



SURFACE VEHICLE INFORMATION REPORT

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The Measurement of Highway Truck and Bus Tire Rolling Resistance

RATIONALE

This technical report is being stabilized because the technical committee has determined that the using community is moving towards newer technology and would like to alert users that this new technology exists which may want to be considered for new design. Refer to SAE J1269 and SAE J1270 for rolling resistance measurement.

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THE MEASUREMENT OF HIGHWAY TRUCK AND BUS TIRE ROLLING RESISTANCE—SAE J1380 AUG83

SAE Information Report

Report of the Truck and Bus Fuel Economy Committee, approved June 1982, revised August 1983.

1. Introduction—This information report is a companion document to SAE Recommended Practice, J1379, "Rolling Resistance Measurement Procedure for Highway Truck and Bus Tires." It provides background information and explanations related to the use of the measurement procedure and follows the same format as SAE J1379.

2. Scope

2.1 Basic Methods—The force, torque, and energy methods of measurement are all in common use and should yield the same test results. Effects of steering, traction, and non steady-state tire operations are excluded from the recommended practice because they are still in the research stage. Methods of correcting laboratory data to road conditions are being developed.

2.1.1 FORCE METHOD—The chief advantage of the force method is that the only parasitic losses in the measurement are tire spindle bearing losses and aerodynamic losses associated with rotation of the tire and wheel assembly. The main disadvantage is that the small longitudinal spindle force, which includes the rolling resistance, may be seriously affected by the very large tire vertical load or by transducer crosstalk. The elimination or compensation of both effects is necessary. A secondary disadvantage is that the loaded radius of the tire must be measured in order to convert spindle force to rolling resistance.

2.1.2 TORQUE METHOD—The torque method has the advantage that the measurement is direct and simple, as the rolling resistance is merely the torque reading divided by the laboratory test wheel radius. Equipment can be calibrated to read directly in rolling resistance if so desired. The main disadvantage of the torque method is that the parasitic losses contained in the measurement include test wheel losses as well as tire spindle rotational losses.

The parasitic losses are larger than for the force method and can be of the same order of magnitude as the rolling resistance itself. Another disadvantage is that speed-hunting oscillations in the drive motor can introduce errors.

2.1.3 ENERGY METHOD—The advantage of the energy method is the low cost and simplicity of instrumentation. No force or torque transducer is necessary. A voltmeter and an ammeter to measure the electrical energy input to the drive system are sufficient. The chief disadvantage of the energy method is that electrical losses are included in the measurement, in addition to all the other parasitic losses of the system. Thus, the parasitic losses are even larger than for the torque method. In some laboratory environments, special control may be needed to prevent line voltage fluctuations from creating power surges which can distort the readings.

3. Definitions

3.1 Rolling Resistance—No further background information is required in this section.

3.2 Rolling Resistance Coefficient—No further background information is required in this section.

3.3 Loaded Radius—No further background information is required in this section.

3.4 Maximum Load—The tire load limits specified by the Tire and Rim Association, Inc.,¹ are expressed in pounds (lb) or kilograms (kg), which are units of mass. For use as TRA design loads in the recommended practice, they must be converted to units of force, either the pound-force (lbf) or the Newton (N).

3.5 Rated Pressure—No further background information is required in this section.

3.6 Capped Air—No further background information is required in this section.

3.7 Regulated Air—No further background information is required in this section.

4. Test Equipment—Test equipment in use for the measurement of rolling resistance ranges from vehicles operated on roadways to machines simulating twin-roll dynamometers. The most common equipment is the 67.23 in (1.7076 m) diameter laboratory test wheel. An objective of this recommended practice is to provide a test procedure which the majority of test organizations can adopt as standard. Therefore, the test wheel serves as a standard for the procedure. However, flat-surface laboratory

test apparatus is being developed at a pace which may soon bring it into common use. The recommended practice can be used without modification when such equipment becomes commonly available. Note that results from a laboratory flat surface test machine and a laboratory test wheel may be somewhat different because of the greater deflection of a given tire under a given load on the curved test wheel surface.

4.1 Test Surface

4.1.1 TEST WHEEL DIAMETER—Most standard laboratory test wheels have a diameter of 67.23 in (1.7076 m)² derived from a surface distance conversion of 300 revolutions per mile.

4.1.2 WIDTH—Most laboratory test wheels have a surface width of at least 12 in (0.30 m).

4.1.3 TEXTURE—Rolling resistance has been shown to be a function of the surface texture on which the tire rolls. Rolling resistance is least on a polished smooth surface and increases with surface roughness. The selection of a medium-coarseness abrasive-type surface for this test procedure is designed to simulate results on a dry, well-maintained public roadway. The reference to 3M Safety-Walk is intended as one example of the type of surface texture recommended, not as a product endorsement. Periodic renewal of the surface may be necessary because of contamination or wear.

4.2 Test Rims—The test rim selected should represent a rim used as original equipment and conform to TRA specifications. Because of the wide variety of rims available for some tire sizes, and because the rim may affect rolling resistance, it is important to report test rim width and contour along with the test results. The rim runout limits are selected on the basis of commonly accepted original equipment specifications.

4.3 Alignment and Control Accuracies—The limits specified are necessary to provide inter-laboratory rolling resistance comparisons within $\pm 5\%$ of the nominally selected test conditions. The accuracies given are intended to cover variations about the specified mean values (standard deviations); they do not include perturbations due to tire and rim non-uniformities.

All of the alignment values can be measured without a tire or wheel installed on the spindle and the required accuracy can be maintained by using appropriate fixtures and commonly available measuring devices. A machine utilizing cantilevered spindles with a horizontal spin axis and horizontal radial load sees an increase in slip angle caused by the weight of the tire and wheel assembly. If the rotation of the roadwheel is such that the tangential force is upward, it would counteract the downward force of the tire/wheel weight. This would be beneficial to all three methods since it would minimize slip angle misalignment. Geometric corrections may still be necessary for misalignments.

Average ambient temperature should be measured adjacent to either sidewall approximately 15 in (0.4 m) from the tire. The ambient temperatures should be measured over a sufficient period of time during each step of the test to determine a representative average. Current research indicates that significant variations in rolling resistance can occur with variations in temperature. The functional relationship between rolling resistance and temperature appears to be linear over the temperature range of interest. However, the function may differ among tires of different constructions or made with different materials. Available laboratory test results show that rolling resistance varies with ambient temperature. The approximate range of variation is -0.08 to -0.14 lbf/°F (-0.64 to -1.12 N/°C) for highway truck tires at average dual load and inflation conditions. Since this is a significant effect, all rolling resistance data should be corrected to 75°F (24°C) by means of a suitable correction equation.³

4.3.1 FORCE METHOD—The geometric misalignment forces can be removed by a suitable static machine calibration, which can be combined with the spindle transducer crosstalk calibration. A bi-directional rotation test can also be used to estimate the misalignment force.

4.3.2 TORQUE METHOD—The effect of slip angle misalignment will be small if kept within the specified tolerance. The torque variation due to

² Conversion between U. S. customary units and metric units are made in accordance with "Rules for SAE Use of SI Metric Units (SAE J916c)." The conversion factors between units depend on the precision of the base measurement to be converted.

³ See for example, D. J. Schuring and G. L. Hall, "Ambient Temperature Effects on Tire Rolling Loss," Rubber Chemistry and Technology, Vol. 58, No. 1, 1985, p. 15.

¹ 3200 W. Market St., Akron, OH 44313.