before failure.

15.104 BRAKES.
15.1040 TESTING OF BRAKES FOR CERTIFICATION.
(a) A wheel-brake combination shall demonstrate satisfactory performance during 100 tests simulating the stopping of an airplane at an average deceleration of at least 10 feet per second, from a speed chosen by the applicant. The kinetic energy absorbed per stop shall be computed and the wheel-brake combination shall be certificated for a kinetic energy absorption not in excess of the amount so determined.
(b) To be eligible for use on airplanes certificated in accordance with the transport category requirements of Part 04, a wheel-brake combination shall further demonstrate satisfactory performance during three tests identical with those specified in paragraph (a) except that the speed shall be increased to obtain a kinetic energy absorption 125% of that determined under that paragraph.

15.1042 DESIGN. Brakes shall be free from any undue tendency to lock or jam, and shall be suitably shielded from water, mud, and oil.
15.1043 STATIC TORQUE. The maximum available static torque in reverse shall be at least 40% of the forward static torque when both are measured at the same applied pedal force.
15.1044 ADJUSTMENT. When necessary to insure satisfactory performance, the brake mechanism shall be equipped with suitable adjustment devices to compensate for disc or lining wear, heat, and other normal service effects.
15.1045 STRENGTH. The brake and all of its attachments to the wheel shall be designed with an ultimate strength sufficient to withstand a torque which is 1.6WR/B, where R is the rolling radius of the tire and B is the number of brakes. A static test of the brake and wheel shall demonstrate that the assembly is capable of withstanding a torque which is 80% of the above without yielding to the point of impairing service operation.
15.1046 TEST LOG. A log of the test runs shall be submitted together with other calculations which are necessary to indicate compliance with the above brake regulations.
15.1047 IDENTIFICATION DATA. Each certificated brake shall bear the following identification as prescribed in § 15.042(e): The foot-pounds of kinetic energy for which it is approved.
15.105 The rim contour of a main landing gear wheel shall conform to the Tire and Rim Association's standards or recommendations unless the wheel is to be used in conjunction with a specially constructed tire.
15.106 A landing gear wheel may be equipped with any make or type of tire: Provided, that the tire is a proper fit on the rim of the wheel: And provided, that the tire rating of the Airplane Tire Committee of the Tire and Rim Association is not exceeded.
15.107 Each unit of a certificated model of main landing gear wheel shall bear the following additional identification data as prescribed in § 15.042(e): The maximum static load for which certificated.
15.108 A request for certification of a type or model or series of models of main landing gear wheels shall be supported by the following additional data as prescribed in
§ 15.0502:
15.1080 A report of the static tests prescribed in § 15.102. The report shall contain complete details of the tests, including records of wheel deflections and photographs of the test set-ups. The report shall be signed by the person making the tests, and shall be certified to unless the tests were witnessed by an inspector of the Administrator, in which case such inspector also will sign the report as a witness.



**5.6.3. Part 03 Reprinted: December 15, 1946**

03.363 **Wheels.** Main landing gear wheels (i.e., those nearest the airplane center of gravity) shall be of an approved type. *Note: reference to Part 15 deleted*

The rated static load of each main wheel shall not be less than the design weight for ground loads (§ 03.240) divided by the number of main wheels. Nose wheels shall have been tested for an ultimate radial load not less than the maximum nose wheel ultimate loads obtained in the ground loads requirements, and for the corresponding side and burst loads. *Note: reference to Part 15 deleted*

03.365 **Brakes.** Same as item 1. above. (ref. 03.365)

**5.6.4. Amendment 03-3 effective 01/01/48:** Added **§** 03.06 and Established approval of parts and appliances by the Administrator via the TSO system. **Specific text** using the TSO system was not added to the regulation until March 5, 1952, § 3.18, amendment 3-7.

Prior to this amendment approval of certain specified appliances was required by type certification. This entailed submission of detailed data for each appliance or variation thereof, which had to be examined and approved by the Administrator of Civil Aeronautics.

The purpose of this amendment was to simplify and expedite approval by permitting, in lieu of type certification, the establishment and publication of specifications, in the form of "Technical Standard Orders (TSOs)" by the Administrator for such appliances. The TSOs were established after collaboration with the industry and upon consideration of pertinent aviation industry, federal, and military specifications. An appliance for which a TSO had been so established was deemed approved by the Administrator when the manufacturer certified that the appliance meets the specifications included therein, and the appliance does in fact meet the specification.

As specifications are formulated for individual appliances now requiring type certification, the Board will consider amending the Civil Air Regulations to deletethe type certification requirements for the particular appliance. The Board finds that this amendment will facilitate the manufacture of aircraft by permitting a simpler procedure for obtaining approval of materials, parts, processes, and appliances without lowering of safety standards. Section 03.300 was repealed and a new § 03.06 was added to read as follows:

**§** 03.06 *Approval of materials, parts, processes, and appliances.* Materials, parts, processes, and appliances shall be approved upon a basis and in a manner found necessary by the Administrator to implement the pertinent provisions of the Civil Air Regulations. The Administrator may adopt and publish such specifications as he finds necessary to administer this regulation, and shall incorporate therein such portions of the aviation industry, Federal, and military specifications respecting such materials, parts, processes, and appliances as he finds appropriate.
Any material, part, process, or appliance shall be deemed to have met the requirements for approval when it meets the pertinent specifications adopted by the Administrator, and the manufacturer so certifies in a manner prescribed by the Administrator.

**5.6.5 Part 03 designated as Part 3 effective 05-01-49**

**5.6.6 Part 3 Reprinted, Effective 11-01-49**

§ 3.361 Wheels.
(a) Main landing gear wheels (i.e., those nearest the airplane center of gravity) shall be of an approved type.
(b) The rated static load of each main wheel shall not be less than the design weight for ground loads (§ 3.242) divided by the number of main wheels. Nose wheels shall have been tested for an ultimate radial load not less than the maximum nose wheel ultimate loads obtained in the ground loads requirements, and for the corresponding side and burst loads.

§ 3.363 *Brakes.* [No change from 03.365] Brakes shall be installed which are adequate to prevent the airplane from rolling on a paved runway while applying take-off power to the critical engine, and of sufficient capacity to provide adequate speed control during taxiing without the use of excessive pedal or hand forces.

**5.6.7 Part 514, Technical Standard Order:** Regulations of the Administrator, Part 514, was made available only through the Federal Register where it appeared on October 12, 1951, 16 FR 10403. Copies of Individual TSO's contained therein were available upon application to the Aviation Information Staff, Civil Aeronautics Administration, Department of Commerce, Washington 25 D.C.

**5.6.8 Amendment 3-7, effective March 5,1952:** (i) Added **§** 3.18-Note in the regulatory text, allowing approval of equipment under the TSO system; (ii) Amendment 3-7 also modified § 3.361 Wheels; and *(iii)*

*The first TSO for wheels and brakes, TSO-C26 was effective 3-15-52. The TSO specified SAE AS-227A, dated February 1, 1952, as the minimum safety standard for strength and performance requirements.* Part 15 of the CAR was rescinded effective March 5, 1952.

(i) **§** 3.18 *Approval of materials, parts, processes, and appliances.* (a) Materials, parts, processes, and appliances shall be approved upon a basis and in a manner found necessary by the Administrator to implement the pertinent provisions of the regulations in this subchapter. The Administrator may adopt and publish such specifications as he finds necessary to administer this regulation, and shall incorporate therein such portions of the aviation industry, Federal, and military specifications respecting such materials, parts, processes, and appliances as he finds appropriate.

NOTE: The provisions of this paragraph are intended to allow approval of materials, parts, processes, and appliances under the system of Technical Standard Orders, or in conjunction with type certification procedures for an airplane, or by any other form of approval by the Administrator.

(b) Any material, part, process, or appliance shall be deemed to have met the requirements for approval when it meets the pertinent specifications adopted by the Administrator, and the manufacturer so certifies in a manner prescribed by the Administrator.

(ii) Amendment 3-7 also modified § 3.361 Wheels to read as follows:

§ 3.361 *Wheels.* Main wheels and nose wheels shall be of an approved type. The maximum static load rating of each main wheel and nose wheel shall not be less than the corresponding static ground reaction under the design maximum weight of the airplane and the critical center of gravity position. The maximum limit load rating of each main wheel and nose wheel shall not be less than the maximum radial load limit determined in accordance with the applicable ground load requirements of this part. (See §§ 3.241 through 3.256.)

§ 3.363 *Brakes.* Same as under item 5., § 3.363

**5.6.9** The TSO-C26 Effective March 15, 1952

See item 5.4.13 for full text of TSO-C26 under Transport Category Airplanes

**5.6.10 Part 3 Reprinted: May 15, 1956: Normal/Utility/Acrobatic Category Airplanes**

§ 3.361 Wheels. No change from 5.6.8.
§ 3.363 Brakes. No change from 5.6.8.

**5.6.11 TSO-C26a Issued, effective 06-01-61: §514.72/AS-227C**

See TSO-C26a provided under Transport Category Airplanes item 5.4.20

**5.6.12 Civil Aeronautics Manual CAM 3, May 1962.**

**Introductory Note.** Through out this document, this note applies to any and all references made to the Civil Aeronautics Manual (CAM) 3.

The CAM 3 included for ease of reference the Civil Air Regulations (CAR) Part 3 immediately preceding the corresponding section of the manual. The manual material therein was not mandatory and was intended only to explain and to show acceptable methods of complying with the pertinent requirement. Alternate methods of showing compliance may be used at the option of the applicant. The function of the Civil Aeronautics Administration (CAA) was to examine such technical data and to conduct or witness such inspection and testing as may be necessary to demonstrate compliance with the Regulations.

§ 3.361 Wheels. No change from 8.
§ 3.363 Brakes. No change from 8.

**5.6.13 TSO-C26a issued as §37.172 {ref. Doc #5065, 29 FR 15317} effective 11-17-64**

See Item 5.4.21 provided under Transport Category Airplanes

**5.6.14 Re-codification of CAR Part 3 to FAR Part 23, Effective February 1, 1965**

CAR 3.361 Wheels became FAR 23.731 Wheels. CAR 3.363 Brakes became FAR 23.735 Brakes. NPRM 64-17, dated April 14, 1964 reference §§ were 23.643 and 23.655 respectively.

§ 23.731 Wheels.
(a) Each main and nose wheel must be approved.
(b) The maximum static load rating of each wheel may not be less than the corresponding static ground reaction with--
(1) Design maximum weight; and
(2) Critical center of gravity.
(c) The maximum limit load rating of each wheel must equal or exceed the maximum radial limit load determined under the applicable ground load requirements of this part.

Sec. 23.735 Brakes.
There must be brakes that are adequate to--
(a) Prevent the airplane from rolling on a paved runway with takeoff power on the critical engine; and
(b) Provide adequate speed control during taxiing without excessive pilot loads.

**5.6.15 TSO-C26a issued as §37.172 amended {ref. Doc #8084, 32 FR 5769} effective 04-11-67**

Same as item 5.6.13. above.

**5.6.16 Amendment 23-7, effective September 14, 1969**

Sec. 23.735 Brakes.
[(a) Brakes must be provided so that the brake kinetic energy capacity rating of each main wheel brake assembly is not less than the kinetic energy absorption requirements determined under either of the following methods:
(1) The brake kinetic energy absorption requirements must be based on a conservative rational analysis of the sequence of events expected during landing at the design landing weight.
(2) Instead of a rational analysis, the kinetic energy absorption requirements for each main wheel brake assembly may be derived from the following formula:
$KE = 0.0444\ WV_{SO}^{2}/N$
where--
KE = Kinetic energy per wheel (ft.-lbs.);
W = Design landing weight (lbs.);
$V_{SO}$= Power-off stalling speed in knots, of the airplane at sea level, at the design landing weight, and in the landing configuration; and
N = Number of main wheels.
(b) Brakes must be able to prevent the wheels from rolling on a paved runway with takeoff power on the critical engine, but need not prevent movement of the airplane with wheels locked.]

Explanation: Part 23 did not provide for the determination of the energy absorption requirements of brakes. The present requirement in Sec. 23.735 (b) may not ensure the design of wheel brake combinations adequate for safe operation of the airplane. Adopted Sec. 23.735 (a) would therefore provide standards similar to the energy absorption determination requirements for transport category airplanes (Sec. 25.735 (f)). Adopted Sec. 23.735(b) would reflect the fact that, for aircraft with high power-to-weight ratios, it may be impossible to prevent motion, with locked wheels, when takeoff power is applied to the critical engine. Some question has arisen as to whether such motion constitutes "rolling" of the airplane within the meaning of present (a). It is not the intent of present (a) to prevent this motion, but only to ensure that the brakes can prevent the wheels themselves from rolling. The adopted energy absorption requirements reflect current industry practice in the design of small airplanes.

**5.6.17 Amendment 37-28 issued TSO-C26b, effective 01-21-71/No ref. to AS-227C**

See item 5.4.24: TSO-C26b is the same document provided under Transport Category Airplanes

**5.6.18 Amendment 23-24, effective December 31, 1979**
Sec. 23.735 Brakes.

(a) Brakes must be provided so that the brake kinetic energy capacity rating of each main wheel brake assembly is not less than the kinetic energy absorption requirements determined under either of the following methods:

(1) The brake kinetic energy absorption requirements must be based on a conservative rational analysis of the sequence of events expected during landing at the design landing weight.

[(2) Instead of a rational analysis, the kinetic energy absorption requirements for each main wheel brake assembly may be derived from the following formula:

$KE = 0.0443WV^2/N$

where--

KE = Kinetic energy per wheel (ft.-lbs.);
W = Design landing weight (lbs.);
V = Airplane speed in knots. V must be not less than , the poweroff stalling speed of the airplane at sea level, at the design landing weight, and in the landing configuration; and
N = Number of main wheels with brakes.]

(b) Brakes must be able to prevent the wheels from rolling on a paved runway with takeoff power on the critical engine, but need not prevent movement of the airplane with wheels locked.



*Changes: The numerical constant in the formula for calculating kinetic energy was changed from 0.0444 to 0.0443 in § 23.735(a)(2)as it is more accurate. The term "$V_{SO}$" in § 23.735(f)(2) is replaced by the term "V".*

§ 37.172 Aircraft Wheels and Wheel-Brake Assemblies---[ TSO-C26c.
TSO-C26b was revised to TSO-C26c by incorporating updates and improved minimum performance standards for the design and construction of aircraft wheels and brakes. To improve the overall strength of wheels and to reduce their susceptibility to fatigue, the standards for wheels were revised. This amendment would require more severe testing of wheels and wheel-brake assemblies to substantiate the load ratings of wheels and the kinetic energy capacity rating of brakes. ]

TSO-C26c is provided as a separate section in this document. See item 5.4.26 under Transport Category Airplanes. This amendment concerning aircraft wheels and wheel-brake assemblies was issued concurrently with the amendment which updated the minimum performance standards applicable to aircraft tires. The preamble to the tires amendment (25-49) explains the background

which led to the need for revised standards for tires and for wheels and wheel-brake assemblies and their interaction.

**5.6.19. Amendment 25-52[21-50, 37-47], effective September 9, 1980**

This is identical to Item 5.4.27 under Transport Category Airplanes. TSO-C26c was eliminated from the regulations, previously published as Subpart B of 14 CFR Part 37. Henceforth, a TSO was not a mandatory standard but to be used as a voluntary standard.

**5.6.20 TSO-C26c with Addendum I issued, effective 05-18-84**

See Item 5.4.28 TSO-C26c under Transport Category Airplanes Files.

**5.6.21 Amendment 23-42, effective February 4, 1991**

Sec. 23.735 Brakes.

(a) Brakes must be provided so that the brake kinetic energy capacity rating of each main wheel brake assembly is not less than the kinetic energy absorption requirements determined under either of the following methods:

(1) The brake kinetic energy absorption requirements must be based on a conservative rational analysis of the sequence of events expected during landing at the design landing weight.

(2) Instead of a rational analysis, the kinetic energy absorption requirements for each main wheel brake assembly may be derived from the following formula:

$KE = 0.0443WV^2/N$

where--

KE = Kinetic energy per wheel (ft.-lb.);

W = Design landing weight (lb.);

V = Airplane speed in knots. V must be not less than , the poweroff stalling speed of the airplane at sea level, at the design landing weight, and in the landing configuration; and

N = Number of main wheels with brakes.

(b) Brakes must be able to prevent the wheels from rolling on a paved runway with takeoff power on the critical engine, but need not prevent movement of the airplane with wheels locked.

[(c) If anti-skid devices are installed, the devices and associated system must be designed so that no single probable malfunction of failure will result in a hazardous loss of braking ability or directional control of the airplane.]



Explanation: The change established minimum airworthiness standards for airplanes equipped with antiskid braking systems. The proposal which would have exempted airplanes weighing 3,000 pounds or less from meeting the requirements in Sec. 23.735(a) was opposed by one commenter on the basis that the current requirements provide a good standard for airplane brakes. The FAA agreed and no further action was taken. Another proposal which recommended a new paragraph (c) be added to Sec. 23.735 for airplanes with antiskid braking systems, was supported by three commenters and the FAA agreed that this requirement is necessary as a minimum standard when antiskid devices are installed.

**5.6.22 Amendment 23-45, effective September 7, 1993**

Sec. 23.731 Wheels.

[(a) The maximum static load rating of each wheel may not be less than the corresponding static ground reaction--

(1) Design maximum weight; and

(2) Critical center of gravity.

(b) The maximum limit load rating of each wheel must equal or exceed the maximum radial limit load determined under the applicable ground load requirements of this part.]

*Change in regulation/Explanation:* The requirement "(a) Each main and nose wheel must be approved." was deleted. Since there is a basic requirement to approve the complete airplane, including all components, parts, and appliances, § 23.731(a) is unnecessary.

**5.6.23 Amendment 23-49, effective March 11, 1996**

Sec. 23.735 Brakes.

[(a) Brakes must be provided. The landing brake kinetic energy capacity rating of each main wheel brake assembly must not be less than the kinetic energy absorption requirements determined under either of the following methods:]

(1) The brake kinetic energy absorption requirements must be based on a conservative rational analysis of the sequence of events expected during landing at the design landing weight.

(2) Instead of a rational analysis, the kinetic energy absorption requirements for each main wheel brake assembly may be derived from the following formula:

$KE = 0.0443WV^2/N$

where--

KE = Kinetic energy per wheel (ft.-lb.);

W = Design landing weight (lb.);

V = Airplane speed in knots. V must be not less than , the poweroff stalling speed of the airplane at sea level, at the design landing weight, and in the landing configuration; and

N = Number of main wheels with brakes.

(b) Brakes must be able to prevent the wheels from rolling on a paved runway with takeoff power on the critical engine, but need not prevent movement of the airplane with wheels locked.

[(c) During the landing distance determination required by Sec. 23.75, the pressure on the wheel braking system must not exceed the pressure specified by the brake manufacturer.

(d) If antiskid devices are installed, the devices and associated systems must be designed so that no single probable malfunction or failure will result in a hazardous loss of braking ability or directional control of the airplane.

(e) In addition, for commuter category airplanes, the rejected takeoff brake kinetic energy capacity rating of each main wheel brake assembly must not be less than the kinetic energy absorption requirements determined under either of the following methods--

(1) The brake kinetic energy absorption requirements must be based on a conservative rational analysis of the sequence of events expected during a rejected takeoff at the design takeoff weight.

(2) Instead of a rational analysis, the kinetic energy absorption requirements for each main wheel brake assembly may be derived from the following formula--

$KE = 0.0443WV^2/N$

where-

KE = Kinetic energy per wheel (ft.-lbs.);

W = Design takeoff weight (lbs.);

V = Ground speed, in knots, associated with the maximum value of V1 selected in accordance with Sec. 23.51(c)(1);

N = Number of main wheels with brakes.]

**Explanation:** Section 23.735(a) was revised to state plainly that wheel brakes must be provided. A new Sec. 23.735(c) would require the brake system to be designed so that the brake manufacturer's specified brake pressures are not exceeded during the landing distance determination required by Sec. 23.75.

A new Sec. 23.735(e), applicable to commuter category airplanes, would require establishing the minimum rejected takeoff brake kinetic energy capacity rating of each main wheel brake assembly. Section 23.45 provides that the determination of the accelerate-stop distance for commuter category airplanes be made in accordance with the applicant's procedures for operation in service. The new requirement is needed to ensure that the brakes will perform safely under accelerate-stop conditions.

### 5.6.24 TSO-C26d issued Effective October 14, 2004

Department of Transportation
**Federal Aviation Administration**
Aircraft Certification Service
Washington, DC

TSO-C26d

Effective Date:
October 14, 2004

# Technical Standard Order

**Subject:** **Aircraft Wheels, Brakes and Wheel/Brake Assemblies for Parts 23, 27 and 29 Aircraft**

1. PURPOSE. This Technical Standard Order (TSO) prescribes the minimum performance standards (MPS) that Parts 23, 27 and 29 aircraft wheels, brakes and wheel/brake assemblies must meet to 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 authorization 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 require 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, for 14 CFR part 25 applications, per 14 CFR § 21.611(b).

> **NOTE:** This TSO does not provide MPS for 14 CFR part 25, Transport Category Airplanes. For transport category airplanes, see TSO-C135, 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.

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.

5. DATA REQUIREMENTS.

a. Application Data. In addition to the data specified in 14 CFR, § 21.605, the manufacturer must furnish one copy each of the following to the Manager of the FAA Aircraft Certification Office (ACO) having geographical purview of the manufacturer's facilities:

(1) The applicable limitations pertaining to installation of wheels, or wheel and brake assemblies on airplane(s), including the data requirements of paragraph 6.1 of appendix 1 of this TSO.

(2) The manufacturer's TSO qualification test report.

b. Data to be Furnished with Manufactured Articles. As specified in 14 CFR, § 23/27/29.1529, the continued airworthiness of the aircraft on which the equipment is to be installed must be considered.

(1) Prior to entry into service use, the manufacturer must make available the applicable maintenance instructions and data necessary for continued airworthiness. The manufacturer must send this information, upon request, to the ACO specified in paragraph 5(a) above (14 CFR, § 21.50(b)).

(2) The manufacturer must provide the applicable maintenance instructions and data necessary for continued airworthiness to each organization or person receiving one or more articles manufactured under this TSO. 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 airplane to determine that the airplane 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 installation is approved by the Administrator.
>
> Additional requirements may be imposed based on airplane 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 airplane requirements.

## 6. 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.

**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/.

**c.** Advisory Circular (AC) 20-110, Index of Aviation Technical Standard Orders, AC 20-36, Index of Articles Certified under the Technical Standard Order System, and TSO-C26d 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 and select from the "Available Information" drop down list.

*David W. Hempe*

David W. Hempe
Manager, Aircraft Engineering Division
Aircraft Certification Service

TSO-C26d 10/14/04

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

This appendix prescribes the Minimum Performance Standard (MPS) of SAE ARP5381, "Minimum Performance Recommendations for Part 23, 27, and 29 Aircraft Wheels, Brakes, and Wheel-Brake Assemblies", dated October 2000, as modified by the FAA in this TSO. Additions to and one deletion from the standard, are shown in italics as follows:

*Additions:*

1. *Page 3, a new paragraph was added after 3.6 to reflect public comments:*

   *Suitable Tire for Brake Tests, $TT_{BT}$*

   *$TT_{BT}$ 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 ($TS_{WR}$). The suitable tire may be different for different tests.*

2. *Page 7, a new paragraph was added after 4.3 to reflect public comments:*

   *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 meet the applicable flammability rules for the part and category of aircraft.*

*Deletion:*

1. *Page 13, paragraph 5.3.3.2 was disregarded. Worn brake testing is not a requirement of Parts 23, 27 or 29, so it cannot be included in this TSO.*

**5.7 TABLE 5-4 History of Regulations Index: 1945-2002: Transport Category Airplanes**

| Date | Action | Tires |
|---|---|---|
| 11-09-45 | Adopted New Part 04 [T] | **04.364** |
| 11-22-46 | Amd't 04-5 Differentiation of ##: New Part 04 became Part 04b | |
| 01-01-48 | Amd't 04b-8 Approval by the Administrator: Materials/Parts | |
| 05-01-49 | Part 04b designated as Part 4b | |
| 10-01-49 | Part 4b Reprinted | **4b.392** |
| 07-20-50 | Part 4b Reprinted | **4b.336** |
| 10-12-51 | Part 514: The TSO System made available | |
| 03-05-52 | Amd't 4b-6Substantive changes: subpart A[4b.18] & others; 48 pages | |
| 12-31-53 | Part 4b Reprinted | **4b.336** |
| 03-13-56 | Amd't 4b-3Misc. | **4b.336** |
| 01-01-58 | CAM 04b | **4b.336** |
| 04-15-61 | First TSO for Tires is issued: **TSO-C62**: See Part 514/§514.67 | |
| 03-20-62 | **TSO-C62a** Issued: Aircraft Tires/Part 514/§514.67 | |
| 05-03-62 | Amd't 4b-12 Miscall. /**4b.334-Protection of Equipment in Wheel Wells** | |
| 09-01-62 | **TSO-C62b** Issued: Aircraft Tires/Part 514/§ 514.67 | |
| 11-17-64 | **TSO-C62b** issued as FAR §37.167 [ref. Doc #5065, 29 F.R.15317] | |
| 02-01-65 | Re codified 4b.336 into FAR § | **25.733** |
| 04-11-67 | **TSO-C62b/§37.167** amended/Doc.# 8084, 32 F.R. 5769/Aug 1.62 Ref. | |
| 04-08-70 | Amd't 25-23 Revised § | **25.733** |
| 12-20-76 | Amd't 25-38 Revised § | **25.733** |
| 12-31-79 | Amd't 25-49 + **TSO-C62c**/§37.167 issued- Tires | |
| 06-09-80 | Amd'ts 21-50/25-52/37-47: Part 37 revoked. TSOs became Voluntary standards. | |
| 09-12-84 | **TSO-C62c with Addendum I** issued: Tires | |
| 07-20-90 | Amd't 25-72 Revised § | **25.733** |
| 09-07-90 | **TSO-C62d** issued: Tires | |
| 03-29-93 | Amd't 25-78 Added **§ 25.733(e)/**nitrogen inflation | |

## 5.8 AIRPLANE TIRES: HISTORY OF REGULATIONS TEXT—1945-2002

**Transport Category Airplane Tires: History of Regulations**

### 5.8.1 Part 04: November 9, 1945: adopted New Part 04[T]

04.364 Tires. A landing gear wheel may be equipped with any make or type of tire, provided that the tire is a proper fit on the rim of the wheel and provided that the approved tire rating is not exceeded under the following conditions:

(a) Airplane weight equal to the design take-off weight.
(b) Load on main wheel tires equal to the airplane weight divided by the number of wheels.
(c) Load on nose wheel tires (to be compared with the dynamic rating established for such tires) equal to the reaction obtained at the nose wheel, assuming the mass of the airplane concentrated at the center of gravity and exerting a force of 1.0g downward and 0.31g forward, the reactions being distributed to the nose and main wheels by the principles of statics with the drag reaction at the ground applied only at those wheels having brakes. When specially constructed tires are used to support an airplane, the wheels shall be plainly and conspicuously marked to that effect. Such markings shall include the make, size, number of plies, and identification marking of the proper tire.Approved ratings are those assigned by the Tire and Rim Association or by the Administrator.

### 5.8.2 Amendment 04-5 effective 11-22-46 changed part 04 to 04b for CAR.

**5.8.3 Amendment 04b-8 effective 01-01-48:** Added § 04b.05 Established approval of parts and appliances by the Administrator via the TSO system. **Specific text** using the TSO system was not added to the regulation until 1952. However, there is no evidence that tires were approved under the TSO system until much later e.g., 1961.

### 5.8.4 Part 04b re-designated as Part 4b effective 05-01-49

### 5.8.5 Part 4b Reprinted—As Amended to October 1, 1949

§ 4b.392 *Tires.* (a) A landing gear wheel may be equipped with any make or type of tire: Provided, That the tire is a proper fit on the rim of the wheel, And provided, That the approved tire rating is not exceeded under the following conditions:

(1) Airplane weight equal to the design take-off weight.
(2) Load on main wheel tires equal to the airplane weight divided by the number of wheels.
(3) Load on nose wheel tires (to be compared with the dynamic rating established for such tires) equal to the reaction obtained at the nose wheel, assuming the mass of the airplane concentrated at the center of gravity and exerting a force of 1.0g downward and 0.31g forward, the reactions being distributed to the nose and main wheels by the principles of statics with the drag reaction at the ground applied only at those wheels having brakes. When specially constructed tires are used to support an airplane, the wheels shall be plainly and conspicuously marked to that effect. Such markings shall include the make, size, number of plies, and identification marking of the proper tire.

(b) Approved ratings are those assigned by the Tire and Rim Association or by the Administrator.

### 5.8.6 Part 4b Reprinted: July 20, 1950

§ 4b.336 *Tires.* (a) Landing gear tires shall be of a proper fit on the rim of the wheel, and their approved rating shall be such that it is not exceeded under the following conditions:
(1) Airplane weight equal to the design take-off weight.
(2) Load on main wheel tires equal to the airplane weight divided by the number of main wheels.
(3) Load on nose wheel tires (to be compared with the dynamic rating established for such tires) equal

to the reaction obtained at the nose wheel, assuming the mass of the airplane concentrated at the center of gravity and exerting a force of 1.0g downward and 0.31g forward, the reactions being distributed to the nose and main wheels by the principles of statics with the drag reaction at the ground applied only at those wheels which have brakes.

**5.8.7 Part 514, Technical Standard Order, effective 10-12-51:** Regulations of the Administrator, Part 514, was made available only through the Federal register where it appeared on October 12, 1951, 16 FR 10403. Copies of Individual TSO's contained therein were available upon application to the Aviation Information Staff, Civil Aeronautics Administration, Department of Commerce, Washington 25, D.C. There was no TSO available for Tires.

**5.8.8 Amendment 4b-6, effective 3-5-52:** Added **§** 4b.18-Note in the regulatory text, allowing approval of equipment under the TSO system. The first TSO for Tires TSO-C62 was issued April 15, 1961. Prior to 1961, commercial aircraft tires were apparently qualified using the military specification, MIL-T-5041. This amendment also revised § 4b.336(a)(2) as shown in 12-31-53 Reprint; see next item.

**5.8.9 Part 4b Reprinted As Amended to December 31, 1953**

**§** 4b.336 *Tires.* (a) Landing gear tires shall be of a proper fit on the rim of the wheel, and their approved rating shall be such that it is not exceeded under the following conditions:

(1) Airplane weight equal to the design take-off weight.

(2) Load on each main wheel tire equal to the corresponding static ground reaction at the critical center of gravity position.

(3) Load on nose wheel tires (to be compared with the dynamic rating established for such tires) equal to the reaction obtained at the nose wheel, assuming the mass of the airplane concentrated at the most critical center of gravity and exerting a force of 1.0g downward and 0.31g forward, the reactions being distributed to the nose and main wheels by the principles of statics with the drag reaction at the ground applied only at those wheels which have brakes.

**5.8.10 Amendment 4b-3, effective March 13, 1956**

There is included a change to section 4b.336 which establishes more up-to-date criteria for the selection of landing gear tires as follows:

**§** 4b.336 *Tires.* Landing gear tires shall be of a proper fit on the rim of the wheel, and of load ratings which are not exceeded under the following conditions:

(a) Main wheel tires: Equal static loads on all main wheel tires corresponding with the most critical combination of maximum takeoff weight and center of gravity position.

(b) Nose wheel tires: Equal loads on all nose wheel tires corresponding with the following conditions:

(1) The static ground reaction per tire corresponding with the most critical combination of takeoff weight and center of gravity position. This load shall correspond with the static rating of the tire.

(2) The dynamic ground reaction per tire at the maximum landing weight, assuming the mass of the airplane concentrated at the most critical location of the center of gravity for this weight and exerting a force of 1.0g downward and 0.31g forward, the reactions being distributed to the nose and main wheels by the principles of statics with a 0.31g drag reaction at the ground applied at those wheels which have brakes. This load shall correspond with the dynamic rating of the tire.

(3) The dynamic ground reaction per tire at design takeoff weight, assuming the mass of the airplane concentrated at the most critical location of the center of gravity for this weight and exerting a force of 1.0g downward and 0.20g forward, the reactions being distributed to the nose and main wheels by the principles of statics with a 0.20g drag reaction at the ground applied at those wheels which have brakes. This load shall correspond with the dynamic rating of the tire.

**5.8.11 Civil Aeronautics Manual 4b: January 1958**

§ 4b.336 Same as item 10. above.

**5.8.12 TSO-C62 is issued, effective April 15, 1961: § 514.67**

FEDERAL AVIATION AGENCY
Washington 25, D. C.

TECHNICAL STANDARD ORDER
Regulations of the Administrator
Part 514
SUBJECT:AIRCRAFT TIRES **TSO-C62**

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Technical Standard Orders for Aircraft Materials,
Parts, Processes, and Appliances

Part 514 contains minimum performance standards and specifications of materials, parts, processes, and appliances used in aircraft and implements the provisions of sections 3.18, 4a.31, 4b.18, 6.18 and 7.18 of the Civil Air Regulations. The regulation uses the Technical Standard Order system which, in brief, provides for FAA-industry cooperation in the development of performance standards and specifications which are adopted by the Administrator as Technical Standard Orders, and a form of self-regulation by industry in demonstrating compliance with these orders.

Part 514 consists of two subparts. Subpart A contains the general requirements applicable to all Technical Standard Orders. These provisions are summarized below for the convenient reference of the public. Subpart B contains the technical standards and specifications to which a particular product must conform, and each Technical Standard Order is set forth in the appropriate section of Subpart B. The subject Technical Standard Order is printed below. ANY TECHNICAL STANDARD ORDER MAY BE OBTAINED BY SENDING A REQUEST TO FAA, WASHINGTON 25, D. C.

SUBPART A- -GENERAL

This subpart provides, in part, that a manufacturer of an aircraft material, part, process, or appliance for which standards are established in Subpart B, prior to its distribution for use on a civil aircraft of the United States, shall furnish a written statement of conformance certifying that the material, part, process, or appliance meets the applicable performance standards established in this part. The statement of conformance must be signed by a person duly authorized by the manufacturer, and furnished to the Chief, Engineering and Manufacturing Division, Bureau of Flight Standards, Federal Aviation Agency, Washington 25, D. C.

Subpart A also requires appropriate marking of materials, parts, processes, and appliances as follows:
(a) Name and address of the manufacturer responsible for compliance,
(b) Equipment name, or type or model designation,
(c) Weight to the nearest pound and fraction thereof,
(d) Serial number and/or date of manufacturer, and
(e) Applicable Technical Standard Order (TSO) number.

In addition, Subpart A provides that no deviation will be granted from the performance standards established in Subpart B, and that the Administrator may take appropriate action in the event of noncompliance with Part 514.

SUBPART B

§ 514.67 Aircraft Tires - TSO-C62

(a) Applicability –

(1) Minimum performance standards. Minimum performance standards are hereby established for aircraft tires, excluding tail wheel tires, which are to be used on civil aircraft of the United States. New type and new design tires, manufactured on or after April 15, 1961, which are to be used on civil aircraft of the United States shall meet the standards specified in Federal Aviation Agency Standard, “Aircraft Tires”* dated February 15, 1961.

(b) Marking. In lieu of the marking requirements of Subpart A, aircraft tires shall be legibly and permanently marked with the following information:

(1)Brand name or name of the manufacturer responsible for compliance and the country of manufacture if outside the United States.

(2)The type, size, ply rating, and serial number.

(3) The qualification test speed and skid depth when the test speed is greater than 160 m.p.h., also, the word "reinforced" if applicable.

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

(c) Data Requirements. (1) One copy of the following data shall be furnished to the Chief, Engineering and Manufacturing Division, Bureau of Flight Standards, Federal Aviation Agency, Washington 25, D. C., with the statement of conformance: tire type and size, static and dynamic load rating, ply rating, rated inflation pressure, outside diameter, skid depth, static unbalance, tire weight and a summary of the Load speed-time parameters used in the high speed dynamometer tests.

(2) The manufacturer shall maintain a current file of complete design data.

(3) The manufacturer shall maintain a current file of complete data describing the inspection and test procedures applicable to his product. (See paragraph (d) of this section.)

(d) Quality control. Tires shall be produced under a quality control system, established by the manufacturer, which will assure that each tire is in conformity with the requirements of this section and is in a condition for safe operation. This system shall be described in the data required under paragraph (c)(3) of this section. A representative of the Administrator shall be permitted to make such inspections and production tests at the manufacturer's facility as may be necessary to determine compliance with the requirements of this section.

* Copies may be obtained upon request addressed to: Aeronautical Reference Branch, Correspondence Inquiry Section, MS-126, Federal Aviation Agency, Washington 25, D.C.

(e) Previously approved equipment. Tire types of a specific design produced prior to April 15, 1961, may continue to be manufactured under the provisions of their original design and test standards.



February 15, 1961

FEDERAL AVIATION AGENCY STANDARD
AIRCRAFT TIRES

1.0 Purpose. To specify minimum requirements for new aircraft tires, excluding tail wheel tires, for civil aircraft applications.

2.0 Scope. This specification covers minimum requirements for the following types of tires, having speed limitations as indicated.

(a) Type III, VII, and VIII (for ground speeds of 160 m.p.h. or less) hereinafter referred to as low speed tires.

(b) Type VII and VIII (for ground speeds greater than 160 m.p.h.) hereinafter referred to as high speed tires.

3.0 General Requirements.

3.1 Materials and Workmanship.

3.1.1 Materials. Materials shall be suitable for the purpose intended. The suitability of the materials shall be determined on the basis of satisfactory service experience or substantiating dynamometer tests.

4.0 Design and Construction.

4.1 Unbalance. The moment of static unbalance in ounce inches shall be no greater than the following moment values as applicable:

Type III tire diameters up to and including 28", Moment = I.5D - .023$D^2$

Type III tire diameters greater than 28",
Moment = .031$D^2$ - .253D

Type VII and VIII tire diameters up to and including 28",
Moment = .01$D^2$ + .38D

Type VII and VIII tire diameters greater than 28",
Moment = .034$D^2$ - .304D

D = Tire diameter (Actual)

4.2 Balance Marker. A balance marker, consisting of a red dot, shall permanently branded into the sidewall of the tire immediately above the bead to indicate the lightweight point of the tire.

4.3 Burst Pressure. New tires shall be capable of withstanding without failure a burst pressure of at least 4.0 times the rated inflation pressure.

4.4Temperature. The airworthiness of tires shall not be adversely affected as a result of their being subjected to extreme ambient temperatures expected to be encountered during normal airplane operation.

4.5 Tread Design. Decreases in the number of tread ribs and grooves and increases in ski depth, made subsequent to tire qualification, shall be substantiated by the dynamometer tests contained herein for the applicable ground speed range involved.

4.5.1 Underskid Thickness. For tires and casings having ribbed type or nonskid tread patterns, the thickness of the rubber between the carcass and the bottom of the tread pattern shall not be less than 30 percent of the mold skid depth, except for helicopter tires, in which case, the minimum thickness shall not be less than 1/32 inch.

4.6 Slippage. Mounted tires, when tested in accordance with the dynamometer tests specified herein, shall show no evidence of slippage on the wheel rim during the first five dynamometer landings. Such slippage as shall subsequently occur shall not damage the tube or valve nor damage the air seal of the tire bead in the case of tubeless tires.

4.7 Tire Airworthiness. The tire shall withstand the dynamometer landings specified herein without failure or visible signs of deterioration other than normal expected tread wear.



5.0 Ratings.

5.1 Static Load Rating (Airplane Tires) Static load ratings shall be established on the basis of 35% deflection for Type III tires and 32% deflection for Types VII and VIII tires.

5.1.1 Static Load Rating (Helicopter Tires). Airplane tires qualified in accordance with the provisions of this standard may also be used on he1icopters. In such case, the maximum static load rating may be increased by 1.5 without any additional qualification testing.

5.1.2 Deflection. The vertical distance from the top of the rim flange to the outermost surface of the tire at no load is considered as the distance equivalent to 100% deflection.

5.1.3 Deflection Tolerances. Deflection tolerances to allow for manufacturing variations shall not

exceed +1%, -4% for Type III tires and +3%, -4% for Type VII and VIII tires.

5.2 Dynamic Load Rating, Nose Wheel Tires. The dynamic load rating (maximum permissible nose wheel tire load during braking) shall be determined as follows:

(a) Type III tires - 1.45 x static load rating.
(b) Type VII tires - 1.50 x static load rating.
(c) Type VIII tires - 1.40 x static load rating.

5.3 Inflation Pressure. The rated inflation pressure shall be established for each specific tire and shall be used as a basis when complying with the tire deflection provisions of Sections 5.1, 5.1.2, and 5.1.3.

5.4 Ply Rating. The ply rating shall be established on the basis of the static or dynamic load requirement, whichever is more critical.

6.0 Dynamometer Test Requirements.

6.1 Low Speed Tires. The tire shall withstand 200 landings on a dynamometer having a stored up kinetic energy computed as follows:

$KE = CWV^2$ , where KE = Kinetic energy, ft. lbs.
W = Tire load, lbs.
V = 120 m.p.h.
C = 0.011

6.1.1 Tire Load. At landing, and during the entire roll test, the tire shall be forced against the flywheel at the rated static load of the tire.

6.1.2 Kinetic Energy. The kinetic energy of the flywheel shall be calculated for the rated maximum static load of the tire. In the event that the correct number of flywheel plates cannot be used to obtain the calculated kinetic energy value or proper flywheel width, a greater number of plates shall be selected and the dynamometer speed shall be adjusted in order that the required kinetic energy may be obtained.

6.1.3 Dynamometer Speeds. The total number of dynamometer landings shall be divided into two equal parts having speed ranges as follows:

(a) In the first series of landings, the landing shall be at 90 m.p.h. and the unlanding at 0 m.p.h. The landing speed shall be decreased as necessary in order that 56 percent of the calculated kinetic energy is absorbed by the tire during this series.

(b) In the second series of landings, the landing shall be at 120 m.p.h. and the unlanding at 90 m.p.h. The unlanding speed shall be increased as necessary in order that 44 percent of the calculated kinetic energy is absorbed by the tire during this series.

6.1.4 Test Inflation Pressure. The test inflation pressure shall be that which is necessary to accomplish the same deflection on the flywheel under the rated static load as the flat plate deflection of the tire at its rated static load and inflation. This determination is made on the unused tire prior to the start of the test.

6.1.5 Landing Interval. The time between landings shall be chosen to be the minimum which will assure carcass peak temperatures of not less than $160^0$F. or contained air peak temperatures of not less than $140^0$F. for each run. Unavoidable deviations from the above shall be noted in the substantiating test data. Carcass temperatures shall be measured within one inch above the rim flange and in the shoulder or crown area.

6.2 High Speed Tires. Substantiation of the tire on the dynamometer shall realistically simulate, insofar as is practicable, runway operation and tire performance for the most critical combination of takeoff weight and speed and airplane center of gravity position. Consideration shall also be given to increased speeds resulting from elevated airport operations and high ambient temperatures. Representative load-speed-time data, compiled by the airplane manufacturer, shall be the basis for establishing the applicable dynamometer tests.

6.2.1 Dynamometer Test Speeds. Applicable dynamometer test speeds for corresponding maximum operational ground speeds shall be as follows:

| Maximum Operational Ground Speed of Aircraft, m.p.h. | | Dynamometer Test Speed m.p.h. |
|---|---|---|
| Over | Not Over | |
| 160 | 180 | 180 |
| 180 | 200 | 200 |
| 200 | 225 | 225 |

6.2.2 Dynamometer Tests. The tire shall withstand 150 dynamometer landings. Fifty of these landings shall be in accordance with the load-speed-time test procedures specified below. Refer to Figs. 1 and 2 for graphic representations of this test. The above tests shall be followed by 100 landings at 90-0 m.p.h. as specified in Paragraphs 6.1 through 6.1.3(a). The provisions of Paragraphs 6.1.4 and 6.1.5 shall apply.

6.2.2.1 Speed Cycle. The tire shall be landed against a dynamometer flywheel rotating at a peripheral speed of $S_1$ m.p.h. Immediately thereafter, the flywheel's peripheral speed shall be decreased at an average deceleration rate of D ft./sec./sec. until a value of $S_2$ is attained. No specific rate of deceleration is required after the flywheel's peripheral speed reaches a value of $S_2$. The peripheral speed of the flywheel shall be decreased in the above manner until a roll distance of RD feet has been covered, at which time, the tire shall be unlanded.

6.2.2.2 Load Cycle. After landing, the load shall be increased from zero to $L_l$ pounds within $T_1$ seconds. The load shall then be further increased linearly with time to a value of $L_2$ pounds within $T_2$ seconds after landing, or at the moment of unlanding, whichever occurs first. If it is necessary to continue the roll after $T_2$ seconds (Ref. Fig. 1) in order to complete the required distance, the load shall be maintained at $L_2$ pounds until the required roll distance RD is completed.

6.2.2.3 Symbol Definitions. The numerical values which are used for the following symbols shall be determined from the applicable airplane load-speed-time data.

$S_1$ = Initial dynamometer test speed
$S_2$ = Speed at which the average deceleration D between $S_1$ and $S_2$ does not exceed the specified value.
D = Constant rate of deceleration between $S_l$ and $S_2$ speeds.
RD = Roll distance in feet
$L_1$ = Initial tire load
$L_2$ = Maximum rated static load of the tire.
$T_1$ = Time for applying $L_l$ load. A $T_1$ tolerance of ± one second is acceptable.
$T_2$ = The elapsed time in applying the $L_2$ load

$$= \frac{S_1 - \sqrt{(S_1^2 - 2D(RD))}}{D}$$

A $T_2$ tolerance of ± 10% is acceptable. When $T_2$ is calculated by the aforementioned formula, $S_2$ may be ignored and D is assumed constant throughout roll distance RD. (Ref. Fig. 2)

6.2.2.4 Test Load Adjustment. If the test load curve, determined on the above basis, results in loads at a given speed being less than those dictated by the applicable aircraft data then adjustments should be made in $T_2$, $L_1$, and/or $T_1$ to eliminate this condition.

6.2.3 Taxi Test. The tire shall satisfactorily withstand at least three dynamometer tests under the following conditions.

Speed = 35 m.p.h.
Tire Load = Maximum static rating
Roll Distance = 35,000 feet

6.2.3.1 Tire Temperature. The tire shall be heated so that, at the start of each of the three taxi test cycles, the tire test temperature shall be no less than $120^0$F. No adjustment shall be made in the inflation pressure to compensate for increases in air pressure due to temperature rise. Rolling the tire on the dynamometer is acceptable in obtaining the minimum $120^0$F tire temperature.

6.2.4 Alternate Dynamometer Tests.

6.2.4.1 Variable Loading. Alternate dynamometer tests incorporating a variable loading procedure which more realistically simulates actual airplane performance on the runway may be used in lieu of the applicable load-speed-time schedules specified herein.

6.2.4.2 Alternate Procedure for Reinforced Tread Tires. Qualification of a given ply rating, reinforced tread, high speed tire in accordance with Paragraph 6.2.2 will automatically qualify a lesser ply rating reinforced tread tire of the same size and skid depth provided:

(a) The lesser ply rating tire, with a non-reinforced tread and identical carcass, has been qualified to the applicable requirements specified herein.

(b) The test conditions $S_1$, RD, D, $S_2$, $T_l$, and $T_2$ are not less severe than those applicable to the lesser ply rating tire.

(c) The ratio of the test loads $L_l$ to $L_2$ is not less than that applicable to the lesser ply rating tire. Any necessary adjustment in this ratio shall be accomplished by increasing $L_l$.

7.0 Optional Test Equipment. Dynamic tests may also be run on a test drum which is a fixed mass, provided the load, speed, time, and roll distance are identical to those which the tire would have if run on an inertia type dynamometer.

**TSO-C62**

FIGURE 1

GRAPHIC REPRESENTATION OF LOAD-SPEED-TIME TEST WHEN TIME $T_2$ OCCURS BEFORE REQUIRED ROLL DISTANCE IS COMPLETED

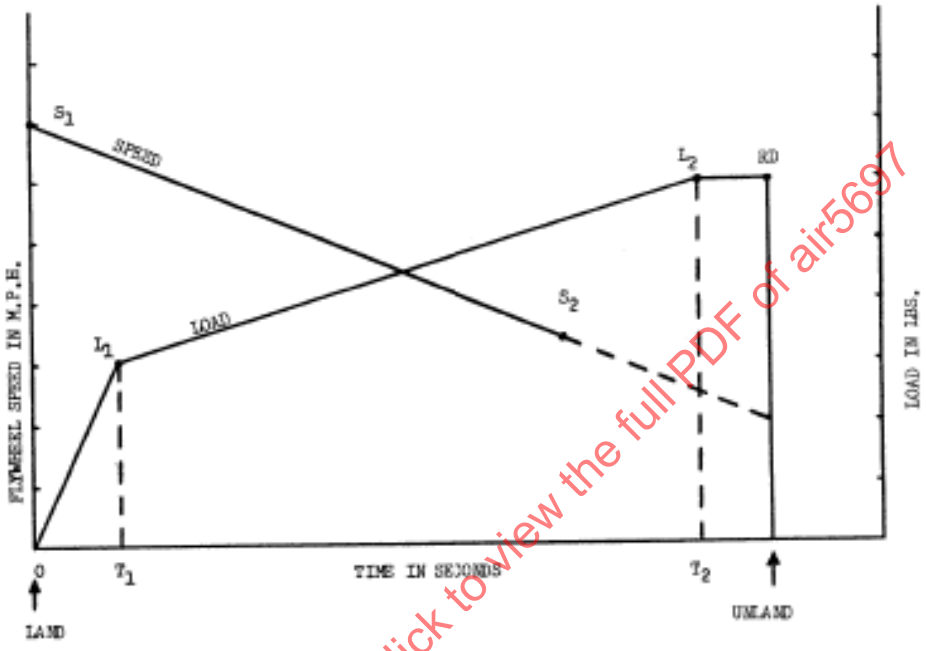
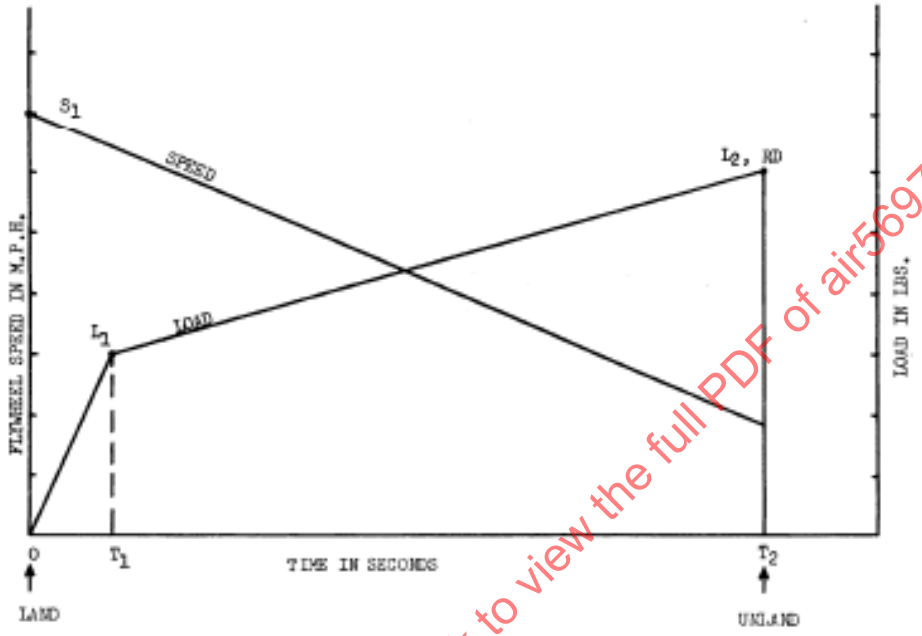


FIGURE 2

GRAPHIC REPRESENTATION OF LOAD-SPEED-TIME TEST WHEN $T_2$ IS CALCULATED




TSO-C62

**5.8.13 TSO-C62a is issued, effective March 20, 1962**

FEDERAL AVIATION AGENCY
Washington 25, D. C.
TECHNICAL STANDARD ORDER
Regulations of the Administrator
Part 514

SUBJECT: AIRCRAFT TIRES **TSO-C62a**

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Technical Standard Orders for Aircraft Materials,
Parts, Processes, and Appliances

Part 514 contains minimum performance standards and specifications of materials, parts, processes, and appliances used in aircraft and implements the provisions of sections 3.18, 4a.31, 4b.18, 6.18 and 7.18 of the Civil Air Regulations. The regulation uses the Technical Standard Order system which, in brief, provides for FAA-industry cooperation in the development of performance standards and specifications which are adopted by the Administrator as Technical Standard Orders, and a form of self-regulation by industry in demonstrating compliance with these orders.

Part 514 consists of two subparts. Subpart A contains the general requirements applicable to all Technical Standard Orders. These provisions are summarized below for the convenient reference of the public. Subpart B contains the technical standards and specifications to which a particular product must conform, and each Technical Standard Order is set forth in the appropriate section of Subpart B. The subject Technical Standard Order is printed below. ANY TECHNICAL STANDARD ORDER MAY BE OBTAINED BY SENDING A REQUEST TO FAA, WASHINGTON 25, D. C.



SUBPART A- -GENERAL

This subpart provides, in part, that a manufacturer of an aircraft material, part, process, or appliance for which standards are established in Subpart B, prior to its distribution for use on a civil aircraft of the United States, shall furnish a written statement of conformance certifying that the material, part, process, or appliance meets the applicable performance standards established in this part. The statement of conformance must be signed by a person duly authorized by the manufacturer, and furnished to the Chief, Engineering and Manufacturing Division, Bureau of Flight Standards, Federal Aviation Agency, Washington 25, D. C.

Subpart A also requires appropriate marking of materials, parts, processes, and appliances as follows:
(a) Name and address of the manufacturer responsible for compliance,
(b) Equipment name, or type or model designation,
(c) Weight to the nearest pound and fraction thereof,
(d) Serial number and/or date of manufacturer, and
(e) Applicable Technical Standard Order (TSO) number.
In addition, Subpart A provides that no deviation will be granted from the performance standards established in Subpart B, and that the Administrator may take appropriate action in the event of noncompliance with Part 514.

SUBPART B

§ 514.67 Aircraft Tires - TSO-C62a--

(a) Applicability –

(1) Minimum performance standards. Minimum performance standards are hereby established for aircraft tires, excluding tail wheel tires, which are to be used on civil aircraft of the United States. New design

tires, manufactured on or after March 20, 1962, which are to be used on civil aircraft of the United States shall meet the standards specified in Federal Aviation Agency Standard, “Aircraft Tires”* dated February 15, 1961. {See section 5.6.12 for Full Text of this standard}

(b)Marking. In lieu of the marking requirements of Subpart A, aircraft tires shall be legibly and permanently marked with the following information:

(1)Brand name or name of the manufacturer responsible for compliance and the country of manufacture if outside the United States.

(2)The size, ply rating, and serial number.

(3) The qualification test speed and skid depth when the test speed is greater than 160 m.p.h., also, the word “reinforced” if applicable.

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

(c)Data Requirements.

(1) One copy of the following data shall be furnished to the Chief, Engineering and Manufacturing Division, Bureau of Flight Standards, Federal Aviation Agency, Washington 25, D.C., with the statement of conformance: tire size, static and dynamic load rating, ply rating, rated inflation pressure, outside diameter, skid depth, static unbalance, tire weight and a summary of the Load speed-time parameters used in the high speed dynamometer tests.

(2) The manufacturer shall maintain a current file of complete design data.

(3) The manufacturer shall maintain a current file of complete data describing the inspection and test procedures applicable to his product. (See paragraph (d) of this section.)

(d) Quality control. Tires shall be produced under a quality control system, established by the manufacturer, which will assure that each tire is in conformity with the requirements of this section and is in a condition for safe operation. This system shall be described in the data required under paragraph (c)(3) of this section. A representative of the Administrator shall be permitted to make such inspections and production tests at the manufacturer's facility as may be necessary to determine compliance with the requirements of this section. _____

* Copies may be obtained upon request addressed to: Publishing and Graphics Branch, Inquiry Section, MS-158, Federal Aviation Agency, Washington 25, D.C.

(e) Previously approved equipment. Tires of a specific design produced prior to March 20, 1962, may continue to be manufactured under the provisions of their original design and test standards.



**5.8.14 Amendment 4b-12, effective May 3, 1962**

a. *Change to Regulation.* Under Retracting mechanism, §4b.334, a new §4b.334(g) was added to read as follows:

(g) *Protection of equipment in wheel wells.* Equipment located in wheel wells, which is essential to safe operation of the airplane, shall be protected from the damaging effects of a bursting tire unless it is shown that a tire cannot burst from overheat, or from the damaging effects of a loose tire tread unless it is shown that a loose tire tread cannot cause damage.

b. *Explanation.* To insure that essential equipment in wheel wells is not damaged by loose tire treads or a bursting tire, a provision is being added which requires protection of such equipment. As a result of comments made on the proposal, alternatives are being added to the requirement, to permit a finding that a tire cannot burst from overheat or that a loose tire tread cannot cause damage. It is intended that such findings will be

based on the use of a wheel which is fitted with a fusible plug and a tubeless tire or that an extended wheel is located so that a tire tread which has separated from the wheel cannot enter the wheel well and that the wheel is braked to a stop before retraction into the wheel well.

**5.8.15 TSO-C62b is issued, effective September 1, 1962.**

FEDERAL AVIATION AGENCY
Washington 25, D. C.

**TECHNICAL STANDARD ORDER**
Regulations of the Administrator
Part 514

SUBJECT:AIRCRAFT TIRES**TSO-C62b**

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Technical Standard Orders for Aircraft Materials,
Parts, Processes, and Appliances

Part 514 which contains minimum performance standards and specifications for materials, parts, and appliances used in aircraft consists of two subparts. Subpart A contains the general requirements applicable to all Technical Standard Orders. Subpart B contains the technical standards and specifications to which a particular product must conform.

ANY TECHNICAL STANDARD ORDER MAY BE OBTAINED BY SENDING A REQUEST TO FAA, WASHINGTON 25, D. C.

***Subpart* A- -GENERAL**

**§ 514.0 Definition of terms**.

As used in this part:

(a) "Administrator" means the Administrator of the Federal Aviation Agency or any person to whom he has delegated his authority in the matter concerned.

(b) "FAA" means Federal Aviation Agency.

(c) "Manufacturer" means a person who controls the design and quality of an article produced under the TSO system, including all parts thereof and processes and services related thereto obtained from outside sources.

(d) "Article" means the materials, parts, or appliances for which approval is required under the Civil Air Regulations for use on civil aircraft.

**§ 514.1 Basis and purpose.**

(a) *Basis*. Section 601 of the Federal Aviation Act of 1958, and §§ 3.18, 4a.31, 4b.18, 5.18, 6.18, 7.18, 10.21, 13.18, and 14.18 of this title (Civil Air Regulations).

(b) *Purpose.* (1) This part prescribes in individual Technical Standard Orders the minimum performance and quality control standards for FAA approval of specified articles used on civil aircraft,[1] and prescribes the methods by which the manufacturer of such articles shall show compliance with such standards in order to obtain authorization for the use of the articles on civil aircraft.

(2) The performance standards set forth in the Individual Technical Standard Orders are those standards found necessary by the Administrator to assure that the particular article when used on civil aircraft will operate satisfactorily, or accomplish satisfactorily its intended purpose under specified conditions.

**§ 514.2 TSO authorization.**

(a) *Privileges*. No person shall identify an article with a TSO marking unless he holds a TSO

[1] Articles may also be approved and manufactured for use on civil aircraft as a part of the type design of a type certificate for an aircraft engine or propeller.
authorization and the article meets the applicable TSO standards prescribed in this part.
(b) *Letters of acceptance issued prior to July 1, 1962*. An FAA letter of acceptance of a statement of conformance issued for an article prior to July 1, 1962, is an authorization within the meaning of this part and the holder thereof may continue to manufacture such article without obtaining an additional TSO authorization, but shall comply with the requirements of § 514:3 through § ;514.10.
(c) *Application.* The manufacturer or his duly authorized representative shall submit an application for a TSO authorization together with the following documents (See Appendix A of this subpart for sample application) to the Chief, Engineering and Manufacturing Branch, Flight Standards Division, in the region in which manufacturer is located.[2] -

(1) A statement of conformance certifying that the applicant has complied with the provisions of Subpart A and the article the applicable performance standards established in Subpart B of this part (See Appendix B of this subpart for sample statement of conformance);

(2) Copies of the technical data required in the performance standards set forth in Subpart B of this part for the particular article;

(3) A description of his quality control system in the detail specified in § 1.36 of this title (Civil Air Regulations). In complying with this provision the manufacturer may refer to current quality control data filed with the Agency, as a part of a previous application.

NOTE: When a series of minor changes in accordance with § 514.5 is anticipated, the manufacturer may set forth in his application the basic model numbered article with open brackets after it to denote that suffix change letters will be added from time to-time e.g.. Model No.100 ( ).

(d) *Issuance*.

(1) Upon receipt of the application and adequate supporting documents specified in paragraph (c) of this section to substantiate the manufacturer's statement of conformance with the requirements of this part and his ability to produce duplicate articles in accordance with the provisions of this part, the applicant will be given an authorization to identify his article with the applicable TSO marking.
(2) If the application is deficient in respect to any requirements, the applicant shall, upon request by the Chief, Engineering and Manufacturing Branch, submit such additional information as may be necessary to show compliance with such requirements. Upon the failure of the applicant to submit such additional information within 30 days after the date of the request therefore, his application will be denied and he will be so notified by the Chief, Engineering and Manufacturing Branch.

NOTE: The applicant will be issued an authorization or notified of the denial of his application within 30 days after the date of receipt of such application , or in the event that additional information has been requested, within 30 days after the date of receipt of such additional information.

**§514.3 Conditions on authorizations.**

The manufacturer of an article under an authorization issued under the provisions of this part shall-

(a) Manufacture such article in accordance with the requirements of Subpart A and the performance standards contained in the applicable TSO of Subpart B of this part;

(b) Conduct the required tests and inspections, and establish and maintain a quality control system adequate to assure that such article, as manufactured, meets the requirements of paragraph (a) of this Section and is in a condition for safe operation;

(c) Prepare and maintain for each type or model of such article a current file of complete technical data and records in accordance with §514.6; and

(d) Permanently and legibly mark each such article with the following information:

(1) Name and address of the manufacturer,

(2) Equipment name, or type or model designation,

(3) Weight to the nearest tenth of a pound,

(4) Serial number and/or date of manufacturer, and

(5) Applicable Technical Standard Order (TSO) number.

[2] Regional Offices are located at New York, Atlanta, Kansas City, Fort Worth, Los Angeles, Anchorage.

**§ 514.4 Deviations.**

Approval for a deviation from the performance standards established in Subpart B may be obtained only if the standard or standards for which deviation is requested are compensated for by factors or design features which provide an equivalent level of safety. A request for such approval together with the pertinent data shall be submitted by the manufacturer to the Chief, Engineering and Manufacturing Branch of the Region in which the applicant is located.

**§514.5 Design changes.**

(a) *By Manufacturer- (1) Minor changes.* The manufacturer of an -article under an authorization issued pursuant to the provisions of this part may take minor design changes to the article without further approval by the FAA. In -such case the changed article shall retain the original model number and the manufacturer shall forward to the Chief, Engineering and Manufacturing Branch such revised data as may be necessary for compliance with §514.2(c).

(2) *Major changes*. If the changes to the article are so extensive as to require a substantially complete investigation to determine compliance with the performance standards established in Subpart B, the manufacturer shall assign a new type or model designation to the article and submit a new application in accordance with the provisions of § 514.2(c).

(b) *By persons other than the manufacturer.* Design changes to an article by a person other than the manufacturer who submitted the statement of conformance for such article are not eligible for approval under this part, unless such person is a manufacturer as defined in § 514.0 and applies for authorization under §514.2(c).

Note: Persons other than a manufacturer may obtain approval for design changes to a product manufactured under a TSO pursuant to the provisions of Part 18 or the applicable airworthiness regulations.

**§ 514.6 Retention of data and records.**

(a) A manufacturer holding an authorization issued pursuant to the provisions of this part shall, for all articles manufactured under such authorization on and after July 1, 1962, maintain and keep at his factory:

(1) A complete and current technical data file for each type or model of article which shall include the design drawings and specifications. This technical data shall be retained for the duration of his operation under the provisions of this part.

(2) Complete and current inspection records to show that all inspections and tests required to ensure compliance with this part have been properly accomplished and documented. These records shall be retained for at least two years.

(b) The data specified in paragraph (a) (1) of this section shall be identified and copies transferred to the FAA for record purposes in the event the manufacturer terminates his business or no longer operates under the provisions of this part.

**§514.7- Inspection and examination of data, articles or manufacturing facilities**.

The manufacturer shall, upon request, permit an authorized representative of the FAA to inspect any article manufactured pursuant to this part, and to observe the quality control inspections and tests and examine the manufacturing facilities and technical data files for such article.

**§ 514.8 Service difficulties.**

Whenever the investigation of an accident or a service difficulty report shows an unsafe feature or characteristic caused by a defect in design or manufacture of an article, the manufacturer shall upon the request of the Chief, Engineering and Manufacturing Branch, report the results of his investigation and the action, if any, taken or proposed by him to correct the defect in design or manufacture (e.g., service bulletin, design changes, etc.). If the defect requires a design change or other action to correct the unsafe feature or

characteristic, the manufacturer shall submit to the Chief, Engineering and Manufacturing Branch, the data necessary for the issuance of an airworthiness directive containing the appropriate corrective action.

**§ 514.9 Noncompliance.**

Whenever the Administrator finds that a manufacturer holding an authorization issued pursuant to the provisions of this part has identified an article by a TSO marking and that such article does not meet the applicable performance -standards of this part, the Administrator may, upon notice thereof to the manufacturer, withdraw the manufacturer's authorization and, where necessary, prohibit any further certification or operation of a civil aircraft upon which such article is installed until appropriate corrective action is taken.

**§ 514.10 Transferability and duration.**

An authorization issued pursuant to the provisions of this part shall not be transferred and is effective until surrendered, or withdrawn, or otherwise terminated by the Administrator.

## APPENDIX A SAMPLE APPLICATION FOR TSO AUTHORIZATION

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Date

(Addressed to : Chief, Engineering and Manufacturing Branch, Federal Aviation Agency, Region.)

Application is hereby made for authorization to use the Technical Standard Order Procedures. Enclosed is a statement of conformance for the article to be produced under TSO-C_____

The required quality control data [1] are transmitted: (herewith) (under separate cover).

Signed _____

## APPENDIX B SAMPLE STATEMENT OF CONFORMANCE

---

Date

(Addressed to: Chief, Engineering and Manufacturing Branch, Flight Standards Division, Federal Aviation Agency).

The undersigned hereby certifies that the article listed below by model, type or part number has been tested and meets the performance standards of Technical Standard Order C_____. In addition, all other applicable provisions of Part 514 of the Regulations of the Administrator have been met.

The technical data required by the TSO in the quantity specified are transmitted: (herewith) (under separate cover).

Authorization to use TSO identification on this article is requested.

Signed _____

[1] Reference may be made to data already on file with the FAA.

**SUBPART B**

§ 514.67 Aircraft Tires - TSO-C62b--(a) Applicability - (1) Minimum performance standards. Minimum performance standards are hereby established for aircraft tires, excluding tail wheel tires, which are to be used on civil aircraft of the United States. New design tires, manufactured on or after the effective date of this section, which are to be used on civil aircraft of the United States shall meet the standards specified in Federal Aviation Agency Standard, "Aircraft Tires" dated August 1, 1962.*

(b) Marking. In lieu of the marking requirements of § 514.3(d), aircraft tires shall be legibly and permanently marked with the following information:

(1)Brand name or name of the manufacturer responsible for compliance and the country of manufacture if outside the United States.

(2)The size, ply rating, and serial number.

(3) The qualification test speed and skid depth when the test speed is greater than 160 m.p.h., also, the word "reinforced" if applicable.

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

(c) Data Requirements. Six copies each of the following shall be furnished the Chief, Engineering and Manufacturing Branch, Flight Standards Division, Federal Aviation Agency, in the region in which the manufacturer is located: tire size, static and dynamic load rating, ply rating, rated inflation pressure, outside diameter, skid depth, static unbalance, tire weight and a summary of the load-speed-time parameters used in the high speed dynamometer tests.

(d)Effective date. September 1, 1962.

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* Copies may be obtained upon request addressed to Publishing and Graphics Branch, Inquiry Section, MS-158, Federal Aviation Agency, Washington 25, D.C.

August 1, 1962

FEDERAL AVIATION AGENCY STANDARD
AIRCRAFT TIRES

1.0 Purpose. To specify minimum requirements for new aircraft tires, excluding tail wheel tires, for civil aircraft applications.

2.0 Scope. This specification covers minimum requirements for the following types of tires, having speed limitations as indicated.

(a) Type III, VII, and VIII (for ground speeds of 160 m.p.h. or less) hereinafter referred to as low speed tires.

(b) Type VII and VIII (for ground speeds greater than 160 m.p.h.) hereinafter referred to as high speed tires.

3.0 General Requirements.

3.1 Materials and Workmanship.

3.1.1 Materials. Materials shall be suitable for the purpose intended. The suitability of the materials shall be determined on the basis of satisfactory service experience or substantiating dynamometer tests.

4.0 Design and Construction.

4.1 Unbalance. The moment of static unbalance in ounce inches shall be no greater than the following moment values as applicable:

Type III tire diameters up to and including 28", Moment = $1.5D - .023D^2$

Type III tire diameters greater than 28",
Moment = $.031D^2 - .253D$

Type VII and VIII tire diameters up to and including 28",
Moment = $.01D^2 + .38D$

Type VII and VIII tire diameters greater than 28",
Moment = $.034D^2 - .304D$

D = Tire diameter (Actual)

4.2 Balance Marker. A balance marker, consisting of a red dot, shall permanently branded into the side wall of the tire immediately above the bead to indicate the lightweight point of the tire.

4.3 Burst Pressure. New tires shall be capable of withstanding without failure a burst pressure of at least 4.0 times the rated inflation pressure.

4.4 Temperature. The airworthiness of tires shall not be adversely affected as a result of their being subjected to extreme ambient temperatures expected to be encountered during normal airplane operation.

4.5 Tread Design. Decreases in the number of tread ribs and grooves and increases in skid depth, made subsequent to tire qualification, shall be substantiated by the dynamometer tests

contained herein for the applicable ground speed range involved.

4.5.1 Underskid Thickness. For tires and casings having ribbed type or nonskid tread patterns, the thickness of the rubber between the carcass and the bottom of the tread pattern shall not be less than 30 percent of the mold skid depth, except for helicopter tires, in which case, the minimum thickness shall not be less than 1/32 inch.

4.6 Slippage. Mounted tires, when tested in accordance with the dynamometer tests specified herein, shall show no evidence of slippage on the wheel rim during the first five dynamometer landings. Such slippage as shall subsequently occur shall not damage the tube or valve nor damage the air seal of the tire bead in the case of tubeless tires.

4.7 Tire Airworthiness. The tire shall withstand the dynamometer landings specified herein without failure or visible signs of deterioration other than normal expected tread wear.

5.0 Ratings.

5.1 Static Load Rating (Airplane Tires) Static load ratings shall be established on the basis of 35% deflection for Type III tires and 32% deflection for Types VII and VIII tires.

5.1.1 Static Load Rating (Helicopter Tires). Airplane tires qualified in accordance with the provisions of this standard may also be used on he1icopters. In such case, the maximum static load rating may be increased by 1.5 without any additional qualification testing.

5.1.2 Deflection. The vertical distance from the top of the rim flange to the outermost surface of the tire at no load is considered as the distance equivalent to 100% deflection.

5.1.3 Deflection Tolerances. Deflection tolerances to allow for manufacturing variations shall not exceed +1%, -4% for Type III tires and +3%, -4% for Type VII and VIII tires.

5.2 Dynamic Load Rating, Nose Wheel Tires. The dynamic load rating (maximum permissible nose wheel tire load during braking) shall be determined as follows:

(a) Type III tires - 1.45 x static load rating.
(b) Type VII tires - 1.50 x static load rating.
(c) Type VIII tires - 1.40 x static load rating.

5.3 Inflation Pressure. The rated inflation pressure shall be established for each specific tire and shall be used as a basis when complying with the tire deflection provisions of Sections 5.1, 5.1.2, and 5.1.3.

5.4 Ply Rating. The ply rating shall be established on the basis of the static or dynamic load requirement, whichever is more critical.

6.0 Dynamometer Test Requirements.

6.1 Low Speed Tires. The tire shall withstand 200 landings on a dynamometer having a stored up kinetic energy computed as follows:

$KE = CWV^2$ , where KE = Kinetic energy, ft. lbs.
W = Tire load, lbs.
V = 120 m.p.h.
C = 0.011

6.1.1 Tire Load. At landing, and during the entire roll test, the tire shall be forced against the flywheel at the rated static load of the tire.

6.1.2 Kinetic Energy. The kinetic energy of the flywheel shall be calculated for the rated

maximum static load of the tire. In the event that the correct number of flywheel plates cannot be used to obtain the calculated kinetic energy value or proper flywheel width, a greater number of plates shall be selected and the dynamometer speed shall be adjusted in order that the required kinetic energy may be obtained.

6.1.3 Dynamometer Speeds. The total number of dynamometer landings shall be divided into two equal parts having speed ranges as follows:

(a) In the first series of landings, the landing shall be at 90 m.p.h. and the unlanding at 0 m.p.h. The landing speed shall be decreased as necessary in order that 56 percent of the calculated kinetic energy is absorbed by the tire during this series.

(b) In the second series of landings, the landing shall be at 120 m.p.h. and the unlanding at 90 m.p.h. The unlanding speed shall be increased as necessary in order that 44 percent of the calculated kinetic energy is absorbed by the tire during this series.

6.1.4 Test Inflation Pressure. The test inflation pressure shall be that which is necessary to accomplish the same deflection on the flywheel under the rated static load as the flat plate deflection of the tire at its rated static load and inflation. This determination is made on the unused tire prior to the start of the test.

6.1.5 Landing Interval. The time between landings shall be chosen to be the minimum which will assure carcass peak temperatures of not less than $160^0$F. or contained air peak temperatures of not less than $140^0$F. for each run. Unavoidable deviations from the above shall be noted in the substantiating test data. Carcass temperatures shall be measured within one inch above the rim flange and in the shoulder or crown area.

6.2 High Speed Tires. Substantiation of the tire on the dynamometer shall realistically simulate, insofar as is practicable, runway operation and tire performance for the most critical combination of takeoff weight and speed and airplane center of gravity position. Consideration shall also be given to increased speeds resulting from elevated airport operations and high ambient temperatures. Representative load-speed-time data, compiled by the airplane manufacturer, shall be the basis for establishing the applicable dynamometer tests.

6.2.1 Dynamometer Test Speeds. Applicable dynamometer test speeds for corresponding maximum operational ground speeds shall be as follows:

| Maximum Operational Ground Speed of Aircraft, m.p.h. | | Dynamometer Test Speed m.p.h. |
|---|---|---|
| Over | Not Over | |
| 160 | 180 | 180 |
| 180 | 200 | 200 |
| 200 | 225 | 225 |

6.2.2 Dynamometer Tests. The tire shall withstand 150 dynamometer landings. Fifty of these landings shall be in accordance with the load-speed-time test procedures specified below. Refer to Figs. 1 and 2 for graphic representations of this test. The above tests shall be followed by 100 landings at 90-0 m.p.h. as specified in Paragraphs 6.1 through 6.1.3(a). The provisions of Paragraphs 6.1.4 and 6.1.5 shall apply.

6.2.2.1 Speed Cycle. The tire shall be landed against a dynamometer flywheel rotating at a peripheral speed of $S_1$ m.p.h. Immediately thereafter, the flywheel's peripheral speed shall be decreased at an average deceleration rate of D ft./sec./sec. until a value of $S_2$ is attained. No specific rate of deceleration is required after the flywheel's peripheral speed reaches a value of $S_2$. The peripheral speed of the flywheel shall be decreased in the above manner until a roll distance of RD feet has

been covered, at which time, the tire shall be unlanded.

6.2.2.2 Load Cycle. After landing, the load shall be increased from zero to $L_I$ pounds within $T_1$ seconds. The load shall then be further increased linearly with time to a value of $L_2$ pounds within $T_2$ seconds after landing, or at the moment of unlanding, whichever occurs first. If it is necessary to continue the roll after $T_2$ seconds (Ref. Fig. 1) in order to complete the required distance, the load shall be maintained at $L_2$ pounds until the required roll distance RD is completed.

6.2.2.3 Symbol Definitions. The numerical values which are used for the following symbols shall be determined from the applicable airplane load-speed-time data.

$S_1$ = Initial dynamometer test speed
$S_2$ = Speed at which the average deceleration D between $S_1$ and $S_2$ does not exceed the specified value.
D = Constant rate of deceleration between $S_I$ and $S_2$ speeds.
RD = Roll distance in feet
$L_1$ = Initial tire load
$L_2$ = Maximum rated static load of the tire.
$T_1$ = Time for applying $L_I$ load. A $T_1$ tolerance of ± one second is acceptable.
$T_2$ = The elapsed time in applying the $L_2$ load

$$= \frac{S_1 - \sqrt{(S_1^2 - 2D(RD))}}{D}$$

A $T_2$ tolerance of ± 10% is acceptable. When $T_2$ is calculated by the aforementioned formula, $S_2$ may be ignored and D is assumed constant throughout roll distance RD. (Ref. Fig. 2)

6.2.2.4 Test Load Adjustment. If the test load curve, determined on the above basis, results in loads at a given speed being less than those dictated by the applicable aircraft data then adjustments should be made in $T_2$, $L_1$, and/or $T_1$ to eliminate this condition.

6.2.3 Taxi Test. The tire shall satisfactorily withstand at least three dynamometer tests under the following conditions.

Speed = 35 m.p.h.
Tire Load = Maximum static rating
Roll Distance = 35,000 feet

6.2.3.1 Tire Temperature. The tire shall be heated so that, at the start of each of the three taxi test cycles, the tire test temperature shall be no less than $120^0$F. No adjustment shall be made in the inflation pressure to compensate for increases in air pressure due to temperature rise. Rolling the tire on the dynamometer is acceptable in obtaining the minimum $120^0$F. tire temperature.

6.2.4 Alternate Dynamometer Tests. Alternate dynamometer tests which more realistically simulate actual airplane performance on the runway may be used in lieu of the applicable load-speed-time schedule. In this respect, an acceleration load-speed-time schedule, wherein the dynamometer flywheel is accelerated to the applicable conditions, is acceptable. In any event, the dynamometer test speed shall be that as specified in the table shown in Paragraph 6.2.1.

6.2.4.1 Alternate Procedure for Reinforced Tread Tires. Qualification of a given ply rating, reinforced tread, high speed tire in accordance with Paragraph 6.2.2 will automatically qualify a lesser ply rating reinforced tread tire of the same size and skid depth provided:

(a) The lesser ply rating tire, with a non-reinforced tread and identical carcass, has been qualified to the applicable requirements specified herein.

(b) The test conditions $S_1$, RD, D, $S_2$, $T_l$, and $T_2$ are not less severe than those applicable to the lesser ply rating tire.

(c) The ratio of the test loads $L_l$ to $L_2$ is not less than that applicable to the lesser ply rating tire. Any necessary adjustment in this ratio shall be accomplished by increasing $L_l$.

7.0 Optional Test Equipment. Dynamic tests may also be run on a test drum which is a fixed mass, provided the load, speed, time, and roll distance are identical to those which the tire would have if run on an inertia type dynamometer.

**Note: Figures 1 and 2 are for TSO-C62b**

FIGURE 1

GRAPHIC REPRESENTATION OF LOAD-SPEED-TIME TEST WHEN TIME $T_2$ OCCURS BEFORE REQUIRED ROLL DISTANCE IS COMPLETED

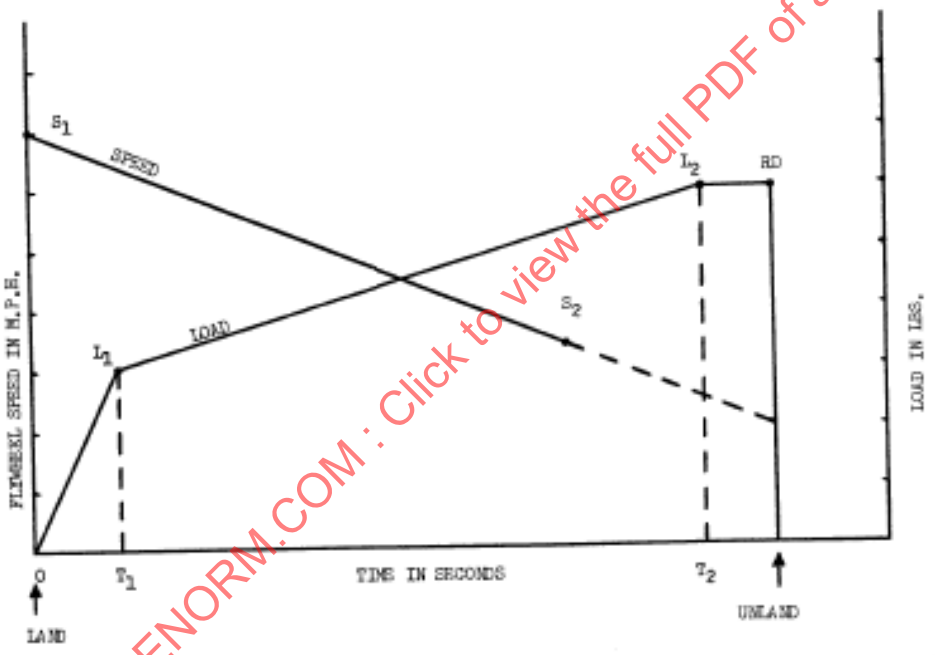
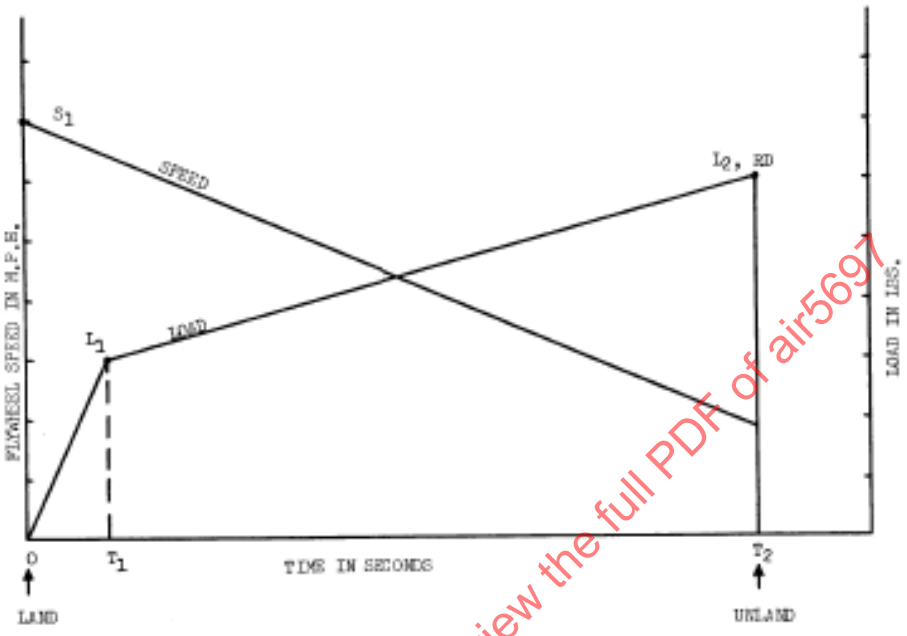


FIGURE 2

GRAPHIC REPRESENTATION OF LOAD-SPEED-TIME TEST WHEN $T_2$ IS CALCULATED




TSO-C62b

**5.8.16 TSO-C62b issued as FAR 37.167{ref. Doc #5065, 29FR 15317}/11-17-64**
**Also issued as § 37.167 {ref. Doc # 8084, 32 FR 5769}/04-11-67**

**§ 37.167 Aircraft Tires---TSO-C62b.**

(a) *Applicability*---(1) *Minimum performance standards*. Minimum performance standards are hereby established for aircraft tires, excluding tail wheel tires, which are to be used on civil aircraft of the United States. New design tires, manufactured on or after the effective date of this section, which are to be used on civil aircraft of the United States shall meet the standards specified in Federal Aviation Administration Standard "Aircraft Tires" dated August 1, 1962.[1] {same as in section 5.6.15.}

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

(1) Brand name or name of the manufacturer responsible for compliance and the country of manufacture if outside the United States.

(2) The size, ply rating, and serial number.

(3) The qualification test speed and skid depth when the test speed is greater than 160 m.p.h., also, the word "reinforced" if applicable.

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

(c) *Data Requirements*. Six copies each of the following shall be furnished the Chief, Engineering and Manufacturing Branch, Flight Standards Division, Federal Aviation Administration [Agency in 1964 version], in the region in which the manufacturer is located: tire size, static and dynamic load rating, ply rating, rated inflation pressure, outside diameter, skid depth, static unbalance, tire weight and a summary of the load-speed-time parameters used in the high speed dynamometer tests.

[Doc. No. 5065, 29 FR 15317, Nov. 17, 1964, as amended by Doc. No. 8084, 32 FR 5769. Apr. 11, 1967]

[1] Copies may be obtained upon request addressed to Library Services Division, HQ-630, Federal Aviation Administration, Washington, D.C. 20553.

### 5.8.17 Federal Aviation Regulations, Part 25, effective February 1, 1965

**§** 25.733 Tires.

(a) Each landing gear wheel must have a tire---

(1) That is a proper fit on the rim of the wheel; and

(2) Whose load rating is not exceeded under---

(i) Equal static loads, corresponding to the most critical combination of maximum takeoff weight and center of gravity position, on each main wheel tire; and

(ii) Equal loads corresponding to the ground reactions in paragraph (b) of this section, on each nose wheel tire.

(b) The applicable ground reactions are as follows:

(1) The static ground reaction for the tire with the most critical combination of takeoff weight and center of gravity position. This load may not exceed the static rating of the tire.

(2) The dynamic ground reaction for the tire at maximum landing weight, assuming that the mass of the airplane is concentrated at the most critical location of the center of gravity for this weight and is exerting a force of 1.0g downward and 0.31g forward with the reactions being distributed to the nose and main wheels by the principles of statics and with a 0.31g drag reaction at the ground applied at each wheel with brakes. This load may not exceed the dynamic rating of the tire.

(3) The dynamic ground reaction for the tire at design takeoff weight, assuming that the mass of the airplane is concentrated at the most critical location of the center of gravity for this weight and is exerting a force of 1.0g downward and 0.20g forward. The reactions in this case must be distributed to the nose and main wheels by the principles of statics and a 0.20g drag reaction at the ground is applied at each wheel with brakes. This load may not exceed the dynamic rating of the tire.

### 5.8.18 TSO-C62b/§ 37.167 amended, Effective April 11, 1967

See 5.6.16 for text.

### 5.8.19 Amendment 25-23, effective May 8, 1970.

a. *Change to Regulation.*

**§** 25.733 Tires.

**[** (a) Each landing gear wheel must be fitted with a suitable tire of proper fit whose speed rating approved by the Administrator is not exceeded under critical conditions, and whose load rating approved by the Administrator is not exceeded under--

**[** (1) Equal static loads, corresponding to the most critical combination of maximum takeoff weight and center of gravity position, on each main wheel tire; and

**[** (2) Equal loads corresponding to the ground reactions in paragraph (b) of this section, on each nose wheel tire. **]**

b. *Explanation.* The landing gear tire requirements specified in **§** 25.733(a) did not require consideration of tire speed. Speed is a critical factor affecting the integrity of tires and the rule would include tire speed ratings as a limitation governing the acceptance of tires for use on particular airplanes. In addition, the rule would require the use of tires with speed ratings and load ratings assigned by the Administrator (not by the Tire and Rim Association). Also, it was made clear that a “suitable tire” means a tire of “proper fit”.

### 5.8.20 Amendment 25-38, effective February 1, 1977.

a. *Change to Regulation.*

**§** 25.733 Tires.

**[** (c) Each tire installed on a retractable landing gear system must, at the maximum size of the tire type expected in service, have a clearance to surrounding structure and systems that is adequate to prevent contact between the tire and any part of the structure or systems. **]**

b. *Explanation.* A new paragraph (c) was added, no comments were received. The rule would require that the selection of tires for installation on retractable landing gear mechanisms take into account the tire

production tolerances and size increases that would be expected to result from service. The FAA believes compliance with this rule could prevent accidents that might result from jamming of landing gear mechanisms by oversize tires.

**5.8.21 Amendment 25-49, effective December 31, 1979.**

a. *Change to Regulation.*

**§** 25.733 Tires.

**[** (a) When a landing gear axle is fitted with a single wheel and tire assembly, the wheel must be fitted with a suitable tire of proper fit with a speed rating approved by the Administrator that is not exceeded under critical conditions and with a load rating approved by the Administrator that is not exceeded under-

**[** (1) The loads on the main wheel tire, corresponding to the most critical combination of airplane weight (up to the maximum ramp weight), center of gravity position, and the effect of engine thrust reacted by inertia at the airplane center of gravity; and

**[** (2) The loads corresponding to the ground reactions in paragraph (b) of this section, on the nose wheel tire, except as provided in paragraphs (b)(2) and (b)(3) of this section.

**[** (b) The applicable ground reactions for nose wheel tires are as follows:

**[** (1) The static ground reaction for the tire corresponding to the most critical combination of airplane weight (up to maximum ramp weight) and center of gravity position with a force of 1.0g acting downward at the center of gravity. This load may not exceed the load rating of the tire.

**[** (2) The ground reaction of the tire corresponding to the most critical combination of airplane weight (up to maximum landing weight) and center of gravity position combined with forces of 1.0g downward and 0.31g forward acting at the center of gravity. The reactions in this case must be distributed to the nose and main wheels by the principles of statics with a drag reaction equal to 0.31 times the vertical load at each wheel with brakes capable of producing this ground reaction. This nose tire load may not exceed 1.5 times the load rating of the tire.

**[** (3) The ground reaction of the tire corresponding to the most critical combination of airplane weight (up to maximum ramp weight) and center of gravity position combined with forces of 1.0g downward and 0.20g forward acting at the center of gravity. The reactions in this case must be distributed to the nose and main wheels by the principles of statics with a drag reaction equal to 0.20 times the vertical load at each wheel with brakes capable of producing this ground reaction. This nose tire load may not exceed 1.5 times the load rating of the tire.

**[** (c) When a landing gear axle is fitted with more than one wheel and tire assembly, such as dual or dual-tandem, each wheel must be fitted with a suitable tire of proper fit with a speed rating approved by the Administrator that is not exceeded under critical conditions, and with a load rating approved by the Administrator that is not exceeded by-

**[** (1) 1.07 times the loads specified in paragraph (a)(1) of this section on each main wheel tire; and

**[** (2) Loads specified in paragraphs (a)(2), (b)(1), (b)(2), and (b)(3) of this section on each nose wheel tire.

**[** (d) Each tire installed on a retractable landing gear system must, at the maximum size of the tire type expected in service, have a clearance to surrounding structure and systems that is adequate to prevent unintended contact between the tire and any part of the structure or systems.**]**

**§ 37.167 Aircraft Tires** ---**[** TSO-C62c. effective 12-31-79

TSO-C62b was revised to TSO-C62c by incorporating updates and improved minimum performance standards applicable to main landing gear and nose wheel aircraft tires along with more comprehensive transport category airplane type design standards covering tire loads and speed ratings. The amendment for tire standards specifies a date after which tire manufacturers can no longer identify certain high speed tires as approved under earlier standards (TSO-C62, TSO-C62a, and TSO-C62b) **]**

b. *Explanation.* (1) Under **§** 25.733(a) and (b), the most critical combination of airplane center of gravity and airplane maximum weight up to maximum ramp or maximum landing weight, as applicable, should be assessed in determining the tire load rating. The engine thrust and inertia effects, while minor, should not be excluded from this established rating.

(2) An operational inflation pressure rating associated with the load rating is not practicable as these pressures, prescribed by the airframe manufacturer, will vary depending upon the maximum operating gross weight of the airplane.

(3) Under § 25.733(c), the 7 percent load factor is intended to cover unequal load conditions. Since the 7 percent load factor can only be maintained with a corresponding increase in inflation pressure, a provision for required inflation pressure necessary to assure the application of this de-rating factor is therefore included in the operating rule.

(4) Under § 25.733(d), intentional tire contact from items such as rub strips, spin brakes, and guide rails is allowed; however, any other contact, considering both static and dynamic conditions, is not allowed.

(5) TSO-C62c is provided as a separate section in this document.

(a) *Applicability.* This technical standard order (TSO) prescribes the minimum performance standards that tires, excluding tail wheel tires, must meet in order to be identified with the applicable TSO marking. Tires which are to be so identified and which are manufactured on or after December 31, 1979, must meet the requirements of the "Federal Aviation Administration Standard for Aircraft Tires," effective December 31, 1979, set forth at the end of this section.

(b) *Marking*. In lieu of the marking requirements of § 37.7(d), aircraft tires must be legibly and permanently marked at least with the following:

(1)Brand name and the name or registered trademark of the manufacturer responsible for compliance.

(2)Speed rating, load rating, size, skid depth, serial number, and the manufacturer's part number and plant code.

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

(c) *Data Requirements*. (1) In addition to the data specified in § 37.5, the manufacturer must also furnish to the Chief, Engineering and Manufacturing Branch, Federal Aviation Administration, (or, in the case of the Western Region, the Chief, Aircraft Engineering Division), in the region in which the manufacturer is located, one copy or copies as otherwise requested by the regional office, of the following technical data: speed rating, load rating, rated inflation pressure, tire size, width, outside diameter, mold skid depth, nominal loaded radius at rated load and inflation pressure, permissible tolerance on the nominal loaded radius, the actual loaded radius of the test tire at rated load and inflation pressure, weight, static unbalance of the test tire, wheel rim designation, manufacturer's part number and, for high-speed tires, a load deflection curve at loads up to 1.5 times load rating, and a summary of the load-speed-time parameters used in the dynamometer tests. As used in this section, the term "high-speed tire" means a tire tested at a speed greater than 120 mph.

(2) The manufacturer must also furnish the applicable maintenance and repair instructions to the regional office identified in paragraph (c)(1) of this section. The maintenance data provided by the manufacturer must include inspection criteria for tires to determine eligibility for used tires to be continued in service. Recapping procedures must be included in the maintenance information along with any special repair methods applicable to the tire and special nondestructive inspection techniques.

(d) *Previously approved equipment.*

(1) Notwithstanding § 37.3(a) and (b) of this Part and the provisions of any specific previous TSO approval, after December 31, 1982, no person may identify or mark a tire having a speed rating above 160 mph with TSO numbers TSO-C62, TSO-C62a, or TSO-C62b.

(2) Aircraft tires, except for those specified in paragraph (d)(1) of this section, approved prior to December 31, 1979, may continue to be manufactured under the provisions of their original approval.

Ch. 9 (Amdt.37-46, Eff. 12/31/79)

December 31, 1979

FEDERAL AVIATION ADMINISTRATION STANDARD
FOR AIRCRAFT TIRES

1.0 **Purpose**. This document contains minimum performance standards for new aircraft tires, excluding tail wheel tires that are to be identified as meeting the standards of TSO-C62c.

2.0 **Scope**. These minimum performance standards apply to aircraft tires having speed and load ratings that are established on the basis of the speeds and loads to which the tires have been tested.

3.0 **Material requirement**. Materials must be suitable for the purpose intended. The suitability of the materials must be determined on the basis of satisfactory service experience or substantiating dynamometer tests.

4.0 **Design and construction.**

4.1 *Unbalance*. The moment (m) of static unbalance in inch ounces may not be greater than the value determined using the formula, moment (M)=0.025$D^2$ rounded off to the next lower whole number. D = maximum outside diameter of the tire in inches.

4.2 *Balance Marker*. A balance marker, consisting of a red dot, must be affixed on the sidewall of the tire immediately above the bead to indicate the lightweight point of the tire. The dot must remain for any period of storage plus the original tread life of the tire.

4.3 *Overpressure*. The tire must withstand at least 3 seconds a pressure of at least 4.0 times the rated inflation pressure (as specified in paragraph 5.2) at ambient temperature.

4.4 *Temperature*.

4.4.1 *Ambient*. It must be substantiated by applicable tests or shown by analysis that the physical properties of the tire materials have not been degraded by exposure of the tire to the temperature extremes of not higher than -40$^0$ F and not lower than + 160$^0$ F for a period of not less than 24 hours at each extreme.

4.4.2 *Wheel rim heat*. It must be substantiated by the applicable tests or shown by analysis that the physical properties of the tire materials have not been degraded by exposure of the tire to a wheel bead seat temperature of not lower than 300$^0$ F for at least 1 hour, except that low-speed tires or nose-wheel tires may be tested or analyzed at the highest wheel-bead seat temperatures expected to be encountered during normal operations.

4.5 *Tread design*. Changes in materials that affect performance or changes in number of location of tread ribs and grooves or skid depth increases, made subsequent to the tire qualification, are major changes and must be substantiated by dynamometer tests in accordance with paragraph 6.0.

4.6 *Slippage*. Tires tested in accordance with the dynamometer tests provided by paragraph 6.0 may not slip on the wheel rim during the first five dynamometer cycles. Slippage that subsequently occurs may not damage the tube, valve, or the air seal of the tire bead of tubeless tires.

4.7 *Leakage*. After an initial 12-hour minimum stabilization period, the tire must be capable of retaining air pressure with a loss of pressure not exceeding 5 percent in 24 hours from the initial pressure equal to the rated inflation pressure.

5.0 **Ratings**.

5.1 *Load ratings*. The load ratings of aircraft tires must be established in accordance with the

provisions under §§ 23.733, 25.733, 27.733, and 29.733 of this chapter, in effect on December 31, 1979, as appropriate.

5.2 *Rated inflation pressure*. The rated inflation pressure must be established at an identified ambient temperature on the basis of the rated load as established under paragraph 5.1.

5.3 *Loaded radius*. The loaded radius is defined as the distance from the axle centerline to a flat surface for a tire initially inflated to the rated inflation pressure and then loaded to its rated load against the flat surface. The nominal loaded radius, the allowable tolerance on the loaded radius, and the actual loaded radius for the test tires must be identified.

6.0 **Dynamometer test requirements**. The tire may not fail the applicable dynamometer tests specified herein or have visible signs of deterioration other than normal expected tread wear except as provided in paragraph 6.3.3.3.

6.1 *General*. The following conditions apply to both low-speed and high-speed tires when these tires are subjected to the applicable dynamometer tests:

6.1.1 *Tire test load*. Unless otherwise specified herein for a particular test, the tire must be forced against the dynamometer flywheel at not less than the rated load of the tire during the entire roll distance of the test.

6.1.2 *Test inflation pressure*. The test inflation pressure must be the pressure required at an identified ambient temperature to obtain the same loaded radius against the flywheel of the dynamometer as the loaded radius for a flat surface as defined in paragraph 5.3 of this standard. Adjustments to the test inflation pressure may not be made to compensate for increases due to temperature rise occurring during the tests.

6.1.3 *Test specimen*. A single tire must be used in the applicable dynamometer test specified herein.

6.2 *Low speed tires*. Tires operating at ground speeds of 120 mph or less must withstand 200 landing cycles on a dynamometer at the following test temperature and kinetic energy and using either test method A or test method B.

6.2.1 *Test temperature*. The temperature of the air contained in the tire or of the carcass measured at the hottest point of the tire must be not lower than 105º F at the start of at least 90 percent of the test cycles. For the remaining 10 percent of the test cycles, the contained air or carcass temperature must be no lower than 80º F at the start of each cycle. Rolling the tire on the flywheel is acceptable for obtaining the minimum starting temperature.

6.2.2 *Kinetic energy*. The kinetic energy of the flywheel to be absorbed by the tire must be calculated as follows:

$$K.E. = CWV^2 = \text{Kinetic energy in foot pounds}$$

where:

C = 0.0113,
W = Load rating of the tire in pounds
V = 120 mph.

6.2.3 *Test method A - variable mass flywheel*. The total number of dynamometer landings must be divided into two equal parts having speed ranges shown below. If the exact number of flywheel plates cannot be used to obtain the calculated kinetic energy value or proper flywheel width, a greater number of plates must be selected and the dynamometer speed adjusted to obtain the

required kinetic energy.

6.2.3.1 *Low-speed landings*. In the first series of 100 landings, the maximum landing speed is 90 mph and the minimum unlanding speed is 0 mph. The landing speed must be adjusted so that 56 percent of the kinetic energy calculated under paragraph 6.2.2 will be absorbed by the tire. If the adjusted landing speed is calculated to be less than 80 mph, the following must be done. The landing speed must be determined by adding 28 percent of the calculated kinetic energy under paragraph 6.2.2 to the flywheel kinetic energy at 64 mph, and the unlanding speed must be determined by subtracting 28 percent of the kinetic energy calculated under paragraph 6.2.2 from the flywheel kinetic energy at 64 mph.

6.2.3.2 *High-speed landings.* In the second series of 100 landings, the minimum landing speed is 120 mph and the nominal unlanding speed is 90 mph. The unlanding speed must be adjusted as necessary so that 44 percent of the kinetic energy calculated under paragraph 6.2.2 will be absorbed by the tire.

6.2.4 *Test method B - fixed mass flywheel*. The total number of dynamometer landings must be divided into two equal parts having speed ranges indicated below. Each landing must be made in a time period, T, calculated so that the tire will absorb the kinetic energy determined under paragraph 6.2.2. The time period must be calculated using the equation:

$$T_C = \frac{KE_C}{\frac{KE_{W(UL)} - KE_{W(LL)}}{T_{L(UL)} - T_{L(LL)}} - \frac{KE_{W(UL)} - KE_{W(LL)}}{T_{W(UL)} - T_{W(LL)}}}$$

For the 90 mph to 0 mph test, the equation reduces to:

$$T_C = \frac{KE_C}{\frac{KE_{W(UL)}}{T_{L(UL)}} - \frac{KE_{W(UL)}}{T_{W(UL)}}}$$

Where:

$T_C$ = Calculated time, in seconds, for the tire to absorb the required kinetic energy.
$KE_C$ = Kinetic energy, in foot pounds, the tire is required to absorb during each landing cycle.
$KE_W$ = Kinetic energy, in foot pounds, of the flywheel at given speed.
$T_L$ = Coast down time, in seconds, with rated tire load on flywheel.
$T_W$ = Coast down time, in seconds, with no tire load on flywheel.
(UL) = Subscript for upper speed limit.
(LL) = Subscript for lower speed limit.

6.2.4.1 *Low-speed landings*. In the first series of 100 landings, the tire must be landed against the flywheel with the flywheel having a peripheral speed of not less than 90 mph. The flywheel deceleration must be constant from 90 mph to 0 mph in the time $T_C$.

6.2.4.2 *High-speed landings*. In the second series of 100 landings, the tire must be landed against the flywheel with the flywheel having a peripheral speed of not less than 120 mph. The flywheel deceleration must be constant from 120 mph to 90 mph in the time $T_C$.

6.3 *High-speed tires*. Except as provided in the alternate test, tires operating at ground speeds greater than 120 mph must be tested on a dynamometer in accordance with paragraph 6.3.3. The

curves to be used as a basis for these tests shall be established in accordance with paragraph 6.3.3.2. The load at the start of the test must be equal to the rated load of the tire. Alternate tests involving a landing sequence for tires operating at ground speeds greater than 120 mph and not over 160 mph are set forth in paragraph 6.3.4.

6.3.1 *Test temperature*. The temperature of the air contained in the tire or of the carcass measured at the hottest point of the tire must be not lower than 120º F at the start of at least 90 percent of the test cycles specified in paragraph 6.3.3.4 and at least $105^0$ F at the start of the overload test (6.3.3.3) and of at least 90 percent of the test cycles specified in paragraphs 6.3.3.2 and 6.3.4. For the remaining 10 percent of each group of cycles, the contained air or carcass temperature must be no lower than 80º F at the start of each cycle. Rolling the tire on the flywheel is acceptable for obtaining the minimum starting temperature.

6.3.2 *Dynamometer test speeds*. Applicable dynamometer test speeds for corresponding maximum ground speeds are as follows:

| Maximum ground speed of aircraft, mph Over | Maximum ground speed of aircraft, mph Not Over | Speed rating of tire, mph | Minimum dynamometer Speed at $S_2$, mph |
|---|---|---|---|
| 120 | 160 | 160 | 160 |
| 160 | 190 | 190 | 190 |
| 190 | 210 | 210 | 210 |
| 210 | 225 | 225 | 225 |
| 225 | 235 | 235 | 235 |
| 235 | 245 | 245 | 245 |

For ground speeds over 245 mph, the tire must be tested to the maximum applicable load-speed-time requirements and appropriately identified with the proper speed rating.

6.3.3 *Dynamometer cycles*. The test tire must withstand 50 takeoff cycles, 1 overload takeoff cycle, and 10 taxi cycles described below. The sequence of the cycles is optional.

6.3.3.1 *Symbol definitions*. The numerical values which are used for the following symbols must be determined from the applicable airplane load-speed-time data:

$L_O$ = Tire load at start of takeoff, pounds (not less than rated load).
$L_1$ = Tire load at rotation, pounds.
$L_2$ = Zero tire load (liftoff).
RD = Roll distance, feet.
$S_O$ = Zero tire speed.
$S_1$ = Tire speed at rotation, mph.
$S_2$ = Tire speed at liftoff, mph (not less than speed rating).
$T_O$ = Start of takeoff.
$T_1$ = Time to rotation, seconds.
$T_2$ = Time to liftoff, seconds.

6.3.3.2 *Takeoff cycles*. For these cycles the loads, speed, and distance must conform to either Figure 1 or Figure 2. Figure 1 defines a test cycle that is generally applicable to any aircraft. If Figure 2 is used to define the test cycle, the loads, speeds, and distance must be selected based on the most critical takeoff conditions established by the applicant.

6.3.3.3 *Overload takeoff cycle*. The cycle must duplicate the takeoff cycles specified under paragraph 6.3.3.2 except that the tire load through the cycle must be increased by a factor of at least 1.5. Upon completion of the overload takeoff cycle, the tire must be capable of retaining air pressure with the loss of pressure not exceeding 10 percent in 24 hours from the initial test

pressure. Good condition of the tire tread is not required.

6.3.3.4 *Taxi cycles*. The tire must withstand at least 10 taxi cycles on a dynamometer under the following test conditions:

| Number of test cycles | Minimum tire load, lbs. | Minimum speed, mph | Minimum roll distance, ft. |
|---|---|---|---|
| 8 | Rated load | 40 | 35,000 |
| 2 | 1.2 times rated load. | 40 | 35,000 |

6.3.4 *Alternate dynamometer tests*. For tires with a speed rating of 160 mph, test cycles which simulate landing may be used in lieu of the takeoff cycles specified in paragraph 6.3.3.2 and 6.3.3.3. The tire must withstand 100 test cycles at rated load in accordance with paragraph 6.3.4.1 followed by 100 test cycles at rated load in accordance with paragraph 6.3.4.2.

6.3.4.1 *Low-speed landings*. In the first series of 100 landings, the test procedures for low-speed landings established under paragraphs 6.2.3 or 6.2.4, as appropriate, must be followed.

6.3.4.2 *High-speed landings*. In the second series of 100 landings, the test procedures for low-speed landings established under paragraph 6.2.3 or 6.2.4, as appropriate, must be followed, except that the tire must be landed against the flywheel rotating at a speed of 160 mph with the rated load applied for the duration of the test. The unlanding speed must be adjusted as necessary in order that 44 percent of the kinetic energy, as calculated in paragraph 6.2,2, is absorbed by the tire during the series of tests.

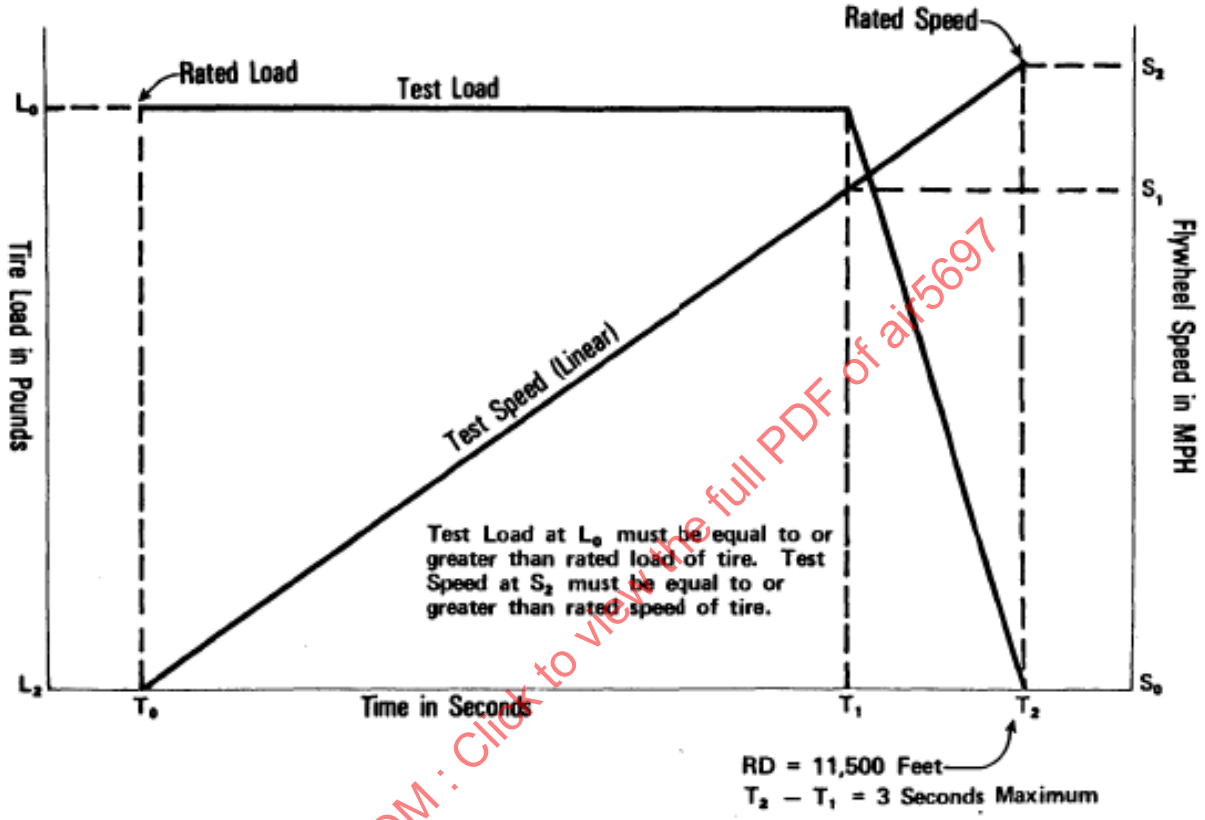
7.0 **Requalification tests**. Requalification in accordance with paragraph 6.0 of a given load rated tire required as a result of a tread design or material change will automatically qualify the same changes in a lesser load rated tire of the same size, speed rating, and skid depth provided-

7.1 The lesser load rated tire has been qualified to the applicable requirements specified in this standard; and

7.2 The ratio of qualifications testing load to rated load for the lesser load rated tire does not exceed the same ratio for the higher load rated tire at any given test condition.

**Figure 1**

**Graphic Representation of a Universal Load-Speed-Time Test Cycle**




**TSO-C62c**

**TSO-C62c**

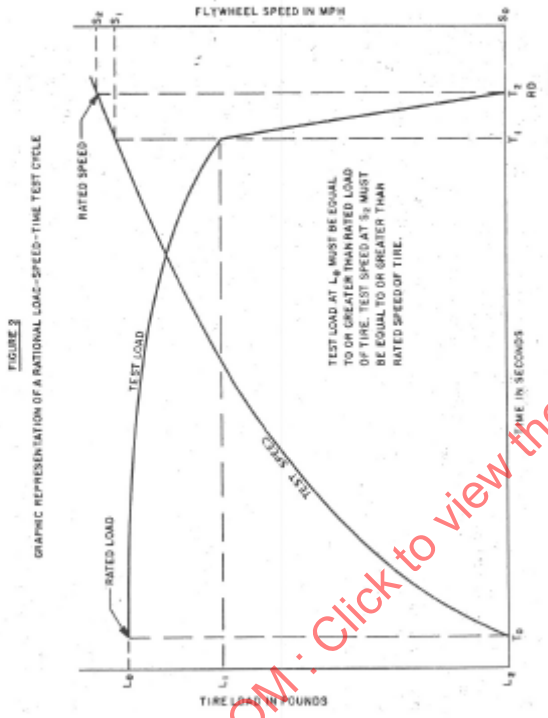



FIGURE 9
GRAPHIC REPRESENTATION OF A RATIONAL LOAD-SPEED-TIME TEST CYCLE

**5.8.22 Amendment 25-52, effective September 9, 1980 {Amendments 21-50 and 37-47}**

a. *Change to Regulation.*

**§** 37.167 Aircraft Tires --- TSO-C62c.

**§** 37.167 Aircraft Tires - TSO-C62c was eliminated from the regulations, previously published as Subpart B of 14 CFR Part 37, and was made available at FAA Headquarters in the Office of Airworthiness, Aircraft Engineering Division, Systems Branch (AWS-130) and at all regional flight Standards Engineering and Manufacturing offices. Part 37 was revoked. Subpart A of 14 CFR Part 37 became Subpart O of 14 CFR Part 21.

b. *Explanation.* Henceforth, a TSO is not a standard of general or particular applicability designed to implement or prescribe law or policy. It does not fall within the definition of “rule” contained in the Administrative Procedures Act (5 U.S.C. 551). There is no requirement that a TSO be published as a notice of proposed rulemaking in the Federal Register. A TSO thus becomes a voluntary standard. Future TSOs will, through incorporation by reference, make maximum use of “voluntary standards” as defined by the Office of Management and Budget (OMB) Circular A-119.