



Designation: C623 – 21

Standard Test Method for Young's Modulus, Shear Modulus, and Poisson's Ratio for Glass and Glass-Ceramics by Resonance¹

This standard is issued under the fixed designation C623; 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 determination of the elastic properties of glass and glass-ceramic materials. Specimens of these materials possess specific mechanical resonance frequencies which are defined by the elastic moduli, density, and geometry of the test specimen. Therefore the elastic properties of a material can be computed if the geometry, density, and mechanical resonance frequencies of a suitable test specimen of that material can be measured. Young's modulus is determined using the resonance frequency in the flexural mode of vibration. The shear modulus, or modulus of rigidity, is found using torsional resonance vibrations. Young's modulus and shear modulus are used to compute Poisson's ratio, the factor of lateral contraction.

1.2 All glass and glass-ceramic materials that are elastic, homogeneous, and isotropic may be tested by this test method.² The test method is not satisfactory for specimens that have cracks or voids that represent inhomogeneities in the material; neither is it satisfactory when these materials cannot be prepared in a suitable geometry. Non-glass and glass-ceramic materials should reference Test Method E1875 for non-material specific methodology to determine resonance frequencies and elastic properties by sonic resonance.

NOTE 1—Elastic here means that an application of stress within the elastic limit of that material making up the body being stressed will cause an instantaneous and uniform deformation, which will cease upon removal of the stress, with the body returning instantly to its original size and shape without an energy loss. Glass and glass-ceramic materials conform to this definition well enough that this test is meaningful.

NOTE 2—Isotropic means that the elastic properties are the same in all directions in the material. Glass is isotropic and glass-ceramics are usually so on a macroscopic scale, because of random distribution and orientation of crystallites.

¹ This test method is under the jurisdiction of ASTM Committee C14 on Glass and Glass Products and is the direct responsibility of Subcommittee C14.04 on Physical and Mechanical Properties.

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² Spinner, S. and Tefft, W. E., "A Method for Determining Mechanical Resonance Frequencies and for Calculating Elastic Moduli From These Frequencies," *Proceedings*, ASTM International, 1961, pp. 1221–1238.

1.3 A cryogenic cabinet and high-temperature furnace are described for measuring the elastic moduli as a function of temperature from –195 to 1200 °C.

1.4 Modification of the test for use in quality control is possible. A range of acceptable resonance frequencies is determined for a piece with a particular geometry and density. Any specimen with a frequency response falling outside this frequency range is rejected. The actual modulus of each piece need not be determined as long as the limits of the selected frequency range are known to include the resonance frequency that the piece must possess if its geometry and density are within specified tolerances.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.6 *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.*

1.7 *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 Reference to these documents shall be the latest issue unless otherwise specified by the authority applying this test method.

2.2 ASTM Standards:³

E1875 Test Method for Dynamic Young's Modulus, Shear Modulus, and Poisson's Ratio by Sonic Resonance

3. Summary of Test Method

3.1 This test method measures the resonance frequencies of test bars of suitable geometry by exciting them at continuously

³ 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.

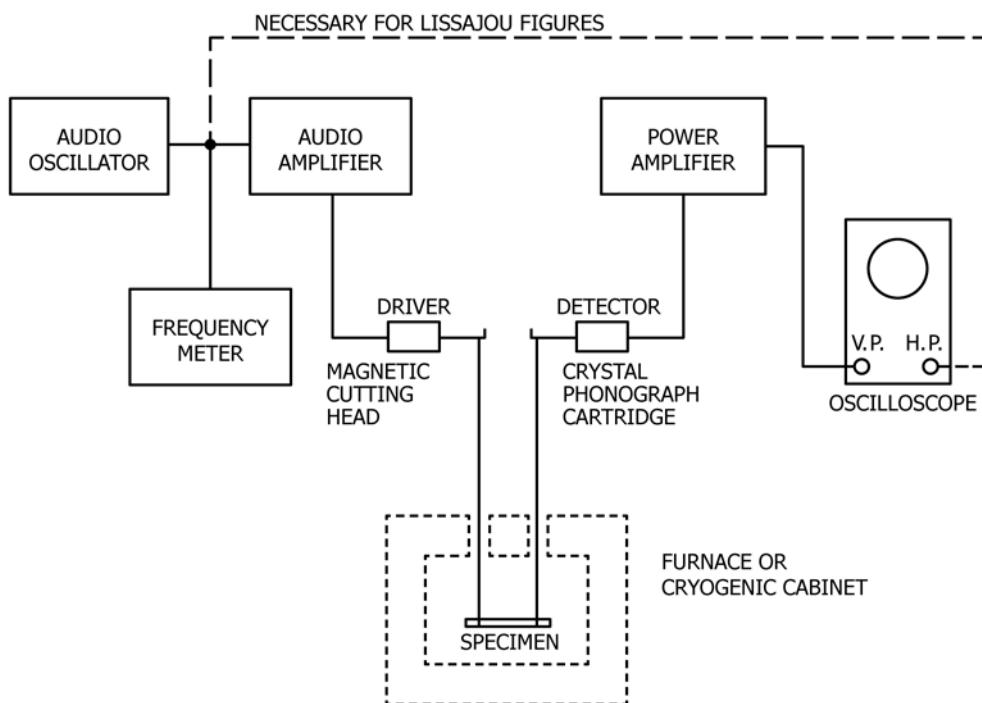


FIG. 1 Block Diagram of Apparatus

variable frequencies. Mechanical excitation of the specimen is provided through use of a transducer that transforms an initial electrical signal into a mechanical vibration. Another transducer 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. The resonance frequencies, dimensions, and mass of the specimen are used to calculate Young's modulus and the shear modulus.

4. Significance and Use

4.1 This test system has advantages in certain respects over the use of static loading systems in the measurement of glass and glass-ceramics:

4.1.1 Only minute stresses are applied to the specimen, thus minimizing the possibility of fracture.

4.1.2 The period of time during which stress is applied and removed is of the order of hundreds of microseconds, making it feasible to perform measurements at temperatures where delayed elastic and creep effects proceed on a much-shortened time scale, as in the transformation range of glass, for instance.

4.2 The test is suitable for detecting whether a material meets specifications, if cognizance is given to one important fact: glass and glass-ceramic materials are sensitive to thermal history. Therefore the thermal history of a test specimen must be known before the moduli can be considered in terms of specified values. Material specifications should include a specific thermal treatment for all test specimens.

5. Apparatus

5.1 The test apparatus is shown in Fig. 1. It consists of a variable-frequency audio oscillator, used to generate a sinusoidal voltage, and a power amplifier and suitable transducer to

convert the electrical signal to a mechanical driving vibration. A frequency meter monitors the audio oscillator output to provide an accurate frequency determination. A suitable suspension-coupling system cradles the test specimen, and another transducer acts to detect mechanical resonance in the specimen and to convert it into an electrical signal which is passed through an amplifier and displayed on the vertical plates of an oscilloscope. If a Lissajous figure is desired, the output of the oscillator is also coupled to the horizontal plates of the oscilloscope. If temperature-dependent data are desired, a suitable furnace or cryogenic chamber is used. Details of the equipment are as follows:

5.2 *Audio Oscillator*, having a continuously variable frequency output from about 100 Hz to at least 20 kHz. Frequency drift shall not exceed 1 Hz/min for any given setting.

5.3 *Audio Amplifier*, having a power output sufficient to ensure that the type of transducer used can excite any specimen the mass of which falls within a specified range.

5.4 *Transducers*—Two are required: one used as a driver may be a speaker of the tweeter type or a magnetic cutting head or other similar device, depending on the type of coupling chosen for use between the transducer and the specimen. The other transducer, used as a detector, may be a crystal or magnetic reluctance type of phonograph cartridge. A capacitive pickup may be used if desired. The frequency response of the transducer shall be as good as possible with at least a 6.5 kHz bandwidth before 3-dB power loss occurs.

5.5 *Power Amplifier*, in the detector circuit shall be impedance matched with the type of detector transducer selected and shall serve as a prescope amplifier.

5.6 *Oscilloscope*, shall be any model suitable for general laboratory work.