UNIVERSITY OF ALBERTA

LABORATORY MEASUREMENT OF SOUND ABSORPTION OF AKUSTUS 12mm PET PANELS USING D50 MOUNTING

Prepared for:

AKUSTUS
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Vancouver, BC, Canada
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REPORT NUMBER: **20-03-F**

19 May 2020

EXECUTIVE SUMMARY

Sound absorption measurements were conducted at the request of **Akustus** of Vancouver, BC, in the small reverberation chamber (227 m^3) at the Mechanical Engineering Acoustics and Noise Unit (the "MEANU") of the University of Alberta in Edmonton, Alberta, Canada. These measurements were conducted in accordance with ASTM C423-17 "Standard Test Method for Sound Absorption And Sound Absorption Coefficients By The Reverberation Room Method".

Akustus had requested the generation of sound absorption data for its 12mm thick PET-panels ("PET" : polyethylene terephthalate), tested using the D50-mounting (elevated 50mm (2in) above Test Chamber floor). Each panel is 600mm (23.6in) wide by 1200mm (47.2in) long and consists of a 12mm (1/2in) thick core of PET felt. Testing was done with a set of ten such panels arranged as a "patch" of five rows by two columns with no gaps between any abutting panels. The panels were supported on aluminum angle so as to realize the 50mm (2in) gap below the set-of-panels. The outer perimeter of the test specimen was enclosed with 76mm (3in) aluminum angle whose outer edge was sealed to the Test Chamber floor with duct tape. No specimen edge was parallel to a Test Chamber wall. The panels were tested "as-received" (no on-site modifications to product). A more detailed description of the specimen panels and the test configuration is given in the body of this Report (Section 5).

The **Noise Reduction Coefficients** ("NRC") and **Sound Absorption Averages** ("SAA") as determined for the set of 12mm panels in D50 mounting were :

Test 20-03-F : sound absorption of Akustus 12mm PET panels using D50 mounting:

NRC = 0.80 / SAA = 0.81

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1.0 INTRODUCTION

The acoustical conditions in a room are determined in large part by the sound absorbing capabilities of walls, surface treatments and any objects contained within the room. This report summarizes the equipment and procedures used and test results obtained in quantifying the sound absorption of a set of 12mm thick PET panels using a D50 mounting according to the requirements of ASTM C423.

The Mechanical Engineering Acoustics and Noise Unit of the University of Alberta in Edmonton was retained by **Akustus** of Vancouver, BC, to conduct the tests summarized in this Report. Formal authorization to conduct this study was received from Akustus. Testing was conducted 14-May-2020 by Corjan Buma, M.Sc., P.Eng., assisted by Ben Walker, EIT.

2.0 DESCRIPTION OF TEST FACILITIES

The Mechanical Engineering Acoustics and Noise Unit (“MEANU”) is owned by the University of Alberta and operated within the Department of Mechanical Engineering. Besides educational uses and availability for fundamental research and research contracts, the MEANU is also equipped to conduct commercial acoustical testing in accordance with the requirements of ASTM International (ASTM), the American National Standards Institute (ANSI) and the International Standards Organization (ISO).

A partial layout of the facility is shown in Figure 1 (page 7). The two inter-connecting reverberation chambers in which most acoustical tests are conducted are arranged as essentially separate buildings on independent foundations. A test opening, nominally 2.4 meters high by 2.7 meters wide, is provided for the installation of wall test specimens. The test opening spans the two chamber walls, the walls being physically connected through lead sheet flashing only. Normally, when testing specimens for their sound-absorbing capabilities, as in this study, only one chamber is used and a specially-constructed plug wall is installed in the test opening to acoustically decouple the two chambers.

In order to satisfy the requirements for adequate sound diffusion, for each chamber its shape, volume and the arrangement of its sound diffusing panels contained within were designed to meet or exceed all applicable testing standards and guidelines. The diffusers can be set into motion (in a slow undulating pattern), however for the tests in this study the diffusers were kept stationary.

3.0 THEORY

The sound absorption of a surface or object is a property of the material(s) comprising the surface or object. It is ideally defined as the fraction of the randomly incident sound power absorbed by the surface. In ASTM test method C423 [1] the absorption of sound in a room is operationally defined by the Sabine equation:

$$A = 0.921\ Vd/c \qquad \text{Eqn 1}$$

where:

- A = room absorption, metric sabins or sabins,
- V = volume of room, m^3 or ft^3,
- d = rate of decay of sound pressure level in the room, dB per second,
- c = speed of sound in the medium, m/s or ft/sec.

The speed of sound is a function of temperature and can be found with:

$$c = 20.047\ \sqrt{(273.15+T)} \qquad \text{Eqn 2}$$

where:

- c = speed of sound, m/s,
- T° = room temperature, C°.

If an object positioned within a room away from any enclosing surfaces contributes to the sound absorption within the room, it is termed a “space absorber”. To quantify the sound absorption contributed by the object, this is determined from the difference in room absorption “A” (Eqn. 1) within a test Chamber with the object present vs. absent. When this difference is divided by the area of the object (as is particularly appropriate for surface treatments) one obtains the “sound absorption coefficient”,

$$\alpha = [(A_2 - A_1) / S] \qquad \text{Eqn 3}$$

where:

- α = absorption coefficient of specimen (dimensionless)
- A_1 = absorption of the empty reverberation room, metric sabins or sabins,
- A_2 = absorption of the room after the specimen has been brought in,
- S = area of test specimen, m^2 or ft^2.

For materials used as a surface treatment, diffraction effects usually cause the area of a specimen to be effectively greater than its geometrical area, thereby increasing the measured coefficient. This phenomenon may cause the derived values of sound absorption coefficient to exceed one (a theoretical impossibility). Since the effects of diffraction are less when specimen area is greater, a specimen size of at least 6.69 m^2 (72 ft^2) is recommended. Since diffraction effects are not yet completely understood, the standard recommends that no adjustments be made and the coefficients simply reported as derived.

Sound absorption coefficients are normally reported in a series of 18 contiguous 1/3-octave band center frequencies ranging from 100 to 5000 Hertz (the standard audible range for good speech intelligibility for humans with average hearing capability). It is common in published data to find only the 6 required standard octave-band center frequencies of 125, 250, 500, 1000, 2000 and 4000 Hertz. Note that these 6 frequency bands are 1/3-octave band data and NOT an average of the three 1/3-octave band center frequencies that comprise a full octave band of that same frequency.

When requested, additional 1/3-octave band sound absorption coefficients may be measured and reported outside the 100-to-5000 Hz frequency range. However, these do not form part of the test procedure according to ASTM C423, and thus are not considered "valid" but only approximate. Often, they provide a useful indication of sound absorption trends outside the "valid" range.

Sound absorption coefficients normally range from a numerical value of zero to one and are defined, ideally, as the fraction of randomly-incident sound power absorbed by the specimen. Sometimes values are reported outside this coefficient range. Coefficients just below a value of zero may occur because of the uncertainty of the measurement. Coefficients exceeding a value of 1 may occur for the same reason or due to the diffraction effects discussed earlier.

The **Noise Reduction Coefficient** (**NRC**), a single number rating, is calculated by determining the arithmetic mean (to the nearest 0.05) of the absorption coefficients in the 250, 500, 1000 and 2000 Hertz 1/3-octave frequency bands. The **Sound Absorption Average (SAA)** is a single number rating calculated by determining the arithmetic average (to the nearest 0.01) of the twelve 1/3-octave frequency band sound absorption coefficients in the range 200 to 2500 Hertz.

4.0 METHODOLOGY

4.1 Equipment

A list of the equipment used in this study is given in the Appendix (page 10).

4.2 Signal Excitation and Measurement

Normally, sound absorption is frequency-dependent and therefore measurements are made in a series of frequency bands. Random noise ("pink") is used as a test signal in the range of 110 dBA and allowed to stabilize for typically 3-to-4 seconds before the noise is abruptly stopped and the decay initiated. When the excitation signal is turned off, the sound pressure level decreases and the rate of decay is determined from measurement of the average time needed for the sound pressure level in a specific frequency band to decay through a certain range. The 1/3-octave band sound pressure levels are measured without any weighting ("linear").

Reverberation time measurements were made by generating 2 channels of random, uncorrelated broadband noise simultaneously through 2 independent loudspeaker systems located in opposite corners of the test chamber. The resulting decays were measured at six microphone locations within a well-defined, allowable region within the test chamber.

This procedure was done both with the specimen present and with the specimen absent. Any difference detected in the average decay rate of the sound was attributed to the presence of the specimen, accounting for any change in sound absorption by the air in the test chamber due to temperature, relative humidity and barometric pressure variations.

As reverberation data was being measured, environmental conditions were also being monitored. A mercury column barometer was used to record barometric pressure changes. A lithium chloride sensor suspended approximately in the center of the test chamber was used to verify that changes in the air absorption of sound due to temperature and relative humidity were accounted for.

Acquisition of acoustic and environmental data was accomplished with custom computer software, with individual-run data being stored temporarily on hard-disk (note that only overall averaged results of reverberation times are retained long-term). The custom software then uses the reverberation-time data, averaged across all decays and for each frequency band, to derive the sound absorption coefficients, with error analysis, according to Equation 3 above. The summary of results for each test specimen is shown in its data-sheet in Figure 4 (page 9). The data in each column of the data-sheet is :

FREQ: one-third octave band frequency; Hertz (cycles per second)

EMPTY RT60: reverberation time in the room with specimen removed; seconds,

SAMPLE RT60: reverberation time in the room with specimen present; seconds,

TOTAL METRIC SABINE: total sound absorption by specimen; metric sabins

ABSORB COEFF: metric sabins of specimen divided by its area; metric sabins/m^2 (dimensionless)

COEFF UNCERTAINTY: estimate of error (precision) of **ABSORB COEFF** based on 95% confidence limits; dimensionless.

The Noise Reduction Coefficient (NRC) shown below the table of data is the single number rating discussed earlier. The Sound Absorption Average (SAA) is calculated separately using the data in the ABSORB COEFF column.

The precision of the average RT60 at each microphone position at each frequency was attained by collecting sufficient decays (typically, about 20) until the precision requirements of ASTM C423 were satisfied. At frequencies of 250 Hz and higher, the absorption of the test chamber, either empty or with-specimen, must be measured with an uncertainty of less than 2% with 95% confidence and at frequencies below 250 Hz, the uncertainty must be less than 4% (with 95% confidence). The precision of sound absorption values was derived from the spatial variation of the average RT60 at each microphone position for each room condition (i.e. with and without specimen) and combining their uncertainties to calculate the uncertainty for absorption coefficient at the 95% confidence level.

5.0 DESCRIPTION OF SPECIMEN AND TEST LAYOUT

The panels submitted for testing were tested "as-received" (no on-site modification). Setup of the panels in the D50 mounting (per ASTM E795) was completed by MEANU staff.

The test specimen consisted of a set of ten panels, each 600mm (23.6in) wide by 1200mm (47.2in) long by 12mm (1/2in) thick. The panels tested consist of PET (polyethylene terephthalate) fibre, compressed into the panel-shape described above (with no embedded cavities). Both faces (and all four edges) are uniform (with no profiling or contouring). The specimen set-of-panels was arranged as one continuous "patch" (two columns of five panels each abutting on 1.2m dimension; all panel edges abutting without gaps); see Figure 2 (page 7). To realize the D50 mounting the panels were supported on four 2in (50mm) aluminum angles set on the Test Chamber floor, positioned approximately 250mm (10in) "in" from each end of the panels – the PET panels have sufficient rigidity so as to remain flat for testing when supported this way. The horizontal member of each supporting aluminum angle was duct-taped to the Test Chamber floor. The outer perimeter of the test specimen was enclosed with 3in (76mm) aluminum angle whose horizontal leg (outer edge) was sealed to the Test Chamber floor with duct tape. No specimen edge was parallel to a Test Chamber wall (see Figure 3, page 8).

For further details on the materials used in these panels, it is suggested the Reader contact Akustus directly.

6.0 RESULTS

The data-sheet resulting from sound absorption testing is given in Figure 4 (page 9). The Noise Reduction Coefficient ("NRC") and Sound Absorption Average ("SAA") derived were:

Test 20-03-F, sound absorption for Akustus 12mm PET panels using D50 mounting:

NRC = 0.80 / SAA = 0.81

7.0 DECLARATION OF COMPLIANCE

Every effort has been made to conduct and report the measurements and derived results in accordance with the requirements of ASTM Standard Test Method C423-17, along with ASTM Standard Mounting Practices E795-16 except where noted. While test procedure C423-17 requires the use of at least five microphone positions with at least 10 reverberation decays per microphone position, the procedure as applied in this study exceeds the minimum requirements.

8.0 DISCLAIMER

The MECHANICAL ENGINEERING ACOUSTICS AND NOISE UNIT (MEANU) has absolutely no financial or managerial interests vested in the Client named in this report nor does the Client so-mentioned have any vested interests in the MEANU.

Although every effort has been made to comply with all aspects of the standards referred to in this report, as of this writing the MEANU has no recognized certification.

9.0 REFERENCES

[1] ASTM C423 – 17: "Standard Test Method for SOUND ABSORPTION AND SOUND ABSORPTION COEFFICIENTS BY THE REVERBERATION ROOM METHOD"; American Society for Testing and Materials, Volume 04.06, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959

[2] ASTM E795 – 16: "Standard Practices for MOUNTING TEST SPECIMENS DURING SOUND ABSORPTION TESTS"; American Society for Testing and Materials, Volume 04.06, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959

[3] ANSI S1.26, "Method for the Calculation of the Absorption of Sound by the Atmosphere", American National Standards Institute, 1430 Broadway, New York, NY, USA 10018.

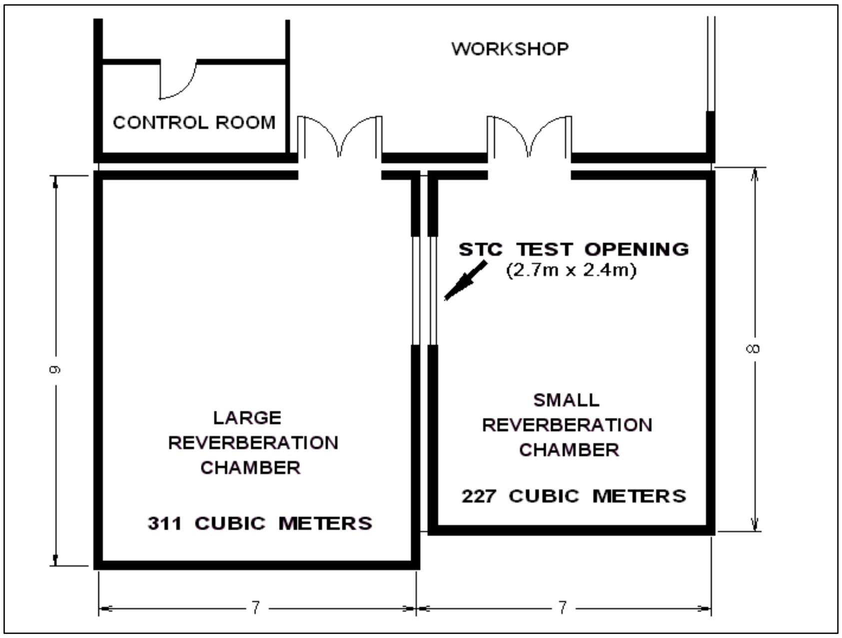

Figure 1 – MEANU Floor Plan (partial)

Figure 2 – Specimen Prepared For Sound Absorption Testing

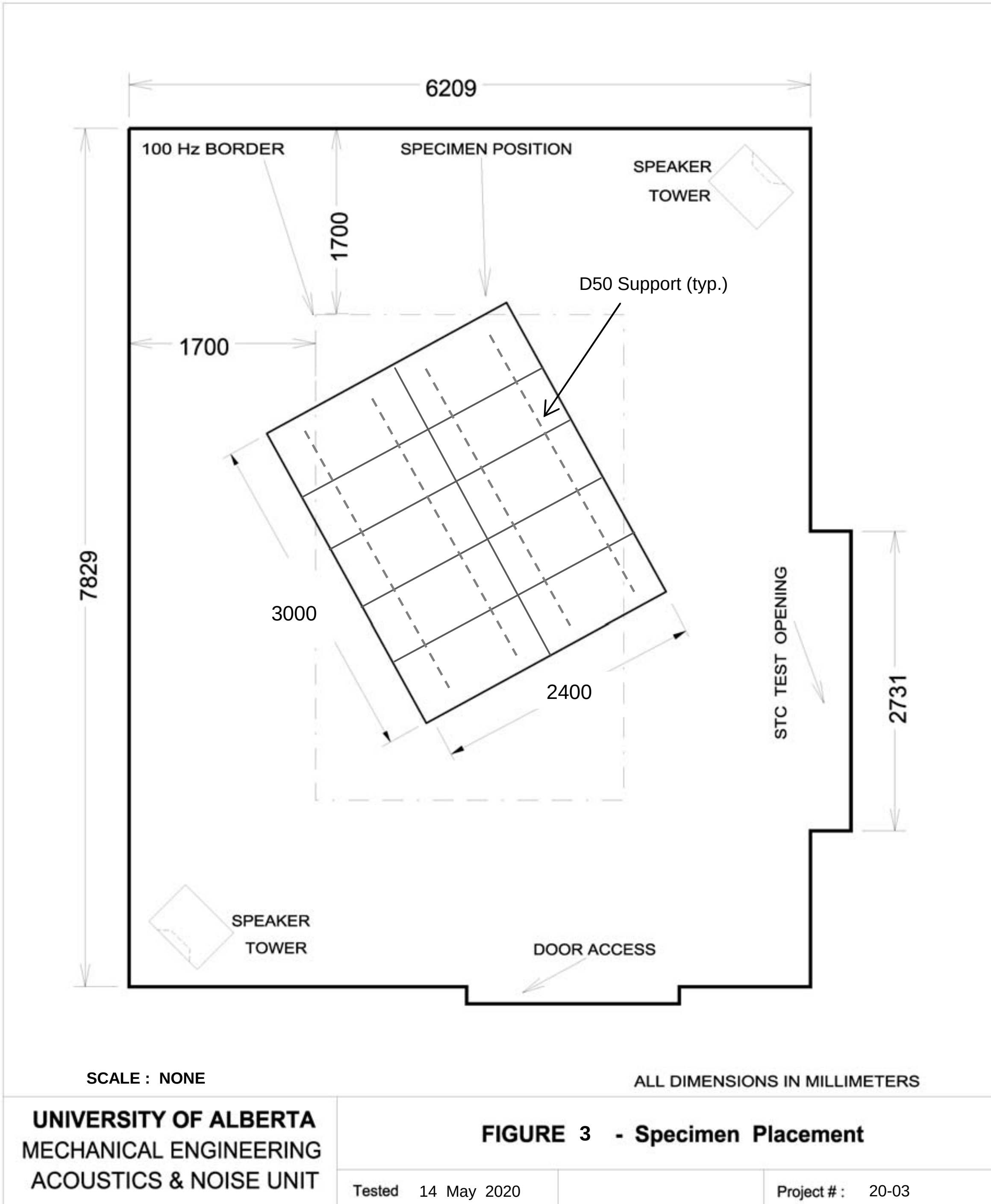

Figure 3 – Placement of Specimen Within Small Reverberation Chamber

UNIVERSITY OF ALBERTA
MECHANICAL ENGINEERING ACOUSTICS AND NOISE UNIT
EDMONTON, ALBERTA, CANADA

DETERMINATION OF NOISE REDUCTION COEFFICIENT (NRC)
ACCORDING TO ASTM STANDARD: C423-17

DATE: 14 MAY 2020, Thrs
CLIENT: Akustus

TEST NO: 20-03_F
TEST PERFORMED BY:
CJ Buma, M.Sc., P.Eng.

REVERB ROOM VOLUME: 228.3621 Cubic Meters
MICROPHONE PLACED AT 6 FIXED POSITIONS

ENVIRONMENT:	TIME	DATE	TEMP(C)	RH(%)	ATMOSPHERIC PRESSURE (KPa)
# 1 EMPTY ROOM:	15:55	05-14-20	15.30	42.88	93.49 (703.4 mm Hg @ 23.1 C)
# 6 EMPTY ROOM:	15:32	05-14-20	15.97	42.12	93.49 (703.4 mm Hg @ 23.1 C)
# 1 SAMPLE ROOM:	16:40	05-14-20	16.97	41.44	93.53 (703.6 mm Hg @ 22.3 C)
# 6 SAMPLE ROOM:	17:05	05-14-20	15.77	42.62	93.53 (703.6 mm Hg @ 22.3 C)

TEST SAMPLE SURFACE AREA : 7.200 Sq m [2.4 m wide by 3 m high]
MOUNTING CONFIGURATION : 'D50'

TEST SAMPLE DESCRIPTION :
Akustus 12mm PET panels (x 10); in D50 mounting; 50mm (2in) aluminum-angle supports below panels; 76mm (3in) aluminum-angle blocks perimeter of specimen, duct-taped to Test Chamber floor; panels abutting, joints not covered.

FREQ (Hz)	EMPTY RT60 (sec)	SAMPLE RT60 (sec)	TOTAL METRIC SABINE	ABSORB COEFF	COEFF UNCERTAINTY (+/-)
100	3.89	3.39	1.41	0.20	0.24
125	3.90	3.46	1.20	0.17	0.08
160	3.94	3.26	1.97	0.27	0.13
200	4.81	3.45	3.07	0.43	0.11
250	5.08	3.44	3.44	0.48	0.04
315	5.01	3.18	4.26	0.59	0.06
400	4.86	2.90	5.11	0.71	0.06
500	4.77	2.66	6.12	0.85	0.03
630	4.46	2.48	6.63	0.92	0.06
800	4.27	2.40	6.70	0.93	0.05
1000	3.79	2.21	6.94	0.96	0.05
1250	3.37	2.08	6.77	0.94	0.04
1600	3.12	1.99	6.77	0.94	0.04
2000	2.89	1.90	6.67	0.93	0.04
2500	2.64	1.79	6.68	0.93	0.07
3150	2.24	1.63	6.19	0.86	0.06
4000	1.84	1.37	7.00	0.97	0.05
5000	1.46	1.15	7.02	0.97	0.07

NRC = 0.80

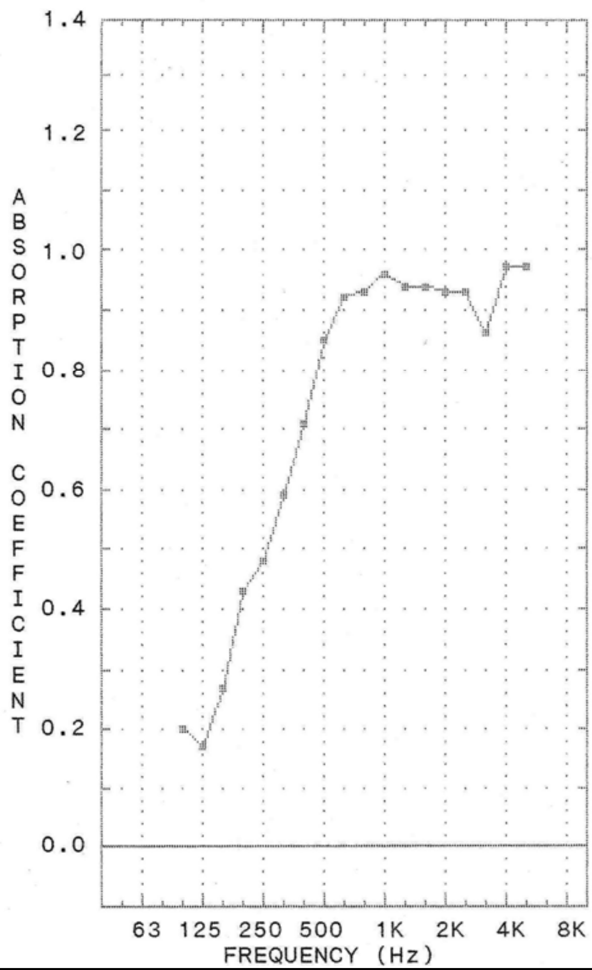

Figure 4 – Sound Absorption of Akustus 12mm PET Panels using D50 Mounting

APPENDIX – EQUIPMENT LIST

The following equipment was used to make the various acoustical measurements:

EXCITATION and CONDITIONING:

Custom-built Dual Channel Pink/White noise Generator
Crest FA-800 Stereo Power Amplifiers (2; "LOW" & "MID")
Crest 7001 Stereo Power Amplifier ("HIGH")
Furman VU-40 Power Monitors (3)
Urei 525 3-Way Stereo Crossover (18 dB/octave)
White 4650 One-Third Octave Band Equalizers (2)

3-Way Loudspeaker Systems (2):
SMALL REVERBERATION CHAMBER:

- EV SH1810L-ER 18" sub-woofer cabinets
- JBL 2220H 15" woofers in custom mid-range cabinets
- JBL 2446J 2" horns in 2385A radial flares

MEASUREMENT:

Pentium II/350 PC compatible computer running custom data-acquisition software
Bruel and Kjaer 4231 Sound Level Calibrator
Bruel and Kjaer 4134 Microphone
Larson-Davis 900B Microphone Preamplifier
Larson-Davis Model 3200 Precision Sound Level Analyzer
Small Reverberation Chamber (227 m^3)

ATMOSPHERIC

Princo Model 453 Mercury column barometer
Hygrodynamics L15-3087 Hygrometer