Designation: F1572 – 08 (Reapproved 2015)

Standard Test Methods for Tire Performance Testing on Snow and Ice Surfaces[1]

This standard is issued under the fixed designation F1572; 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 These test methods cover the evaluation of tire performance on snow and ice surfaces utilizing passenger car or light truck vehicles. Since the tires are evaluated as part of a tire/vehicle system, the conclusions reached may not be applicable to the same tires tested on a different vehicle.

1.2 These test methods do not purport to identify every maneuver useful for determining tire performance in a winter environment.

1.3 These test methods are not meant to evaluate vehicle performance. Allowing for the variability of test results with different vehicles, these procedures have been developed and selected to evaluate relative tire-snow performance.

1.4 These test methods are 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.

1.5 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.6 *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]

E178 Practice for Dealing With Outlying Observations

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

F457 Test Method for Speed and Distance Calibration of Fifth Wheel Equipped With Either Analog or Digital Instrumentation

F538 Terminology Relating to the Characteristics and Performance of Tires

F811 Practice for Accelerometer Use in Vehicles for Tire Testing

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

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

F1805 Test Method for Single Wheel Driving Traction in a Straight Line on Snow- and Ice-Covered Surfaces

2.2 *SAE Standards:*[3]

SAE J1466 Passenger Car and Light Truck Tire Dynamic Driving Traction in Snow

3. Terminology

3.1 *Definitions:*

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

3.1.1.1 *Discussion*—The term "candidate object" may be used in the same sense as *candidate tire*. **F538**

3.1.2 *candidate tire set, n*—a set of candidate tires. **F538**

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

3.1.3.1 *Discussion*—A control tire may be of either type and typical tire use is the reference (control) tire in Practice F1650 that provides algorithms for correcting (adjusting) test data for bias trend variations (See Practice F1650 and Annex A1). **F538**

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

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

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

[1] These test methods are under the jurisdiction of ASTM Committee F09 on Tires and are the direct responsibility of Subcommittee F09.20 on Vehicular Testing.

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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 SAE Automotive Headquarters, 755 W. Big Beaver, Suite 1600, Troy, MI 48084.

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

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

3.1.9 *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

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

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

3.1.14 *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 meets the requirements of Specification E1136, commonly used as control tire or a surface monitoring tire.

3.1.16.1 *Discussion*—This is a Type 1 reference tire. F538

3.1.16.2 *Discussion*—A surface monitoring tire may also be used as a control tire.

3.1.17 *surface monitoring tire, n*—a reference tire used to evaluate changes in a 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).

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. F538

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.

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

3.1.21 *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.

3.1.21.1 *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 submitted for test tire, if a test tire set is required for the testing. F538

3.1.22 *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 a series of vehicle maneuvers which can be utilized by the tire and vehicle industry to consistently measure the properties of a tire's performance on snow and ice surfaces in the braking, driving and cornering traction modes.

4.2 These test methods outline the procedures for conducting the following tests:

4.2.1 Road circuit handling,

4.2.2 Winter hill climb,

4.2.3 Winter slalom,

4.2.4 Acceleration—straight ahead,

4.2.5 Braking—straight ahead, and

4.2.6 Step steer.

5. Significance and Use

5.1 These test methods describe techniques for assessing the performance characteristics of tires in a winter environment on snow and ice surfaces in a standardized manner. When only snow is referred to hereafter, it should be understood that ice is implied as appropriate.

5.2 A series of maneuvers are conducted to characterize several aspects of the tire performance in snow, since a single maneuver is not sufficient to characterize all aspects of a tire's performance.

6. Interferences

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

6.1.1 Snow/ambient temperature,

6.1.2 Mechanical breakdown of snowflake into granular crystals,

6.1.3 Solar heat load and tire temperature,

6.1.4 Tire wear condition or preparation,

6.1.5 Tire pressure and vertical load,

6.1.6 Test vehicle characteristics,

6.1.7 Snow surface characteristics,

6.1.8 Test driver, and

6.1.9 Rim selection.

7. Apparatus

7.1 Due to the nature of these test methods, specific requirements for apparatus will be limited. A general discussion of types of apparatus and their uses follows.

7.1.1 *Time Measurement*—This provides one of the simplest and lowest cost methods of quantifying tire performance. However, since time measurement inherently involves averaging over a time period, the measurements obtained provide only a general overview of performance.

7.1.1.1 Time measurement apparatus may be onboard the vehicle or stationary and may vary from handheld stopwatches to optical start/stop gates or combined apparatus for measurement of time and other properties (for example, fifth wheel apparatus).

7.1.1.2 Many tests measure time to complete a slalom or hill-and-curve course. Other tests involve measuring the time necessary to reach some condition, such as the time necessary to stop from a given speed or the time to achieve a certain speed from rest.

7.1.2 *Speed and Distance Measurement*—Vehicle speed and distance measurement may be used for evaluating tire snow performance. There are a number of technologies for measuring speed and distance.

7.1.2.1 *Fifth Wheel Based*—This test method requires that a lightly loaded free-rolling wheel be attached to the vehicle. A revolution counting device on this wheel is used to provide typical distance resolutions of 1 cm (0.4 in.). Fifth wheel type devices are highly reliable but may slip on low friction surfaces or bounce on a rough surface, providing inaccurate readings. A fifth wheel may not be appropriate on a road circuit handling course. Fifth wheel type devices are not suitable for use in radical maneuvers or situations where the vehicle may slide or spinout, as these maneuvers may cause damage to the devices. See Test Method F457 for additional information on fifth wheels.

7.1.2.2 *Non-Contact Optical*—Optical sensors are available which can measure both longitudinal and lateral speed. Since these sensors do not contact the road surface they may be used without damage in tests which may involve spinouts or significant lateral motion. However, optical sensors depend on surface microtexture and they may not work on all surface conditions.

7.1.2.3 *Wheel Speed*—A wheel speed sensing device (optical encoder or tachometer) mounted on the wheels of the test vehicle permits the measurement of rotational speed of the wheels and the calculation of distance traveled. These test methods may be prone to error due to wheel slip or changing rolling radius. Wheel speed sensors are usually used in conjunction with 7.1.2.1 or 7.1.2.2 to determine the extent of wheel spin.

7.1.2.4 *Accelerometers*—Several commercial performance computers exist which calculate speed and distance traveled based on internally mounted accelerometers.[4] These devices perform numerical integration to compute speed and distance from the acceleration signal. Accelerometer-based devices are non-contact and self-contained; they are easy to transfer between vehicles. These devices are best suited to tests which involve primarily straight ahead motion and which involve events of short duration.

7.1.2.5 *Radar*—Self-contained radio and microwave speed sensing devices are not widely used for tire performance testing. Development of these devices is continuing.

7.1.2.6 *Telemetry*—Vehicle position sensing equipment is available which utilizes both stationary and vehicle mounted transceivers. Using multiple stationary antennae, this equipment may provide dynamic vehicle position, speed and orientation data with great accuracy. The disadvantages to this approach are the cost of the systems and the difficulty in moving the system to a different test site. Telemetry is not widely used at present but may be of value in the future.

7.1.3 *Acceleration Measurement*—Acceleration measurement is a primary technology used for evaluating tire snow performance. Due to their low cost and ease of mounting, three-axis accelerometers provide a simple way to evaluate some aspects of tire performance.

7.1.3.1 Accelerometers function by measuring the acceleration of a vehicle. This acceleration depends on the forces existing at the tire/surface interface.

7.1.3.2 Accelerometers typically have bandwidths in excess of 100 Hz, allowing dynamic measurement of forces in a handling test.

7.1.3.3 Drawbacks to the use of accelerometers include: sensitivity to wind and vehicle orientation changes, such as body pitch and roll, which occur in handling maneuvers (gyro-stabilized platforms can be used to eliminate this problem); the need to mount the accelerometer at or near the center of gravity of the test vehicle to obtain accurate data; the fact that accelerations on snow and ice surfaces are typically small in magnitude; and the fact that accelerometer signals are typically noisy, leading to the need for filtration of the signal. See Practice F811 for additional accelerometer usage information.

7.1.4 *Vehicle Orientation*—Devices to measure vehicle orientation include gyroscopes, wheel steer angle transducers and some telemetry systems.

7.1.4.1 Measurement of the test vehicle's orientation about its pitch and roll axis is typically used for correction of accelerometer based test systems.

7.1.4.2 Measurement of the test vehicle's orientation about its yaw axis as well as wheel steer angle measurement are used in cornering performance testing.

7.1.4.3 Due to high cost, vehicle orientation measurement devices are typically used only on tests requiring a high degree of accuracy.

7.1.5 *Force*—Direct measurement of tire/surface forces is normally accomplished using load cells.

7.1.5.1 Load cells provide the most accurate measure of tire forces under dynamic conditions.

7.1.5.2 Using specially designed suspensions, load cell based systems may be built which are not significantly affected by body roll of the test vehicle.

7.1.5.3 Due to mounting requirements, load cell-based systems typically are not easily transferred between multiple vehicles.

8. Selection and Preparation of Test Tires

8.1 Ensure that all test tires are approximately the same age and stored essentially at the same conditions prior to testing unless otherwise specified.

8.2 Test tires shall be mounted on Tire and Rim Association (TRA)[5] or applicable document,[6,7] recommended rims by

[4] The sole source of supply of the apparatus, Vericom VC-200, known to the committee at this time is Vericom Corp., 6000 Culligan Way, Minnetonka, MN 55345. 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.

[5] Current yearbook of The Tire and Rim Association (TRA), Inc., 175 Montrose West Avenue, Suite 150, Copley, OH 44313.

[6] Current yearbook of the European Tyre and Rim Technical Organization (ETRTO), 32, avenue Brugmann, Bte 2, 1060 Bruxelles, Belgium.

using conventional mounting methods. Proper bead seating shall be assured by use of suitable lubricant. Excessive use of lubricant should be avoided to prevent slipping of the tire on the wheel rim.

8.3 Test tire balance is optional.

8.4 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 result on ice surfaces.

8.5 The removal of tread area protuberances is recommended.

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

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

8.8 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.

8.9 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.

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

9. Preparation of Apparatus

9.1 The test vehicle shall normally be representative of the type on which the test tires are used. The test vehicle shall be operated with approximately the same static weight throughout the test maintaining the same number of on-board personnel and the fuel load between one-half and three-fourths full. Any ballasting shall be a function of the individual program test requirements.

9.2 Safety equipment shall be selected based upon the severity of the tests. Seat belts shall be utilized during all testing. The use of roll bars or roll cages, warning lights, etc. is recommended.

9.3 Instrumentation shall be installed in accordance with manufacturer's recommendations.

10. Calibration

10.1 *Fifth Wheel*—Calibrate in accordance with Test Method F457.

10.2 Calibrate other instrumentation in accordance with manufacturer's recommendations.

11. Procedure

11.1 *Course Surface*—See Annex A1 – Annex A4 for climate and snow properties, surface characterization, course preparation and course maintenance.

11.2 *Organizing the Tire Test Program*—If two or more candidate (or experimental) tire sets are to be evaluated for any of the six tire performance procedures of 4.2.1 – 4.2.6, Practice F1650 should be consulted to layout or organize the test program with respect to the number and sequence of control tires to be tested. Practice F1650 also provides calculation procedures to determine if any time trend or other environmental changes have occurred in the testing conditions and if such changes have occurred Practice F1650 provides algorithms for applying corrections to produce performance data that are free from the perturbations induced by such changes.

11.3 *Performance Tests—Winter Handling:*

11.3.1 *Road Circuit Handling Test*—This test is designed to provide actual road performance confirmation of the differences measured in the winter traction tests. As with all performance tests, vehicle dynamics enter into the observations and can influence tire performance. Prior to any performance data presentation, analyze the raw or as obtained performance data according to the protocols as given by Practice F1650 and if data corrections are required use corrected data for the final presentation.

11.3.1.1 *Test Course*—Select a winter road handling course to provide a range of varying winter environment driving conditions. The course is comprised of packed snow, frozen ice, and other conditions representing a cross section of winter driving environments. Incorporate hills and curves in the course to subjectively evaluate the tractive potential of a vehicle equipped with test tires. The course may feature a variety of corner and radius combinations with uphill acceleration, downhill braking, and high speed level areas. See X1.1 for sample course. Pre-runs of the course for driver orientation and placement of pylons or markers for control of driving line are recommended. Position pylons or markers at the start and at the end of the course. The test criteria consists of best effort time over measured course along with identification of each mode of control loss.

11.3.1.2 *Road Circuit Handling Test Procedure*—Initiate the test from a stop at the starting pylon or marker, starting the vehicle and a timing device simultaneously and accelerating to a speed considered by the driver to be the maximum limit for the conditions. A stop of maximum deceleration is accomplished at the end of the course and the elapsed time recorded. Make subjective notes after each lap. Repeat the test a minimum of two times on each set of test tires with control tires being run at the start and end of the test sequence. When instruments are used, log the lateral and longitudinal acceleration data for each test run.

11.3.1.3 *Data Analysis*—Summarize the outcome of individual tests performed on each tire. The information provided as a result of the subjective handling tests shall include lap times, a multi-point subjective evaluation and control loss description. Calculate a rating comparing total elapsed time to negotiate the test course for the test tires compared to the control tires. Calculate a rating comparing the average subjective performance of each tire set. Analyze the subjective hill and curve data to relate the mechanism of traction loss and the controllability of each of the tire sets. The times recorded for each of the test runs is related to the controllability of the

[7] Current yearbook of the Japan Automobile Tyre Manufacturers Association (JATMA), No. 33 Mori Building, 3-8-21 Toranomon, Minato-ku, Tokyo, Japan 105-0001.

system. Analyze the data from the on-board computer (if used) to establish the test tire sets longitudinal and lateral *g*-capabilities as it relates to the test surface and specific vehicle maneuver in a dynamic operating mode.

11.3.1.4 *Data Reporting*—Present the data to compare the performance of the test tires by their relative performance to the control tire set and show a general overview of the tests by groups, method and conditions. The report shall include observations and comments. Present the data from the instrumented testing in a graphical format with peak longitudinal and lateral *g*-values identified. Include a map of the test course in the report.

11.3.2 *Winter Hill Climb*—This test is designed to provide actual driving traction evaluations of tires in a winter traction environment. As with all performance type tests, some vehicle dynamics enter into the observations and can influence tire performance.

11.3.2.1 *Test Course*—Select a test course to provide a sufficient grade, covered with snow or ice to allow starting and subsequently reaching the traction limit of a vehicle equipped with test tires. The recommended test course shall be either parabolic or constant straight grade starting at 0 % grade and increasing to 15 % minimum for snow and 10 % for ice. See X1.2 for sample course. Position pylons or markers at the start and at the end of the course.

11.3.2.2 *Winter Hill Climb Test Procedure*—Initiate the test from a stop, start the vehicle and a stop watch simultaneously and accelerate to the maximum speed attainable. Test criteria consists of the best effort time over the measured course and the maximum grade attainable along with identification of the characteristic of traction loss. It may be necessary to limit the throttle application to prevent inertial effect from influencing the tire evaluation. Evaluate the tire set by the vehicle stall position on the grade: adjustments may be required prior to starting the actual testing to ensure the criteria is met. Repeat the test for four climbs on each test tire set with a control tire set being run at the start of each test sequence and at the end of the test sequence.

11.3.2.3 *Data Analysis*—The information provided as a result of the hill climb tests include the maximum grade attainable averaged for all runs, times from start to stall or time to complete the climb and control loss description and subjective comments. Calculate a rating comparing the average climbing performance of each test tire set and a rating comparing total elapsed time to negotiate the test course for the test tires to the control tire set.

11.3.2.4 *Data Reporting*—The test results will summarize the outcome of the individual tests performed on each tire, and show a general overview of the test by groups, method and condition. Prior to any performance data presentation, analyze the raw or as obtained performance data according to the protocols as given by Practice F1650 and if data corrections are required use corrected data for the final presentation.

11.3.3 *Winter Slalom*—This test is designed to provide discrete lateral performance characteristics of tires in a winter environment. As with all handling type tests, some vehicle dynamics enter into the observations and can influence the tire performance. A controlled surface winter slalom can be utilized to allow evaluations of lateral traction to supplement dynamic longitudinal (Test Method F1805) driving traction testing.

11.3.3.1 *Test Course*—Select a test course to provide a smooth, level surface with sufficient area to allow starting, accelerating to the test speed and reaching the lateral traction limit of a vehicle equipped with test tires. Position obstacles to require sinusoidal or passing maneuvers or both. See X1.3 for sample course layout. If two conditions (surfaces) are used, identify each condition. A minimum of six pylons for a slalom course must be used to ensure the transient vehicle dynamics do not influence the tire evaluation. The slalom course shall have a total length adequate to accelerate to the test speed prior to entering the test section. A lane width of 3.6 m (12 ft) or more is required to allow the vehicle to negotiate a series of pylons or markers spaced at 15- to 30-m (50- to 100-ft) intervals. The pylon spacing can be either uniform spacing or decreasing spacing. Position pylons or markers at the start and at the end of the course. The test criteria consists of best effort time over the measured course with identification of the mode of control loss. A minimum of four recorded runs shall be made.

11.3.3.2 *Winter Slalom Test Procedure*—The instrumented slalom testing utilizes the same instrumentation package as the road circuit handling. Initiate the test from a stop or gate. Start the vehicle and a stop watch simultaneously and accelerate to a maximum speed. The recommended procedure for this test is constant speed, incrementally stepping the speed each run. The speeds should be increased from a controllable condition to control loss. Evaluate the tire set by the maximum speed at which the vehicle can negotiate the course without control loss and the maximum lateral acceleration as well as by subjective comments. Record the time for each test run, repeat the test for four runs on each test tire set with a control tire set being run at the start and at the end of the test sequence.

11.3.3.3 *Data Analysis*—The information provided as a result of the slalom tests include elapsed times for each speed, maximum lateral accelerations and control loss description. Calculate a rating comparing total elapsed time to negotiate the test course and maximum lateral traction for the test tires compared to a control tire set. The times recorded for each of the runs is related to the controllability of the system. Analyze this data from the on-board computer to give a profile of the tire as it relates to the test surface in a dynamic operating mode.

11.3.3.4 *Data Reporting*—Present the data from the instrumented testing as a rating of the test tires to the control tire set for peak lateral traction and overall course elapsed time. Include observations and comments in the data package. Analyze this data from the on-board computer to give a profile of the tire as it relates to the test surface in a dynamic operating mode. Prior to any performance data presentation, analyze the raw or as obtained performance data according to the protocols as given by Practice F1650 and if data corrections are required use corrected data for the final presentation.

11.3.4 *Acceleration, Straight-Ahead*—This test is designed to provide discrete straight line acceleration characteristics of tires in a winter environment.

11.3.4.1 *Test Course*—Select a test course to provide a smooth, level surface with sufficient area to allow acceleration to the test speed with a suitable braking area. See X1.4.

11.3.4.2 *Straight-Ahead Acceleration Test Procedure*—Make a series of acceleration runs from 1.6 to 40 km/h (1 to 30 mph). The driver makes every effort to accelerate as quickly as possible with a minimum of tire slip. Monitor the time for each run using a performance computer. The computer is activated by the driver at the beginning of acceleration. Terminate the run when the 40 km/h (30 mph) threshold has been reached. Record the time for each run from the computer display. The control tire is normally used at the start and the end of every test sequence and after every two or three test tires.

11.3.4.3 *Data Analysis*—Analyze the data for the average of the five best (lowest) times. Practice E178 may be used to identify outliers.

11.3.4.4 *Data Reporting*—Present the data to compare the relative performance of the test tire sets to that of the control tire set. Prior to any performance data presentation, analyze the raw or as obtained performance data according to the protocols as given by Practice F1650 and if data corrections are required use corrected data for the final presentation.

11.3.5 *Braking, Straight-Ahead*—This test is designed to provide discrete straight line deceleration characteristics of tires in a winter environment.

11.3.5.1 *Test Course*—Select a test course to provide a smooth, level surface with sufficient area to allow acceleration to the test speeds with a suitable braking area. See X1.4.

11.3.5.2 *Straight-Ahead Braking Test Procedure*—Make a series of braking runs from 40 or 64 km/h (30 or 40 mph) to a full stop. The driver travels down the test lane at the appropriate speed and applies full brake pedal force or modulates the brakes (best effort with minimum lockup) as desired. Monitor the measured initial speed and the braking distance for each run by using a performance computer. The computer signals an end of test when the vehicle comes to a complete stop. Record the measured initial speed (±3.2 km/h (±2 mph) of selected speed) and stopping distance for each run from the computer display. Record the average time, distance, and initial speed. Peak and sustained deceleration may also be recorded. The control tire is normally used at the start and the end of every test sequence and after every two or three test tires.

11.3.5.3 *Data Analysis*—Correct the braking distance for each stop to the nominal initial speed using the velocity squared ratio as follows:

$$\text{Corrected Braking Distance} = \text{Measured Braking Distance} \times (\text{nominal speed})^2 / (\text{Measured Speed})^2 \quad (1)$$

Practice E178 may be utilized to identify outliers.

11.3.5.4 *Data Reporting*—Report the nominal initial speed and the average corrected braking distance. Present the data to compare the relative performance of the test tire sets to that of the control tire set. Prior to any performance data presentation, analyze the raw or as obtained performance data according to the protocols as given by Practice F1650 and if data corrections are required use corrected data for the final presentation.

11.3.6 *Step Steer—Maximum Lateral Acceleration*—This test is designed to provide discrete maximum lateral traction characteristics of tires in a winter environment. The test also provides for a subjective analysis of vehicle response in extreme maneuvers.

11.3.6.1 *Test Course*—Select a test course to provide a smooth, level surface with sufficient area to allow for vehicle recovery in event of control loss. See X1.3.

11.3.6.2 *Step Steer Test Procedure*—Perform a sequence of maneuvers at appropriate speeds to generate the maximum lateral acceleration achievable. The driver begins by moving down one lane at the appropriate speed. The driver then turns the steering wheel 180° as quickly as possible. Once the vehicle attitude has stabilized, the driver corrects the steering wheel and recovers a straight heading. Conduct multiple runs for each set of tires on a given vehicle, including both left and right lane changes. Continuously record the lateral acceleration during each run using a lateral-axis recording accelerometer. Perform a subjective evaluation during this test rating each set of tires for oversteer, understeer, steering response, and recovery.

11.3.6.3 *Data Analysis*—Analyze the data for both the peak and average maximum lateral acceleration for each run. Rate tires based upon the subjective evaluation.

11.3.6.4 *Data Reporting*—Present the data to compare the performance of the test tires by their relative performance to a control tire utilizing both analytical and subjective data. The report shall include subjective observations and comments. Prior to any performance data presentation, analyze the raw or as obtained performance data according to the protocols as given by Practice F1650 and if data corrections are required use corrected data for the final presentation.

12. Precision and Bias

12.1 *Precision*—Data are not yet available for making a statement on the repeatability or reproducibility of these test methods.

12.2 *Bias*—There are no standards or reference values with which the results of these test methods can be compared. The function of the test procedure as indicated in Section 11 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 procedure are adequate for making such comparisons without external references for assessing bias.

13. Keywords

13.1 light truck tires; passenger car tires; snow/ice surfaces

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 climatic 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, or no less than ½-h intervals.

A1.1.2 *Wind*—Wind speed and direction relative to the test course shall be measured at no less than ½-h intervals.

A1.1.3 *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.[8]

A1.1.4 *Surface Traction Coefficient*—A single wheel driving traction test vehicle utilizing a surface monitoring tire may be used to obtain surface traction coefficients per Test Method F1805. A standard reference test tire (SRTT) meeting the requirements of Specification E1136 is typically used.

[8] The sole source of supply of the apparatus, 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.

A2. SURFACE CHARACTERIZATION

A2.1 The ability to quantitatively or subjectively characterize the test surface, or both, 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. Temperature measurement devices with a resolution of 0.5°C (1°F) and an accuracy of ±1°C (±2°F) are acceptable means of measurement. Take surface compaction readings with a penetrometer in accordance with Test Method F1805. A sufficient number of measurements over the whole course shall be taken to establish a meaningful average. Obtain SRTT tractive coefficients in accordance with SAE J1466.

TABLE A2.1 Course Characteristics

NOTE 1—Determining the need for snow regrooming is largely subjective; however, regrooming is generally required when the surface becomes excessively rutted or packed, or when the control tire performance changes significantly.

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
	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.	Freshly fallen snow or deeply groomed base snow.
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.	Generally obtained by grooming packed base prior to testing in morning.
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.	Typical surface for tire/vehicle handling tests.
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.	Packed base with no grooming.
Ice-Dry	+0°C (+32°F)	N/A	–4°C (+25°F)	93–98	0.07–0.10	Smooth ice with no loose materials. No footprint.	Avoid bright sun on course. Broom or resurface as required.

[A] See SAE J1466; note that surface descriptions for these test methods differ from SAE J1466.
[B] See Specification E1136.
[C] Footprint characteristics are determined by walking or drying on the prepared surface and examining the extent of the imprint or lack thereof.
[D] Testing in the range above 0.38 should be avoided.

A3. COURSE PREPARATION

A3.1 *Surface Preparation*—Course preparation is critical for obtaining valid and repeatable results. The snow test surface should be flat for all test methods except the road circuit and hill climb (maximum 1 % grade) and of sufficient width and length to perform the test maneuvers. A large prepared area is desirable to reduce the instances of regrooming during daily testing. A snow test area of about 21 × 610 m (70 × 2000 ft) will normally be sufficient for most testing; however, smaller areas have been successfully used. Developing a base is the most critical step in the preparation of snow test areas. Test Method F1805 provides guidance for snow site preparation. See Table A2.1 for course characteristics. Manmade ice surface areas may be built of varying 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. Best test results are obtained by moving to a new vehicle path for each successive run.

A3.3 *Medium Pack Snow*—A consistent medium pack snow surface is best developed by manually grooming a prepared hard pack base which 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 which 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 driving path should be either regroomed or the course moved to a new location if excessive rutting or polishing of base of snow course or significant changes in control tire performance occurs. In the case of an ice course, the course should be either recoated with water and allowed to refreeze or moved if excessive rutting or polishing of ice course or significant changes in control tire performance occurs.

APPENDIX

(Nonmandatory Information)

X1. SAMPLE COURSES

X1.1 Sample Winter Road Circuit Handling Test Course

X1.1.1 *Course Length*—Sufficient to incorporate all desired features, typically 1.0 km (0.6 miles) or more.

X1.1.2 *Course Features*—Hill and curve. Maximum grades recommended are 6 to 10 %. Minimum vehicle lane width 3.6 m (12 ft).

X1.1.3 *Course Surfaces*—One surface for ease of maintenance but may consist of loose snow, packed snow and patch ice, if desired.

X1.1.4 *Course Maintenance*—See Annex A4.

X1.2 Sample Winter Hill Climb Course

X1.2.1 *Course Length*—61 m (200 ft) minimum.

X1.2.2 *Course Features*—Grades from 0 to 15 % with a minimum course width of 6.1 m (20 ft).

X1.2.3 *Course Surfaces*—Packed snow or dry ice.

X1.2.4 *Course Maintenance*—See Annex A4.

X1.3 Sample Winter Slalom and Step Steer Test Course

X1.3.1 *Course Length*—As required, normally at least 152 m (500 ft).

X1.3.2 *Course Features*—Level surface, 3.6 m (12 ft) minimum vehicle lane width (see Fig. X1.1).

X1.3.3 *Course Maintenance*—See Annex A4.

X1.4 Sample Level Surface Test Course

X1.4.1 *Course Length*—As required, normally at least 152 m (500 ft).

X1.4.2 *Course Features*—Level surface 3.6 m (12 ft) minimum vehicle lane width.

X1.4.3 *Course Maintenance*—See Annex A4.

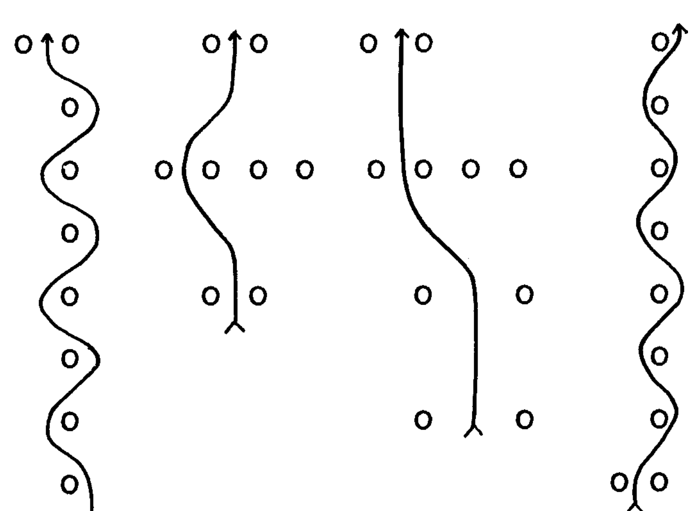

FIG. X1.1 Typical Slalom Courses