Designation: F 1805 – 00

# 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 F 1805; 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. 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:*

E 274 Test Method for Skid Resistance of Paved Surfaces Using a Full-Scale Tire[2]

E 1136 Specification for a Radial Standard Reference Test Tire[2]

F 424 Test Method for Tires for Wet Driving Traction in Straight-Ahead Motion Using Highway Vehicles[3]

F 377 Practice for Calibration of Braking/Tractive Measuring Devices for Testing Tires[3]

F 457 Test Method for Speed and Distance Calibration of a Fifth Wheel Equipped with Either Analog or Digital Instrumentation[3]

F 538 Terminology Relating to the Characteristics and Performance of Tires[3]

F 1046 Guide for Preparing Artificially Worn Passenger and Light Truck Tires for Testing[3]

F 1572 Test Methods for Tire Performance Testing on Snow and Ice Surfaces[3]

F 1650 Practice for Evaluating Tire Traction Performance Data Under Varying Test Conditions[3]

## 3. Terminology

3.1 *Definitions:*

3.1.1 *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). **F 538**

3.1.1.1 *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.

3.1.2 *test run*, *n*—a single pass of a loaded tire over a given test surface. **F 538**

3.1.3 *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. **F 538**

3.1.4 *test tire*, *n*—a tire used in a test. **F 538**

3.1.5 *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. **F 538**

3.1.5.1 *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.

3.1.6 *candidate tire*, *n*—a test tire that is part of a test program. **F 538**

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

3.1.7 *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. **F 538**

3.1.8 *reference tire*, *n*—a special tire included in a test

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[1] This test method is under the jurisdiction of Committee F09 on Tires and is the direct responsibility of Subcommittee F09.20 on Vehicular Testing.

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[2] *Annual Book of ASTM Standards*, Vol 04.03.

[3] *Annual Book of ASTM Standards*, Vol 09.02.

program; the test results for this tire have significance as a base value or internal benchmark. **F 538**

3.1.9 *control tire*, *n*—a reference tire used in a specified manner throughout a test program. **F 538**

3.1.9.1 *Discussion*—A control tire may be of either type and typical tire use is the reference (control) tire in Practice F 1650 that provides algoritms for correcting (adjusting) test data for bias trend variations (See Practice F 1650).

3.1.10 *surface monitoring tire*, *n*—a reference tire used to evaluate changes in the test surface over a selected time period. **F 538**

3.1.11 *standard reference test tire (SRTT)*, *n*—a tire that meets the requirements of Specification E 1136, commonly used as a control tire or a surface monitoring tire. **F 538**

3.1.12 *vertical load*, *n*—the normal reaction of the tire on the road which is equal to the negative of normal force. **F 538**

3.1.13 *spin velocity*, *n*—the angular velocity of the wheel about its spin axis. **F 538**

3.1.14 *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. **F 538**

3.1.15 *longitudinal force (F)*, *n*— *of a tire*, the component of the tire force vector in the X′ direction. **F 538**

3.1.16 *driving force (F)*, *n*— *of a tire*, the positive longitudinal force resulting from the application of driving torque. **F 538**

3.1.17 *driving coefficient (nd)*, *n*—the ratio of the driving force to a normal force. **F 538**

3.1.18 *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. **F 538**

3.1.19 *snow, medium pack*, *n*— *in tire testing*, groomed packed base with 2.5 to 5.0 cm (1 to 2 in.) loose snow. **F 538**

3.1.20 *snow, medium hard pack*, *n*— *in tire testing*, packed base with some loose snow. **F 538**

3.1.21 *snow, hard pack*, *n*— *in tire testing*, packed base without loose snow. **F 538**

3.1.22 *ice, dry*, *n*—smooth ice without loose surface materials. **F 538**

3.1.23 *grooming*, *v*—*in tire testing*, mechanically reworking a snow test surface in order to obtain a surface with more consistent properties. **F 538**

## 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 F 1572 for test methods for braking and lateral traction properties on snow or ice, or both. Refer to Test Method F 424 for longitudinal driving traction testing utilizing the two-vehicle dynamometer method.

## 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/hr (± 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 under 4536 kg (10 000 lbs) 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 The tire installed opposite the instrumented test wheel shall have a traction coefficient at least 50 % greater than any anticipated test tire. A tire chain may be utilized when testing on snow surfaces. The 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 64.0 km/h (40.0 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.

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 revolution. The output shall be recorded.

7.8.4 *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 within a range from 0 to at least 125 % of the applied vertical load. The transducers shall have a minimum full scale range of 0 to 8.9 Kn (2000 lbs). 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.

7.8.5 *Vertical Load*— The vertical load-measuring transducer shall measure the vertical load at the test wheel during driving torque application. The transducer 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 lenear output with necessary gain and date 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 30 Hz, within ±1 %,

7.8.6.2 Tire vertical load, longitudinal force, vehicle and wheel speeds and a time base must be recorded in phase (0 to 30 Hz ±5°),

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

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

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

7.8.6.6 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),

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

7.8.6.8 The individual analog inputs shall have a sample rate of not less than 100 samples/second,

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 Mercury thermometers or electronic 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).

## 8. Calibration

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

8.2 Calibrate the reference loadcell 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 Test Method F 377.

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.

## 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.

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 F 1046.

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.

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 *Test Vehicle:*

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

10.1.2 Fill the fuel tank. Fuel level is to be maintained between full and one-half full during all test operations.

10.1.3 Set front and non-test rear tires to pressure utilized during calibration.

10.1.4 Install a P195/75R14 tire at 241 kPa (35 psi) opposite the test wheel position. A chained tire may be used in snow at the tester's option.

10.1.5 Install a P195/75R14 SRTT (Specification E 1136) control tire at rear test position. Pressure is set at 241± 3.5 kPa (35 ± 0.5 psi) just prior to start of testing.

10.1.6 Ballast the test tire position for 468 kg ± 2.3 kg (1031 ± 5 static pounds) based upon previous calibration.

10.1.7 Turn on instrumentation and allow to warm up as required for stabilization.

10.1.8 Adjust the vehicle ride height to the level established during the calibration for zero crosstalk.

10.1.9 Set the automatic throttle applicator to keep fore-aft force increase to a maximum of 1780 n/sec (400 lb/sec).

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

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

10.1.12 With the transmission in park, zero the tractive force and the vertical load input and check predetermined resistive shunt calibration.

10.1.13 Zero the vehicle and test wheel speeds and check the predetermined span calibration.

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

## 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 11.4.2, a medium packed snow surface shall be used.

11.2 The control tire is now installed at the test wheel position with the vehicle jacked up.

11.3 Install a tire opposite the test wheel position which has an outside diameter within ± 2.5 cm (± 1 in.) of the test tire. A chained tire is optional in snow.

11.4 Ballast the test tire for the desired load and set the tire to the specified test inflation pressure. 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. See Annex A5 for examples of load and pressure determination for options 1 and 2.

11.4.1 Option 1. The test load for passenger car tires (P-metric) shall be the lower value of 85 % of the 180 kPa (26 psi) load recommended in the Tire & Rim Association Yearbooks[4] or 567 kg (1250 lb.). The test load for light truck tires (LT-metric) shall be 567 kg (1250 lb.). An inflation pressure of 240 kPa (35 psi) shall be used for P-metric tires and 345 kPa (50 psi) shall be used for LT-metric tires.

11.4.2 Option 2. The test load shall be equal to 74 % of the test inflation rated load. This option meets the requirement for equivalent percentage loads as specified in the "RMA Definition for Passenger and Light Truck Tires for use in Severe Snow Conditions"[5].

11.4.3 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.

11.5 Reset the tractive and vertical force channel zeros as necessary after the load and ride height have been set.

11.6 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 and adjust the 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.

11.7 Begin a test by activating automatic throttle applicator when on 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).

11.8 Repeat step 11.7 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

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

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

a calculated sample coefficient of variation (C.V.) less than 0.15 (15 %). If requirements are met, record data and return to tire changing area. Rerun test tire if requirements are not met. Surface monitoring tire (SRTT) coefficients should be noted, ensuring compliance with the specified range 0.25–0.41 for medium pack snow.

11.9 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 1—A single control or candidate tire may be used repeatedly as long as the tread surface maintains a "new" appearance.

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

11.11 Each new test tire shall be run on an unused surface as near as possible to the previous pass. Care must be taken not to drift into disturbed snow of the previous test runs.

11.12 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 seconds. 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 kg or lb, and
$W$ = average vertical load kg or 1b.

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:

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

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 The practice F 1605 is the reference standard that gives a comprehensive background and recommended control and candiate tire test sequence as well as procedures for making these corrections. (See Section 7.) F 1650 permits corrections to be made if there is any significant time trend or other perturbation in environmantal 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 F 1650, 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 TPI is computed as follows:

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

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

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 (TIP) (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:

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

## 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.

14.2 State that the test was performed in accordance with ASTM Test Method F 1805

## 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.[6]

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 E 1136 typically is used.

[6] The CTI Penetrometer has been found satisfactory for this use. It is available from Smithers Scientific Services, Inc., 425 W. Market St., Akron, OH 44303.

## 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 cm (12 in.) above the surface. Take surface temperatures with the temperature probe inserted 2.5 cm (1 in.) below the surface in an unshaded area. Take surface compaction readings with a penetrometer in accordance with Appendix X1. At least 10 measurements over the whole course shall be taken to establish a meaningful average. Obtain SRTT tractive coefficients in accordance with Section 10.

**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[A] | SRTT Tractive Coefficient[A,B] | Surface and Footprint Characteristics[C] | Remarks |
|---|---|---|---|---|---|---|---|
| | | Surface | | | | | |
| | Amb. Max | Min. | 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. | D |
| Medium pack snow | +3°C (+38°F) | –15°C (+5°F) | –4°C (+25°F) | 70–80 | 0.25–0.41[E] | 2.5–5.0 cm (1–2 in.) loose snow. Distinctive footprint. | F |
| 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. | G |
| 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. | H |
| Ice-dry | 0°C (+32°F) | –20°C (–5°F) | –4°C (+25°F) | 93–98 | 0.07—0.10 | Smooth ice with no loose materials. No footprint. | I |

[A] See Appendix X1 note that surface descriptions and compaction values for this test method differ from SAE J1466.
[B] See Specification E 1136.
[C] Footprint characteristics are determined by walking or driving on the prepared surface and examining the extent of the imprint or lack thereof.
[D] Freshly fallen snow or deeply groomed base snow.
[E] Testing in the range above 0.38 should be avoided.
[F] Generally obtained by grooming packed base prior to testing in morning.
[G] Typical surface for snow tire/vehicle handling tests.
[H] Packed base with no grooming.
[I] 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 Snow Monitoring Tire friction coefficients of .25 to .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 Snow Monitoring Tire.

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*—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; 240kPa(35psi), 300kPa(44psi) or 350kPa(51psi). However, the maximum load of a tire marked with any of these pressures is that load which corresponds to the 240kPa(35psi) pressure. Examples of the determination of the loads and pressures to be used in 11.4.1 (Option 1) and 11.4.2 (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 A5.1 P195/65R15 Marked with a Maximum Inflation Pressure of 240kPa(35psi)**

| | 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 |

A5.1.1 Example 1: In this example, the P195/65R15 tire is assumed to be marked on the sidewall with a pressure of 240kPa (35psi) and that the Test Vehicle has a load capacity equal to 680 kg (1500 lb). As shown in this example, the test conditions for both options are identical.

A5.1.1.1 Under Option 1 the test load for passenger car tires is defined as the lower value of 85 % of the 180 kPa (26 psi) load recommended in the Tire & Rim Association Yearbooks[7] or 567 kg (1250 lb.). Taking 85 % of the 180 kPa load as shown in Table A5.1 yields:

$$0.85 \times 505\text{kg} = 429 \text{ kg } (946 \text{ lb.}) \quad \text{(A5.1)}$$

Since the value calculated above is less than 567kg (1250 lb), the test load for this option is 429kg (964 lb.). The test inflation pressure to be used is 240kPa(35psi) 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 the maximum load. Taking 74 % of the 240 kPa (35 psi) load as shown in Table A5.1 yields:

$$0.74 \times 580\text{kg} = 429 \text{ kg } (946 \text{ lb.}) \quad \text{(A5.2)}$$

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

A5.1.2 Example 2: In this example, the P245/75R15 tire is assumed to be marked on the sidewall with a pressure of 300kPa(44psi) and that the Test Vehicle has a load capacity equal to 680 kg (1500 lb). As shown in this example, the test conditions for both options are not identical.

A5.1.2.1 Under Option 1 the test load for passenger car tires

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

is defined as the lower value of 85 % of the 180 kPa (26 psi) load recommended in the Tire & Rim Association Yearbooks[8] or 567 kg (1250 lb.). Taking 85 % of the 180 kPa load as shown in Table A5.2 yields:

$$0.85 \times 855\text{kg} = 727 \text{ kg } (1603 \text{ lb.}) \quad (A5.3)$$

Since the value calculated above is greater than 567kg (1250 lb.), the test load for this option is 567kg (1250 lb.). The test inflation pressure to be used is 240kPa(35psi) 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 the maximum load. Taking 74 % of the 240 kPa (35 psi) load as shown in Table A5.2 yields:

$$0.74 \times 1000\text{kg} = 740 \text{ kg } (1650 \text{ lb.}) \quad (A5.4)$$

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.

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

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

| | 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 |

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

$$0.74 \times 945\text{kg} = 699 \text{ kg } (1541 \text{ lb.}) \quad (A5.5)$$

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:

$$0.74 \times 900\text{kg} = 666 \text{ kg } (1468 \text{ lb.}) \quad (A5.6)$$

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 666kg (1468 lb.) at a test inflation pressure of 200kPa (29psi).

# 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 (1⁄16in.) 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, 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.

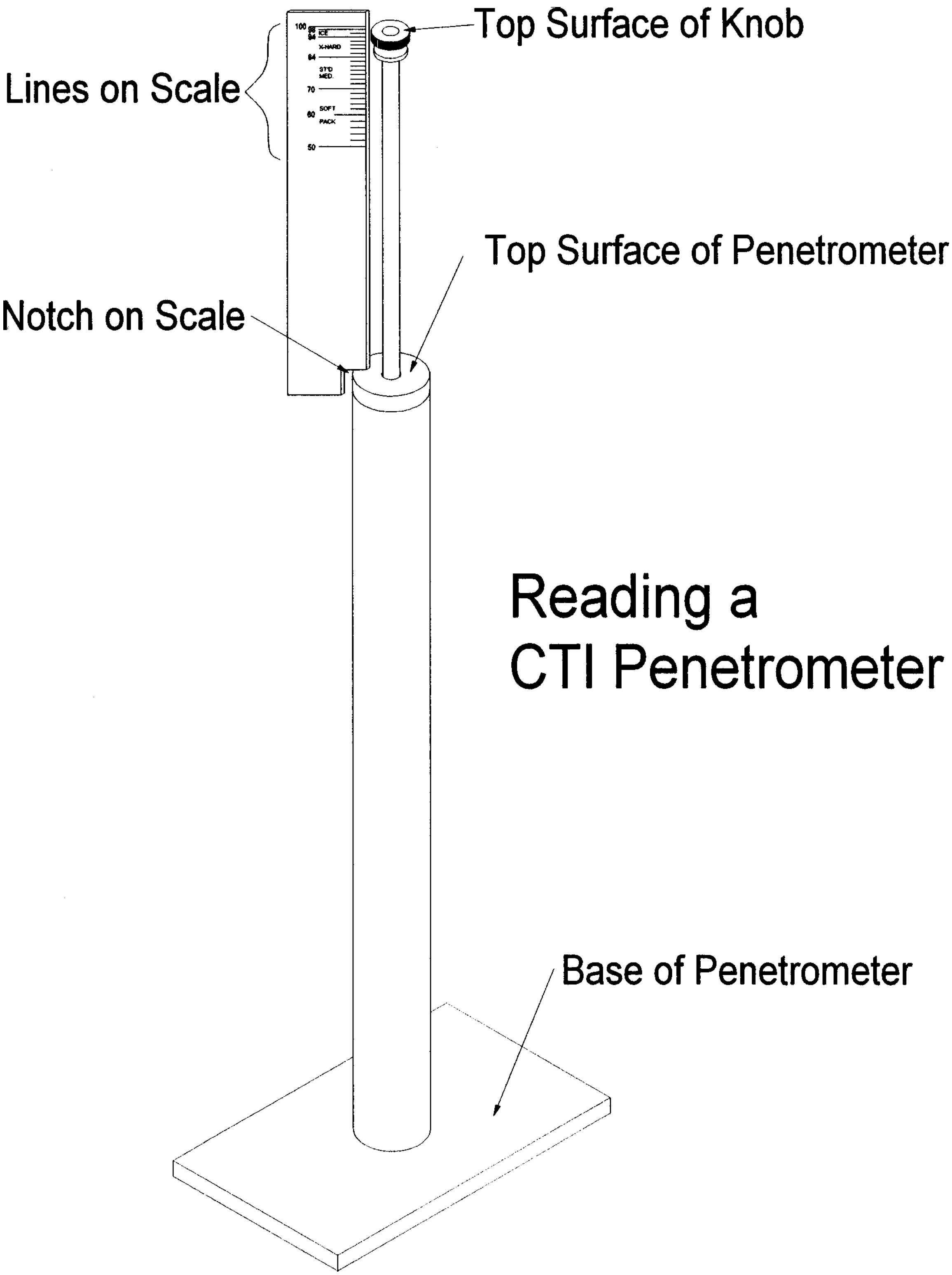


FIG. X1.1 Reading a CTI Penetrometer

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.