TYRÉNS

REPORT

SUNDBYBERG KOMMUNHUS, EVALUATION OF OPEN PLAN OFFICES ACC. TO ISO 3382-3

2014-09-03

TYRÉNS

Project:	253520, Sundbyberg, mätning av rumsakustiska parametrar enligt SS-EN 3382-3
Report title:	Sundbybergs Kommunhus, Measurement and evaluation of room acoustic parameters in open plan offices acc. ISO 3382-3:2012
Version:	
Date:	2014-09-03

Participants

Customer:	Saint-Gobain Ecophon AB
Contact:	Frans Davidsson
Consultant:	Tyréns AB
Project manager:	Philip Zalyaletdinov
Administrator:	Philip Zalyaletdinov
Quality manager:	Martin Höjer

Revision

Revision date	2014-11-28
Version:	Rev.02
Initials:	

Author: Philip Zalyaletdinov

Date: 2014-11-28

Quality manager: Martin Höjer

Date: 2014-11-28

Tyréns AB

118 86 Stockholm
Besök: Peter Myndes Backe 16

Tel: 010 452 20 00
www.tyrens.se

Säte: Stockholm
Org.Nr: 556194-7986

Contents

1 Bakground

Room acoustic parameters of four open plan offices at Sundbybergs kommunhus have been evaluated according to ISO 3382-3:2012.

Following acoustic parameters have been evaluated:

- D_2,s – Spatial decay rate of speech
- $L_{p,}$A,S,4 m – A-weighted sound pressure level of speech at distance of 4 m
- $L_{p,}$A,B – A-weighted background noise level
- $r_{D\ -}$ Distraction distance
- r_P – Privacy distance
- r_C – Radius of comfort[1]

Measurements were carried out along four measurement paths in open offices situated on buildings floor 4 and 5.

Three different acoustic conditions were evaluated for each measurement path:

1. Partly reflective ceiling (55 % of the sound absorbing ceiling tiles were replaced with sound reflective plaster board)
2. Sound absorbing ceiling
3. Sound absorbing ceiling with complementary sound absorbing segments on walls see Figure 1 and 2)

[1] The distance from the sound source where the sound pressure of speech meets 48 dBA, which is the targeted value of $L_{p,}$A,S,4 m according to ISO 3382-3:2012. The radius of comfort formula was suggested by E. Nilsson and B. Hellström (Nordic Innovation, NT technical report 619). Formula: $r_C = 4 \times 10^{0,3(Lp,A,S,4m-Lc)/D2,S}$, 48 dBA in this case defined as the comfort level $L_{c.}$

2 Room description and measurement procedure

Measurements were carried out along four measurement paths, two of the paths are situated on the floor 4 (path 4.1 and 4.2) and the other two on floor 5 (path 5.1 and 5.2). Sound source- and measurement positions are presented in Figure 1. Office floors are acoustically connected by an open atrium, situated in the center of the building. Measurement path 4.1 and 5.1 are situated in close proximity to the atrium.

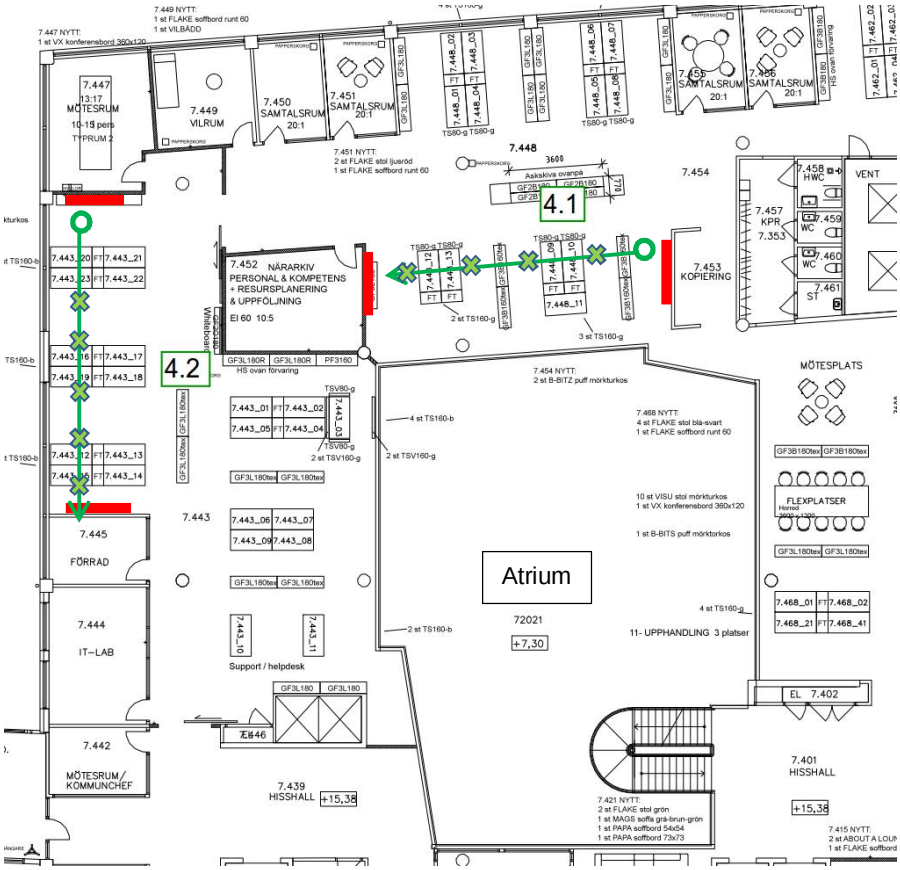


Figure 1 Location of measurement paths and on floor 4. Sound absorbing wall segments are marked with red.

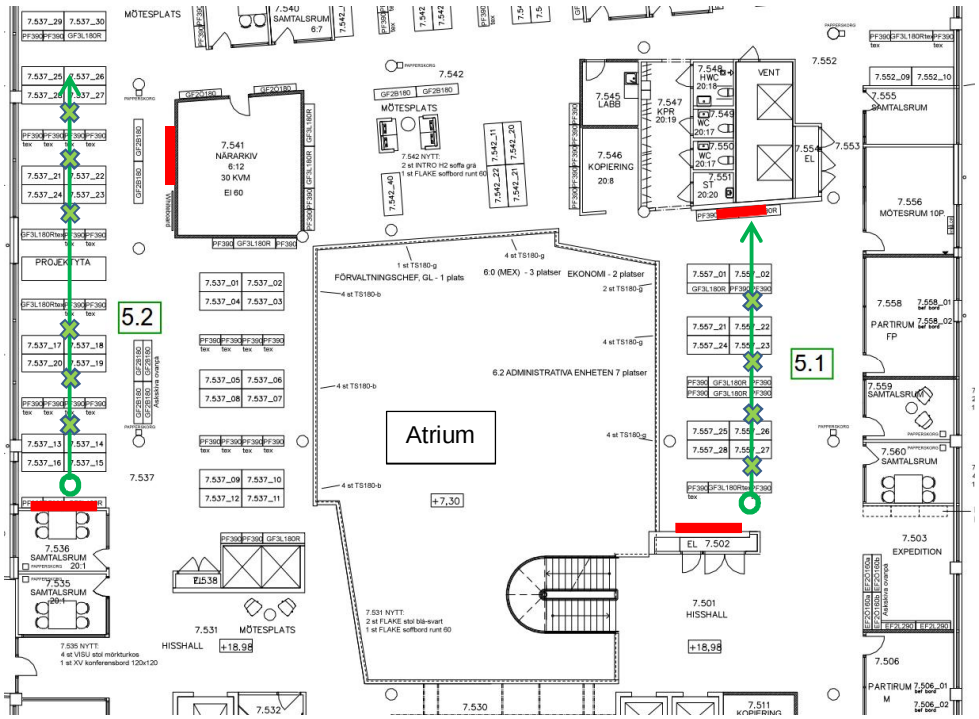


Figure 2 Location of measurement paths and on floor 5. Sound absorbing wall segments are marked with red.

The measurements have been performed in furnished rooms without staff. Placement of measurements points and sound sources was chosen in accordance with ISO 3382:3, e.g.1,2 m above floor surface, minimum 0,5 m from table surfaces, minimum 2 m from large, reflecting surfaces (walls).

Because of the current furnishment plan it was not always possible to fulfill the ISO 3382:3 recommendation regarding closest distance to walls

Gain of the measurement signal (pink noise) was adjusted so that measured sound pressure levels of the measurement signal was at least 10 dB higher (octave bands 125 Hz – 8kHz) than the background noise level in all measurement positions.

All table mounted sound screens along the measurement paths were adjusted for same height above the floor level (1,15 m). Workgroups (4 work stations) along the path are divided with 1,3 m high, closed book cases.

The ceiling was covered with sound absorbing, suspended tiles (Ecophon Gedina 15 mm), mounted 2,8 m above the floor, see Appendix 1 for sound absorption data.

For acoustic condition with reflective ceiling 55 % of the sound absorbing ceiling tiles were replaced with 13 mm plaster board.

For the acoustic condition with complementary sound absorbing segments the wall surfaces marked with red in Figure 1 and 2 were partly covered with 40 mm Ecophon Wallpanel, see Appendix 1 for sound absorption data.

The floor was covered with textile carpeting.

The study was divided in two different measurement sessions:

Acoustic conditions 2 and 3 (2- sound absorbing ceiling, 3- absorbing ceiling with complementary wall absorption) for path 4.1 and 4.2 and acoustic condition 1 (partly reflective ceiling) were evaluated during the second measurement session.

Acoustic condition 1 for path 4.1 and 4.2 and acoustic conditions 2 and -3 for path 5.1 and 5.2 were evaluated during the second measurement session.

Ventilation system was turned off during the first measurement session, background noise levels are therefore not presented for acoustic conditions that were evaluated during the first session.

The STI-based acoustic parameters r_P and r_C were calculated from measured impulse responses. Background noise levels that were used in calculations of these parameters were registered during the second measurement session.

Reverberation time (T_{20} and EDT) were evaluated from measured impulse responses. It was not possible to evaluate T_{20} for all acoustic conditions and paths because of highly unlinear reverberation decays[2] (that was especially evident for measurement points close to the atrium path 4.1 and 5.1).

Figure 3 Measurment path 5.2, Acoustic condition 3 – sound absorbing ceiling with complementary wall absorption

[2] The reverberation field of most open offices is not diffuse (long, flat rooms with sound absorption concentrated to the ceiling), which results in highly unlinear reverberation decays with several slopes. The classic theory (Sabine, Eyring) relationship between the reverberation time and sound absorption area is not valid in this type of rooms. In rooms with low diffusivity bigger sound absorption area can in some cases give rise to longer measured reverberation times (2D and 1D sound fields dominate the decay curve).

Figure 4 Measurement path 5.1 – Acoustic condition 1 –partly reflective ceiling

Figure 5 Measurement path 4.2 – loudspeaker placement

3 Results – Spatial decay rate

Measurement path 4.1

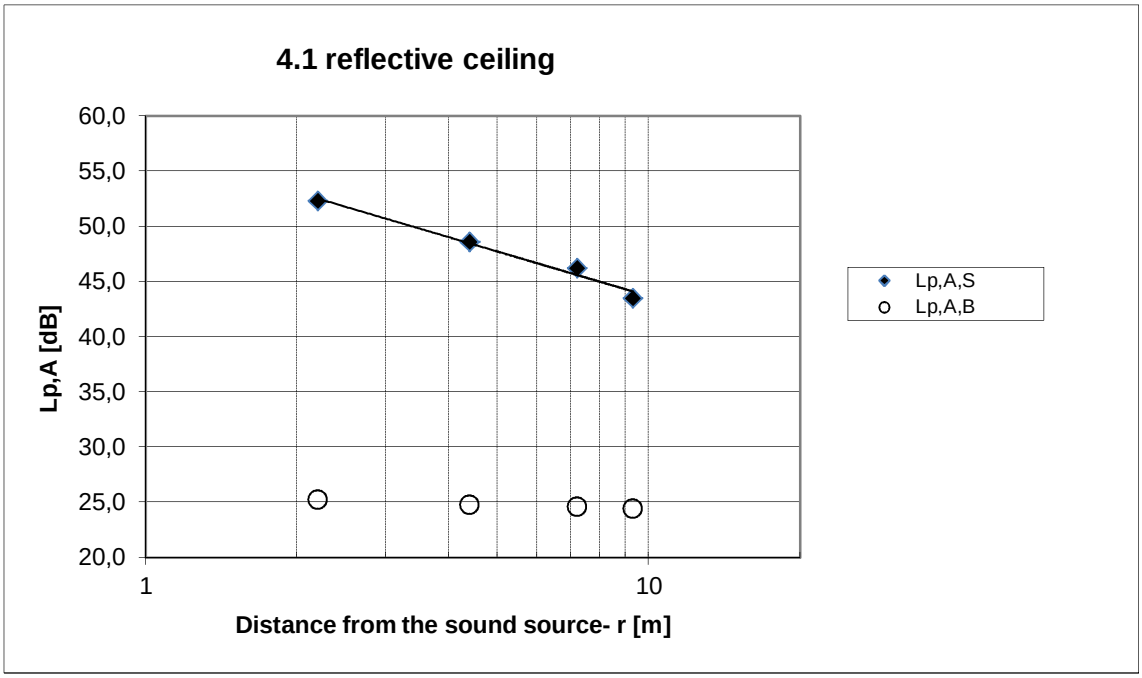


Figure 6 Sound pressure level of speech and measured background noise level along path 4.1 – with reflective ceiling

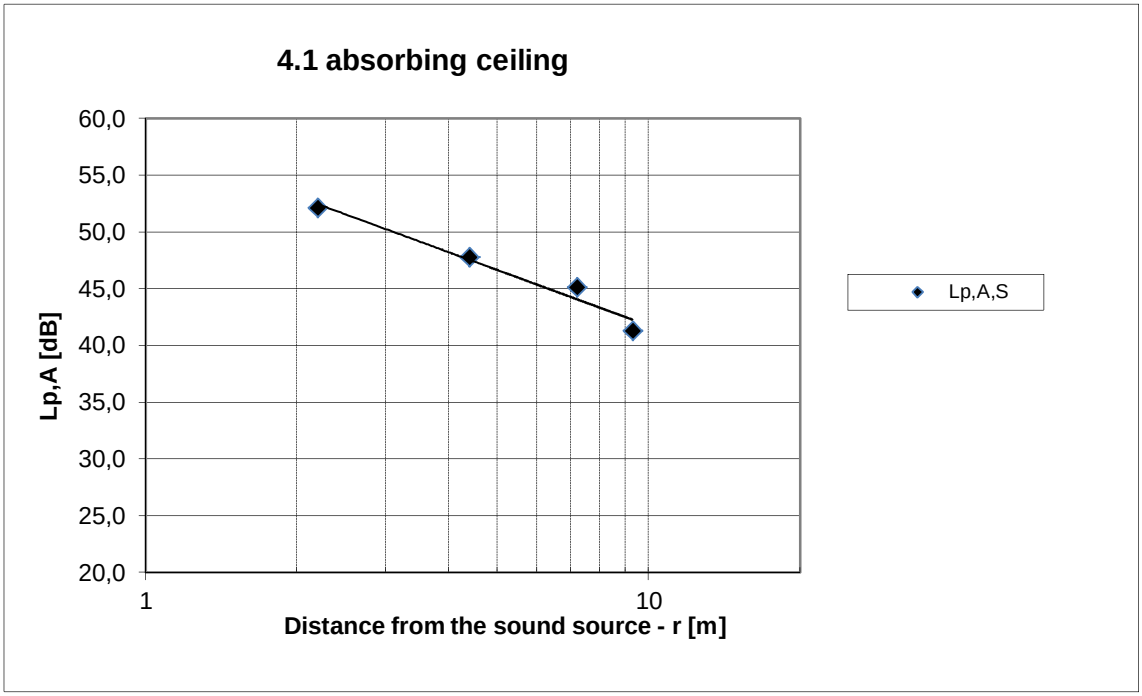


Figure 7 Sound pressure level of speech along path 4.1 – with sound absorbing ceiling

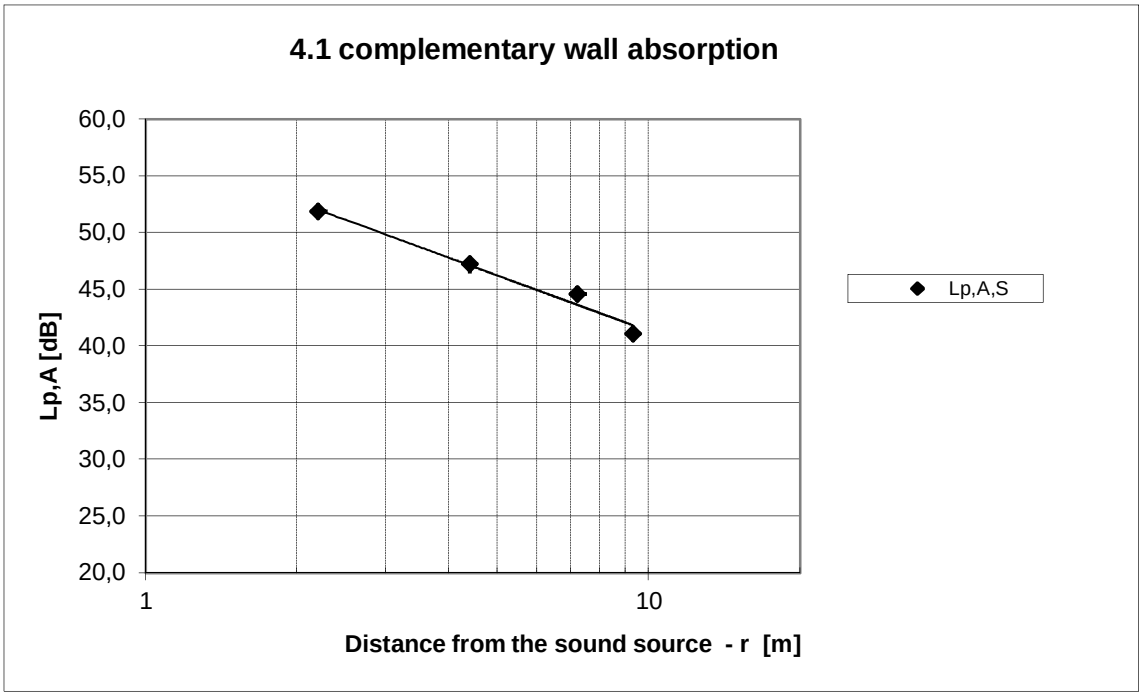


Figure 8 Sound pressure level of speech along path 4.1 – with sound absorbing ceiling and wall absorption

Measurement path 4.2

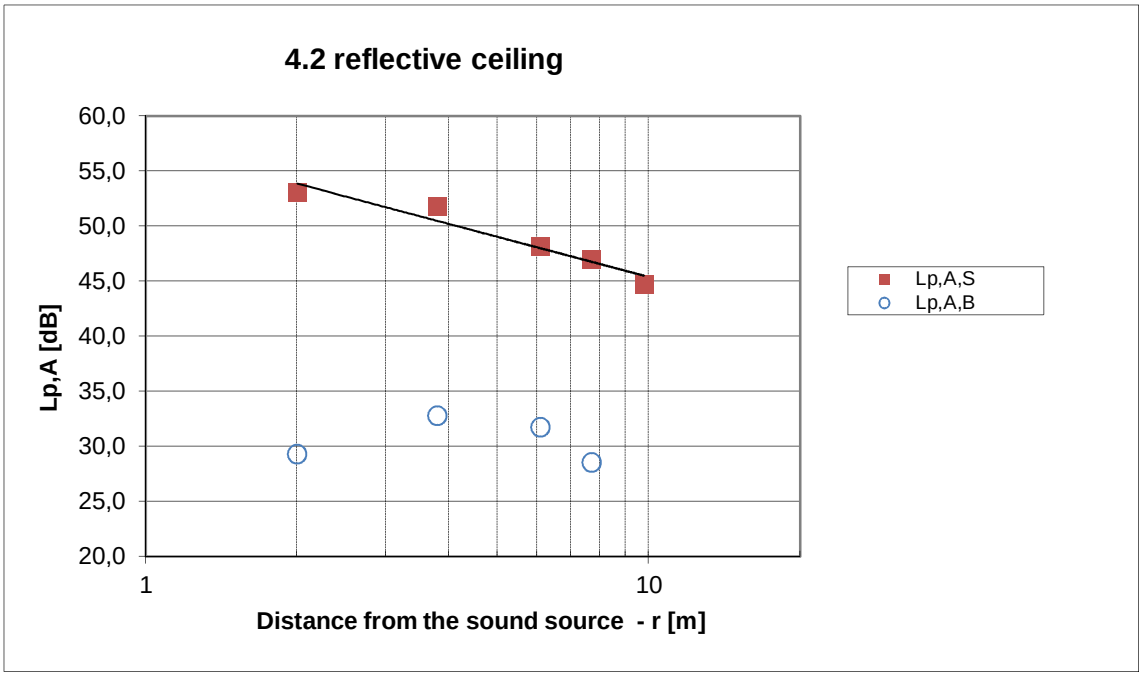


Figure 9 Sound pressure level of speech and measured background noise level along path 4.2 – with reflective ceiling

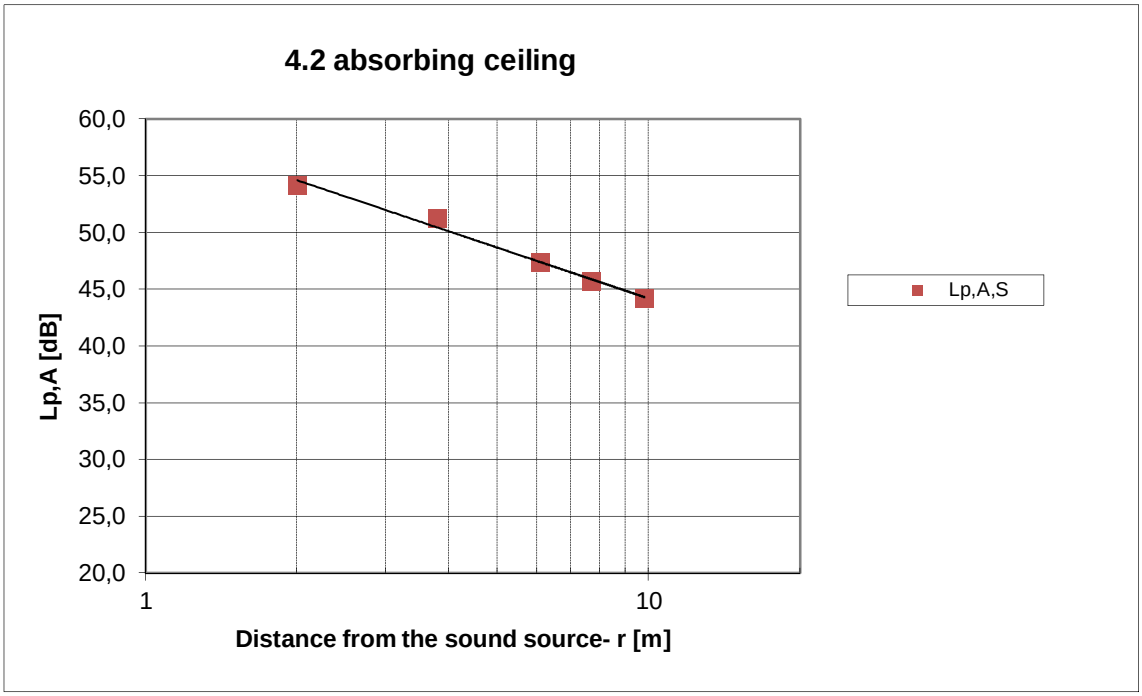


Figure 10 Sound pressure level of speech along path 4.2 – with sound absorbing ceiling

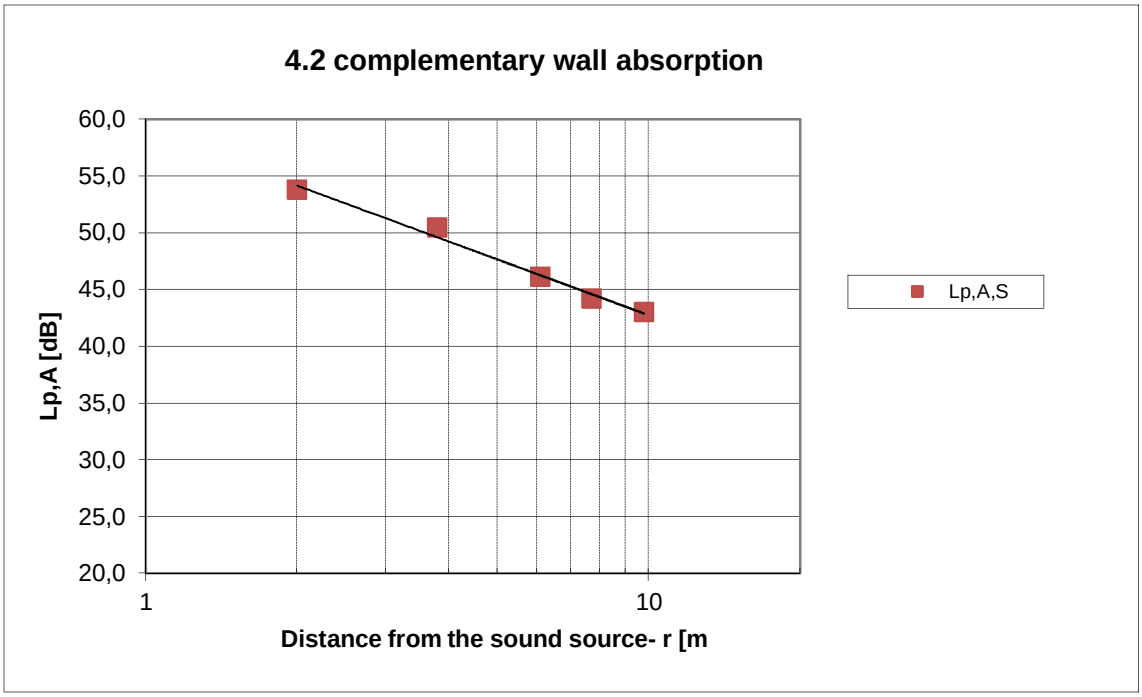


Figure 11 Sound pressure level of speech along path 5.1 – with sound absorbing ceiling and wall absorption

Measurement path 5.1

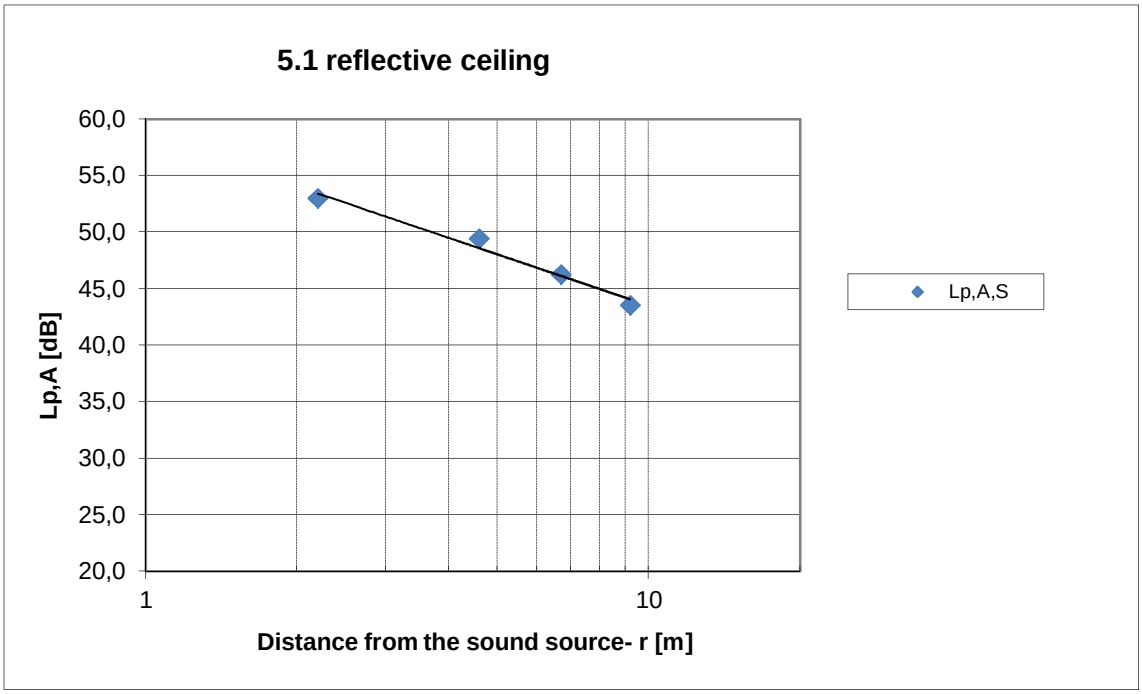


Figure 12 Sound pressure level of speech along path 5.1 – with reflective ceiling

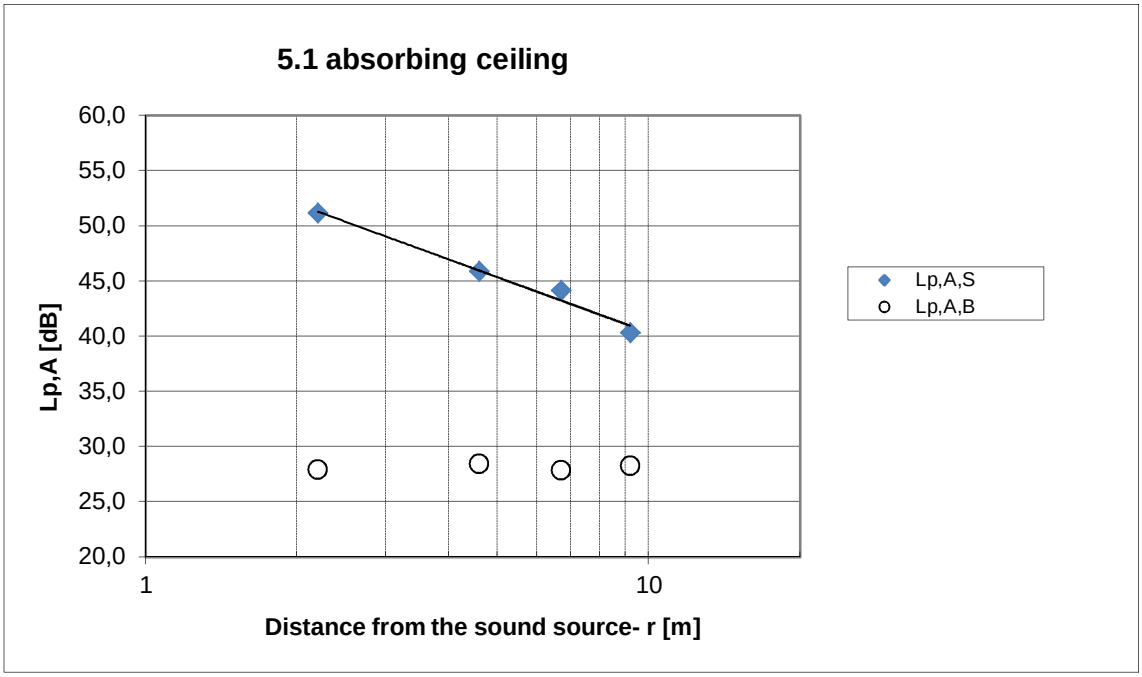


Figure 13 Sound pressure level of speech and measured background noise level along path 5.1 – with sound absorbing ceiling

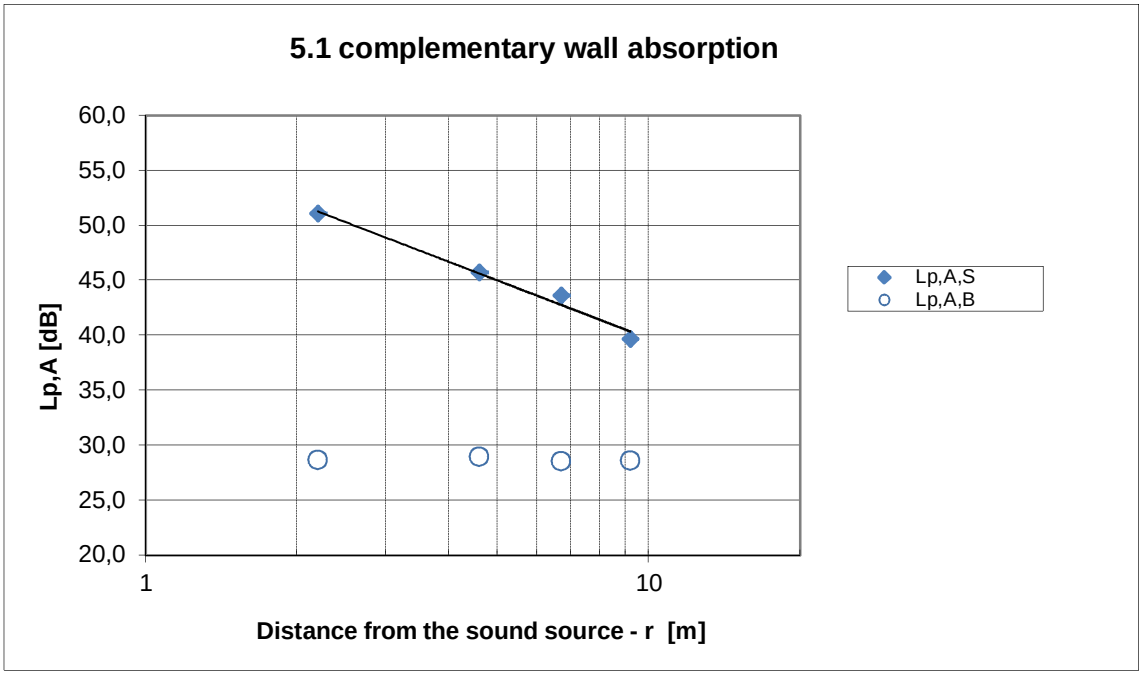


Figure 14 Sound pressure level of speech and measured background noise level along path 5.1 – with sound absorbing ceiling and wall absorption

Measurement path 5.2

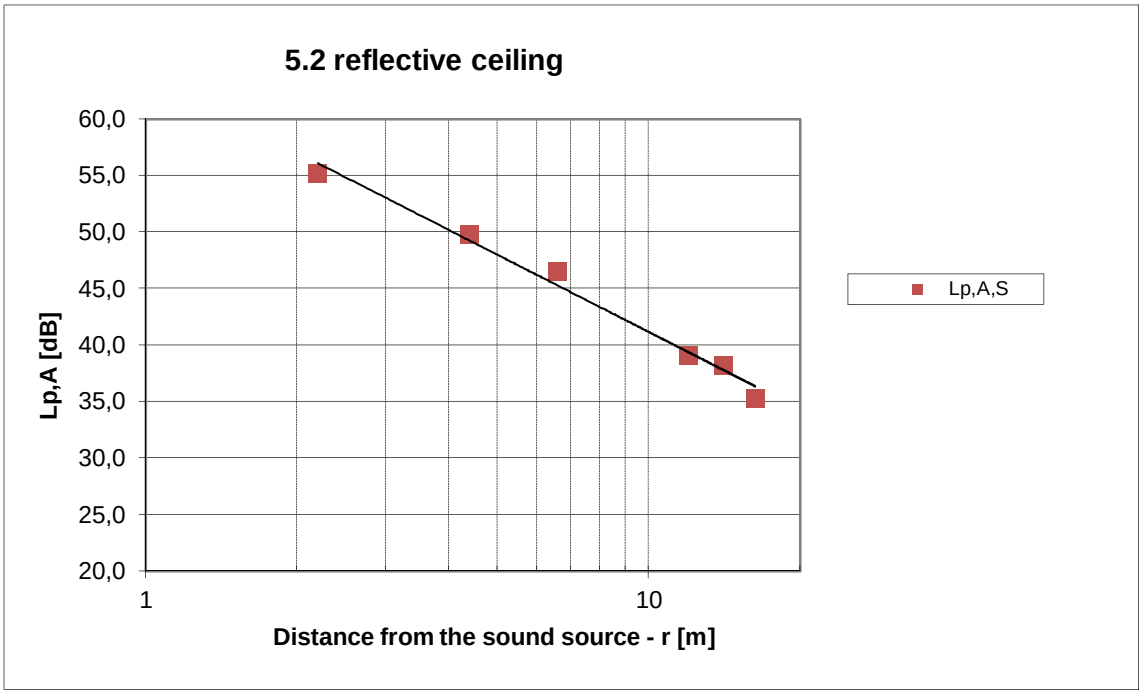


Figure 15 Sound pressure level of speech along path 5.2 – with reflective ceiling

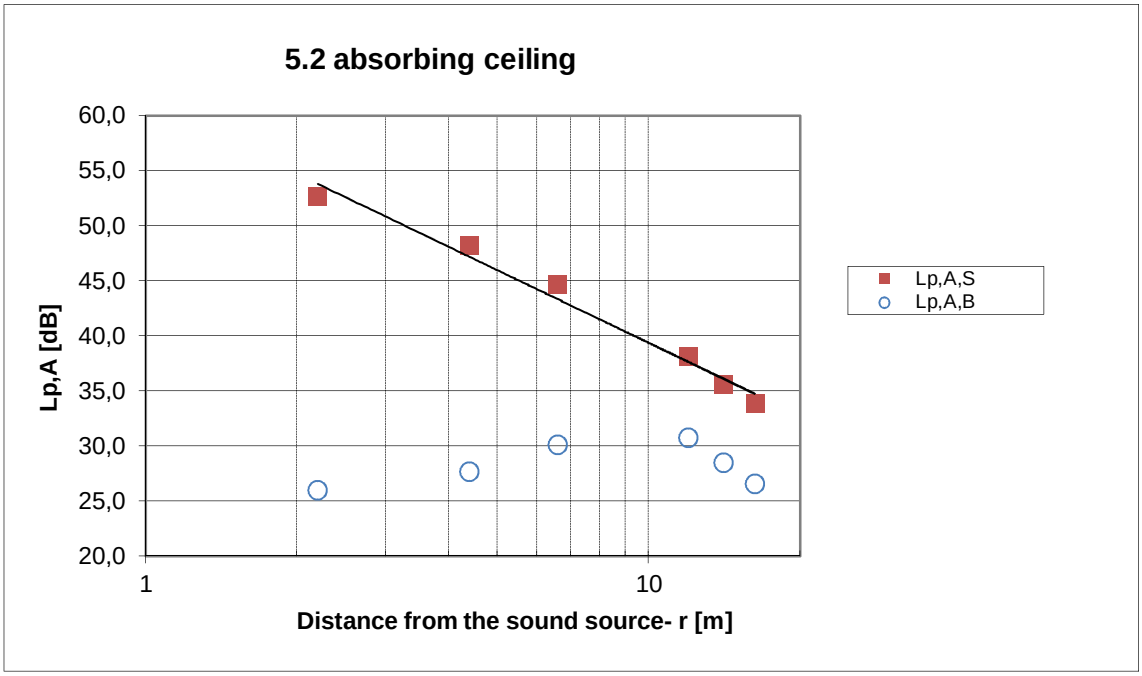


Figure 16 Sound pressure level of speech and measured background noise level along path 5.2 – with sound absorbing ceiling

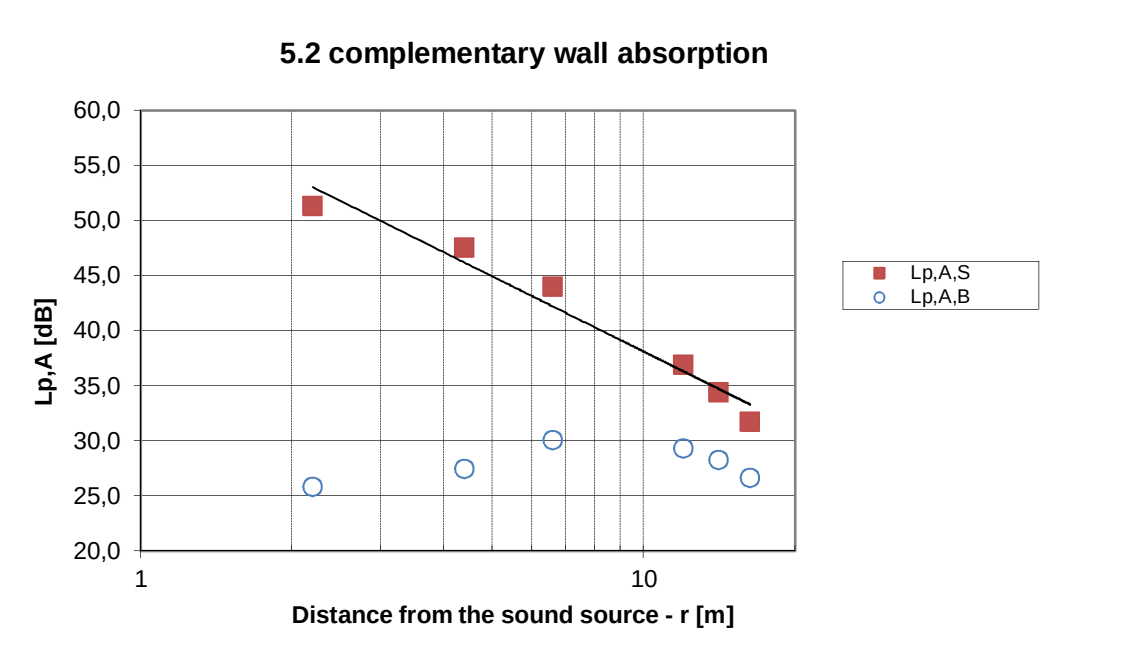


Figure 17 Sound pressure level of speech and measured background noise level along path 5.2 – with sound absorbing ceiling and wall absorption

Summary

Table 1 Summary of the measurement results

Path	Acoustic condition	$D_{2,S}$ [dB]	L_p,A,S,4 m [dB]	r_C [m]
4.1	Reflective ceiling	4,0	49,0	5,3
4.1	Absorbing ceiling	4,9	48,2	4,5
4.1	Complementary wall absorption	4,9	47,8	4,2
4.2	Reflective ceiling	3,6	50,2	6,8
4.2	Absorbing ceiling	4,5	50,1	6,1
4.2	Complementary wall absorption	4,9	49,3	5,2
5.1	Reflective ceiling	4,5	49,5	5,5
5.1	Absorbing ceiling	5,0	47,0	3,8
5.1	Complementary wall absorption	5,3	46,7	3,7
5.2	Reflective ceiling	6,8	50,2	5,3
5.2	Absorbing ceiling	6,6	48,1	4,3
5.2	Complementary wall absorption	6,8	47,1	3,9

$D_{2,S} \geq 7$ dB och **L_p,A,S,4 m $\leq$ 48 dB** are considered as appropriate target values for open plan offices with good acoustic conditions, acc. to SS-EN ISO 3382-3:2012 Annex A

4 Results – STI based parameters

Measurement path 4.1

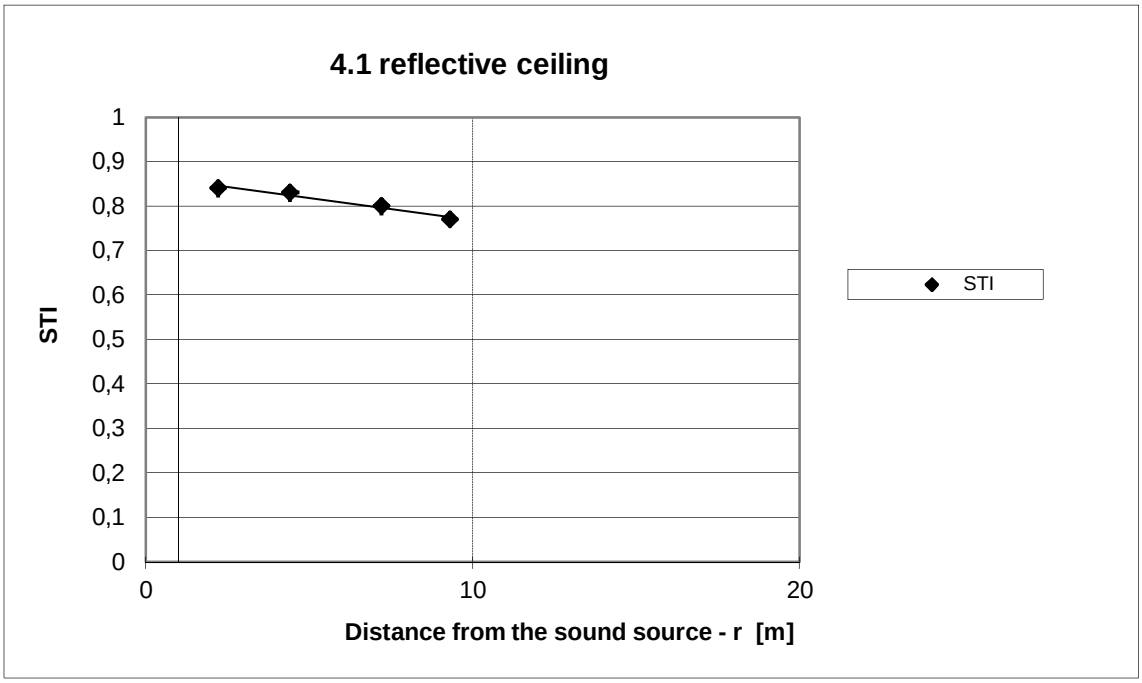


Figure 18 STI along path - 4.1 with sound reflective ceiling

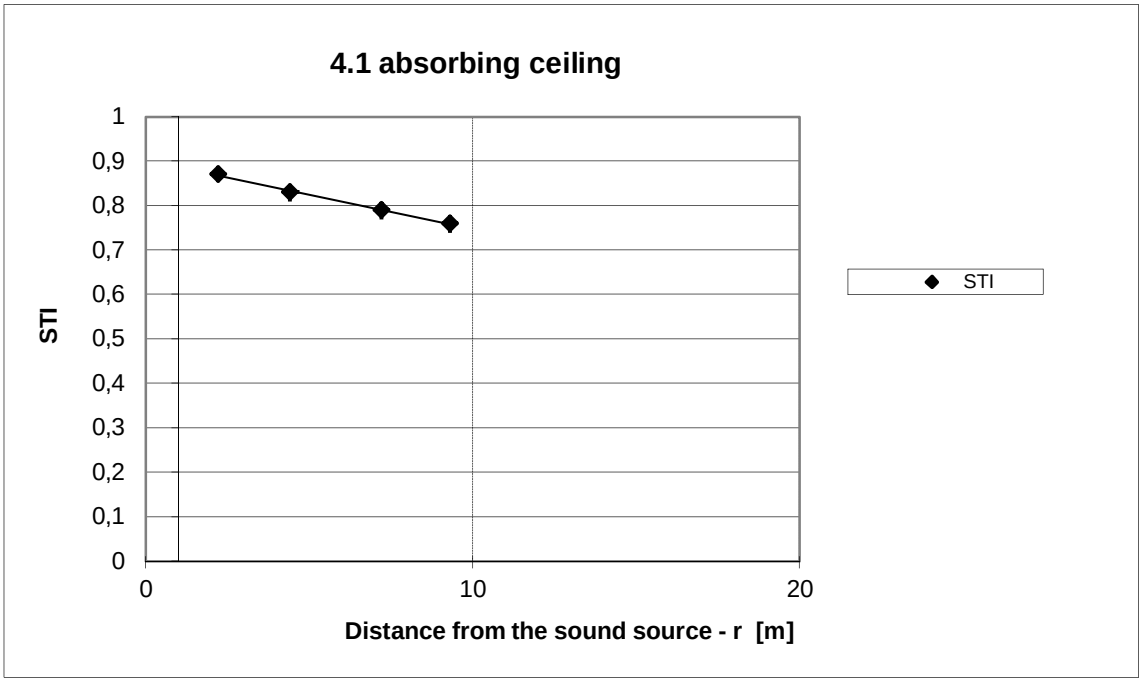


Figure 19 STI along path - 4.1 with sound absorbing ceiling

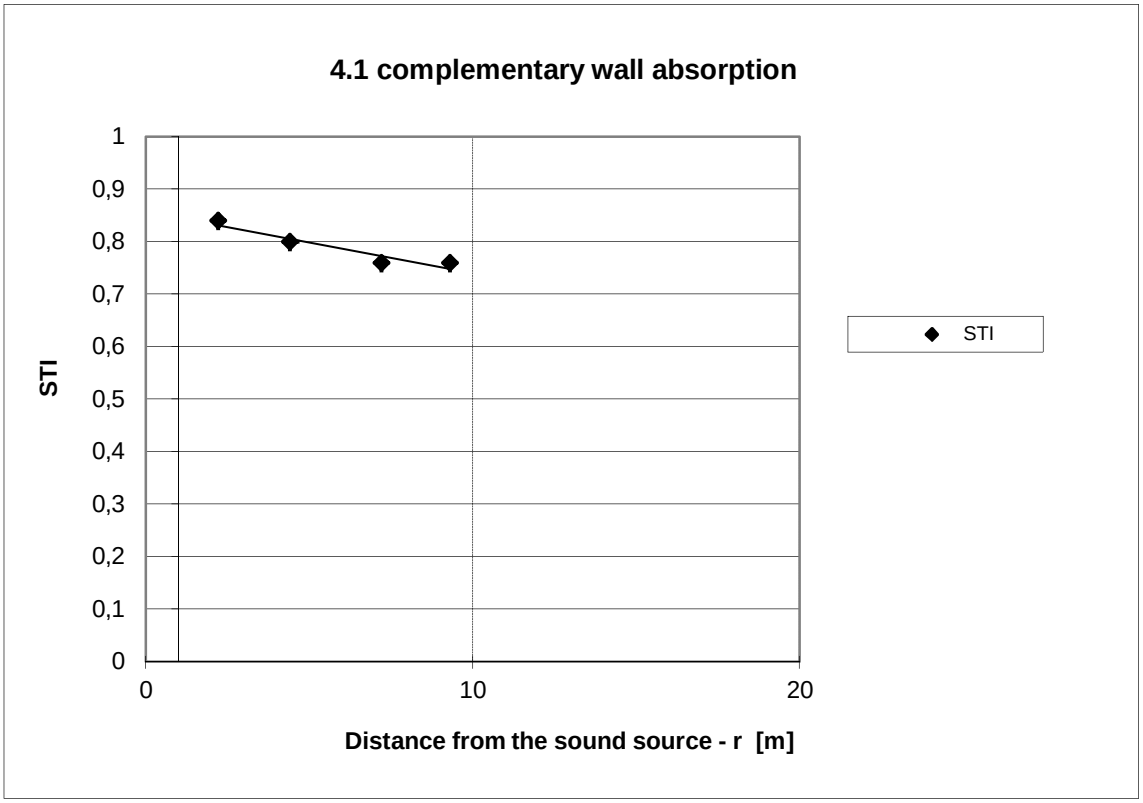


Figure 20 STI along path - 4.1 with sound absorbing ceiling and wall absorption

Measurement path 4.2

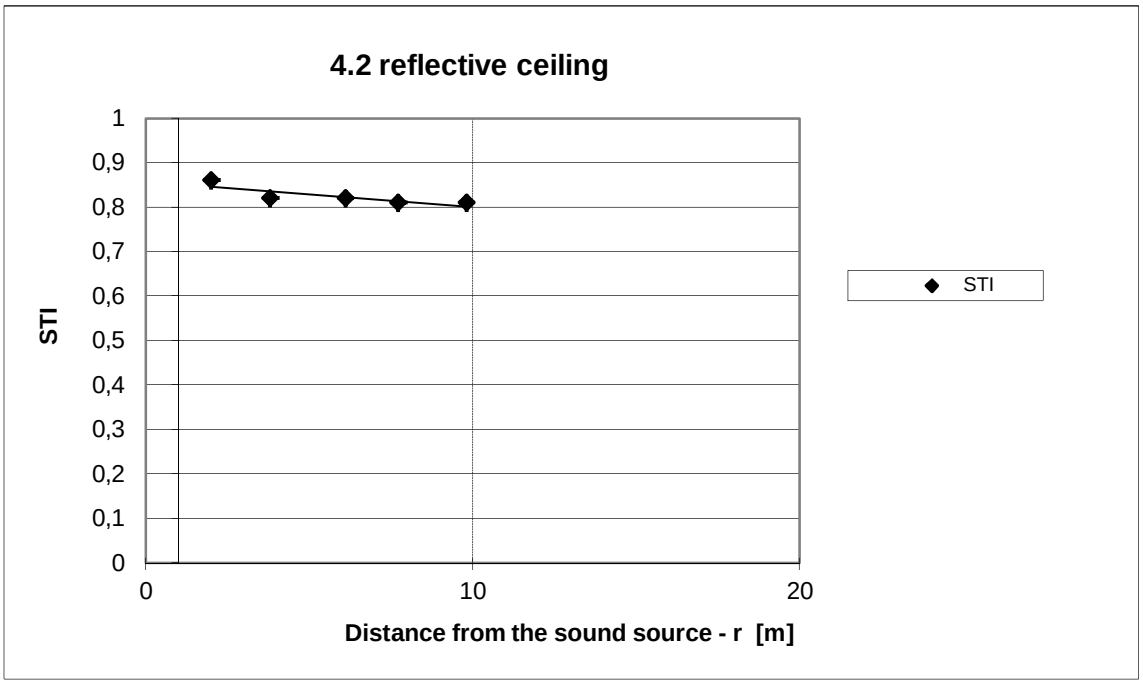


Figure 21 STI along path - 4.2 with sound reflective ceiling

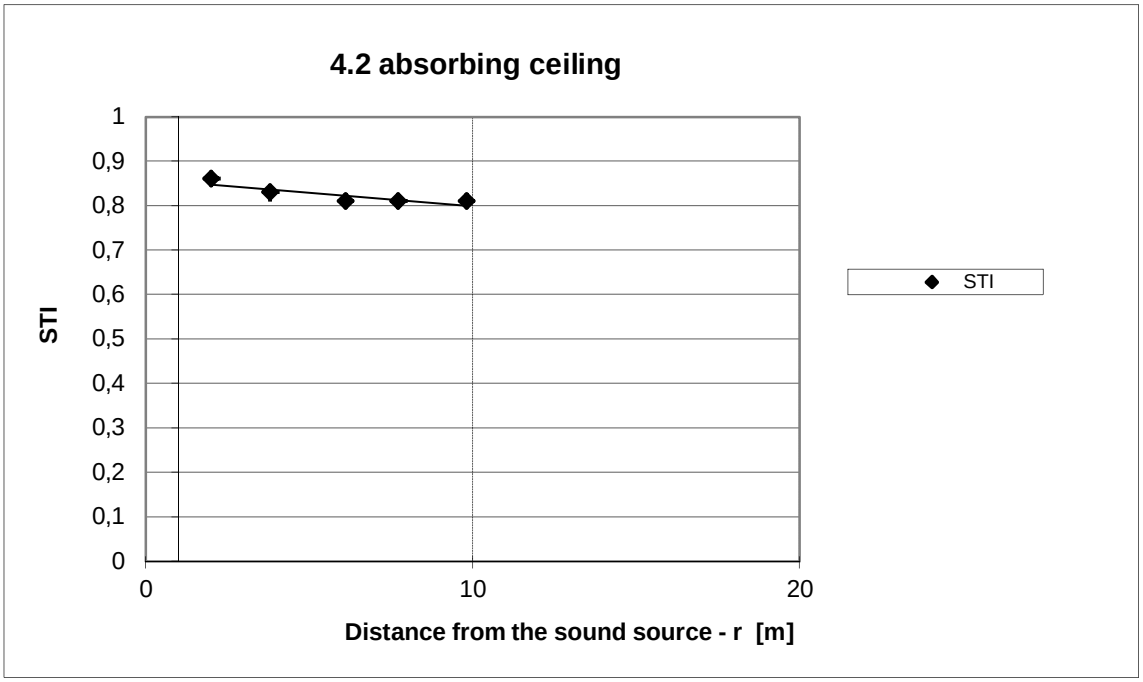


Figure 22 STI along path - 4.2 with sound absorbing ceiling

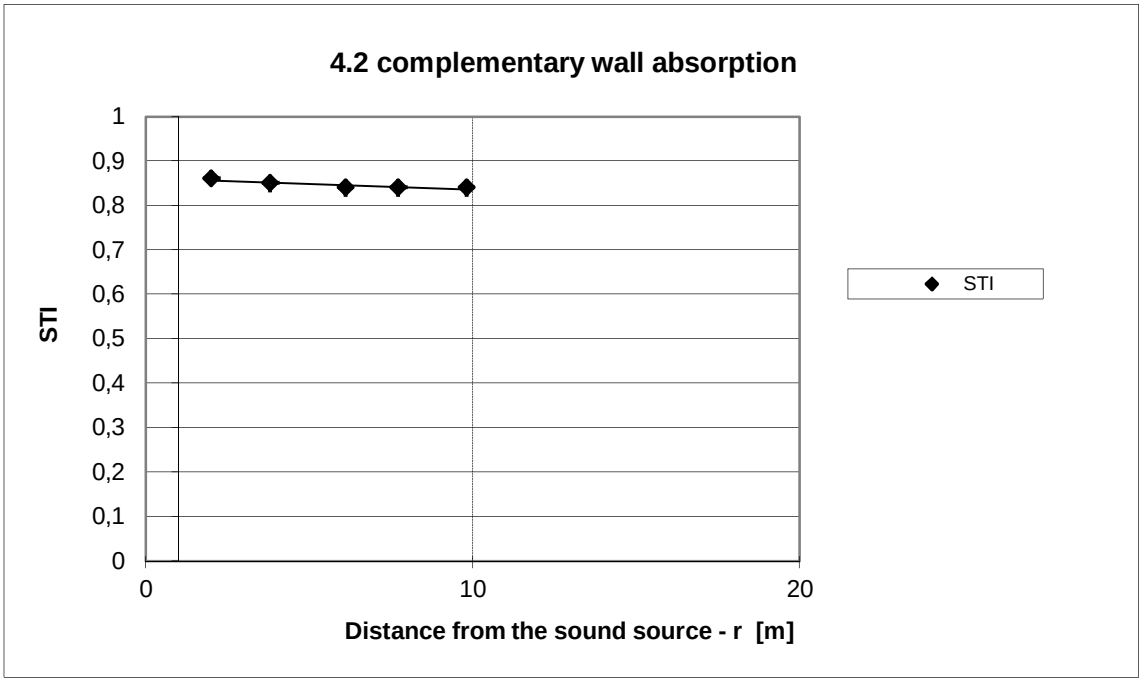


Figure 23 STI along path - 4.2 with sound absorbing ceiling and wall absorption

Measurement path 5.1

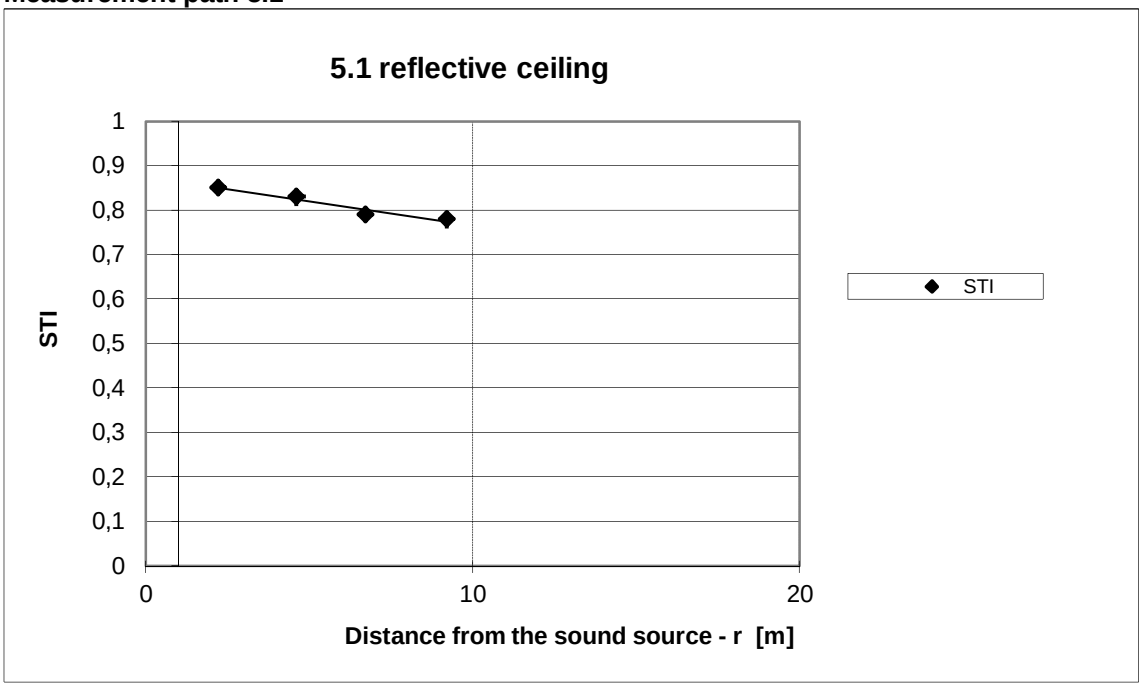


Figure 24 STI along path - 5.1 with sound reflective ceiling

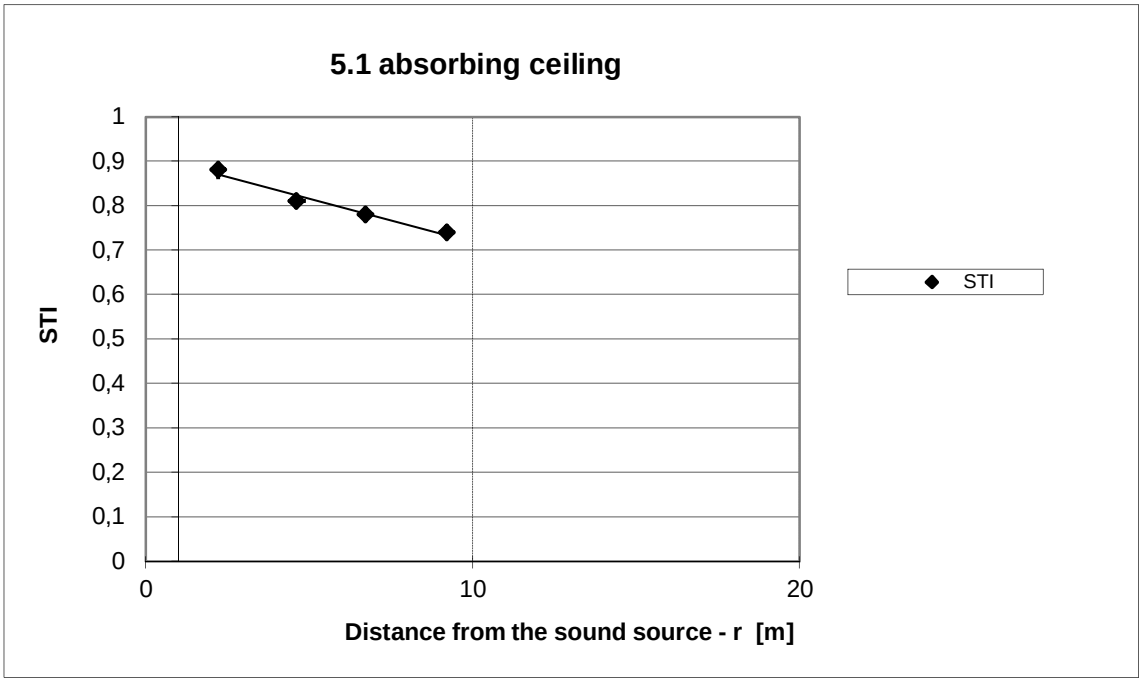


Figure 25 STI along path - 5.1 with sound absorbing ceiling

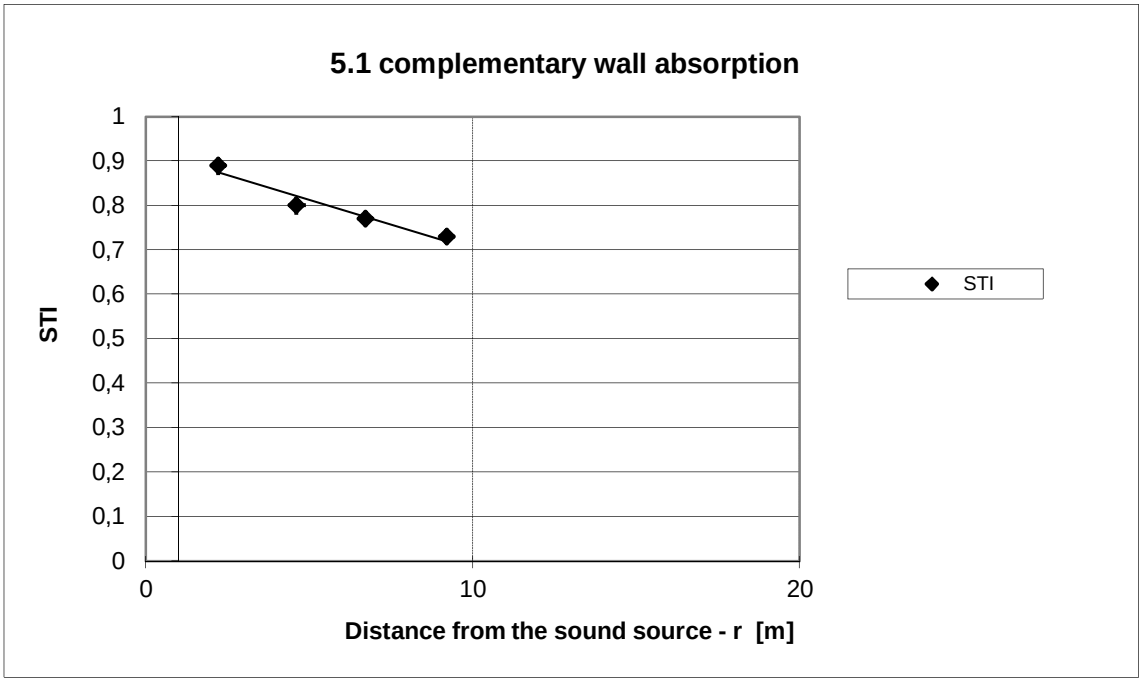


Figure 26 STI along path - 5.1 with sound absorbing ceiling and wall absorption

Measurement path 5.2

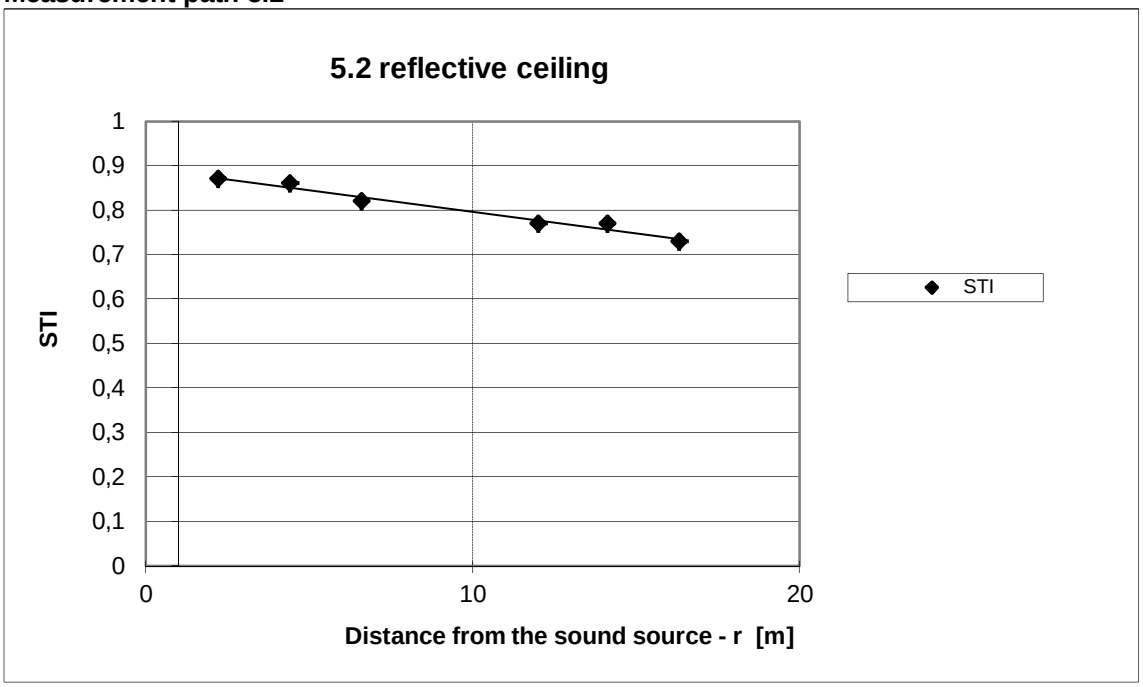


Figure 27 STI along path - 5.2 with sound reflective ceiling

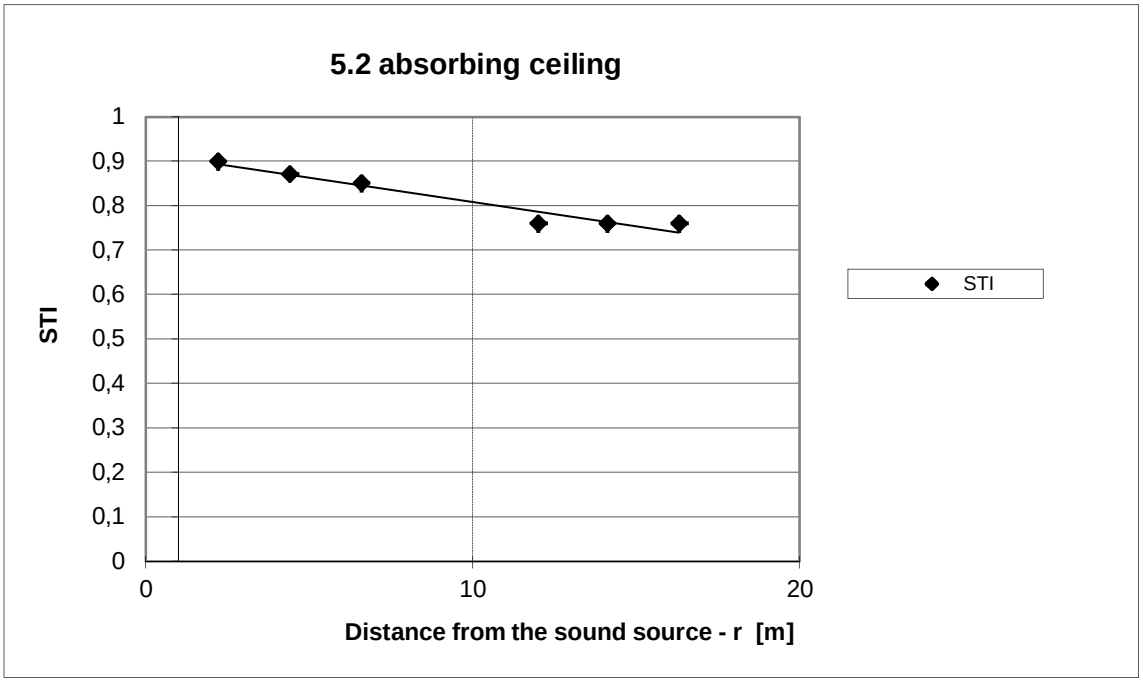


Figure 28 STI along path - 5.2 with sound absorbing ceiling

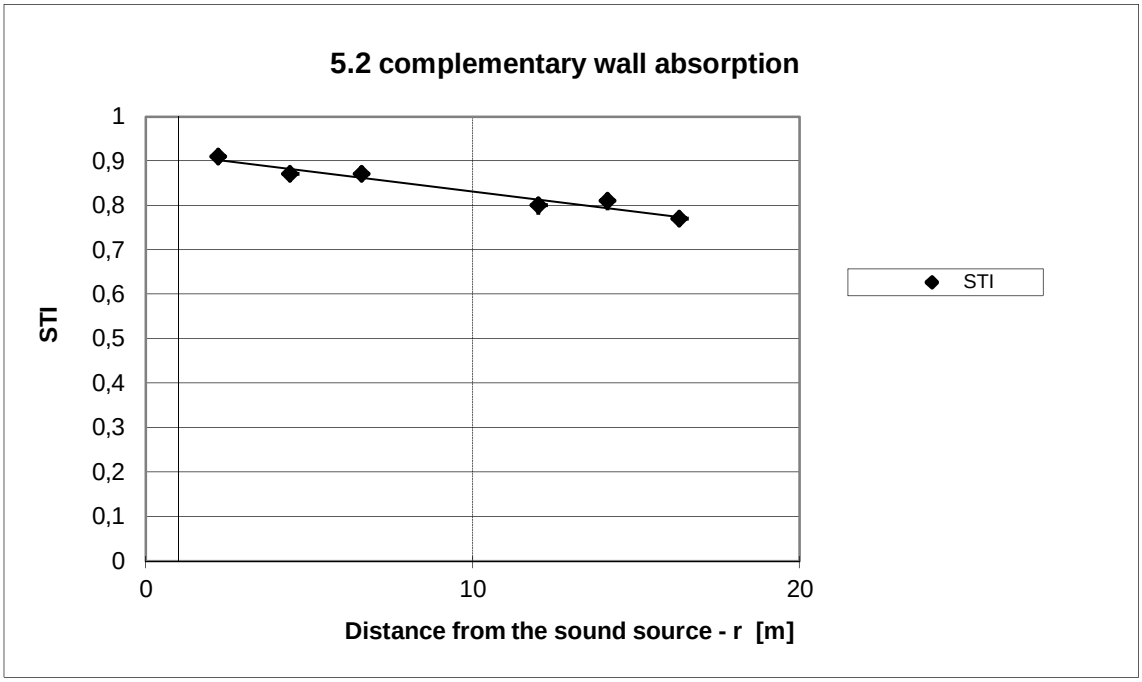


Figure 29 STI along path - 5.2 with sound absorbing ceiling and wall absorption

Summary

Table 2 Summary of the measurement results

Path	Acoustic condition	r_D [m]	r_p [m]
4.1	Reflective ceiling	37	67
4.1	Absorbing ceiling	26	46
4.1	Complementary wall absorption	31	56
4.2	Reflective ceiling	64	117
4.2	Absorbing ceiling	58	107
4.2	Complementary wall absorption	139	254
5.1	Reflective ceiling	35	63
5.1	Absorbing ceiling	21	37
5.1	Complementary wall absorption	19	33
5.2	Reflective ceiling	41	71
5.2	Absorbing ceiling	38	65
5.2	Complementary wall absorption	46	79

4.1 Results – Reverberation time

Measurement path 4.1

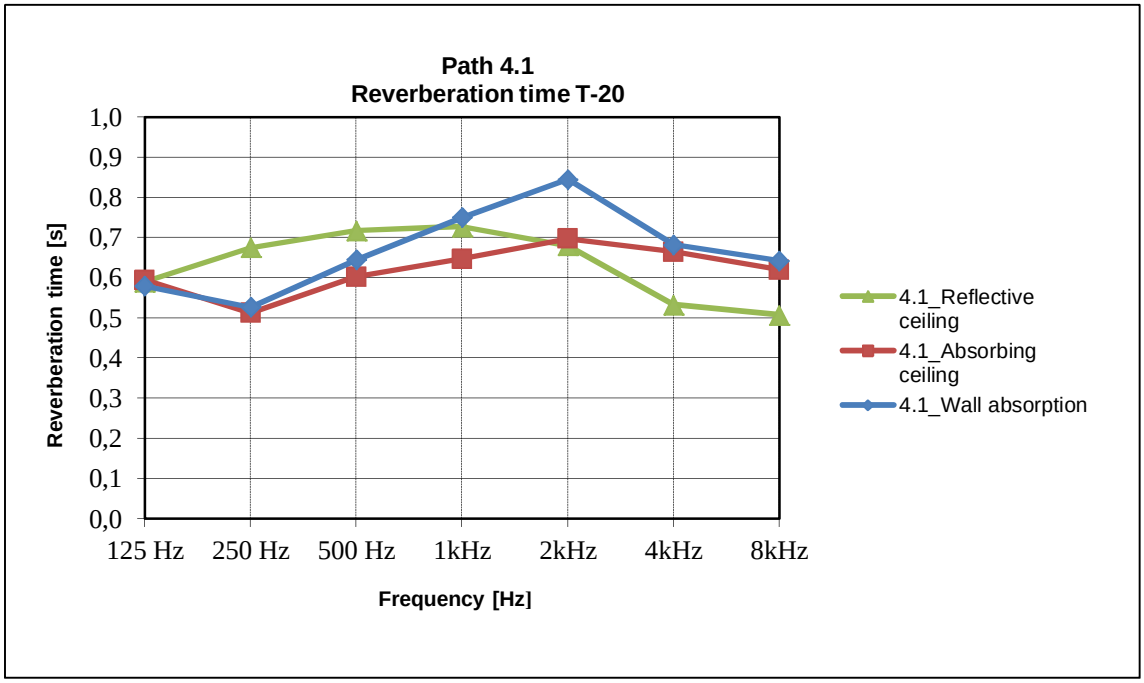


Figure 30 Reverberation time T_{20} – Path 4.1

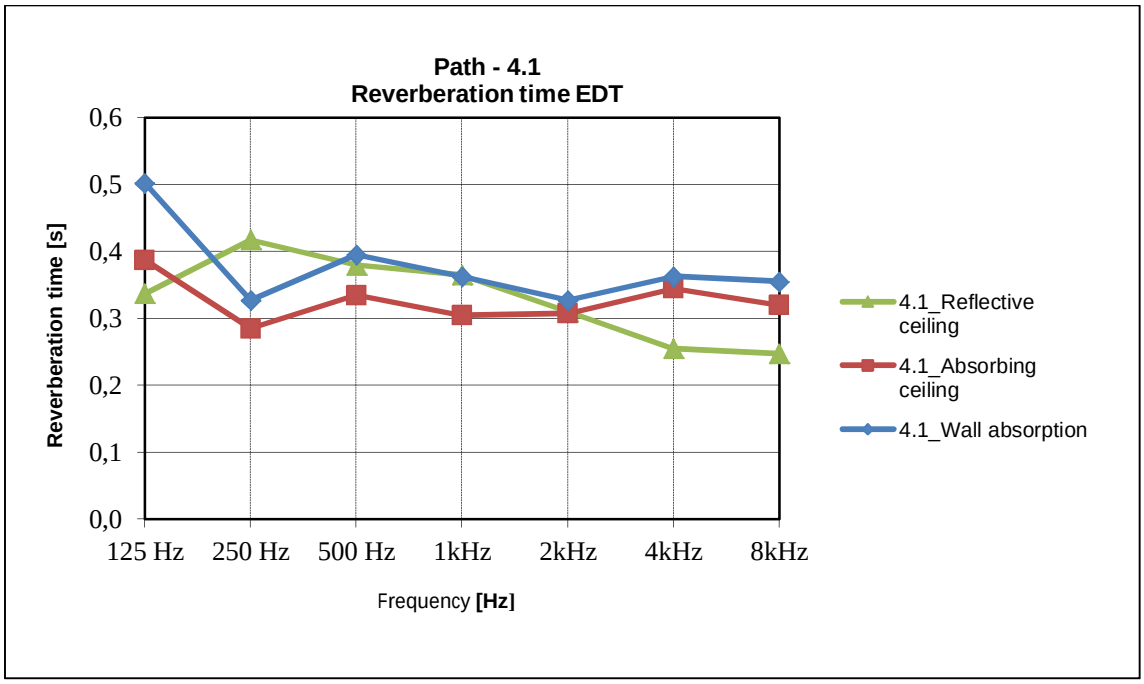


Figure 31 Reverberation time EDT – Path 4.1

Measurement path 4.2

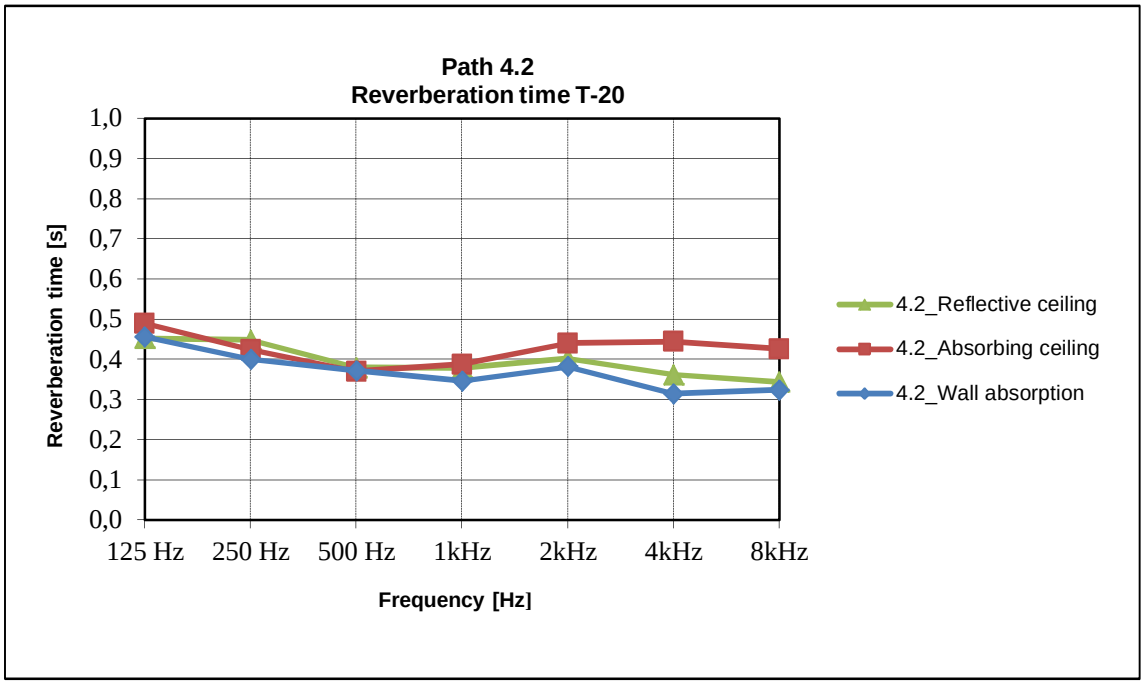


Figure 32 Reverberation time T20 – Path 4.2

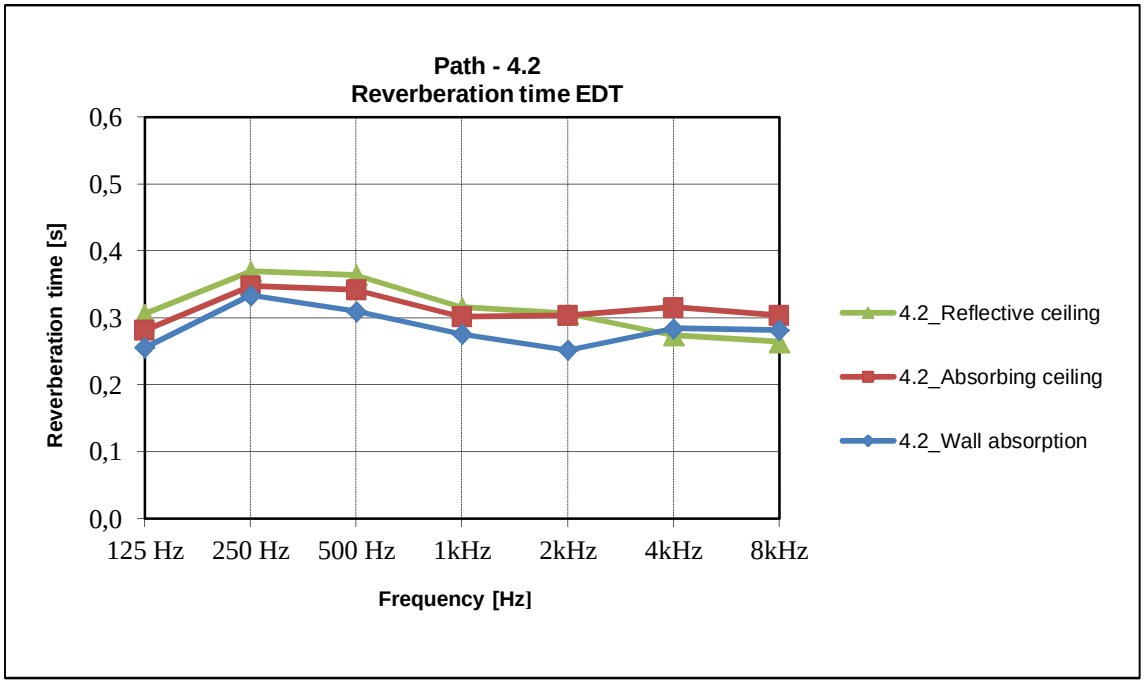


Figure 33 Reverberation time EDT – Path 4.2

Measurement path 5.1

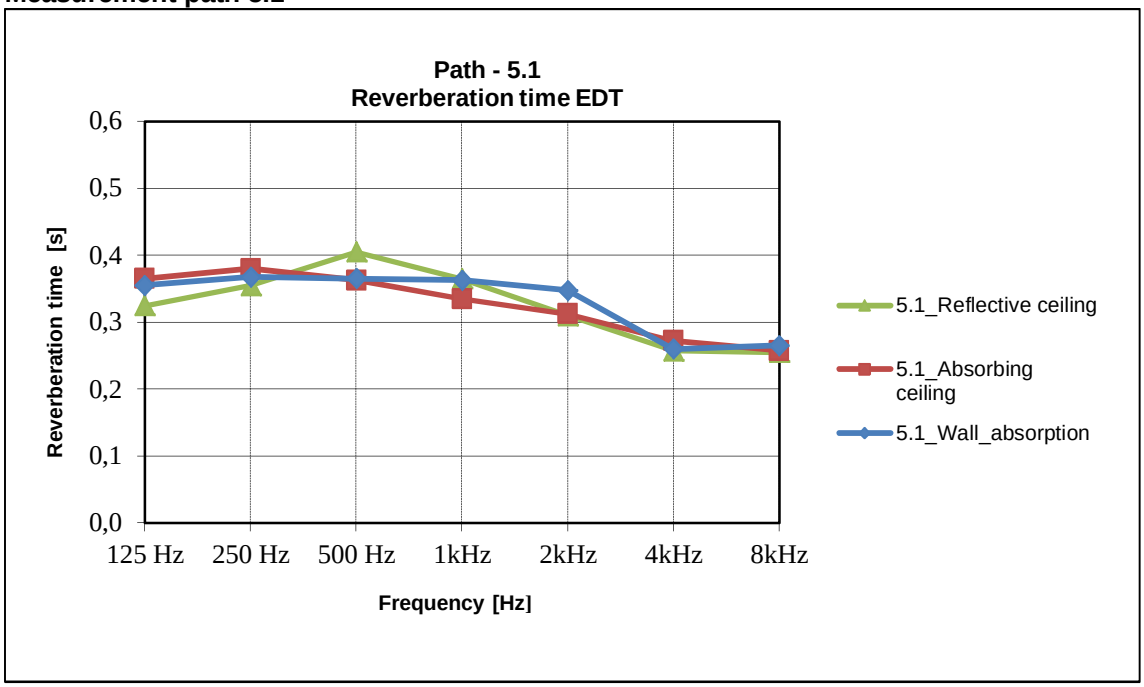


Figure 34 Reverberation time EDT – Path 5.1

Measurement Path 5.2

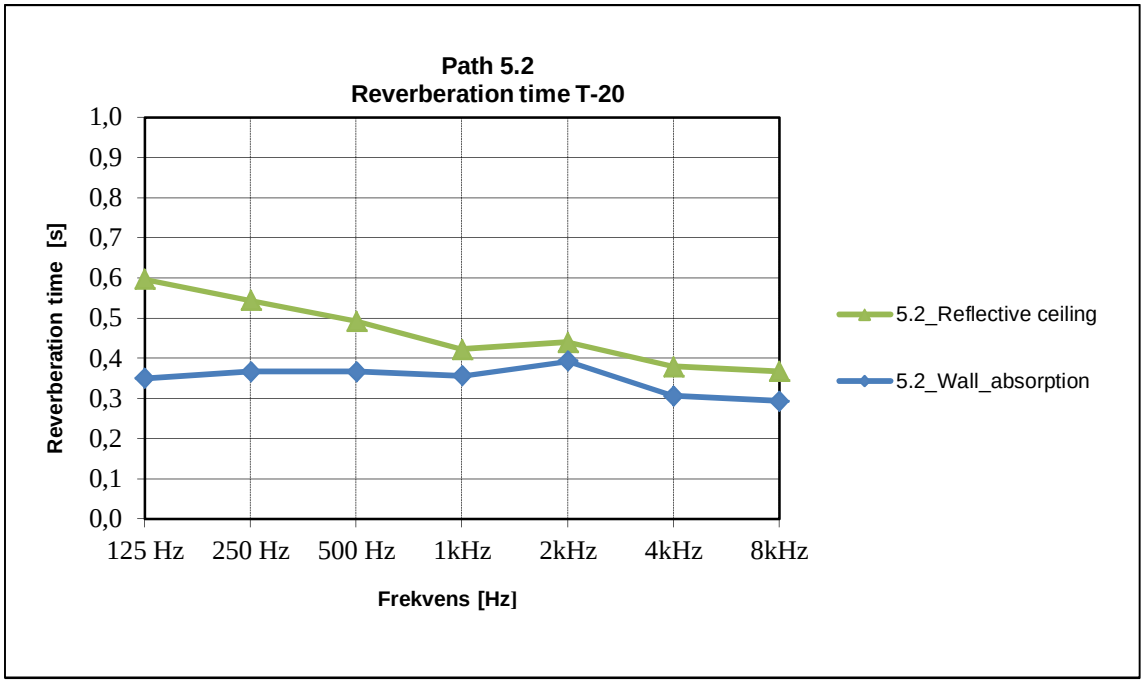


Figure 35 Reverberation time T20 – Path 5.2

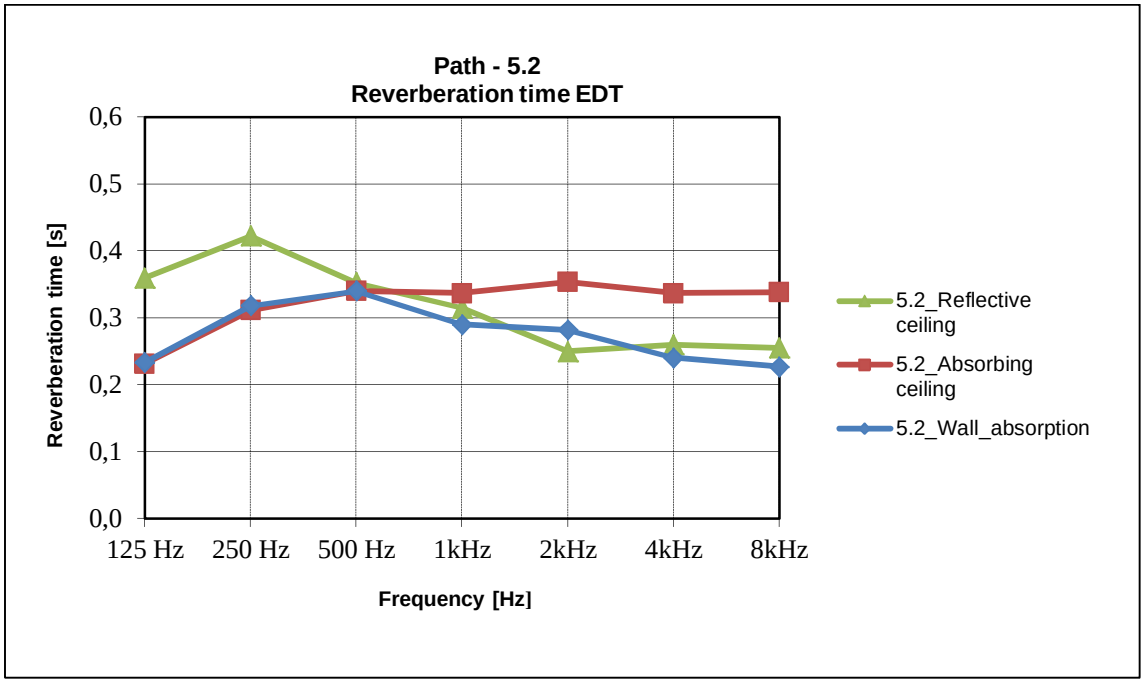


Figure 36 Reverberation time EDT – Path 5.2

5 Measurement

Date:	2014-03-06, 2014-04-22
Personnel:	2014-03-06: Martin Höjer, Josefin Lindebrink Tyréns AB 2014-04-22: Martin Höjer, Philip Zalyaletdinov, Tyréns AB
Location:	Storkontor på plan 4 och 5, Sundbybergs Kommunhus, Sundbyberg
Method:	SS-EN ISO 3382-3:2012 Byggakustik – mätning av rumsakustiska parametrar – Del 3 Kontorslandskap.

5.1 Measurement equipment:

Type	*Brand*	*Model*	*Label*
Real time analyzer	Norsonic	Nor 140	LA 01s
Amplifier / Omni directional loudspeaker	Norsonic	Nor 276/Nor 270	RH01s
Measurement system for impulse responses	WaveCapture	RoomCapture 1.53	RoomCapture

Measurement instruments are calibrated according to national and international standards and our internal quality system.

6 Appendix 1

Ecophon Gedina:

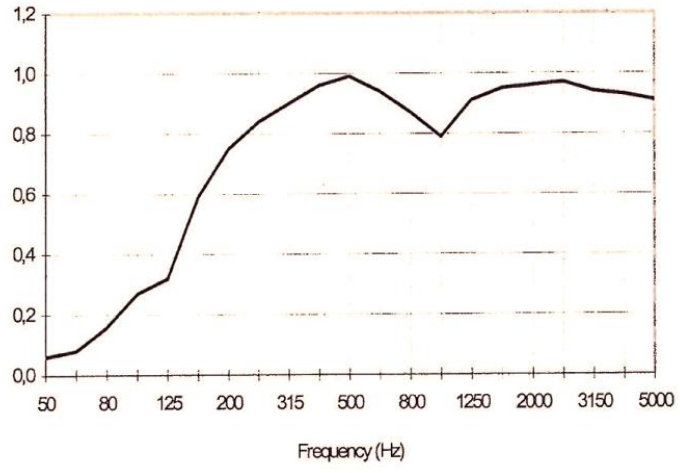
SP **REPORT**

Date	Reference	Page
2007-04-27	P701910-A	1 (2)
Rev.date 2007-08-06		
	Appendix 7	

Measurement of sound absorption coefficient

Test	Measurement of sound absorption coefficient in a reverberation room according to EN ISO 354 and evaluation according to EN ISO 11654
Client	SG-Ecophon AB Erling Nilsson
Object	Gedina A Thickness: 15 mm. Panel size: 600 mm x 600 mm.
Date of test	April 3, 2007
Conditions	Mounting depth: 200 mm. Surface area: 10,8 m^2. Room volume: 200 m^3. Temperature at measurement on object/in empty room: 20/ 20 °C. Relative humidity at measurement on object/in empty room: 85/ 85 %.
Result	Sound absorption class **A**. Weighted sound absorption coefficient α_w = **0,95**.

Sound absorption coefficient



Frequency (Hz)	α_s
50	0,06
63	0,08
80	0,16
100	0,27
125	0,32
160	0,59
200	0,75
250	0,84
315	0,90
400	0,96
500	0,99
630	0,94
800	0,87
1000	0,79
1250	0,91
1600	0,95
2000	0,96
2500	0,97
3150	0,94
4000	0,93
5000	0,91

Ecophon Wallpanel:

SP **REPORT**

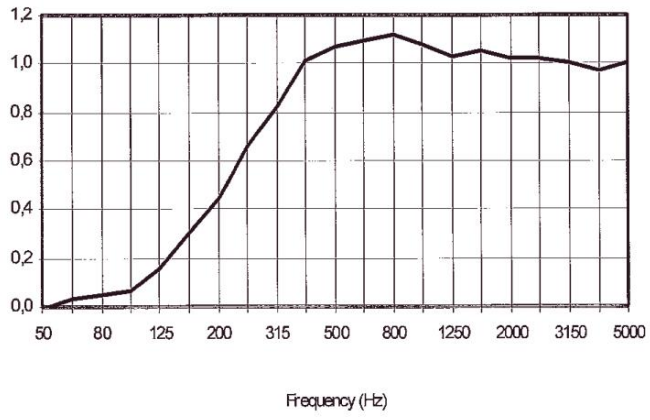
Date	Reference	Page
2008-10-29	P805245	1 (2)

Appendix 17

Measurement of sound absorption coefficient

Test	Measurement of sound absorption coefficient in a reverberation room according to EN ISO 354 and evaluation according to EN ISO 11654
Client	Ecophon AB Christer Persson
Object	Wallpanel A/texona Thickness: 40 mm. Panel size: 2700 mm x 1200 mm.
Date of test	October 29, 2008
Conditions	Mounting depth: 40 mm. Surface area: 10,8 m^2. Room volume: 200 m^3. Temperature at measurement on object/in empty room: 20/ 20 °C. Relative humidity at measurement on object/in empty room: 84/ 84 %.
Result	Sound absorption class **A**. Weighted sound absorption coefficient α_w = **0,95**.

Sound absorption coefficient



Frequency (Hz)	α_s
50	-0,01
63	0,03
80	0,05
100	0,07
125	0,16
160	0,30
200	0,44
250	0,66
315	0,82
400	1,01
500	1,07
630	1,09
800	1,12
1000	1,08
1250	1,03
1600	1,05
2000	1,02
2500	1,02
3150	1,00
4000	0,97
5000	1,00

Suspended gypsum board:

Estimated sound absorption for suspended gypsum ceiling

Frequency [Hz]	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
Absorption [α]	0,12	0,1	0,08	0,06	0,06	0,06