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SURFACE VEHICLE RECOMMENDED PRACTICE

Submitted for recognition as an American National Standard

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(R) WET OR DRY PAVEMENT PASSENGER CAR TIRE PEAK AND LOCKED WHEEL BRAKING TRACTION

Foreword—This Document has not changed other than to put it into the new SAE Technical Standards Board Format.

1. ***Scope***—This SAE Recommended Practice defines the best known techniques for evaluating peak and locked wheel braking traction. It covers an important phase of tire braking traction, namely, the wet or dry pavement straight ahead conditions. However, this is but a small portion of the whole field of tire traction. As test procedures are established for other phases of this complex study, additional supplementary procedures will be written. A discussion of this entire subject is contained in Appendix B to this recommended practice.

1.1 **Object**—The object of this SAE Recommended Practice is to provide a general test procedure for measuring the braking traction of passenger car tires on wet or dry pavement.

2. ***References***—There are no referenced publications specified herein.

3. ***Preparation of Tire(s) for Tests***—New tires, both control and design tires to be tested, shall be trimmed to remove all protuberances in the tread area caused by mold air vents or flashes at mold junctions. Tires shall be mounted on Tire and Rim Association (T&RA) recommended rims; inflated to 24 psi; loaded to (80–100%) T&RA maximum load for 24 psi; and run on a passenger car for 100 miles at 60–70 mph on dry roads, 50 miles on front wheels and 50 miles on rear wheels. This is a break-in run to remove mold lubricant and mold sheen from the tread surface. Excessive acceleration, braking, and cornering that might result in abnormal tread surface wear are to be avoided.

4. ***Equipment***—A suitable test device designed to measure tire braking forces and meeting requirements outlined in Appendix A.

Control reference tires of specified design, compounds, and construction.

5. ***Test Procedure***

5.1 **Test Conditions**

Load: 100% T&RA load limit at 24 psi ± 25 lb
Inflation Pressure: 24 psi cold ± 1/2 psi
Test Speed: 20, 40, 60 ± 1 mph

5.2 **Test Surface—**Test surface shall be any clean, level surface for which tire-surface braking coefficient information is required. In tests requiring vehicle provided watering, the test surface shall be watered at a rate proportional to speed to provide a 0.020 in. ± 25% calculated film depth independent of test speed. External watering may be provided to fulfill any specific test condition.

5.3 **Testing Procedure—**Bring test device up to test speed prior to reaching test site. Apply brakes on test wheel(s) until wheels are locked. Hold wheels locked for a minimum of two seconds. Hold test vehicle at required test speed ±1 mph. Record tire braking traction force, vehicle speed, and all other desired parameters, starting a minimum of 1 sec before initiation of lockup to 1 sec after unlocking the test tire.

For each specific test, a minimum of ten readings, five each in opposite directions, are to be made for each tire.

The sequence of testing to be as follows:

a. Control test tire.
b. Tests of tire(s) to be evaluated (no more than two).
c. Repeat of control test tire.
d. Repetition of steps (b) and (c) to complete all required test tires.

For each test, record the following information:

a. Tire description (make, type, size, cord material, etc.)
b. Tire static load.
c. Tire cold inflation pressure.
d. Date.
e. Time.
f. Ambient temperature.
g. Surface temperature.
h. Water temperature.
i. Speed.
j. Surface description.
k. Water depth.
l. Whether force or torque.
m. General remarks.

6. Data Reduction and Analysis

6.1 **Raw Data Reduction—**Peak and locked wheel sliding force shall be read for each specific test run. The sliding value shall be the average value between 0.2 and 1.2 sec after the test wheel lockup. The data processor should note any unusual anomalies appearing in the data.

6.2 **Data Reduction—**Each separate peak and sliding coefficient should be reduced to a braking coefficient by dividing the force by the applicable tire vertical load corresponding to the force. If the test equipment used is a trailer which does not measure the tire load, changes in tire load due to weight transfer must be compensated for by calculating coefficient according to the following formula:

$$\text{Braking Coefficient } (\mu) = \frac{F}{W - \frac{h}{L}F} \quad \text{(Eq. 1)}$$

where:

F = friction force, lb (per wheel)
W = static trailer weight, lb (per wheel)
h = trailer hitch height, in.
L = trailer wheel base length, center of axle to center of hitch, in.

All 10 individual coefficients are to be averaged. Calculate the standard deviation to provide an index of data variance by the following formula:

$$\text{Standard Deviation} = \sqrt{\frac{\sum_{i=1}^{n}(X_i - \bar{X})^2}{n-1}} \qquad \text{(Eq. 2)}$$

where:

X_i = individual data points
$\bar{X}$ = average of data points
n = total number of data points

6.3 Data Analysis—Each averaged data point for a test tire at a test condition provides a measure of the braking traction value of the specific tire and surface combination under the conditions at the time of that test.

7. Notes

7.1 Marginal Indicia—The change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. An (R) symbol to the left of the document title indicates a complete revision of the report.

PREPARED BY THE SAE TIRE COMMITTEE

APPENDIX A

PERFORMANCE SPECIFICATIONS FOR A TIRE BRAKING TRACTION COEFFICIENT TEST DEVICE

A.1 Scope—This specification is designed to provide needed performance specifications for a device to evaluate tire braking traction coefficients. Specifications are provided for force measuring as well as torque measuring transducers. However, torque transducers are not recommended for tire testing and should be considered as a temporary expediency. Consult Appendix B for further discussion.

A.2 Specifications—The following specification assumes design conforming to good engineering practice to provide those requirements dictated by experience which are necessary to produce the most repeatable, accurate, and significant data. This specification is written, in general, for a trailer type device. However, all basic design criteria are relevant for any type of equipment.

A.3 Trailer (if device is of trailer type)

A.3.1 Suspension system shall provide adequate load carrying capabilities and be of such a design as to isolate suspension resonance.

A.3.2 Trailer shall be designed to allow loading to at least 100% of 24 psi T&RA loads for all listed passenger car tire sizes.

A.3.3 Trailer shall be designed to allow the hitch height to be no higher than loaded tire radius and the length from hitch ball to axle centerline to be no less than 10 times hitch height.

A.3.4 Trailer shall be designed to accommodate all T&RA passenger car rim sizes.

A.3.5 Location of center of gravity height should be as close as possible to trailer hitch height.

A.3.6 Hitch vertical load should be 150 ± 50 lb.

A.3.7 It is desirable to have a trailer hitch arrangement such that the trailer can be towed in line or offset with the towing vehicle tires. For external watering, the trailer hitch on the towing vehicle shall be so arranged that the trailer tires will run in tracks separate from the tire tracks of the towing vehicle.

A.4 Transducers

A.4.1 Force Measuring—The tire force measuring transducer should be designed to measure tire force with minimum inertial effects. Transducer should have an output directly proportional to force with less than 1% hysteresis and less than 1% nonlinearity. It should have less than 1% sensitivity to any expected cross axis loading or torque loading. The transducer shall be suspended in such a manner as to experience less than 1 deg angular rotation with respect to its measuring plane at the maximum expected loading.

A.4.2 Torque Measuring—A torque measuring transducer is not recommended for tire testing. If requirements dictate use of a device of this type, the transducer must meet the following performance specifications:

Transducer shall provide an output directly proportional to torque with less than 1% hysteresis and less than 1% nonlinearity. It should have less than 1% sensitivity to any expected cross axis loading.

A.4.3 Additional transducer outputs for measuring quantities, such as vertical load, etc., must meet requirements stated in A4.1.

A.4.4 Vehicle speed measuring transducers, such as "fifth wheel," etc., shall provide speed resolution better than ±0.5 mph over the expected range of operation. Output should be directly viewable by operator and also recorded.

A.5 Signal Conditioning and Recorder System

A.5.1 All transducers measuring parameters subject to inertia loading should be designed and/or located in such a manner as to minimize this effect. If the foregoing is not practical, data correction must be made for these effects if they exceeded 2% of actual data based on expected operation. All signal conditioning and recorder are to be capable of providing linear output with necessary gain to allow better than 2% data reading resolution. All systems must provide a minimum band width of at least 0–20 Hz (flat ±2%).

A.5.2 All strain gage transducers must be equipped with resistance shunt calibration resistors which can be applied before and after test sequences.

A.5.3 Vehicle speed, tire friction force, and a time base signal must be recorded in phase (0–20 Hz ± 5 deg). Any additional desired inputs, such as vertical load, wheel speed, torque, etc., must meet these requirements as well as the requirements in 5.1.

A.5.4 All cabling and system design to follow good engineering practice with respect to environment protection. A signal-to-noise ratio *of at least* 20/1 is desirable on all recorded channels.

A.6 Towing Vehicle

A.6.1 Towing vehicle and trailer must comply with all legal requirements applicable to state or states when operated on public roads.

A.6.2 Vehicle should have sufficient engine capacity to provide an adequate speed range and to allow 60 mph measurements with a speed loss of not greater than 1 mph.

A.7 Watering System

A.7.1 Either a self-contained watering system or a method for wetting a test pad to a uniform prescribed depth may be used.

A.7.2 A self-contained watering system, if deemed necessary, shall water at a rate to provide a uniform calculated film thickness of 0.020 ± 25%, regardless of speed, and at least as wide as the test tire.

A.7.3 Adequate water storage should be supplied to meet individual needs.

A.7.4 A water nozzle system for trailer shall be of such a design as to meet the requirements of A7.2.

A.8 Calibration

A.8.1 Each wheel of the assembled unit with its own instrumentation should be placed on a suitable calibration platform and loaded vertically to the test load and with the correct tire pressure. The entire trailer should be leveled. The calibration platform should utilize air bearings (or equivalent) so that the platform is not able to induce any lateral or fore and aft forces. Care must be taken to assure applied load is in plane of transducer sensitivity.

Incremental loading should be applied up to a fore-aft force of at least 70% of T&RA load at 24 psi.

A.8.2 The foregoing technique is suitable for calibrating all other transducers, including brake torque devices. A calibration of torque transducers by this method is accurate only for the tire used at the load, pressure, and environment at the time of test calibration. While this provides a partial correction for footprint center point relocation, it in no way reduces the inherent errors explained in Appendix B unless each and every tire is calibrated at test load and pressure. Pure torque arm calibration is suitable assuming calibrations are corrected for individual test tire static loaded radius. This method does not give any correction for footprint center point location.

A.8.3 Test Equipment—Reference load cells, instrumentation, etc. should have an accuracy and sensitivity of at least twice that of the object system. This will insure reasonable accuracy and resolution during calibration.

A.8.4 Sound engineering practices and judgment should be used throughout the calibration process.