SAE International™	SURFACE VEHICLE INFORMATION REPORT	J1270	REV. SEP2006
		Issued 1979-10 Revised 2006-09 Superseding J1270 SEP2000	

Measurement of Passenger Car, Light Truck, and Highway Truck and Bus Tire Rolling Resistance

RATIONALE

This information report provides background information and explanations related to the use of the Measurement Procedure and follows the same format as SAE J1269.

This document has been modified in order to provide a relevant single point test condition (Standard Reference Condition [SRC]) appropriate for high volume rolling resistance testing such as for regulatory or comparative purposes.

FOREWORD

This information report is a companion document to SAE Recommended Practice, J1269, Rolling Resistance Measurement Procedure for Passenger Car, Light Truck and 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 J1269.

1. SCOPE

1.1 Basic Methods

The force, torque, and power methods of measurement are all in common use and should yield the same test results. Effects of steering, traction, surface texture, and non-steady-state tire operations are excluded from the recommended practice because they are still in the research stage.

1.1.1 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 its wheel. The main disadvantage of this method is that the spindle force measured can contain a severe error caused by load misalignment and load-spindle force interaction ("crosstalk"). Elimination or compensation of these effects is necessary. A minor disadvantage is that the loaded radius of the tire must be measured in order to convert spindle force to rolling resistance.

1.1.2 Torque Method

The torque method has the advantage that the measurement is direct: rolling resistance is the net torque divided by the test wheel radius. The main disadvantage of the torque method is that parasitic losses contained in the measurement include rotational test wheel losses as well as tire spindle losses. Hence, the parasitic losses are larger than those of the force method and can be of the same order of magnitude as the rolling resistance itself. In addition, speed-hunting oscillations in the drive motor can introduce errors.

1.1.3 Power Method

The advantage of the power method is that 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 power 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 those of the torque method. In some laboratories, special control may be needed to prevent line voltage fluctuations from creating power surges which can distort the readings.

2. REFERENCES

2.1 Applicable Publications

The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated, the latest revision of SAE publications shall apply.

2.1.1 SAE Publication

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

SAE J1269 Rolling Resistance Measurement Procedure for Passenger Car, Light Truck, and Highway Truck and Bus Tires

2.1.2 Other Publications

1. D. J. Schuring and G. L. Hall, "Ambient Temperature Effects on Tire Rolling Loss," Rubber Chemistry and Technology, Vol. 54, No. 5, pp. 1113–1123 (1981).

2. R. Masaki, Y. Tanida, C. Ikeya, and I. Harada, "Research on Rolling Resistance of Tires," J. Mech. Lab., Japan, Vol. 4, No. 1, p. 43 (1958).

3. S. K. Clark, "Rolling Resistance Forces In Pneumatic Tires," DOT/TSC, Report No. DOT-TSC-76-1 (January 1976).

4. J. R. Luchini, "Test Surface Curvature Reduction Factor For Truck Tire Rolling Resistance," SAE Paper No. 821264 (1982).

3. DEFINITIONS

3.1 Rolling Resistance

The definition given in the recommended practice applies only to the free-rolling mode. The universal rolling resistance definition from which it is derived is defined as the energy expended by the tire per unit distance traveled.

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 maximum tire load is expressed in kilograms (kg) or pounds (lb), which are units of mass. For use in the recommended practice, these units must be converted to units of force, either to the newton (N) or the pound-force (lbf).

3.5 Base Inflation Pressure

Base inflation pressure is the inflation pressure corresponding to the maximum load listed in the tire load tables of the current TRA Yearbook or in corresponding tables published by similar organizations concerned with standardization.

3.6 Capped Inflation Pressure

As the tire with inflation pressure capped is run under load, the rising tire temperature will cause the inflation pressure to increase. Thus, capped inflation pressure reflects actual road service conditions.

3.7 Regulated Inflation Pressure

Pressure is most commonly regulated by a constant pressure source attached to the tire through a rotating union.

3.8 Ambient Temperature

An overall ambient room temperature representing air temperatures throughout the test room is difficult to define and measure. Therefore, a location close to the cooler part of the tire/wheel assembly was selected for ambient temperature measurements.

3.9 Ambient Reference Temperature

Variations in rolling resistance occur with changes in ambient temperature. Because precise control of room temperature is difficult, rolling resistance data must be referred to 24 °C (75 °F) according to paragraph 7.4 of SAE J1269.

4. TEST EQUIPMENT

An objective of the recommended practice is to provide a test procedure that nearly all test organizations can adopt as standard. Since the most common equipment is the laboratory test wheel, it serves as a standard for the procedure. However, most of the provisions of this recommended practice do apply to flat-surface laboratory test apparatus. Note that rolling resistance results from a laboratory test wheel are usually slightly higher than corresponding results from a flat surface test machine because of the greater tire deflection on the curve test wheel surface (see 8.3).

4.1 Test Surface

4.1.1 Test Wheel Diameter

Most standard laboratory test wheels have a diameter of 1.708 m (67.23 in) derived from a circumferential length of 1/300 mile.

4.1.2 Width

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

4.1.3 Texture

Rolling resistance is affected by road texture in a manner still under study. The selection of medium-coarseness abrasive-type surface for this test procedure is designed to simulate results on a dry, well-maintained public roadway. Periodic renewal of the surface is necessary because contamination or wear adds variability to the test results.

4.2 Test Rims

The test rim selected should represent a rim used as original equipment and conform to specifications of the TRA or similar organizations. 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. Since rim runout may affect rolling resistance, good quality rims must be used.

4.3 Alignment and Control Accuracies

The limits given are selected to minimize the error of rolling resistance data and thus to aid accurate comparisons of different rolling resistance facilities. The limits reflect standard deviations from the true value; they do not cover systematic errors, which must be eliminated by careful calibration and proper data processing.

4.3.1 Force Method

Misalignment of the tire load may result in a significant spindle force component that could be misinterpreted as rolling resistance. To eliminate this effect, very low limits for tire load offsets would be required (on the order of 0.005 degree for angular offset and 0.02 mm for fore-aft offset). To avoid maintaining impractically low load offsets, a correction technique for load misalignment must be developed for facilities employing the force method. The load misalignment correction technique is frequently combined with the correction technique for load-spindle force crosstalk (see 7.2).

4.3.2 Torque Method

The large polar moment of inertia of the test wheel gives rise to substantial torque variations even if speed variations are very small. Since these torque variations can be misread as rolling resistance, they must be filtered out either statistically or electronically.

4.3.3 Power Method

If surface speed cannot be controlled to ±0.3 km/h (0.2 mph) for passenger car and light truck tires, or controlled to ±0.8 km/h (0.5 mph) for highway truck and bus tires, the input electrical power should be averaged over several speed cycles and the average speed used in the rolling resistance calculation.

4.4 Instrumentation Accuracy

The values selected reflect common accuracies of modern equipment. In laboratories where more accurate instruments are available, better measurement resolution is encouraged. The specific values recommended are adequate for the following:

TABLE 1 – INSTRUMENTATION ACCURACY

	Typical Normal Load	Typical Rolling Resistance Produced
Passenger Car Tire	5 kn (1100 lbf)	35 N (8 lbf)
Light Truck Tire	10 kn (2200 lbf)	100 N (22 lbf)
Highway Truck and Bus Tires	22 kn (5000 lbf)	220 N (50 lbf)

4.4.1 Force Method

This method requires measurement of spindle force and loaded radius. The force measurement must be very precise; it requires careful selection or specification of current-technology equipment.

4.4.2 Torque Method

This method requires precise measurement of input torque. Modern torque cells may require separate over-torque protection to ensure the needed resolution.

4.4.3 Power Method

This method requires precise measurement of electrical power and speed. The speed resolution required for this method is higher than for the other methods because the average speed during the measurement interval is used in the calculation of rolling resistance.

5. TEST CONDITIONS

5.1 Load and Inflation Pressure—Standard Test

The capped inflation pressure test condition (Test Point 1) in combination with the regulated inflation pressure test conditions constitute the basis for predicting rolling resistance over a wide range of operating conditions.

5.2 Load and Inflation Pressure—Alternate Test

The accuracy of the predicted values at various loads and inflation pressures is not compromised if the first test point is run at regulated inflation pressure, indicated as Test Point 1A. The final capped inflation pressure at temperature equilibrium of Test Point 1 will usually be close to the regulated inflation pressure at Test Point 1A so that both points will yield very similar rolling resistance values. Regulated pressure is believed to enhance testing efficiency and to improve the predictive accuracy of the regression model (see 8.2). Note, however, that the alternate test does not deliver information about the pressure rise that would occur under normal road service conditions.

5.3 Test Sequence

Experiments have suggested that steady-state conditions are achieved more quickly for steps of decreasing rolling resistance. Thus, in order to shorten the total test and at the same time ensure steady-state values at all test conditions, testing in the order of decreasing values of rolling resistance is recommended.

5.4 Standard Reference Condition (SRC) for PC and LT Tires

The SRC is intended to serve as a simple, single-point measurement that can be used for comparison of the coefficient of rolling resistance between tires of different sizes, under their typical use conditions, and for high volume rolling resistance evaluations.

5.5 Test Speed

A single speed is recommended, because rolling resistance at equilibrium (steady-state) is relatively insensitive to speed over the range from 60 to 100 km/h (40 to 60 mph).

5.6 Ambient Temperature

The recommended procedure is a compromise of sufficient accuracy for temperature compensations (see 7.4) within the range between 20 °C (68 °F) and 28 °C (82 °F). A representative temperature average is required for each test point. The control of ambient temperature varies between different laboratories, and various methods may be used to obtain an average temperature for each point. A method for obtaining an average would be to measure the ambient temperature at the beginning, middle, and end of a test point and average the three values. Other averaging techniques may provide similar results. The intent here is to measure an average temperature and not to take an instantaneous temperature reading. An instantaneous reading may not accurately reflect ambient conditions because the ambient temperature may change during a test.

6. TEST PROCEDURE

6.1 Break-In

The cool-down period of at least 2 h for passenger car and light truck tires, or at least 6 h for highway truck and bus tires is recommended to assure that the tire has reached a uniform temperature equal to the ambient temperature. If the tire has undergone other tests prior to the rolling resistance test, break-in may not be necessary.

6.2 Thermal Conditioning

Thermal conditioning is recommended to avoid inadvertent testing of a tire which has just been removed from hot or cold storage location. Without such conditioning, the thermal state of the tire immediately before a test could distort the test results and jeopardize comparison with other tires having different thermal histories. The physical layout of many test laboratories is such that ambient conditions and the logistics of tire storage and preparation satisfy the thermal conditioning requirement and hence eliminate the need for any special arrangements.

6.3 Warm-Up

The duration of the warm-up time required at each set of test conditions depends on the tire itself. The recommended values have been found to be generally satisfactory. There is evidence that some tires may require more time. Thus, the warm-up times given in the recommended practice are only a guide. The user of the procedure must ensure to his own satisfaction that a steady-state value has been achieved for each reading.

6.4 Measurement and Recording

6.4.1 Identification

No further background information is required in this section.

6.4.2 Test Variables

Measured values of load, inflation pressure, speed, etc., must be reported for data analysis.

6.5 Measurement of Parasitic Losses

Parasitic losses are caused mostly by bearing friction, and to a lesser extent by aerodynamic friction and other sources. Note that bearing friction is both temperature and load dependent. The extent of such dependence should be determined (for instance, by consulting the bearing manufacturer's specifications) before relying upon the rather simple skim or machine offset method.

6.5.1 Skim Readings

During a skim reading, the tire must be kept rolling without slippage at a tire load at which the energy loss within the tire itself is practically zero. Various methods have been devised to approximate this condition, most commonly by controlling the load at about 100 to 200 N (20 to 50 lbf) depending on the type of tire tested. Note that the skim reading does not represent the parasitic losses under test load.

6.5.2 Machine Offset Reading

A machine offset reading accounts for the parasitic losses of the unloaded test machine; losses in the rotating spindle bearings, which carry the tire, are not measured and must be obtained by other means. Therefore, machine offset reading does not apply to the force method, although the reading could be useful for any method as a zero reference. Note again that the effect of load is not recognized.

7. DATA REDUCTION

7.1 Net Readings via Subtraction of Parasitic Readings

7.1.1 Skim Reading

The skim reading contains the zero-load losses of the test apparatus and the rotating tire and rim. Therefore, unless parasitic losses are strongly increasing under the test loads, the difference between gross and skim readings approximates the rolling resistance of the tire.