Designation: C 1100 – 88 (Reapproved 1998)

Standard Test Method for Ribbon Thermal Shock Testing of Refractory Materials[1]

This standard is issued under the fixed designation C 1100; 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 procedure for determining the relative resistance of fired fireclay and high alumina refractories to thermal shock conditions resulting from specified heating and cooling cycles. The equipment specified is based on test units currently in use at several industrial laboratories.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are provided for information purposes only.

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

2. Referenced Documents

2.1 *ASTM Standards:*

C 885 Test Method for Young's Modulus of Refractory Shapes by Sonic Resistance[2]

3. Significance and Use

3.1 The measurement or assessment of thermal shock damage of refractory materials is an important consideration in refractory selection for process vessels and furnaces.

3.2 This test method allows for a quantitative assessment of thermal shock damage based on either destructive or nondestructive test methods, or both.

4. Apparatus

4.1 *Burner Frame*—Sheet metal and angle iron provide support for the line burner, protective liner brick, and test samples. A cross section view of the unit is shown in Fig. 1. The unit is approximately 15 in. (0.38 m) wide, 69 in. (1.75 m) long, and 25 in. (0.64 m) high. Provision should be made to easily adjust the vertical burner-to-sample (hot face) distance, if needed. Wheels can be attached to the frame to permit easy relocation of the unit. Fig. 2 shows the material and dimension details needed for constructing the burner frame.

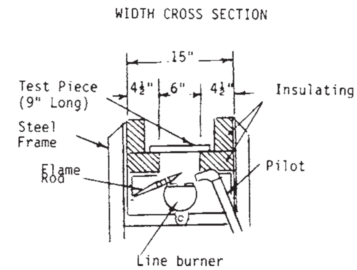

FIG. 1 Diagram Showing a Cross Section View of the Basic Components of the Ribbon Test Furnace

4.2 *Burner*—A segmented line burner (gas), with five 12 in. (0.305 m) connected sections is suggested. Burners of 300 000 to 900 000 BTU/h capacity are in use. Both center and end-fed burners are in use. Consideration should be given to the end-to-end temperature variation and control (±10°F (±5.5°C)) of whichever burner system is used. A typical burner system is shown in Fig. 3. An ignition device is needed to initiate firing for each of the heating cycles. A safety device is needed to shut off the gas in case of flame-out or other unexpected shutdown.

4.3 *Temperature Measurement*—Sample hot face temperature should be measured at the center and each end of the sample setting. The capability is needed to insert a protected (alumina (Al_2O_3) tube) thermocouple horizontally through the frame into a cut hot face slot in dummy brick positioned across the burner at each of the desired measurement sites.[3] The thermocouple bead should be positioned in the center (hottest zone) of the flame, within the groove in the dummy brick. During testing, a sharply defined flame should actually contact the hot face surface of the test brick (original face) creating a "red hot" central band approximately 2 in. (50 mm) wide. Cold face thermocouples can be used if desired, to monitor the temperature gradient. An appropriate temperature-measuring or recording device, or both, should be attached to properly monitor the test conditions.

4.4 *Gas/Air Flow System*—The basic components for gas/air flow control, with the line burner, are shown in Fig. 3. Valves are needed to turn gas on and off at specified times during the cyclic operation. A gas regulator is used to maintain

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[1] This test method is under the jurisdiction of ASTM Committee C-8 on Refractories and is the direct responsibility of Subcommittee C08.02 on Thermal Stress Resistance.

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[2] *Annual Book of ASTM Standards*, Vol 15.01.

[3] Barna, G., "Ruggedness Evaluation of the Ribbon Test," Report to ASTM Subcommittee C08.02 (based on RRC test data), March 1982.

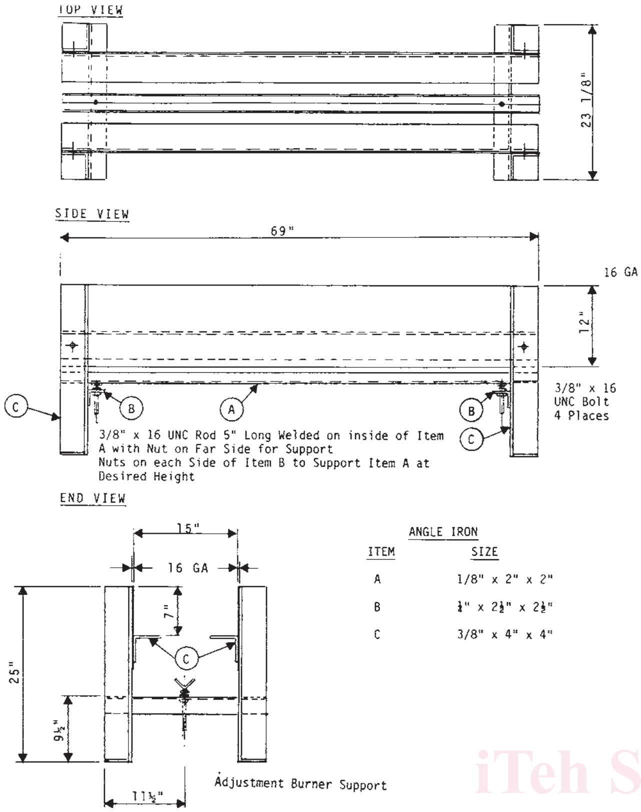

FIG. 2 Multiple (Top, Side, and End) Views Showing the Material and Dimension Details for a Ribbon Furnace Frame

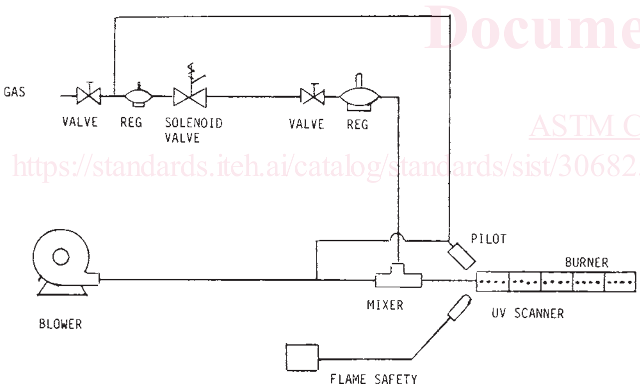

FIG. 3 Schematic of Ribbon Test Furnace Combustion Components

uniform flow. Blowers of from 75 to 150 ft^3/min (2.1 to 4.2 m^3/min) capacity are in use. The blower operates continuously during the heating and cooling cycles of the test. If desired, automated cycling operation of this test can be provided.

4.5 *Sample Evaluation Equipment*—Degradation of samples, due to thermal shock exposure can be quantified by measured property changes (before and after test). The preferred, most statistically valid evaluation procedure[3] involves measurement of modulus of elasticity, in accordance with Test Method C 885 (sonic resonance technique). An alternative procedure, described in the literature[4], using ultrasonic velocity measurements, can provide calculated modulus of elasticity values. Modulus of rupture measurements can also be used for sample evaluation, providing another quantitative means of ranking the relative thermal shock resistance of fireclay and high alumina refractories.

4.6 *Sample Preparation*—A diamond saw should be used to obtain the appropriate sample geometry.

4.7 *Dryer*—Any samples that become wet during cutting, storage, or shipment, or combination thereof, should be dried overnight at 230°F (110°C), prior to thermal shock testing.

5. Test Specimens

5.1 Five samples of each of any brand or product type should be tested to permit generation of a representative average value. The sample size is discussed in this section.

5.2 Samples of various size and orientation have been used in various laboratories. The sizes have included 9 in. (228 mm) straights, splits, soaps, quarter brick, and bars, tester either flat, or on edge in cases where the thickness and width differ. The 9 in. (228 mm) sample length is maintained in all cases, but different widths and thicknesses have been used. To properly compare the thermal shock performance of different brands or product types, the samples should all be of the same size, tested in the same orientation and after the same cycling comparison, they should be exposed together in the same test. The hot face to cold face sample thickness is very important, as it (thermal gradient) controls the amount of damage the samples will incur. A sample with greater hot face to cold face thickness will show more damage than a thinner sample, with equal hot face exposure area. Materials that are more susceptible to thermal shock damage are more significantly affected by changes in the sample thickness.[5] A single sample size cannot be specified for evaluating all products, but general guidelines are presented to permit selection of the sample configuration that is appropriate for most comparative test purposes (see Fig. 4). It should be remembered that in order to compare the relative thermal shock resistance of two or more types of refractories, the same sample size and orientation must be used. For materials of poor thermal shock resistance (60 % Al_2O_3, or less) thinner samples should be used. The suggested sample size is a quarter brick cut from a 9 in. (228 mm) by 2½ in. (64 mm) by 1½in. (38 mm) cut from a 9 in. (228 mm) straight, to be tested flat (2½ in. (64 mm) hot face width. The cutting of samples from a 9 in. (228 mm) straight is shown in Fig. 5. Two samples can be taken from each brick, one of which can be used for modulus of rupture testing.

5.3 Wherever possible, a reference or material of known performance should be included in the test.

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[4] Semler, C. E., "Nondestructive Ultrasonic Evaluation of Refractories," *Interceram*, Vol 5, pp. 485–488, 1981.

[5] Coppack, T. J., "A Method for Thermal Cycling Refractories and an Appraisal of its Effect by a Nondestructive Technique," *Journal of the British Ceramics Society*, Vol 80, No. 2, pp. 43–46, 1981.