SAE Aerospace
An SAE International Group

AEROSPACE STANDARD

SAE AS4833

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Aircraft New Tire Standard - Bias and Radial

RATIONALE

This document has been reaffirmed to comply with the SAE 5-Year Review policy.

1. SCOPE:

This SAE Aerospace Standard (AS) sets forth criteria for the selection and verification processes to be followed in providing tires that will be suitable for intended use on civil aircraft. This document encompasses new and requalified radial and bias aircraft tires.

1.1 Purpose:

This document establishes the minimum recommended performance standards for new tires to be used on civil aircraft. All new or requalified tires shall meet these standards.

2. REFERENCES:

There are no referenced publications specified herein.

2.1 Definitions:

BIAS TIRE: A pneumatic tire in which the ply cords extend to the beads and are laid at alternate angles substantially less than 90° to the centerline of the tread.

RADIAL TIRE: A pneumatic tire in which the ply cords extend to the beads and are laid substantially at 90° to the centerline of the tread, the casing being stabilized by an essentially inextensible circumferential belt.

LOAD RATING: Load rating is the maximum permissible load at a specific inflation pressure. Load ratings are established and standardized by the Tire & Rim Association (TRA) or the European Tire & Rim Technical Organization (ETRTO). The rated load combined with the rated inflation pressure will be utilized when selecting tires for application to an aircraft and for testing to the performance requirements of this document.

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2.1 (Continued):

LOADED INFLATION PRESSURE: The recommended pressure determined by multiplying an unloaded calculated tire inflation pressure by the factor 1.04.

RATED INFLATION PRESSURE: The specified inflation pressure corresponding to the tire's static loaded radius at its rated load.

UNLOADED OPERATING INFLATION PRESSURE: The calculated inflation pressure for the tire's operating load based upon a tire's load rating at rated pressure.

MAXIMUM RAMP WEIGHT: The maximum ramp weight of an aircraft is its maximum operational weight. This maximum ramp weight shall be used to determine the minimum load ratings and corresponding inflation pressures of the tires used on an aircraft.

PLY RATING: This term is used to identify the maximum recommended load rating and inflation pressure for a specified tire. It is an index of tire strength.

MAIN TIRES: Main tires support the principal weight of the aircraft.

AUXILIARY TIRES: Auxiliary tires support the remaining weight of the aircraft not supported by the main tires.

NOSE TIRE: A nose tire is an auxiliary tire which is mounted on the front of the aircraft.

TAIL TIRE: A tail tire is an auxiliary tire which is mounted on the rear of an aircraft.

SINGLE TIRE APPLICATIONS: Single tire applications are those in which one tire/wheel assembly is provided to support the load carried by one landing gear strut.

MULTIPLE TIRE APPLICATIONS: Multiple tire applications are those where the load on one landing gear strut is shared by two or more tire/wheel assemblies.

SPEED RATING: The speed rating is the maximum ground speed to which the tire has been tested in accordance with this document.

DYNAMIC BRAKING LOAD: The load applied to a nose tire during deceleration of an aircraft during a landing or rejected takeoff (RTO).

STATIC LOADED RADIUS (SLR): The static loaded radius is the perpendicular distance between the axle centerline and the surface against which the tire is loaded, when supporting its rated load, while inflated to its rated inflation pressure.

3. TIRE IDENTIFICATION MARKINGS:

3.1 Airworthiness Compliance:

The tire shall be marked with the labeling required by the appropriate airworthiness authority standards, for example, Technical Standard Order (TSO-C62).

3.2 Load Rating:

Tires shall be marked with a load rating as established by the TRA or ETRTO for the specific tire ply rating.

3.3 Manufacturer's Name or Trademark:

Tires shall be marked with the name or registered trademark of the manufacturer responsible for compliance.

3.4 Ply Rating/Inflation Pressure:

Tires may be marked with a ply rating as established by the TRA or ETRTO. If ply rating is marked on the tire, the load rating marked on the tire must be consistent with the ply rating as established by the TRA or ETRTO.

If the tire is not marked with ply rating, it must be marked with the inflation pressure which is consistent with the load rating marked on the tire. This load and inflation pressure should be proportioned to the next higher ply rating rated load and inflation pressure for the tire size as established by the TRA or ETRTO.

3.5 Size:

Tires shall be marked with the size as established by the TRA or ETRTO.

3.6 Tire Manufacturer's Plant Code:

Each tire shall have a tire manufacturer's plant code, or country code if only one plant exists within a country, on the tire sidewall. This may be encoded in the serial number.

3.7 Date Code:

Each tire shall have the date of production marked on the sidewall. This may be encoded in the serial number.

3.8 Serial Number:

Each aircraft tire must have a unique identification number marked on one sidewall. This is referred to as the serial number and may include the plant code and date code.

3.9 Speed Rating:

All tires shall be marked with a speed rating in mph. This rating shall be equal to or less than the speed to which the tire has been qualified. The speed marked must be equivalent to those shown in 4.2.

3.10 Tire Manufacturer's Part Number:

Each tire shall have a tire manufacturer's part number marked on the tire sidewall.

3.11 Tube Type Tires:

Tube type tires require that a tube be used with the tire and wheel to maintain the inflation pressure within the assembly. The words "Tube Type" shall be marked on all tires requiring a tube in their operation.

4. DESIGN REQUIREMENTS:

4.1 General Standards:

Tires selected for use on a specific aircraft must be able to demonstrate their suitability through appropriate laboratory simulation of duty cycles of that aircraft.

4.1.1 Material Suitability:

4.1.1.1 Temperature: It shall be substantiated by applicable tests or shown by analysis that the physical properties of the tire materials are not degraded by exposure to temperature extremes of -40 °F and +160 °F for a period of not less than 24 h at each extreme.

4.1.1.2 Wheel Rim Heat: For braked tires, it shall be substantiated by the applicable tests or shown by analysis that the physical properties of the tire bead seat materials are not degraded by their exposure to a minimum temperature of 300 °F for at least 1 h.

4.2 Speed Rating:

The speed rating of the tire shall be equal to or greater than the maximum ground speed at takeoff that the aircraft will reach.

Applicable dynamometer test speeds for corresponding maximum takeoff speeds are as follows in Table 1.

For takeoff 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.

TABLE 1 - Applicable Dynamometer Test Speeds

Maximum Takeoff Speed of Aircraft - MPH Over	Maximum Takeoff Speed of Aircraft - MPH Not Over	Speed Rating of Tire - MPH	Minimum Dynamometer Speed at Liftoff (Figures 1, 2, or 3)
0	120	120	120
120	160	160	160
160	190	190	190
190	210	210	210
210	225	225	225
225	235	235	235
235	245	245	245

4.3 Overpressure:

The tire shall successfully withstand a hydrostatic pressure of at least four times its rated inflation pressure for 3 s without burst occurring.

4.4 Helicopter Tires:

Aircraft tires qualified in accordance with provisions of this standard may also be used on helicopters. In such cases, the maximum static load rating may be increased by a factor of 1.5 with a corresponding increase in rated inflation pressure without any additional qualification testing.

4.5 Dimensions:

The tire size with respect to outside diameter, shoulder diameter, section width and shoulder width shall be maintained within the tolerances established by the TRA or ETRTO.

4.5.1 Outside Diameter, Shoulder Diameter, Section Width and Shoulder Width: For the bias ply tire, outside diameter and section width are specified to a maximum and minimum value after a 12 h growth period at rated inflation pressure. Shoulder diameter and width dimensions are specified to a maximum value after a 12 h growth period at rated inflation pressure. Radial tire dimensions are limited by the grown tire envelope in accordance with the static loaded radius (SLR) requirement per 4.5.2.

Due to the increased inflation pressures permitted when using an aircraft tire in a helicopter application, tire dimensions are permitted to be 4% larger.

4.5.2 Static Loaded Radius (SLR):

4.5.2.1 Bias Tires: For bias tire constructions, the design SLR is specified by the TRA or ETRTO. The actual SLR shall be determined on a new tire which has been stretched for a minimum of 12 h at rated inflation pressure

4.5.2.2 Radial Tires: For radial tire constructions, the design SLR limits are specified by the TRA or ETRTO. The actual SLR of a radial tire shall be determined at rated inflation pressure after running 50 takeoffs per 5.3.2 requirements.

5. TIRE TEST REQUIREMENTS:

5.1 Balance:

All tires shall be tested for static unbalance.

5.1.1 Auxiliary Tires: The moment of static unbalance (M) for auxiliary tires shall not be greater than the value determined by using Equation 1.

$$M = 0.025D^2 \qquad \text{(Eq. 1)}$$

The values determined must be rounded off to the next lower whole number where M is in inch-ounces and D is the standardized maximum new tire inflated outside diameter of the tire in inches. Tires outside the limits must be corrected by an appropriate means.

5.1.2 Main Tires: The moment of static unbalance (M) for main tires shall not be greater than the value determined by using Equation 2:

$$M = 0.035D^2 \qquad \text{(Eq. 2)}$$

The values determined must be rounded off to the next lower whole number where M is in inch-ounces and D is the standardized maximum new inflated outside diameter of the tire in inches. Tires outside the limits must be corrected by an appropriate means.

5.2 Inflation Retention:

After an initial 12 h minimum stabilization period at rated inflation pressure, the tire must be capable of retaining inflation pressure with a loss of pressure not exceeding 5% in 24 h. Ambient temperature shall be measured at the start and finish of the test to assure that the pressure change was not caused by an ambient temperature change.

5.3 Qualification Procedure:

A single test specimen must be used for a qualification test. The tire must withstand the following cycles without detectable signs of deterioration, other than normal expected tread surface abrasion, except when the overload takeoff condition is run last (see 5.3.9).

5.3.1 Dynamometer Cycle Requirements: All aircraft tires shall satisfactorily withstand 58 dynamometer cycles as a demonstration of overall performance, plus 3 overload dynamometer cycles as a demonstration of the casing's capability under overload. The 58 dynamometer cycles shall consist of 50 takeoff cycles and 8 taxi cycles. The overload cycles shall consist of 2 taxi cycles at 1.2 times rated load and 1 overload takeoff cycle starting at 1.5 times rated load. The sequence of running the dynamometer cycles is optional. If the overload takeoff is not run last, the tire must not show detectable signs of deterioration, other than normal expected tread surface abrasion after this test.

5.3.2 Takeoff Cycles: The 50 takeoff cycles shall realistically simulate tire performance during runway operations for the most critical combination of takeoff weight and speed, and aircraft center-of-gravity position. Consideration must be given to increased speeds resulting from elevated airport operations and high ambient temperatures. The load-speed-time (LST) data shall be compiled by the airframe manufacturer in compliance with the applicable airworthiness authority requirements. Refer to Figures 1, 2, or 3 for graphic representations of the test.

Starting at zero speed, the tire shall be loaded against the dynamometer flywheel. The test cycles shall simulate one of the curves in Figure 1, 2, or 3.

a. Figure 1 defines a test cycle that is applicable to any aircraft tire with a speed rating of 120 mph or 160 mph.

b. Figure 2 defines a test cycle that is applicable to any aircraft tire with a speed rating greater than 160 mph.

c. Figure 3 defines a test cycle that is applicable for any speed rating and is based on the most critical takeoff loads, speeds and distances based on the airframe manufacturer's specifications.

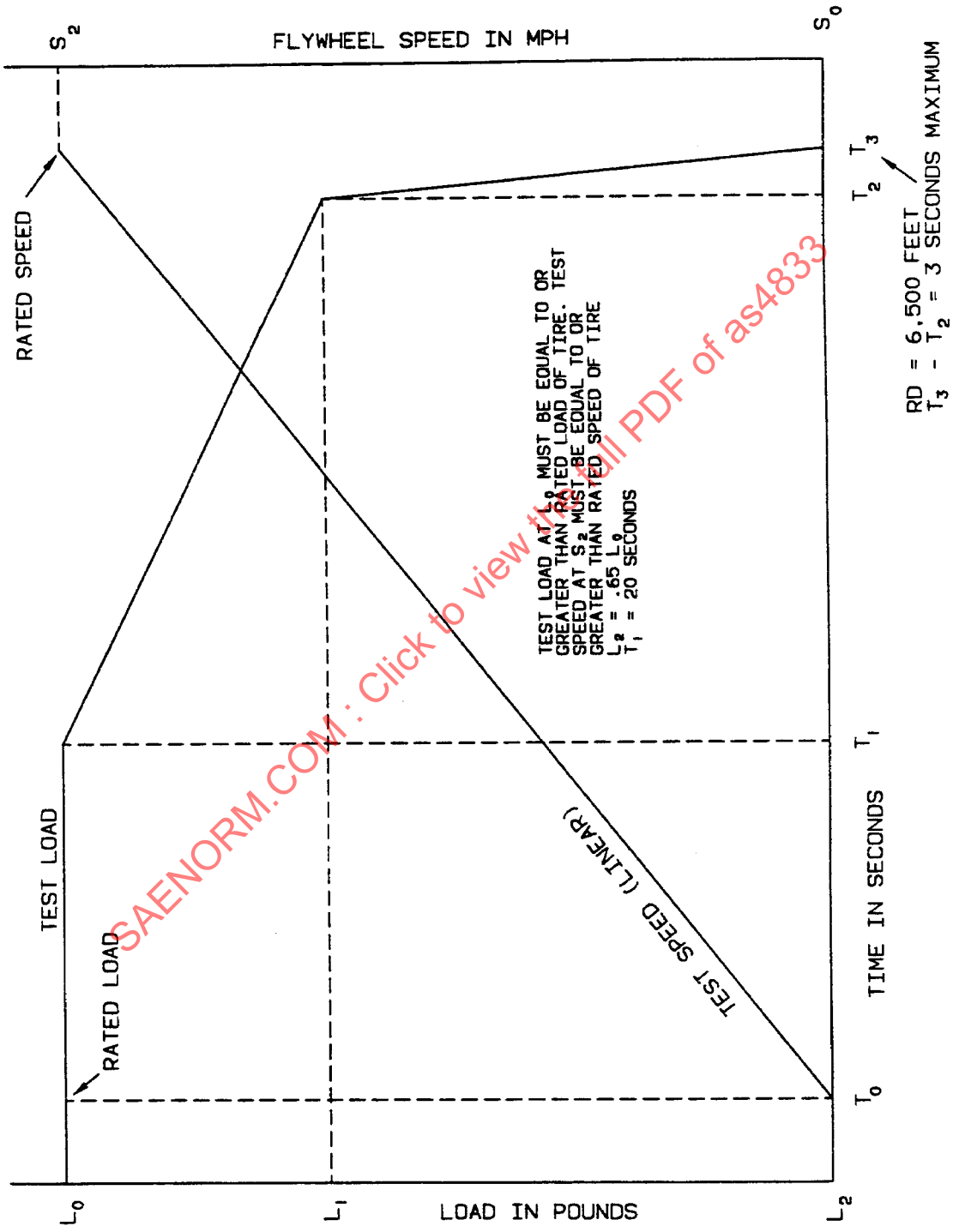

FIGURE 1 - Graphic Representation of a Universal Load-Speed-Time Test Cycle
(For 120 MPH and 160 MPH Tires)

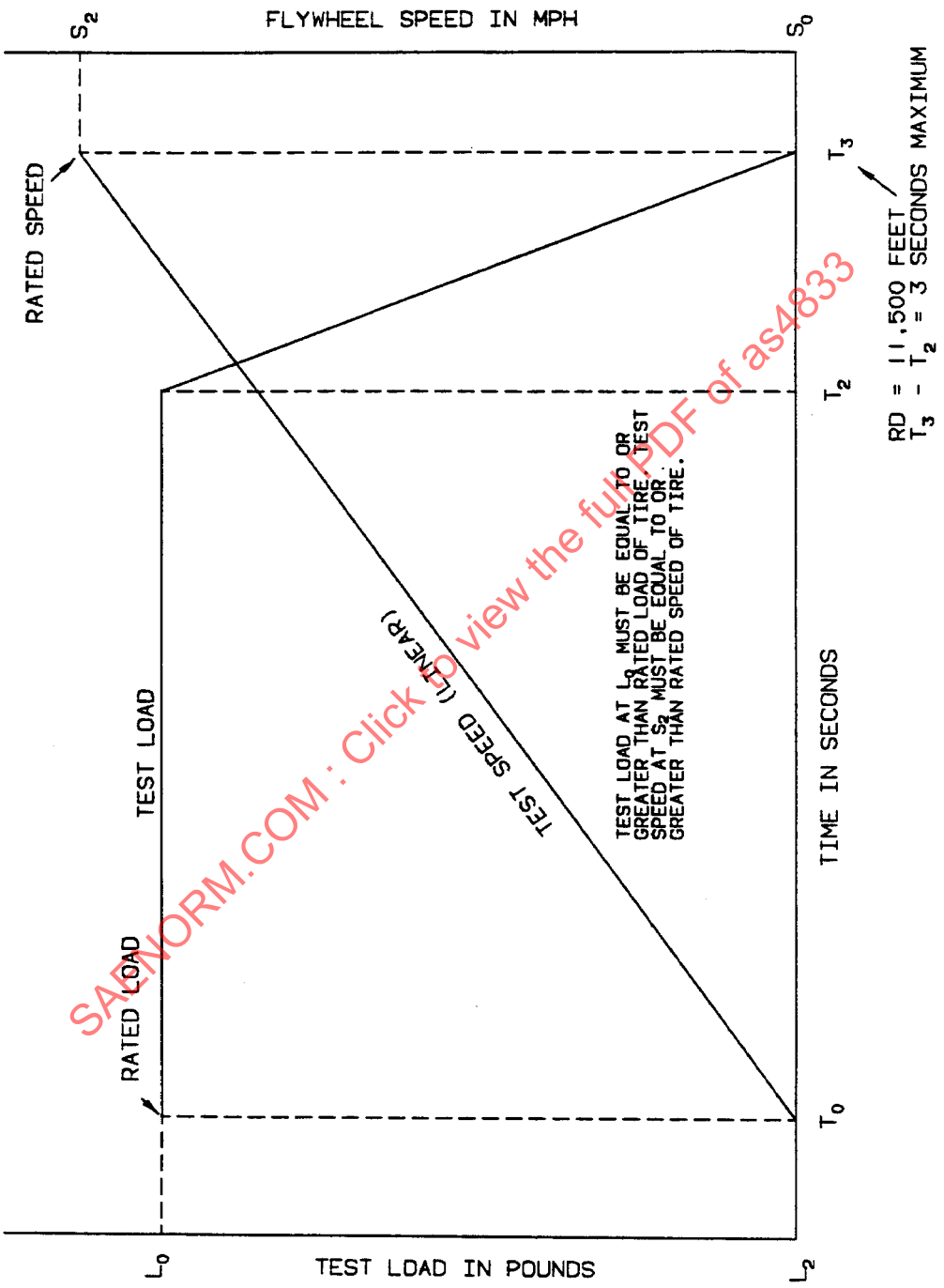

FIGURE 2 - Graphic Representation of a Universal Load-Speed-Time Test Cycle
(For Tires Rated Above 160 MPH)

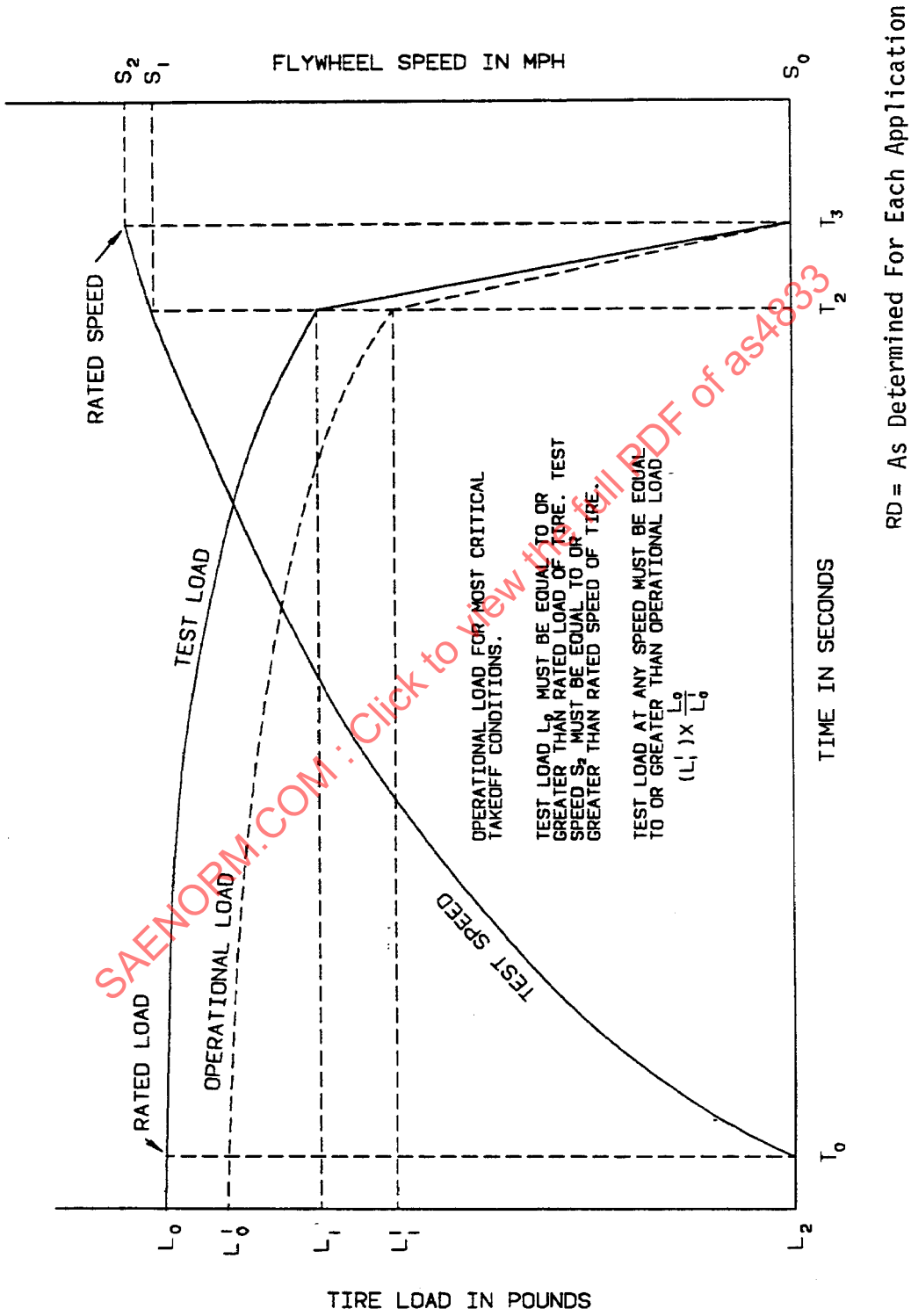

FIGURE 3 - Graphic Representation of a Rational Load-Speed-Time Test Cycle

5.3.3 Test Load: The load at the start of the test must be no less than the rated load of the tire. The test loads must conform to Figures 1, 2, or 3. Figures 1 and 2 define a test cycle that is generally applicable to any aircraft. If Figure 3 is used to define the test cycle, the loads must be selected based on the most critical takeoff conditions established by the applicant based on the data obtained from the airframe manufacturer. At any speed throughout the test cycle, the ratio of the test load to the airframe manufacturer's LST curve shall be the same as or greater than at the start of the test.

5.3.4 Test Inflation Pressure: The test inflation pressure shall be that which is necessary to provide the same loaded radius on the flywheel as was obtained on a flat surface at the rated load and inflation pressure of the tire. Both determinations shall be made at the same ambient temperature. An adjustment in test inflation pressure may not be made to compensate for changes created by temperature variations during the test.

5.3.5 Test Temperatures and Cycle Interval: The temperature of the gas contained in the tire or of the casing measured at the hottest point of the tire may not be lower than 105 °F at the start of the overload takeoff and at the start of at least 45 of the 50 takeoff cycles, and 120 °F at the start of at least 9 of the 10 taxi cycles. For the remaining cycles, the contained gas or casing temperature may not be lower than 80 °F at the start of each cycle. Rolling the tire on the dynamometer flywheel is acceptable to obtain the minimum starting temperature.

5.3.6 Dynamometer Takeoff Cycle Speeds: The dynamometer test speeds for corresponding maximum Aircraft takeoff speeds follow those shown in 4.2.

5.3.7 Symbol Definitions (Figures 1, 2, and 3):

LO = Tire load at start of takeoff in pounds (not less than the load rating), Figures 1, 2 and 3.
LO'= Tire load at start of takeoff in pounds for the operational load curve, Figure 3.
L1 = Tire load at rotation in pounds, Figures 1 and 3
L1' = Tire load at rotation in pounds, Figure 3
L2 = Tire load at liftoff, 0 pounds, Figures 1, 2 and 3
S0 = Zero (0) mph, Figures 1, 2 and 3
S1 = Speed at rotation in mph, Figure 3
S2 = Tire speed at liftoff in mph (not less than the speed rating), Figures 1, 2 and 3
T0 = Time at start of takeoff, 0 s, Figures 1, 2 and 3
T1 = 20 s, Figure 1
T2 = Time to rotation in seconds, Figures 1, 2 and 3
T3 = Time to liftoff in seconds, Figures 1, 2 and 3
RD = Tire Roll Distance in Feed

5.3.8 Taxi Cycles: The tire must withstand 10 taxi cycles on a dynamometer under the following test conditions:

TABLE 2 - Test Conditions

Number of Taxis	Minimum Tire Load-lb	Minimum Speed-MPH	Minimum Roll Distance-ft Tire Speed Rating-MPH 120/160	Minimum Roll Distance-ft Tire Speed Rating-MPH Over 160
8	Rated	40	25 000	35 000
2	1.2xRated	40	25 000	35 000

5.3.9 Overload Takeoff Cycle: The overload takeoff cycle shall duplicate the test noted in 5.3.2 except that the test load shall be increased by a factor of 1.5 throughout. Good condition of the tire tread is not required after completion of this test cycle if it is run last. If the overload takeoff cycle is not run last, it must withstand the cycle without detectable signs of deterioration, other than normal expected tread surface abrasion.

5.3.10 Diffusion Test: Upon completion of the 61 test cycles, the tire must be capable of retaining inflation pressure with the loss of pressure not exceeding 10% in 24 h from the initial test pressure. Ambient temperature should be measured at the start and finish of this test to assure that the pressure change was not caused by an ambient temperature change.

5.3.11 Tire/Wheel Slippage: Slippage of the tire on the rim during dynamometer testing must not damage the tube valve of tube type tires, or the gas seal of the tire bead of tubeless tires.

5.4 Alternate Qualification Procedures - 120 MPH Rated Tires:

For 120 mph speed rating tires, the following variable mass flywheel procedure may be used:

5.4.1 Test Load: The load must not be less than the rated load of the tire during the entire roll distance of the test.

5.4.2 Test Inflation Pressure: The test inflation pressure shall be that which is necessary to provide the same loaded radius on the flywheel as was obtained on a flat surface at the rated load and inflation pressure of the tire. Both determinations shall be made at the same ambient temperature. An adjustment in test inflation pressure may not be made to compensate for changes created by temperature variations during the test.

5.4.3 Temperature and Cycle Interval: The temperature of the gas contained in the tire or of the casing measured at the hottest point of the tire may not be lower than 105 °F at the start of at least 180 of the 200 landing cycles. For the remaining cycles, the contained gas or casing temperature may not be lower than 80 °F at the start of each cycle. Rolling on the dynamometer is acceptable for obtaining the minimum starting temperature.

5.4.4 Kinetic Energy: The kinetic energy of the flywheel to be absorbed by the tire must be calculated as follows:

$$KE = CW(V^2) = \text{Kinetic Energy in ft-lb} \qquad \text{(Eq. 3)}$$

where:

C = 0.0113
W = Load rating of the tire in pounds
V = 120 mph

5.4.5 Dynamometer Cycle Requirements: The tire shall satisfactorily withstand 200 landing cycles on a variable mass dynamometer flywheel. If the exact number of flywheel plates cannot be used to obtain the calculated kinetic energy value, a greater number of plates must be selected and the dynamometer speed adjusted to obtain the required kinetic energy. The total number of dynamometer landings must be divided into two equal parts having the speed ranges shown below.

5.4.5.1 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% of the kinetic energy calculated under 5.4.4 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% of the calculated kinetic energy under 5.4.4 to the flywheel kinetic energy at 64 mph, and the unlanding speed must be determined by subtracting 28% of the kinetic energy calculated under 5.4.4 from the flywheel kinetic energy at 64 mph.

5.4.5.2 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% of the kinetic energy calculated under 5.4.4 will be absorbed by the tire.

6. REQUALIFICATION:

A tire shall be requalified if there are any changes in materials, design, or manufacturing processes that could adversely affect tire reliability.

6.1 Requalification By Similarity Based on Load Rating:

Requalification 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 the lesser load rated tire has been qualified to the applicable requirements specified in this standard and the ratio of qualification test load to rated load for the lesser load rated tire does not exceed the same ratio to the higher load rated tire at any given test condition.