



Standard Test Methods for Strength Properties of Prefabricated Architectural Acoustical Tile or Lay-In Ceiling Panels¹

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INTRODUCTION

Materials used for absorbing sound generally have a porous, low-density structure. In comparison with many building materials they may be relatively fragile. Materials are available that possess adequate strength and stability and at the same time provide good sound absorption. The test methods described here cover procedures for evaluating those physical properties related to strength. The methods are of use in developing, manufacturing, and selecting acoustical tile or lay-in panels.

It should be kept in mind that a property related to strength is only one of several considerations important in judging the usefulness of an acoustical material. For example, a material judged to be quite weak by one of these tests may still be desired for other reasons, and with adequate precautions, may be shipped and installed successfully.

1. Scope

1.1 These test methods cover the determination of the strength properties of prefabricated architectural acoustical tile or lay-in ceiling panels as follows:

Tests	Sections
Hardness	4 to 9
Friability	10 to 16
Sag	17 to 23
Transverse strength	24 to 30

1.2 Not all of the tests described in these test methods may be necessary to evaluate any particular product for a specific use. In each instance, it will be necessary to determine which properties are required.

1.3 These test methods specify procedures that may be used in product development, manufacturing control, specification acceptance, and service evaluation.

1.4 Properties determined by these test methods reflect the performance of the materials under the specific conditions of the test, and do not necessarily indicate performance under conditions other than those specified herein.

1.5 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each

system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards*²

C634 Terminology Relating to Building and Environmental Acoustics

3. Terminology

3.1 Terms defined in Terminology **C634**.

3.1.1 *acoustical material*

3.1.2 *sound absorption*

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *fissures*—irregular depressions of varying lengths widths, and depths extending below the basic product face.

3.2.2 *friable*—easily crumbled.

3.2.3 *sag*—deviation of the acoustical tile or panel at its geometric center from the plane formed by the edges.

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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.



HARDNESS

4. Significance and Use

4.1 Knowledge of hardness is useful in the development and the quality control of acoustical tile and lay-in ceiling panels. Deviation from an established hardness range will assist in pointing out processing errors or defective raw materials, thereby aiding the maintenance of uniform product quality.

4.2 This property is also useful in comparing the relative abilities of materials to resist indentations on the panel surface caused by impacts.

4.3 Since the hardness varies with the thickness, only samples of the same thickness may be directly compared.

5. Apparatus

5.1 *Testing Machine*—Any standard mechanical or hydraulic testing machine capable of applying and measuring the required load within an accuracy of $\pm 1\%$ may be used. It shall be equipped with a 2.00 in. [50.8 mm] diameter metal ball, or hemispherically shaped penetrator that bears upon the specimen surface.

6. Test Specimens

6.1 Cut five 4 by 4 in. [100 by 100 mm] specimens from a single tile or panel. Cut the five specimens from representative areas of the tile or ceiling panel.

7. Conditioning

7.1 The strength properties of acoustical materials often depend on the moisture content at the time of the test. Therefore, condition materials for test under “room conditions” to constant weight (within $\pm 1\%$) in an atmosphere maintained at a relative humidity of $50 \pm 2\%$, and a temperature of $73 \pm 2^\circ\text{F}$ [$23 \pm 1^\circ\text{C}$]. State in the test report any departure from this recommended condition.

8. Procedure

8.1 Place the specimen in the conditioning chamber and let it remain until equilibrium is obtained.

8.2 Place the specimen on a flat surface under the loading penetrator of the test machine. Force the penetrator into the specimen 0.25 ± 0.01 in. [6.5 ± 0.3 mm] below the original surface (Note 1) at a rate of 0.10 in./min [2.5 mm/min] (Note 2).

NOTE 1—The original surface is defined as the point where the penetrator first contacts the specimen.

NOTE 2—When possible, the penetrator should bear between perforations or fissures when testing perforated or fissured material.

8.3 Record the load shown on the testing machine when the penetrator reaches the specified depression as the hardness of the specimen in newtons or pounds-force [newtons].

9. Report

9.1 The report shall include the following:

9.1.1 Identification of the test material,

9.1.2 Method of conditioning including time of conditioning, temperature, $^\circ\text{F}$ or $^\circ\text{C}$, and relative humidity, %,

9.1.3 Statement describing whether the finished or unfinished surface was tested and whether the face or the back of the specimen was tested,

9.1.4 Average thickness for the five specimens, in. or [mm],

9.1.5 Individual thicknesses for each of the five specimens, in. or [mm],

9.1.6 Average hardness for the five specimens, lbf or [N], and

9.1.7 Individual hardness for each of the five specimens, lbf or [N].

FRIABILITY

10. Significance and Use

10.1 The friability test measures the susceptibility of an acoustical product to edge and corner damage that might be sustained during shipping, handling, and installing. Products that are friable and soft may erode considerably when subjected to rough treatment.

11. Apparatus

11.1 *Balance*, accurate to within 0.5 % of the weight of the smallest specimen tested.

11.2 *Testing Container*, consisting of an oak box with inside dimensions of $7\frac{3}{4}$ in. [200 mm] square by $7\frac{1}{2}$ in. [190 mm] deep and fitted with a cover on one end for inserting and removing the specimens. The box shall be mounted so that it may be rotated at 60 ± 2 r/min on a horizontal axis that is perpendicular to its square dimension.

11.3 *Red or White Oak Cubes*, 24, $\frac{3}{4} \pm \frac{1}{32}$ in. [19 ± 1 mm] on an edge, having a specific gravity of 0.65 ± 0.02 .

NOTE 3—Number each group of wood cubes 1 to 24. At the end of every 600-revolution test period, remove one “used” cube (follow the number sequence and remove and discard the oldest cube) and replace with a corresponding numbered “new” cube. In this manner, cube wear is eliminated as an uncontrolled variable in the test method. When the corners of the wood cubes have been worn so that the radius of curvature is greater than $\frac{1}{16}$ in. [1.5 mm] or the cubes have become altered so as not to be comparable with new cubes, they shall be discarded and new ones used. A conventional machinist’s radius gage may be used for checking the cube edge wear.

11.4 *Timer*, consisting of a watch or clock capable of measuring intervals of 10 min within ± 5.0 s.

12. Test Specimens

12.1 Cut twelve 1 by 1 in. [25 by 25 mm] square specimens from a single tile or panel. The specimen thickness is equal to the tile or panel thickness.

NOTE 4—If the friability of original edges is of importance, separate tests should be run on 1 by 1 in. [25 by 25 mm] specimens having one or two original edges.

13. Conditioning

13.1 Maintain standard conditions as described in 7.1 during preparation and testing of specimens.

14. Procedure

14.1 Weigh the twelve specimens and record the combined weight to the nearest 0.1 g.

14.2 Place the 12 specimens and the 24 oak cubes in the testing container. Close the top of the testing container and rotate the container about its axis at a speed of 60 rpm for two 10 min periods. At the end of each 10 min period, remove the specimens from the box and determine the percentage of mass loss, due to pulverization and breakage. In the case of badly abraded specimens, remove up to twelve of the largest pieces remaining and weigh these for the determination. In rare cases, no pieces may remain from an individual specimen. In this case, the weight loss shall be reported as 100 %.

15. Calculation

15.1 Calculate the percent mass loss for the 10 min and 20 min periods to two significant figures using Eq 1

$$\text{mass loss, \%} = [(M_1 - M_2)/M_1] \cdot 100 \quad (1)$$

M_1 = original mass, g, and

M_2 = mass after 10 min period and mass after 20 min period.

16. Report

16.1 The report shall include the following:

16.1.1 Identification of the test material,

16.1.2 Method of conditioning including time of conditioning, temperature, °F or [°C], and relative humidity, %, and

16.1.3 Percentage mass loss for the 10 and 20 min periods.

SAG

17. Significance and Use

17.1 This test method is for the purpose of determining the sag properties of ceiling tile or panels under various conditions of humidity exposure. Tiles or panels of various sizes can be tested by using appropriately sized supporting frames.

17.2 The test method will provide both the initial reading in reference to the plane of the edge support system and the total humidity-induced sag.

17.3 This test method is not designed to establish the expected performance of the ceiling panels under field conditions of use, but only the sag properties for the specific temperature, humidity, exposure time, and mounting conditions used in the test.

18. Apparatus

18.1 *Controlled-Atmosphere Chamber (Environmental Chamber)*, capable of operating at a dry-bulb temperature of 73 to 90 ± 3°F [23.0 to 32.0 ± 1.5°C], and relative humidities of 50, 60, 70, 80, or 90 ± 2 %. The chamber should be equipped with suitable recording equipment to record wet- and dry-bulb temperatures (or dry bulb and relative humidity). This equipment shall be checked periodically and calibrated with a psychrometer that shall also be used to establish the test conditions.

18.2 *Sample Test Frames and Racks*, fabricated from non-ferrous metal, such as aluminum, and of suitable linear dimensions as shown in Fig. 1. Frames shall be constructed of ¼ by 1½ in. [6 by 38 by 38-mm] angle with miter-cut corners.

Inside surfaces of corners shall be welded and ground smooth. Frames shall be fabricated so they are level and square. Overall inside dimensions of the frames shall be such that the panels do not touch the vertical edges of the frame if they expand under prolonged exposure to conditions of high humidity.

18.2.1 Racks may be constructed of a convenient design to hold one or more test frames in a horizontal plane; however, a sufficient distance shall be maintained between frames to permit adequate circulation of the test atmosphere and permit test measurements without moving panels.

18.3 *Zero-Plane Plate*—In the event that measurements are made using the zero-plane plate, means of zeroing the dial indicator (Note 5), a zero-plane plate fabricated of ¼ in. [6-mm] thick by 3 in. [80 mm] wide steel or aluminum stock, shall be provided. The length of the plate shall be ¼ in. [6 mm] less than the inside width of the test frame.

NOTE 5—In the case of panels with a width of 24 in. [610 mm] or less, an alternative means of zeroing the sag bar dial indicator may be used. This consists of placing a zero-plane plate in the test specimen frame parallel with the shortest member of the frame, and centered in the longest member of the frame. The sag bar is then placed beneath the frame and the dial gage is adjusted to read zero at the plane of the specimen surface.

18.4 *Sag Bar*, equipped with a dial or digital gage indicator having a minimum movement of 1 in. [25 mm] calibrated in increments of 0.001 in. [0.025 mm] or less. The indicator shall be equipped with a 0.50 in. [13 mm] diameter pressure foot. The bar shall be equipped with individually adjustable feet having ¾ in. [20 mm] diameter bearing surfaces. The distance between centers of the bearing surfaces shall be equal to the nominal width of the test panel or tile. Fig. 2 shows a suitable sag bar design including spacing between bearing surfaces.

19. Test Specimens

19.1 Test specimens shall be full-size tile or panels as shipped for installation in the field.

20. Conditioning

20.1 Condition specimens as described in 7.1 prior to placing in the controlled atmosphere chamber for sag testing.

21. Procedure

21.1 Adjust the chamber controls to provide one of the temperature and humidity conditions selected from those listed in 18.1.

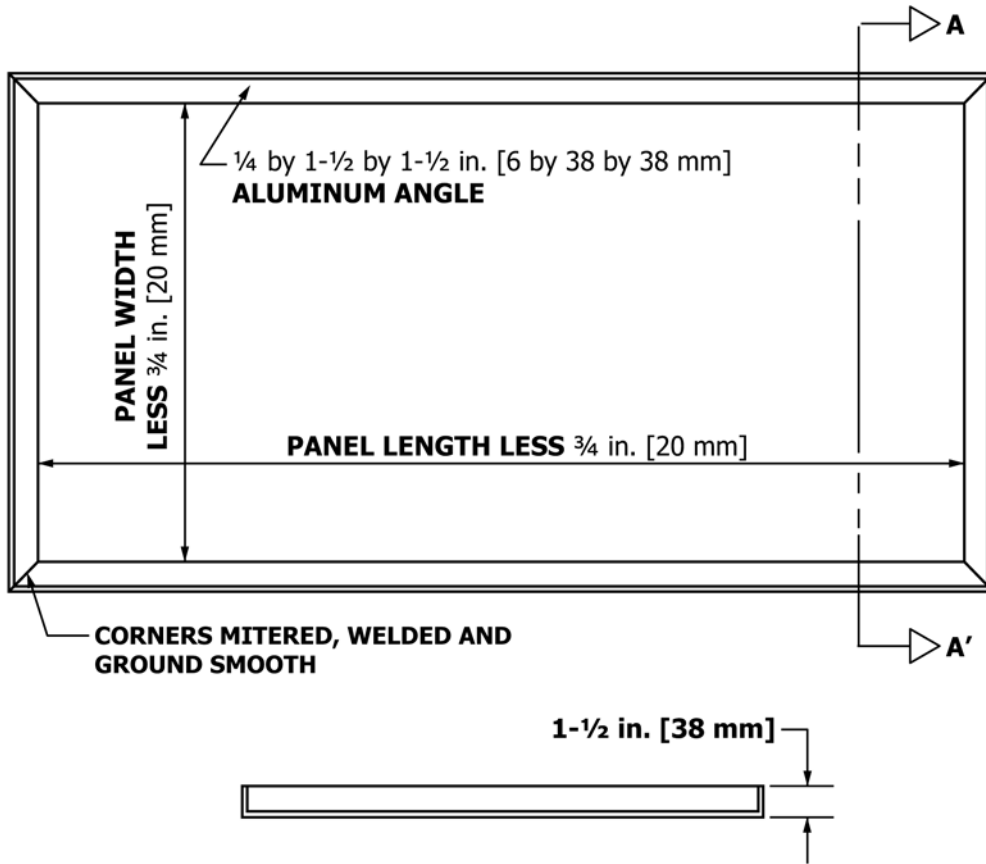
21.2 Place the sag bar on a flat surface, such as a rigid aluminum bar of a length appropriate to the size of the sag bar (Note 5).

21.3 Adjust the gage indicator to read the thickness of the test frame angle. This will provide an indication of 0 in. [0 mm] when the indicator foot is in the plane of the test panel supporting surface.

21.4 Mark the geometric center of the tile or panel on the finished surface at the intersection of diagonals drawn from corner to corner.

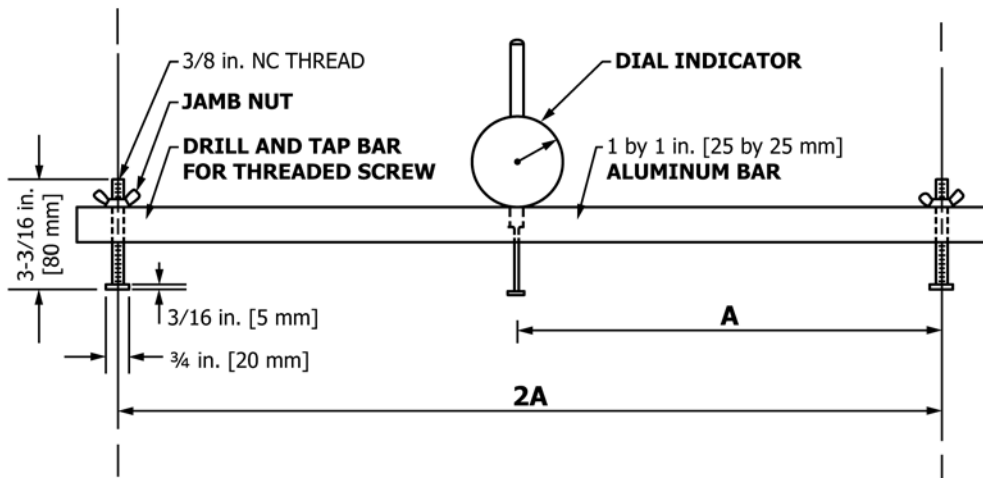
21.5 Install the tile or panel in the test rack within the environmental chamber with the finished surface facing down.

21.6 Record the gage reading as the “initial reading.”



SECTION A-A'

FIG. 1 Sag Test Frame



Panel Minimum Linear Dimension, in. [mm]	Dimension A, in. [mm]
12 [305]	6 [150]
24 [610]	12 [305]
48 [1220]	24 [610]
60 [1525]	30 [760]

FIG. 2 Sag Bar

21.7 Place the sag bar under the test panel or tile with the sag bar feet pressed firmly into contact with the horizontal

members of the frame and with the bar parallel with the shortest (if not symmetrical) members of the frame. The feet



should be positioned at the center of the span of the longest frame member and the gage foot should be located at the panel or tile center as marked in 21.4.

21.8 Adjust the environmental chamber to provide the desired temperature and relative humidity. These conditions should be obtained over a time period not exceeding 15 min. Hold at these conditions for 17 h (which excludes the adjustment time). Record the gage reading as the “wet reading.” (See Note 6.)

21.9 Return the sample to the conditions used to obtain the “initial reading” in 21.6. Again this change should occur over a time period not exceeding 15 min. Maintain the sample at these conditions for 6 h (again this time period excludes the adjustment time). Record the gage reading as the “final reading.” (See Note 6.)

NOTE 6—If the sag exceeds the capacity of the gage, insert gage blocks between the sag bar feet and the bottom of the test frame to obtain a sag reading. Add the gage block thickness to the indicated reading.

22. Calculation

22.1 Calculate the total humidity-induced sag and recovery as follows:

$$Z - Y = \text{Total humidity induced sag, in. or [mm]} \quad (2)$$

$$X - Y = \text{Recovery, in. or [mm]} \quad (3)$$

where:

Y = initial reading,

Z = wet reading

X = final reading

23. Report

23.1 The report shall include the following:

23.1.1 Identification of the test material,

23.1.2 Specimen length, width, and thickness in mm or in. and mass in lb_m or [kg] after conditioning at 73°F [23°C] and 50 % relative humidity,

23.1.3 A statement to the effect that the specimens were preconditioned to constant weight at 73°F [23°C] and 50 % relative humidity,

23.1.4 Temperature, °F or [°C], and relative humidity, % at the test conditions,

23.1.5 Test duration, h,

23.1.6 Initial reading (Y), in. or [mm],

23.1.7 Total humidity-induced sag, in. or [mm], and

23.1.8 Recovery, in. or [mm].

TRANSVERSE STRENGTH

24. Significance and Use

24.1 Transverse strength and modulus of rupture tests are of practical usefulness in the development and in the quality control of acoustical tile or panels. Performance characteristics in the handling, shipping, and installing of acoustical tile or panels may often be predicted by strength testing. The numerical results obtained are not necessarily comparable for tiles or panels of different thicknesses made from the same base material or for tiles or panels of the same thickness made from different materials.

25. Apparatus

25.1 *Testing Machine*—Any standard mechanical or hydraulic testing machine capable of applying the load at a speed of 0.5 to 2 ± 1/16 in./min [12.7 to 50 ± 1.5 mm/min] (and measuring the load within ±2 %. The loading beam shall have a bearing surface at least 1 in. [25 mm] high by at least 3 in. [80 mm] wide rounded to a radius of 3/8 in. [10 mm] . The supporting surfaces shall be at least 4 in. [100 mm] high by 3 in. [80 mm] wide with a radius of 3/8 in. [10 mm] and shall be set for a span of no shorter than the ratio of 16:1 span: thickness. All bearing surfaces shall be self-aligning so as to maintain full contact with the specimen. Means for measuring the deflection at the breaking load shall be provided.

NOTE 7—For example, for a board 0.75 in. [19mm] thick, the span should be 16 × 0.75 in. [16 × 19 mm] = 12 in. [304 mm].

26. Test Specimens

26.1 Test specimens shall be 3 in. [80 mm] wide by a length equivalent to the supporting surfaces span plus 2 in. [50 mm]. Five specimens each, in the machine direction and across the machine direction, shall be prepared for each test.

27. Conditioning

27.1 Condition cut specimens as described in 7.1 prior to testing.

28. Procedure

28.1 Place the specimen in the testing machine so that the specimen rests on the supporting span, and the load is applied at the midspan of the specimen. Apply the load at a rate of 0.5 to 20 ± 1/16 in./min [12.7 to 50 ± 1.5 mm/min] (until a failure occurs. Read and record the load and deflection at break.

29. Modulus of Rupture (MOR)

29.1 The MOR in lb/in.² [N/mm²] of each specimen is calculated from the following equation, using the data from the transverse strength measurements:

$$\frac{3 \times P \times L}{2 \times b \times d^2} \quad (4)$$

where:

P = maximum load, lbf [N],

L = length of span, in. [mm],

b = specimen width, in. [mm], and

d = specimen thickness, in. [mm].

30. Report

30.1 The report shall include the following:

30.1.1 Identification of the test material,

30.1.2 Method of conditioning including the time of conditioning, temperature, °F or [°C], and relative humidity, %,

30.1.3 Statement describing whether the specimens were tested with the finished face up or down,

30.1.4 Statement that indicates the width and length of the specimens tested as well as the span with the load applied at midspan,

30.1.5 Statement of the rate that the load was applied,



30.1.6 Average thickness (d) for the five cross machine specimens, in. or [mm],

30.1.7 Average thickness (d) for the five machine direction specimens, in. or [mm],

30.1.8 Average breaking strength (P) and deflection for the five cross machine specimens, lbf or [N], and

30.1.9 Average breaking strength (P) and deflection for the five machine direction specimens, lbf or [N],

30.1.10 Average MOR for the five cross machine specimens, lb/in.² [N/mm²], and

30.1.11 Average MOR for the five machine direction specimens, lb/in.² [N/mm²].

PRECISION AND BIAS

31. Precision and Bias

31.1 *Precision*—The precision of these test methods will be established after inter-laboratory study.

31.2 *Bias*—No statement can be made on the bias of these test methods since the true values of the properties have not been established by standard reference materials.

32. Keywords

32.1 acoustical panel; acoustical tile; friability; hardness; sag; strength properties; transverse strength

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