Designation: D 2210 – 00

Standard Test Method for Grain Crack and Extension of Leather by the Mullen Test[1]

This standard is issued under the fixed designation D 2210; 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 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.

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.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 1610 Practice for Conditioning Leather and Leather Products for Testing[2]

D 1813 Test Method for Measuring Thickness of Leather Test Specimens[2]

3. Terminology

3.1 *Definitions:*

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*,[3] 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 ± 0.010 in. (31.50 ± 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 ± 0.003 in. (5.56 ± 0.08 mm) thick and have an opening of 1.240 ± 0.01 in. (31.50 ± 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 ± 0.002 in. (0.86 ± 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 Gage*, 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 gage 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.

[1] 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 E 58 – 1965).

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[2] *Annual Book of ASTM Standards*, Vol 15.04.

[3] 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

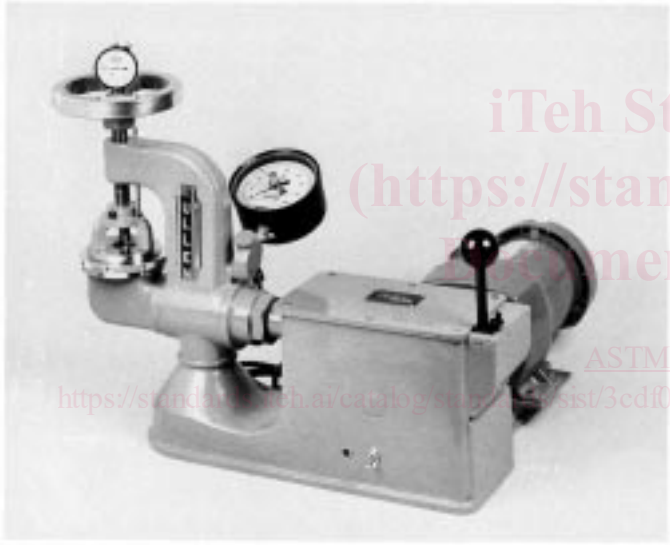

FIG. 2 Mullen Tester with Dial Gage

5.6 *Bourdon Tube*—The apparatus shall be equipped with a Bourdon tube, maximum-reading-type, pressure gage 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 gage shall be such that the individual readings will be not less than 25 % nor more than 75 % of the total capacity of the gage.

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 ± 10 mL/min or by turning a handwheel at approximately 30 r/min. 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 ± 2 mL/min or by turning a handwheel at approximately 3 r/min.

5.8 *Thickness Gage*—A dead-weight type of thickness gage as described in Test Method D 1813.

6. Test Specimen

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

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

7. Conditioning

7.1 All specimens shall be conditioned for 48 h in an atmosphere maintained at 73.4 ± 1.8°F (23 ± 1°C) and 50 ± 4 % relative humidity and tested under these conditions as described in Practice D 1610.

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 gage on the flat surface of the specimen and set the gage 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 gage, and record the value as the cracking strength of the specimen.

9. Report

9.1 The report shall include 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).

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[A]	16	22
Glove	11	20

[A] 3 ± 1 oz, 0.0468 ± 0.0156 in. (1.189 ± 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 1—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 2—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 3—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

ANNEX

(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. = ⅝ in.)

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

$$i = \sqrt{r^2 - a^2} \tag{A1.1}$$

then:

$$h + \sqrt{r^2 - a^2} = r \tag{A1.2}$$

solving for r:

$$r = (a^2 + h^2)/2h \tag{A1.3}$$

then:

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

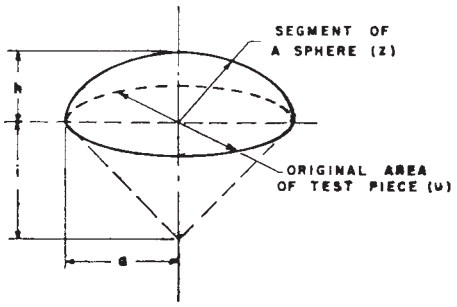

FIG. A1.1 Geometry for Derivation of Equation for Percentage Stretch