



## Standard Test Method for Peel Strength of Metal Electroplated Plastics<sup>1</sup>

This standard is issued under the fixed designation B533; 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.

### 1. Scope

1.1 This test method gives two procedures for measuring the force required to peel a metallic coating from a plastic substrate.<sup>2</sup> One procedure (Procedure A) utilizes a universal testing machine and yields reproducible measurements that can be used in research and development, in quality control and product acceptance, in the description of material and process characteristics, and in communications. The other procedure (Procedure B) utilizes an indicating force instrument that is less accurate and that is sensitive to operator technique. It is suitable for process control use.

1.2 The tests are performed on standard molded plaques. This method does not cover the testing of production electroplated parts.

1.3 The tests do not necessarily measure the adhesion of a metallic coating to a plastic substrate because in properly prepared test specimens, separation usually occurs in the plastic just beneath the coating-substrate interface rather than at the interface. It does, however, reflect the degree that the process is controlled.

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 Document

#### 2.1 ASTM Standards:<sup>3</sup>

#### E4 Practices for Force Verification of Testing Machines

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee B08 on Metallic and Inorganic Coatings and is the direct responsibility of Subcommittee B08.05 on Decorative Coatings.

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<sup>2</sup> This test is also known as the Jacquet Test. A detailed treatment of the test has been published by Saubestre et al in *Plating*, Vol 52, 1965, p. 982.

<sup>3</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. Summary of Test Method

3.1 A properly prepared standard test specimen, called a plaque, is copper electroplated, with no additional metal coating. The coated plaque is either tested as is, or it is conditioned by a low-temperature bake and then tested. The coating is cut through to the plastic substrate in a way that forms two strips of coating (see Fig. 1). Each strip is peeled from the substrate at a right angle using an instrument that indicates the force required to separate it from its substrate.

### 4. Significance and Use

4.1 The force required to separate a metallic coating from its plastic substrate is determined by the interaction of several factors: the generic type and quality of the plastic molding compound, the molding process, the process used to prepare the substrate for electroplating, and the thickness and mechanical properties of the metallic coating. By holding all others constant, the effect on the peel strength by a change in any one of the above listed factors may be noted. Routine use of the test in a production operation can detect changes in any of the above listed factors.

4.2 The peel test values do not directly correlate to the adhesion of metallic coatings on the actual product.

4.3 When the peel test is used to monitor the coating process, a large number of plaques should be molded at one time from a same batch of molding compound used in the production moldings to minimize the effects on the measurements of variations in the plastic and the molding process.

### 5. Apparatus

5.1 *Procedure A*—A tension testing machine that has self-aligning grips and that has a loading range that includes the forces to be measured, 5 to 200 N, shall be used to separate the coating from the substrate, and measure the force required. The machine shall meet the verification requirements of Practices E4.<sup>4,5</sup> The speed of separation of the crossarms of the machine

<sup>4</sup> The sole source of supply of the Instron universal testing machine known to the committee at this time is Instron Corp., Canton, MA.



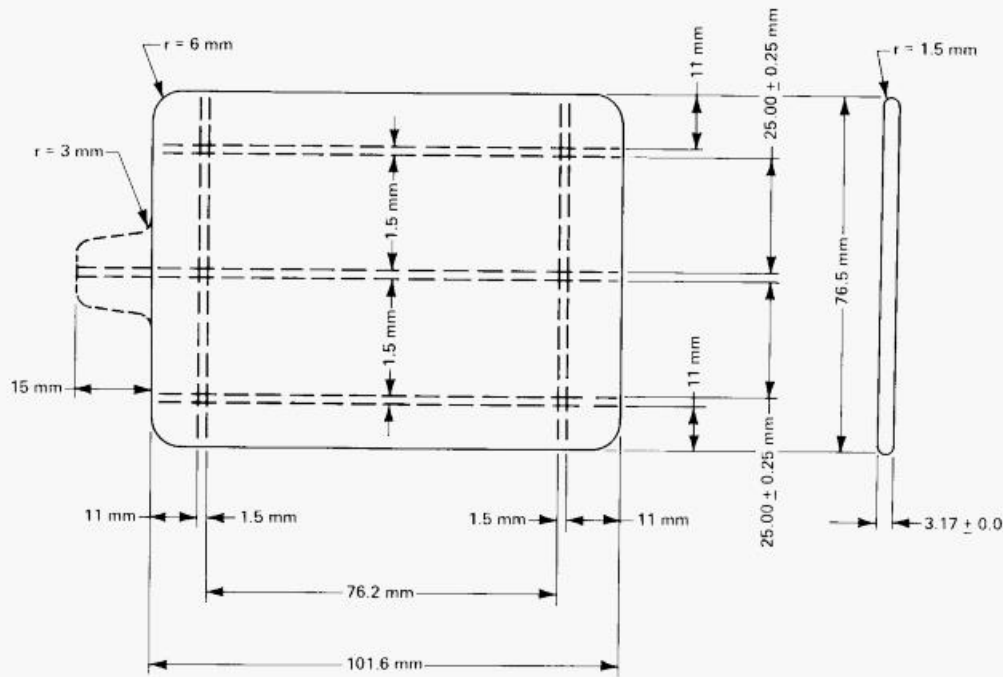


FIG. 1 Plaque

shall be adjusted to give a separation rate of  $25 \pm 3$  mm/min. The machine shall automatically and continuously record on a chart the load on one coordinate and the amount of peel on the other coordinate. The amount of peel may be obtained from calculation, using a known chart speed.

5.2 *Procedure B*—A spring-loaded, force-indicating instrument with a measurement range that includes the force to be measured, 5 to 200 N, shall be used to measure the force required to separate the coating. The indicated force shall be accurate to  $\pm 10\%$ .

## 6. Sampling

6.1 A sampling procedure is not applicable to this test method.

## 7. Test Specimen

7.1 Perform the test using a flat, molded plastic plaque such as shown in Fig. 1. Plaque dimensions may vary up to  $\pm 10\%$  provided that the edges of slit peel strips are not closer than 11 mm from any plaque edge.

## 8. Conditioning

8.1 Condition the electroplated plaques requiring conditioning by baking for 1 h in an air-circulating oven operated at  $70 \pm 3^\circ\text{C}$ . Place the plaques in the oven in a way that permits free circulation of air around all surfaces of the plaques. Allow the conditioned plaques to cool to room temperature and then test them within 1 h. Test the plaques that do not require conditioning within 30 to 60 min following the coating process.

<sup>5</sup> If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee<sup>1</sup>, which you may attend.

NOTE 1—The separation strength of an unconditioned plaque will change with time. The separation strength of a conditioned plaque may change with time after conditioning.

## 9. Procedure

9.1 Mold the required number of plaques using the specified molding compound and molding procedure.

NOTE 2—When the test is used as a control of the coating process, commercially prepared plaques can be used.

9.2 Clean, activate, and electroplate the plaques as specified. The thickness of the metallic coating in the test area (see Fig. 1) shall be  $40 \pm 4 \mu\text{m}$ .

NOTE 3—It is necessary to have a ductile copper coating to perform this test. The thickness and uniformity of thickness of the metallic coating directly influence the peel strength; therefore, in order to standardize this test, the coating thickness is specified. If a different coating thickness is used, the results will not be comparable to other test results. It may be necessary to use shielding during plating to obtain the required coating thickness uniformity.<sup>6</sup>

9.3 Cut through the coating along the dashed lines shown in Fig. 1, and also along the centerline so as to produce two parallel strips of coating that are  $25.00 \pm 0.25$  mm wide and approximately 75 mm long.

NOTE 4—Following are methods that can be used to cut the coating:  
(a) Slit the coating with a milling machine equipped with a slitting saw.<sup>5,7</sup> Operate the saw at a peripheral speed of 300 mm/s and a feed of 5 mm/s.

<sup>6</sup> Shielding methods are described in the *Technical Proceedings of the American Electroplaters' Society*, Vol 47, 1960, p. 94, and in the *Monthly Review of the American Electroplaters' Society*, Vol 34, 1947, p. 1361.

<sup>7</sup> The sole source of supply of the Union HSG #14-0.064 slitting saw known to the committee at this time is Union Twist Drill Co., Athol, MA.. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,<sup>1</sup> which you may attend.

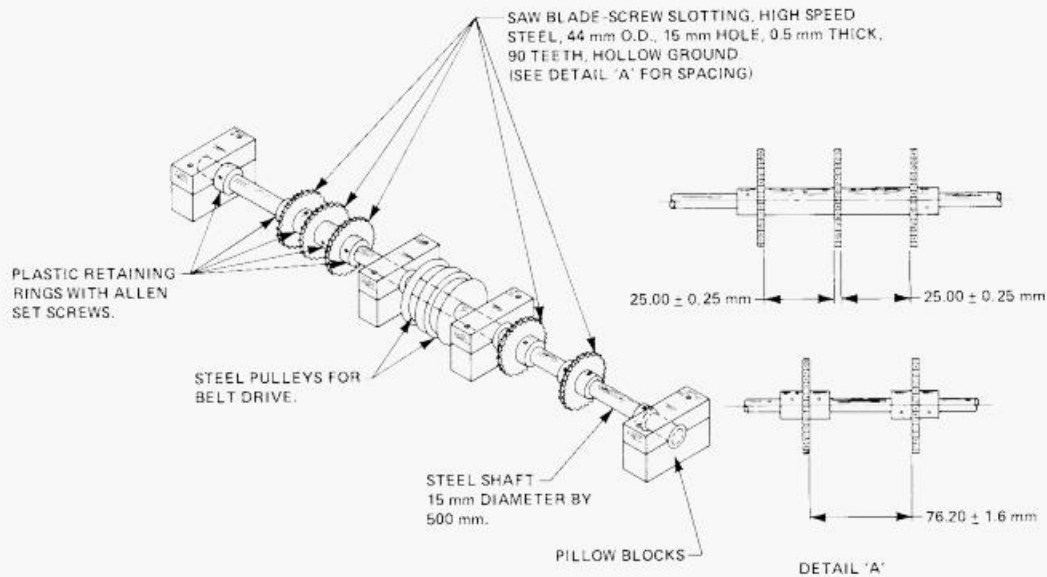


FIG. 2 Table Slitting Device

(b) Slit with a device such as shown in Fig. 2.

(c) Cut the coating with a sharp blade guided by a straightedge.<sup>5,8</sup>

9.4 Using a sharp chisel or knife, peel back an approximately 15-mm tab of one of the strips at the end adjacent to the mold gate. Fiberglass-reinforced adhesive-backed tape may be applied to the two surfaces of the tab to improve the grip on the tab between the jaws of the testing machine.

#### 9.5 Procedure A:

9.5.1 Install a holding fixture on the fixed arm of the testing machine. The fixture shall support the plaque at a right angle to the pull direction of the machine. A suitable fixture is illustrated in Fig. 3.

<sup>8</sup> The sole source of supply of the Specimen Scriber known to the committee at this time is Plateq Corp., New Haven, CT. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,<sup>1</sup> which you may attend.

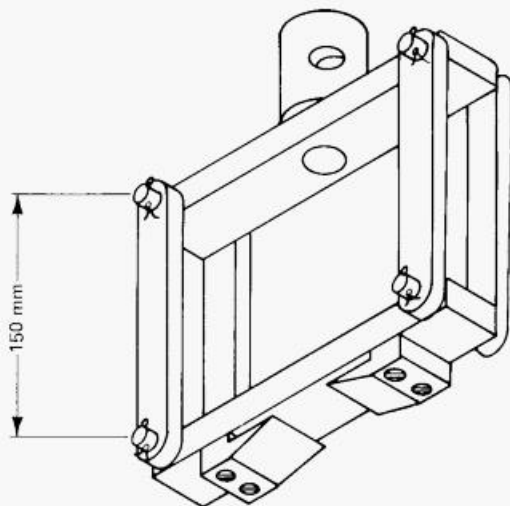


FIG. 3 Parallelogram Device for Use with the Universal Testing Machine

9.5.2 Place the plaque in the holding fixture with the tab end facing out. Locate the plaque so that the strip to be tested is centered over the centerline of the fixture.

9.5.3 Clamp the tab in the jaws of the movable crossarm of the testing machine.

9.5.4 Separate the strip from the plaque at a speed of  $25 \pm 3$  mm/min, and continuously record the force.

9.5.5 Repeat the test using the other strip on the plaque.

9.5.6 If a strip tears during separation, discontinue the test. The readings obtained up to the point of tearing may be used if at least 25 mm of the strip were separated before the tear.

#### 9.6 Procedure B:

9.6.1 Restrain the plaque in a way that permits separating the strip.

9.6.2 Attach the tab to the spring-loaded tester.

9.6.3 Separate the strip from the plaque at an angle of  $90 \pm 5^\circ$  to the plaque and at a rate of  $25 \pm 3$  mm/min.

9.6.4 During the separation the force on the indicator will rise to peak values and fall back. Record the peak values.

9.6.5 Repeat the test using the other strip on the plaque.

9.6.6 If a strip tears during separation, discontinue the test. The readings obtained up to the point of tearing may be used if at least 25 mm of the strip were peeled before the tear.

9.7 Repeat the peel test with a second plaque.

9.8 Examine the underside of the peeled strip and the bared area of the plaque and determine whether the separation occurred in the surface layers of the plaque (cohesive failure) or at the interface (adhesive failure). Plastic adhering to the underside of the strip is not always apparent to the naked eye, and therefore should be verified microscopically.

9.9 Remove any plastic from the strip by means of a suitable solvent. Acetone, for example, will remove ABS. Measure the thickness of the strip in several locations using a ball micrometer that can be read to the nearest  $1 \mu\text{m}$ . (A micrometer that reads in inches may be used if it can be read to the nearest  $0.0001 \text{ in.}$ ,  $0.0001 \text{ in.} = 2.5 \mu\text{m}$ .)





## 10. Calculation

10.1 *Peel, Procedure A*—Calculate the arithmetic mean of the highest and the lowest forces that were recorded for each strip. Calculate the arithmetic mean of the four pull tests (two strips on two plaques). If the testing machine indicates the force in units other than newtons, convert the values to newtons.

10.2 *Peel, Procedure B*—Calculate the arithmetic mean of the recorded peak values. If the tester indicates the force in units other than newtons, convert the values to newtons.

10.3 *Thickness*—Calculate the arithmetic mean thickness of each strip. Calculate the arithmetic mean thickness of the four strips (two strips on two plaques).

## 11. Report

11.1 Report the following information:

11.1.1 Identification of the plastic in the plaque by generic type, manufacturer, and by manufacturer's grade and lot designations.

11.1.2 The molding conditions used.

11.1.3 The cleaning, activating, and plating processes used.

11.1.4 The procedure (A or B) used.

11.1.5 The mean peel strength of the four tests and the highest and lowest peel values obtained. Report the values in newtons per 25-mm width. Report separately, identifying each, the results obtained with the unconditioned and the conditioned plaques.

11.1.6 The arithmetic mean coating thickness and the maximum and minimum thicknesses. Report the values in micrometres. Report separately, identifying each, the thicknesses for the unconditioned and the conditioned plaques.

11.1.7 Whether the failure was cohesive or adhesive or mixed. Report separately, identifying each, the findings for the unconditioned and the conditioned plaques.

## 12. Precision and Bias

12.1 The precision and bias of this test method have not yet been determined, but the test is useful in controlling the quality of electroplated plastics.

## 13. Keywords

13.1 electroplated plastic; peel strength test

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