



Designation: D2210 – 21

## Standard Test Method for Grain Crack and Extension of Leather by the Mullen Test<sup>1</sup>

This standard is issued under the fixed designation D2210; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the U.S. Department of Defense.*

### 1. Scope

1.1 This test method covers the determination of the resistance of leather to grain cracking and for measuring the extension of the leather. It is limited to light leathers such as shoe uppers, garment, gloves, and upholstery. This test method does not apply to wet blue or wet white.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

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

1.4 *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:*<sup>2</sup>

**D1610 Practice for Conditioning Leather and Leather Products for Testing**

**D1813 Test Method for Measuring Thickness of Leather Test Specimens**

### 3. Terminology

3.1 *Definitions:*

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D31 on Leather and is the direct responsibility of Subcommittee D31.03 on Footwear. This test method was developed in cooperation with the American Leather Chemists Assn. (Standard Method E58 – 1965).

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.1.1 *extension*—the amount of stretch of leather over the diaphragm under pressure.

3.1.2 *grain cracking*—the appearance of cracks on the surface of the leather as the leather is extended over a diaphragm under pressure to form a sphere.

### 4. Significance and Use

4.1 The test method is designed to measure the force required to crack the grain of leather by steady hydraulic pressure on a diaphragm of definite diameter applied to the flesh side of the specimen to form a sphere. The cracking of the grain is a result of failure under elongation or stretch. The elongation or stretch of the leather can be measured at different loads or at the failure of the grain to determine if the stress leather will withstand under lasting conditions. Cuts, scratches, and other defects will cause considerable variation in the results by concentration of the applied force to the weak points. This test method is excellent for manufacturing control, specification acceptance, and service evaluation in the lasting property of leather. This test method may not apply when the conditions of the test employed differ widely from those specified in the test method.

### 5. Apparatus

5.1 *Testing Machine*,<sup>3</sup> as shown in Fig. 1. The machine shall be hand- or power-driven. The machine shall hold the specimen firmly, without slippage, between two annular, plane, unpolished (matte) surfaces that may have fine, spiral tool marks not over 0.010 in. (0.25 mm) in depth.

5.2 *Upper Clamping Surface*—The upper clamping surface (clamping ring) shall have a circular opening 1.240 in.  $\pm$  0.010 in. (31.50 mm  $\pm$  0.25 mm) in diameter and shall be connected to the clamping mechanism through a swivel joint to ensure an even clamping pressure.

5.3 *Lower Clamping Surface*—The lower clamping surface (diaphragm plate) shall be 0.219 in.  $\pm$  0.003 in. (5.56 mm  $\pm$

<sup>3</sup> The sole source of supply of the apparatus known to the committee at this time is B. F. Perkins, 939 Chicopee St., Chicopee, MA 01013-2797, (413) 536-1311. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.

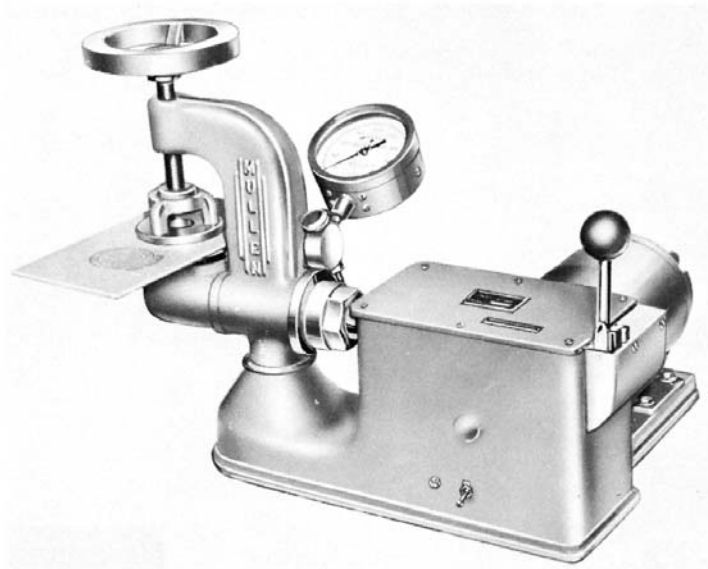


FIG. 1 Mullen Tester, Model A

0.08 mm) thick and have an opening of 1.240 in.  $\pm$  0.01 in. (31.50 mm  $\pm$  0.52 mm) in diameter. The circular edges of the openings that come in contact with the specimen and the rubber diaphragm shall be rounded to a radius of not over 0.025 in. (0.64 mm) to prevent any cutting action. During the test, the circular edges of the openings in the two clamping plates shall be substantially concentric with no overlapping of any point.

5.4 *Diaphragm*, of rubber, 0.034 in.  $\pm$  0.002 in. (0.86 mm  $\pm$  0.05 mm) thick, clamped under the lower clamping plate so that, before the diaphragm is stretched by pressure underneath it, the center of its upper surface is below the plane of the clamping surface.

5.5 *Dial Gauge*, as shown in Fig. 2, to measure the extension of the leather specimen and mounted on the machine through screw shaft or on side of clamps on platform. This

gauge shall be calibrated to read directly to the nearest 0.001 in. (0.03 mm). It shall be equipped with a flat anvil and a presser foot.

5.6 *Bourdon Tube*—The apparatus shall be equipped with a Bourdon tube, maximum-reading-type, pressure gauge graduated in pounds-force per square inch and accurate throughout the entire range of its scale to within a value of 1 % of its maximum capacity. The capacity of the gauge shall be such that the individual readings will be not less than 25 % nor more than 75 % of the total capacity of the gauge.

5.7 *Pressure Control*—The machine shall be equipped with means of applying controlled increasing hydraulic pressure to the underside of the diaphragm until the specimen cracks. This pressure shall be generated by a piston forcing a liquor (usually glycerin) into the pressure chamber of the apparatus. For machines shown in Fig. 1 where the cracking pressure is the only measurement, the pressure will be generated by pumping liquid at a rate of 170 mL/min  $\pm$  10 mL/min or by turning a handwheel at approximately 30 r/min. Record pumping rate or cranking rate. For machines shown in Fig. 2 where cracking pressure and extension are measured, the pressure will be generated by pumping liquid at a rate of 15 mL/min  $\pm$  2 mL/min or by turning a handwheel at approximately 3 r/min.

NOTE 1—When equipment does not have a gauge to measure the flow rate or uses a hand crank method, consult the equipment manufacturer or operating manual. Results from the different tester may not be comparable because of the different flow rates.

5.8 *Thickness Gauge*—A dead-weight type of thickness gauge as described in Test Method D1813.

## 6. Test Specimen

6.1 The specimen shall be a square of leather 3 in. by 3 in. (76 mm by 76 mm) cut from the test unit of leather.

6.2 The specimen shall be free of mechanical damage and surface defects.

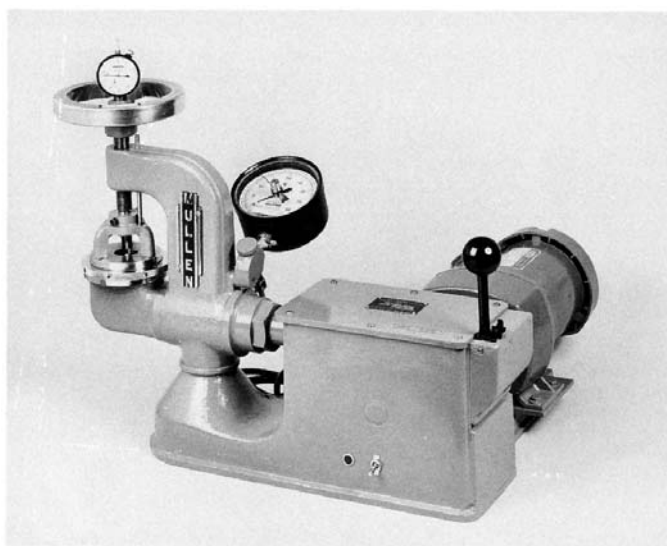


FIG. 2 Mullen Tester with Dial Gauge

## 7. Conditioning

7.1 All specimens shall be conditioned in accordance with Practice **D1610**.

## 8. Procedure

8.1 Determine the thickness of the specimen by taking three measurements in the area to be cracked and determine the average value.

8.2 Place the flesh side of the specimen in contact with the rubber diaphragm of the testing machine.

8.3 Clamp the specimen securely in the apparatus in such a manner that the leather will not be damaged.

8.4 Rest the presser foot of the extension gauge on the flat surface of the specimen and set the gauge at zero.

8.5 Apply pressure to the specimen until the specimen cracks.

8.6 At the moment the first crack appears in the specimen stop the machine, note the applied pressure from the gauge, and record the value as the cracking strength of the specimen.

## 9. Report

9.1 The report shall include one or more of the following:

9.1.1 Cracking pressure to the nearest 5 psi (35 kPa) for each specimen or averaged and reported as the average of the test unit,

9.1.2 Extension of the leather to the nearest 0.001 in. (0.03 mm), converted to percentage (see **Annex A1**) and reported as percentage stretch, and

9.1.3 Thickness to the nearest 0.001 in. (0.03 mm) reported for each specimen or averaged and reported as the thickness of the sample.

9.1.4 Speed the liquid was pumped to build pressure to the nearest 10 % (see **5.7**). Record revolutions per minute.

## 10. Precision and Bias

10.1 The following criteria may be used to judge the acceptability of the results if at least 15 units have been tested:

10.1.1 *One Operator, Duplicate Specimens, Same Skin*—Results by the same operator in duplicate adjacent specimens in a skin taken from the official sampling position should not be considered suspect unless the coefficient of variation exceeds:

Leathers	Cracking Pressure, psi	Extension at Grain Crack, %
Shoe upper	26	13
Upholstery	17	14
Calfskin <sup>A</sup>	16	22
Glove	11	20

<sup>A</sup> 3 oz ± 1 oz, 0.0468 in. ± 0.0156 in. (1.189 mm ± 0.396 mm).

10.1.2 *Two Laboratories, Duplicate Specimens, Same Skin*—Results for the same group of light leathers listed in **10.1.1** submitted by each of two laboratories on duplicate adjacent specimens in a skin taken from the official sampling position should not be considered suspect unless the two average results differ by more than 5 %.

NOTE 2—The reproducibility reported in **10.1.2** is based on data obtained at two laboratories, and a different operator. The results show close correlation between laboratories.

NOTE 3—The results given in Section **10** are based on tests on 30 sides of leather and do not apply to findings and cut parts.

NOTE 4—The precision data for between skins are not included because the results were based on different skins from several production lots. The variables in leather for between skins will give a higher variation of the results, but this factor should not affect the precision of the method.

## 11. Keywords

11.1 burst strength extension; grain crack; leather; Mullen

(Mandatory Information)

A1. DERIVATION OF EQUATION FOR PERCENTAGE STRETCH

A1.1 Referring to Fig. A1.1,

$h$  = deflection (measured by Mullen tester), and

$a$  = radius of test area (0.625 in. =  $\frac{5}{8}$  in.)

From geometry,  $z = 2\pi rh$ ,  $u = \pi a^2$ , and  $h + i = r$ .

but:

$$i = \sqrt{r^2 - a^2} \quad (A1.1)$$

then:

$$h + \sqrt{r^2 - a^2} = r \quad (A1.2)$$

solving for  $r$ :

$$r = (a^2 + h^2)/2h \quad (A1.3)$$

then:

$$\begin{aligned} \text{Stretch, \%} &= 100 [(z - u)/u] \\ &= 100 [(2\pi rh - \pi a^2)/\pi a^2] \\ &= 100 \left( \frac{2h[(a^2 + h^2)/2h] - a^2}{a^2} \right) \\ &= 100 (h^2/a^2) = 100 h^2/(25/64) = 100 \\ &\quad \times (64/25)h^2 \\ &= 100 (2.56 h^2) \end{aligned}$$

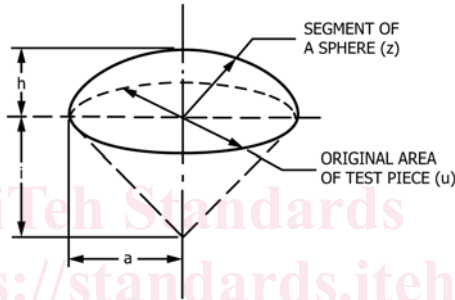


FIG. A1.1 Geometry for Derivation of Equation for Percentage Stretch