Designation: F421 – 15

Standard Test Method for Measuring Groove and Void Depth in Passenger Car Tires[1]

This standard is issued under the fixed designation F421; 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 describes standard procedures for measuring the groove and void depth in passenger car tires.

1.2 Any mechanical, optical, or electronic device capable of measuring groove (void) depth can be used, but only the contact methodology is described here. Noncontact methodology is beyond the scope of this test method.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are 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 and health practices and determine the applicability of regulatory limitations prior to use.*

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

F538 Terminology Relating to the Characteristics and Performance of Tires

F1426 Practice for Identifying Tire Tread Surface Irregular Wear Patterns Resulting from Tire Use

3. Terminology

3.1 *Definitions:*

3.1.1 *circumferential line, n— on a tire*, any real or imaginary circle on the surface of a tire, lying in a plane that is perpendicular to the spin axis. **F538**

3.1.2 *element, n*—an isolated (totally bounded by void) projection. **F538**

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

3.1.4 *groove average depth, [L], n*—the average of all tire groove depth measurements in a single groove. **F538**

3.1.5 *groove (void) depth, [L], n*—a measurement of the perpendicular distance from a real or calculated reference plane defined by edges of two adjacent ribs (lugs) to the lowest point of contact in the groove (void).

3.1.5.1 *Discussion*—The reader is cautioned that the probe tip used for the depth measurement must have a sufficiently small cross-section compared to the width of the void being measured. The probe must be able to reach the bottom of the void without contacting the tread elements that form the sides of the void.

Special consideration should be given to measuring sipes. (See definition in Terminology F538.) Since the sipe is substantially narrower than a major groove, a very small diameter probe tip must be used to achieve an accurate measurement of sipe depth. **F538**

3.1.6 *irregular wear, n*—a type of treadwear characterized by substantial variations of tread loss both from projection to projection and frequently from point to point on a given projection. **F538**

3.1.7 *projection, n*—a pavement contacting area of the tread band, bounded by void. **F538**

3.1.8 *rib, n*—a continuous circumferential projection. **F538**

3.1.9 *treadwear indicator, n*—a raised portion of a groove bottom or void bottom that is molded in a tire at fairly regular intervals around the circumference to provide a visual indication that most of a tread has been worn away. **F538**

3.1.10 *uniform wear, n*—a type of treadwear characterized by equal tread loss both from projection to projection and from point to point on a given projection, resulting in a smooth appearance of all parts of the tread pattern. **F538**

3.1.11 *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 gives the detailed procedures and the needed precautions for the measurement of the groove or void depth of the tread pattern in a tire. Calculations for various

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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.

types of average groove or void depths are given in addition to the required nomenclature for effective communication of the groove or void measurement results.

5. Significance and Use

5.1 The groove (void) depth affects the tire's ability to develop tractive forces in various operating environments. Groove (void) depth also defines the state of wear of a tire and is used in the determination of the rate of wear.

6. Apparatus

6.1 *Gauge:*

6.1.1 The apparatus shall consist of a mechanical or electro-mechanical depth gauge fitted with a foot through which a spindle passes. The foot may have any of a variety of shapes, including but not limited to cylindrical, semi-cylindrical, and rectangular. The reference surface of the foot shall be made of a non-deformable material, ground planar and perpendicular to the gauge spindle. Examples of mechanical gauges and typical available gauge feet are illustrated in Figs. 1 and 2. A typical electro-mechanical gauge system is illustrated in Fig. 3.

6.1.2 The reading of the depth gauge shall be accurate to within ±0.025 mm (0.001 in.) over a range of 25 mm (1 in.). The resolution of the gauge shall be at least 0.025 mm (0.001 in.).

6.1.3 The gauge spindle shall extend at least 25 mm (1 in.) beyond the reference surface of the foot. Spindles may have any of a variety of shapes and diameters suitable for the tread to be measured. Two frequently used spindles are illustrated in Fig. 4.

6.1.4 The spindle shall not touch the side of the hole in the foot.

6.1.5 *Zero Adjustment*—The system shall be adjustable to zero when the foot is pressed against a flat surface. The repeatability on the flat surface shall be within ±20 % of one division (0.005 mm (0.0002 in.)).

6.1.6 The accuracy shall be to within 0.025 mm (0.001 in.) for distances up to 12.7 mm (0.5 in.) and to within 0.125 mm (0.005 in.) for distances from 12.7 to 25 mm (0.5 to 1 in.).

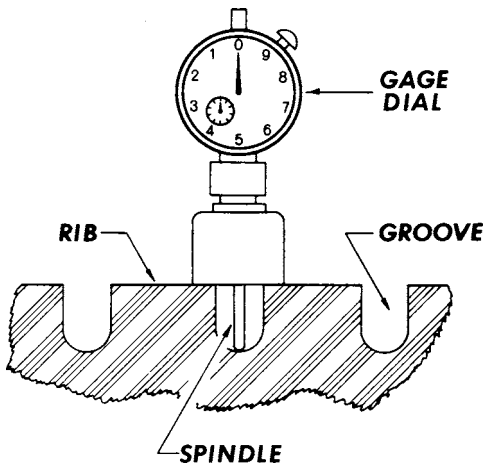

FIG. 1 Illustration of Principle of Method

6.1.7 The overall variability for a series of repeated measurements on the flat surface shall be within ±20 % of one division.

6.1.8 Calibration shall be made using gauge blocks with dimensions traceable to the National Institute of Standards and Technology primary standard.

7. Preparation

7.1 *Gauge Zero Adjustment*—Place the foot of the gauge against a non-deformable flat surface such as a glass plate and adjust dial to zero.

7.2 *Preparation of Tire:*

7.2.1 Mount the tire on an approved width rim and inflate to the required pressure.

7.2.2 The tire shall be in temperature equilibrium with the environment in which it is measured.

NOTE 1—For purposes of this test method, temperature equilibrium exists if the gauge pressure remains within 7 kPa (1 psi) of the required inflation pressure during the complete measurement process.

7.2.3 The tire must be dry and free of any foreign material that would interfere with accurate measurement.

7.2.4 Avoid the rubber vents on the tread during measurement or remove them, leaving no projections above the tread surface.

8. Procedure

8.1 *Tires with Uniform Wear*—Place the foot of the gauge so that it bridges adjacent ribs or lugs over the area to be measured, avoiding treadwear indicators, and so that the spindle makes perpendicular contact with the groove or void bottom as shown in Fig. 1. This single measurement characterizes the groove (void) depth at this location.

8.2 *Tires Exhibiting Irregular Wear*—Proceed in accordance with 8.1, except the spindle does not have to make perpendicular contact at base of groove as shown in Fig. 2.

9. Characterization of Groove (Void) Depth for the Whole Tire

9.1 The depth of a groove (void) of a tire is characterized by the arithmetic mean of a number of individual measurements.

9.2 *Location of Measurements on Ribbed Tires:*

9.2.1 *Preferred Method*—Make measurements on all ribs or in all grooves.

9.2.2 *Minimum Requirement*—Make measurements on two outer grooves and on either the center groove or, in the absence of a center groove, on the two grooves adjacent to the centerline of the tread.

9.3 *Location of Measurements on Lug Tires:*

9.3.1 *Tires with Tread Width Greater Than 180 mm (7 in.)*—Locate six or seven circumferential lines equally spaced across the tread symmetrically arranged around a line at the center of the tread. The two outer lines shall be within 25 mm (1 in.) of the shoulders.

9.3.2 *Tires with Tread Width Less Than 180 mm (7 in.)*—Locate four or five circumferential lines equally spaced across

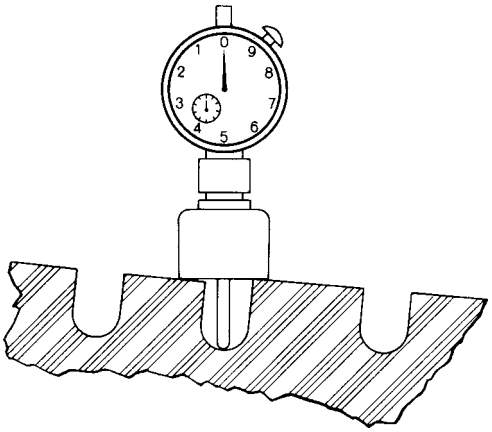

FIG. 2 Irregular Wear Measured Using a Cylindrical Foot

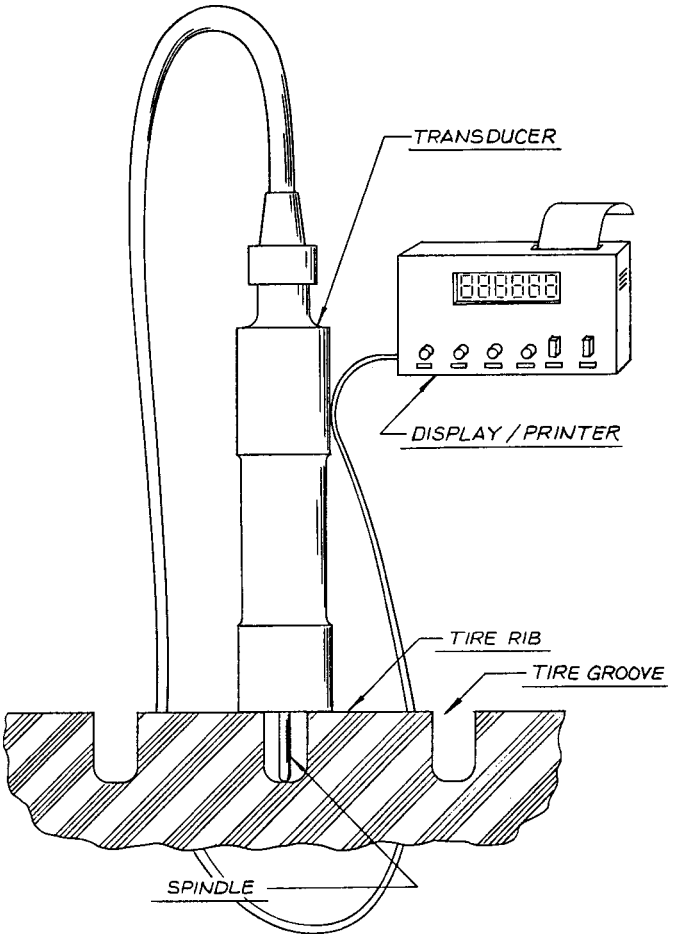

FIG. 3 Electro-Mechanical Gauge System

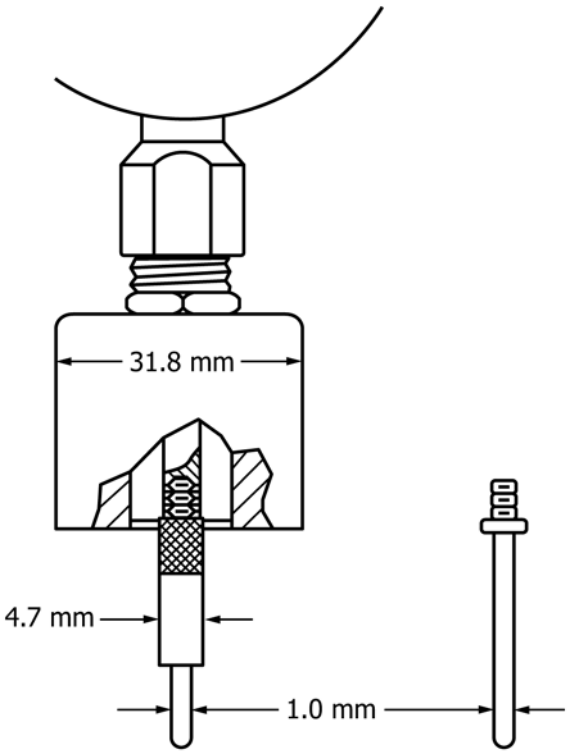

FIG. 4 Cylindrical Foot with Typical Spindles

the tread symmetrically arranged around a line at the center of the tread. The two outer lines shall be within 25 mm (1 in.) of the shoulders.

9.3.3 *Minimum Requirements*—Proceed in accordance with no restriction on tread width.

9.4 *Number of Measurements:*

9.4.1 *Preferred Method*—Ten equally spaced measurements around each rib or circumferential line avoiding treadwear indicators.

NOTE 2—The measurement should be taken at the nearest point along the circumferential line at which a proper measurement can be taken.

9.4.2 *Minimum Requirement*—Six equally spaced measurements on each rib or circumferential line (Note 2) avoiding treadwear indicators.

9.4.3 *Measurement of Treadwear Indicator Height*—If the height of the treadwear indicators is required, take measurements at all of the indicators.

9.5 *Calculations:*

9.5.1 *Average Groove Depth*—Calculate the arithmetic mean and standard deviation for all measurements in one groove.

9.5.2 *Average Void Depth on a Circumferential Line*—Calculate the arithmetic mean and standard deviation for all measurements made on one circumferential line.

9.5.3 *Average Tread Depth*—Calculate the arithmetic mean using all measurements made on the tire.

9.5.4 *Treadwear Indicator Height*—The height of treadwear indicators is determined by calculating the difference between the depth from the tread's surface to the top of the treadwear indicator, and the depth from the tread's surface to the bottom of the tread groove close to the slope at the base of the treadwear indicator.

9.6 *Report:*

9.6.1 Report the following information:

9.6.1.1 Complete tire description,

9.6.1.2 Complete rim description,

9.6.1.3 Inflation pressure of the tire and ambient temperature at the time of measurement,

9.6.1.4 The complete raw data set, including number of measurements, their arithmetic mean, standard deviation (where appropriate), and location,

9.6.1.5 Gauge description, including foot and pin configurations, and

9.6.1.6 Method of zero gauge adjustment.

9.6.2 The report shall be in columnar form.

10. Characterization of a Tire Exhibiting Irregular Wear

10.1 The determination of the tire groove (void) depth is frequently made in connection with experiments related to predicting the tread life of a tire or in relationship to its tractive properties. The occurrence of irregular wear may render the tire unsuitable for the test purpose.

10.2 It is beyond the scope of this test method to determine the manner in which irregular wear may relate to definitions of legal tread depths or to warranty agreements between tire buyers and sellers.

10.3 See Practice F1426 if irregular wear is suspected on the test tire.

11. Precision and Bias

11.1 On the basis of experience with this test method with tires not exhibiting any form of irregular wear, the following within-laboratory single-operator gaging precision can be expected. The arithmetic mean of six measurements in a groove will have a repeatability, *r*, of approximately 0.004 in. (0.10 mm) for repeated measurements of that groove or void. See Practice D4483 for the definition of repeatability.

11.2 No concept of accuracy in the sense of a bias from a true value is applicable to tire tread measurements. Reference values do not exist for this test method, since the value or level of the test property is exclusively defined by the test method. Bias, therefore, cannot be determined.

12. Keywords

12.1 depth gauge; groove depth; irregular wear; tread depth