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Reverberation room A3-006.

Measurement concerning fullfillment standard related to reverberation rooms. Our room now contains a Low Frequency Chamber (LFC) which have been used for Low frequency experiments with humans. Due to this the room volume have been decreased and the shape have changed. Measurements have been made to check if the room still fulfills iso354/3741/3742 and can be used eg. for classification of absorbtionpanels (iso 11654 / iso354) or for declaration of noiseemmison from eg. IT-equipment (iso 9296 / iso 7779). The last part with can be difficult due to relatively high (~35dbA) background noise level (ventilation, toilets, people in buildning) during normal daytime.

Volumen of our room is now 199m3, and this means that the physical demand which we have trouble fullfilling is the demand in iso354 of $l_{max} < 1.9 \times V^{1/3}$ and a volumen of minimum 200m3 for measurements down to 100Hz (1/3octave band). Our room have and l_{max} of 11.2m which is a little more than the demand set in above formula which gives a value of 11.1m. This minor detail will be fixed later on. Number of diffusers have been decreased from 7 to 5 after the LFC have been constructed. This have been tested with succes according to iso354/annex A.2.

Measurements have been carried out with mainly abrupted pink-noise, since it's the easiest way to obtain a good (>40dB in all freq.bands) signal to noise ratio. However to see how results obtained with this method a number of measurements have also been carried out with "integrated impulse-response method". Furthermore the first of these methods are also considerably faster due to the posibility of using our 4channel Harmonie measuring system (4channels, all freq.bands simultaneously in about 15secs) compared with B&K2231+BZ7109 (1channel, 1 freq.band in 30-10secs – depending on frequency).

In the following figures and tables it can be seen to which extend the room can be used if standard iso354/3741/3742 should be fullfilled. Picture shows actual setup used during this measurement session.

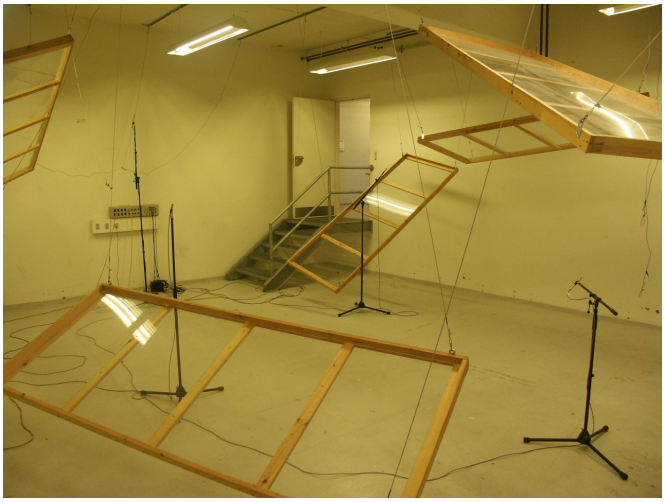


Table 1 - shows an overview of data obtained in the reverberation room.

Frequency	Measured data			ISO354			ISO3741/42		
	absorp.area	Rt ***	average	diff. mean	max absorp	fulfilled?	Rt min	α_s max	fulfilled?
Hz	m*m	sec.	α_s	%	m*m		sec		
100	2,8	11,29	0,01	-4%	6,5	yes	0,87	0,16	yes
125	2,9	10,89	0,01	-1%	6,5	yes	0,87	0,16	yes
160	3,3	9,74	0,01	2%	6,5	yes	0,87	0,16	yes
200	3,2	9,99	0,01	0%	6,5	yes	0,87	0,16	yes
250	3,3	9,84	0,01	0%	6,5	yes	0,87	0,16	yes
315	3,4	9,42	0,01	-1%	6,5	yes	0,87	0,16	yes
400	3,7	8,58	0,02	0%	6,5	yes	0,87	0,06	yes
500	4,1	7,84	0,02	0%	6,5	yes	0,87	0,06	yes
630	4,3	7,43	0,02	-1%	6,6	yes	0,87	0,06	yes
800	4,8	6,64	0,02	-2%	6,8	yes	0,87	0,06	yes
1 k	6,2	5,16	0,03	1%	7,0	yes	0,87	0,06	yes
1.25 k	7,0	4,59	0,03	2%	7,8	yes	0,87	0,06	yes
1.6 k	6,9	4,65	0,03	-1%	8,6	yes	0,87	0,06	yes
2 k	7,3	4,37	0,03	-1%	9,5	yes	0,87	0,06	yes
2.5 k	8,5	3,76	0,04	0%	10,6	yes	0,87	0,06	yes
3.15 k	9,9	3,22	0,04	0%	11,8	yes	0,87	0,06	yes
4 k	11,4	2,81	0,05	-1%	13,0	yes	0,87	0,06	yes
5 k	13,9	2,31	0,06	-1%	14,1	yes	0,87	0,06	yes
6.3 k	17,5	1,83	0,08	-1%	15,3	no	0,87	0,06	no
8 k	22,8	1,41	0,10	-1%	16,4	no	0,87	0,06	no
10 k	30,8	1,04	0,13	36%	17,6	no	0,87	0,06	no

*** Measured Rt (average of 60 measurements) is used for calculating Absorption area from Sabin's formula.

note that iso 354 are not fullfilled for physical dimensions (se previous page)!!

Table 2 - shows diffences between abrupted pink noise and integrated impulse methods

Frequency	Measured data dBati32			Measured data B&K2231		
	absorp.area	Rt ***	std.dev	absorp.area	Rt**	st.dev
Hz	m*m	sec.		m*m	sec	
100	2,8	11,29	1,13	3,0	10,66	1,26
125	2,9	10,89	1,09	3,1	10,42	1,17
160	3,3	9,74	1,16	3,5	9,21	1,06
200	3,2	9,99	0,54	3,4	9,54	0,60
250	3,3	9,84	0,56	3,3	9,58	0,73
315	3,4	9,42	0,40	3,5	9,23	0,51
400	3,7	8,58	0,32	3,8	8,37	0,32
500	4,1	7,84	0,20	4,2	7,71	0,18
630	4,3	7,43	0,21	4,3	7,43	0,20
800	4,8	6,64	0,18	4,7	6,77	0,21
1 k	6,2	5,16	0,15	6,1	5,21	0,15
1.25 k	7,0	4,59	0,10	7,0	4,60	0,08
1.6 k	6,9	4,65	0,09	6,9	4,67	0,08
2 k	7,3	4,37	0,08	7,3	4,37	0,12
2.5 k	8,5	3,76	0,05	8,7	3,69	0,09
3.15 k	9,9	3,22	0,05	9,9	3,23	0,04
4 k	11,4	2,81	0,04	11,3	2,83	0,04
5 k	13,9	2,31	0,03	13,9	2,30	0,04
6.3 k	17,5	1,83	0,03	17,6	1,82	0,03
8 k	22,8	1,41	0,02	22,8	1,41	0,02
10 k	30,8	1,04	0,02	31,5	1,02	0,01

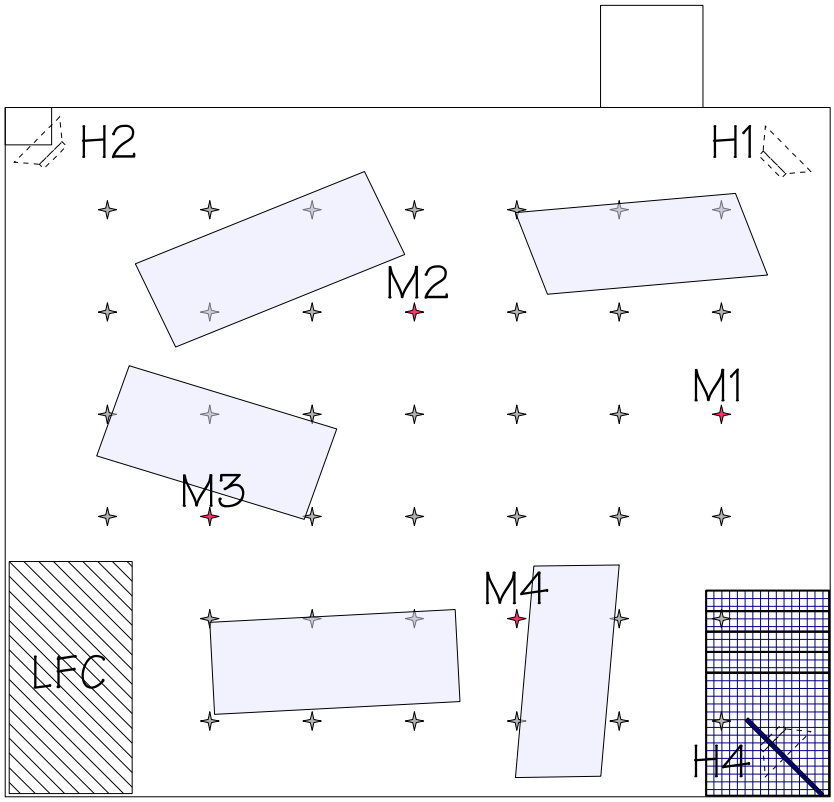
** Measured Rt bk2231 (average 12 measurements/decays) used for calculating Absorption area from Sabin's formula
*** Measured Rt dBati32 (average of 60 measurements/decays) is used for calculating Absorption area from Sabin's formula.

Table 3 - shows diffences between "std.mic.pos" and random selected mic.positions.

Frequency	Measured Rt data dBati32 **					
	Standard mic. positions			random mic. positions		
	H1	H2	H4	H1	H2	H4
Hz	sec.	sec.	sec.	sec.	sec.	sec.
100	11,73	11,17	11,14	11,66	11,11	10,81
125	11,85	11,65	10,91	10,78	11,24	11,26
160	9,17	10,08	8,83	8,90	10,32	8,86
200	9,87	9,67	9,56	10,03	9,92	10,25
250	9,85	9,61	9,97	9,69	9,69	9,97
315	9,73	9,64	9,80	9,90	9,72	9,73
400	8,79	8,55	8,65	8,69	8,74	8,91
500	7,76	7,90	7,76	7,86	7,94	7,88
630	7,35	7,31	7,32	7,37	7,39	7,29
800	6,63	6,62	6,61	6,61	6,68	6,70
1 k	5,16	5,20	5,17	5,20	5,21	5,17
1.25 k	4,59	4,61	4,62	4,60	4,57	4,65
1.6 k	4,57	4,65	4,60	4,67	4,65	4,63
2 k	4,31	4,30	4,33	4,36	4,31	4,34
2.5 k	3,71	3,72	3,72	3,73	3,74	3,74
3.15 k	3,17	3,20	3,17	3,15	3,14	3,20
4 k	2,75	2,74	2,76	2,76	2,78	2,75
5 k	2,25	2,25	2,23	2,27	2,26	2,25
6.3 k	1,79	1,79	1,79	1,79	1,80	1,78
8 k	1,35	1,37	1,34	1,37	1,37	1,37
10 k	1,00	1,01	0,99	1,00	1,01	1,00

** Each value for Rt is calculated as average of 4 mic.positions 3 repetions – table shows for 3 different speaker-positions as seen at 160Hz loudspeaker position have some influence on measured values.

Figure 1 – sketch showing room with std.mic.& speaker positions and diffusors.



Measurements done by: Claus Vestergaard Skipper
Document updated: 19. september 2006

Equipment used during these measurements:
B&K 2231 SLM aauno.8236 + BZ7109 Reverberation Module
01dB Harmonie system (pc with DAQ-unit) 56524 & 60923
Microphones: 2x B&K4134 aauno 8129 & 8130, 2x B&K4166 aauno 8601 & 8602
Microphone preamps: GRAS 26AK aauno 52664, 52665, 56525 & 56526
Microphone powersupply: 2x B&K 2804 aauno 6998 & 7304
Loudspeaker: EV-S200 aauno. 8722- eq present setting
PowerAmplifier: Pioneer A-616 aauno. 8249 - fixed gain 20dB setting

Measurements in reverberation room have been done in the periode from 31.juli 2006 – 14.september 2006 ,.

Figure 2 – measurement setup.