Designation: F414 – 21

Standard Test Method for Energy Absorbed by a Tire When Deformed by Slow-Moving Plunger[1]

This standard is issued under the fixed designation F414; 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 determination of tire plunger energy required to completely penetrate the tread area of an inflated tire as indicated by a rupture, loss of inflation pressure, sudden drop in plunger force or bottom-out. The test requires utilization of a laboratory testing machine capable of slowly penetrating the tread surface of a tire with a plunger having a hemispherical end.

1.2 This test method is applicable to pneumatic tires for vehicles normally used on the road.

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

1.4 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D4483 Practice for Evaluating Precision for Test Method Standards in the Rubber and Carbon Black Manufacturing Industries

E4 Practices for Force Calibration and Verification of Testing Machines

F538 Terminology Relating to Characteristics and Performance of Tires

F1082 Practice for Tires—Determining Precision for Test Method Standards (Withdrawn 2005)[3]

IEEE/ASTM SI10-02 American National Standard for Use of the International System of Units (SI): The Modern Metric System

3. Terminology

3.1 *Definitions:*

3.1.1 *bottom out, v*—to deform a tire by radial load on the tread until radial movement of the inside surface is stopped by the rim or other tire inside surface. **F538**

3.1.2 *groove, n*—a void that is relatively narrow compared to its length. **F538**

3.1.3 *load range, n*—a letter designation (A, B, C, D) or, for P-metric tires, standard load (SL), light load (LL), or extra load (XL), used to identify a given size tire with its load and inflation limits when used in a specific type of service. **F538**

3.1.4 *load rating [M], n*—the maximum load a tire is rated to carry for a given usage at a specific cold inflation pressure. **F538**

3.1.5 *maximum load rating [M], n—of a passenger tire*, the load rating at the maximum permissible cold inflation pressure for that tire. **F538**

3.1.6 *maximum plunger travel [L], n—in tire testing*, the relative displacement of tread surface by a plunger, measured from the point of initial contact of the plunger with the tread surface to the point of maximum force at rupture or at the bottom-out point. **F538**

3.1.7 *nominal plunger energy, W = (F × P)/2, n—in tire testing,* one half of the product of a peak force (required to rupture the tire structure in tread area) and maximum plunger travel into a tire at the time of rupture. **F538**

3.1.8 *plunger, n—in tire testing*, a cylindrical rod with a hemispherical end. **F538**

[1] This test method is under the jurisdiction of ASTM Committee F09 on Tires and is the direct responsibility of Subcommittee F09.30 on Laboratory (Non-Vehicular) Testing.

Current edition approved Sept. 1, 2021. Published October 2021. Originally approved in 1975. Last previous edition approved in 2015 as F414 – 15. DOI: 10.1520/F0414-21.

[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] The last approved version of this historical standard is referenced on www.astm.org.

3.1.9 *void, n*—a volume (in the tread band) defined by the lack of rubber; the depth dimension of this volume may vary from point to point in (on) the tread band. F538

4. Summary of Test Method

4.1 This test method measures tire plunger energy required to force a cylindrical plunger with a hemispherical end into the tread of the tire to produce a rupture of the carcass or a bottom-out condition.

5. Significance and Use

5.1 This test method establishes a standard procedure of test and provides data that can be related to tire strength, but does not measure tire performance or establish specification or tolerances.

6. Apparatus

6.1 *Testing Machine* that incorporates a cylindrical plunger, which can be forced, at 50.8 ± 1.58 mm/min (2.0 ± 0.0625 in./min) radially into a tread of a tire, while the force and plunger motion are indicated or recorded.

6.1.1 The force-indicating device shall have an accuracy of ±1 % of the indicated force and shall reflect an instantaneous change in force from zero to full scale in no more than 3.0 s.

6.1.2 Relative plunger travel distance shall be indicated to an accuracy of ±1 % of the distance from the original undeformed tire tread surface, taking into account any motion or deflection of the force-measuring mechanism or supporting devices.

6.2 *Means for Calibration of the Testing Machine,* for plunger force, plunger travel, and rate of plunger travel is necessary.

6.3 *Calibrating Weights or Other Calibrating Devices,* conforming to Practices E4, are required for verification of calibration.

6.4 *Means for Mounting a Tire on a Test Rim,* and mounting the test assembly on the testing machine is necessary.

6.5 *Test Rims,* with dimensions as shown in the current issue of Tire and Rim Association Year Books,[4] ETRTO,[5] JATMA,[6] or as listed in a publication by the tire manufacturer, are necessary.

6.6 *Plunger (Circular Cylinder),* having a diameter as shown in Table 1 for the tire being tested, and having the working end in the shape of a hemisphere, hardened to a minimum Rockwell hardness 35 HRC, and polished to a 0.50-µm (16-µin.) finish or better with no visible tool marks, is required. It must be long enough to penetrate from the undeformed tire tread surface to the bottom-out condition.

TABLE 1 Plunger Diameter

Tire Load Identification[A]	Tire Characteristics	Plunger Diameter, mm (in.)
A, B, C	Motorcycle	7.9 ± 0.1 (0.313 ± 0.005)
A, B, C, D, SL, XL, E, F	All 12 rim diameter code or smaller, except motorcycle	19.0 ± 0.1 (0.750 ± 0.005)
B, C, D, SL, LL, XL, T	Passenger car	19.0 ± 0.1 (0.750 ± 0.005)
B, C, D, E, F, G, H	Light truck	19.0 ± 0.1 (0.750 ± 0.005)
B, C, D, E, F, G, H	17.5 rim diameter code or smaller, tubeless	19.0 ± 0.1 (0.750 ± 0.005)
C, D, E, F	Larger than 17.5 rim diameter code, tubeless	31.8 ± 0.1 (1.250 ± 0.005)
C, D, E, F	Larger than 17.5 rim diameter code, tube type	31.8 ± 0.1 (1.250 ± 0.005)
G, H, J, L, M, N	Larger than 17.5 rim diameter code, tubeless	38.1 ± 0.1 (1.500 ± 0.005)
G, H, J	Larger than 17.5 rim diameter code, tube type	38.1 ± 0.1 (1.500 ± 0.005)

[A] Temporary use 60-psi tires and standard load, light load, and extra load "P metric" tires are described as T, SL, LL, and XL. All other letter designations refer to load range.

7. Sampling

7.1 A sample is one or more tires taken from a lot as directed in any applicable specification, or as taken from a shipping unit, or as agreed upon between the purchaser and the seller.

7.2 Record the manufacturer's identification, brand name, tire identification number, tire outside diameter, rim diameter, size, load range, fabric type, and type of tire. Visually inspect the tire completely for excessive mold lubricant and for any obvious faults or conditions that could affect the test.

8. Conditioning

8.1 The ambient temperature for tire conditioning and in the test area shall be any known temperature between 18 and 40°C (65 and 105°F).

8.2 The test tire, after being mounted on a test rim and inflated to the applicable test pressure, shall remain at the ambient temperature of the test room for at least 3 h prior to testing.

9. Procedure

9.1 Mount the tire on a test rim and inflate the tire with air to the pressure as specified in Table 2 when testing passenger car tires or corresponding to the maximum load or maximum dual load where there is both a single and dual load marked on the tire for all other type tires. The inflation pressure tolerance shall be ±3.5 kPa (0.5 psi). Condition the mounted tire in accordance with 8.1 and 8.2.

9.1.1 Table 2 provides the inflation pressure to use when testing various passenger car tire sizes. There are three common styles for tire size designators in current use; each style is listed in separate sections of the table.

[4] Available from Tire and Rim Association, Inc., 4000 Embassy Parkway, Suite 390, Akron, OH 44333.

[5] Available from the European Tyre and Rim Technical Organization, 78/80, rue Defacqz, B-1060, Brussels, Belgium.

[6] Available from the Japan Automobile Tire Manufacturers Association, Inc., No. 33 Mori BLDG, 8th Floor, 3-8-21 Toranomon, Minato-KU, Tokyo, Japan 105-001J.