Designation: C 1419 – 99a (2004)

Standard Test Method for
Sonic Velocity in Refractory Materials at Room Temperature and Its Use in Obtaining an Approximate Young's Modulus[1]

1. Scope

1.1 This test method describes a procedure for measuring the sonic velocity in refractory materials at room temperature. The sonic velocity can be used to obtain an approximate value for Young's modulus.

1.2 The sonic velocity may be measured through the length, thickness, and width of the specimen.

1.3 *This standard does not purport to address 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:*[2]

C 134 Test Methods for Size, Dimensional Measurements, and Bulk Density of Refractory Brick and Insulating Firebrick

C 179 Test Method for Drying and Firing Linear Change of Refractory Plastic and Ramming Mix Specimens

C 769 Test Method for Sonic Velocity in Manufactured Carbon and Graphite Materials for Use in Obtaining Young's Modulus

C 885 Test Method for Young's Modulus of Refractory Shapes by Sonic Resonance

E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E 380 Practice for Use of the International System of Units (SI) (the Modernized Metric System)

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *longitudinal sonic pulse*, *n*—a sonic pulse in which the displacements are in the direction of propagation of the pulse.

3.1.2 *pulse travel time*, *(T_t)*, *n*—the total time, measured in microseconds, required for the sonic pulse to traverse the specimen being tested, and for the associated electronic signals to traverse the circuits of the pulse propagation circuitry.

3.1.3 *zero time*, *(T_o)*, *n*—the travel time (correction factor), measured in microseconds, associated with the electronic circuits in the pulse-propagation system.

4. Summary of Test Method

4.1 The velocity of sound waves passing through the test specimen is determined by measuring the distance through the specimen and dividing by the time lapse between the transmitted pulse and the received pulse.[3,4] An approximate value for Young's modulus can be obtained as follows:

$$E = \rho v^2 \qquad (1)$$

where:
E = Young's modulus of elasticity, Pa,
ρ = density, kg/m^3, and
v = signal velocity, m/s.

4.2 Strictly speaking, the elastic constant given by this measurement is not E but C_{33}, provided the sonic pulse is longitudinal and the direction of propagation is along the axis of symmetry.[3,4]

5. Significance and Use

5.1 This test method is used to determine the sonic velocity and approximate Young's modulus of refractory shapes at room temperature. Since this test is nondestructive, specimens may be used for other tests as desired.

---

[1] This test method is under the jurisdiction of ASTM Committee C08 on Refractories and is the direct responsibility of Subcommittee C08.01 on Strength.
Current edition approved March 1, 2004. Published June 2008. Originally published as C 1419 – 99. Last previous edition C 1419 – 99a.

[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.

[3] Schreiber, Anderson, and Soga, "Elastic Constants and Their Measurement," McGraw-Hill Book Co., 1221 Avenue of the Americas, New York, NY 10020, 1973.

[4] *American Institute of Physics Handbook*, 3rd ed., McGraw-Hill Book Co., 1221 Avenue of the Americas, New York, NY 10020, 1972, pp. 3–98ff.

5.2 This test method is useful for research and development, engineering application and design, manufacturing quality and process control, and for developing purchasing specifications.

6. Apparatus

6.1 *Driving Circuit*, which consists of an ultra sonic pulse generator capable of producing pulses in a frequency range from 0.5 to 2.5 MHz.

6.2 *Transducer*, input.

6.3 *Transducer*, output.

6.4 *Oscilloscope*, dual trace with a preamplifier and time delay circuity.

6.5 See Fig. 1 for a typical set-up.

7. Test Specimen

7.1 Specimens may be prisms of any desired length with parallel smooth surfaces. Opposite surfaces across the length, width, and thickness shall be parallel. The smallest dimension shall be greater than 5 times the diameter of the largest aggregate in the refractory. The surface on which the transducers will be located must have a width of at least 1.5 times the diameter of the transducer being used.
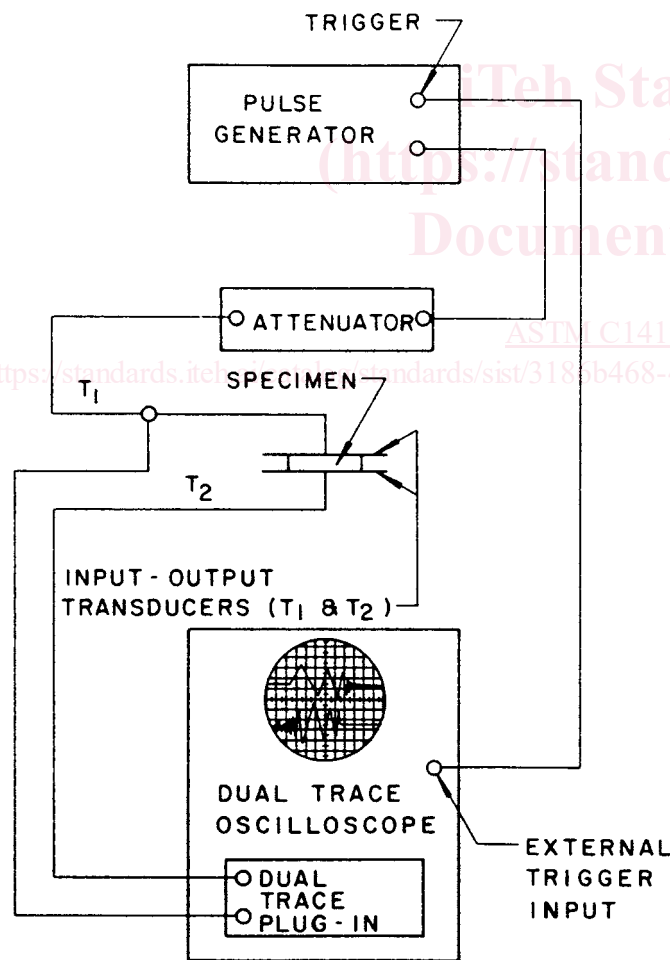

FIG. 1 Equipment Set-up

7.2 Dry the specimens in an oven at 110°C (230°F) for a minimum of 5 h. Cool to room temperature. Test for sonic velocity within 5 h of drying.

7.3 *Measurement of Density and Dimensions*—Calculate the density of the specimens by Test Methods C 134 and determine the specimen lengths by either Test Methods C 134 or C 179.

8. Procedure

8.1 Assemble and connect the apparatus as shown in Fig. 1 and refer to the equipment manufacturer's instructions for hook up precautions. If using commercially available equipment designed to measure sonic velocity, refer to the manufacturer's set-up and operating instructions.[5] Allow adequate time for the test apparatus to warm up and stabilize.

8.2 Provide a suitable coupling medium on the transducer faces.

NOTE 1—Petroleum jelly or grease couple well but may be difficult to remove for subsequent tests on the same specimen.

8.3 Position the transducers on opposite surfaces so that they provide a mirror image and that the distance between the input transducer and the output transducer is minimal and equals the dimension through which the measurement is performed.

8.4 Bring the transducer faces into intimate contact, but do not exceed the manufacturer's recommended contact pressure.

8.5 Determine T_o, the zero time (zero correction) measured in microseconds, associated with the electronic circuits in the pulse propagation instrument and coupling. Alternately, if a commercially available apparatus is used, which utilizes a zero offset and a supplied calibration standard, the instrument can be zeroed using the standard and T_o does not have to be determined or used in the final calculation.

8.6 Measure and weigh and calculate the density of the test specimen as in 7.3.

8.7 Lightly coat the faces of the test specimen that will be in contact with the transducers with the coupling medium. Place the transducers against the test specimen. Apply firm pressure until the pulse travel time stabilizes.

8.8 Determine T_t, the pulse travel time from the oscilloscope traces as illustrated in Fig. 2, or, if the instrument used has a zero correction, T_c, the corrected travel time.

9. Calculation

9.1 *Velocity of Signal*:

$$v = \frac{L}{T_t - T_o} \qquad (2)$$

or

$$v = \frac{L}{T_c} \qquad (3)$$

[5] Equipment found suitable for use is available from James Instruments Inc., 3727 N. Kedzie Avenue, Chicago, IL 60618.