

	SURFACE VEHICLE RECOMMENDED PRACTICE	SAE J1263 MAR2010
		Issued 1979-06 Revised 2010-03
		Superseding J1263 JAN2009
Road Load Measurement and Dynamometer Simulation Using Coastdown Techniques		

RATIONALE

The value change and proper unit formatting correct oversights in the original document.

FOREWORD

This procedure was originally designed in the English units system and has been converted to the metric (MKS) system of units. This will explain the somewhat awkward values used in this procedure.

1. SCOPE

This procedure covers measurement of vehicle road load on a dry, straight, level road at speeds less than 113 km/h (70 mi/h).

1.1 Purpose

This SAE Recommended Practice provides uniform testing procedures for measuring the road load force on a vehicle as a function of vehicle velocity and for simulation of that road load force at 80 km/h (50 mi/h) on a hydrokinetic chassis dynamometer. For application to electric dynamometers, refer to SAE J2263.

2. REFERENCES

2.1 Applicable Publications

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

2.1.1 SAE Publication

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 J1100 Motor Vehicle Dimensions

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 reaffirmed, revised, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2010 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: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
http://www.sae.org

SAE WEB ADDRESS:

Full document details: SAE J1263_201003

SAE values your input. To provide feedback on this Technical Report, please visit http://www.sae.org/technical/standards/J1263_201003

2.1.2 Federal Regulations

Available from the Superintendent of Documents, U.S. Government Printing Office, Mail Stop: SSOP, Washington, DC 20402-9320.

Code of Federal Regulations, 40 CFR 600, Appendix I

2.2 Related Publications

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

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.

R. A. White and h. h. Korst, "The Determination of Vehicle Drag Contribution from Coast-Down Test," SAE Paper 720099, 1972

T. P. Yasin, "The Analytical Basis of Automobile Coastdown Testing," SAE Paper 780334, 1978

B. Dayman, Jr., "Tire Rolling Resistance Measurements from Coast-Down Tests," SAE Paper 760153, 1976

G. D. Thompson, "Prediction of Dynamometer Power Absorption to Simulate Light Duty Truck Road Load," SAE Paper 770844, 1977

J. R. Smith, J. C. Tracy, and D. s. Potter, "Tire Rolling Resistance—A Speed Dependent Contribution," SAE Paper 780255, 1978

B. Dayman, Jr., "Realistic Effects of Winds on the Aerodynamics Resistance of Automobiles," SAE Paper 780337, 1978

3. DEFINITIONS

3.1 Test Weight

Is the weight of the vehicle as tested; including driver, operator (if necessary), and all instrumentation.

3.2 Test Mass

Is the mass of the vehicle as tested; including driver, operator (if necessary), and all instrumentation.

3.3 Effective Mass

Is equal to the sum of the test mass and the effective mass of rotating components.

3.4 Effective Mass of Rotating Components

The rotational inertia of driveline and non-drive axle components that rotate with the wheels, expressed as additional "linear mass". For passenger cars without dual drive tires, if the actual effective mass of rotating components is unknown, the effective mass of all rotating components may be estimated as 3.0% of the vehicle test mass.

3.5 Frontal Area

Is the area of the orthogonal projection of the vehicle including tires and suspension components onto a plane perpendicular to the longitudinal axis of the vehicle.

4. SYMBOLS

a	= Slope of the actual dynamometer horsepower— $1/\delta t$ curve (kW-s or hp-s)
A	= Vehicle frontal area (see 8.6) (m^2 or ft^2)
b	= Zero intercept of the actual dynamometer horsepower— $1/\delta t$ curve (kW or hp)
C_D	= Aerodynamic drag coefficient (dimensionless)
C'_D	= Aerodynamic drag coefficient for nonzero yaw (dimensionless) (see 10.2)
C_{DY}	= Crosswind aerodynamic drag coefficient (dimensionless)
D	= Denominator of expressions to determine a and b from vehicle-dynamometer coastdown data
D_{tot}	= Total drag force (N or lb)
f_0, f_2	= Coefficients of the zeroth and second order terms (respectively) in the road load force equation (N or lb and N/[km/h ²] or lb/mph ²)
f'_0, f'_2	= Coefficients of the zeroth and second order terms (respectively) in the road load force equation (N or lb and N/[kmh ²] or lb/mph ²) corrected to standard conditions
g	= Acceleration of gravity 9.81 m/s ² or 32.174 ft/s ²
I	= Moment of inertia of tire, wheel, and brake rotor or drum kg-m ² or ft-lb-s ²
IW	= Inertia weight or equivalent weight of inertia simulation mechanism (N or lb)
k	= Drag coefficient dependence on yaw angle ψ
k_t	= Temperature coefficient of rolling resistance ($^{\circ}C^{-1}$ or $^{\circ}F^{-1}$)
M	= Vehicle test mass (kg or slugs)
m_e	= Effective mass of a wheel, tire, and brake assembly (kg or slugs)
M_{DLC}	= Total equivalent mass of drivetrain components (kg or slugs)
M_{IW}	= Equivalent mass of dynamometer inertia simulation mechanism (IWC/g) (kg or slugs)
M_e	= Total effective vehicle mass (kg or slugs)
N	= Number of data points used in Part 2
P_0	= Reference atmospheric pressure 736.6 mm Hg (29.00 in Hg)
r	= Tire rolling radius (m or ft)
S	= +1 or -1, depending on vehicle coastdown direction
t_0	= Time (seconds)
$t-t_0$	= Coastdown time interval (seconds)
δt	= Vehicle coastdown time on the chassis dynamometer(s)
T	= Ambient temperature of test area (K or $^{\circ}R$)
T_0	= Standard temperature (20 $^{\circ}C$ = 293.15 K, 68 $^{\circ}F$ = 527.67 $^{\circ}R$)
V	= Vehicle speed (km/h or mi/h)
$\mathbf{V}$	= Vehicle velocity (km/h or mi/h)
V_1, V_0	= Final and initial speeds in the calculation of the coastdown time interval (km/h or mi/h)
v_x	= Component of wind parallel to track (km/h or mi/h)
v_y	= Component of wind perpendicular to track (km/h or mi/h)
W	= Vehicle test weight (N or lb)
W_w	= Weight of tire, wheel, and brake rotor or drum (N or lb)
μ	= Coefficient of rolling resistance (dimensionless)
μ_0	= Velocity-independent coefficient of rolling resistance (dimensionless)
μ'	= Velocity-dependent coefficient of rolling resistance ([km/h] ⁻² or [mi/h] ⁻²)
ρ	= Air mass density (kg/m ³ or slugs/ft ³)
Ψ	= Aerodynamic yaw angle (radians)

5. PART 1—VEHICLE ROAD LOAD MEASUREMENT

5.1 Instrumentation

All instrumentation must be calibrated.

5.2 Speed Time

An instrument to measure vehicle speed as a function of elapsed time is used in this procedure. The device must meet the following specifications:

a. Time:

1. Accuracy $\pm 0.1\%$ of total coastdown time interval
2. Resolution 0.1 s

b. Speed:

1. Accuracy ± 0.4 km/h (± 0.25 mi/h)
2. Resolution ± 0.2 km/h (0.1 mi/h)

5.3 Temperature

The temperature indicating devices must have a resolution of 1 °C or 2 °F and an accuracy of ± 1 °C or ± 2 °F. The sensing element must be shielded from radiant heat sources.

5.4 Atmospheric Pressure

A barometer with an accuracy of ± 0.7 kPa or ± 0.2 in Hg is necessary.

5.5 Wind

Wind speed and direction during the test should be continuously monitored. Wind measurements should permit the determination of average longitudinal and crosswind components to within ± 1.6 km/h (± 1 mi/h).

5.6 Vehicle Weight

Vehicle weight should be measured to an accuracy of ± 5 kg (± 10 lb) per axle.

5.7 Tire Pressure

Should be measured to an accuracy of ± 3 kPa (± 0.5 psi).

6. TEST MATERIAL

6.1 Test Vehicle

The test vehicle should be uniquely described on the Vehicle Road Test Data Sheet (see Figure 1). In particular, any modifications from the normal configuration of the vehicle should be noted.

7. TEST CONDITIONS

7.1 Ambient Temperature

Ambient temperatures shall be between 5 °C and 35 °C (41 to 95 °F). Data obtained at temperatures outside this range cannot be reliably adjusted to standard conditions by Section 10.5.

7.2 Fog

Tests may not be run during foggy conditions.

7.3 Winds

Tests may not be conducted when wind speeds average more than 16 km/h (10 mi/h) (or when peak wind speeds are more than 20 km/h [12.3 mi/h]). The average of the component of the wind velocity perpendicular to the test road may not exceed 8 km/h (5 mi/h).

7.4 Road Conditions

Roads must be dry, clean, smooth, and must not exceed 0.5% grade. In addition, the grade should be constant and the road should be straight since variations in grade or straightness can significantly affect results. (The road surface should be concrete or rolled asphalt (or equivalent) in good condition since rough roads can significantly affect rolling resistance.)

7.5 Coastdown Speed Range

The range of speeds over which the vehicle is coasted should be as long as possible considering the length of the straightaway. The speed interval must include 80 km/h (50 mi/h) and should include the range of 100 to 40 km/h (60 to 25 mi/h).

8. VEHICLE PREPARATION

8.1 Break-In

The test vehicle should have accumulated a minimum of 500 km (300 miles) prior to testing. The tires should have accumulated a minimum of 3500 km (2175 miles) and should have at least 50% of the original tread depth remaining. In addition, if a twin roll dynamometer is to be used, the drive axle tires should have a minimum of 1 h at 80 km/h (50 mi/h) on the dynamometer rolls before conducting the dynamometer road load simulation portion of this procedure. All tire break-in should be performed on the test vehicle or under load conditions similar to those imposed by the test vehicle.

8.2 Vehicle Check-In

The following items should be compared to manufacturer's recommendation and recorded on the Vehicle Road Test Data Sheet (see Figure 1) prior to the test:

- a. Tire type, size, and cold inflation pressure (see 8.5)
- b. Wheel size, conditions, and presence of wheel covers
- c. Brake adjustment
- d. Lubricants in the drivetrain and in the nondriving wheel bearings
- e. Vehicle suspension heights

8.3 Instrumentation

The speed-time measuring device and other necessary equipment must be installed so that they do not hinder vehicle operation or alter the operating characteristics of the vehicle.

8.4 Pretest Weight

The weight of the vehicle prior to testing should be appropriate for the vehicle represented; for example, consideration should be given to the effect of the added weight of the test instrumentation.

8.5 Tire Pressure

Inflate the tires of the test vehicle to the manufacturer's recommended cold inflation pressure, corrected for the temperature difference (if any) between the vehicle tires and the test area. The tire pressure should be increased 1 psi for each 13 °F that the vehicle preparation area temperature the test is above the test temperature or 1 kPa for each Celsius degree. Record the actual inflation pressure and preparation area temperature on the Vehicle Road Test Data Sheet (see Figure 1).

VEHICLE DESCRIPTION: Model Year _____ Make _____ Model _____ Inertia Weight Class _____ Ballast - <table border="0" style="width: 100%;"> <tr> <td style="width: 50%; text-align: center;">Amount</td> <td style="width: 50%; text-align: center;">Location</td> </tr> <tr><td>_____</td><td>_____</td></tr> <tr><td>_____</td><td>_____</td></tr> <tr><td>_____</td><td>_____</td></tr> <tr><td>_____</td><td>_____</td></tr> </table> Weight Removed _____ Trim Heights - <table border="0" style="width: 100%;"> <tr> <td style="width: 50%;">LF _____</td> <td style="width: 50%;">RF _____</td> </tr> <tr> <td>LR _____</td> <td>RR _____</td> </tr> </table> FINAL WEIGHT (TEST WEIGHT): Fifth Wheel Down and Off Scale - <table border="0" style="width: 100%;"> <tr> <td style="width: 50%;">LF _____</td> <td style="width: 50%;">RF _____</td> </tr> <tr> <td style="text-align: center;">Total Front</td> <td>_____</td> </tr> </table> Fifth Wheel Down and Off Scale - <table border="0" style="width: 100%;"> <tr> <td style="width: 50%;">LR _____</td> <td style="width: 50%;">RR _____</td> </tr> <tr> <td style="text-align: center;">Total Rear</td> <td>_____</td> </tr> <tr> <td style="text-align: center;">Total</td> <td>_____</td> </tr> </table> Fifth Wheel Included - <table border="0" style="width: 100%;"> <tr> <td style="width: 50%;">LF _____</td> <td style="width: 50%;">RF _____</td> </tr> <tr> <td style="text-align: center;">Total Front</td> <td>_____</td> </tr> </table> Fifth Wheel Included - <table border="0" style="width: 100%;"> <tr> <td style="width: 50%;">LR _____</td> <td style="width: 50%;">RR _____</td> </tr> <tr> <td style="text-align: center;">Total Rear</td> <td>_____</td> </tr> <tr> <td style="text-align: center;">Total</td> <td>_____</td> </tr> </table> EQUIVALENT INERTIA: Front Wheel/Brake/Tire (each) _____ Rear Wheel/Brake/Tire (each) _____ Total Non-Driven Axle _____ Total Drive Line _____ Total _____ [] Check, if estimated	Amount	Location	_____	_____	_____	_____	_____	_____	_____	_____	LF _____	RF _____	LR _____	RR _____	LF _____	RF _____	Total Front	_____	LR _____	RR _____	Total Rear	_____	Total	_____	LF _____	RF _____	Total Front	_____	LR _____	RR _____	Total Rear	_____	Total	_____	Date _____ Vehicle No. _____ Odometer Reading _____ TIRES: Size _____ Manufacturer _____ Description _____ Tread Depth >50% yes [] no [] Pressures - <table border="0" style="width: 100%;"> <tr> <td style="width: 30%;"></td> <td style="width: 35%; text-align: center;">Specified</td> <td style="width: 35%; text-align: center;">Actual</td> </tr> <tr> <td>LF</td> <td>_____</td> <td>_____</td> </tr> <tr> <td>RF</td> <td>_____</td> <td>_____</td> </tr> <tr> <td>LR</td> <td>_____</td> <td>_____</td> </tr> <tr> <td>RR</td> <td>_____</td> <td>_____</td> </tr> </table> Dynamometer Test Drive Wheel Tire Pressures <table border="0" style="width: 100%;"> <tr> <td style="width: 50%;">Left _____</td> <td style="width: 50%;">Right _____</td> </tr> </table> WHEELS: Size _____ Wheel Covers _____ CHASSIS: Axle Ratio _____ Transmission Type _____ Brake Type - <table border="0" style="width: 100%;"> <tr> <td style="width: 50%;">Front _____</td> <td style="width: 50%;">Rear _____</td> </tr> </table> Toe-in (+/-in) _____ FRONTAL AREA DETERMINATION: Area _____ [] Check, if estimated. Note - Check Brake Drag and Fluid Levels COMMENTS: _____ _____ _____ _____ _____		Specified	Actual	LF	_____	_____	RF	_____	_____	LR	_____	_____	RR	_____	_____	Left _____	Right _____	Front _____	Rear _____
Amount	Location																																																					
_____	_____																																																					
_____	_____																																																					
_____	_____																																																					
_____	_____																																																					
LF _____	RF _____																																																					
LR _____	RR _____																																																					
LF _____	RF _____																																																					
Total Front	_____																																																					
LR _____	RR _____																																																					
Total Rear	_____																																																					
Total	_____																																																					
LF _____	RF _____																																																					
Total Front	_____																																																					
LR _____	RR _____																																																					
Total Rear	_____																																																					
Total	_____																																																					
	Specified	Actual																																																				
LF	_____	_____																																																				
RF	_____	_____																																																				
LR	_____	_____																																																				
RR	_____	_____																																																				
Left _____	Right _____																																																					
Front _____	Rear _____																																																					

AMBIENT CONDITIONS:

Temperature-Start _____	Finish _____	Average _____ (°C, °F)
-------------------------	--------------	------------------------

Wind -

Average Wind _____ (km/h, mi/h)	
Direction _____ (deg)	
Peak Gusts _____ (km/h, mi/h)	

Atmospheric Pressure - Start _____ Finish _____ Average _____ (mm Hg, in Hg)

NO RAIN OR FOG - ROADS MUST BE DRY

PREPARATION AREA:

Temperature _____ (°C, °F)	Average _____ (mm Hg, in Hg)
----------------------------	------------------------------

FIGURE 1 - VEHICLE ROAD TEST DATA SHEET

8.6 Vehicle Frontal Area

The vehicle frontal area must be known, measured, or estimated and the value recorded on the Vehicle Road Test Data Sheet (see Figure 1). The frontal area may be estimated by the following equation:

$$A = 0.8 (H101) \times (W103) \quad (\text{Eq. 1})$$

where:

H101 = Body height (meters [feet]) measured according to SAE J1100

W103 = Body width (meters [feet]) measured according to SAE J1100

8.7 Vehicle Warm-Up

The vehicle must be driven a minimum of 30 min at an average speed of 80 km/h (50 mi/h) immediately prior to the test.

9. COASTDOWN TEST

9.1 Alternating Directions

A minimum of 10 runs are made in alternating directions. The runs must be paired for the data reduction process in order to reduce error.

9.2 Procedure

The vehicle windows must be closed. At the start of each run, accelerate the vehicle to a speed 8 km/h (5 mi/h) above the high point of the coastdown speed range, start the recording equipment, and shift into neutral and let the engine idle. The vehicle clutch must be engaged. At a speed less than the lower point of the coastdown speed range, stop the recording equipment, engage the transmission, and prepare for the next run.

Vehicle regenerative braking shall be disabled during coastdown testing, minimizing any changes to the mechanical system (see SAE J1634).

9.3 Lane Changes

While coasting, lane changes should be avoided if at all possible. If necessary, they should be done as slowly as possible and over a distance of at least a half kilometer (a quarter mile). If such a gradual change cannot be made, abort the run.

9.4 Data to be Recorded

Record the direction and number of each run (including aborted runs) in such a way that the speed time data can be separated by run number. Record the ambient temperature and atmospheric pressure after the warm-up and after the test. Average the two values to determine the value to be used in the data reduction.

The total wind and either the wind direction or the crosswind component of the total wind must be recorded. The wind quantities should be recorded, screened for gusts exceeding the ambient condition limits in 7.3, and averaged. Record the results on the Vehicle Road Test Data Sheet (see Figure 1).

9.5 Vehicle Test Weight or Mass

After the coastdown run, weigh the vehicle to determine the vehicle test weight or mass. Include the weight of the fifth wheel, driver, and all instrumentation used. Record on the Vehicle Road Test Data Sheet (see Figure 1).

9.6 Axle Weights

Measure each axle weight as in 9.5 except with the fifth wheel (if used) in the operating position and off the scale. Record on the Vehicle Road Test Data Sheet (see Figure 1).

10. DATA REDUCTION

This section prescribes the technique for analyzing a set of coastdown data and the correction factors employed in the determination of the coefficients of the road load force equation. These corrected coefficients are used to calculate the time required to freely decelerate from 88 to 72 km/h (55 to 45 mi/h) on a chassis dynamometer.

10.1 Road Load Force

A two-parameter road load force equation is fitted to the $V(t)$ data of Section 9 according to the technique of White and Korst (SAE Paper 720099). The coefficients of the road load force equation are determined for each individual $V(t)$ coastdown and are then averaged over all pairs of coastdowns in each data set. Corrections are applied for wind (both parallel and perpendicular to the coastdown path), for the temperature dependence of rolling resistance, and for the density dependence of aerodynamic drag. The corrected coefficients are then used to construct the vehicle force-velocity equation characteristics of the vehicle under standard ambient conditions with no wind. This force is then corrected for inertial differences between the road test configuration and the dynamometer test configuration, and the resultant force is used to calculate the time to coast from 88 to 72 km/h (55 to 45 mi/h) on a chassis dynamometer.

10.1.1 Additional Applications

For dynamometers with more than one adjustable load parameter, the force-velocity and coastdown time-speed interval equations (Equations 6 and 18) may be used to simulate the vehicle road load in several speed intervals within the experimental data range.

10.2 Solution to Force Equations

The general form of the equation of motion can be written as:

$$M_e \frac{\partial \mathbf{V}}{\partial t} = \mathbf{D}_{\text{tot}} \quad (\text{Eq. 2})$$

Noting that drag forces always act in a direction opposite vehicle speed, and breaking the magnitude of drag forces into separate terms, then equation 2 can be written in scalar form as:

$$-M_e \frac{dV}{dt} = \mu W + 1/2 \rho C'_D A \left[(V + S v_x)^2 + v_y^2 \right] \quad (\text{Eq. 3})$$

where:

$$\mu = \mu_o (1 + \mu' V^2)$$

The drag coefficient C'_D is the sum of the drag coefficient at zero yaw (C_D) and a coefficient k times the square of the sine of the yaw angle.

$$C'_D = C_D + k \sin^2 \psi = C_D + k v_y^2 / [(V + S v_x)^2 + v_y^2] \quad (\text{Eq. 4})$$

The road load force magnitude can now be expressed as:

$$-M_e \frac{dV}{dt} = \mu_o W (1 + \mu' V^2) + 1/2 \rho C_D A (V^2 + v_x^2) + 1/2 \rho (C_D + k) A v_y^2 \quad (\text{Eq. 5})$$

where:

The term linear in V has been ignored. The error introduced by ignoring this term (and the road grade) is minimized by the averaging process subsequently applied because these terms change sign for each change in coastdown direction.

Collecting terms, Equation 5 may be rewritten as:

$$-M_e \frac{dV}{dt} = f_0 + f_2 V^2 \quad (\text{Eq. 6})$$

where:

$$\begin{aligned} f_2 &= \mu_0 \mu' W + 1/2 \rho C_{DY} A \\ f_0 &= \mu_0 W + (f_2 - \mu_0 \mu' W) V_x^2 + 1/2 \rho C_{DY} A V_y^2 \end{aligned}$$

The crosswind aerodynamic drag coefficient C_{DY} is a measure of the response of the vehicle to the crosswind component of the wind at small yaw angles. It may be calculated by:

$$C_{DY} = C_D + k \quad (\text{Eq. 7})$$

The integral solution to this equation is:

$$t - t_0 = \frac{M_e}{\sqrt{f_0 f_2}} \left(\tan^{-1} \left(\sqrt{\frac{f_2}{f_0}} V_1 \right) - \tan^{-1} \left(\sqrt{\frac{f_2}{f_0}} V_2 \right) \right) \quad (\text{Eq. 8})$$

This is the equation which, after correction of the coefficients determined by the White and Korst technique or equivalent, is used to calculate the coastdown time interval. The units for M_e , f_0 , f_2 , V , and V_0 must be chosen so that the argument of the inverse tangent function is dimensionless and the resultant coastdown time is in seconds. The individual terms and their corrections are described in the following paragraphs.

10.3 Effective Vehicle Mass

The effective vehicle mass (M_e) is the sum of the final vehicle test mass ($M = W/g$) and the effective mass of the rotating components. The effective mass of the drivetrain components other than the wheels, tires, and brakes may be ignored. For each tire, wheel, and brake rotor or drum, the effective mass, m_e is:

$$m_e = \frac{I}{r^2} \quad (\text{Eq. 9})$$

where:

r is the rolling radius of the tire and I is the polar moment of inertia of the assembly. The polar moment of inertia may be measured or may be estimated by a circular disk expression:

$$I = \frac{W_w}{g} \frac{r^2}{2} \quad (\text{Eq. 10})$$

where:

W_w is the weight of the tire, wheel, and brake rotor or drum. If no measurements are available, the effective inertia of all the rotating components may be estimated as 3.0% of the vehicle test mass.

$$M_e = 1.03 \frac{W}{g} = 1.03M \quad (\text{For use in Equation 8}) \quad (\text{Eq. 11})$$

Vehicles that employ arrangements other than a normal four tire/wheel configuration require specific estimation of the effective mass of their rotating components.

For chassis dynamometer calculations the equivalent inertia of the driveline components, M_{DLC} is the effective inertia of two tire and wheel assemblies plus the effective inertia of two drive wheel brake rotors or drums. If no measurements are available, M_{DLC} may be estimated as 1.5% of the test mass.

$$M_{DLC} = 0.015 \frac{W}{g} = 0.015M \quad (\text{For use in Equations 18 and 19}) \quad (\text{Eq. 12})$$

10.4 Data Acceptability Criteria

Experience has shown that the criteria of this section are necessary and sufficient to provide accurate and precise test results. Data which exceed these criteria generally arise from wind gusts or driver inputs, which violate the assumption that the forces on the vehicle are depicted by Equation 6.

10.4.1 Analyze each individual coastdown $V(t)$ in the set of paired runs obtained in Section 9 by the White and Korst method, or equivalent, to obtain the coefficients f_0 and f_2 . A computer program that performs this task is supplied in Appendix A along with a sample data set (see Figure A1 and Figure A2) and the corresponding output. Using Equation 8 of 10.2, compare each individual $V(t)$ trace and its analytical counterpart $V(f_0, f_2, t)$. If the root-mean-square difference (error) exceeds 0.40 km/h (0.25 mi/h) on any individual run, discard that run and the paired run in the opposite direction. If less than three pairs comply with this criterion, the test run is invalid.

10.4.2 Of the paired runs meeting the criterion of 10.4.1, those which fail to satisfy the following criteria regarding f_0 and f_2 must also be discarded.

- a. The standard deviation of the f_0 's must be less than 11 N (2.5 lb) or 5% of the mean. If this value is exceeded, discard the run and its pair with f_0 farthest from mean and recompute the standard deviation until compliance is obtained or until the remaining pairs number less than three.
- b. The standard deviation of all the f_2 's must be less than $0.011 \text{ N}/(\text{km/h})^2$ ($0.001 \text{ lb}/[\text{mi/h}]^2$) or 3% of the mean. If this value is exceeded, discard the run and its pair with f_2 farthest from the mean and recompute the standard deviation until compliance is obtained or until the remaining pairs number less than three. If less than three pairs remain, the test run is invalid. Average f_0 's of all remaining runs to determine an f_0 . Average f_2 's of all remaining runs to determine an f_2 .

10.5 Data Correction

The average f_0 and f_2 values must now be corrected to a standard set of ambient conditions. The standard conditions are:

- a. Temperature—20 °C (68 °F)
- b. Atmospheric pressure—736.6 mm Hg (29.00 in Hg)
- c. Zero wind
- d. The effect of humidity on air density may be ignored

10.5.1 Wind Corrections to F_0

Separate the rolling resistance from wind effects as follows:

$$\mu_0 W = (f_0 - f_2 v_x^2 - 1/2 \rho C_{DY} A v_y^2) / (1 - \mu' v_x^2) \quad (\text{Eq. 13})$$

where:

ρ = mass density of ambient air
 μ' = velocity-dependent coefficient of rolling resistance
 C_{DY} = crosswind aerodynamic drag coefficient
 v_x = component of wind parallel to track
 v_y = component of wind perpendicular to the track

Unless specific information about the test vehicle is available, use the following values for the coefficients:

$$\begin{aligned} \mu' &= 19 \times 10^{-6} (\text{km/h})^{-2} & [50 \times 10^{-6} (\text{mi/h})^{-2}] & (\text{Eq. 14}) \\ C_{DY} &= 0.122 (\text{m/s})^2 / (\text{km/h})^2 & [3.4 (\text{ft/s})^2 / (\text{mi/h})^2] \end{aligned}$$

10.5.2 Temperature Correction to F_0

The temperature dependence of rolling resistance shall be corrected by:

$$f_0' = \mu_0 W [1 + k_t (T - T_0)] \quad (\text{Eq. 15})$$

Unless specific information about the test vehicle is available, use:

$$k_t = 8.6 \times 10^{-3} / ^\circ\text{C} = 4.8 \times 10^{-3} / ^\circ\text{F} \quad (\text{Eq. 16})$$

NOTE: Significant changes in sun load may affect rolling resistance and thereby contribute to test variations.

10.5.3 Weight Correction

Equation 15 may be used to correct the test results for small weight differences (less than 50 kg or 100 lb) between the actual vehicle test weight and a desired vehicle test weight (see 9.5).

10.5.4 Air Density Correction to F_2

Adjust the coefficient of the V^2 term to standard ambient conditions ($\rho = 1.1678 \text{ kg/m}^3$ [$\rho = 0.002266 \text{ slugs/ft}^3$]) by the equation:

$$f_2' = (\rho_0 T / \rho T_0) [f_2 - \mu' (\mu_0 W)] + \mu' f_0' \quad (\text{Eq. 17})$$

where:

p = barometric pressure
 $p_0 = 736.6 \text{ mm Hg (29.00 in)}$
 T = absolute temperature of ambient air (K or $^\circ\text{R}$)
 $T_0 = 293.16 \text{ K (527.69 } ^\circ\text{R)}$

10.6 Calculation of Coastdown Time

10.6.1 Calculation of 55 to 45 mph Coastdown Time

The 55 to 45 mph coastdown time on a chassis dynamometer, which duplicates the force at 50 mph, measured on the road is given by:

$$\delta t = t - t_0 = \frac{1.467(M_{IW} + M_{DLC})}{\sqrt{f_0' f_2'}} \left(\tan^{-1} \left(\sqrt{\frac{f_2'}{f_0'}} \right)_{55} - \tan^{-1} \left(\sqrt{\frac{f_2'}{f_0'}} \right)_{45} \right) \quad (\text{Eq. 18})$$

10.6.2 Calculation of 88 to 72 km/h Coastdown Time

The 88 to 72 km/h coastdown time on a chassis dynamometer, which duplicates the force at 80 km/h, measured on the road is given by:

$$\delta t = t - t_0 = \frac{(M_{IW} + M_{DLC})}{3.6 \sqrt{f_0' f_2'}} \left(\tan^{-1} \left(\sqrt{\frac{f_2'}{f_0'}} \right)_{88} - \tan^{-1} \left(\sqrt{\frac{f_2'}{f_0'}} \right)_{72} \right) \quad (\text{Eq. 19})$$

11. PART 2—CHASSIS DYNAMOMETER SIMULATION OF VEHICLE ROAD LOAD

This portion of the procedure covers the measurement of total load on the vehicle as a function of dynamometer absorber horsepower when the vehicle is mounted on a chassis dynamometer. This procedure is written to determine the total load on the vehicle at 80 km/h (50 mi/h). It may also be extended to determine the load on the vehicle at other speeds.

12. DEFINITIONS

12.1 Indicated Horsepower

The indicated horsepower is the load horsepower which is set on the dynamometer and does not include the friction in the dynamometer bearings or inertia simulation mechanism.

12.2 Actual Horsepower

The actual horsepower is the load horsepower which includes the friction in the dynamometer bearings and inertia simulation mechanism.

13. EQUIPMENT

13.1 Test Site

A chassis dynamometer, which has an adjustable power absorber setting capability, is necessary. The dynamometer speed during this test must be measured from the shaft, which drives the power absorber and weights. The dynamometer must be calibrated over a range of horsepower settings and at the inertia weight used in the test.

13.2 Test Instrumentation

An instrument that can measure the time to coastdown between two speeds on a chassis dynamometer will be used. The specifications for this instrument are as follows: