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2024-11-04
M182253/02 Version 1 MT/SCHJ

Acoustic measurements for the determination of the sound power level

Halcyon Silent

Report No. M182253/02

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Total number of pages:	7 pages

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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 operating conditions. In the present case, the product Halcyon Silent was tested.

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 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 allows 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 Müller-BBM Industry Solutions GmbH. The room has a very low background noise of about 1 dB(A). The device was placed on the floor in the center of the room. A total of 9 microphones were installed at a 1 m distance to the device on a cuboid surface. Figure 1 shows the semi-anechoic measurement room, the device under test (Halcyon Silent) and the 9 microphone positions.

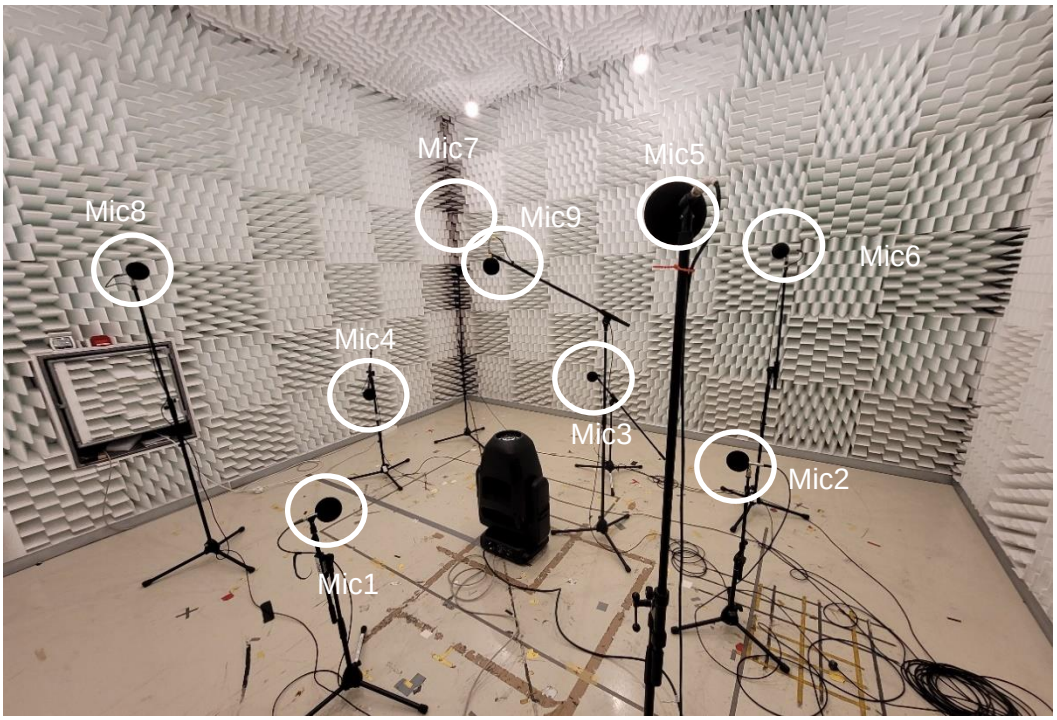


Figure 1. Semi-anechoic measurement room, the device under test and the microphone positions.

3.2 Procedure

Date:	2024-10-17
Time:	09:00 – 13:00
Temperature:	23.9 °C
Relative humidity:	45.5 %
Müller-BBM staff:	Otto Martner
ETC staff:	Dimitrii Dragunov

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“ Cond.-Mikrofon Set	PCB	378B02	LW111126
	½“ Cond.-Mikrofon Set	PCB	378B02	145474
	½“ Cond.-Mikrofon Set	PCB	378B02	129393
	½“ Cond.-Mikrofon Set	PCB	378B02	127890
	½“ Cond.-Mikrofon Set	PCB	378B02	133958
	½“ Cond.-Mikrofon Set	PCB	378B02	106365
	½“ Cond.-Mikrofon Set	PCB	378B02	111128
	½“ Cond.-Mikrofon Set	PCB	378B02	159088
	½“ Cond.-Mikrofon Set	PCB	378B02	106371
Acoustic calibrator	Sound pressure	Brüel & Kjaer	4230	782824
Multichannel measurement system	Controller	Mecalc	PQ20 G2	0617M9927
	Input card	Mecalc	SC42 G2	1015M2124
	input-module	Mecalc	ICP4211 G2	0716M0798
	input-module	Mecalc	ICP4211 G2	0215M8020
	input-module	Mecalc	ICP4211 G2	0215M8029
Software	Measurement and evaluation software	Müller-BBM VibroAkustik GmbH	PAK 6.2	Service Release 0

The device was controlled by Dimitrii Dragunov via a control board outside of the measurement room. The acoustic measurements were also controlled from outside 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

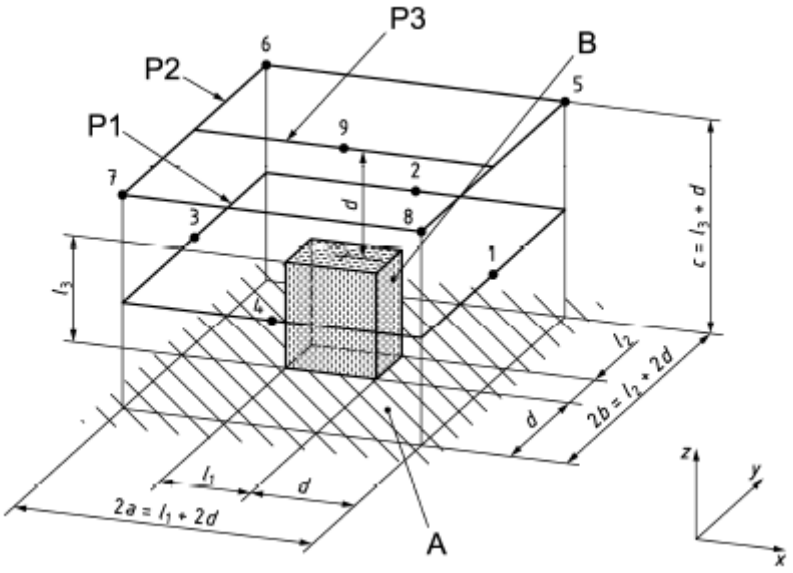
In the evaluation the A-weighted sound pressure level L_{Aeq} of all 9 measurement positions was energetically averaged. In addition, a correction of the background noise was carried out. Therefore, the background noise level $L_{Aeq,BGN}$ was energetically subtracted from the averaged sound pressure 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 9 microphone positions, dB re 20 µPa
S	measurement surface, here S = 22.3 m², 10 log (S/S_0) dB = 13.5 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 = 0.45 m
l_2	width of the reference cuboid, here l_2 = 0.28 m
l_3	height of the reference cuboid, here l_3 = 0.77 m
P1 to P3	path 1 to path 3

Figure 2. Scheme of the measurement setup with the device under test, the 9 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.

Results from the background noise correction with negative sound pressure levels were labelled with “<0” dB. These sounds are practically not relevant.

4 Halcyon Silent – 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, Halcyon Silent Unplugged		16	-
Halcyon Silent calibration sequence –approx. 1 min 10 seconds		40	53
Tilting – 0 degrees (downfiring) to 90 (parallel to floor) degrees, continuous over 1 min with 3 sec cues from -270° to +270°, lamp off		35	49
Panning – 0 degrees to 90 degrees, continuous over 1 min with 3 sec cues from -270° to +270°, lamp off		34	47
Zooming -0 to 100%, continuous over 1 minute, lamp off		20	33
Zooming -0 to 100%, continuous over 1 minute, lamp off (5 second cues)		38	52
Gobo wheel spin –fixture held parallel to floor (90 degrees) continuous cycling over 1 minute, lamp on		24	38
Gobo wheel spin & rotation -fixture held parallel to floor (90 degrees) continuous cycling over 1 minute, lamp on		25	38
Color mixing (cycle) – fixture downfiring (90 degrees) continuous cycling over 1 minute, lamp on (CMY Color Mix FX)*		30	43
Framing -continuous over 1 minute, lamp on (2 second cycle)		7	21
Framing -continuous over 1 minute, lamp on (1 second cycle)+Rotation		25	39
Focusing –continuous over 1 minute, lamp off		36	50
Diffusion (frosting) –continuous over 1 minute, lamp off		<0	-
Lamp On, Downfiring 100% Brightness -continuous over 15 seconds	LED16 kHz	13	26
	LED 2,4 kHz	20	33
Lamp On, Downfiring 50% Brightness -continuous over 15 seconds	LED16 kHz	4	17
	LED 2,4 kHz	16	30
Lamp On, Downfiring 10% Brightness -continuous over 15 seconds	LED16 kHz	<0	-
	LED 2,4 kHz	<0	-
Lamp On, Angled 100%Brightness -continuous over 15 seconds, angled approx. 45 degrees from vertical	LED16 kHz	<0	-
	LED 2,4 kHz	17	31
Lamp On, Angled 50%Brightness -continuous over 15 seconds, angled approx. 45 degrees from vertical	LED16 kHz	<0	-
	LED 2,4 kHz	14	27
Lite Stress Test –continuous over 15 seconds, lamp on		38	51
Moderate Stress Test –continuous over 15 seconds, lamp on		39	52
Hight Stress Test –continuous over 15 seconds, lamp on		44	57
	sound pressure levels < 20 dB normally inaudible		

5 Conclusion

Sound pressure level measurements on a surface at 1 m distance to the device under test (Halcyon Silent) were carried out. Level values were found in the range of the background noise with 16 dB(A) up to 40 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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