Designation: C522 – 03 (Reapproved 2022)

Standard Test Method for Airflow Resistance of Acoustical Materials[1]

This standard is issued under the fixed designation C522; 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 measurement of airflow resistance and the related measurements of specific airflow resistance and airflow resistivity of porous materials that can be used for the absorption and attenuation of sound. Materials cover a range from thick boards or blankets to thin mats, fabrics, papers, and screens. When the material is anisotropic, provision is made for measurements along different axes of the specimen.

1.2 This test method is designed for the measurement of values of specific airflow resistance ranging from 100 to 10 000 mks rayls (Pa·s/m) with linear airflow velocities ranging from 0.5 mm/s to 50 mm/s and pressure differences across the specimen ranging from 0.1 Pa to 250 Pa. The upper limit of this range of linear airflow velocities is a point at which the airflow through most porous materials is in partial or complete transition from laminar to turbulent flow.

1.3 A procedure for accrediting a laboratory for the purposes of this test method is given in Annex A1.

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

1.4.1 Table 1 is provided for user to convert into cgs units.

1.5 *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.*

1.6 *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]

E384 Test Method for Microindentation Hardness of Materials

C634 Terminology Relating to Building and Environmental Acoustics

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions:* The definitions used in this test method are contained in Terminology C634.

3.2 *Definitions of Terms Specific to This Standard:* The following items have been modified to exclude alternating flow.

3.2.1 *airflow resistance, R;* mks acoustic ohm (Pa·s/m ^{3})—the quotient of the air pressure difference across a specimen divided by the volume velocity of airflow through the specimen.

3.2.2 *airflow resistivity, r_0;* mks rayl/m (Pa·s/m^2)— *of a homogeneous material*, the quotient of its specific airflow resistance divided by its thickness.

3.2.3 *lateral airflow resistivity— of an anisotropic homogeneous material*, the airflow resistivity when the direction of airflow is parallel to the face of the material from which the test specimen is taken.

3.2.4 *specific airflow resistance, r;* mks rayl (Pa·s/m)—the product of the airflow resistance of a specimen and its area. This is equivalent to the air pressure difference across the specimen divided by the linear velocity of airflow measured outside the specimen.

3.2.5 *transverse airflow resistivity— of an anisotropic homogeneous material*, the airflow resistivity when the direction of airflow is perpendicular to the face of the material from which the test specimen is taken.

3.3 *Application of Terms*:

3.3.1 The term *airflow resistance* can be applied to specimens of any kind.

[1] This test method is under the jurisdiction of ASTM Committee E33 on Building and Environmental Acoustics and is the direct responsibility of Subcommittee E33.01 on Sound Absorption.

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[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.

TABLE 1 Conversion from cgs to mks and SI units

To convert from	to	Multiply by
cgs acoustic ohm	mks acoustic ohm (Pa·s/m^3)	10^5
cgs rayl	mks rayl (Pa·s/m)	10
cgs rayl/cm	mks rayl/m (Pa·s/m^2)	10^3
cgs rayl/in.	mks rayl/m (Pa·s/m^2)	394
mks rayl/in.	mks rayl/m (Pa·s/m^2)	39.4

3.3.2 The term *specific airflow resistance* has meaning only when applied to a specimen of uniform thickness that is homogeneous in directions parallel to its surface but not necessarily homogeneous in the direction of airflow perpendicular to its surface.

3.3.3 The term *airflow resistivity* has meaning only when applied to a specimen that is homogeneous in directions parallel to a and perpendicular to its surface but not necessarily isotropic.

3.4 *Symbols:*

3.4.1 P = air pressure difference across test specimen, Pa.

3.4.2 U = volume velocity of airflow through the specimen, m^3/s.

3.4.3 $u = U/S$ = linear velocity of airflow outside the specimen, m/s.

3.4.4 S = area of specimen, m.^{2}

3.4.5 T = thickness of specimen, m.

4. Summary of Test Method

4.1 This test method describes how to measure a steady flow of air through a test specimen, how to measure the air pressure difference across the specimen, and how to measure the volume velocity of airflow through the specimen. From the measurements may be calculated the airflow resistance, R, the specific airflow resistance, r, and the airflow resistivity, r_0.

5. Significance and Use

5.1 The specific airflow resistance of an acoustical material is one of the properties that determine its sound-absorptive and sound-transmitting properties. Measurement of specific airflow resistance is useful during product development, for quality control during manufacture, and for specification purposes.

5.2 Valid measurements are made only in the region of laminar airflow where, aside from random measurement errors, the airflow resistance ($R = P/U$) is constant. When the airflow is turbulent, the apparent airflow resistance increases with an increase of volume velocity and the term "airflow resistance" does not apply.

5.3 The specific airflow resistance measured by this test method may differ from the specific resistance measured by the impedance tube method in Test Method E384 for two reasons. In the presence of sound, the particle velocity inside a porous material is alternating while in this test method, the velocity is constant and in one direction only. Also, the particle velocity inside a porous material is not the same as the linear velocity measured outside the specimen.

6. Apparatus

6.1 The apparatus, assembled as shown schematically in Fig. 1, consists of the following components:

6.1.1 *Air Supply,* a suction generator or positive air supply arranged to draw or force air at a uniform rate through the test specimen.

NOTE 1—It may be necessary to use a large surge tank or other means to reduce pressure fluctuations.

6.1.2 *Flowmeter,* to measure the volume velocity of airflow through the specimen. It is preferable to have two or more flowmeters with overlapping ranges to enable different airflow velocities to be measured to the same precision.

6.1.3 *Differential Pressure Measuring Device,* for measuring the static pressure difference between the faces of the specimen with respect to atmosphere.

NOTE 2—A slant manometer or pressure transducer system with a range from 0 Pa to 250 Pa is usually satisfactory, but a second instrument with a smaller range, for example, 0 Pa to 25 Pa, may be necessary for measuring small pressures to the desired precision.

6.1.4 *Specimen-Mounting Assembly,* consists essentially of a mounting plate and a specimen holder as shown in Fig. 2. The mounting plate has two holes for tube connections to the pressure measuring device and to the airflow supply. The specimen holder, which is sealed to the mounting plate, is preferably a transparent plastic tube at least 150 mm long with a diameter not less than 50 mm. For testing materials that will support themselves, such as disks cut from boards, a slight taper at the top of holder will enable the specimen to be pressed into position with a tight fit. For testing materials that will not support themselves, a removable screen held in position at least 25 mm above the mounting plate may be used alone or with a plunger assembly that can compress the specimen to a known thickness. For testing thin materials, such as fabrics or papers, a flange at the top of the holder, together with a clamping ring, will enable the specimen to be held securely for testing. Specimens larger than the area of the holder can be tested with suitable fittings attached to the end of the holder. In such cases, care must be taken to ensure that the airflow through the edges of the specimen is negligible in comparison to that through the face.

NOTE 3—If measurements are made concurrently by the impedance tube method, Test Method E384, the two instruments may conveniently have the same inside diameter.

7. Sampling

7.1 Three or more specimens of a uniform sample material should be tested. When the sample is not uniform the specimens should be selected to include the variations in the proper proportion, or several representative specimens of the materials should be tested and the results averaged.

8. Test Specimens

8.1 *Boards*—Relatively hard, firm materials at least 5 mm thick. For transverse airflow resistance, disks are cut or sawed from the sample with diameter to fit tightly into the specimen holder. Coating the edges of the disks with grease may be necessary to form an airtight seal between the specimen and the holder wall. For lateral airflow resistance, several boards are laminated together and a new board cut with faces at right angles to the original faces of the boards. Disks cut from the laminated board are tested in the usual manner.

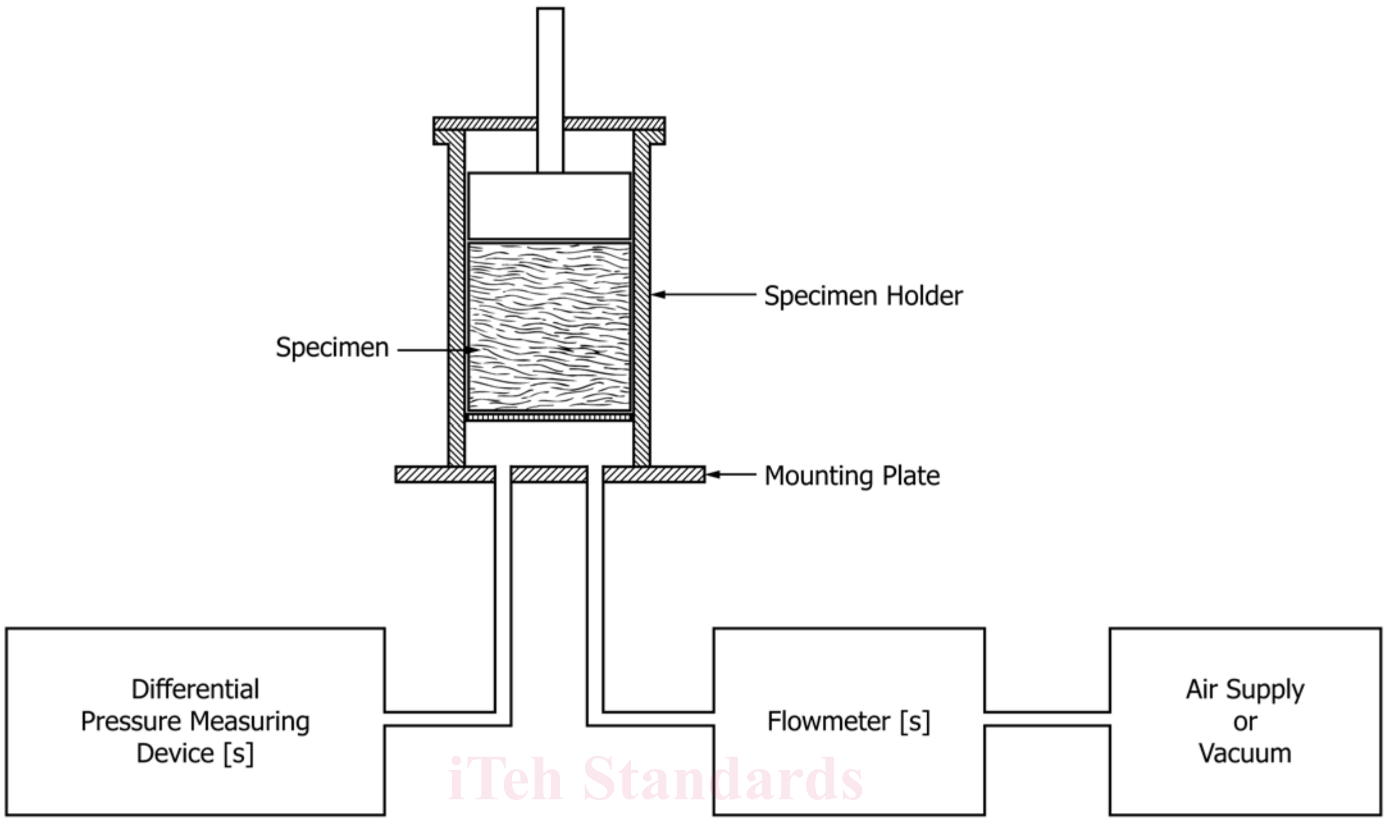

FIG. 1 Schematic Diagram of Airflow Apparatus

8.2 *Blankets*—Relatively soft, flexible materials at least 5 mm thick. Disks cut from the sample are laid on the removable screen. If desired, the plunger assembly may be used to compress the blanket to the desired thickness. Care must be taken to prevent leakage around the edge of the specimen. A transparent holder helps in spotting leaks.

8.3 *Sheets*—Materials less than 5 mm thick. Disks with diameter a little less than the outer diameter of the flange at the top of the specimen holder are held in place with the clamping ring with grease on the flange to limit the porous part of the specimen to the inside diameter of the holder. Grease is also used to prevent flow of air into the edges of the specimen. Sheet materials with very low specific airflow resistance may be tested by stacking layers of specimens separated with air spaces to obtain a measurable pressure drop. The average result for a single layer should be reported.

9. Procedure

9.1 Mount the test specimen according to the type of test to be made. Seal the specimen holder to the mounting plate and adjust the airflow to give readable settings on the flowmeter and pressure measuring device. Start at an airflow velocity well below 50 mm/s. Record the differential pressure, P, the flow rate, U, and the calculated quotient, $R = P/U$.

9.2 Repeat the measurements several times, using a larger airflow rate each time. If the apparent resistance increases in a steady way, the airflow is probably turbulent and the readings must be discarded. Make a series of at least three measurements at well separated airflow velocities (25 % recommended minimum differential) below the turbulent level.

9.3 Measurements should be made where possible within a temperature range of 22 °C ± 5 °C. No adjustment to the calculated results shall be made for barometric pressure.

10. Calculation

10.1 Calculated the airflow resistance in mks acoustic ohms (Pa·s/m^3) from the expression:

$$R = P/U \quad (1)$$

where P/U is the average value of ten or more readings made in the region of laminar airflow.

10.2 Calculate the specific airflow resistance in mks rayls (Pa·s/m) from the expression:

$$r = SP/U \quad (2)$$

10.3 Calculate the airflow resistivity in mks rayls/m (Pa·s/m^2) from the expression:

$$r_0 = SP/TU \quad (3)$$

10.4 See Table 1 to convert from cgs to mks and SI units.

11. Report

11.1 Report the following information:

11.1.1 Complete identification and description of the material,

11.1.2 Type of test and mounting,

11.1.3 Description and dimensions of test specimen,

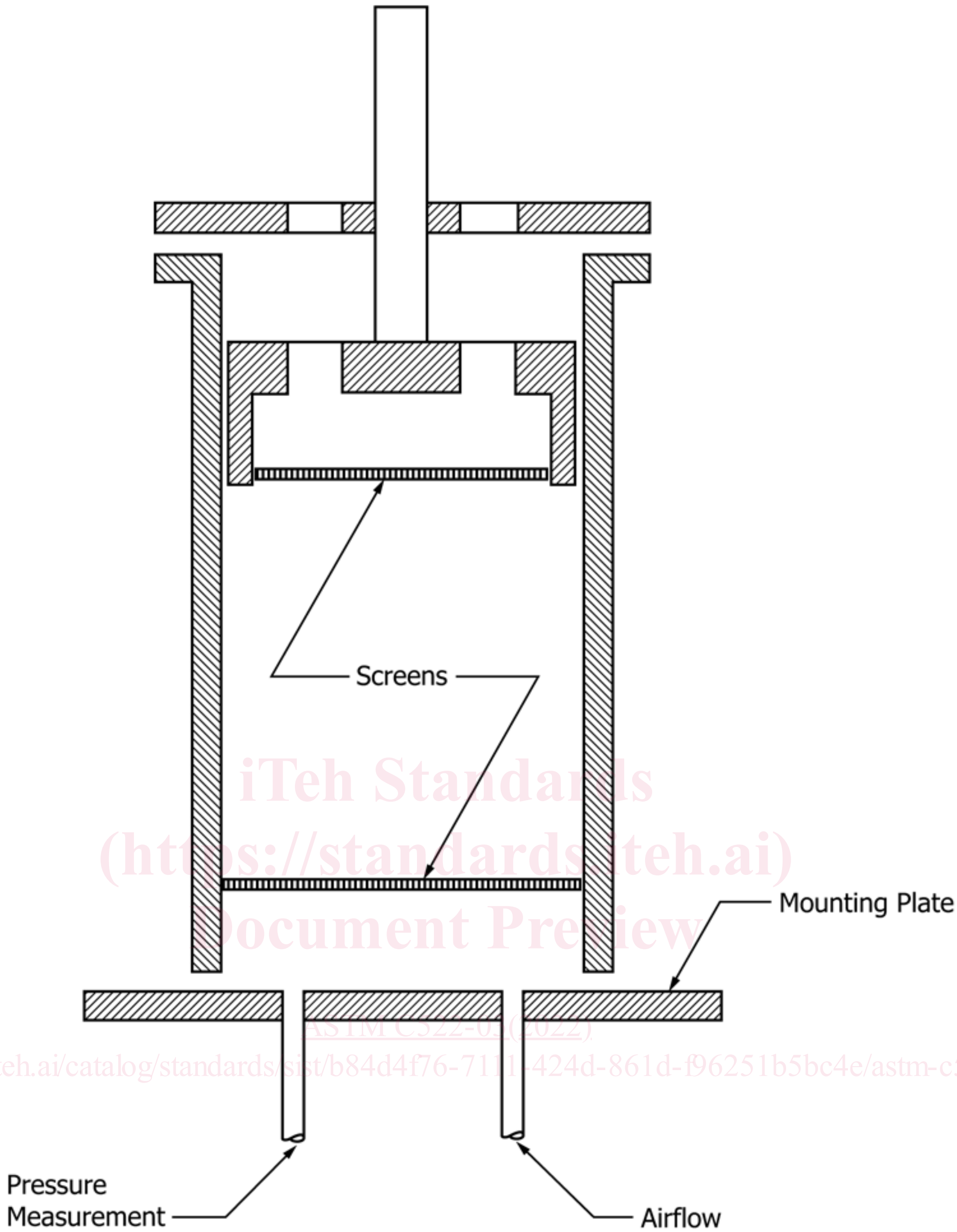

FIG. 2 Specimen Holder

11.1.4 Conditioning procedure used, if any,

11.1.5 Number of specimens tested,

11.1.6 Individual and average values of test results, in mks units, and

11.1.7 Temperature, barometric pressure, and relative humidity.

11.2 If a test is made intentionally in the transitional or turbulent airflow region, the reason should be given, and the linear airflow velocities at which the measurements are made shall be stated.

12. Precision and Bias

12.1 No quantitative statement on bias can be made at this time since there is presently no material available with known true values of performance, which can be used for determining the bias of this test method.

12.2 The within- and between-laboratory precision of this test method, expressed in terms of the within-laboratory, 95 % Repeatability Interval, *I(r)*, and the between-laboratory, 95 %, Reproducibility Interval, *I(R)*, is listed in Table 2. These statistics are based on the results of a round-robin test program involving seven laboratories.

12.3 The significance of the Repeatability and Reproducibility Intervals is as follows:

12.3.1 *Repeatability Interval, I(r)*—In the same laboratory on the same material, the absolute value of the difference in two test results will be expected to exceed *I(r)* only about 5 % of the time.