



SURFACE VEHICLE RECOMMENDED PRACTICE

J2452™**JUL2017**Issued 1999-06
Revised 2017-07

Superseding J2452 JUN1999

Stepwise Coastdown Methodology for Measuring Tire Rolling Resistance

RATIONALE

The revisions in this version are to address missing SI units a typo in section 3.10 and to clarify issues associated with zero speed points in the MERF/SMERF calculations.

FOREWORD

This SAE Recommended Practice establishes a laboratory method for determination of tire rolling resistance of Passenger Car and Light Truck tires. The method provides a standard for collection and analysis of rolling resistance data with respect to vertical load, inflation pressure, and velocity. The primary intent is for estimation of the tire rolling resistance contribution to vehicle force applicable to SAE Vehicle Coastdown recommended practices SAE J2263 and SAE J2264.

1. SCOPE

This SAE Recommended Practice is applicable to pneumatic Passenger Car "P" Type, Light Truck Metric, and Light Truck High Flotation tires, or similar tires approved by bodies other than Tire & Rim Association. The methodology is applicable within normal operating ranges of vertical load and inflation pressure, and for velocities between 115 km/h and 15 km/h (71 mph and 9 mph) during a relatively short duration event such as a coastdown. This procedure is applicable only to operation in the free-rolling mode at zero slip and camber angle for ambient temperatures between 20 °C and 28 °C (68 °F and 82 °F) and for surfaces with diameters of 1.2 m (48 in) diameter or greater. Details regarding the equipment, tires, and test methods used specifically for validation of this document are included in Appendix A. Two basic measurement methods covered by this document are as follows:

1.1 Force Method

Measures the reaction forces at the tire spindle and converts it to rolling resistance. The chief advantage of this 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 is that the measured spindle force can contain large errors 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.

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be revised, reaffirmed, stabilized, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2017 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of SAE.

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
http://www.sae.org

SAE WEB ADDRESS:

Full document details: SAE J2452_201707

SAE values your input. To provide feedback on this Technical Report, please visit http://standards.sae.org/J2452_201707

Documents
Document Sharing Hub

1.2 Torque Method

Measures the torque input to the test machine and converts it to rolling resistance. The advantage of this method is that the measurement is direct: rolling resistance is the net torque divided by the test surface radius. The main disadvantage 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. Accurate measurement and compensation for these losses is necessary. Speed hunting oscillation in the drive motor can also induce large measurement errors due to the high moment of inertia of the test surface.

2. REFERENCES

2.1 Applicable Documents

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

2.1.1 SAE Publications

Available from SAE International, 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 J1270 Measurement of Passenger Car, Light Truck, and Highway Truck and Bus Tire Rolling Resistance

SAE J2263 Road Load Measurement Using Onboard Anemometry and Coastdown Techniques

SAE J2264 Chassis Dynamometer Simulation of Road Load Using Coastdown Techniques

SAE 980251 "Modeling of Rolling Resistance Test Data," P. S. Grover, Michelin Corp.

SAE 1999-01-0787 "New Parameters for Comparing Tire Rolling Resistance," P. S. Grover and S. H. Bordelon

2.1.2 Other Publications

2.1.2.1 "Numerical Recipes The Art of Scientific Computing" W. H. Press et al. Cambridge: Cambridge University Press, 1989.

2.1.2.2 Jain, R. B., 1981, "Percentage Points of Many-Outlier Detection Procedures", Technometrics, American Statistical Association, V23, N1, pp 71-75.

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 SAE Publications

Available from SAE International, 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

SAE J2047 Tire Performance Terminology

2.2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org

ASTM F 551-84 Standard Practice for Using a Nominal 67.23-in. (1.707-m) Diameter Laboratory Test Roadwheel in Testing Tires

2.2.3 Other Publications

"Tests on Rolling Resistance: Load, Pressure, and Speed," Paper #31 148th Meeting of Rubber Division, American Chemical Society, Cleveland, Ohio; 17-20-1995 by S. H. Bordelon and S. M. Padula.

"An Analytical Model for Transient Rolling Resistance Behavior of Tires," Mars, Will V.; Luchini, John R.; Journal of Tire Science and Technology, v27#4, 1999.

3. DEFINITIONS

3.1 ROLLING RESISTANCE

Rolling resistance is the energy consumed per unit distance and is equivalent to the scalar sum of all contact forces tangent to the test surface and parallel to the wheel plane of the tire. Units are Newtons (lbf).

3.2 ROLLING RESISTANCE COEFFICIENT

Rolling resistance coefficient is the ratio of the rolling resistance to the tire load. Units are Newtons per 1000 N of applied load. (Pounds per 1000 lbs of applied load or kg/ton (1000 kg))

3.3 LOADED RADIUS

Loaded radius is the perpendicular distance from the axis of rotation of the loaded tire to the surface on which it is rolling. Units are mm (in).

3.4 MAXIMUM LOAD

Maximum load is molded in the sidewall and is listed as load limit in the tire load tables of the current Tire & Rim Association, Inc. (TRA) Yearbook, or in corresponding tables published by similar organizations concerned with standardization. For Light Truck tires, the maximum load is defined as the maximum load (or load limit) given for single tire operation. This is given in mass units (kg) which must be converted to units of force (N) unless the load scale is calibrated in kg (lbf). A mass of 1 kg results in a vertical force of 9.80665 N because of the acceleration due to gravity ($g=9.80665 \text{ m/s}^2$).

3.5 BASE INFLATION PRESSURE

For this document, the base inflation pressure is determined from the Inflation Pressure as marked on the tire sidewall and revised to reflect actual tire inflation pressure usage. Base inflation pressure for Passenger Car “P” Type tires is defined in Table 1.

TABLE 1 - BASE INFLATION PRESSURE - “P” TYPE

Inflation Pressure (marked on sidewall) kPa	Base Inflation Pressure kPa
240 or 250 Standard Load	250
300 Standard Load	250
350 Standard Load	250
280 Extra Load	290
340 Extra Load	290

For Light Truck (LT metric and High Flotation) tires, the base inflation pressure is defined as the inflation pressure corresponding to the maximum load for single tire operation (see 3.4). Units are kPa (psi).

3.6 REGULATED INFLATION PRESSURE

The state of regulated inflation pressure is achieved by inflating the tire to the required pressure independent of its temperature and maintaining this inflation pressure during testing. This is normally done by the use of a rotating union.

3.7 AMBIENT TEMPERATURE

The term ambient temperature refers to the temperature of the air measured during a rolling resistance test at a fixed location near the cooler part of the tire/wheel assembly. Units are °C (°F).

3.8 AMBIENT REFERENCE TEMPERATURE

All rolling resistance data are referenced to an ambient temperature of 24 °C (75 °F).

3.9 TIRE ROLLING RESISTANCE EQUILIBRIUM

A tire is said to have achieved ‘equilibrium’ when its rolling resistance does not change with time under constant operating conditions. In context of this laboratory test, equilibrium is attained when the tire operating temperature has stabilized for a given load, pressure, speed, and ambient temperature, resulting in a relatively constant rolling resistance.

3.10 STANDARD REFERENCE CONDITION

A single value of tire load, regulated inflation pressure, and speed specified such that tires can be compared at a single condition. For this method, standard reference conditions are as follows:

3.10.1 Passenger Car “P” Type tires

- Tire Load: 70% of T&RA load at 240 kPa
- Inflation Pressure: 260 kPa (38 psi)
- Speed: 80 km/h (50 mph)

3.10.2 Light Truck - Metric Tires

- a. Tire Load: 70% of T&RA load at 350 kPa
- b. Inflation Pressure: 370 kPa (54 psi)
- c. Speed: 80 km/h (50 mph)

3.10.3 Light Truck - High Flotation Tires

- a. Tire Load: 70% of T&RA load at 250 kPa
- b. Inflation Pressure: 260 kPa (38 psi)
- c. Speed: 80 km/h (50 mph)

3.11 MACHINE MEASUREMENTS

Tire spindle force (F_x) or torque measurements which are obtained at the machine prior to any compensation for crosstalk, parasitic losses, or ambient temperature. For the force method, units are N (lbf). For the torque method, units are N-m (in-lbf).

3.12 CROSSTALK (FORCE METHOD)

The error in the machine spindle force reading due to load misalignment and interactions between load and spindle force transducers. This applies only to the force method. Units are N (lbf).

3.13 GROSS TIRE SPINDLE FORCE

Net tire spindle force plus parasitic loss forces. It is obtained by subtracting the appropriate crosstalk from the machine measurements. Units are N (lbf).

3.14 PARASITIC LOSSES

The errors in the machine readings due to machine friction. For the force method, this includes spindle bearing friction. Units are N (lbf). For the torque method, this includes both flywheel and spindle bearing friction. Units are N-m (in-lbf). For this work, aerodynamic losses of the tire/wheel/machine assembly are considered to be negligible.

3.15 NET TIRE SPINDLE FORCE (FORCE METHOD)

The force at the machine spindle due to tire-rolling resistance only. It is obtained by applying the appropriate crosstalk corrections to machine measurements and subtracting parasitic losses. For force machines where rolling resistance is in the vertical plane, tire, wheel, and spindle weight must also be accounted for. Units are N (lbf).

3.16 NET INPUT TORQUE (TORQUE METHOD)

The torque at the roadwheel input shaft due only to tire rolling resistance. It is obtained by subtracting the appropriate parasitic losses from the machine measurements. Units are N-m (in-lbf).

3.17 MEAN EQUIVALENT ROLLING FORCE (MERF)

The average rolling resistance of a tire, at a given load/inflation condition, over a driving cycle with a specified speed-time profile. This implicitly weights the rolling resistance for each speed using the length of time spent at that speed during the cycle. For the purpose of this document, MERF is a combined weighting of MERFs calculated using the standard EPA urban and highway driving cycles. Specifically, this weighting is 55% for the EPA Urban (FTP) Cycle and 45% for the EPA Highway Fuel Economy Cycle.

3.18 STANDARD MEAN EQUIVALENT ROLLING FORCE (SMERF)

For any tire is the MERF for that tire under standard load/inflation conditions defined in 3.10. For this document, the final SMERF is also calculated by weighting the SMERF obtained for the EPA urban and highway cycles, as discussed previously for MERF calculation.

4. SYMBOLS

See specific section where in use.

5. CONVERSION FACTORS

TABLE 2 - CONVERSION FACTORS

Quantity	Unit—SI	Multiply By	Units
Velocity	Km/h	0.62137	mph
Pressure	Kilo-Pascal	0.145037	pounds/in ² (psi)
Vertical Load	Kg	9.80665	Newtons (N)
Force	Newton (N)	0.224809	pound-force (lbf)
Torque	Newton-meter (N-m)	8.850748	inch-pound-force (in-lbf)
Temperature	Degrees Celsius (C)	C*9/5 + 32	degrees Fahrenheit (F)
Energy	Joule (J)	0.73756	foot-pound-force (ft-lbf)

6. TEST EQUIPMENT

The equipment most commonly used for this procedure is the laboratory test wheel.

6.1 Test Surface

6.1.1 Test Surface Diameter

The minimum diameter of the test surface is recommended to be 1.219 m (48 in). A 1.707 m (67.23 in) surface is most commonly used.

6.1.2 Width

The width of the test surface must exceed the loaded contact width of the test tire. Common test surface width is at least 0.30 m (11.8 in).

6.1.3 Texture

The surface shall be textured with a medium grit (80 grit) particulate size. The recommended surface is aluminum oxide resin bound to a cotton cloth fabric backing and grained at 80 grit. Periodic renewal of the surface is recommended as contamination or wear adds variability to test results. Break-in of the surface may be required in order to stabilize its effect on rolling resistance. The acceptability of new surfaces should be verified using an appropriate control tire or monitoring process. See Appendix B for additional information on surface conditioning.

6.2 Test Rims

The test rims must have an approved contour and width for the size of the tire tested as specified by the Tire & Rim Association, Inc. or similar organizations for the size of the tire tested. The normal rim for testing is the measuring rim for a particular tire, although other approved rims may be used. The rim width and contour used must be reported with the test results. Typical radial/lateral runout should be less than 1.3 mm (0.05 in) total reading.

6.3 Temperature

An overall ambient room temperature representing air temperatures throughout the test room is difficult to define and measure. Therefore, the location of ambient temperature is to be fixed at a lateral distance 0.4 m (16 in) from a point on either rim flange farthest from the test surface, as depicted in Figure 1. Measurements can be made at other locations if demonstrated to result in the same temperature as this specified location.

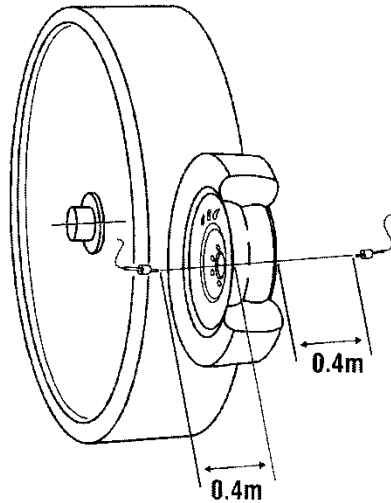


FIGURE 1 - AMBIENT TEMPERATURE MEASUREMENT POINT

6.4 Alignment Accuracies

The following alignment accuracies are specified such that the effect on rolling resistance does not surpass 0.5 N (0.1 lb). This does not cover systematic errors which must be eliminated by careful calibration and proper data processing. Accuracies should be maintained in the loaded condition, up to the operating load of tests to be run.

- a. Tire Load Fore-Aft Offset: ± 0.2 mm (0.01 in)
- b. Tire Load Angular Offset: ± 0.3 degree
- c. Tire Slip Angle: ± 0.1 degree
- d. Tire Inclination Angle: ± 0.2 degree

6.4.1 Crosstalk Compensation (Force Method)

Using the force method, load misalignment as well as interactions between load and spindle force transducers can introduce large errors in the spindle force reading. Such errors must be quantified and eliminated by subtracting them from machine measurements to obtain gross spindle force. Two commonly used methods for accomplishing this are described as follows, although other methods may be used if their technical validity can be demonstrated.

6.4.1.1 Forward and Reverse Runs

A stepwise coastdown is run in the forward direction of rotation, then repeated in the reverse direction. The tire-rolling resistance and parasitic loss forces reverse with direction of rotation, but crosstalk and load misalignment do not. Forward and reverse spindle force measurements are subtracted and divided by two, resulting in gross spindle force (net spindle force plus parasitic spindle force losses). For analysis purposes, other measured parameters such as tire load, inflation pressure, speed, and ambient temperature should be averaged for the forward and reverse stepwise coastdown runs. A graphical example of this method of crosstalk compensation is provided in Figure 2.

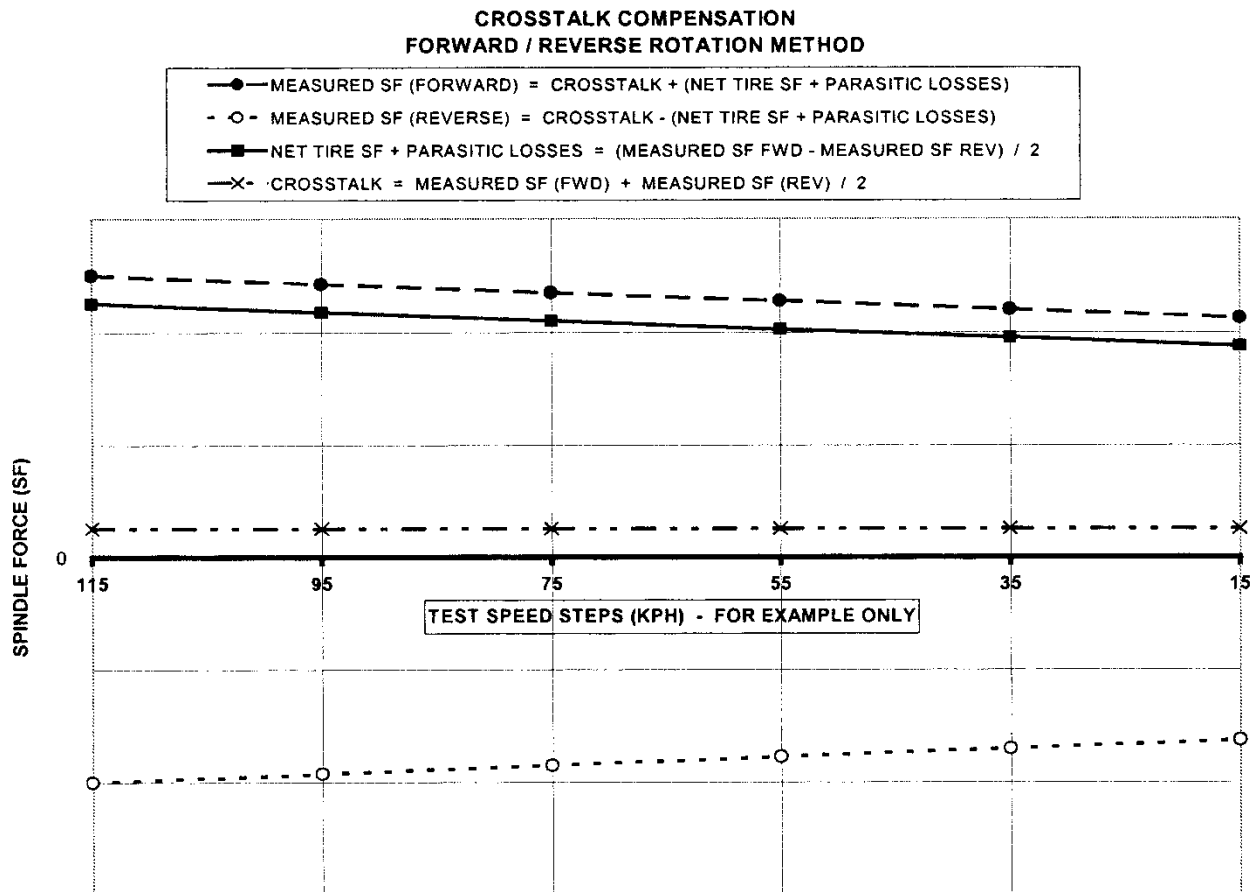


FIGURE 2 - CROSSTALK COMPENSATION EXAMPLE

6.4.1.2 Machine Characterization

Crosstalk and load misalignment are characterized as a function of test load and test speed. This is usually accomplished by experiment, allowing a calculated correction to be subtracted from machine spindle force readings to obtain gross spindle force (net spindle force plus parasitic spindle force loss).

6.5 Instrumentation Accuracies

The instrumentation used for the reading and recording of test data must be sufficiently accurate and precise to provide rolling resistance measurements with a standard deviation of 0.5 N (0.1 lb) or less. To achieve this accuracy, measurements common to both methods of rolling resistance determination must be maintained within the following accuracies:

- a. Tire Load: The greater of ± 10 N (2 lb) or $\pm 0.5\%$
- b. Inflation Pressure: ± 1 kPa (0.1 psi)
- c. Speed: ± 1 km/h (0.5 mph)
- d. Temperature: ± 0.2 °C (0.5 °F)

- e. Force Method – In addition to the common accuracies specified previously, the use of this method requires the following accuracies:
1. Spindle Force: The greater of ± 0.1 N (0.02 lb) or $\pm 0.5\%$
 2. Loaded Radius: ± 1 mm (0.04 in)
- f. Torque Method – In addition to the common accuracies specified previously, the use of this method requires Input Torque Accuracy of: the greater of ± 0.1 N*m (0.9 in-lb) or 0.5% .

6.6 Control Accuracies

Test conditions must be maintained at their specified values such that the overall variability of the rolling resistance measurement is minimized. The standard deviation of the test shall not exceed 0.5 N (0.1 lbf) as quantified by a suitable gage repeatability and reproducibility method. To meet this requirement, the average value of measurement taken during the rolling resistance data collection period must be within the accuracies stated as follows:

- a. Tire Load: The greater of ± 20 N (5 lb) or $\pm 0.5\%$
- b. Inflation Pressure: ± 1.5 kPa (0.2 psi)
- c. Test Surface Speed: ± 1.5 km/h (1.0 mph)
- d. Ambient Temperature: ± 4 °C (± 7 °F)

6.7 Stability

The test should maintain speed, tire load, inflation pressure, and ambient temperature at stable values within the limits stated in 6.6 to the greatest extent possible as rolling resistance data is collected. Generally, data should be collected over a period of at least two full machine oscillations of all parameters. This is of particular importance in reducing torque variations due to “speed hunting” errors when the torque method is used.

7. TEST CONDITIONS

The recommended method consists of a stepwise coastdown from 115 to 15 km/h (71 to 9 mph) per 8.4. In order to obtain a complete quantification of tire rolling resistance as a function of load, inflation pressure, and speed, the load/pressure matrices specified in 7.2.1 should be used. However, if needed, the stepwise coastdown can be performed for a single load/pressure condition.

7.1 Test Speed versus Time Requirements

The specified velocity versus time profile represents a vehicle coastdown with a duration of 180 s from 115 to 15 km/h and is defined by Equations 1 and 2.

$$\text{Speed (km/h)} = 115 - 0.934 \cdot t + 0.0021 \cdot t^2 \quad (\text{Eq. 1})$$

$$\text{Speed (mph)} = 71.5 - 0.58 \cdot t + 0.0013 \cdot t^2 \quad (\text{Eq. 2})$$

where:

t = Time (s)

Time for a given data point is defined as the endpoint time of the data acquisition window, with $t=0$ at the 115 km/h (71 mph) data point. Data must be taken within ± 2 s of the target curve. A minimum of 6 speed steps are required, including the first at 115 km/h (71 mph) and the last at 15 km/h (9 mph). Data points should be spaced across the entire speed range, although it is accepted that equal spacing may not be practical, because the time spent at each test velocity point depends on the response time of different dynamometer systems. The curve and limits are depicted graphically in the Figure 3.

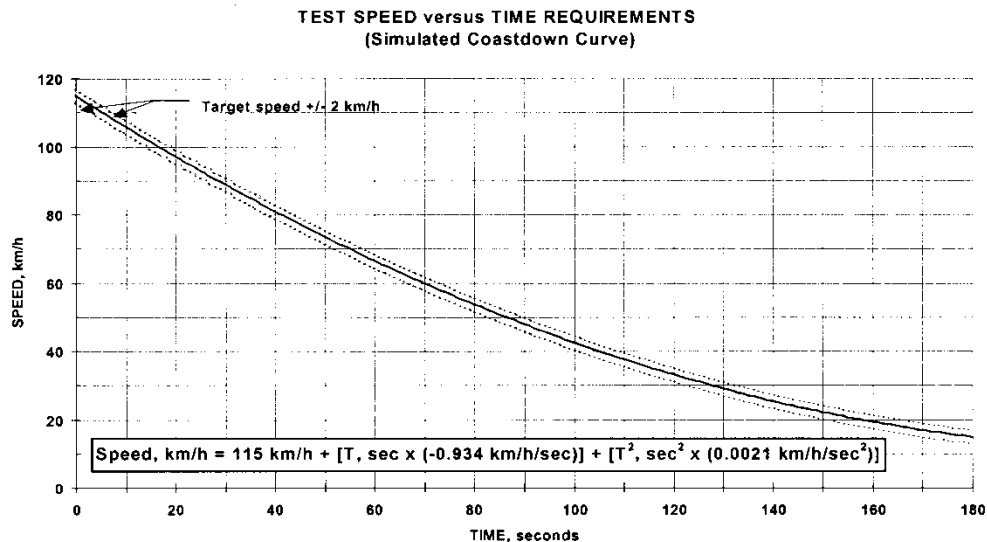


FIGURE 3 - SIMULATED COASTDOWN CURVE

7.2 Load and Inflation

Rolling resistance measurements using stepwise coastdown (as per 7.1) may be performed for the entire load and inflation matrix or at a single load and inflation condition. In either case, the test data must be reduced as described in Section 9.

7.2.1 Load and Inflation Matrix

Stepwise coastdowns are to be run at each of the load/pressure conditions specified for Passenger Car and Light Truck tires in Table 3. The order of the test steps should follow the matrix because the steps are ordered corresponding to increasing rolling resistance. Since tires heat up more quickly than they cool, this allows for minimum time to establish rolling resistance equilibrium between steps.

TABLE 3 - LOAD AND INFLATION TEST MATRICES

Passenger Car Tires Step #	Passenger Car Tires Load (% of Max)	Passenger Car Tires Inflation Pressure (base $\pm$)	Light Truck Tires Step #	Light Truck Tires Load (% of Max)	Light Truck Tires Inflation Pressure (% of Max)
1	30	+10 kPa	1	20	110
2	60	-40	2	40	50
3	90	+60	3	40	100
4	90	-40	4	70	60
			5	100	100

The terms “Passenger Car Tires” and “Light Truck Tires” refer to the tire type, not the vehicle application. Passenger Car Tires are those with a “P” Type designation, and Light Truck Tires are those with a “Light Truck Metric” or “Light Truck High Floatation” designation as standardized by the Tire & Rim Association or similar tire type as designated by other standards organizations such as ETRTO or JATMA.

7.2.2 Single Load and Inflation Test

This test has applicability for comparing tires at a specific load and inflation such as the standard reference condition or for determining rolling resistance at specific vehicle conditions. Because the measurement is being made at a single condition, adhering to the control accuracies stated in 6.6 is critical.

7.2.3 Skim Load

For tests which include a skim loss reading, load on the tire shall be just sufficient to maintain tire rotation across the tested speed range. A load of 100 N (20 lbf) is recommended for Passenger Car tires, and 150 N (30 lbf) for Light Truck tires.

7.3 Ambient Temperature

The ambient temperature surrounding the test tire should be held between 20 °C and 28 °C (68 to 82 °F). An average ambient temperature is recorded for each test coastdown run. All rolling resistance values must be corrected to the Ambient Reference Temperature of 24 °C (75 °F).

8. TEST PROCEDURE

8.1 Break-In

Tires that undergo significant permanent change in their dimensions or material properties with their first dynamometer test operation, require a break-in and cooling period prior to the start of the test. Break-in is accomplished by operating the tire at test step 1 (7.2.1) for a period of 1 h at 80 km/h (50 mph), followed by a cool-down period to ambient test room temperature of at least 2 h. If the tire has undergone other tests prior to the rolling resistance test, break-in may not be necessary. An alternative to this is to consider the first 30 min of operation during the rolling resistance test to be adequate break-in for the measurement of new tire rolling resistance.

8.2 Thermal Conditioning

Prior to the start of testing, the tire/wheel assembly should be in a thermal environment as stated in the test conditions section (24 °C ± 4 °C, 75 °F ± 7 °F ambient temperature). Two hours of thermal conditioning is sufficient for both Passenger Car and Light Truck tires.

8.3 Warm-Up

For each set of load/inflation pressure test conditions, the tire must be brought to rolling resistance equilibrium at a test speed of 80 km/h (50 mph) prior to beginning the stepwise coastdown sequence. Several valid methods are described as follows. Other methods may be used if their technical validity can be demonstrated.

8.3.1 Fixed Time

For the first load/inflation pressure condition, warm up the tire for 30 min for passenger tires and 60 min for Light Truck tires. For subsequent load/inflation pressure conditions, equilibrate the tire for 10 min for Passenger Car tires and 15 min for Light Truck tires.

8.3.2 Rate of Change

Achievement of rolling resistance equilibrium may be determined by analysis of the rolling resistance versus time data during the warm-up period. When using this method, a minimum time of 10 min for Passenger Car tires and 20 min for Light Truck tires is required for the first load/inflation pressure test condition. In general, rolling resistance equilibrium can be assumed if a gradient of ≤ 0.13 N/min (0.03 lb/min) is verified over a period of no less than 90 s. This gradient can be verified by calculating differences between consecutive data samples, linear regression of rolling resistance data samples versus time, or other suitable methods.

8.4 Stepwise Coastdown

When the tire has reached rolling resistance equilibrium at 80 km/h for load/inflation step #1, the stepwise coastdown begins by accelerating the test tire to 115 km/h (71 mph). When speed, load, and pressure are stabilized, data is acquired. Not more than 60 s should be spent in accelerating to 115 km/h and gathering the first data point. The test tire is then decelerated to the next lower target speed, stabilized, and data is acquired. Repeat the previous action for all speed steps within the constraints of 7.1 until the final speed step, 15 km/h (9 mph), is completed. The warm-up and stepwise coastdowns are then repeated for all load/inflation steps test points in the appropriate test matrix defined in 7.2.1. A graphical example of speed versus time for a stepwise coastdown is provided in Figure 4.

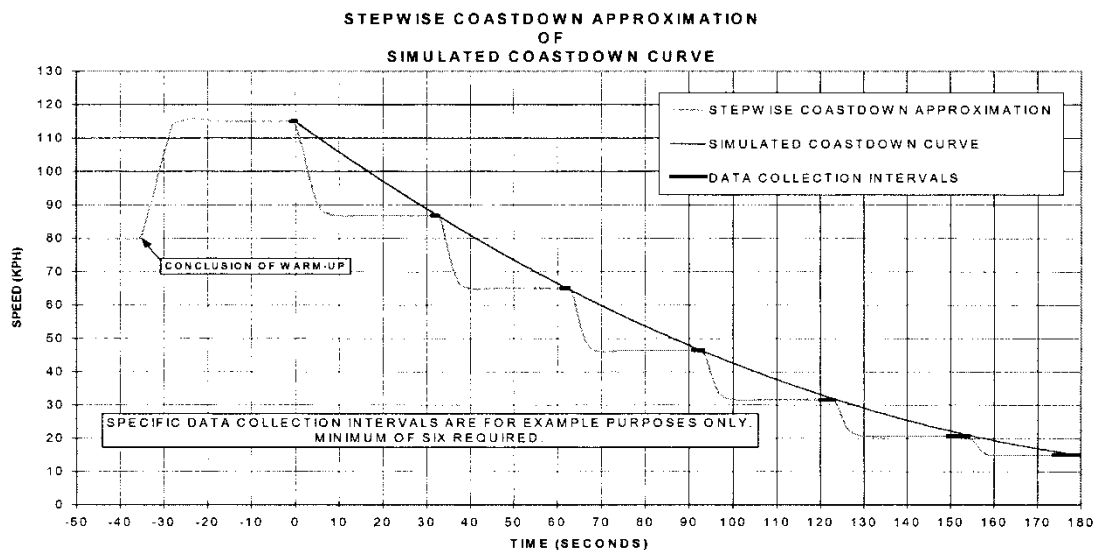


FIGURE 4 - STEPWISE COASTDOWN EXAMPLE

8.5 Measurement of Parasitic Losses

Parasitic losses are caused by bearing friction and to a lesser extent by tire aerodynamic friction. Parasitic losses must be quantified and subtracted from gross spindle force unless determined to be less than 1% of net spindle force. Two commonly used methods for accomplishing this are described as follows. Other methods may be used if their technical correctness can be demonstrated. All methods must ensure that the speed effect of the parasitic loss is carefully measured and accounted for.

8.5.1 Skim Reading

A tire load is applied which is just sufficient to maintain tire contact with the test surface a stepwise coastdown. Spindle force or input torque, whichever applies for the machine type, is measured at this skim load. Recommended skim loads are provided in the Test Conditions section of this document. At this load, tire rolling resistance is considered negligible. The skim reading is then subtracted from the gross spindle force or from the machine torque readings at each test condition. The skim load test can be performed anytime during the test series after step #1. This is needed to ensure that the bearings of the test machine are warmed to operating temperature. A graphical depiction of the skim reading method of parasitic loss correction is shown in Figure 5.