Designation: C839 – 82 (Reapproved 2020)

Standard Test Method for Compressive Stress of Porcelain Enamels by Loaded-Beam Method[1]

This standard is issued under the fixed designation C839; 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.

INTRODUCTION

Many methods and tests have been used in the industry to determine the relative compressive stress of porcelain enamel ground coats and cover coats. Three methods have been most commonly used. They are loaded-beam, warp, and split-ring methods. In the loaded-beam method the measure of stress is the load required to bring a specimen back to a plane after it has been bowed by controlled application of the enamel under test to one side of the specimen. The degree of the deflection of a specimen from a plane caused by controlled application of enamel to one side is the indicating measure of stress in the warp test. The indicating measurement in the split-ring test is the force required to just open a split ring after controlled application of test enamel to the outside surface of a ring.

1. Scope

1.1 This test method covers the measurement of the compressive stresses (Note 1) developed by fired porcelain enamels using the loaded-beam method.

NOTE 1—Although some may interpret the calculations that are used in this test method as indicating compressive load, it is commonly referred to as compressive stress within the porcelain enamel industry.

1.2 This test method is limited to the use of the loaded-beam method. However, this method includes charts (Fig. 1 and Fig. 2) that provide for conversion of loaded-beam test results to warp and ring stress values.

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

1.5 *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:*[2]

A424 Specification for Steel, Sheet, for Porcelain Enameling

3. Terminology

3.1 *Description of Term Specific to This Standard*

3.2 *compressive stress or stress*—a term used to designate the degree of compression that exists in a porcelain enamel on steel after processing.

4. Significance and Use

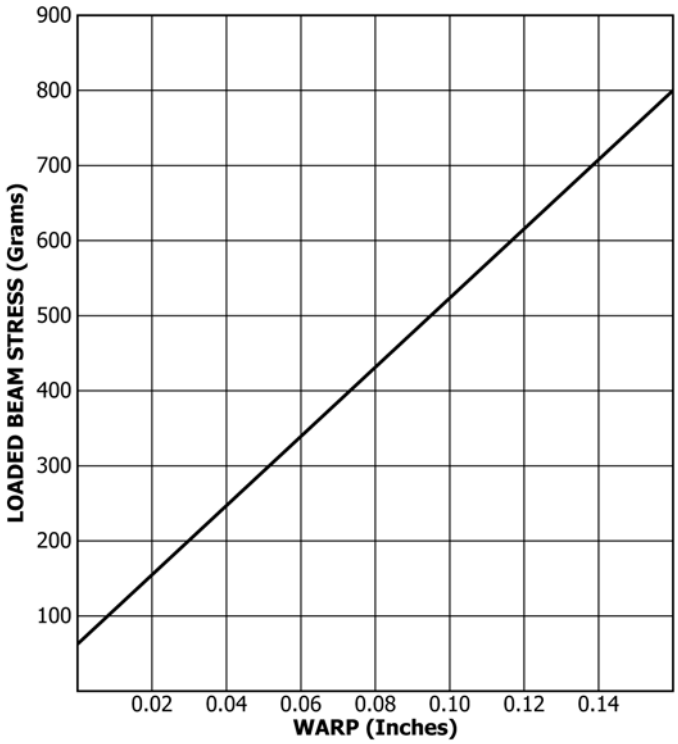
4.1 All porcelain enamel coatings or glass coatings are by necessity under some degree of compression at room temperature. The desired degree of compression or stress depends upon the type of ware and the end use of the item. Some method of determining relative compressive stress of enamels is necessary to establish the suitability of an enamel for a proposed application.

[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.

This test method was developed at the National Bureau of Standards under the sponsorship of the Porcelain Enamel Institute, Inc., and was published as PEI Technical Publication No. T-30 (1973).

Current edition approved Nov. 1, 2020. Published December 2020. Originally approved in 1976. Last previous edition approved in 2015 as C839 – 82(2015). DOI: 10.1520/C0839-82R20.

[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.



Metric Equivalents

in.	mm	in.	mm
0.02	0.51	0.10	2.54
0.04	1.02	0.12	3.05
0.06	1.52	0.14	3.56
0.08	2.03		

FIG. 1 Conversion Chart for Loaded-Beam Stress to Warp Stress

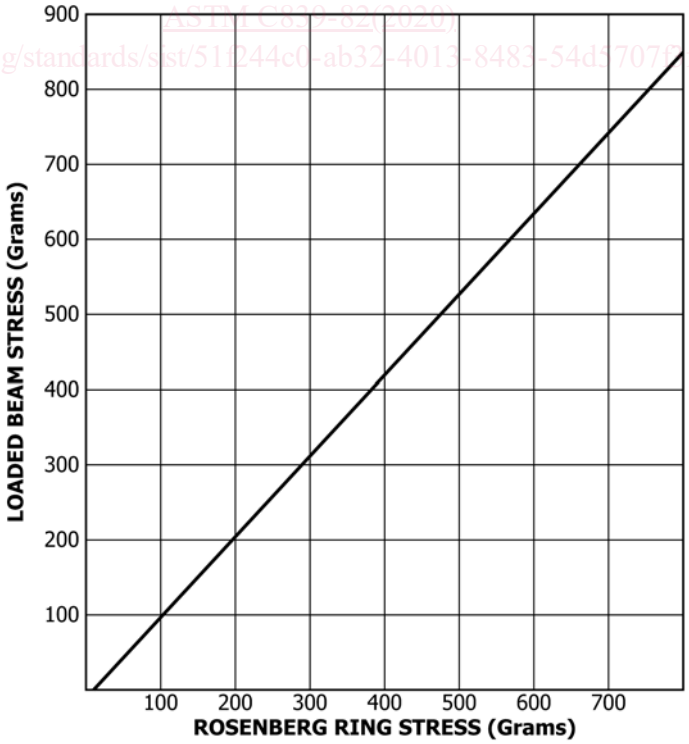


FIG. 2 Conversion Chart for Loaded-Beam Stress to Ring Stress

5. Apparatus

5.1 *Furnace,* suitable for simultaneous firing of at least six 1 by 12-in. (25 by 305-mm) specimens in vertical hanging position.

5.2 *Firing Rack,* suitable for furnace.

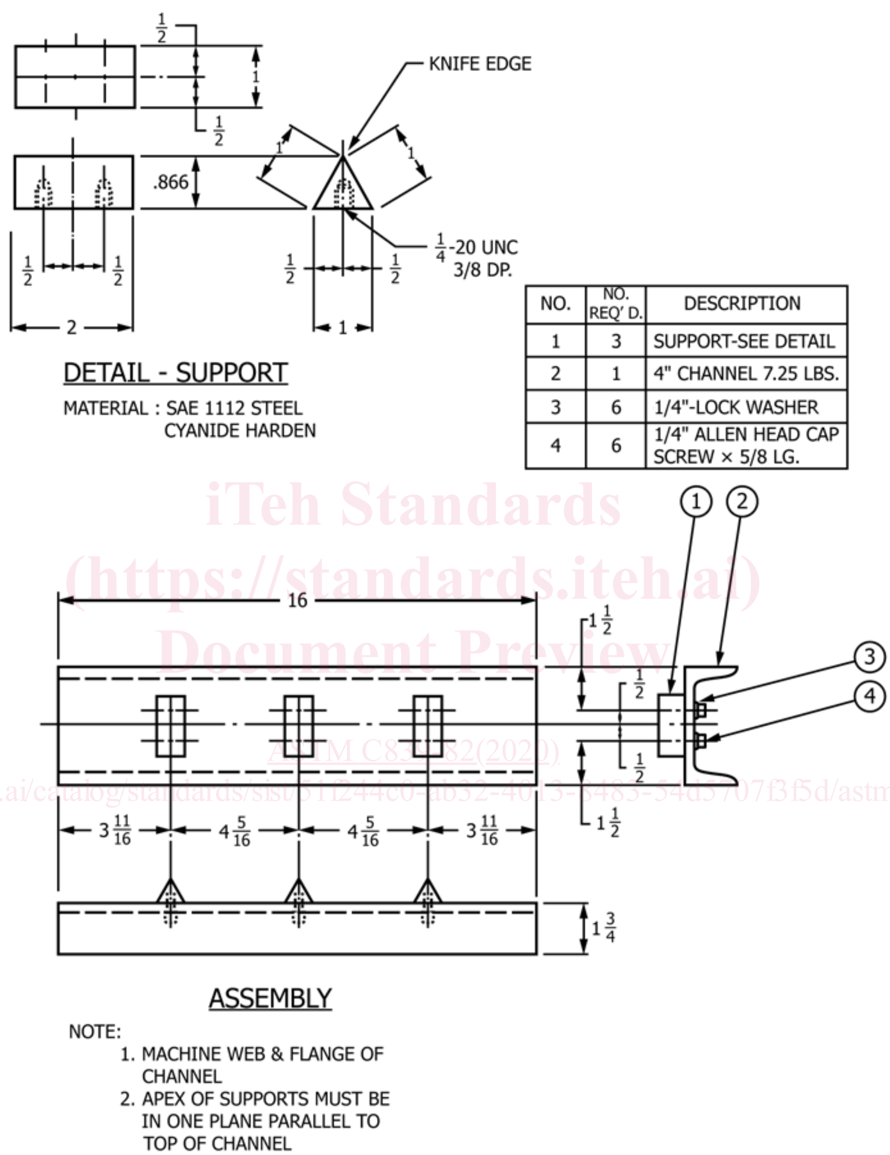
5.3 *Loaded-Beam Test Apparatus* (see Fig. 3 and Fig. 4).

5.4 *Metric Weights,* slotted, 1 to 500 g.

5.5 *Laboratory Balance,* accurate to 10 mg with necessary weights (1 to 100 g).

5.6 *Brushing Template,* 2¹⁄₁₆ by 10¹⁵⁄₁₆ in. (52 by 278 mm) (see Fig. 5 for one example of achieving the desired end result).

5.7 *Stencil Brush.*



Metric Equivalents

in.	mm	in.	mm
¼	6.35	1¾	44.45
⅜	9.53	2¹⁄₁₆	52.39
⁷⁄₁₆	11.11	3¹¹⁄₁₆	93.68
½	12.7	4	101.6
⅝	15.88	4⁵⁄₁₆	109.54
0.866	22.0	8⅝	219.08
1	25.4	10¹⁵⁄₁₆	277.81
1¼	31.75	12	304.8
1½	38.1	16	406.4
1¹¹⁄₁₆	42.86		

FIG. 3 Loaded-Beam Test Apparatus

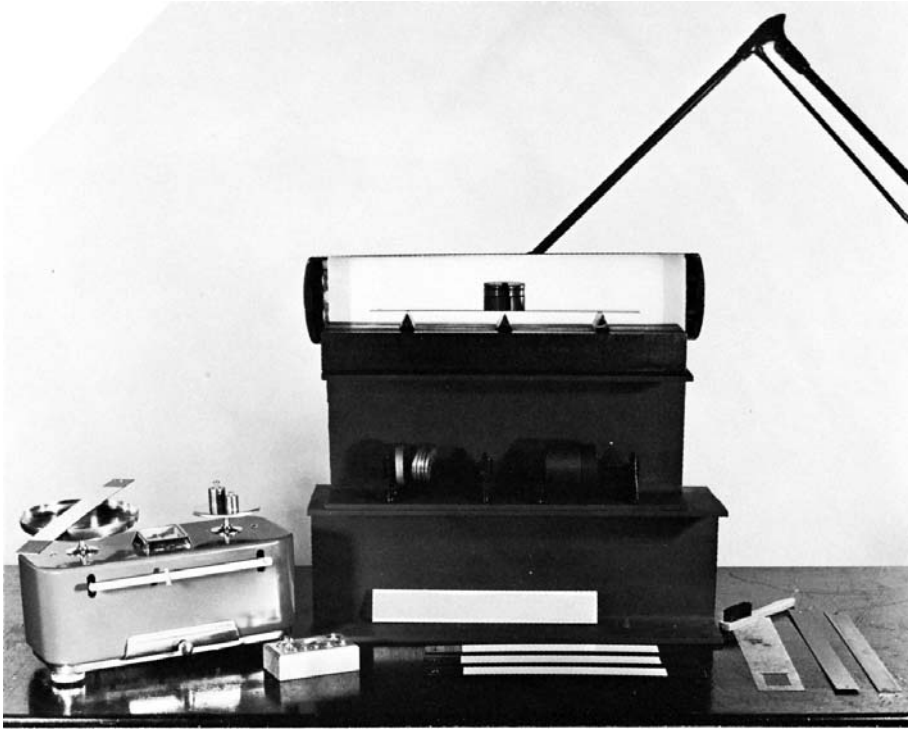
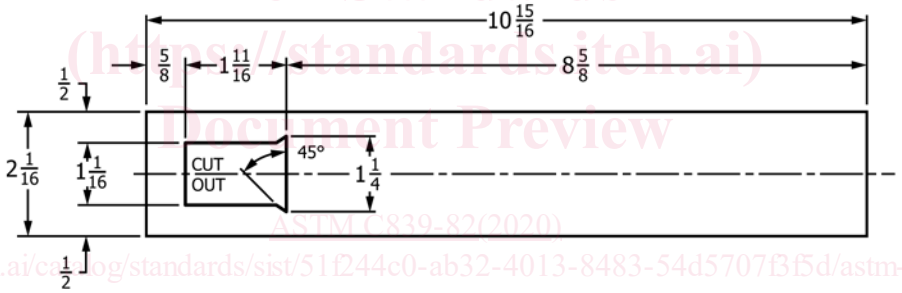


FIG. 4 Loaded-Beam Test Apparatus



NOTE 1—See Fig. 3 for metric equivalents.

FIG. 5 Brushing Template

5.8 *Fluorescent Light Fixture* with diffusion panel and adjustable support.

6. Test Specimens

6.1 Six specimens are required for each enamel tested.

6.2 Specimens 1 by 12 in. (25 by 305 mm) shall be cut by shearing from flat sheets of 20-gage Commercial Quality Type II enameling iron (see Specification A424) with thickness 0.036 ± 0.002 in. (0.91 ± 0.05 mm). The 12-in. dimension should be cut perpendicular to the direction of rolling of sheet. Care should be exercised to prevent formation of burrs during shearing. Burrs that are formed may be removed by carefully filing edges or by lightly touching edges to a sanding belt. Since opposing sides of the sheet may produce slightly different results, one side of the sheet should be scribed in such a manner that the scribe mark will appear about 1 in. from one end of the resulting strips after shearing. A ¼-in. (6.35-mm) diameter hole should be punched in one end of the specimen for hanging purposes during drying and firing. The center of the hole should be on the center line 7⁄16 in. (11 mm) from the end of the specimen. Specimens should be numbered for identification during the testing procedure. They may be permanently identified by metal stamping on the scribed side while being supported on an anvil (see Fig. 6).

7. Procedure

7.1 *Application of Ground Coat to Test Strips:*

7.1.1 Subject the specimens to a pickle procedure normal for ground coat application. Pickle in a suspended vertical position to prevent distortion.

7.1.2 Measure and record metal thickness of the test specimens.

7.1.3 Apply a medium high-temperature ground coat (1520 to 1540 °F (825 to 840 °C)) by spraying. With scribed sides up,