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Standard Test Method for Adherence of Porcelain Enamel Coatings to Sheet Metal¹

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^{ε1} NOTE—Abstract and ratings in Figures 3 and 4 were added editorially in May 2013.

INTRODUCTION

The purpose of this test is to provide a standardized procedure to determine and rate the impact adhesion of porcelain enamels on sheet steel.

1. Scope

1.1 The scope of this test method is:

1.1.1 To determine quantitatively the amount of enamel remaining after the porcelain enamel coating specimen has been deformed;

1.1.2 To standardize the deformation parameters for testing adherence of porcelain enamel to sheet metal; and,

1.1.3 To provide a quantitative adherence rating scale for comparison to reference standards.

1.2 This adherence test method is applicable to porcelain enamel coatings on substrates from 18 to 24 gauge (0.0478 to 0.025 in. or from 1.214 to 0.654 mm).

1.3 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.

1.4 *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. Significance and Use

2.1 The measurement of adherence in porcelain enamel systems, such as ground coat, ground coat/cover coat, and direct-on cover-coat enamels, is an important procedure for monitoring process variables in metal preparation, enamel application thickness, steel selection, and enamel selection, as well as assuring the ultimate quality of the finished product.

¹ This test method is under the jurisdiction of ASTM Committee B08 on Metallic and Inorganic Coatings and is the direct responsibility of Subcommittee B08.12 on Materials for Porcelain Enamel and Ceramic-Metal Systems.

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3. Apparatus

3.1 *Drop Weight Deformation Device*², see Figs. 1 and 2.

3.2 The drop weight deformation device as shown in Fig. 1 shall impart a single impact blow from a hemispherical indenter to a coated specimen supported over a sharp-edged bottomless die. The area of the deformation and the concomitant damage to the coating is largely influenced by the size of the hemispherical indenter; the die opening size and edge sharpness; and, the energy of the blow at impact.

3.3 A satisfactory degree of deformation and damage are obtained if the conditions in 3.2 use the following parameters: 0.50 in. (12.7 mm) diameter hemispherical indenter, 0.75 in. (19.1 mm) diameter bottomless die (lower plunger guide in Fig. 1) with sharp edge, and 80 in./lb (9.03 J) energy at impact.

3.4 *Deformation Devices*, of other designs may be used provided that the parameters in 3.3 are used.

3.5 *Adherence Reference Standards*, see 7.1.

4. Test Specimens

4.1 The test specimens shall be flat enameled panels not less in size than 4 in.² (101.6 mm²). Larger sizes and shapes may be used provided that a flat surface can be held firmly against and parallel to the lower plunger guide during deformation.

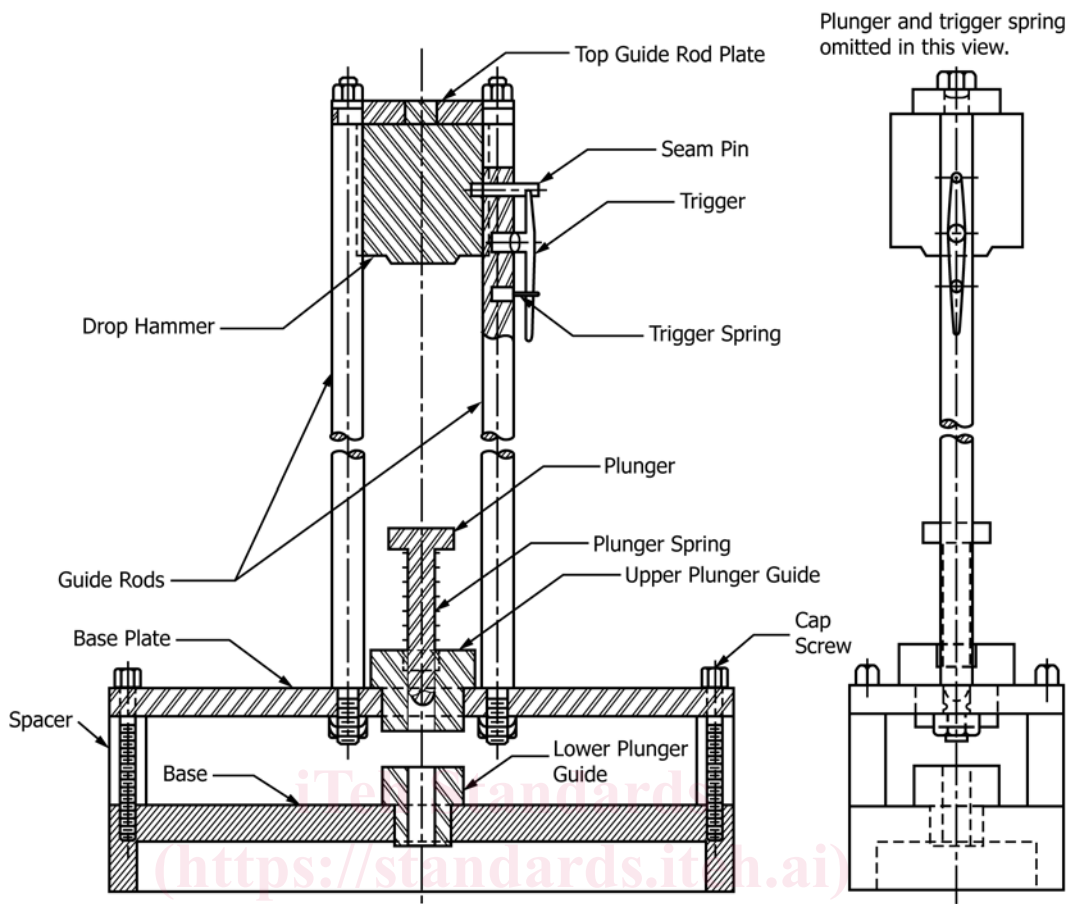
5. Safety Precautions

5.1 During the procedure in 6.1, fine enameled chips may be released with some force from the steel surface; therefore, it is recommended that personnel in the immediate vicinity of the test wear safety goggles.

6. Procedure

6.1 *Specimen Deformation*—The hammer weight of the suggested drop weight device is 5 lb (2268 g), which requires

² A drop weight device that has been found suitable is available from Pacific Scientific Co., Gardner/Neotech Instrument Div., 2431 Linden Lane, Silver Spring, MD 20910.



SECTION A-A
 FIG. 1 Drawing of Suitable Drop Weight Device

a 16 in. (406.4 mm) drop distance to yield the specified 80 in./lb (9.03 J) energy at impact. The hammer weight of the drop weight device may range from 2 to 8 lb (907 to 3629 g). If the hammer weight is within this range, but not 5 lb, calculate the drop distance to yield 80 in./lb of energy at impact. The center of the area to be deformed shall be at least 1½ in. (38.1 mm) from the edge of the specimen. If two or more deformations are made on a single specimen, place them at least 3 in. (76.2 mm) between centers and average and treat the measurements on them as a single measurement. Raise and secure the hammer to obtain the required drop distance. Hold the specimen firmly against and parallel to the top surface of the die with the enameled side up and release the hammer.

6.2 The specified drop weight device is provided with a spring to limit the indenter to a single impact blow against the specimen. If the device to be used is not designed in this way, use another means or procedure to avoid a restrike of the indenter.

6.3 A visual examination of the impact area is then made. Evaluation of the degree of adherence obtained is judged by the amount of glass retained in the impact area.

7. Rating of Adherence

7.1 Examine the impacted area and compare to the following reference standards (see Figs. 3 and 4):

- 0 = No adherence—only shiny metal showing, and enamel may be flaking off beyond the impact area.
- 1 = Poor adherence—very little glass adhering, less than 10%, and only at the outer edges of the impact area.
- 2 = Fair adherence—glass particles adhering in at least 25 to 30% of the impact area.
- 3 = Good adherence—glass particles adhering in at least 50 to 60% of the impact area.
- 4 = Very good adherence—glass particles adhering in at least 70 to 80% of the impact area.
- 5 = Excellent adherence—glass particles covering almost all of the impact area—at least 90%.

7.2 Report adherence rating, estimated to the nearest 0.5.

8. Referee Method

8.1 Since adherence depends on factors other than the enamel, that is, steel, firing, and metal preparation, in cases of disputed results, a direct comparison should be made between the test enamel known to have acceptable adherence by coating one-half of a panel with each of the enamels and comparing results as in 7.1.

9. Precision and Bias

9.1 The precision and bias of this test method is being established.

10. Keywords

10.1 adherence; porcelain enamel coatings; sheet metal