Designation: F1805 – 16

Standard Test Method for Single Wheel Driving Traction in a Straight Line on Snow- and Ice-Covered Surfaces[1]

This standard is issued under the fixed designation F1805; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers a procedure for measuring the driving traction of passenger car and light truck tires while traveling in a straight line on snow- or ice-covered surfaces.

1.2 This test method utilizes a dedicated, instrumented, four-wheel rear-wheel drive test vehicle with a specially instrumented drive axle to measure fore-aft and vertical forces acting on a single driven test tire.

1.3 This test method is suitable for research and development purposes where tires are compared during a single series of tests. They may not be suitable for regulatory statutes or specification acceptance because the values obtained may not necessarily agree or correlate either in rank order or absolute traction performance level with those obtained under other environmental conditions on other surfaces or the same surface after additional use.

1.4 The values stated in SI units are to be regarded as the standard. Ordinarily, N and kN should be used as units of force. This standard may utilize kgf as a unit of force in order to accommodate the use of load and pressure tables, as found in other standards both domestic and global that are commonly used with this standard. The values given in parentheses are for information only.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E1136 Specification for P195/75R14 Radial Standard Reference Test Tire

F377 Practice for Calibration of Braking/Tractive Measuring Devices for Testing Tires

F538 Terminology Relating to the Characteristics and Performance of Tires

F1046 Guide for Preparing Artificially Worn Passenger and Light Truck Tires for Testing

F1572 Test Methods for Tire Performance Testing on Snow and Ice Surfaces

F1650 Practice for Evaluating Tire Traction Performance Data Under Varying Test Conditions

F2493 Specification for P225/60R16 97S Radial Standard Reference Test Tire

2.2 *Other Standards:*

The European Tyre and Rim Technical Organisation Standards Manual[3]

The Japan Automobile Tyre Manufacturers Association, Inc. Yearbook[4]

The Tire & Rim Association, Inc. Year Book[5]

Tire Information Service Bulletin, Vol. 37/No. 3 Rubber Manufacturers Association (RMA) Definition for Passenger and Light Truck Tires for Use in Severe Snow Conditions[6]

3. Terminology

3.1 *Definitions:*

3.1.1 *candidate tire, n*—a test tire that is part of a test program. **F538**

3.1.1.1 *Discussion*—The term "candidate object" may be used in the same sense as *candidate tire*.

3.1.2 *control tire, n*—a reference tire used in a specified manner throughout a test program. **F538**

3.1.2.1 *Discussion*—A control tire may be of either type and typical tire used is the reference (control) tire in Practice F1650

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from The European Tyre and Rim Technical Organisation, 78/80, rue Defacqz B-1060, Brussels, Belgium.

[4] Available from The Japan Automobile Tyre Manufacturers Association, Inc., No. 33 Mori Bldg. 8th Floor, 3-8-21 Toranomon, Minato-ku, Toyko, Japan 105-0001.

[5] Available from The Tire & Rim Association, Inc., 175 Montrose West Ave., Suite 150, Copley, OH 44321.

[6] Available from the Rubber Manufacturers Association, 1400 K Street, N.W., Washington D.C. 20005.

that provides algorithms for correcting (adjusting) test data for bias trend variations. (See Practice F1650. See also the discussion in 3.1.16.)

3.1.3 *driving coefficient (nd), n*—the ratio of the driving force to a normal force. **F538**

3.1.4 *driving force (F), n— of a tire*, the positive longitudinal force resulting from the application of driving torque. **F538**

3.1.5 *grooming, v—in tire testing*, mechanically reworking a snow test surface in order to obtain a surface with more consistent properties. **F538**

3.1.6 *ice, dry, n*—smooth ice without loose surface materials. **F538**

3.1.7 *longitudinal force (F), n— of a tire*, the component of the tire force vector in the X' direction. **F538**

3.1.8 *longitudinal slip velocity (L/T), n*— the effective rolling radius multiplied by the difference between the spin velocity (in rad/unit time) of a driven or braked tire and that of a free rolling tire when each is traveling in a straight line. **F538**

3.1.9 *maximum rated load, n*—the load corresponding to the maximum tire load capacity at the rated inflation pressure in accordance with the publications of tire and rim standards current at the time of manufacture. **F538**

3.1.10 *reference tire, n*—a special tire included in a test program; the test results for this tire have significance as a base value or internal benchmark. **F538**

3.1.11 *snow, hard pack, n— in tire testing*, packed base without loose snow. **F538**

3.1.12 *snow, medium pack, n— in tire testing*, groomed packed base with 2.5 to 5.0 cm (1 to 2 in.) loose snow. **F538**

3.1.13 *snow, medium hard pack, n— in tire testing*, packed base with some loose snow. **F538**

3.1.14 *snow, soft pack, n— in tire testing*, freshly fallen or deeply groomed base snow with 5.0 to 7.5 cm (2 to 3 in.) loose snow. **F538**

3.1.15 *spin velocity, n*—the angular velocity of the wheel about its spin axis. **F538**

3.1.16 *standard reference test tire (SRTT), n*—a tire that is used as a control tire or surface monitoring tire (for example, Specification E1136 and Specification F2493 tires). **F538**

3.1.16.1 *Discussion*—While ASTM designates several tire specifications as Standard Reference Test Tires, Test Method F1805 has historically used the Specification E1136 tire as its primary reference tire and this specification is specifically identified as the control tire in the RMA Tire Information Service Bulletin Vol. 37/No. 3, which specifies requirements for application of the Severe Snow Use Symbol (3 peak mountain snowflake).

3.1.17 *surface monitoring tire, n*—a reference tire used to evaluate changes in the test surface over a selected time period. **F538**

3.1.18 *test (or testing), n*—a procedure performed on an object (or set of nominally identical objects) using specified equipment that produces data unique to the object (or set). **F538**

3.1.18.1 *Discussion*—Test data are used to evaluate or model selected properties or characteristics of the object (or set of objects). The scope of testing depends on the decisions to be made for any program, and sampling and replication plans (see definitions below) need to be specified for a complete program description.

3.1.19 *test matrix, n— in tire testing* a group of candidate tires, usually with specified reference tires; all tests are normally conducted in one testing program. **F538**

3.1.20 *test run, n*—a single pass of a loaded tire over a given test surface. **F538**

3.1.21 *test tire, n*—a tire used in a test. **F538**

3.1.22 *test tire set, n*—one or more test tires, as required by the test equipment or procedure, to perform a test, thereby producing a single test result. **F538**

3.1.22.1 *Discussion*—The four nominally identical tires required for vehicle stopping distance testing constitute a test tire set. In the discussion below where the test tire is mentioned, it is assumed that the test tire set may be substituted for the test tire, if a test tire set is required for the testing.

3.1.23 *traction test, n— in tire testing,* a series of *n* test runs at a selected operational condition; a traction test is characterized by an average value for the measured performance parameter. **F538**

3.1.24 *vertical load, n*—the normal reaction of the tire on the road which is equal to the negative of normal force. **F538**

4. Summary of Test Method

4.1 These test methods describe the use of an instrumented vehicle with a single test wheel capable of measuring the tire performance properties under drive torque on snow and ice surfaces when traveling in a straight line.

4.2 The test is conducted by driving the test vehicle over the test surface. Driving torque is gradually increased to the test wheel while maintaining the vehicle speed by applying braking torque to the non-test wheels of the vehicle. The driving traction coefficient is determined from the measured values of longitudinal and vertical forces over a specified slip or time range. The recommended vehicle test speed is 8.0 km/hr (5.0 mph).

5. Significance and Use

5.1 This test method describes a technique for assessing the performance characteristics of tires in a winter environment on snow and ice surfaces. When snow is referred to hereafter, ice is implied as appropriate.

5.2 The measured values quantify the dynamic longitudinal traction properties of tires under driving torque. Dynamic traction properties are obtained on snow surfaces prepared in accordance with the stated test procedures and attempts to quantify the tires' performance when integrated into a vehicle-environmental system. Changing any one of these environmental factors will change the measurements obtained on a subsequent test run.

5.3 This test method addresses longitudinal driving traction properties only on snow and ice surfaces. Refer to Test

Methods F1572 for test methods for braking and lateral traction properties on snow or ice, or both.

6. Interferences

6.1 Factors that may affect tire snow performance and must be considered in the final analysis of data include:

6.1.1 Snow temperature,

6.1.2 Ambient temperature,

6.1.3 Mechanical breakdown of the agglomerated snowflake into granular crystals,

6.1.4 Solar load,

6.1.5 Tire temperature,

6.1.6 Tire wear condition (preparation),

6.1.7 Tire pressure,

6.1.8 Tire vertical load,

6.1.9 Snow surface characteristics, and

6.1.10 Rim selection.

7. Apparatus

7.1 The test vehicle shall have the capability of maintaining the specified test speed ± 0.8 km/h (± 0.5 mph) during all levels of driving torque application.

7.2 The test vehicle shall be equipped with an automatic throttle actuator to allow the gradual increase of driving torque at a predetermined (repeatable) rate.

7.3 The test vehicle shall be a rear drive, four wheel passenger car or a light truck less than or equal to 44.5 kN (10 000 lbf) GVW. The range of test tires and load conditions will determine the vehicle size and selection. Utilizing a front wheel drive test vehicle is not addressed in this standard although the basic procedures could be applied with appropriate conditional modifications.

7.4 The test vehicle shall be instrumented to measure longitudinal and vertical forces at the tire and test surface interface during the application of driving torque.

7.5 The test vehicle shall have provisions to automatically and completely disengage the brake on the test wheel (if installed) prior to throttle application. Complete disengagement is necessary to eliminate all drag that might be caused by the brake assembly.

7.6 *Opposite Tire:*

7.6.1 The tire installed opposite the instrumented test wheel shall have a sufficiently large traction coefficient to minimize slip of this tire during the traction test. The opposite tire should have a coefficient at least 50 % greater than the expected coefficient of the test tire. A tire chain may be utilized to increase the traction of the opposite tire when testing on snow surfaces.

7.6.2 The opposite tire shall be selected to have an outside diameter that is within ±2.5 cm (±1 in.) of that of the test tire.

7.7 A suitable ride height adjustment system on the rear axle shall be provided to permit adjustment for each tire size and load to minimize transducer crosstalk as established during calibration.

7.8 *Instrumentation*—The test wheel position on the test vehicle shall be equipped with a wheel rotational velocity measuring system and with transducers to measure the dynamic longitudinal force and vertical load at the test wheel.

7.8.1 *General Requirements for Measurement System*—The instrumentation system shall conform to the following overall requirements at ambient temperatures between –23 and 43°C (–10 and 110°F):

7.8.1.1 *Overall system accuracy, force*—± 1.5 % of vertical load or traction force from 450 N (100 lbf) to full scale.

7.8.1.2 *Overall system accuracy, speed*—± 1.5 % of speed from 6.4 km/h (4.0 mph) to 48.0 km/h (30.0 mph).

7.8.1.3 *Shunt Calibration*—All strain-gage transducers shall be equipped with shunt calibration resistors that can be connected before or after test runs. The calibration signal shall be in the range of the expected measurement for each analogue channel..

7.8.1.4 *Ruggedness*—The exposed portions of the system shall tolerate 100 % relative humidity (rain or spray) and all other adverse conditions such as dust, shock, and vibrations which may be encountered in regular operation.

7.8.2 *Vehicle Speed*—Vehicle forward speed (normally obtained from a front non-driven wheel on the test vehicle) shall be measured digitally with an encoder or optical system having a minimum of 500 counts per revolution. Output shall be directly visible to the driver and shall be simultaneously recorded. It may be necessary on a very low coefficient surface, i.e., ice, to disconnect any braking action to the wheel being utilized for measuring vehicle speed. A separate fifth-wheel system may be utilized to measure vehicle forward speed.

7.8.3 *Test Wheel Speed*—Test wheel speed shall be measured digitally with an encoder or optical system having a minimum of 1000 counts per wheel revolution. The output shall be recorded.

7.8.4 *Vertical Load*—The vertical load-measuring transducer shall measure the vertical load at the test wheel during driving torque application. The transducer full scale range shall be in excess of the dynamic loading during a test. Data points shall be evaluated to ensure dynamic loading is within the calibrated range of the transducer. The static load should be less than 80 % of the calibrated range. The transducer design and location shall minimize inertial effects and vibration-induced mechanical resonance. The transducer shall have an output directly proportional to the force with less than 1 % hysteresis and less than 1 % nonlinearity at full scale. It shall have less than 2 % cross-axis sensitivity at full scale. The transducer shall be installed in such a manner as to experience less than 1° angular rotation with respect to its measuring axes at a maximum expected driving torque. The transducers typically have a minimum full scale range of 0 to 8.9 kN (2000 lbf).

7.8.5 *Driving Traction Forces*—The driving traction force-measuring transducers shall measure longitudinal force generated at the tire-road interface as a result of driving torque application with a full scale range of at least 100 % of the applied static vertical load. Otherwise, the transducers shall have the same specifications as those described in 7.8.4.

7.8.6 *Signal Conditioning and Recording System*—All signal conditioning and recording equipment shall provide linear output with necessary gain and reading resolution to meet the requirements of 7.8.1. Additionally, it shall have the following specifications:

7.8.6.1 *Minimum Frequency Response*—flat from dc to 18 Hz, within ±1 %,

NOTE 1—Based on a study of a sample acquisition and force transducer system, a resonant frequency of 20 Hz was measured.

7.8.6.2 *Signal-to-Noise Ratio*—at least 20/1,

7.8.6.3 Gain shall be sufficient to permit full-scale display for full-scale input signal level,

7.8.6.4 Input impedance shall be at least ten times larger than the output impedance of the signal source,

7.8.6.5 The system must be insensitive to vibrations, acceleration, and changes in ambient temperature. The error in reading shall not exceed 1 % full scale when subjected to vibration acceleration of 49.0 m/s^2 (5 g's) in the 0.5 to 40 Hz frequency range and operating temperature range from –23 to 43°C (–10 to 110°F),

7.8.6.6 The system shall not be affected by storage temperature variations between –40 and 71°C (–40 and 160°F),

7.8.6.7 The individual data inputs shall have a sample rate of not less than 100 samples/s. For a given sample, vehicle speed, test wheel speed, vertical load, and driving traction force shall all be recorded within 0.0005 s,

7.8.7 *Power Supply*—The power supply for transducers and recording system shall meet or exceed requirements specified by transducer and recorder manufacturers.

7.8.8 Temperature measurement devices for taking surface and ambient temperatures shall have a resolution of 0.5°C (1°F) and an accuracy of ±1°C (±2°F).

7.8.9 Pressure measurement devices for setting tire pressure shall have a resolution of 3.5 kPa (½ psi) and an accuracy of ±3.5 kPa (±½ psi).

8. Calibration

8.1 All instrumentation shall be calibrated within six months prior to testing.

8.2 Calibrate the reference load cell by inputting known vertical and horizontal forces. The known forces must be traceable to the National Institute of Standards and Technology (NIST).

8.3 Calibrate the transducer for measuring vertical and horizontal forces on the test wheel with the reference load cell in accordance with Practice F377.

8.3.1 For longitudinal force calibration, place vehicle transmission in "park" position. Restrain the test vehicle using the vehicle brakes normally used while testing.

8.4 Calibrate the vehicle and test tire speed transducers and any other instrumentation in accordance with the manufacturers' specification.

8.5 Calibrate temperature measuring devices (snow and ambient temperatures) in accordance with the manufacturer's recommendations.

8.6 Calibrate pressure measuring devices in accordance with the manufacturer's recommendations.

9. Selection and Preparation of Test Tires

9.1 Ensure all test tires are approximately the same age and stored essentially at the same conditions prior to testing unless otherwise specified. When testing to the requirements of the Tire Information Service Bulletin Vol. 37/No. 3, the SRTT Specification E1136 control tire shall be less than 2 years old based on the week/year manufacture date molded into the tire sidewall.

9.2 Test tires shall have no evidence of force or run-out grinding.

9.3 New test tires shall be trimmed to remove all protuberances in the tread area caused by mold air vents or flashing at mold junctions.

9.4 Any objects (for example, shipping labels) in the tread area shall be removed prior to testing.

9.5 Tires that have been buffed to simulate wear must be prepared and run until all evidence of buffing is removed in accordance with Guide F1046.

9.6 Mount the test tires on rims specified by the appropriate tire and rim standards organization, using conventional mounting methods. Ensure proper bead seating by the use of a suitable lubricant. Excessive use of lubricant should be avoided to prevent slipping of the tire on the wheel rim. Ensure tires are mounted so the intended rotational direction of the tire corresponds with the test wheel position of the test vehicle. If rotation direction of the tire is not specified, the tire shall be mounted so during testing it rotates clockwise when viewed from the intended outboard sidewall of the tire.

9.7 Test tire balance is not necessary.

9.8 New test tire break-in is optional, however, the design of the test may necessitate on-the-road conditioning of up to 322 km (200 miles). Tire break-in may improve repeatability of results on ice surfaces.

9.9 Mounted test tires shall be placed near the test site in such a location that they all have the same temperature prior to testing. Test tires should be shielded from the sun to avoid excessive heating by solar radiation.

9.10 Test tires shall be checked and adjusted for specified pressure just prior to testing.

10. Preparation of Apparatus

10.1 All transducers and instrumentation shall have been calibrated in accordance with Section 8.

10.2 Turn on the test vehicle instrumentation and allow it to warm up as required for stabilization.

10.3 Ensure the test vehicle has sufficient fuel to complete a test matrix.

10.4 Maneuver the test vehicle to the tire changing area.

10.5 Position the temperature measurement devices.

10.6 Allow sufficient time to ensure that the temperatures of all equipment have stabilized.

10.7 Set the front speed reference tire or fifth wheel to the pressure utilized during the speed calibration ±3.5 kPa (±0.5 psi). Non-test rear tire pressures should be set as appropriate.

10.8 Perform a resistive shunt calibration on the force transducers once per day at a minimum. It is recommended that a resistive shunt calibration check be performed at the start and end of each testing day.

11. Procedure

11.1 *Course Surface*—See Annex A1 – Annex A4 for environmental and snow properties, surface characterization, course preparation, and course maintenance. When testing to the requirements of the Tire Information Service Bulletin Vol. 37/No. 3, a medium-packed snow surface shall be used.

11.2 Lift the rear axle so that the rear tires are off the ground.

11.3 Install a control or candidate tire at the test wheel position with the vehicle jacked up.

11.4 Opposite the test wheel position install a tire that has an outside diameter within ±2.5 cm (±1 in.) of the test tire. A chained tire is optional in snow.

11.5 Record basic test information and tire conditions. Ambient and surface temperatures shall be updated with each control tire.

11.6 With the transmission in park or neutral, tare vertical load and tractive force by zeroing the signals.

11.7 Verify the vehicle and test wheel speeds are zero.

11.8 Lower the rear axle, placing the tires on the ground.

11.9 Ballast the test tire for the desired load, ±22 N (±5 lbf), and set the tire to the specified test inflation pressure, ±3.5 kPa (±0.5 psi). One of the following three options shall be selected for determining load and inflation pressure for testing. The option selected shall be noted in the final report. If computed test load exceeds the test equipment capabilities, test inflation rated load and its corresponding pressure may be reduced to the next lower load/pressure increment and a new test load/pressure recomputed. See Annex A5 for examples of load and pressure determination for options 1 and 2. Table 1 summarizes the various test load and pressure options.

NOTE 2—A P195/75R14 SRTT (Specification E1136) control tire is tested at a load of 468 kgf (1031 lbf) and a pressure of 240 kPa (35 psi).

11.9.1 *Option 1*—The test load for passenger car tires shall be the lower value of 70 % of the maximum rated load of the tire or 567 kgf (1250 lbf). The test load for light truck tires shall be the lower value of 70 % of the maximum rated load of the tire or 567 kgf (1250 lbf). An inflation pressure of 250 kPa (36 psi) shall be used for passenger tires and 350 kPa (51 psi) shall be used for light truck tires.

11.9.2 *Option 2*—The test load shall be equal to 74 % of the rated load at the test inflation pressure as shown in the Tire &

TABLE 1 Test Load and Test Pressure Options

F1805 Test Option	Tire Type	Marked Sidewall max psi	F1805 Test Load	F1805 Test Pressure psi
1	Passenger car tire (TRA/ETRTO/JATMA)	Any	70 % of Maximum rated load or 567 kgf (1250 lbf) max	36
	Light Truck (TRA/ETRTO/JATMA)	Any	70 % of Maximum rated load or 567 kgf (1250 lbf) max	51
2	Pmetric LL,SL	35	74 % * table value at test pressure	35
		44	74 % * table value at test pressure	35
		51	74 % * table value at test pressure	35
	Pmetric XL	41	74 % * table value at test pressure	41
		50	74 % * table value at test pressure	41
	LT-metric		74 % * table value at test pressure	50
	Flotation-LT		74 % * table value at test pressure	35
	Eurometric C (Commercial LT)		74 % * table value at test pressure	51
	Eurometric SL	32	74 % * table value at test pressure	32
		36	74 % * table value at test pressure	36
		44	74 % * table value at test pressure	36
		51	74 % * table value at test pressure	36
	Eurometric XL	42	74 % * table value at test pressure	42
		51	74 % * table value at test pressure	42
3	Any		Any	Any

Rim Association (TRA) Year Book, in the European Tyre and Rim Technical Organisation Manual (ETRTO), or in the Japan Automobile Tyre Manufacturers Association Manual (JATMA). See Table 1. This option meets the requirement for equivalent percentage loads as specified in the RMA Tire Information Service Bulletin Vol. 37/No. 3.

11.9.3 *Option 3*—The test tire loads and inflation pressures shall be any other loads and pressures required to meet the individual requirements of a specific test program.

11.10 Adjust the vehicle ride height to the value established during the calibration for minimum crosstalk taking into account differences in tire dimensions.

11.11 Re-verify test load. Adjusting vehicle ride height may change the test load. Several load/ride height adjustments may be necessary before meeting both requirements.

11.12 Calibrate the test wheel speed for each test tire by bringing the vehicle up to approximately 8 km/h (5.0 mph). Place the vehicle in neutral or reduce throttle position to a minimum. Adjust the test wheel speed to be equal to vehicle speed. Care must be taken to see that the vehicle is going in a straight line without tire slippage during speed calibration.

11.13 Set the automatic throttle applicator to keep fore-aft force increase to less than a maximum of 1780 N/s (400 lbf/s).

11.14 Begin a test by activating the automatic throttle applicator when on the test course. A straight line should be maintained throughout testing and a smooth modulated brake load applied to maintain an 8.0 ± 0.8 km/h (5.0 ± 0.5 mph) test vehicle speed. In the course of testing do not use any test run when a test tire digs through the base material or where the average vehicle speed is outside 8.0 ± 0.8 km/h (5.0 ± 0.5 mph).

11.15 Repeat step 11.14 a minimum of ten times. At the completion of ten or more test runs, process the data and examine for a minimum of eight valid test runs after outliers (individual test run data values more than 1.5 standard deviations from the calculated average) have been eliminated and for a calculated sample coefficient of variation (C.V.) less than 0.15 (15 %). If requirements are met, record data and return to the tire changing area. Rerun the test tire if requirements are not met. Surface monitoring tire (SRTT, Specification E1136) coefficients should be noted, ensuring compliance with the specified range 0.25–0.41 for medium pack snow.

11.16 Run a control tire at the beginning and end of each test sequence or test matrix and every third test in between. For example: C, T1, T2, C, T3, T4, C, where C represents a control tire and T represents a candidate tire.

NOTE 3—A single control or candidate tire may be used repeatedly as long as the tread surface maintains a "new" appearance.

11.17 Each candidate tire should be tested at least three times, preferably on different days.

11.18 Each new test tire shall be run on a surface as near as possible to the previous pass. Care must be taken not to allow the test tire to drift into disturbed snow used during previous test runs.

11.19 Testing continues until the total test sequences or test matrix is completed or the available test surface is exhausted. Regrooming the course will normally allow testing to continue.

12. Calculation

12.1 For each test run of each control and candidate tire, read from accumulated data the values of longitudinal force and vertical load corresponding to the values of longitudinal slip velocity within the range 1.6 and 24 km/h (1 and 15 mph) or a range starting at 3.2 km/h (2 mph) and continuing for 1.5 s. Calculate the average force and load values over the specified slip or time range. Calculate the average values of driving coefficient as follows:

$$u = \frac{F}{W} \tag{1}$$

where:

u = average driving coefficient,
F = average longitudinal force kN or lbf, and
W = average vertical load kN or 1bf.

12.2 Calculate the values of longitudinal slip velocity as follows:

$$V_S = \frac{V_o(W_d - W_o)}{W_o} \tag{2}$$

where:

V_s = longitudinal slip velocity km/h or mph,
V_o = test vehicle speed km/h or mph,
W_o = spin velocity of non-driven wheel, and
W_d = spin velocity of driven wheel.

12.3 Calculate the average value of test run driving coefficients for each test tire and the value of sample standard deviation for ten or more test runs. Eliminate any individual test run value more than 1.5 standard deviations from the calculated average. A minimum of eight test runs shall remain. Recalculate the average and standard deviation for each test tire.

12.4 Calculate the traction test coefficient of variation as follows:

$$C.V. = \frac{\text{Sample Standard Deviation}}{\text{Mean}} \tag{3}$$

If the data have a C.V. greater than 0.15, the tire data set should not be used and the entire test run shall be repeated.

13. Data Adjustment Procedures

13.1 The traction performance (traction coefficients) of the candidate tires in any extended sequence of testing may vary due to changing environmental or other test conditions. To evaluate traction performance without this potentially perturbing influence it is common practice to adjust or correct candidate tire coefficients based on the values obtained for one or more control tires tested throughout the evaluation program.

13.2 Practice F1650 is the reference standard that gives a comprehensive background and recommended control and candidate tire test sequence as well as procedures for making these corrections. (See Section 7.) Practice F1650 permits corrections to be made if there is any significant time trend or other perturbation in environmental or other testing conditions during the testing program.

13.3 Other correction procedures are also in current use. These are the Gradient Correction Procedure and the Average Correction Procedure. The calculation algorithms for these two are given below. The Gradient Procedure which uses weighted control tire values for correcting candidate tire coefficients is equivalent to the procedure as given in Practice F1650, Annex A2. (See Plan A or B.)

13.4 *Gradient Correction Method*—The gradient method makes adjustments for changes of control tire values that bracket the candidate tire runs. For the normal sequence of Control 1, Candidate Tire 1, Candidate Tire 2, Control 2, the traction performance index (TPI) rating is computed as follows:

$$\text{TPI}\ (T_1) = \frac{\text{TC}\ (T_1)}{\text{TC}\ (C_1) + 1/3\ [\text{TC}\ (C_2) - \text{TC}\ (C_1)]} \times 100 \quad (4)$$

$$TPI\ (T_2) = \frac{\text{TC}\ (T_2)}{\text{TC}\ (C_1) + 2/3\ [\text{TC}\ (C_2) - \text{TC}\ (C_1)]} \times 100 \quad (5)$$

where:

TC (T_1) = Average Tractive Coefficient Candidate Tire 1,
TC (T_2) = Average Tractive Coefficient Candidate Tire 2,
TC (C_1) = Average Tractive Coefficient First Control Run, and
TC (C_2) = Average Tractive Coefficient Second Control Run.

13.4.1 The TPI for second and subsequent candidate tires is calculated utilizing the new bracketing control tire values, that is, C_2 and C_3, C_3 and C_4, etc.

13.5 *Average Correction Method*—Calculate the average value of all control tire driving coefficients within a day's test tire matrix. To obtain the traction performance index (TPI) rating, divide individual candidate tire driving traction coefficient values by the tire matrix average control tire coefficient and multiply by 100 to obtain the TPI:

$$\text{TPI} = \frac{\text{Coefficient (Candidate Tire)}}{\text{Coefficient (Control Tire Avg.)}} \times 100 \quad (6)$$

14. Report

14.1 Report the following information:

14.1.1 Candidate tire TPI (rating).

14.1.2 Correction method applied to the "as measured" tractive coefficient.

14.1.3 Ambient and surface temperatures.

14.1.4 Type of surface.

14.1.5 Tire I.D., load and inflation as tested.

14.2 State that the test was performed in accordance with ASTM Test Method F1805

15. Precision and Bias

15.1 *Precision*—Data are not yet available for making a statement on the precision or reproducibility of this test method. When such data becomes available, a statement on precision will be included in the method.

15.2 *Bias*—There are no standards or reference values with which the results of this test method can be compared. The function of the test as indicated in the scope is to be able to make comparisons among types of tires tested within the same test program. It is believed that the results of the test method are adequate for making such comparisons without external references for assessing bias.

16. Keywords

16.1 driving traction (snow, ice); single test wheel vehicle; snow/ice surfaces; traction measurement

ANNEXES

(Mandatory Information)

A1. ENVIRONMENTAL AND SNOW PROPERTIES

A1.1 Snow and ice surfaces often exhibit significant variation in traction properties due to changes in temperature and other climactic conditions. For determining relative tire performance on snow or ice surfaces, or both, it is necessary to be able to quantify these conditions.

A1.1.1 *Temperature*—Air and surface temperature shall be measured throughout testing at least at every control tire run.

A1.1.2 *Snow Properties*—Snow density, temperature, water content, crystal structure, and shear strength all affect snow traction. Typically, multiple snow properties are combined into one measurement made by an apparatus such as a penetrometer.

A1.1.3 *Surface Traction Coefficient*—A single test wheel driving traction vehicle utilizing a surface monitoring tire may be used to obtain surface traction coefficients in accordance with Section 11. A standard reference test tire (SRTT) meeting the requirements of Specification E1136 typically is used.

A2. SURFACE CHARACTERIZATION

A2.1 The ability to quantitatively or subjectively characterize the test surface is essential in preparing and maintaining a uniform test surface and minimizing surface variation. In addition, characterization is important in initial preparation as well as in determining the need for surface regrooming during testing. Methods of surface characterization include measurement of surface compaction or hardness, surface and ambient temperatures, and surface monitoring tire (SMT) driving tractive coefficients. Table A2.1 lists the various course surface characteristics and recommended measurement values. Take ambient temperatures in a shaded area 30 ± 5 cm (12 ± 2 in.) above the surface. Take surface temperatures with the temperature measurement device inserted 2.5 ± 1.3 cm (1 ± 0.5 in.) below the surface in an unshaded area. Optionally, take surface compaction readings with a penetrometer[7] in accordance with Appendix X1. At least ten measurements over the whole course shall be taken to establish a meaningful average. Obtain SRTT tractive coefficients in accordance with Section 11.

[7] The sole source of supply of the apparatus (the CTI Penetrometer) known to the committee at this time is Smithers Scientific Services, Inc., 425 W. Market St., Akron, OH 44303. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

TABLE A2.1 Course Characteristics

NOTE 1—Determining the need for regrooming is largely subjective; however, regrooming is required after the test course has been fully utilized.

NOTE 2—A packed base is generally obtained by mechanically smoothing and packing the test course and allowing the resultant smooth surface to set up in the overnight cold temperatures (preferably –12°C (10°F) or less).

Surface Description	Temperatures			Penetrometer Snow Compaction	SRTT (E1136) Tractive Coefficient[A]	Surface and Footprint Characteristics[B]	Remarks
	Amb. Max	Surface Min.	Surface Max.				
Soft pack (new) snow	+3°C (+38°F)	–15°C (+5°F)	–4°C (+25°F)	50–70	0.18–0.22	5.0–7.5 cm (2–3 in.) loose snow. Distinctive footprint.	[C]
Medium pack snow	+3°C (+38°F)	–15°C (+5°F)	–4°C (+25°F)	70–80	0.25–0.41[D]	2.5–5.0 cm (1–2 in.) loose snow. Distinctive footprint.	[E]
Medium hard pack snow	+3°C (+38°F)	–15°C (+5°F)	–4°C (+25°F)	80–84	0.20–0.25	1.0–2.0 cm (0.4–0.8 in.) loose snow. Slight footprint.	[F]
Hard pack snow	+3°C (+38°F)	–15°C (+5°F)	–4°C (+25°F)	84–93	0.15–0.20	No loose snow. Little or no footprint.	[G]
Ice-wet	0°C (+32°F)	–8°C (+18°F)	0°C (+32°F)	93–98	0.06–0.12	Smooth ice with no loose materials. No footprint.	[H]
Ice-dry	0°C (+32°F)	–20°C (–4°F)	–7°C (+20°F)	93–98	0.06—0.14	Smooth ice with no loose materials. No footprint.	[H]

[A] See Specification E1136.
[B] Footprint characteristics are determined by walking or driving on the prepared surface and examining the extent of the imprint or lack thereof.
[C] Freshly fallen snow or deeply groomed base snow.
[D] Testing in the range above 0.38 should be avoided.
[E] Generally obtained by grooming packed base prior to testing in morning.
[F] Typical surface for snow tire/vehicle handling tests.
[G] Packed base with no grooming.
[H] Avoid bright sun on course. Broom or resurface as required.

A3. COURSE PREPARATION

A3.1 *Surface Preparation*—Course preparation is critical for obtaining valid and repeatable results. The snow test surface should be flat with a maximum 2 % grade and of sufficient width and length to perform the test. A large prepared area is desirable to reduce the instances of regrooming during daily testing. A snow test area of about 21 × 185 m (70 × 600 ft) will normally be sufficient for most testing; however, smaller areas have been used successfully. The site should have a limited access and can be paved or unpaved. All vegetation should be removed if an unpaved site is used. Once a site has been selected, a course must be prepared. Developing a base is the most critical step in this preparation. A good base must adhere to the firm subsurface and be completely smooth and uniform in consistency. Without a good base, it is impossible to develop good test data.

A3.1.1 Deep loose snow cannot be compacted into a satisfactory hard pack base. Therefore, it should be packed in layers. Excessive snow should be removed to a depth 5 to

10 cm (2 to 4 in.) depending on the compressibility of the snow before packing. After the first layer is packed, the snow that was previously removed can be brought in to a depth of about 5 cm (2 in.) and compacted again. This process is repeated until sufficient base depth is developed. Allowing a base to sit undisturbed overnight or longer will usually firm it up. The base must be of sufficient depth so that a spinning test tire does not dig down to anything but more base snow. Required depth changes depending on test tread designs, but usually a minimum of 2 in. is necessary. Throughout a test season, it will be necessary to groom the surface to keep it smooth and free from holes and undulations. In extreme cases, use of a road grader or snow plow may be required.

A3.1.2 Once a base is established, the preferred method is to wait for natural snow to accumulate to a sufficient depth to allow appropriate testing conditions. When a large test area is available, various sections can be designated as soft, medium, and hard pack test areas. The preferred snow condition for best discrimination among tire types is medium packed snow over a hard packed base. Medium packed snow must correspond to CTI penetrometer readings between 70 and 80 and SRTT (Specification E1136) friction coefficients of 0.25 to 0.41. Test surfaces not meeting these values shall be reground to these levels. Test surfaces should always be quantified by averaging several locations along the test course. The range of these measurements shall not exceed 8 points for the penetrometer or 0.05 coefficient for the SRTT (Specification E1136).

A3.1.3 Each time a surface is used for testing, it gets packed down and consequently becomes harder. Therefore, the same test area cannot be used over and over for the same compaction range without grooming. Mechanical snow grooming to loosen hard packed snow can be used when fresh snow is not available. However, whenever a surface is regroomed, it should be rechecked to ensure that the penetrometer and the Snow Monitoring Tire Measurements are correct.

A3.1.4 It is also necessary to check a test surface periodically during a test day to ensure that it has not changed significantly. This may be accomplished by monitoring the SMT test results and rechecking with the Penetrometer. See Table A2.1 for course characteristics. Man-made ice surface areas may be built of various size depending upon the test requirements, or a frozen lake can be utilized. Extreme caution must be used on frozen lakes due to the possibility of vehicles falling through surfaces that are too thin.

A3.2 *Soft Pack Snow*—Soft pack snow is normally not used in tire performance testing due to the inability to maintain a consistent surface and the rapid surface changes that take place with repeated travel. However, if soft pack is desired, it can be obtained by deep grooming an existing snow base or allowing at least 5.0 to 7.5 cm (2.0 to 3.0 in.) of fresh snow to accumulate over an existing base.

A3.3 *Medium Pack Snow*—A consistent medium pack snow surface is best developed by manually grooming a prepared hard pack base that has firmed up overnight.

A3.4 *Medium Hard Pack Snow*—A snow course that has a properly prepared base will yield a medium hard pack surface in the morning following course smoothing and packing the previous day followed by some setting up overnight when it does not get less than approximately –9°C (15°F) at night or a small amount of fresh snow falls on the course.

A3.5 *Hard Pack Snow*—A snow course that has a properly prepared base will normally yield a hard pack surface in the morning following course smoothing and packing the previous day followed by setting up overnight in cold weather, typically less than –12°C (10°F). This assumes no new snow has fallen overnight.

A3.6 *Ice-Dry/Ice-Wet*—An ice course can be developed by repeated application of thin coats of water over a smooth flat surface or by utilizing a frozen lake. In either case, a smooth surface without potholes or ridges is required. A rough lake surface can be smoothed up by the repeated application of thin coats of water sprayed onto the surface. Applying water in heavy coats will not be satisfactory due to uneven freezing and the development of air pockets. Self-propelled ice surface conditioning equipment can be used where safety requirements can be met for the heavily loaded equipment. Sweeping the surface will be required when testing is being conducted during falling snow to prevent variations in surface friction coefficient.

A4. COURSE MAINTENANCE

A4.1 Course maintenance is critical for obtaining valid and repeatable results. Following initial preparation and testing, the course shall be either regroomed or the test area moved to a new location. In the case of ice, the course should be either recoated with water and allowed to refreeze or moved if excessive rutting or significant changes in control tire performance occurs.

A5. DETERMINATION OF LOADS AND PRESSURES

A5.1 Standard Load and Light Load P-metric tires may be marked with one of three maximum inflation pressures: 240 kPa (35 psi), 300 kPa (44 psi), or 350 kPa (51 psi). However, the maximum load of a tire marked with any of these pressures is that load which corresponds to the 240 kPa (35 psi) pressure. Extra Load P-metric tires may be marked with one of two maximum inflation pressures: 280 kPa (41 psi) or 340 kPa (50 psi). However, the maximum load of a tire marked with any of these pressures is that load that corresponds to the 280 kPa (41 psi) pressure. New tire sizes, as approved, will have internationally harmonized load ratings which are and will be based on the new reference pressures of 250 kPa (36 psi) for standard load, LL and SL (ISO) tires, and 290 kPa (42 psi) for extra load, XL and XL (ISO) tires. The maximum load of a tire marked with 250 kPa (36 psi) or 290 kPa (42 psi) is that load which corresponds to the respective 250 kPa (36 psi) or 290 kPa (42 psi) pressure. Refer to the TRA Year Book, or the ETRTO Manual, or the JATMA Manual to determine rated pressure and load of a tire. The rated pressure and load for a given size of passenger tire will correspond to the appropriate bolded column in the yearbook. Examples of the determination of the loads and pressures to be used in 11.9.1 (Option 1) and 11.9.2 (Option 2) are shown below. The load capabilities of the test vehicles as stated below are examples only. Actual load capabilities will be determined by the tester.

A5.1.1 *Example 1*—In this example, the P195/65R15 tire is assumed to be marked on the sidewall with a pressure of 240 kPa (35 psi) and that the Test Vehicle has a load capacity equal to 680 kgf (1500 lbf).

A5.1.1.1 Under Option 1 the test load for passenger car tires is defined as the lower value of 70 % of the maximum rated load shown in the TRA Year Book or 567 kg (1250 lb.). Taking 70 % of the 240 kPa load as shown in Table A5.1 yields:

$$0.70 \times 580 \text{ kgf} = 406 \text{ kgf} \left(895 \text{ lbf}\right) \quad (A5.1)$$

Since the value calculated above is less than 567 kgf (1250 lbf), the test load for this option is 406 kgf (895 lbf). The test inflation pressure to be used is 250 kPa (36 psi) as defined in Option 1.

A5.1.1.2 Under Option 2 the test load for passenger car tires is defined as equal to 74 % of the test inflation rated load. In this case the test inflation is that associated with the maximum load. Taking 74 % of the 240 kPa (35 psi) load as shown in Table A5.1 yields:

$$0.74 \times 580 \text{ kgf} = 429 \text{ kgf} \left(946 \text{ lbf}\right) \quad (A5.2)$$

The test load for this option is 429 kgf (946 lbf) at a test inflation pressure of 240 kPa (35 psi).

A5.1.2 *Example 2*—In this example, the P245/75R15 tire is assumed to be marked on the sidewall with a pressure of 300 kPa (44 psi) and that the Test Vehicle has a load capacity equal to 680 kgf (1500 lbf).

A5.1.2.1 Under Option 1 the test load for passenger car tires is defined as the lower value of 70 % of the maximum rated load shown in the TRA Year Book or 567 kgf (1250 lbf). Taking 70 % of the 240 kPa load as shown in Table A5.2 yields:

$$0.70 \times 1000 \text{ kgf} = 700 \text{ kgf} \left(1544 \text{ lbf}\right) \quad (A5.3)$$

Since the value calculated above is greater than 567 kgf (1250 lbf), the test load for this option is 567 kgf (1250 lbf). The test inflation pressure to be used is 250 kPa (36 psi) as defined in Option 1.

A5.1.2.2 Under Option 2 the test load for passenger car tires is defined as equal to 74 % of the test inflation rated load. In this case the test inflation is that associated with the maximum load. Taking 74 % of the 240 kPa (35 psi) load as shown in Table A5.2 yields:

$$0.74 \times 1000 \text{ kgf} = 740 \text{ kgf} \left(1632 \text{ lbf}\right) \quad (A5.4)$$

Since the value calculated above is greater than the Test Vehicle load capacity it is necessary to go to the next lower load/pressure increment.

Taking 74 % of the 220 kPa (32 psi) load as shown in Table A5.2 yields:

$$0.74 \times 945 \text{ kgf} = 699 \text{ kgf} \left(1541 \text{ lbf}\right) \quad (A5.5)$$

Since the value calculated above is again greater than the Test Vehicle load capacity it is again necessary to go to the next lower load/pressure increment.

Taking 74 % of the 200 kPa (29 psi) load as shown in Table A5.2 yields:

$$0.74 \times 900 \text{ kgf} = 666 \text{ kgf} \left(1468 \text{ lbf}\right) \quad (A5.6)$$

Since the value calculated above is less than the Test Vehicle load capacity this load becomes the test load. Thus the test load for this option is 666 kgf (1468 lbf) at a test inflation pressure of 200 kPa (29 psi).

A5.1.3 *Example 3*—In this example, the LT265/75R16 tire is assumed to be marked on the sidewall with a pressure of 550 kPa (80 psi) and that the Test Vehicle has a load capacity equal to 680 kgf (1500 lbf).

TABLE A5.1 P195/65R15 Marked with a Maximum Inflation Pressure of 240 kPa (35 psi)

	TIRE LOAD LIMITS (kg/lb) AT VARIOUS COLD INFLATION PRESSURES (kPa/psi)					
kPa	140	160	180	200	220	240
kg	445	475	505	530	560	580
lb	981	1047	1113	1168	1235	1279
psi	20	23	26	29	32	35

TABLE A5.2 P245/75R15 Marked with a Maximum Inflation Pressure of 300 kPa (44 psi)

	TIRE LOAD LIMITS (kg/lb) AT VARIOUS COLD INFLATION PRESSURES (kPa/psi)					
kPa	140	160	180	200	220	240
kg	755	805	855	900	945	1000
lb	1664	1775	1885	1984	2083	2205
psi	20	23	26	29	32	35

A5.1.3.1 Under Option 1 the test load for light truck tires (LT-metric) is defined as the lower value of 70 % of the maximum load capacity recommended in the TRA Year Book or 567 kgf (1250 lbf). Taking 70 % of the 550 kPa load as shown in Table A5.3 yields:

$$0.70 \times 1550\ \text{kgf} = 1085\ \text{kgf}\ (2392\ \text{lbf}) \qquad (A5.7)$$

Since the value calculated above is greater than 567 kgf (1250 lbf), the test load for this option is 567 kgf (1250 lbf). The test inflation pressure to be used is 350 kPa (51 psi) as defined in Option 1.

A5.1.3.2 Under Option 2 the test load is defined as equal to 74 % of the test inflation rated load. The test inflation rated load for LT-metric light truck tires is determined at 345 kPa (50 psi). Taking 74 % of the 345 kPa (50 psi) load as shown in Table A5.3 yields:

$$0.74 \times 1120\ \text{kgf} = 829\ \text{kgf}\ (1828\ \text{lbf}) \qquad (A5.8)$$

Since the value calculated above is greater than the Test Vehicle load capacity it is necessary to go to the next lower load/pressure increment.

Taking 74 % of the 45 psi load as shown in Table A5.3 yields:

$$0.74 \times 2280\ \text{lbf} = 1687\ \text{lbf} \qquad (A5.9)$$

Since the value calculated above is again greater than the Test Vehicle load capacity it is again necessary to go to the next lower load/pressure increment.

Taking 74 % of the 40 psi load as shown in Table A5.3 yields:

$$0.74 \times 2100\ \text{lbf} = 1554\ \text{lbf} \qquad (A5.10)$$

Since the value calculated above is again greater than the Test Vehicle load capacity it is again necessary to go to the next lower load/pressure increment.

Taking 74 % of the 35 psi load as shown in Table A5.3 yields:

$$0.74 \times 1910\ \text{lbf} = 1413\ \text{lbf} \qquad (A5.11)$$

Since the value calculated above is less than the Test Vehicle load capacity this load becomes the test load. Thus the test load for this option is 1413 lbf at a test inflation pressure of 35 psi.

A5.2 For Eurometric (non-P-metric) and "commercial" tires with a specified size and load index the ETRTO Standards Manual defines a single rated load and inflation pressure. The rated pressure and load for a given size of passenger tire will correspond to the appropriate columns in the Standards Manual (Note that the Commercial Tire loads are defined per axle, rather than per tire, and thus these must be divided by two to obtain per-tire loads). Examples of the determination of the loads and pressures to be used in 11.9.1 (Option 1) and 11.9.2 (Option 2) are shown below. The load capabilities of the test vehicles as stated below are examples only. Actual load capabilities will be determined by the tester.

TABLE A5.3 LT265/75R16 Marked with a Maximum Inflation Pressure of 550 kPa (80 psi)

	TIRE LOAD LIMITS (kg/lb) AT VARIOUS COLD INFLATION PRESSURES (kPa/psi)					
kPa				350	450	550
kg				1120	1360	1550
lb	1910	2100	2280	2470	3000	3415
psi	35	40	45	50	65	80

A5.2.1 *Example 4*—In this example, a 195/65R14 tire is assumed to be marked on the sidewall with a pressure of 250 kPa (36 psi) and that the Test Vehicle has a load capacity equal to 680 kgf (1500 lbf).

A5.2.1.1 Under Option 1 the test load is defined as equal to 70 % of the maximum rated load capacity. The maximum load capacity can be found in the ETRTO Standards Manual. The tire's maximum load is 580 kg (1280 lbf). Taking 70 % of the rated load yields:

$$0.70 \times 580\ \text{kgf} = 406\ \text{kgf}\ (895\ \text{lbf}) \qquad (A5.12)$$

The test load for this option is 406 kgf (895 lbf) at a test inflation pressure of 250 kPa (36 psi).

A5.2.1.2 Under Option 2 the test load is defined as equal to 74 % of the test inflation rated load. In this case, the test inflation is that associated with the maximum load, which can be found in the ETRTO Standards Manual. The tire's rated load is 580 kg (1280 lbf) with a rated inflation of 250 kPa (36 psi). Taking 74 % of the rated load yields:

$$0.74 \times 580\ \text{kgf} = 429\ \text{kgf}\ (946\ \text{lbf}) \qquad (A5.13)$$

The test load for this option is 429 kgf (946 lbf) at a test inflation pressure of 250 kPa (36 psi).

A5.2.2 *Example 5*—In this example, the 225/70R16 tire is assumed to be marked on the sidewall with a pressure of 290 kPa (42 psi) and that the Test Vehicle has a load capacity equal to 680 kgf (1500 lbf).

A5.2.2.1 Under Option 1 the test load is defined as equal to 70 % of the maximum load capacity. The maximum load capacity can be found in the ETRTO Standards Manual. Under the columns labeled Reinf. The tire's rated load is 975 kg (2150 lbf) with a rated inflation of 290 kPa (42 psi). Taking 70 % of the rated load yields:

$$0.70 \times 975\ \text{kgf} = 683\ \text{kgf}\ (1506\ \text{lbf}) \qquad (A5.14)$$

Since the value calculated above is greater than 567 kgf (1250 lbf), the test load for this option is 567 kgf (1250 lbf) at a test inflation pressure of 250 kPa (36 psi).

A5.2.2.2 Under Option 2 the test load is defined as equal to 74 % of the test inflation rated load. In this case, the test inflation is that associated with the maximum load, which can be found in the ETRTO Standards Manual. Under the columns labeled Reinf. The tire's rated load is 975 kg (2150 lbf) with a rated inflation of 290 kPa (42 psi). Taking 74 % of the rated load yields:

$$0.74 \times 975\ \text{kgf} = 721\ \text{kgf}\ (1590\ \text{lbf}) \qquad (A5.15)$$

Since the value calculated above is greater than the Test Vehicle load capacity it is necessary to adjust the load by the method provided in the ETRTO Standards Manual. Begin by reviewing the notes. Note 5.4 (P section) and Note 3 (C Section) specify a load-inflation adjustment using the polynomial:

$$Q = Q_T\left(\frac{P}{P_T}\right)^a \qquad (A5.16)$$

where:

Q = the maximum test load of the Test Vehicle,
Q_T = the rated load of the tire,
P = the test inflation pressure,
P_T = the rated inflation pressure, and
a = an exponent (either 0.80 or 0.65, as specified for the tire size)

Rearranging this equation, it becomes:

$$P = P_T \left(\frac{Q}{Q_T} \right)^{\frac{1}{a}} \quad \text{(A5.17)}$$

Plugging in values:

$$P = 290\ kPa \left(\frac{680\ \ kgf}{721\ \ kgf} \right)^{\frac{1}{0.80}} = 269.5\ \ kPa(39.1\ \ \ psi) \quad \text{(A5.18)}$$

However, test inflation pressures are typically rounded down to the nearest 5 kPa or 1 psi for purposes of testing, thus one final step is required. The pressure determined in Eq A5.18 is rounded and inserted into equation Eq A5.16. For this example, assume test inflation pressure is rounded to 39 psi (268.9 kPa) so:

$$Q = 721\ \ kgf \left(\frac{268.9\ \ kPa}{290\ \ kPa} \right)^{0.8} = 679\ kgf\,(1496\ \ \ lbf) \quad \text{(A5.19)}$$

Thus the test load for option 2 is 679 kgf (1496 lbf) at a test inflation pressure of 270 kPa (39 psi).

APPENDIX

(Nonmandatory Information)

X1. PENETROMETERS

X1.1 The compaction and shear strength of snow have a major effect on the snow traction performance of tires. These parameters cannot be isolated, but a rating can be placed on the results of both variables by making a combined vertical and horizontal compression test.

X1.2 The CTI Snow Compaction Gauge is shaped like a plumb bob (see Fig. X1.1), except that the point is rounded with a 1.6 mm (1⁄16 in.) radius. A measuring rod is fitted in the other end. Each gauge is adjusted in the laboratory to have a weight of 220 ± 1 g (0.485 ± 0.002 lb), including the knurled nut on top of the drop rod. The drop height has been adjusted to 218.9 ± 0.25 mm (8.92 ± 0.01 in.).

X1.3 In use, the mass of the projectile and the measuring rod is dropped a preset distance through a guide tube with a flange end which rests on the test surface. The kinetic energy is expended in both vertical penetration and side compression. The penetration distance is converted by a hand-held scale to read the compaction numbers (50–100) directly.

X1.4 The recommended snow test conditions of 70–80 represent a range in which good discrimination among tire types can be obtained. The range obtained when measuring different locations on a test course should be no greater than 8 to ensure course consistency.

X1.5 Instructions for Use

X1.5.1 When using the CTI Snow Compaction Gauge in the field, it should be kept on the top of the snow to maintain the metal at approximately the same temperature as the snow. It is also necessary that the gauge does not accumulate an excessive amount of snow on the inside. This will not happen if the plunger is wiped after each drop. Should it occur through unforeseen circumstances, it is preferable to melt the snow from the inside, rather than disassemble the unit. If for some reason the unit must be disassembled, be sure to note the position of all components before reassembly.

X1.5.2 Standard practice in the field is to drive the front wheels of the test vehicle equipped with highway tires over the test course, then turn the vehicle to the right or left to expose a tire track. Place the gauge in the center of the tire track. With the plunger rod raised, rotate the gauge 45° and back to gently smooth the tread pattern left by the tire. Be sure the plunger is bottomed internally on the upper part of the drop tube. Keep a very light pressure on the aluminum foot to prevent it from changing position or lifting off the snow.

X1.5.3 Release the drop rod assembly and immediately set the brass engraved measurement scale on top of the drop tube, close to the knurled nut. Read the CTI Compaction Number from the scale at the top outer edge of the knurled nut.

X1.5.4 Calibration may be checked by placing the unit on a smooth hard surface with the plunger in the "down" position. The gauge should now read 100 to the top of the knurled nut. If the unit should be disassembled for any reason, then the drop length should be checked for 218.9 ± 0.25 mm (8.62 ± 0.01 in.) and the plunger assembly weight adjusted for 220 ± 1 g.

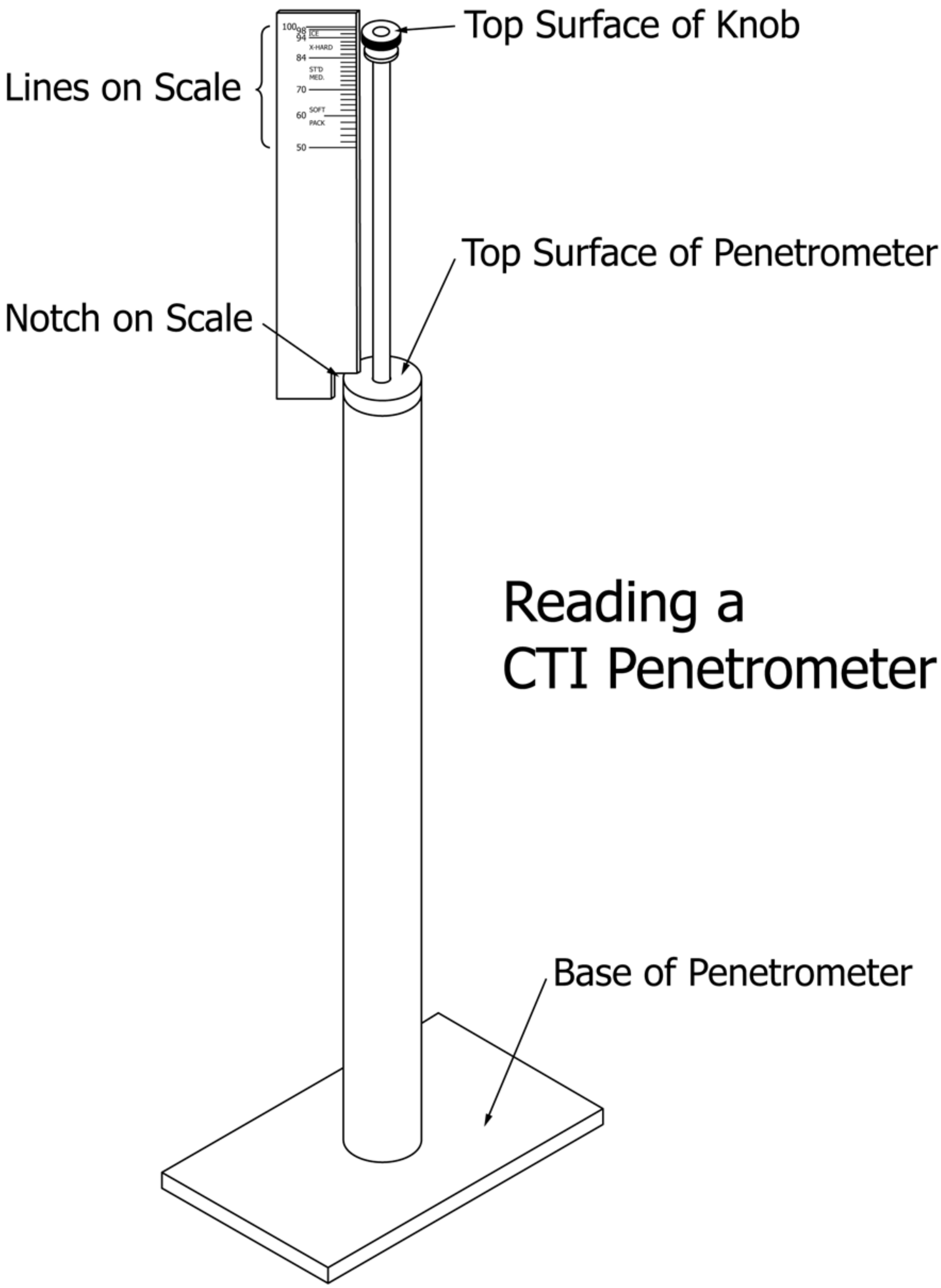

FIG. X1.1 Reading a CTI Penetrometer