

Determination of equivalent sound absorption area in a reverberation room according to ISO 354 and SS-ISO 20189

(4 appendices)

Client

BE-GE Frapett

Test object

Two types of double-sided desk top absorbers were mounted standing on the floor (Felt 3D Two types wall hung absorbers were tested. They were mounted laying down on the floor during the tests.

For more details regarding the mounting and selection of the test objects see sections *Pictures of the test object* and *Mounting*.

The panels were of type:

- **Hexagon 600 mm**
- **Kvadrat rundade**

Date of test

October 24, 2023

Results

A summary of the test results is presented in table 1. The octave band values are calculated as arithmetic averages of the three third octave band values in the band of interest, according to SS-ISO 20189.

Complete results of the equivalent sound absorption area (A_{obj}) are given in enclosures 1 to 6.

The results are valid for the tested items only.

RISE Research Institutes of Sweden AB

Postal address
Box 857
501 15 BORÅS
SWEDEN

Office location
Brinellgatan 4
504 62 Borås
SWEDEN

Phone / Fax / E-mail
+46 10-516 50 00
+46 33-13 55 02
info@ri.se

Confidentiality level

C2 - Internal

This report may not be reproduced other than in full, except with the prior written approval of the issuing laboratory.



Accred. No. 1002
Testing
ISO/IEC 17025

Table 1 – Summary of results

Test Object: Hexagon 600 mm, 310 mm side length thickness: 51 mm Mass per object: 1.5 kg	Equivalent sound absorption area per test object in octave bands, ($A_{obj} m^2$)						Enclosure
	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	
Mounted laying on floor (6 test objects in the room)	0,1 ²⁾	0,2	0,5	0,5	0,5	0,4	1
Mounted laying on floor (12 test objects in the room) ¹⁾	0,1 ²⁾	0,2	0,4	0,5	0,5	0,4	2
Test Object: Kvadrat rundade, 600 x 600 mm thickness: 53 mm Mass per square metre: 2.7 kg/m ²	Equivalent sound absorption area per test object in octave bands, ($A_{obj} m^2$)						Enclosure
	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	
Mounted laying on floor (6 test objects in the room)	0,1 ²⁾	0,3	0,6	0,6	0,6	0,5	3
Mounted laying on floor (12 test objects in the room) ¹⁾	0,1 ²⁾	0,3	0,5	0,6	0,6	0,5	4

- 1) The individual distance of 2 m between the test objects was not fulfilled. The distance was ≥ 1 m between objects.
- 2) The measurable change in the equivalent sound absorption area of the room was not fulfilled.

Measurement method

The measurements have been carried out according to SS-ISO 20189:2019 and SS-EN ISO 354:2003, which is equivalent to EN ISO 354 and ISO 354. RISE is accredited for the Swedish versions of the standards. The evaluation has been carried out according to ISO 354.

4 loudspeaker positions and 6 microphone positions have been used giving 24 different combinations for the reverberation time measurements. For empty room 3 decays have been used for averaging the time and for test objects 5 decays have been used, for each combination of loudspeaker and microphone.

The equivalent sound absorption area per object A_{obj} has been evaluated from:

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

where

V = Volume of the reverberation room (m³)

n	=	Number of test objects
c	=	Speed of sound in air (m/s)
c	=	$331 + 0.6t$
t	=	Temperature in the air (°C)
T ₁	=	Reverberation time of the room without test object (s)
T ₂	=	Reverberation time of the room with test object (s)

The reverberation time of the empty room in each frequency band is expressed by the arithmetic mean of the total number of reverberation time measurements made in that frequency band. In table 2 the reverberation time for the empty room, T₁, is given.

The following deviations from the standard have been made:

Hexagon 600 mm

The measurable change in the equivalent sound absorption area of the room was not fulfilled in the one-third octave frequency bands at and below 250 Hz in the test with 6 pcs of absorbers (Enclosure 1). In the test with 12 pcs of the same absorber the change in the equivalent sound absorption area of the room was still not fulfilled in the one-third octave frequency band at and below 200 Hz (Enclosure 2). The individual distance of 2 m between the objects was not fulfilled. See more info under mounting below.

Kvadrat rundade 600x600mm

The measurable change in the equivalent sound absorption area of the room was not fulfilled in the one-third octave frequency bands at 100 and 125 Hz in the test with 6 pcs of absorbers (Enclosure 3). In the test with 12 pcs of the same absorber the change in the equivalent sound absorption area of the room was still not fulfilled in the one-third octave frequency band at 100 Hz (Enclosure 4). The individual distance of 2 m between the objects was also not fulfilled. See more info under mounting below.

Table 2 – The reverberation time (T_1) of the empty reverberation room at respective measurement presented in enclosures 1-4

Frequency [Hz]	$T_{1(i)}$ [s]
50	11.90
63	14.12
80	9.11
100	8.28
125	7.36
160	6.18
200	6.90
250	6.40
315	6.40
400	5.60
500	5.07
630	5.04
800	5.59
1000	5.74
1250	5.45
1600	5.00
2000	4.54
2500	3.91
3150	3.49
4000	3.02
5000	2.53

Measurement uncertainty

The measurement uncertainty in table 3 has been calculated from a world-wide Round Robin, in which RISE took part in 2022 together with 16 other laboratories. The uncertainty U is defined here as twice the standard deviation for Reproducibility, $U = 2 \times S_R$, rounded to the nearest 0,05. The data from the Round Robin is documented in a report from the test organizers to the participating laboratories.

Table 3 – The reverberation time uncertainty of the empty reverberation room

Frequencies (Hz)	Uncertainty
100 – 315	± 0,05
400 – 1000	± 0,10
1250 - 2500	± 0,15
3150-5000	± 0,10

Pictures of the test object

Picture 1 – Hexagon 600mm, setup with 6 pcs mounted on the floor of the reverberation room.



Picture 2 – Hexagon 600mm, setup with 12 pcs mounted on the floor of the reverberation room.



Picture 3 – kvadrat rundad 600x600mm, setup with 6 pcs mounted on the floor of the reverberation room.



Picture 3 – kvadrat rundad 600x600mm, setup with 6 pcs mounted on the floor of the reverberation room.

Test room

A reverberation room with the dimensions 7,64 m x 6,16 m x 4,25 m giving the volume 200 m³ and the total surface area 211 m² was used.

Mounting

The panels were placed randomly as individual objects at least 2 m apart. They were placed at least 1 m from the walls and non-parallel to the walls.

With regards to the absorbers, two tests were conducted with 6 pcs and 12 pcs of the test objects mounted in the room during the measurements. The aim was to investigate if increasing the number of absorbers would increase the difference in equivalent sound absorption area in the room below the one-third octave band 250 Hz. This was still not enough difference in equivalent sound absorption area in the room below the one-third octave bands below 200 Hz. With this increase of test objects, it was not possible to fulfil the requirement of at least 2 m between test objects, the distance between the test objects was in the latter case approximately 1 m.

List of instruments

Instrument	Manufacturer	Type	Serial no/RISE no.
Microphone	Brüel & Kjaer	4943	BX32058
Microphone	Brüel & Kjaer	4943	503326
Microphone	Brüel & Kjaer	4943	503324
Microphone	Brüel & Kjaer	4943	503325
Microphone	Brüel & Kjaer	4943	503323
Microphone	Brüel & Kjaer	4943	503322
Microphone Preamplifier	Brüel & Kjaer	2619	502246
Microphone Preamplifier	Brüel & Kjaer	2619	502244
Microphone Preamplifier	Brüel & Kjaer	2619	502259
Microphone Preamplifier	Brüel & Kjaer	2619	502217
Microphone Preamplifier	Brüel & Kjaer	2619	502225
Microphone Preamplifier	Brüel & Kjaer	2619	502220
Microphone Calibrator	Brüel & Kjaer	4230	500931
Analyzer	Norsonic	850	BX41346
Hygrometer/ Temperature meter	Testo	605i	BX80648
Loudspeakers	SP	HGT2, HGT7, HGT4, HGTtak	

RISE Research Institutes of Sweden AB
Department Building and Real Estate - Building Envelopes and Building Physics

Performed by



Pontus Gräsberg

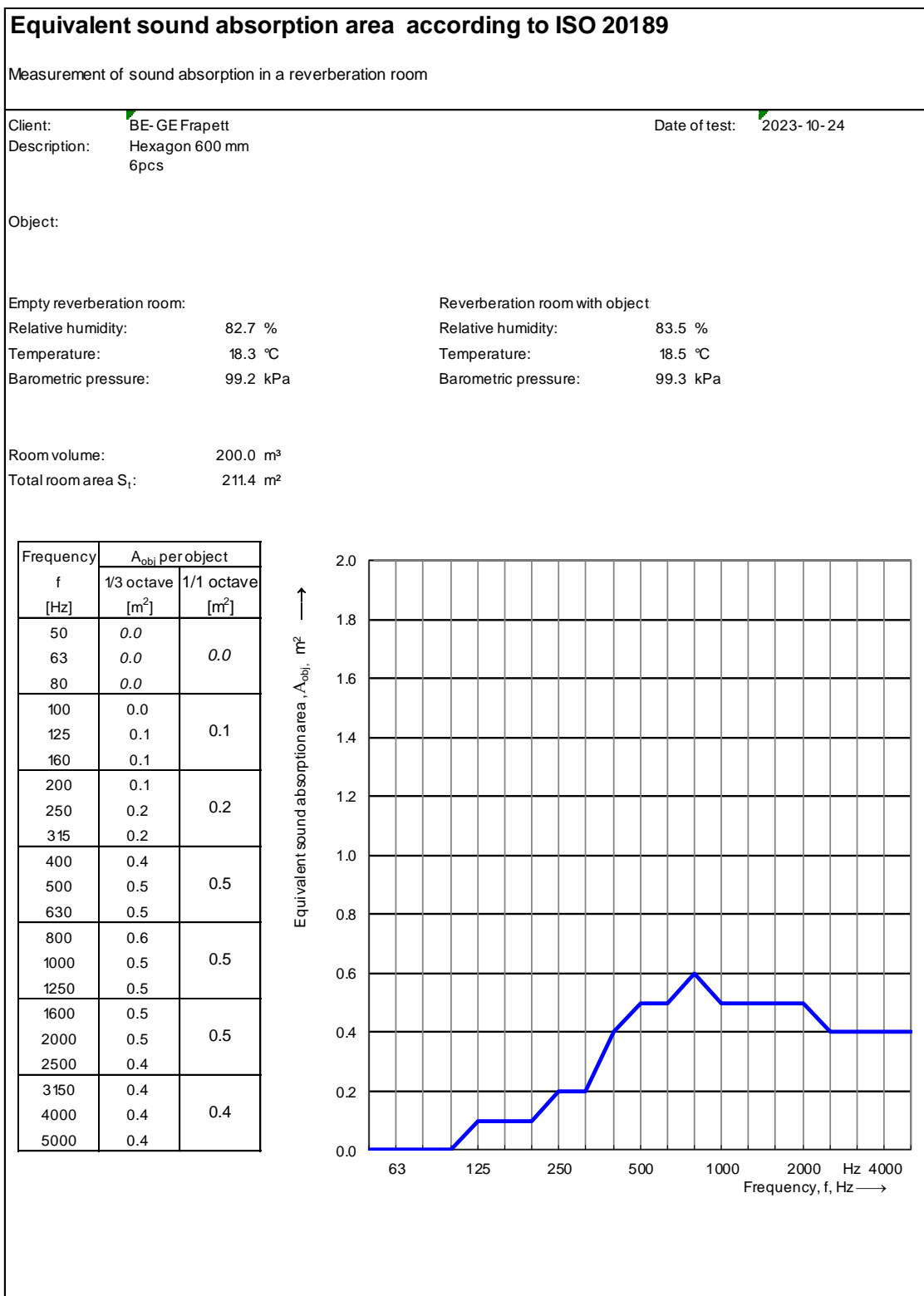
Examined by



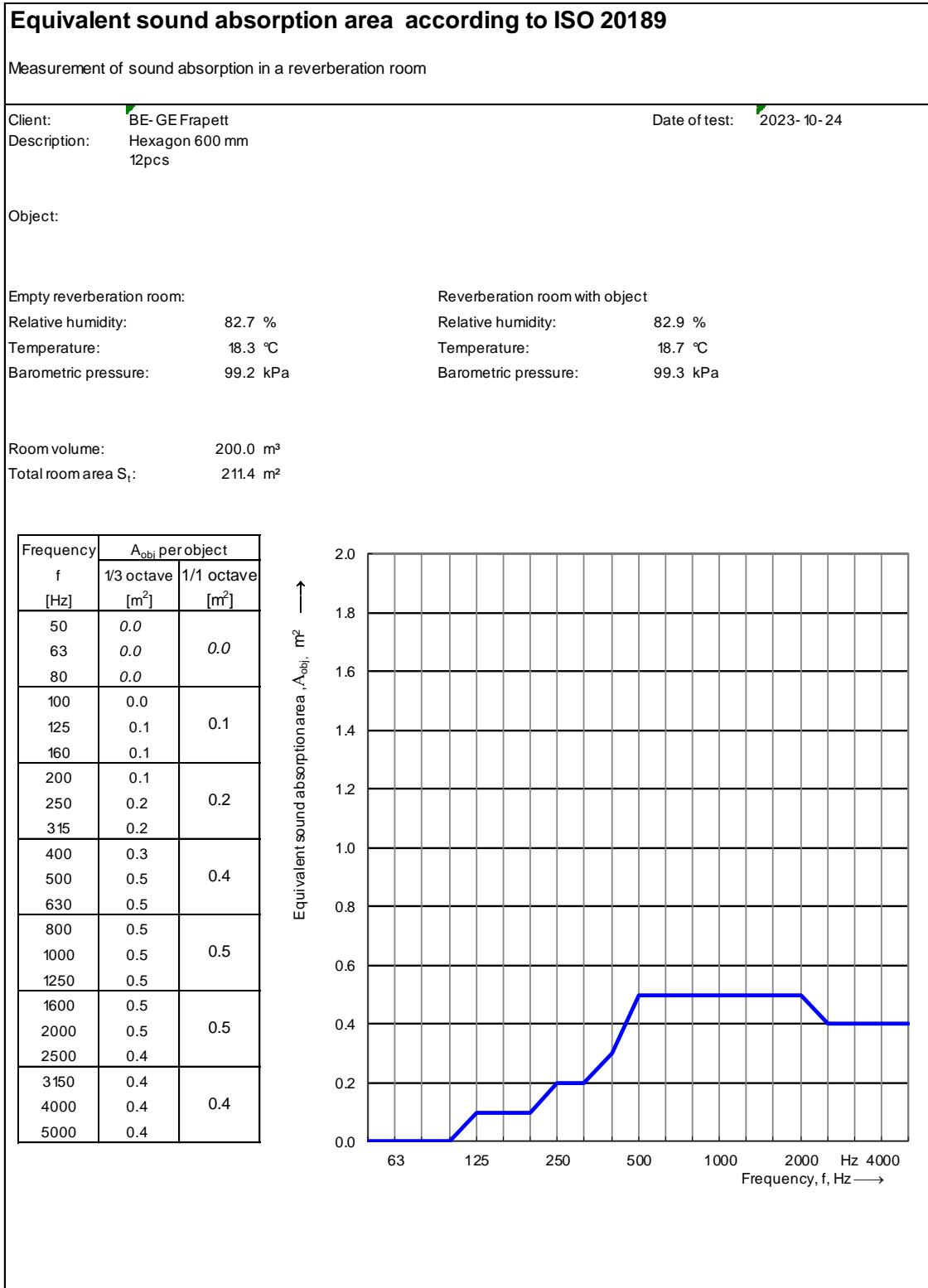
Geir Andresen

Appendices

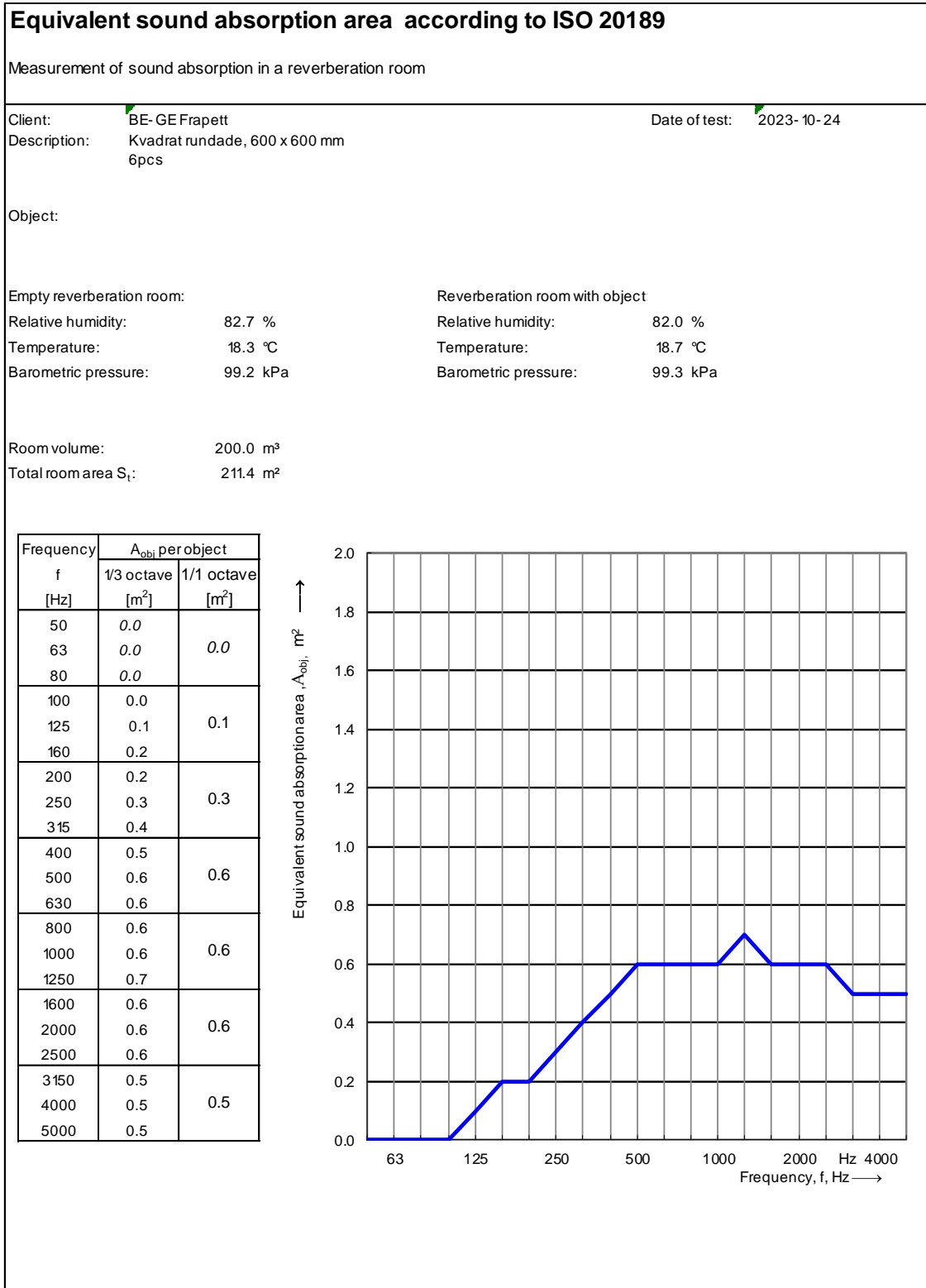
Appendix 1



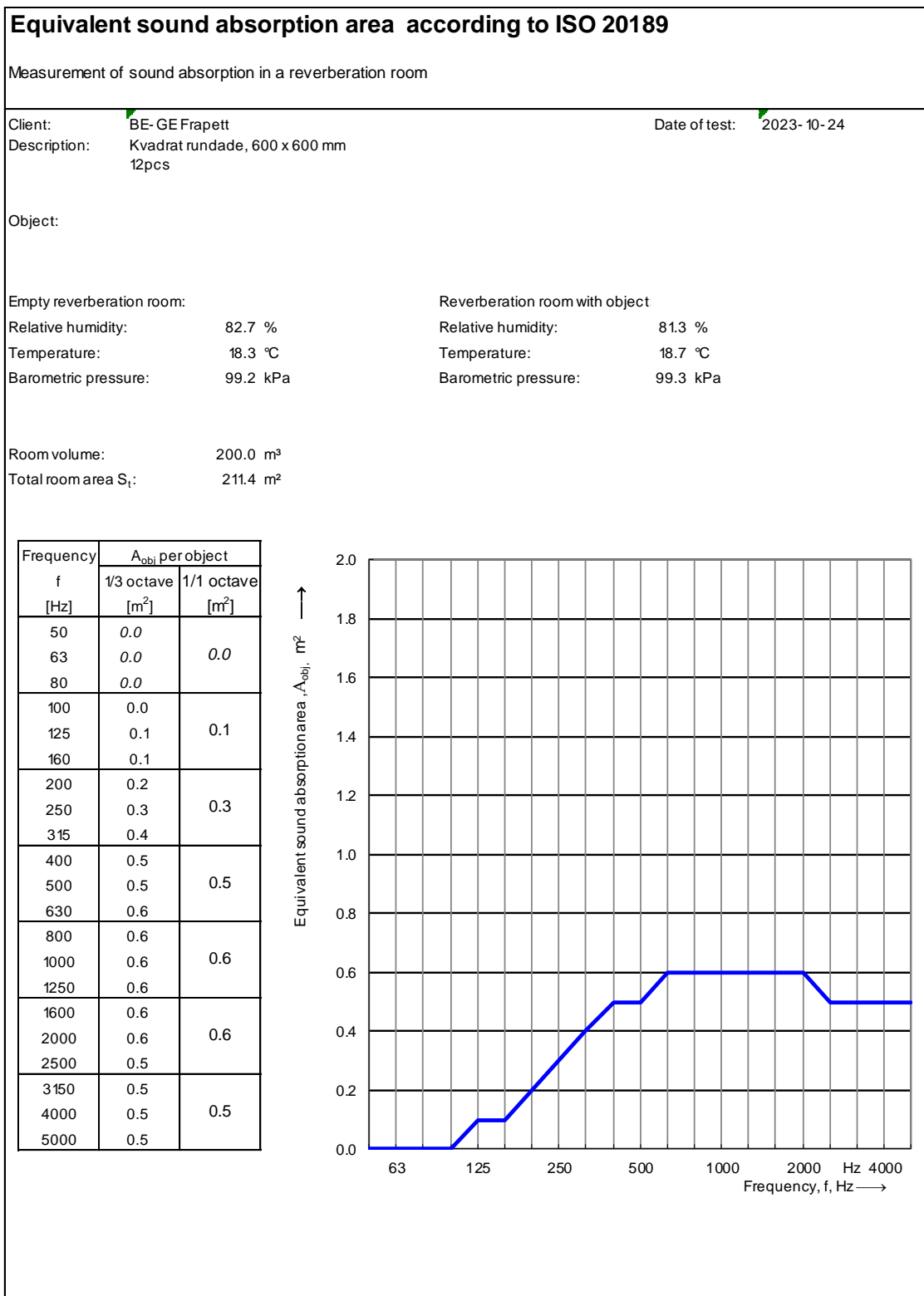
Appendix 2



Appendix 3



Appendix 4



Verification

Transaction 09222115557504429641

Document

O100282-1223036

Main document

12 pages

Initiated on 2023-11-09 15:47:32 CET (+0100) by Pontus Gräsberg (PG)

Finalised on 2023-11-13 08:15:24 CET (+0100)

Signatories

Pontus Gräsberg (PG)

RISE Research Institutes of Sweden AB

Company reg. no. 556464-6874

pontus.grasberg@ri.se

+46 10 516 68 17

Pontus Gräsberg

Signed 2023-11-13 08:15:24 CET (+0100)

Geir Andresen (GA)

RISE

geir.andresen@ri.se

Geir Andresen

Signed 2023-11-10 10:12:20 CET (+0100)

This verification was issued by Scrive. Information in italics has been safely verified by Scrive. For more information/evidence about this document see the concealed attachments. Use a PDF-reader such as Adobe Reader that can show concealed attachments to view the attachments. Please observe that if the document is printed, the integrity of such printed copy cannot be verified as per the below and that a basic print-out lacks the contents of the concealed attachments. The digital signature (electronic seal) ensures that the integrity of this document, including the concealed attachments, can be proven mathematically and independently of Scrive. For your convenience Scrive also provides a service that enables you to automatically verify the document's integrity at: <https://scrive.com/verify>

