SPONSOR: **University of Michigan**
Ann Arbor, MI

Sound Absorption
RAL™-A21-474

CONDUCTED: 2021-09-09

ON: Flower Six - Most Severe Span

TEST METHODOLOGY

Riverbank Acoustical Laboratories™ is accredited by the U.S. Department of Commerce, National Institute of Standards and Technology (NIST) under the National Voluntary Laboratory Accreditation Program (NVLAP) as an ISO 17025:2017 Laboratory (NVLAP Lab Code: 100227-0) and for this test procedure. The test reported in this document conformed explicitly with ASTM C423-17: "Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method." Test Specimens During Sound Absorption Tests." A description of the measurement procedure and room specifications are available upon request. The results presented in this report apply to the sample as received from the test sponsor.

INFORMATION PROVIDED BY SPONSOR

The test specimen was designated by the sponsor as Flower Six - Most Severe Span. The following nominal product information was provided by the sponsor prior to testing. The accuracy of such sponsor-provided information can affect the validity of the test results.

Specimen Under Test

Specimen Name:	Flower Six - Most Severe Span
Fabricator:	University of Michigan

SPECIMEN MEASUREMENTS & TEST CONDITIONS

Through a full external visual inspection performed on the test specimen, Riverbank personnel verified the following information:

Base frame and support rods

Materials:	Flat grid of thirteen (13) equilateral triangles
	Twelve (12) support rods, each anchored at a vertex of the triangular grid
Dimensions:	1822 mm (71.75 in.) by 2102 mm (82.75 in.)
Frame Thickness:	19.25 mm (0.758 in.)
Installation:	Base frame placed on horizontal surface of test chamber
	Support rods used to hold test specimen panels
Overall Weight:	19.05 kg (42 lbs)

Test Specimen

Materials:	Fourteen (14) glass hexagonal curved panels arranged in seven (7) pairs, various degrees of curvature, perforations on some curved panels
Panel Geometry:	Regular hexagons with side length @ 381 mm (15 in.)
Thickness:	Curved panel pairs @ various thicknesses
Installation:	Each pair comprised of a second panel stacked atop the first with no horizontal translation Seven (7) pairs of panels placed atop support rods in a hexagonal array Array consists of center pair, with other six (6) pairs evenly placed around center and with top surfaces of each parallel to a common horizontal plane Air spaces between each adjacent pair in array @ 10.97 mm (0.432 in.)
Overall Weight:	52.39 kg (115.5 lbs)

Test Environment

Room Volume:	291.98 m³
Temperature:	22.3 °C ± 0.1 °C (Requirement: ≥ 10 °C and ≤ 5 °C change)
Relative Humidity:	63.05 % ± 0.1 % (Requirement: ≥ 40 % and ≤ 5 % change)
Barometric Pressure:	98.9 kPa (Requirement not defined)

MOUNTING METHOD

Non-standard mounting: The specimen is an array of pairs of glass panels. The panels were supported by rods anchored to a base frame on the horizontal test surface such that the bottommost point of the curved panels was located approximately 305 mm (12 in.) from the horizontal test surface.

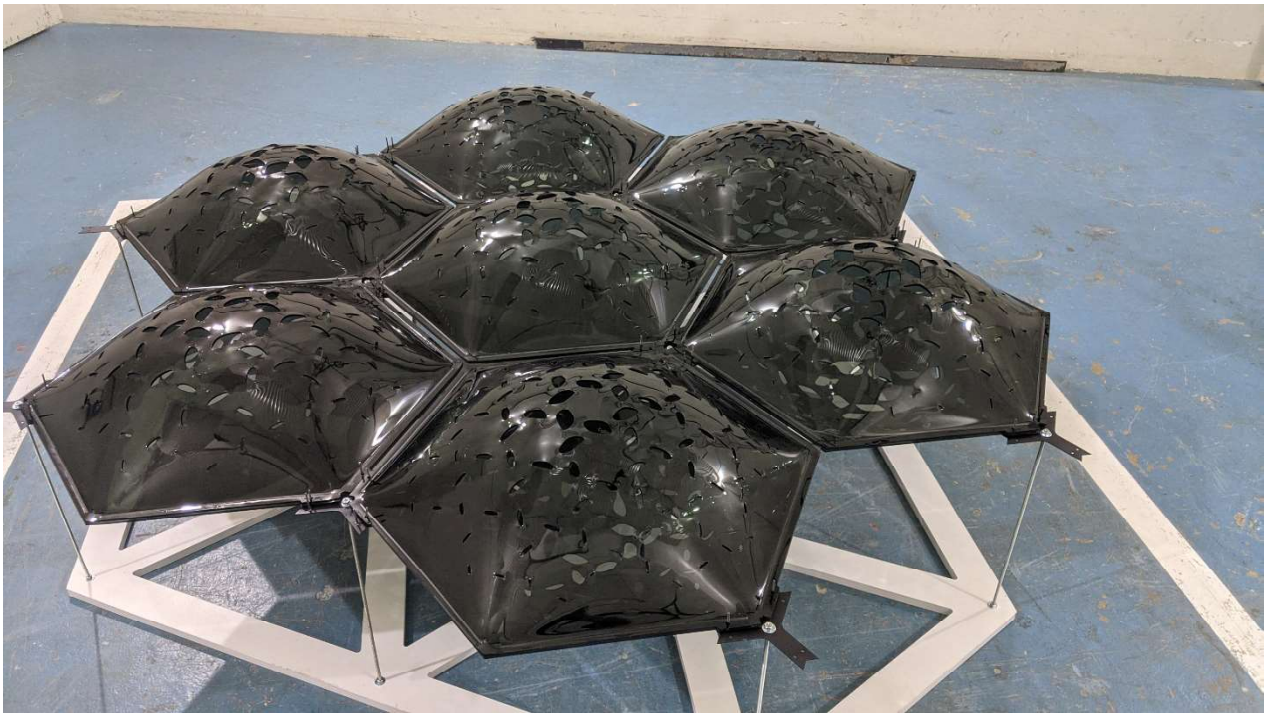

Figure 1 – Specimen mounted in test chamber

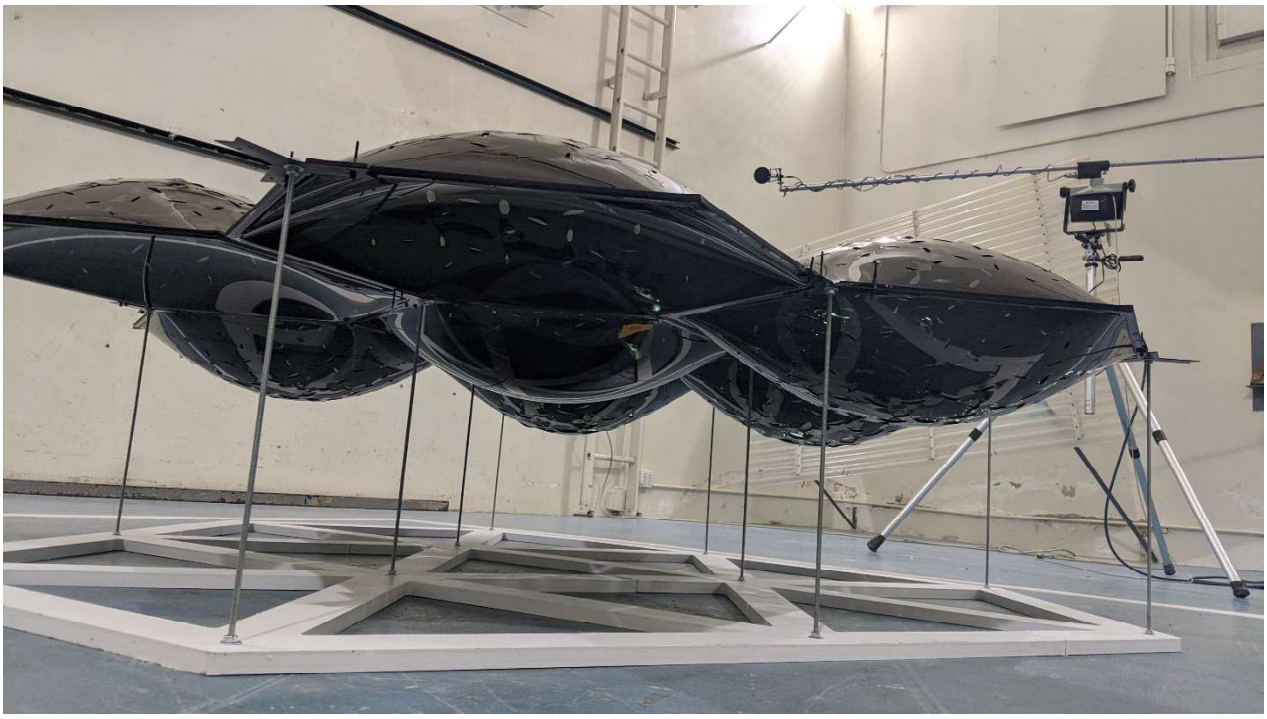

Figure 2 – Specimen mounted in test chamber

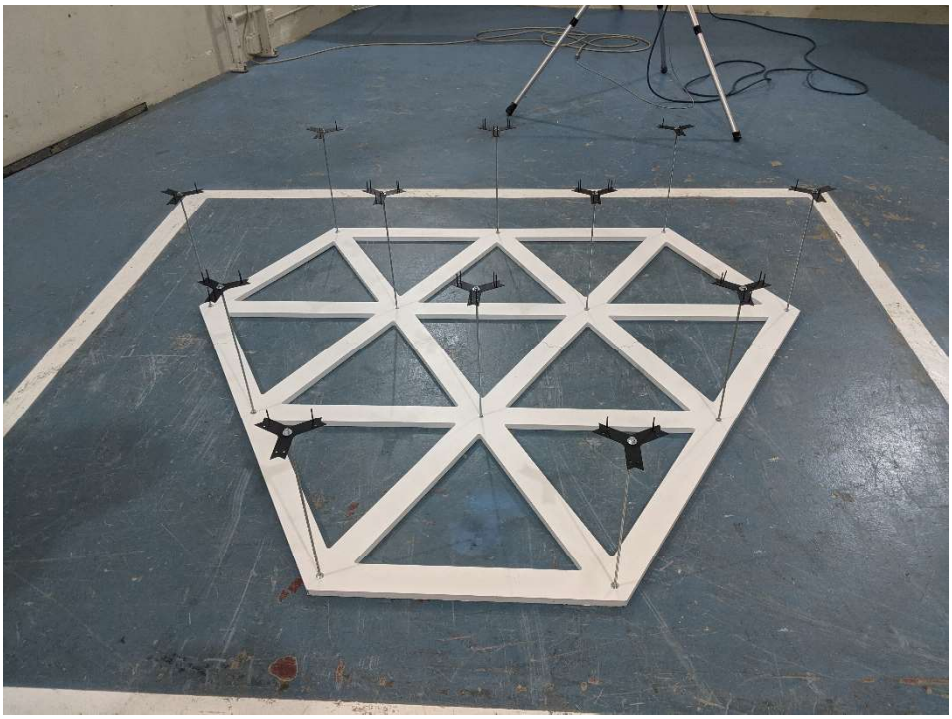

Figure 3 – Base frame and support rods in test chamber prior to installation of glass units

Figure 4 – Detail of support rod

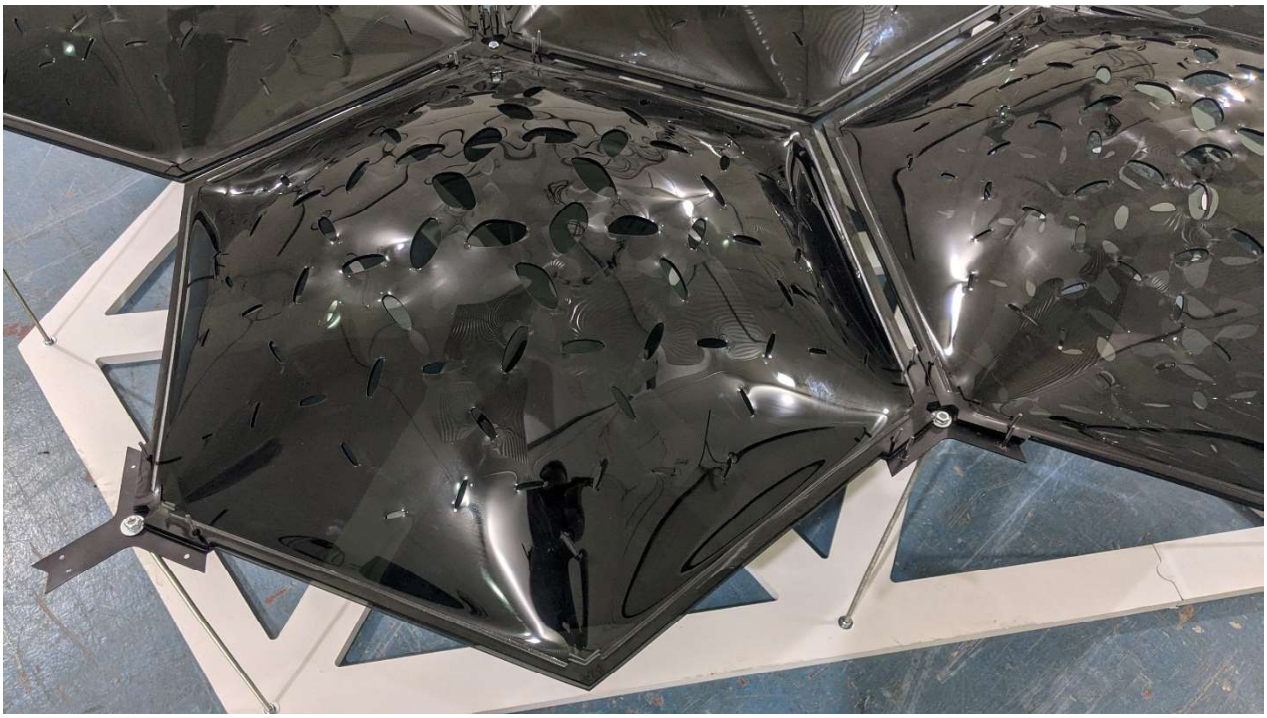

Figure 5 – Detail of curvature and perforations on some specimen glass panels

Figure 6 – Detail of air gaps between adjacent pairs of glass plates

TEST RESULTS

Note: The empty room absorption test, which is used as a correction factor for the specimen absorption test data, was conducted with the base frame and support rods in the test chamber to minimize the effect of these elements on the specimen absorption data. As such, the specimen absorption data should theoretically represent the acoustic absorption of only the glass panel elements.

1/3 Octave Center Frequency (Hz)	Total Absorption (m^2)	Total Absorption (Sabins)
100	-0.23	-2.48
** 125	0.54	5.80
160	0.38	4.09
200	0.66	7.12
** 250	0.43	4.63
315	0.37	3.95
400	0.27	2.96
** 500	0.53	5.67
630	0.41	4.36
800	0.48	5.17
** 1000	0.45	4.86
1250	0.46	4.93
1600	0.37	4.03
** 2000	0.32	3.44
2500	0.28	3.01
3150	0.21	2.31
** 4000	0.15	1.64
5000	0.12	1.25

Tested by _____
Marc Sciaky
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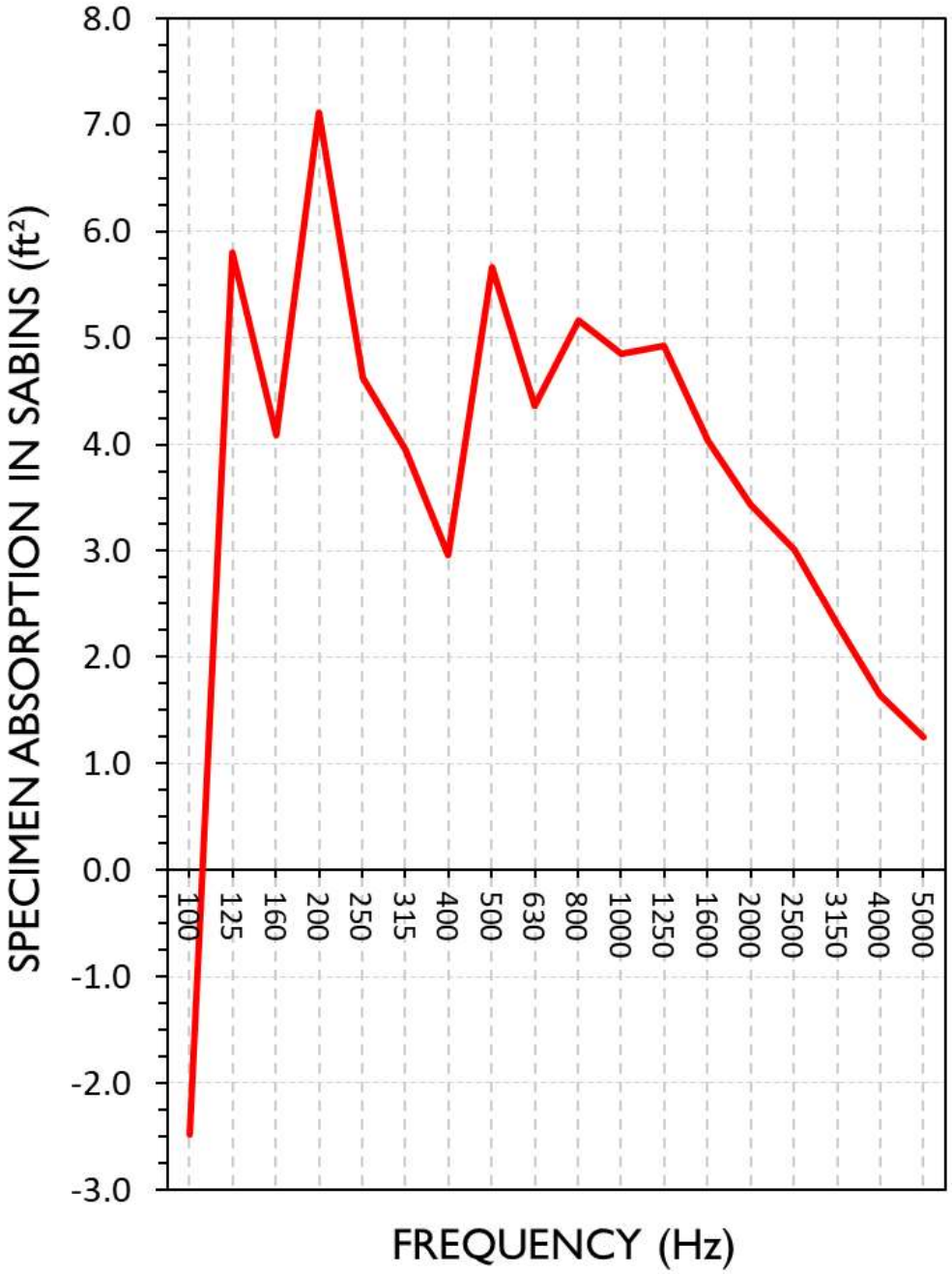
Report by _____
Keith Kimberling
Associate Test Engineer

Approved by _____
Eric P. Wolfram
Laboratory Manager

Digitally signed by Eric P Wolfram
Date: 2021.12.09 11:21:28 -06'00'

SOUND ABSORPTION REPORT

Flower Six - Most Severe Span



APPENDIX A: Extended Frequency Range Data

Specimen: Flower Six - Most Severe Span (See Full Report)

The following non-accredited data were obtained in accordance with ASTM C423-17, but extend beyond the defined frequency range of 100Hz to 5,000Hz. These unofficial results are representative of the RAL test environment only and intended for research & comparison purposes.

1/3 Octave Band Center Frequency (Hz)	Total Absorption (m^2)	Total Absorption (Sabins)
31.5	-0.01	-0.10
40	-0.03	-0.37
50	-0.18	-1.91
63	0.54	5.79
80	0.16	1.77
100	-0.23	-2.48
125	0.54	5.80
160	0.38	4.09
200	0.66	7.12
250	0.43	4.63
315	0.37	3.95
400	0.27	2.96
500	0.53	5.67
630	0.41	4.36
800	0.48	5.17
1000	0.45	4.86
1250	0.46	4.93
1600	0.37	4.03
2000	0.32	3.44
2500	0.28	3.01
3150	0.21	2.31
4000	0.15	1.64
5000	0.12	1.25
6300	0.10	1.08
8000	-0.05	-0.51
10000	0.28	2.98
12500	-0.96	-10.30

APPENDIX B: Instruments of Traceability

Specimen: Flower Six - Most Severe Span (See Full Report)

Description	Model	Serial Number	Date of Certification	Calibration Due
System 1	Type 3160-A-042	3160-106968	2021-07-01	2022-07-01
Bruel & Kjaer Mic And Preamp A	Type 4943-B-001	2311428	2020-09-30	2021-09-30
Bruel & Kjaer Pistonphone	Type 4228	2781248	2021-08-13	2022-08-13
EXTECH Hygro 639	SD700	A.103639	2020-12-18	2021-12-18

APPENDIX C: Revisions to Original Test Report

Specimen: Flower Six - Most Severe Span (See Full Report)

Date	Revision
2021-12-08	Original report issued

END

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SPONSOR: **University of Michigan**
Ann Arbor, MI

Report Referenced: **RAL™-A21-474**

CONDUCTED: 2021-09-09

ON: Flower Six - Most Severe Span (See Full Test Report for Details)

Appendix D to ASTM C423 Sound Absorption Test
Non-standard calculation of equivalent NRC Rating and Absorption Coefficients from spaced absorbers

At this time, ASTM C423 does not provide a standard method for determining absorption coefficients of spaced object absorbers. Tests of a set of sound absorbing objects spaced apart from each other will yield higher absorption rates than a specimen joined together as a single patch (A-Mount or E-Mount). For this reason it is unfair to provide NRC or absorption coefficient ratings for specimens that consist of a spaced set of absorbers. Despite this, the architectural industry has expressed great demand for a simple "single number" rating for these treatments. Likewise, acoustical consultants desire equivalent absorption coefficient data for use in acoustical modeling software. The following is an attempt to appease these demands until ASTM develops a standard method for calculation. Several alternate non-standard calculation methods are provided. Riverbank Acoustical Laboratories prefers method 1. Rating titles for these methods are prepended with the word “Apparent”. These rating names and their associated acronyms are provided by RAL and shall not be misconstrued as originating from any current standard.

Method 1) Apparent Sound Absorption Coefficient calculated from extended test specimen envelope
The total sound absorption yielded by the specimen is divided by the surface area of the test surface covered by the suspended objects, including intermediate spaces, with additional added area to allow theoretical extrapolation for larger arrays. The object rigging covered {EnvelopeMetric} m^2 ({EnvelopeImp} ft^2) of horizontal test surface area. With an extra {Spacing1} of width and {Spacing2} of length to account for the space between the tested array and what would be the next objects in a larger array, the total covered surface area comes to {BigEnvelopeMetric} m^2 ({BigEnvelopeImp} ft^2). Apparent sound absorption coefficients, and subsequently the Apparent Noise Reduction Coefficient (A*NRC) and Apparent Sound Absorption Average (A*SAA) ratings, are calculated using this surface area based on the methods described in ASTM C423-17. This may be the most accurate method for comparing object arrays to ceiling tile products. The apparent sound absorption coefficient data can be assigned to a single horizontal surface or plane in acoustical modeling software for approximation of object array performance. Such approximations rely on the assumptions that object spacing is similar to that of the tested array across the entire surface, that gaps are negligibly small between adjacent rows of objects if the test specimen consists of a single row, and that the installation occurs over a perfectly reflective surface material.

Method 2) Apparent Sound Absorption Coefficient calculated from total exposed surface area of specimen
The total sound absorption yielded by the specimen is divided by the total surface area of all exposed specimen faces ({AreaPerMetric} m^2 ({AreaPerImp} ft^2) per object x {Quantity} objects = {TotalAreaMetric} m^2 ({TotalAreaImp} ft^2) total surface area). Apparent sound absorption coefficients, and subsequently the Apparent Noise Reduction Coefficient (A*NRC) and Apparent Sound Absorption Average (A*SAA) ratings, are calculated using this surface area based on the methods described in ASTM C423-17. This method shows the actual absorption occurring at the exposed surfaces but does not provide a fair comparison with materials mounted as a uniform patch (in A-mount or E-mount).

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Appendix D (continued)

Method 3) Apparent Sound Absorption Coefficient calculated from one face per object

The total sound absorption yielded by the specimen is divided by the surface area of one side of one large face for each object in the specimen ({OneSidePerMetric} m^2 ({OneSidePerImp} ft^2) per object x {Quantity} objects = {OneSideTotalMetric} m^2 ({OneSideTotalImp} ft^2) total surface area). Apparent sound absorption coefficients, and subsequently the Apparent Noise Reduction Coefficient (A*NRC) and Apparent Sound Absorption Average (A*SAA) ratings, are calculated using this surface area based on the methods described in ASTM C423-17. This method is favored by some material manufacturers since it yields very high NRC figures, but does not provide a fair comparison with other ceiling tile or wall panel products. Riverbank Acoustical Laboratories recommends that results obtained from this method be used for research and comparison purposes only; such results should not be used for marketed claims of product performance.

Method 4) Apparent Sound Absorption Coefficient calculated from specimen envelope without extension

The total sound absorption yielded by the specimen is divided by the rectangular test surface area covered by the suspended objects, including intermediate spaces. The object rigging covered {EnvelopeMetric} m^2 ({EnvelopeImp} ft^2) of horizontal test surface area. Apparent sound absorption coefficients, and subsequently the Apparent Noise Reduction Coefficient (A*NRC) and Apparent Sound Absorption Average (A*SAA) ratings, are calculated using this surface area based on the methods described in ASTM C423-17. While similar in concept to Method 1, attempting to model any array larger than the tested specimen using these results would imply instances of adjacent objects with zero spacing scattered throughout the extrapolated array. Riverbank Acoustical Laboratories recommends that results obtained from this method be used for research and comparison purposes only; such results should not be used for marketed claims of product performance.

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Appendix D: Data Note: See full test report for details of mounting position, spacing, and configuration, as these parameters greatly affect sound absorption performance.

Specimen Absorption (ft^2)			Method 1	Method 2	Method 3	Method 4
Freq. (Hz)	Sabins	Sabins / Object	Apparent Abs. Coefficient From Total Coverage Area ({BigEnvelopeImp} ft^2)	Apparent Abs. Coefficient From Total Exposed Surface Area ({TotalAreaImp} ft^2)	Apparent Abs. Coefficient From One Face per Object ({OneSideTotalImp} ft^2)	Apparent Abs. Coefficient From Unextended Envelope Area ({EnvelopeImp} ft^2)
31.5	-0.10	-0.01				
40	-0.37	-0.05				
50	-1.91	-0.27				
63	5.79	0.83				
80	1.77	0.25				
100	-2.48	-0.35				
125	5.80	0.83				
160	4.09	0.58				
200	7.12	1.02				
250	4.63	0.66				
315	3.95	0.56				
400	2.96	0.42				
500	5.67	0.81				
630	4.36	0.62				
800	5.17	0.74				
1,000	4.86	0.69				
1,250	4.93	0.70				
1,600	4.03	0.58				
2,000	3.44	0.49				
2,500	3.01	0.43				
3,150	2.31	0.33				
4,000	1.64	0.23				
5,000	1.25	0.18				
6,300	1.08	0.15				
8,000	-0.51	-0.07				
10,000	2.98	0.43				
12,500	-10.30	-1.47				
		Apparent NRC:				
		Apparent SAA:				

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