SAE Aerospace
An SAE International Group

AEROSPACE RECOMMENDED PRACTICE

SAE ARP4834

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Aircraft Tire Retreading Practice - Bias and Radial

RATIONALE

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

1. SCOPE:

This SAE Aerospace Recommended Practice (ARP) sets forth criteria for the selection, inspection, retread and repair of worn civil aircraft tires, and the means to verify that the retreaded tire is suitable for continued service. This document is applicable to both bias ply and radial aircraft tires qualified subsequent to the adoption of this document.

1.1 Purpose:

This document sets forth the minimum recommended requirements for retreaded tires used on civil aircraft. It also provides criteria for the escalation of retread level of tires used on civil aircraft. The combined recommendations contained in this document form, an acceptable practice, but not the only practice, for retreaded aircraft tires.

2. REFERENCES:

2.1 Applicable Documents:

The following publications form a part of this specification 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 specification and references cited herein, the text of this specification takes precedence. Nothing in this specification, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AS4833 Aircraft New Tire Standard - Bias and Radial

2.1.2 ASTM Publications: Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM D 413 American Society for Testing and Materials - Rubber Property: Adhesion to Flexible Substrate

2.1.3 FAA Publications: Available from FAA, 800 Independence Avenue, SW, Washington, DC 20591.

FAA AC145-4	Advisory Circular - Inspection, Retread, Repair and Alteration of Aircraft Tires
FAA TSO-C62d	Technical Standard Order - Tires
FAA FAR21	Federal Aviation Regulation - Part 21

2.2 Applicable References:

T&RA Tire and Rim Association - Standards

ETRTO European Tire and Rim Technical Organization - Standards

3. DEFINITIONS:

RETREADING: The term retreading refers to the methods of restoring a worn tire by renewing the tread area, or by renewing the tread area plus one or both sidewalls. Repairs are included in the tire retreading process.

PROCESS SPECIFICATION: Documents approved by the cognizant airworthiness authorities which contain information for performing specialized maintenance, such as retreading tires.

RETREAD LEVEL (R-LEVEL) ESCALATION: Retread level (R-level) escalation is the process used to verify that a population of retreaded tires is suitable for an additional service life.

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 standard.

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.

SPEED RATING: The speed rating is the maximum takeoff speed to which the tire has been tested.

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.

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.

3. (Continued):

NOSE TIRE: A nose tire is an auxiliary tire which is mounted forward of the center of gravity of an aircraft.

TAIL TIRE: A tail tire is an auxiliary tire which is mounted aft of the center of gravity of an aircraft.

CASING: The casing is the structural part of the tire.

COMPATIBLE CASING: A compatible casing for retreading is one capable of passing all acceptance criteria of the retreader for that size, ply rating, and speed rating.

4. MARKINGS:

4.1 Retread Identification:

The following minimum information must appear in permanent markings between the wearing surface and the edge of the newly applied rubber.

a. Retreader's name or trademark
b. Retread plant identification
c. Month and year of retread
d. The letter "R" followed by the number of times that retreading has been performed on the casing.

4.2 Casing Identification:

Retread processing may obliterate some or all of the casing identification. The following information must be restored if removed during retread processing:

a. Airworthiness compliance markings
b. Load rating
c. Casing manufacturer's name or trademark
d. Ply rating or inflation pressure
e. Size
f. Casing manufacturer's plant code
g. Date of manufacture
h. Serial number
i. Speed rating
j. Casing manufacturer's part number
k. Tube type, if applicable

4.3 Regrading Procedure:

a. The ply rating/load rating and/or speed rating on either the casing or the retread may be decreased without approval. All performance and qualification parameters under the new rating must be met.

4.3 (Continued):

b. If the casing ply rating, load rating and speed rating do not agree with the retread markings, they must be buffed off, and the correct markings applied.

c. The casing manufacturer's part number must not be altered without the appropriate airworthiness authority approval.

4.4 Cut Identification:

Radial casings containing cut repairs in the tread area at the maximum allowable limit should be identified with a sidewall brand. The guidelines and conditions under which this brand is applied should be specified by the casing manufacturer and be on file with the cognizant airworthiness authority.

5. CASING SELECTION:

The new tire casing must have been approved by the cognizant airworthiness authority. Unless otherwise restricted by the manufacturer or airworthiness authority, any aircraft tire may be retreaded provided that it meets the inspection and defect limitation criteria established in the retreader's process specification approved by the cognizant airworthiness authority.

5.1 Inspection:

The following non destructive inspection techniques are available in the industry.

5.1.1 Visual: All tires shall be visually inspected in the tread, sidewall, bead and liner areas for conditions which need repair or which cause the tire to be scrapped.

5.1.2 Air Injection: Tubeless tires may be air injected with a dry filtered gas (i.e., air/nitrogen) to inspect the casing for proper venting, separations, bead and liner condition, etc. Typical air injection pressure range is 100 to 125 psi.

5.1.3 Other Testing: Holographiy, shearography, ultrasonics, X-ray, etc. should be used as necessary.

5.2 Disposition of Tire Casings:

5.2.1 Acceptable Casings: Tires which meet the acceptable limits for repair listed in the retreader's process specification shall be repaired/retreaded and returned to service.

5.2.2 Nonacceptable Casings: Tires which fail the acceptable limits for repair listed in the retreader's process specification shall be rejected from further aircraft use. Casings not returned to the customer should have the serial number and airworthiness compliance markings removed or obliterated.

6. REPAIRING:

Repairs are permitted if the anomaly does not exceed the limitations of the casing manufacturer or the rejection criteria specified in the retreader's process specification as approved by the cognizant airworthiness authority.

The repair procedures must also be specified in the retreader's process specification and be approved by the cognizant airworthiness authority.

See Appendix A for bias tire guidelines. Radial tire guidelines are under development.

Each retreader should file a plan with the cognizant airworthiness authority for validating the maximum permissible repair before it is entered into service.

7. RETREADING PROCESS:

The retreading process includes removal of old material, renewing the tread area and curing and bonding of the new material to the casing. A process specification describing each retreader's process must be approved by the cognizant airworthiness authority.

Unworn retreaded tires often weigh more than the new tire. Retreaded tires having the same skid depth as the original new tire may weigh up to 5% more. In no case should the retreaded tire exceed the maximum weight specified by the airframe manufacturer.

8. QUALIFICATION TESTING:

The test procedures described herein are intended to ensure compatibility between the original tire casing and newly applied retread. The retread should not fail the applicable dynamometer tests specified herein or have any signs of structural deterioration other than normal expected treadwear. Casings selected for retread tests should be worn at least 80% of their new tire skid depth by aircraft usage or have undergone simulated equivalent operation through dynamometer cycling.

The differences in design and construction between radial tires of different manufacture dictate that retread dynamometer testing be conducted on each manufacturer's casing. Qualification of bias tire retreads on a single manufacturer's casing qualifies the retread on other manufacturers' compatible casings of the same size, ply rating and speed rating.

8.1 Dynamometer Cycles:

The retread test tire shall satisfactorily withstand 61 dynamometer cycles as a demonstration of overall performance. The 61 dynamometer cycles shall consist of 50 takeoff cycles, 8 taxi cycles at rated load, 2 taxi cycles at 1.2 times rated load, and 1 overload takeoff cycle starting at 1.5 times rated load. The sequence of the cycles is optional. A single tire specimen must be used to complete these cycles.

8.1.1 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 should 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 FAR requirements. Refer to Figures 1, 2, or 3 for graphic representation of test.

Starting at zero speed, the tire shall be loaded against the dynamometer wheel. The test cycles shall simulate one of the curves in Figures 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 above 160 mph.

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

8.1.2 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 operational load shall be the same as at the start of the test.

8.1.3 Test Inflation Pressure: The test inflation pressure shall be that which is necessary to provide the same static loaded radius on the curved surface 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.

8.1.4 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 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 is acceptable to obtain the minimum starting temperature.

8.1.5 Dynamometer Takeoff Test Speeds: Applicable dynamometer test speeds for corresponding maximum takeoff speeds are as follows in Table 1.

For takeoff speeds over 245 mph, the tire is required to be tested to the maximum applicable load-speed-time requirements and appropriately identified with the proper speed rating.

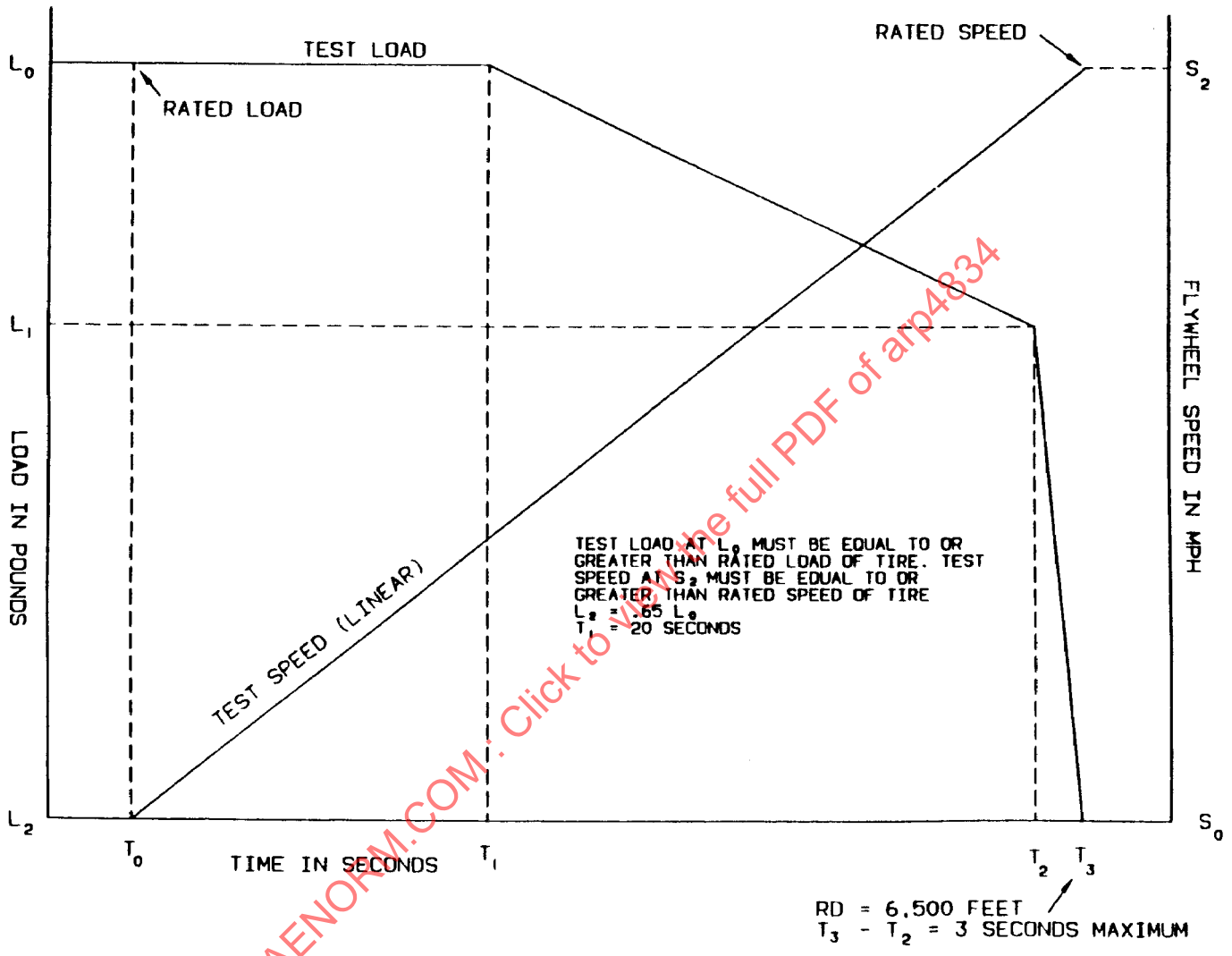

FIGURE 1 - Graphic Representation of a Universal Load-Speed-Time Test Cycle
(for 120 MPH and 160 MPH Tires)

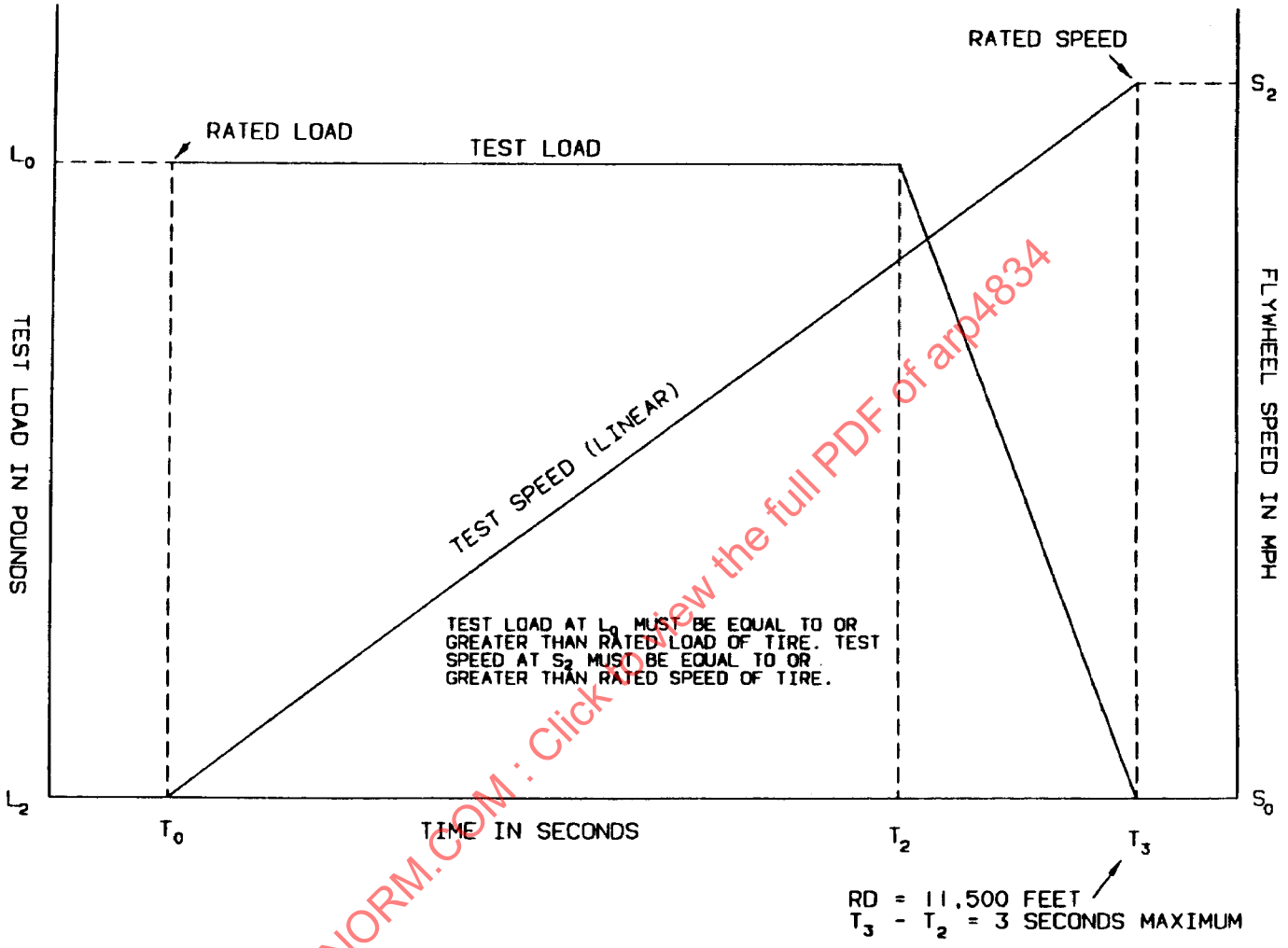

FIGURE 2 - Graphic Representation of a Universal Load-Speed-Time Test Cycle
(for Tires Rated Above 160 MPH)

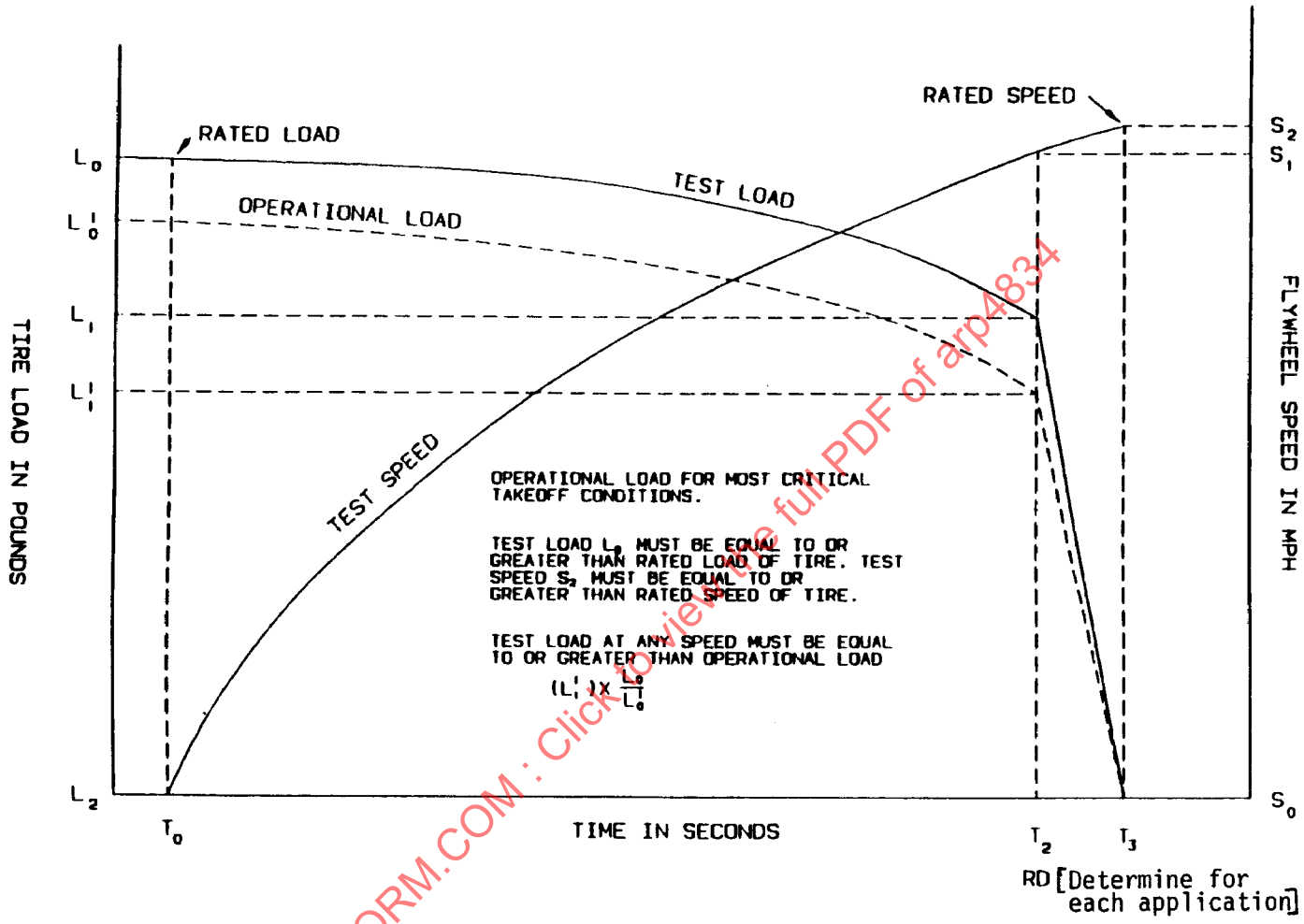

FIGURE 3 - Graphic Representation of a Rational Load-Speed-Time Test Cycle

TABLE 1 - Takeoff 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 Takeoff Figures 1, 2, 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

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

L_{o_1} = Tire load at start of takeoff in pounds (not less than the load rating), Figures 1, 2 and 3
L_{o_1} = Tire load at the start of takeoff in pounds for the operational load curve, Figure 3
L_{11} = Tire load at rotation in pounds, Figures 1 and 3
L_1 = Tire load at rotation in pounds for the operational load curve, Figure 3
L_2 = Tire load at liftoff, zero (0) pounds, Figures 1, 2 and 3
S_0 = Zero (0) mph, Figures 1, 2 and 3
S_1 = Speed at rotation in mph, Figure 3
S_2 = Tire speed at liftoff in mph (not less than the speed rating), Figures 1, 2 and 3
T_0 = Time at start of takeoff, zero (0) seconds, Figures 1, 2 and 3
T_1 = Twenty (20) seconds, Figure 1
T_2 = Time to rotation in seconds, Figures 1, 2 and 3
T_3 = Time to liftoff in seconds, Figures 1, 2 and 3
RD = Tire Roll Distance in Feed

8.1.7 Taxi Cycles: The tire must withstand at least 10 taxi cycles on a dynamometer under the following test conditions in Table 2:

TABLE 2 - Taxi Cycles

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	1.2 X Rated	40	25 000	35 000

8.1.8 Overload Takeoff Cycle: The overload takeoff cycle shall duplicate the test noted in 8.1.1 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.

8.1.9 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.

8.2 Alternate Qualification Procedures - 120 MPH Rated Tire:

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

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

8.2.2 Test Inflation Pressure: The test inflation pressure shall be that which is necessary to provide the same loaded radius on the curved surface as was obtained on a flat surface at the rated load and inflation pressure of the tire. Both determinations shall be 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.

8.2.3 Test 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.

8.2.4 Kinetic Energy: The kinetic energy of the dynamometer wheel to be absorbed by the tire must be calculated as follows in Equation 1:

$$KE = CW(V^2) = \text{Kinetic Energy in foot-pounds} \qquad \text{(Eq. 1)}$$

where:

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

8.2.5 Dynamometer Cycle Requirements: The tire shall satisfactorily withstand 200 landing cycles on a variable mass dynamometer wheel. If the exact number of wheel 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.

8.2.5.1 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 8.2.4 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 8.2.4 to the flywheel kinetic energy at 64 mph, and the unlanding speed must be determined by subtracting 28% of the kinetic energy calculated under 8.2.4 from the flywheel kinetic energy at 64 mph.

8.2.5.2 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 8.2.4 will be absorbed by the tire.

8.3 Requalification:

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

8.3.1 Requalification By Similarity Based on Load Rating: Requalification of a given load rated retreaded tire required as a result of a retread tread design or material change will automatically qualify the same changes in a lesser load rated retreaded tire of the same size, speed rating, and skid depth provided the lesser load rated retreaded tire has been qualified to the applicable requirements specified in this standard.

8.3.2 Requalification By Similarity - Blanket Change: Requalification of any change which affects multiple sizes may be made by similarity provided:

a. Five representative sizes, including tires of the highest load and speed rating and angular velocity, have been qualified to the minimum performance standard with the change, and,

b. This data in support of the change in the listed sizes should be submitted to and approved by the cognizant airworthiness authority.

8.4 Overpressure:

A retreaded tire, processed similarly to the example tested on the dynamometer, shall successfully withstand a hydrostatic pressure of three times its rated pressure for 3 s without failure. The tire used to do the dynamometer qualification testing may be used if desired.

8.5 Tire/Rim 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.

9. RETREAD DIMENSIONS:

The retreaded tire size, when inflated to rated inflation pressure and allowed to stretch due to inflation for 12 h, must meet the grown tire dimensional envelope established for that size by TRA or ETRTO. In addition, the retreaded tire, when inflated to its rated pressure and rotated at its rated speed, must meet the “grown and thrown” dimensional envelope established for that size by TRA or ETRTO.

10. RETREAD BALANCE:

All tires must be tested for static unbalance.

10.1 Auxiliary Tires:

The moment of static unbalance (M) for auxiliary tires shall not be greater than the value determined by the following formula:

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

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

10.2 Main Tires:

The moment of static unbalance (M) for main tires shall not be greater than the value determined by using Equation 3:

$$M = 0.035\ D^2 \qquad \text{(Eq. 3)}$$

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

11. INFLATION RETENTION:

After an initial 12 h minimum stabilization period at the 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 and the pressure corrected to account for the pressure change caused by an ambient temperature change.