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Acoustic measurements for the determination of the sound power level

SolaFrame Studio

Report No. M159478/04

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1 Situation and task

The company ETC – Electronic Theatre Controls GmbH is producing stage lights. Their products shall be tested regarding the noise emission during several operation conditions. For this purpose, the devices should be installed on the floor of a semi-anechoic room at Müller-BBM and the sound pressure level should be measured at a distance of, for example, 1 m to the contour of the device. During the measurements, the signals of the measurement microphones should be sampled and digitally stored for a flexible evaluation. A sample frequency of f_s = 65536 Hz allowed a spectral evaluation up to 25600 Hz.

2 Standards

[1] ISO 3744: Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Engineering methods for an essentially free field over a reflecting plane – 2010-10.

3 Measurements

3.1 Setup

The measurements were carried out in a semi-anechoic room at the Müller-BBM laboratories. The room has a very low background noise of about 1 dB(A). The device under test was set on the floor in the middle of the room. Then all in all nine microphones were installed at 1 m distance on a box shaped measurement surface. Figure 1 shows the semi-anechoic measurement room, the device under test (SolaFrame Studio) and the nine microphone positions.

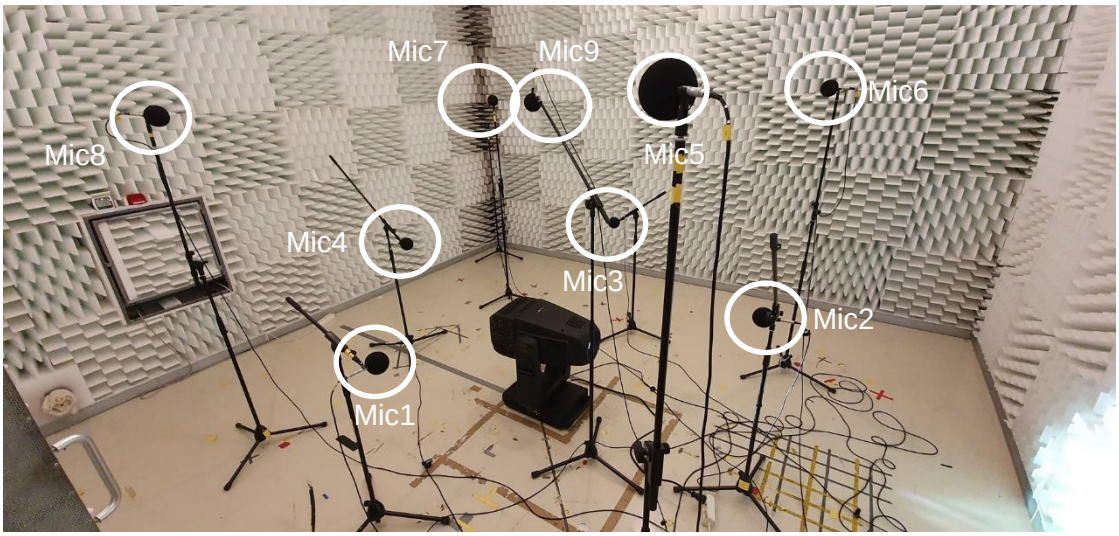


Figure 1. Semi-anechoic measurement room, the device under test (SolaFrame Studio) and the nine microphone positions.

3.2 Procedure

Date:	2020-10-21
Time:	09:00 – 13:00
Temperature:	22.6 °C
Relative humidity:	39.7 %
Müller-BBM staff:	Otto Martner
ETC staff:	Hannes Oberauer

The used measurement equipment is listed in Table 1. For each microphone the calibration was checked with an acoustic calibrator before and after the measurement. No significant deviation was found.

Table 1. Measurement equipment.

Name	Description	Manufacturer	Type	Serial No.
Mic 1 to Mic 9	½“ condenser microphone	Brüel & Kjaer	4190	2150421
	Preamplifier	Brüel & Kjaer	2669C	2159775
	½“ condenser microphone	Brüel & Kjaer	4190	2166157
	Preamplifier	Brüel & Kjaer	2669C	2159776
	½“ condenser microphone	Brüel & Kjaer	4190	2166158
	Preamplifier	Brüel & Kjaer	2669C	2159777
	½“ condenser microphone	Brüel & Kjaer	4190	2150422
	Preamplifier	Brüel & Kjaer	2669C	2159778
	½“ condenser microphone	Brüel & Kjaer	4190	2853939
	Preamplifier	Brüel & Kjaer	2669C	2159779
	½“ condenser microphone	Brüel & Kjaer	4190	2058439
	Preamplifier	Brüel & Kjaer	2669C	2159780
	½“ condenser microphone	Brüel & Kjaer	4190	2166164
	Preamplifier	Brüel & Kjaer	2669C	2159781
	½“ condenser microphone	Brüel & Kjaer	4190	2166163
	Preamplifier	Brüel & Kjaer	2669C	2159782
	½“ condenser microphone	Brüel & Kjaer	4190	2334796
	Preamplifier	Brüel & Kjaer	2669C	2159785
Acoustic calibrator	Sound pressure	Brüel & Kjaer	4230	1511269

Name	Description	Manufacturer	Type	Serial No.
Multichannel measurement system	Controller	Mecalc	PQ12	0910M0137
	Input card	Mecalc	SC42	0705M8633
	Input card	Mecalc	SC427	1110M1641
	MIC-module	Mecalc	MIC42X5	1010M0848
	MIC-module	Mecalc	MIC423	1108M5973
	MIC-module	Mecalc	MIC42X5	0512M0760
	MIC-module	Mecalc	MIC42X5	0512M0752
	MIC-module	Mecalc	MIC423	1008M5457
Software	Measurement and evaluation software	Müller-BBM VibroAkustik GmbH	PAK 5.11	Service Release 2 Build: 537

The device was controlled by Hannes Oberauer via a control board outside of the measurement room. Also, the acoustic measurements were controlled from outside of the room.

Each action was set for about one minute. The different actions such as calibration, tilting, panning, zooming and many more were defined by ETC before the tests.

3.3 Evaluation

In the evaluation the A-weighted sound pressure level L_{Aeq} of all nine measurement positions was energetically averaged. In addition a correction of the background noise was carried out. Therefore the background noise level $L_{Aeq,BGN}$ was energetically subtracted from the averaged sound pressure level $L_{Aeq,m}$:

$$L_{Aeq} = 10 \log (10^{L_{Aeq,m}/10} - 10^{L_{Aeq,BGN}/10}) \text{ dB}.$$

The A-weighted sound power level L_{WA} was calculated according to [1] with

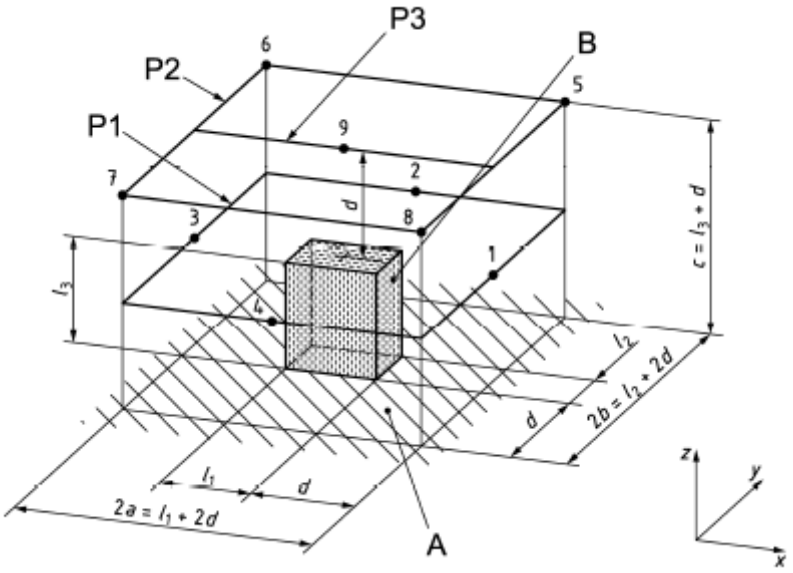
$$L_{WA} = L_{Aeq} + 10 \log (S/S_0) \text{ dB}$$

L_{WA} A-weighted sound power level, dB re 1 pW,

L_{Aeq} energetic average value of the A-weighted sound pressure level at the nine microphone positions, dB re 20 µPa,

S measurement surface, here S = 21.8 m², 10 log (S/S_0) dB = 13.4 dB,

S_0 reference surface, S_0 = 1 m².



Legend:

1 to 9	measurement positions
A	reflecting plane
B	reference cuboid
2*a*	length of the measurement surface
2*b*	width of the measurement surface
c	height of the measurement surface
d	measurement distance, here d = 1 m
l_1	length of the reference cuboid, here l_1 = 0.36 m
l_2	width of the reference cuboid, here l_2 = 0.32 m
l_3	height of the reference cuboid, here l_3 = 0.75 m
P1 to P3	path 1 to path 3

Figure 2. Scheme of the measurement setup with the device under test, the nine microphone positions according to ISO 3744 [1] and the measurement surface.

No additional corrections were considered for

- K_1 background noise correction,
- K_2 room influence correction,
- C_1, C_2 meteorological influence according to temperature and relative humidity.

4 SolaFrame Studio – A-weighted sound pressure levels and sound power levels

Description	Remark	A-weighted sound pressure level (1m distance, 9 microphone positions), dB re 20µPa, incl. background noise correction	A-weighted sound power level L_{WA}, dB re 1 pW
Background Noise of test chamber -HVAC & Light Off, SolaFrame Studio Unplugged		16	-
SolaFrame Studio calibration sequence –approx. 1 min 10 seconds		36	49
Tilting – 0 degrees (downfiring) to 90 (parallel to floor) degrees, continuous over 1 min with 3 sec cues from -270° to +270°, lamp off		32	45
Panning – 0 degrees to 90 degrees, continuous over 1 min with 3 sec cues from -270° to +270°, lamp off		28	41
Zooming -0 to 100%, continuous over 1 minute, lamp off		16	29
Zooming -0 to 100%, continuous over 1 minute, lamp off (5 second cues)		32	45
Gobo wheel spin –fixture held parallel to floor (90 degrees) continuous cycling over 1 minute, lamp on		3	16
Gobo wheel spin & rotation -fixture held parallel to floor (90 degrees) continuous cycling over 1 minute, lamp on		12	26
Color mixing (cycle) – fixture downfiring (90 degrees) continuous cycling over 1 minute, lamp on (CMY Color Mix FX)*		23	37
Framing -continuous over 1 minute, lamp on (2 second cycle)		14	27
Framing -continuous over 1 minute, lamp on (1 second cycle)		18	31
Focusing –continuous over 1 minute, lamp off		10	23
			13
Diffusion (frosting) –continuous over 1 minute, lamp off		7	21
Lamp On, Downfiring 100% Brightness -continuous over 15 seconds	LED16 kHz	9	22
	LED 2,4 kHz	14	28
Lamp On, Downfiring 50% Brightness -continuous over 15 seconds	LED16 kHz	0	13
	LED 2,4 kHz	12	26
Lamp On, Downfiring 10% Brightness -continuous over 15 seconds	LED16 kHz	0	13
	LED 2,4 kHz	0	13
Lamp On, Angled 100%Brightness -continuous over 15 seconds, angled approx. 45 degrees from vertical	LED16 kHz	11	24
	LED 2,4 kHz	8	21
Lamp On, Angled 50%Brightness -continuous over 15 seconds, angled approx. 45 degrees from vertical	LED16 kHz	10	24
	LED 2,4 kHz	12	26
Lite Stress Test –continuous over 15 seconds, lamp on		26	39
Moderate Stress Test –continuous over 15 seconds, lamp on		34	47
Hight Stress Test –continuous over 15 seconds, lamp on		36	49
	sound pressure levels < 20 dB normally inaudible		

5 Conclusion

Sound pressure levels on a surface at 1 m distance to the device under test were carried out. Level values were found in the range of the background noise with 16 dB(A) up to 39 dB(A) during the calibration sequence.

Sound pressure levels above 20 dB(A) occurred during tilting, panning and zooming. Sound pressure levels below 20 dB(A) were found during changes of the brightness and are supposed to be inaudible under normal conditions in a theater or concert hall.

The sound power level values can be used for the prognosis of the sound pressure distribution in rooms based on simulations and calculation models.

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