



Designation: F 424 – 98

Standard Test Method for Tires for Wet Driving Traction in Straight-Ahead Motion Using Highway Vehicles¹

This standard is issued under the fixed designation F 424; 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 measurement of driving traction of tires designed for and to be mounted on cars or trucks traveling straight ahead on a prepared surface.

1.2 *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.*

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

2. Referenced Documents

2.1 ASTM Standards:

E 274 Test Method for Skid Resistance of Paved Surfaces Using a Full-Scale Tire²

E 1337 Test Method for Determining Longitudinal Peak Braking Coefficient of Paved Surfaces Using a Standard Reference Test Tire²

F 377 Practice for Calibration of Braking/Tractive Measuring Devices for Testing Tires³

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

3. Terminology

3.1 Definitions:

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

3.1.2 *driving coefficient, peak (nd), n*—the maximum value of the driving coefficient. **(F 538)**

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

3.1.4 *driving torque, [ML²/T²], n*—of a wheel, the positive wheel torque. **(F 538)**

3.1.5 *effective rolling radius, n*—the ratio of the linear velocity of the wheel center of the free rolling tire in the X' direction to the spin velocity.

3.1.6 *free rolling tire, n*—a loaded tire rolling without applied driving or braking torque. **(F 538)**

3.1.7 *inclination angle, n*—of a tire, the angle between the Z'-axis and the wheel plane. **(F 538)**

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

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. **F 538**

3.1.10 *slip angle, n*—of a tire, the angle between the X'-axis and direction of travel of the center of tire contact. **(F 538)**

3.1.11 *spin axis, n*—of a wheel, the axis of rotation of a wheel. **(F 538)**

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

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

3.1.14 *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.

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

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

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.

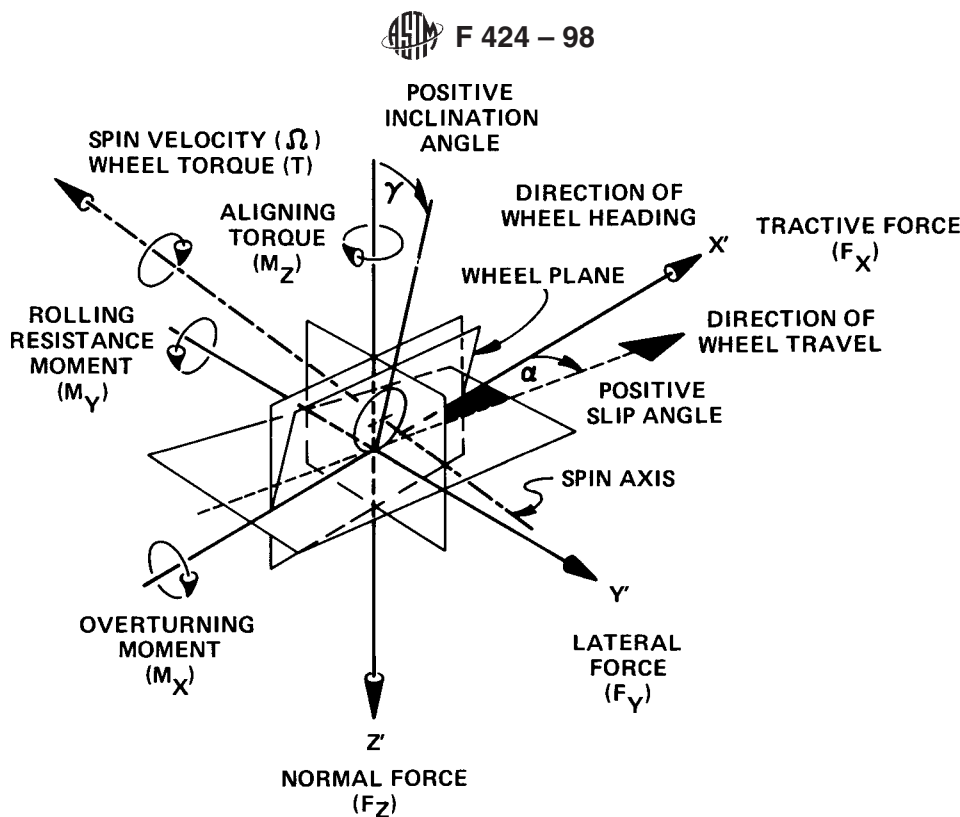


FIG. 1 Tire-Axis System

3.1.16 *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 This test method is conducted by towing a dynamometer vehicle behind the test vehicle moving in a straight line and gradually increasing the draw bar pull force by increasing the throttle setting of the test vehicle to compensate for brake application on the dynamometer vehicle. The dynamometer brake application is to be increased only as much as is necessary to maintain a constant test speed. The test progresses with increased throttle setting and dynamometer brake application until spinning of the test tires occurs.

4.2 The recommended vehicle test speed is 2.5 to 7 mph (4 to 10 km/h).

4.3 The test may be conducted utilizing a single-wheel driving traction truck or other specialized vehicles utilizing an independently loaded and driven test wheel position. A description of these specialized test vehicles and their appropriate test procedures are not detailed in this test method.

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 on 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:

6.1.1 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).

6.1.2 The test vehicle shall be equipped, if possible, with the highest available power engine and the numerically highest available transmission and rear axle ratio.

6.2 *Towing Dynamometer Vehicle*—The towed dynamometer shall have capability to develop a draw-bar pull force up to at least 4 000 lbf (17.8 kN).

6.3 Instrumentation:

6.3.1 *Force Transducer*, to measure draw-bar pull force. The transducer shall meet the following requirements:

6.3.1.1 *Minimum Full-Scale Range*—0 to 4 000 lbf (17.8 kN).

6.3.1.2 *Accuracy*— ± 10 lbf (44 N).



6.3.1.3 *Maximum Nonlinearity and Hysteresis at Full Scale*—Less than 1 %.

6.3.1.4 *Maximum Cross-Axis Sensitivity at Full Scale*—Less than 2 % without electronic compensation of a signal.

6.3.2 *Torque Meter*, to measure vehicle drive shaft torque (optional instrumentation). The torque meter shall meet the following requirements:

6.3.2.1 *Minimum Full-Scale Range*—0 to 1500 lbf·ft (0 to 2030 N·m).

6.3.2.2 *Accuracy*— ± 10 lbf·ft (13.6 N·m).

6.3.2.3 *Maximum Nonlinearity and Hysteresis of Full Scale*—Less than 1 %.

6.3.2.4 *Maximum Cross-Axis Sensitivity at Full Scale*—Less than 2 %.

6.3.3 The fifth wheel used to measure vehicle speed shall have specifications in accordance with Method F 457.

6.3.3.1 *Accuracy*— ± 0.5 mph (0.8 km/h).

6.3.4 *Tachometer*, to measure angular velocity of each test wheel, installed on the test vehicle. The tachometer shall meet the following requirements:

6.3.4.1 *Slewing Rate*—0 to full-scale output volts in 0.05s.

6.3.4.2 *Minimum Full-Scale Range*—0 to 1200 rpm.

6.3.4.3 *Accuracy*— ± 1 rpm.

6.3.5 *Multichannel Recorder or XXY, or XYY Function Plotter*, meeting the following requirements:

6.3.5.1 *Minimum Frequency Response*—Flat (± 1 %) dc to 30 Hz full scale.

6.3.5.2 *Gain*—Sufficient to permit full-scale display for full-scale input signal level.

6.3.5.3 *Input Impedance*—Seven times larger than the output impedance of signal source.

6.3.5.4 It must be insensitive to vibrations, acceleration, and ambient temperature change. The error in reading shall not exceed 1 % of full scale when subjected to vibrational acceleration of $5 g$ (49 m/s^2) in the 0.5 to 40.0-Hz frequency range and operating temperature range between 32 and 125°F (0 and 52°C).

6.3.5.5 It shall not be affected by storage temperature variations between -20 and 160°F (-29 and 71°C).

6.3.5.6 The multichannel recorder shall have a variable chart speed with a maximum of at least 25 mm/s.

6.3.6 *Power Supply*, for transducers and recorder meeting requirements specified by the transducer and recorder manufacturers.

7. Selection and Preparation of Test Tires

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

7.2 Trim the test tires to remove all protuberances in the tread areas caused by mold air vents or flashes at mold junctions.

7.3 Mount the test tires on T & RA⁴ recommended rims by using conventional mounting methods. Assure proper bead seating 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. Allow the tires to stand at least 24 h between mounting and testing in order to allow the mounting lubricant to dry.

7.4 Break-in the test tires a minimum of 50 miles (80 km) at T & RA⁴ load and inflation at speeds of 50 to 55 mph (80 to 88 km/h) without excessive cornering, braking, or acceleration to avoid uneven wear. There shall be no visible surface scuffing. 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 5 % of the new tire tread depth.

7.5 Place the mounted test tires near the test site in such a location that they all have the same ambient temperature prior to testing. Shield the tires from the sun to avoid excessive heating by solar radiation.

7.6 Check the air pressure of the test tires just prior to testing. The test tire inflation pressure at standard test load specified in 8.1.1 shall be 24.0 ± 0.5 psi (165.0 ± 3.5 kPa) at ambient temperature (cold).

8. Preparation of Apparatus

8.1 Test Vehicle:

8.1.1 Weigh the test vehicle prior to testing with a full tank of gasoline, instrumentation, and test personnel seated in the same locations as that to be used during testing. Adjust the vehicle static weight by ballasting to match the static wheel load specified for test tires. In no case shall the static wheel load exceed the maximum wheel load capacity of the vehicle or of the tire. The load recommended by the T & RA manual for 24-psi (165-kPa) inflation pressure of the test 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, particularly on high-friction surfaces.

8.1.2 Install the test tires on the rear wheels and use a pair of similar tires, not necessarily identical to the test tires on the front wheels.

8.2 Instrumentation:

8.2.1 Install the force transducer and torque meter in locations that minimize vibration effects.

8.2.2 Install the fifth wheel according to the manufacturer's specifications and locate it as near as possible to the mid-tract position on the vehicle. Record the output of the fifth wheel and arrange for a visual display for the dynamometer operator to monitor vehicle speed.

8.2.3 Install the tachometers on driven and non-driven wheels in accordance with the manufacturer's specifications.

9. Calibration

9.1 Calibrate the transducer for measuring draw-bar pull force in a tensile force machine or some other appropriate test fixture with the drawer-bar transducer installed in series with the load cell.

9.2 Calibrate the torque meter in an appropriate test fixture equipped with the load cell.

9.3 The load cells used for calibration of draw-bar force transducer and torque meter shall be calibrated according to a dead-weight procedure using Class F weights, the calibration of which is traceable to the National Bureau of Standards (NBS).

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