



Designation: F 403 – 98

Standard Test Method for Tires for Wet Traction in Straight-Ahead Braking, Using Highway Vehicles¹

This standard is issued under the fixed designation F 403; 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 the accelerometer-based measurement of braking traction of tires designed for and mounted on cars or trucks without ABS equipped brakes traveling straight ahead on a wet or dry paved surfaces, snow, or ice.

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

1.3 *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 Tire²

F 457 Test Method for Speed and Distance Calibration of a Fifth Wheel Equipped with Either Analog or Digital Instrumentation³

F 538 Terminology Relating to the Characteristics and Performance of Tires³

F 811 Practice for Accelerometer Use In Vehicles for Tire Testing³

F 1650 Practice for Evaluating Tire Traction Performance Data Under Varying Test Conditions³

3. Terminology

3.1 Definitions

3.2 *braking force*, $[F]$, n —of a tire, the negative longitudinal force resulting from braking torque application. **F 538**

3.3 *braking force coefficient*, n —of a tire, the ratio of braking force to normal force. **F 538**

3.4 *braking force coefficient, peak*, n —of a tire, the maximum value of tire braking force coefficient that occurs prior to wheel lockup as the braking torque is progressively increased. **F 538**

3.5 *braking force coefficient, slide*, n —of a tire, the value of braking force coefficient obtained on a locked wheel.

3.6 *braking torque*, $[ML^2/T^2]$, n —of a vehicle, the negative wheel torque. **F 538**

3.7 *longitudinal force*, $[F]$, n —of a tire, the component of a tire force vector in the X' direction. **F 538**

3.8 *normal force*, $[F]$, n —of a tire, the component of a tire force vector in the Z' direction. **F 538**

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

3.10 *tire-axis system*, n —the origin of the tire-axis system is the center of the tire contact. The X' axis is the intersection of the wheel plane and the road plane with a positive direction forward. The Z' axis is perpendicular to the road plane with a positive direction downward. The Y' axis is in the road plane, its direction being chosen to make the axis system orthogonal and right-hand.

3.10.1 *Discussion*—See Fig. 1. **F 538**

3.11 *tire forces*, $[F]$, n —the external forces acting on a tire by the road. **F 538**

3.12 *torque*, $[FL]$, n —of a wheel, the external torque applied to a tire from a vehicle about the wheel spin axis. **F 538**

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

4. Summary of Test Method

4.1 The measurements are conducted on either two front tires or as an option, one front and one rear tire positioned diagonally across the vehicle. Brakes are to be applied firmly until both test tires are locked and then held locked for a period of at least 1 s at speeds ranging from 20 mph (32 km/h) to 60 mph (96 km/h). The other wheels are free rolling.

¹ This test method is under the jurisdiction of ASTM Committee F-9 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.

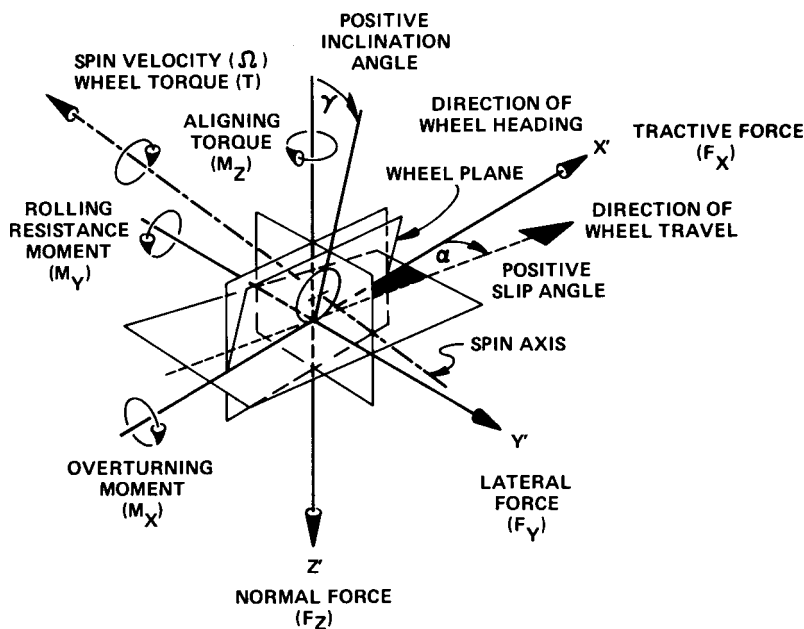


FIG. 1 Tire-Axis System

4.2 Recommended vehicle test speeds are: 20, 40, and 60 mph (32, 64, and 96 km/h). The maximum test speed selected for a given road surface texture and water film thickness should be below hydroplaning speed.

5. Significance and Use

5.1 The measured values are traction properties of tires in operation on a passenger car or light truck representative of the type on which the test tires would be used. These are obtained on a given road surface, under given environmental conditions (ambient and road surface temperature, humidity, wind speed and direction, purity, and film depth of water used to wet the road surface) in accordance with the stated test procedures and reflect the performance of the total vehicle-environmental system. A change in any one of these factors may change the measurements of a subsequent run of the test.

5.2 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 on other road surfaces (or the same surface after additional wear), under other environmental conditions, or other test vehicles (especially if not representative of the normal usage of the test tires) or with results obtained with other test procedures.

6. Apparatus

6.1 *Test Vehicle*—The test vehicle shall be a rear-wheel drive, four-wheel passenger car or a light truck under 10 000 lbf (44.5 kN) GVW (gross vehicle weight), representative of the type on which the test tires are used.

6.2 Instrumentation:

6.2.1 *Accelerometer*, to measure longitudinal deceleration of the vehicle. The accelerometer shall have the following specifications:

6.2.1.1 Minimum frequency response: dc to 10 Hz.

6.2.1.2 Minimum full-scale range ± 1.0 g,

6.2.1.3 Accuracy of ± 0.01 g, and

6.2.1.4 Maximum cross-axis sensitivity of 0.002 g/g.

6.2.2 *Fifth Wheel*, to measure vehicle speed. The fifth wheel shall have the following specifications:

6.2.2.1 Minimum full-scale range of 100 mph (160 Km/h),

6.2.2.2 The magnitude of the bias shall be less than or equal to 1 mph (1.609 Km/h), and

6.2.2.3 A 95 % repeatability interval of $I(r) = 2$ mph (3.218 Km/h).

6.2.3 *Tach-Generator*, to measure the revolutions per minute of each test wheel, installed on the vehicle. The tach-generator shall have the following specifications:

6.2.3.1 Minimum full-scale range of 0 to 1200 rpm (0 to 125.7 rps), and

6.2.3.2 The magnitude of the bias shall be ≤ 1 rpm (≤ 0.105 rps).

6.2.4 *Multichannel Recorder*, having the following specifications:

6.2.4.1 Minimum frequency response of dc flat (± 1 %) to 30 Hz full scale,

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

6.2.4.3 Input impedance shall be seven to ten times larger than the output impedance of signal source,

6.2.4.4 Must be insensitive to vibrations, acceleration and ambient temperature range. The error in reading shall not exceed 1 % of full scale when subjected to vibrational acceleration of 5 g's in the 0.5 to 40-Hz frequency range and operating temperature range from 32 to 110°F (0 to 43°C).

6.2.4.5 Shall not be affected by storage temperature variations between -20 and $+160$ °F (-29 and $+71$ °C), and

6.2.4.6 Shall have a variable chart speed with at least 25 mm/s.



6.2.5 *Power Supply* for transducers and recorder, meeting requirements specified by transducers and recorder manufacturers.

7. Selection and Preparation of Test Tires

7.1 All test tires should be approximately of the same age and shall be stored essentially at the same conditions.

7.2 Test tires shall be trimmed to remove all protuberances in the tread area caused by mold air vents or flashes at mold junctions.

7.3 Test tires shall be mounted on Tire and Rim Association (T & RA)⁴ recommended rims by using conventional mounting methods. Proper bead seating shall be assured by use of suitable lubricant and the subsequent warm-up procedures. Excessive use of lubricant should be avoided to prevent slipping of the tire on the wheel rim.

7.4 Test tires shall be balanced statically.

7.5 Test tires shall have a minimum of 50 miles (80 km) break-in at T & RA⁴ load and inflation at speeds of 60 to 70 mph (96 to 113 km/h) without excessive cornering, braking, or acceleration to avoid uneven wear. The break-in is necessary to remove mold lubricant and mold sheen from tread surface. Break-in mileage should be accumulated on the front and rear axles equally for a given tire. New tire average wear prior to testing shall not exceed 10 % of the new tire tread depth.

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

7.7 Test tires shall be checked for specified pressure just prior to testing.

7.8 It is recommended that the sample size of test tires be a minimum of three sets (of two each).

8. Preparation of Apparatus

8.1 Test Vehicle:

8.1.1 Check the front wheels of the test vehicle loaded to the test weight prior to testing. Set alignment in accordance with the manufacturer's specifications.

8.1.2 Weigh the test vehicle prior to testing with a half-full tank of gasoline, instrumentation, and test personnel seated in the same locations as that to be used during testing. Adjust vehicle static weight by ballasting to match static wheel load specified for test tires. In no case shall the static wheel load exceed the maximum wheel load capacity of the vehicle. The load recommended by the T & RA⁴ Yearbook for 26-psi (180-kPa) inflation pressure for a "P"-type tire or 24-psi (165-kPa) inflation pressure for an alphanumeric-type tire, shall be regarded as standard.

NOTE 1—In some cases it may not be possible to use static loads recommended by the T & RA⁴ Yearbook, particularly on high-friction surfaces.

8.1.3 Install the test tires on the front wheels or on one front and one rear wheel diagonally. Use a pair of similar tires, not

necessarily identical to test tires, on the wheels not undergoing test. Apply brakes only to test tires. The other tires remain free rolling.

8.1.4 For front-braked vehicles, rear brakes shall be inoperative; for diagonally braked vehicles, the wheels not undergoing tests shall have inoperative brakes.

8.2 Instrumentation:

8.2.1 Install the accelerometer in accordance with the manufacturer's specification and rigidly fix to the vehicle's sprung mass at or near its center of gravity such that it measures acceleration of the sprung mass in the direction parallel to the vehicle longitudinal axis and parallel to the ground plane at zero roll and pitch of the vehicle. It may be desirable to provide a hinge pivot in the mounting to permit a system calibration check.

8.2.2 Install the fifth wheel in accordance with the manufacturer's specifications and locate it as near as possible to the mid-track position on the vehicle. Record the output of the fifth wheel. Situate the output so that the test driver will be able to monitor the vehicle speed.

8.2.3 Install the tach-generators on the test wheels in accordance with the manufacturer's specifications (see 6.2.3).

9. Calibration

9.1 Conduct calibration of the accelerometer statically by tilting the accelerometer on the rotary table or another test fixture to incrementally increased or decreased angles with respect to a true horizontal plane and record the accelerometer output values for each angle value by observing the chart trace deflections on the recorder used in testing.

9.1.1 Set the rotary table at zero inclination.

9.1.2 Mount the accelerometer on the rotary table according to the manufacturer's specifications and adjust the amplifier or recorder setting, or both, until the chart trace reads zero.

9.1.3 Rotate the rotary table about horizontal axis to 10° (0.173 g) in a clockwise direction and record the chart table displacement.

9.1.4 Continue 9.1.3 at 30° (0.5 g), 45° (0.707 g), 60° (0.866 g), and 90° 00' (1.0 g).

9.1.5 Rotate the rotary table from the 90° 00' (1.0 g) position in a counterclockwise direction to 60° (0.866 g) angle and record the chart trace displacement in inches.

9.1.6 Continue to rotate the rotary table in the counterclockwise direction incrementally through the reverse sequence of angles specified in 9.1.3 and 9.1.4 until the initial zero value is reached.

9.1.7 Plot the values of longitudinal acceleration in g's versus chart trace displacement.

9.1.8 Determine the value of static calibration constant *C*, the slope of the curve longitudinal acceleration versus chart trace displacement. Record calibration values, date of calibration, and model and serial number of accelerometer.

9.2 Calibrate fifth wheel in accordance with Method F 457.

9.3 Tach-Generator Calibration:

9.3.1 Calibrate the tach-generator in accordance with the manufacturer's specifications.

⁴ Current Issue; available from the Tire and Rim Assn., 175 Montrose West Ave., Suite 150, Copley, OH 44321.