

# TEST REPORT

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## Reverberation time measurement with and without AqTube


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Ver. 2011.11.04 PHe

### Summary:

Grontmij's acoustic department, Acoustica, carried out on the 27<sup>th</sup> of March 2012 room acoustic measurements in the room "Salen" at Guldborgsund Music School. The room is equipped with the AqTube system and measurements are carried when the system is respectively activated (ON) and inactivated (OFF).

The following reverberation times (T20 [s]) have been measured according to DS/EN ISO 3382-1:

Nr.	Measured object	Reverberation time $T_{63\text{Hz}} \pm \sigma$	Reverberation time $T_{125\text{Hz}} \pm \sigma$	Reverberation time $T_{250\text{Hz}} \pm \sigma$	Reverberation time $T_{500\text{Hz}-4\text{ kHz, max}} \pm \sigma$
T1	"Salen" - AqTubes ON	1,30 s $\pm$ 0,09 s	0,84 s $\pm$ 0,05 s	0,84 s $\pm$ 0,04 s	1,03 s $\pm$ 0,01 s
T2	"Salen" - AqTubes OFF	2,08 s $\pm$ 0,12 s	1,23 s $\pm$ 0,06 s	1,23 s $\pm$ 0,04 s	1,20 s $\pm$ 0,02 s



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## INTRODUCTION

Niels Werner Adelman-Larsen from Flex acoustics has requested Grontmij's acoustic department, Acoustica, to carry out room acoustic measurements in the room "Salen" at Guldborgsund Music School. The aim of the measurement campaign is to determine the reverberation time when the AqTube system is respectively activated (ON) and inactivated (OFF).

The measurement arrangement as well as the measurement positions are defined by Acoustica.

Involved entities:

Client:

Flexacoustics, Diplomvej bygning 377, 2600 Kgs. Lyngby, phone: (+45) 40 88 37 23, represented by Niels Werner Adelman-Larsen.

## 1 OBJECT

The room tested is "Salen" at Guldborgsund Music School. It had the following characteristics:

- Dimensions of the hall:  $L \times W \times H = 18,9 \times 9,5 \times 5,5 \text{ m}$
- Volume of the hall:  $V = 987,5 \text{ m}^3$
- 12 tables and 48 chairs with upholstered seat and plastic back are in the hall.
- Curtains are placed behind the stage and in the four corners of the room.
- AqTubes as adjustable absorbers are placed below the ceiling with the following dimensions: 15 tubes of dimension  $L \times H = 8,5 \times 1,25 \text{ m}$
- The room is measured without the presence of an audience.
- The stage furnishing consists of a piano, a drum set and several other smaller instruments.

A plan of the measured room is presented in appendix C.

## 2 MEASUREMENT METHOD

### 2.1 Methods used

The reverberation time is measured according to DS/EN ISO 3382-1. The noise source used is a dodecahedron loudspeaker excited by an exponential sweep. One-third-octave band filters are used. The result is given as the maximum value in the octave bands 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz as well as the values at the 63 Hz, 125 Hz and 250 Hz octave bands.

## 2.2 Measurement uncertainty

The measurement uncertainty is calculated in accordance with DS/EN ISO 3382-1. The result is given in terms of relative standard deviation of the reverberation time  $T_{20}$  [s],  $\sigma(T_{20})$ [%].

Relative standard deviation of the measured reverberation time  $T_{20}$ ,  $\sigma(T_{20})$ [%]:

f [Hz]	$\sigma(T_{20}$ ON) [%]	$\sigma(T_{20}$ ON) [%]	$\sigma(T_{20}$ OFF) [%]	$\sigma(T_{20}$ OFF) [%]
	1/1 oct.	1/3 oct.	1/1 oct.	1/3 oct.
50	7	7	6	6
<b>63</b>		7		5
80		7		6
100	6	7	5	6
<b>125</b>		6		5
160		5		4
200	4	5	4	4
<b>250</b>		4		4
135		6		5
400	3	4	3	3
<b>500</b>		3		3
630		3		2
800	2	2	2	2
<b>1000</b>		2		2
1250		2		2
1600	1	2	1	1
<b>2000</b>		1		1
2500		1		1
3150	1	1	1	1
<b>4000</b>		1		1
5000		1		1

## 2.3 Equipment used

A list of the equipment used is given in appendix D.

### 3 RESULTS

The results from the measurement of the reverberation time are presented in the measurements sheets in appendices A and B.

Reverberation time  $T_{20}$  [s] measured according to DS/EN ISO 3382-1:

Nr.	Measured object	Reverberation time $T_{63\text{Hz}} \pm \sigma$	Reverberation time $T_{125\text{Hz}} \pm \sigma$	Reverberation time $T_{250\text{Hz}} \pm \sigma$	Reverberation time $T_{500\text{Hz}-4\text{kHz, max}} \pm \sigma$
T1	"Salen" AqTubes ON	1,30 s $\pm$ 0,09 s	0,84 s $\pm$ 0,05 s	0,84 s $\pm$ 0,04 s	1,03 s $\pm$ 0,01 s
T2	"Salen" AqTubes OFF	2,08 s $\pm$ 0,12 s	1,23 s $\pm$ 0,06 s	1,23 s $\pm$ 0,04 s	1,20 s $\pm$ 0,02 s

### 4 CONCLUSION

Grontmij's acoustic department, Acoustica, carried out on the 27th of March 2012 room acoustic measurements at Guldborgsund Music School, Skolegade 3C, 4800 Nykøbing Falster, Denmark. Measurements positions are chosen by Acoustica.

The measurements carried out in the room "Salen" show that the AqTube system has a significant effect on the reverberation time, especially at low frequencies. The effect is largest in the 63 Hz octave band.

## Appendix A: Result of reverberation time measurement

<b>Client:</b>	Flex Acoustics	<b>Measurement:</b> T1
	Diplomvej, bygning 377	<b>Measurement date:</b> 29-03-2012
	DK-2800 Kgs. Lyngby	<b>Executed by:</b> PIE

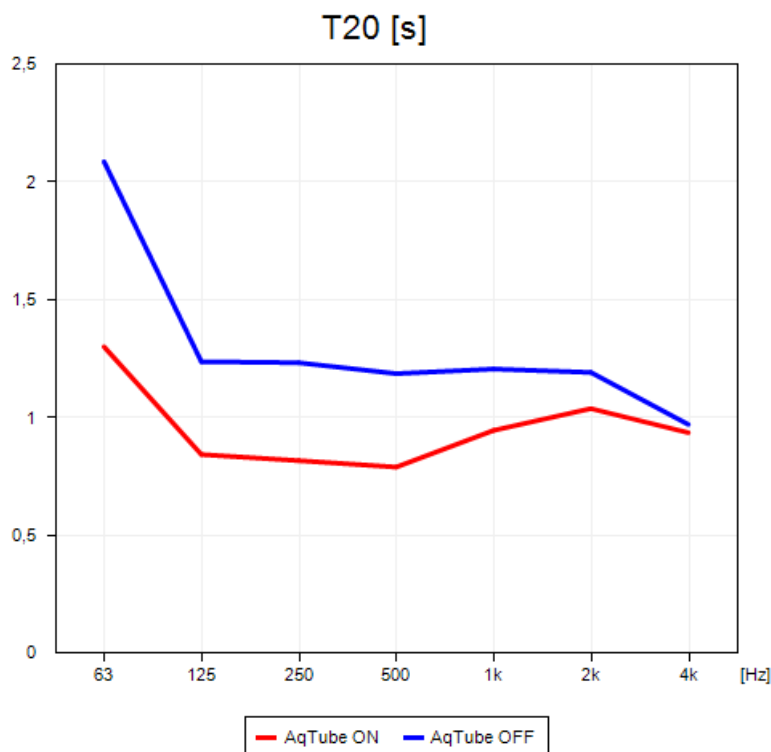
### Description of the measured object

Room "Salen" at Guldborgsund Music School – AqTube system respectively ON and OFF

**Volume of the room:** 987,5 m<sup>3</sup>

### Remarks

Results presented in full-octave-bands



f [Hz]	AqTube ON	AqTube OFF
	T20 [s]	T20 [s]
63	1,30	2,08
125	0,84	1,23
250	0,81	1,23
500	0,79	1,18
1000	0,94	1,20
2000	1,03	1,19
4000	0,93	0,97

## Appendix B: Result of reverberation time measurement

**Client:** Flex Acoustics

Diplomvej, bygning 377

DK-2800 Kgs. Lyngby

**Measurement:** T2

**Measurement date:** 29-03-2012

**Executed by** PIE

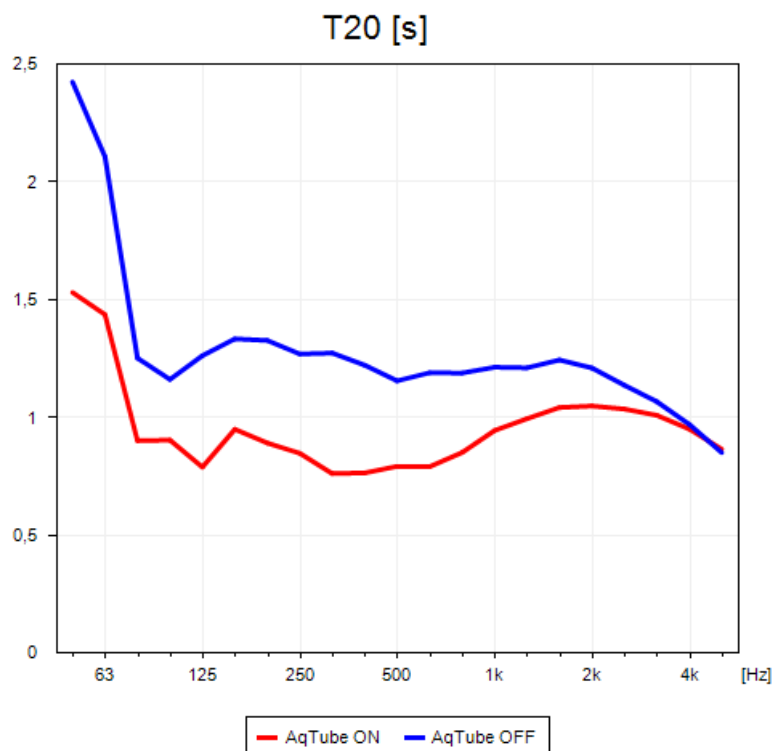
### Description of the measured object

Room "Salen" at Guldborgsund Music School – AqTube system respectively ON and OFF

**Volume of the room:** 987,5 m<sup>3</sup>

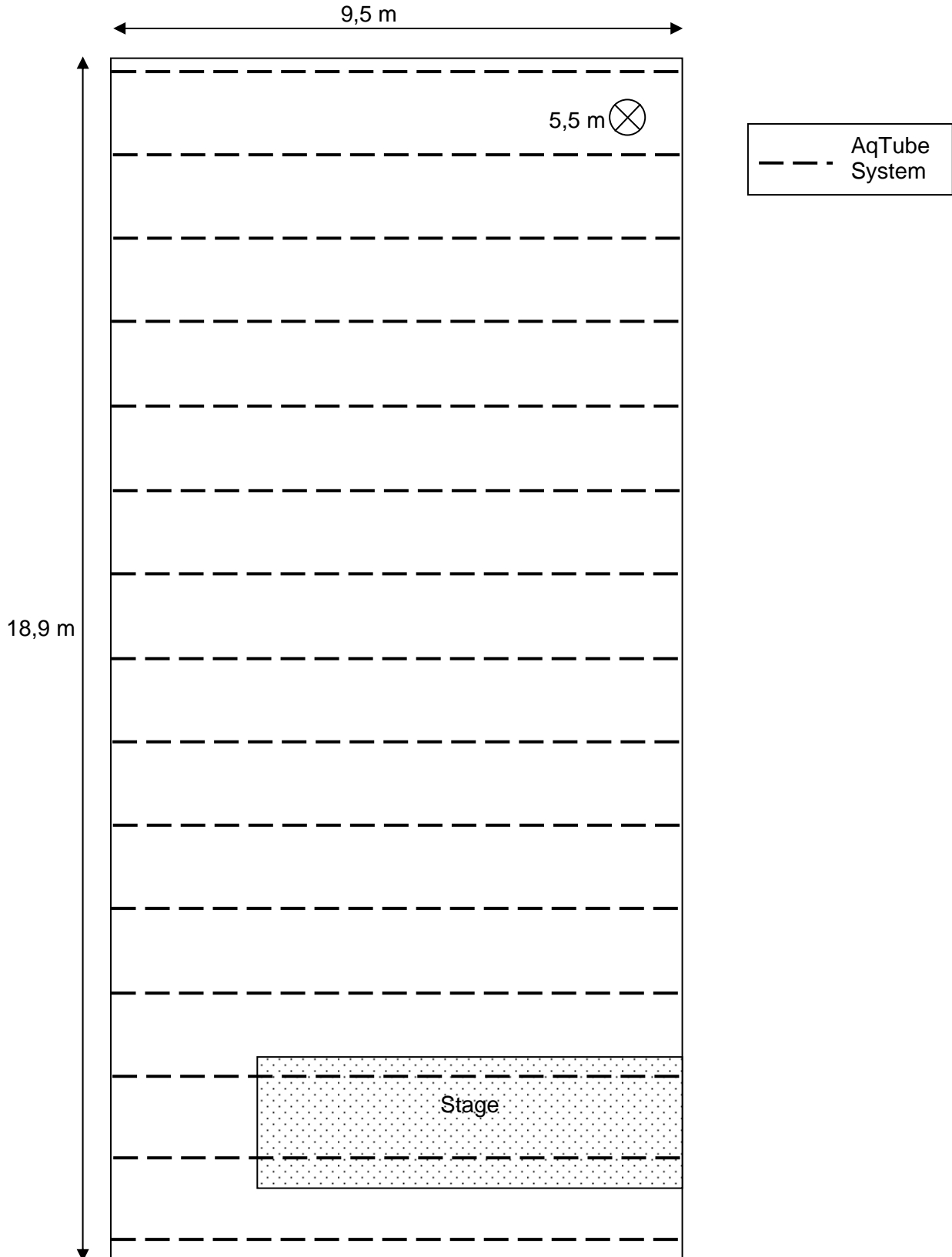
### Remarks

Results presented in third-octave-bands



f [Hz]	AqTube ON	AqTube OFF
	T20 [s]	T20 [s]
50	1,53	2,42
63	1,43	2,10
80	0,90	1,25
100	0,90	1,16
125	0,79	1,26
160	0,95	1,33
200	0,89	1,32
250	0,84	1,27
315	0,76	1,27
400	0,76	1,22
500	0,79	1,15
630	0,79	1,19
800	0,85	1,19
1000	0,94	1,21
1250	0,99	1,21
1600	1,04	1,24
2000	1,05	1,21
2500	1,03	1,13
3150	1,01	1,06
4000	0,95	0,97
5000	0,86	0,85

### Appendix C: Plan of the measured room





## Appendix D: Equipment used

Designation	Producer	Type	ACA nr.	Last control	Next control
Microphone 1/2"	Brüel & Kjær	4148	647	31-05-2011	31-05-2013
Sound level meter	Brüel & Kjær	2236 B-008	646	31-05-2011	31-05-2013
Dodecahedron loudspeaker	Lab. for Akustik		600	04-10-2007	02-04-2012
Power amplifier	Behringer	Inuke NU3000DSP		-	02-04-2012
Laptop	IBM	ThinkPad T43	2038	-	-
Hardware key - Dirac	Brüel & Kjær	HASP	176	-	-
Laser distance meter	Leica	DISTO A5	2035	-	-