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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Test Method for Young's Modulus of Refractory Shapes by Sonic Resonance¹

This standard is issued under the fixed designation C 885; 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.

^{ε1} NOTE—Editorial changes were made in Sections 10 and 11 in November 1997.

1. Scope

1.1 This test method covers a procedure for measuring the resonance frequency in the flexural (transverse) mode of vibration of rectangular refractory brick or rectangularly shaped monoliths at room temperature. Young's modulus is calculated from the resonance frequency of the shape, its mass (weight) and dimensions.

1.2 *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 134 Test Methods for Size, Dimensional Measurements, and Bulk Density of Refractory Brick and Insulating Firebrick²
- C 215 Test Method for Fundamental Transverse, Longitudinal, and Torsional Frequencies of Concrete Specimens³
- C 623 Test Method for Young's Modulus, Shear Modulus, and Poisson's Ratio for Glass and Glass-Ceramics by Resonance⁴
- C 747 Test Method for Moduli of Elasticity and Fundamental Frequencies of Carbon and Graphite Materials by Sonic Resonance²
- C 848 Test Method for Young's Modulus, Shear Modulus, and Poisson's Ratio for Ceramic Whitewares by Resonance⁴

3. Summary of Test Method

3.1 Test specimens are vibrated in flexure over a broad frequency range; mechanical excitation is provided through the use of a vibrating driver that transforms an initial electrical

signal into a mechanical vibration. A detector senses the resulting mechanical vibrations of the specimen and transforms them into an electrical signal that can be displayed on the screen of an oscilloscope to detect resonance by a Lissajous figure. The calculation of Young's modulus from the resonance frequency measured is simplified by assuming that Poisson's ratio is $\frac{1}{6}$ for all refractory materials.

4. Significance and Use

4.1 Young's modulus is a fundamental mechanical property of a material.

4.2 This test method is used to determine the dynamic modulus of elasticity of rectangular shapes. Since the test is nondestructive, specimens may be used for other tests as desired.

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

4.4 The fundamental assumption inherent in this test method is that a Poisson's ratio of $\frac{1}{6}$ is typical for heterogeneous refractory materials. The actual Poisson's ratio may differ.

5. Apparatus

5.1 A block diagram of a suggested test apparatus arrangement is shown in Fig. 1. Details of the equipment are as follows:

5.1.1 *Audio Oscillator*, having a continuously variable calibrated-frequency output from about 50 Hz to at least 10 kHz.

5.1.2 *Audio Amplifier*, having a power output sufficient to ensure that the type of driver used can excite the specimen; the output of the amplifier must be adjustable.

5.1.3 *Driver*, which may consist of a transducer or a loudspeaker from which the cone has been removed and replaced with a probe (connecting rod) oriented parallel to the direction of the vibration; suitable vibration-isolating mounts.

NOTE 1—For small specimens, an air column may preferably be used for "coupling" the loudspeaker to the specimen.

5.1.4 *Detector*, which may be a transducer or a balance-mounted monaural (crystal or magnetic) phonograph pick-up

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

³ *Annual Book of ASTM Standards*, Vol 04.02.

⁴ *Annual Book of ASTM Standards*, Vol 15.02.

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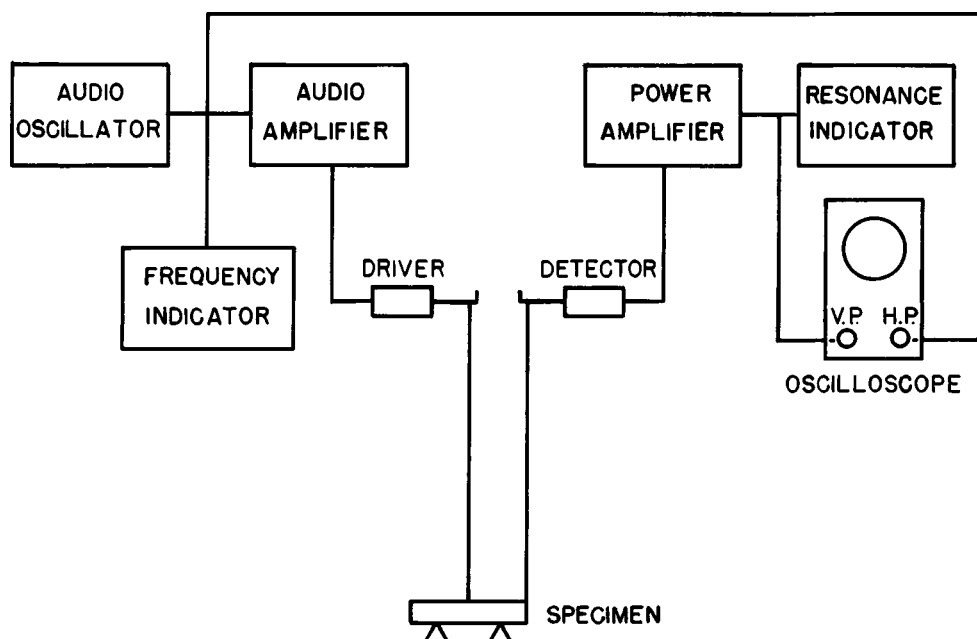


FIG. 1 Block Diagram of Apparatus

cartridge of good frequency response; the detector should be movable across the specimen; suitable vibration-isolating mounts.

5.1.5 *Pre-Scope Amplifier* in the detector circuit, impedance-matched with the detector used; the output must be adjustable.

5.1.6 *Indicating Devices*, including an oscilloscope, a resonance indicator (voltmeter or ammeter), and a frequency indicator, which may be the control dial of the audio-oscillator (accurately readable to ± 30 Hz or better) or, preferably, a frequency meter, for example, a digital frequency counter.

5.1.7 *Specimen Support*, consisting of two knife edges (can be steel, rubber-coated steel, or medium-hard rubber) of a length at least equal to the width of the specimens; the distance between the knife edges must be adjustable.

NOTE 2—The support for the knife edges may be a foam rubber pad, and should be vibration-isolated from drive and detector supports.

NOTE 3—Alternatively, knife edges can be omitted and the specimen may be placed directly on a foam rubber pad if the test material is easily excitable due to its composition and geometry.

6. Sampling and Specimen Preparation

6.1 Specimens must be rectangular prisms. They may be full straight brick or rectangular samples cut from brick shapes; rectangular straight shapes of monolithic refractories, or rectangular specimens cut from monolithic shapes. For best results, their length to thickness ratio should be at least 3 to 1. Maximum specimen size and mass are primarily determined by the test system's energy capability and by the resonance response characteristics of the material. Minimum specimen size and mass are primarily determined by adequate and optimum coupling of the driver and the detector to the specimen, and by the resonance response characteristics of the material. Measure the mass (weight) and dimensions of the dry specimens in accordance with Test Methods C 134 and record.

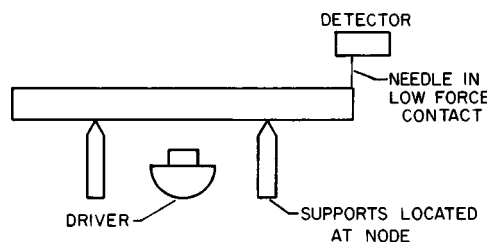


FIG. 2 Typical Specimen Positioning for Measurement of Flexural Resonance

7. Procedure

7.1 Refractories can vary markedly in their response to the driver's frequency; the geometry of the specimens also plays a significant role in their response characteristics. Variations in the following procedure are permissible as long as flexural and fundamental resonance are verified (Note 6 and Note 7). Fig. 2 and Fig. 3 illustrate a typical specimen positioning and the desired mode of vibration, respectively.

7.2 *Sample Placement*—Place the specimen “flat” (thickness dimension perpendicular to supports) on parallel knife edges at $0.224 l$ (where l is the length of the specimen) from its ends. Optionally, the specimen can be placed on a foam rubber pad.

7.3 *Driver Placement*—Place the driver preferably at the center of the top or bottom face of the specimen using moderate balanced pressure or spring action.

NOTE 4—Especially with small (thin) specimens, the lightest possible driver pressure to ensure adequate “coupling” must be used in order to achieve proper resonance response. In small specimens, exact placement of the driver at the very center of the flat specimen is important; also, an air column may be used for “coupling.”

7.4 *Detector Placement*—Place the detector preferably at one end of the specimen and at the center of either the width or thickness (considering the orientation of maximum response of the detector) using minimal pressure.