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DELTA Test Report

TEST Reg. no. 100

Measurement of Sound Absorption for AqFlex ON, one Sample as a discrete Object

Performed for Flex Acoustics

DANAK 100/1652
Project no.: T202611

21 January 2013

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Title
Measurement of Sound Absorption for AqFlex ON, one Sample as a discrete Object

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DANAK 100/1652	T202611	DH/HSO/ilk	20 November 2012

Client
Flex Acoustics
Diplomvej, Bygning 377
2800 Kongens Lyngby
Denmark

Client ref.
Niels Werner Adelman-Larsen

Summary

Laboratory measurements of the equivalent sound absorption area per object were carried out in a reverberation room according to the test method of EN ISO 354:2003.

Product: AqFlex ON, one sample as a discrete object
Module size: 0.70 m x 3.20 m x 1.00 m

The double tube was placed directly over the concrete floor of the reverberation room. The object was tested in two locations.

The test results per one-third octave are shown in tabular form and graphically on the graph sheet.

Descriptions of reverberation room and test procedure are found in Appendix 1.

Remark

The test results apply only to the object tested.

DELTA, 21 January 2013

Dan Hoffmeyer
Acoustics

1. Introduction

At the request of Flex Acoustics measurements of the sound absorption in a reverberation room were carried out for an AqFlex double tube.

2. Description of the Test Specimen Based on the Client's Specifications

Product: AqFlex ON, one sample as a discrete object
Module size: 0.70 m x 3.20 m x 1.00 m

ON refers to air-filled tube.

3. Mounting in the Laboratory

The double tube was hung directly over the concrete floor of the reverberation room.

The object was placed in two randomly chosen positions, successively.

The test specimen was placed so that no part of it was closer than 1 m to any edge of the boundary of the room.

4. Test Method

The measurements were carried out according to the test method of EN ISO 354:2003: "Measurement of Sound Absorption in a Reverberation Room".

The equivalent sound absorption area per object was calculated from the reverberation times measured with and without the test specimen.

Two measurements with different locations of the test object were performed and the results averaged.

The measurements were performed in Room 005, Building 355 at the Technical University of Denmark. Brief descriptions of the reverberation room and test procedure are found in Appendix 1.

5. Instrumentation

The following instruments were used for the test:

Instrument	Type	A&V No.
Real-Time Frequency Analyser	B&K 2144	1025L
Measuring Microphone	B&K 4144	859L
Measuring Microphone	B&K 4144	731L
Microphone Preamplifier	B&K 2619	853L
Microphone Preamplifier	B&K 2619	1188L
Microphone Power Supply	B&K 2807	722L
Sensor for Temperature and Humidity	Elpro Ecolog TH1	1216L

6. Measurement Conditions

The reverberation time was recorded in 6 microphone positions, each placed in the range 1.55 m to 2.85 m above the floor. The number of sound source positions was two.

The reverberation time T_1 per third octave of the room without test specimen and the reverberation time T_2 per third octave of the room with test specimen (averaged values):

Frequency f [Hz]	Reverberation Time T_1 [sec.]	Reverberation Time T_2 [sec.]
100	7.44	5.15
125	7.89	5.39
160	8.61	5.61
200	8.38	5.31
250	7.31	5.18
315	7.40	4.89
400	6.90	4.59
500	6.67	4.44
630	6.77	4.57
800	6.05	4.54
1000	5.65	4.42
1250	5.31	4.41
1600	4.87	4.29
2000	4.35	4.00
2500	3.94	3.65
3150	3.07	2.94
4000	2.58	2.50
5000	2.12	2.06

Temperature and relative humidity in the reverberation room during measurements:

Room without test specimen: 16.5°C, 61% RH. Date of test: 20 November 2012
Room with test specimen: 16.5°C, 62% RH. Date of test: 20 November 2012

The correction of the absorption area due to differences in temperature and relative humidity during measurements of T_1 (the reverberation time of the empty room) and T_2 (the reverberation time of the room with test specimen) was 0.01 m^2 at 2000 Hz, 0.03 m^2 at 2500 Hz, 0.05 m^2 at 3150 Hz, 0.08 m^2 at 4000 Hz, 0.13 m^2 at 5000 Hz, and 0 at all other frequencies.

7. Test Results

The test result – the equivalent sound absorption area per object, A_{obj} - per one-third octave from 100 Hz to 5000 Hz is shown in tabular form and graphically on Graph Sheet 1.

8. Measurement Uncertainty

The measurement uncertainty for the equivalent sound absorption area per object per one-third octave is estimated to ±0.3 m^2.

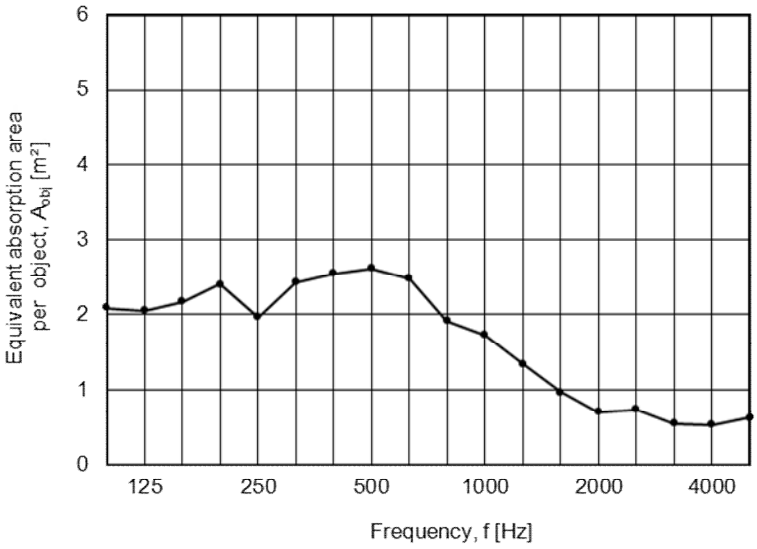
Laboratory Measurement of Sound Absorption according to EN ISO 354:2003

Client: Flex Acoustics, Diplomvej, Bygning 377, 2800 Kongens Lyngby, Denmark
Date of test: 20 November 2012

Test specimen: AqFlex ON, one sample as a discrete object
Module size: 0.70 m x 3.20 m x 1.00 m
Average from measurements of a double tube in two positions directly over the concrete floor of the reverberation room. ON refers to air-filled tube.

Room volume: 215 m³
Room surface: 305 m²

Frequency f [Hz]	A_{obj} [m²]
100	2.1
125	2.1
160	2.2
200	2.4
250	2.0
315	2.4
400	2.6
500	2.6
630	2.5
800	1.9
1000	1.7
1250	1.3
1600	1.0
2000	0.7
2500	0.7
3150	0.6
4000	0.5
5000	0.6



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Dan Hoffmeyer, Acoustics

Description of Reverberation Room

The measurements are performed in a reverberation room (Room 005, Building 355 at the Technical University of Denmark) with walls, ceiling, and floor of 300 mm in situ cast concrete. Length, width, and height of the room are 7.85 m, 6.25 m, and 4.95 m, respectively. The volume of the room is approx. 215 m³, and the total surface area is approx. 305 m². Sound diffusion elements of concrete, of damped steel plate, and of acrylic sheets are placed in the room.

Test Procedure

Measurement of sound absorption according to EN ISO 354:2003 is carried out in a reverberation room. The reverberation time is measured with and without the test specimen, and the sound absorption is evaluated using Sabine's formula.

The test signal used is broad band pink noise emitted successively by two loudspeakers located in two opposite corners of the room. The reverberation time is measured in six microphone positions for each loudspeaker. For each microphone/loudspeaker position three repeated excitations are used. One-third octave filters (100-5000 Hz) are included in the receiving equipment.

The reverberation time is evaluated from the averaged slope of the decay curve over a range from 5 dB to 25 dB below the steady state level.

The equivalent sound absorption area per object A_{obj} is calculated using the following formula:

$$A_{obj} = \frac{55.3 \cdot V}{c \cdot n} \cdot \left(\frac{1}{T_2} - \frac{1}{T_1} \right) - \frac{4V}{n} \cdot (m_2 - m_1)$$

where V = Volume of the empty reverberation room [m³]

c = Velocity of sound in air [m/s]

n = Number of test objects

T_1 = Reverberation time of the empty reverberation room [s]

T_2 = Reverberation time of the reverberation room after the test specimen has been introduced [s]

m_1 = Attenuation coefficients due to air absorption during measurement of T_1 (m^{-1})

m_2 = Attenuation coefficients due to air absorption during measurement of T_2 (m^{-1})

The attenuation coefficient of sound in air varies with relative humidity, temperature, and frequency. During a series of measurements of reverberation times T_1 and T_2, the relative humidity and the temperature are held as constant as possible. A correction term as given in the formula above is applied. The correction is based on data from ISO 9613-1:1993.