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M112237/01 MSG/PRFTN

Consumer vacuum breast-pumps

Determination of the sound power level according to ISO 3741

Test report No. M112237/01

Client:	Ardo medical AG Gewerbestraße 19 6314 Unterägeri Schweiz
Consultant:	M.Eng. Philipp Meistring
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Date of measurements:	23rd May 2014
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Certified quality management system according to ISO 9001
Accredited testing laboratory according to ISO/IEC 17025

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1 Situation and task

On behalf of Ardo medical AG, 6314 Unterägeri, Switzerland, the sound power level of consumer vacuum breast-pumps were to be determined by measurements in the reverberation room acc. to DIN EN ISO 3741 [2]. The tests were to be carried out for eight pumps (two single pumps, two double pumps and four pumps with single and double mode).

In the present test report, the execution of the tests and the test results will be described.

2 References

[1] DIN EN ISO 3740: Acoustics – Determination of sound power levels of noise sources – Guidelines for the use of basic standards. 2001-03

[2] DIN EN ISO 3741: Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Precision methods for reverberation test rooms. 2011-01

[3] DIN EN ISO 3382-2: Acoustics – Measurement of room acoustic parameters – Part 2: Reverberation time in ordinary rooms. 2008-09

3 Test objects and operating conditions

Several different types of consumer vacuum breast-pumps of various manufacturers were examined. The test objects were prescribed and delivered to the test laboratory by the client. According to the information of the client, the test objects were purchased in May 2014 in the usual commercial way.

The pumps can be classified in single and double pumps according to their operating modes or their number of simultaneously operable suction bottles. In several pumps both operating modes are alternatively available. Other operating parameters can be set according to the respective pump, i. e. vacuum performance, cycle frequency and pump mode (stimulation mode / suction mode). For the tests, all pumps were operated in suction mode, each at its maximum vacuum performance. As far as possible, all pumps were set to the same cycle frequency, i. e. 45 min^{-1}…52 min^{-1}. For the power supply during the test, the mains adapter delivered with each pump was used.

The operating conditions for the tests were also prescribed by the client or defined by the test laboratory in accordance with the client before the tests. The operating conditions determined for the tests (full load & cycle frequency 45 min^{-1}…52 min^{-1}) reflect the actual use in practice according to the client.

Table 1 gives an overview of the pumps tested. In the test certificates in Appendix A, the operating conditions during measurements are indicated. Appendix B shows photos of the pumps tested.

The arrangement of the test objects in the reverberation room was set up by employees of the test laboratory.

For the tests, the breast-pumps were connected to the suction bottles and funnels. In order to create the necessary vacuum, the suction funnels of the bottles were sealed by means of an artificial breast. The artificial breast was fixed to the suction funnel by an adhesive tape.

For the reverberation room test, the complete breast-pump setup was placed directly onto the reflecting reverberation room floor according to DIN EN ISO 3741 [2]. For all tests the same position on the reverberation room floor was used. In order to avoid contact noise between specimen and reverberation room floor, a pad of closed-cell polyurethane foam was laid underneath. For all tests, the operating state of the pumps was controlled before and after the test in terms of noise caused by the setup (rattling noise of the pump as a result of hoses lying loose on the pump or noise of the mounting base, or similar; air sucked in due to improperly positioned or slipped off artificial breast, etc.).

Appendix B shows photos of the test arrangement.

4 Execution of the tests

The tests were carried out on 23rd May 2014 between 18:00 h und 23:00 h in the reverberation room of Müller-BBM GmbH, Planegg.

The climatic conditions during the tests are described in the test certificates in Appendix A.

The test method and the test equipment used are documented in Appendix D.

5 Evaluation

The sound power levels were determined in third-octave bands from 100 Hz…10000 Hz based on which the sound power levels in octaves from 125 Hz…8000 Hz and the A-weighted sound power levels L_{WA} were calculated.

6 Test results

The determined sound power levels in one third-octave bands are contained in the result tables in Appendix C. In the result sheets in Appendix A, the sound power levels summarized in octave bands as well as the A-weighted sound power levels L_{WA} are listed.

Table 1 shows the comparison between the A-weighted sound power levels L_{WA} determined for all pumps tested.

Table 1. Overview of examined pumps and test results: A-weighted sound power levels L_{WA}.

Test No. / test certificate Appendix A, Page	**Manufacturer / type**	**Serial No.**	**Mode tested**	**L_{WA} [dB]**
1	Ardo / Calypso	14621129	single	46.0
2	Medela / Freestyle™	F20134300130	single	57.8
3	Medela / Swing™	G20140302318	single	55.1
4	Philips / AVENT SCF 332	0238978	single	55.1
5	Lansinoh® / Affinity Pro™	SN0172	single	55.6
6	Ameda / Purely Yours™ (ident. Ameda / Lactaline)	24502082	single	55.1
7	Ardo / Calypso Double Plus	14621129	double	46.4
8	Medela / Freestyle	F20134300130	double	58.0
9	Lansinoh® / Affinity Pro™	SN0172	double	56.6
10	Ameda / Purely Yours™ (ident. Ameda / Lactaline)	24502082	double	54.9
11	Medela / Swing Maxi™	M20140500034	double	49.6
12	Philips / AVENT SCF 334	0045539	double	56.6

The requirements of DIN ISO 3741 [2] in terms of background noise criteria acc. to sections 5.4.1.1 and 5.4.1.2 could not be complied with in all frequency bands. If applicable, the respective sound levels in the test certificates and in the result tables in Appendix C are marked accordingly.

However, the relative criterion for the determination of the A-weighted sound power level acc. to sect. 5.4.1.3 of DIN ISO 3741 [2] is met in all tests carried out. It may therefore be assumed that the A-weighted sound power level of the background noise criteria calculated from the data of all frequency bands complies with the standard.

7 Remarks

The present test results exclusively refer to the conditions prevailing on the day of measurement.

M. Eng. Philipp Meistring

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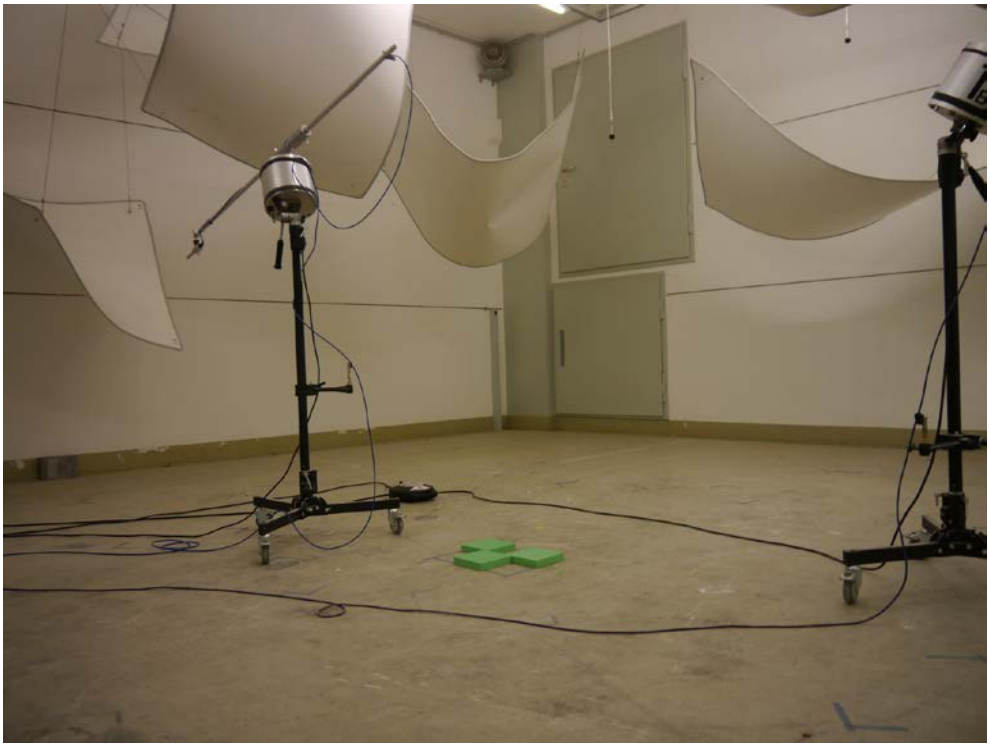

Figure B.1. Reverberation room and test position without test object.

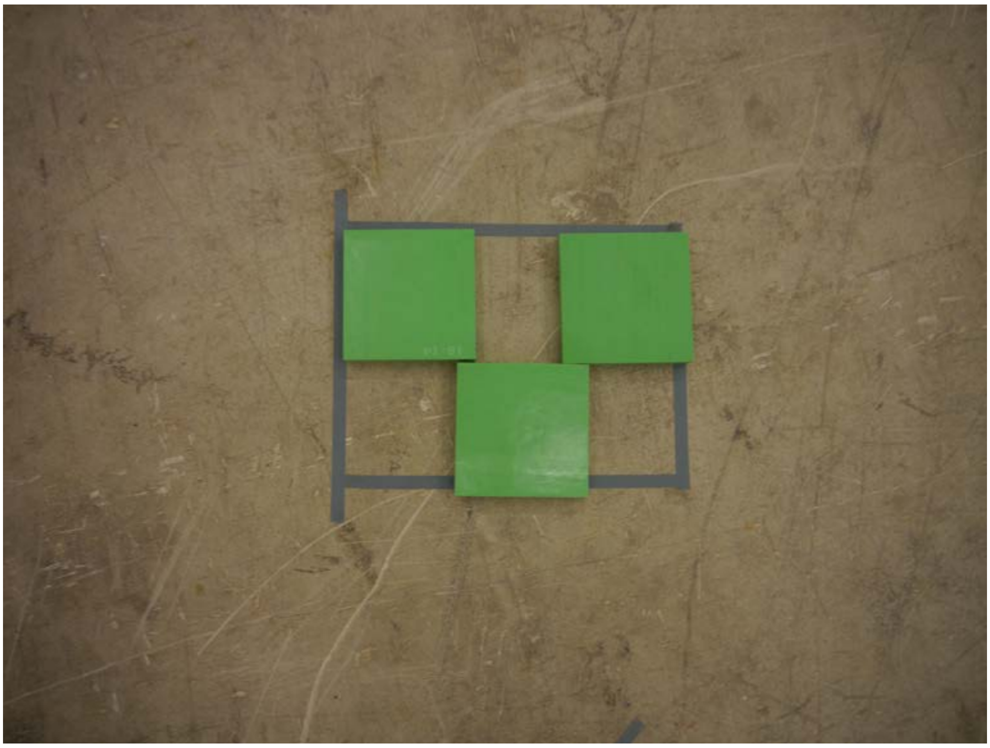

Figure B.2. Test position on the reverberation room floor without test object.

Figure B.3. Test arrangement on the reverberation room floor.

Figure B.4. Suction bottle with fixed artificial brest.

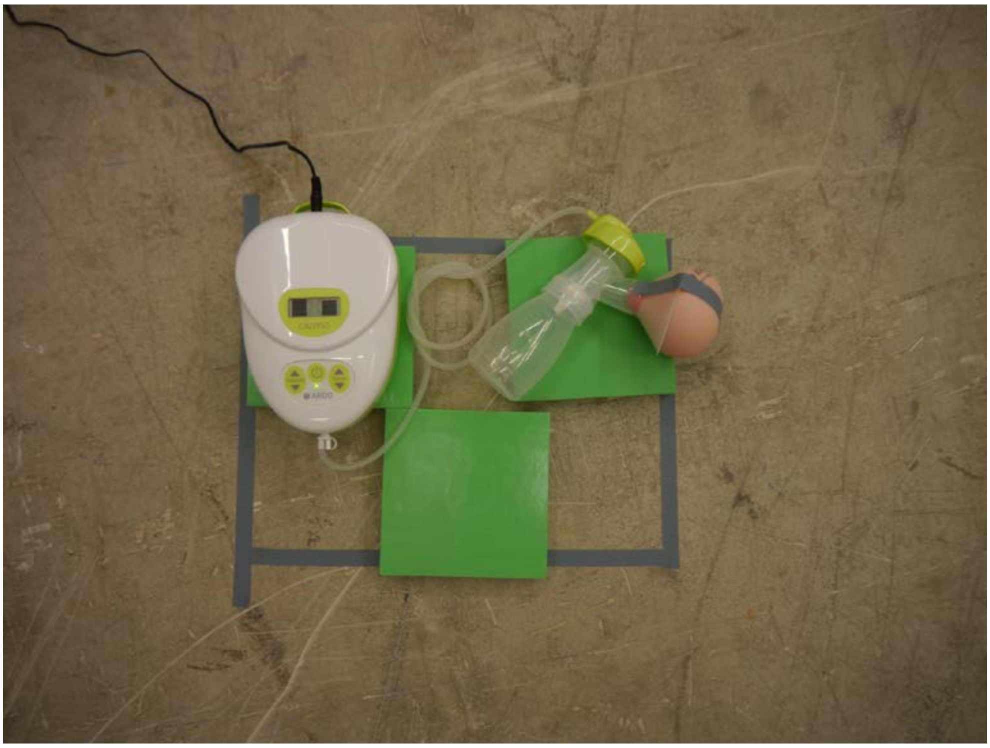

Figure B.5. Test No. 1: Ardo Calypso (single pump).

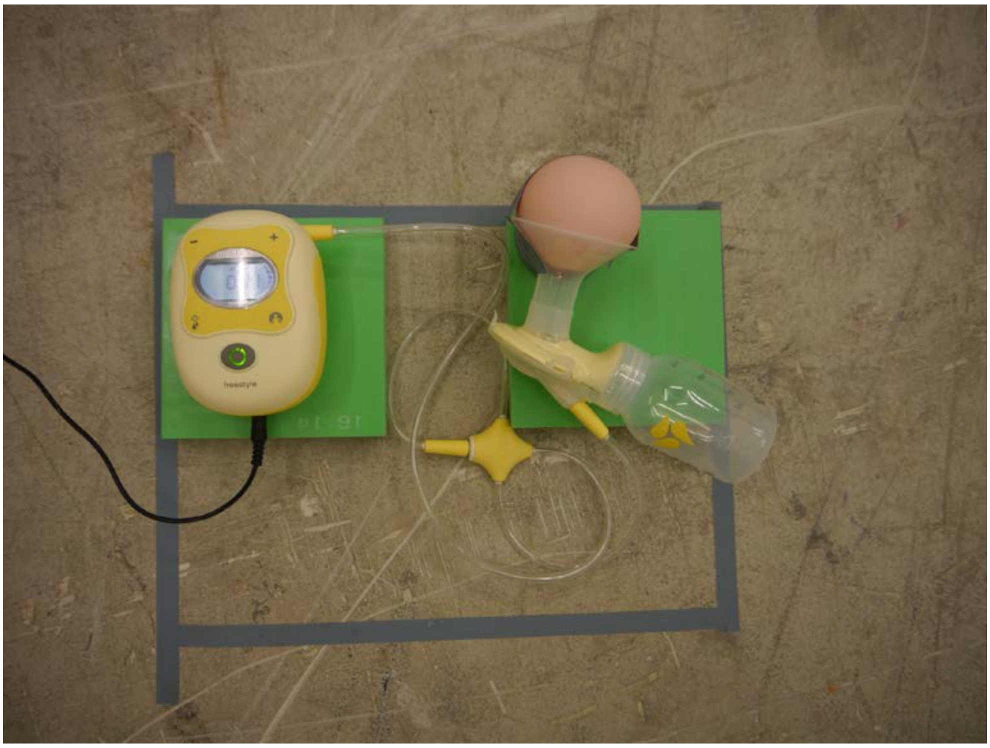

Figure B.6. Test No. 2: Medela Freestyle™ (single pump).

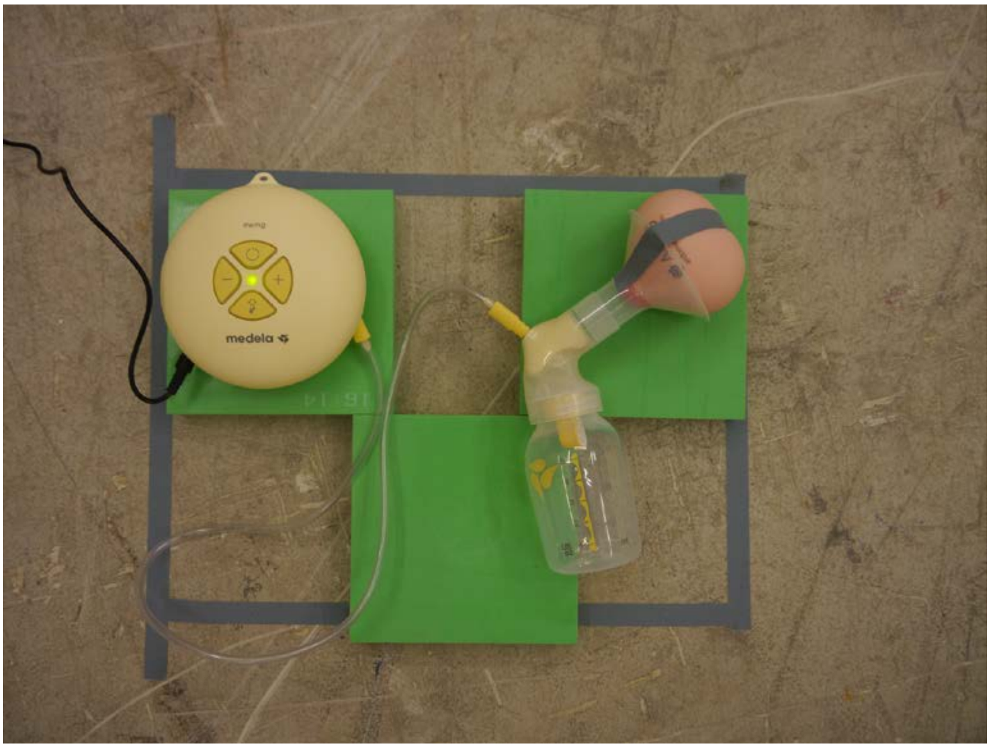

Figure B.7. Test No. 3: Medela Swing™ (single pump).

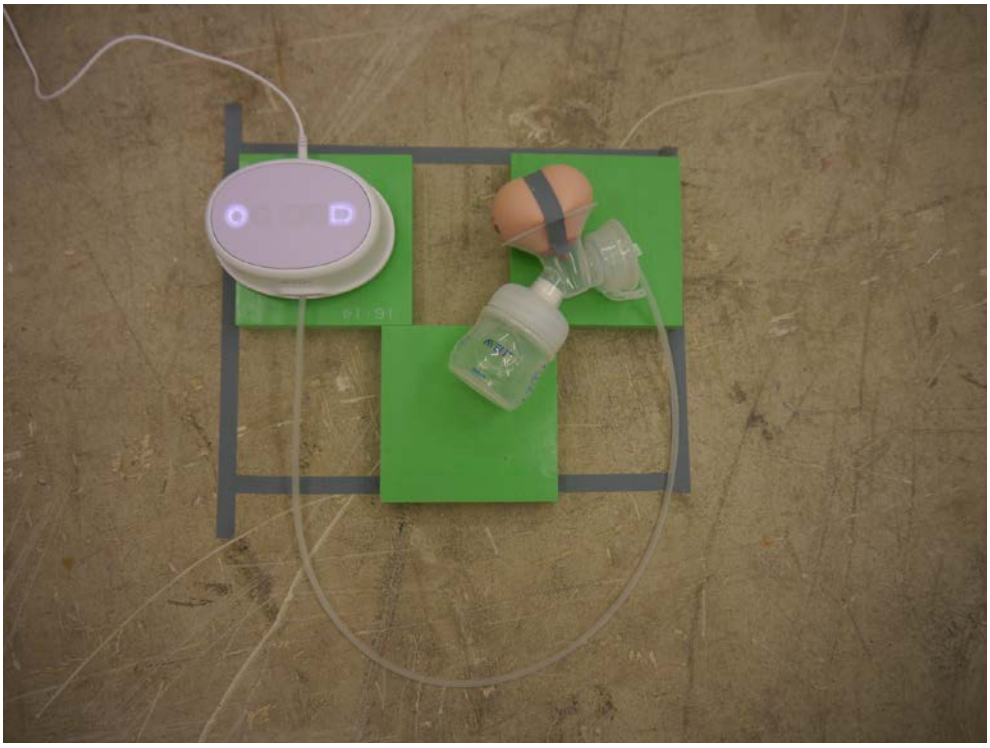

Figure B.8. Test No. 4: Philips AVENT (single pump).

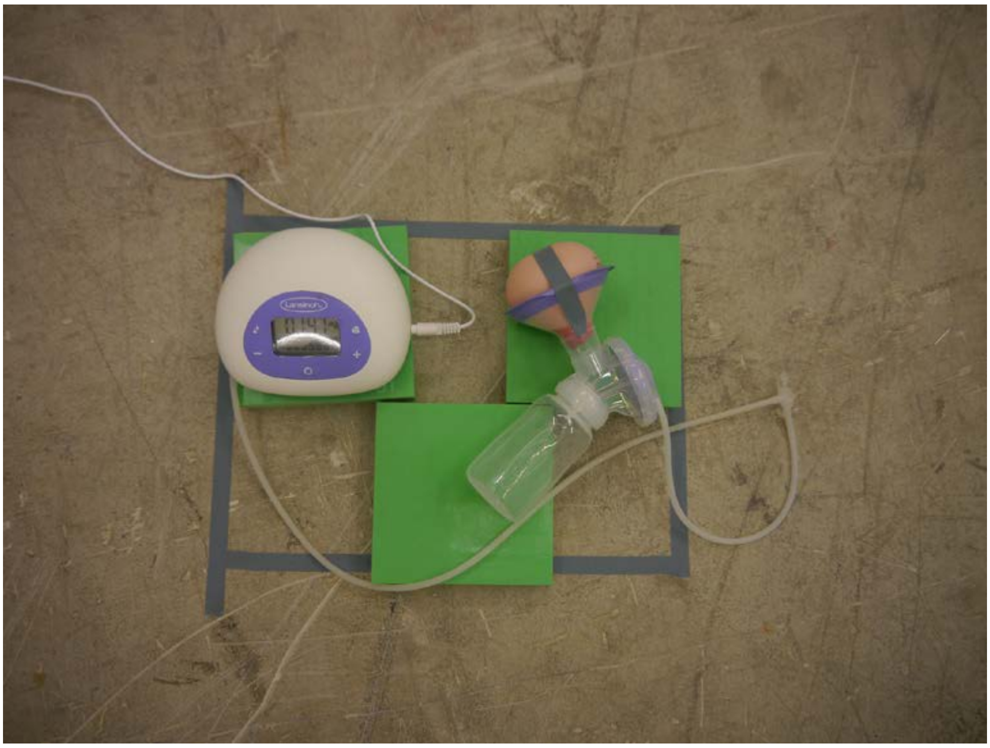

Figure B.9. Test No. 5: Lansinoh® Affinity Pro™ (single pump).

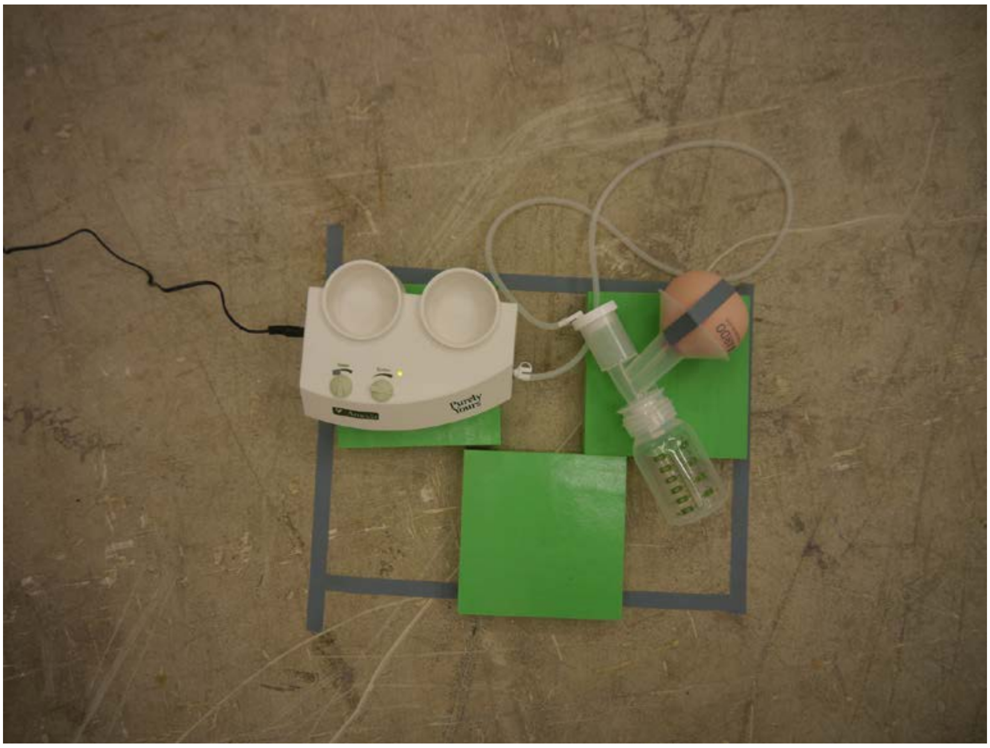

Figure B.10. Test No. 6: Ameda Purely Yours™ (single pump).

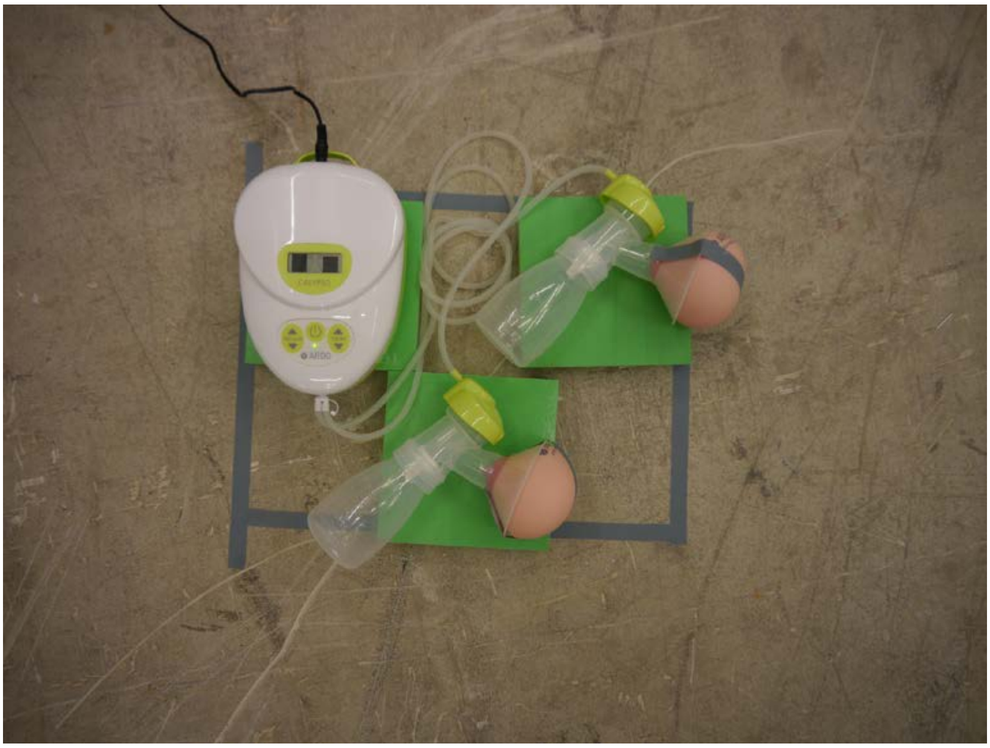

Figure B.11. Test No. 7: Ardo Calypso Double Plus (double pump).

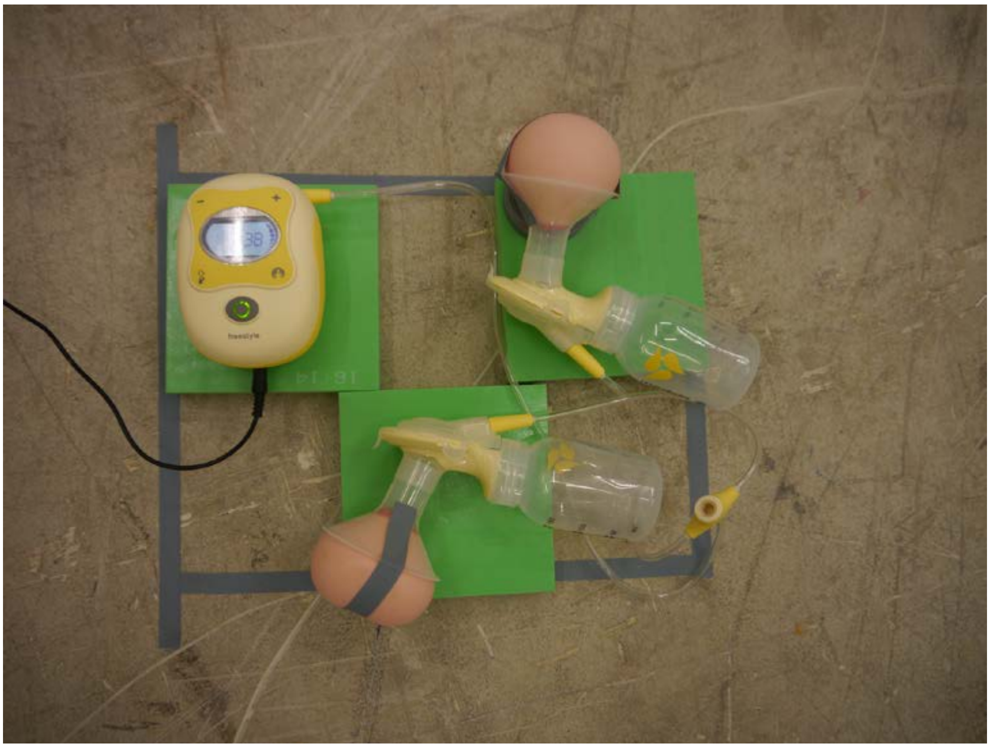

Figure B.12. Test No. 8: Medela Freestyle™ (double pump).

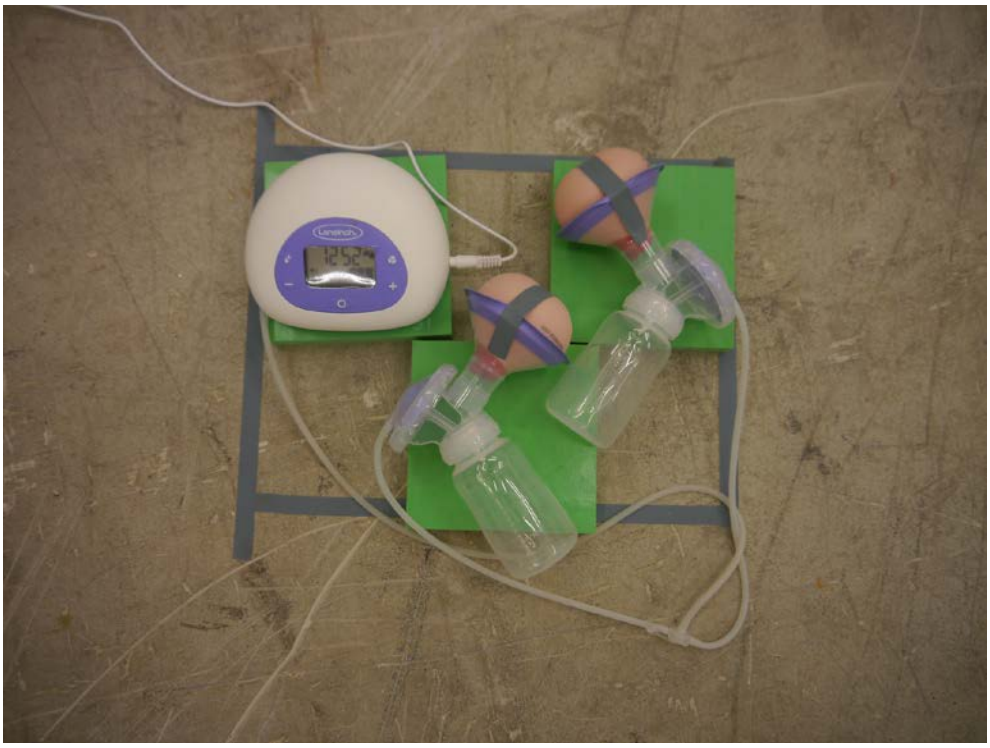

Figure B.13. Test No. 9: Lansinoh® Affinity Pro™ (double pump).

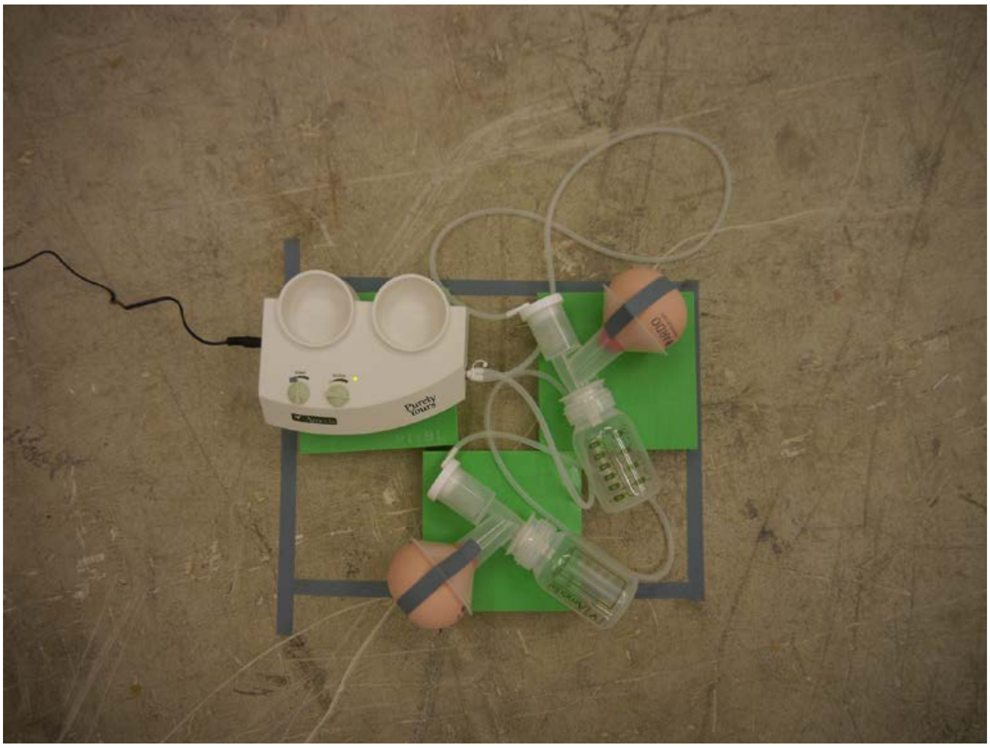

Figure B.14. Test No. 10: Ameda Purely Yours™ (double pump).

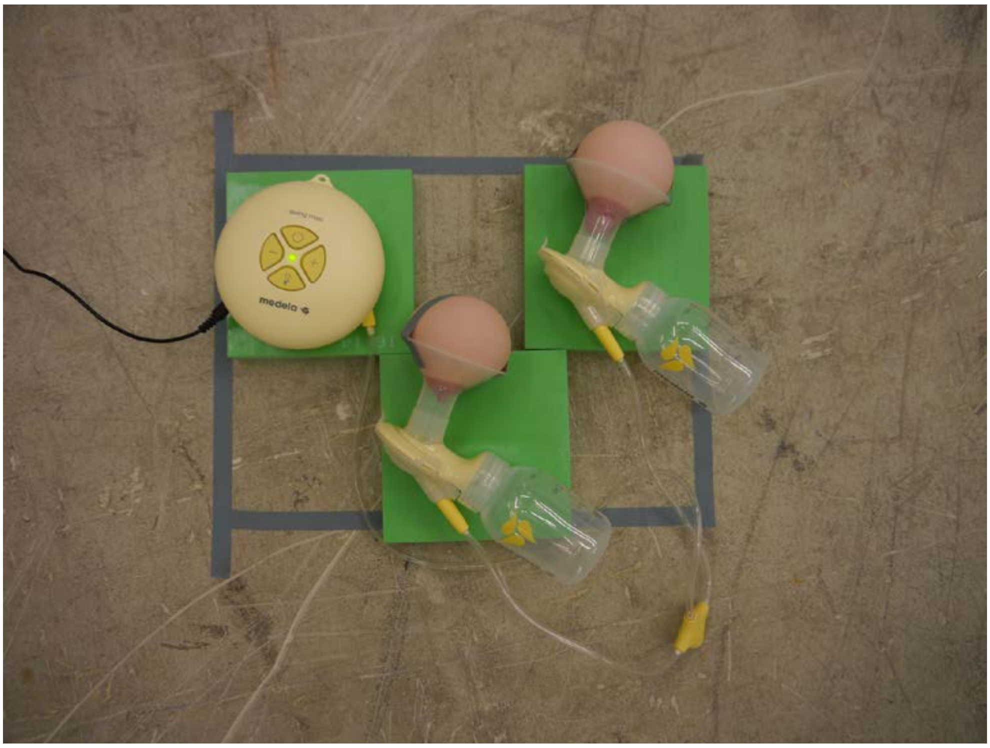

Figure B.15. Test No. 11: Medela Swing Maxi™ (double pump).

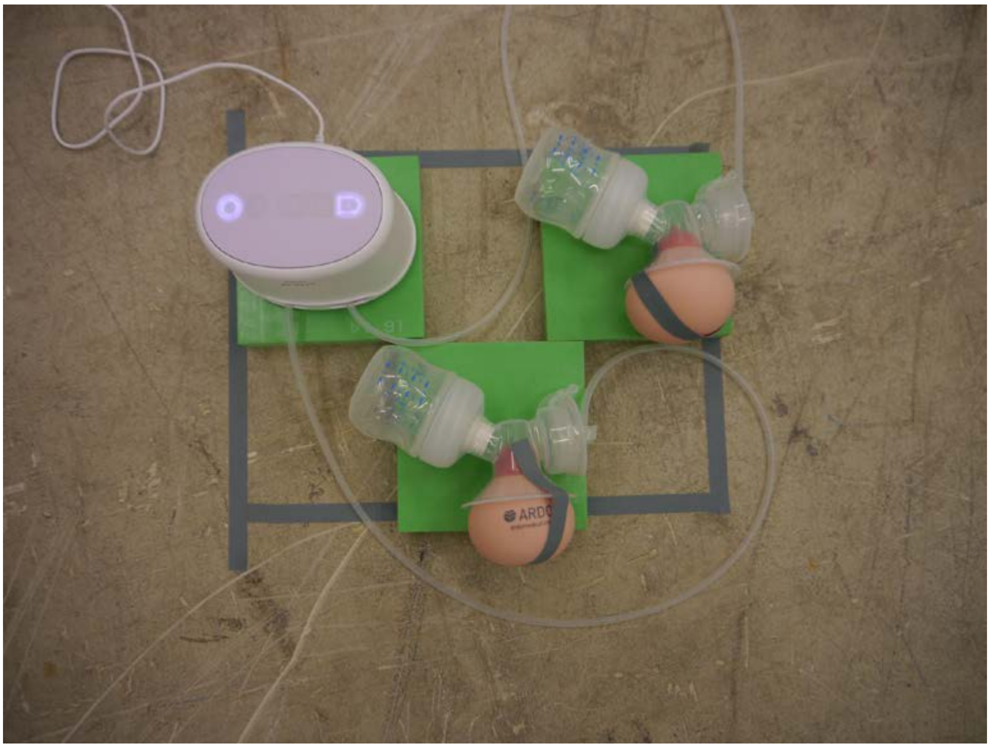

Figure B.16. Test No. 12: Philips AVENT (double pump).

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Result tables

The markings in the following tables signify:

Column "Corr.": background noise correction

without	no influence of background noise	$\Delta L_p \geq 15$ dB; $K_{1i} = 0$ dB
*	Measurement value influenced by background noise:	
	100 Hz…200 Hz und ≥ 6300 Hz:	6 dB ≤ ΔL_p < 15 dB; K_{1i} = 0.0…1.3 dB
	250 Hz…5000 Hz:	10 dB ≤ ΔL_p < 15 dB; K_{1i} = 0.0…0.5 dB
**	Measurement value determined by background noise (minimum value):	
	100 Hz…200 Hz und ≥ 6300 Hz:	ΔL_p < 6 dB; K_{1i} = 1.3 dB (= max.)
	250 Hz…5000 Hz:	ΔL_p < 10 dB; K_{1i} = 0.5 dB (= max.)

Column "Crit.": Compliance with relative criterion

without	Relative criterion acc. to 5.4.1.1 and 5.4.1.2 of ISO 3741 [2] complied with
n. c.	Relative criterion acc. to 5.4.1.1 and 5.4.1.2 of ISO 3741 [2] not complied with.

Table C.1. Tests Nos. 1 to 4 (test certificates Appendix A, pages 1 to 4): Determined sound power levels L_W in third-octave bands in dB(A).

Frequency	Test No. 1			Test No. 2			Test No. 3			Test No. 4		
	L_W	Corr.	Crit.	L_W	Corr.	Crit.	L_W	Corr.	Crit.	L_W	Corr.	Crit.
100	15.7	**		38.0			20.2	**		29.9	*	
125	14.3	**		27.3	*		22.9	*		39.7		
160	11.6	**		45.0			37.2			25.7	*	
200	16.6	**		44.9			31.7	*		34.0	*	
250	21.0	**		48.3			39.1			47.8		
315	29.2	*		47.0			37.9			43.7		
400	34.1			50.8			44.9			47.8		
500	38.8			52.5			45.8			42.1		
630	36.3			46.8			48.4			43.4		
800	31.9	*		44.3			48.5			39.8		
1000	38.3			41.4			47.6			43.9		
1250	38.4			38.7			41.7			39.6		
1600	35.0			39.9			39.3			41.6		
2000	33.2	*		40.7			36.0			44.4		
2500	29.6	*		32.3	*		31.5	*		42.3		
3150	30.1	*		32.2	*		34.6			38.8		
4000	25.6	**	n. c.	28.7	*		36.3			36.8		
5000	24.4	**	n. c.	26.6	**		32.9	*		33.5	*	
6300	25.5	**	n. c.	29.2	*		27.5	*		34.8	*	
8000	24.0	**	n. c.	27.8	*		28.6	*		35.6	*	
10000	23.8	**		26.3	**		30.0	*		34.9	*	

Table C.2. Tests Nos.5 to 8 (test certificates Appendix A, pages 5 to 8):
Determined sound power levels L_W in third-octave bands in dB(A).

Frequency	Test No. 5			Test No. 6			Test No. 7			Test No. 8		
	L_W	Corr.	Crit.	L_W	Corr.	Crit.	L_W	Corr.	Crit.	L_W	Corr.	Crit.
100	16.5	**		15.4	**		18.4	**		42.2		
125	14.0	**		11.7	**		16.3	**		29.5	*	
160	21.1	*		16.9	**		14.6	**		43.7		
200	28.8	*		17.9	**		15.8	**		45.0		
250	49.0			32.2	*		19.8	**		48.2		
315	43.7			34.6	*		29.1	*		47.5		
400	35.5			43.7			32.9	*		50.7		
500	48.4			44.4			39.5			52.7		
630	43.2			43.7			39.5			47.7		
800	43.1			43.5			36.1			44.9		
1000	43.4			47.2			38.0			41.7		
1250	49.8			49.9			37.3			38.7		
1600	43.5			45.2			34.2			40.2		
2000	33.2	*		40.9			31.9	*		39.8		
2500	32.3	*		36.2			29.4	*		31.1	*	
3150	32.7	*		35.8			28.9	*		31.5	*	
4000	29.8	*		40.6			25.5	**	n. c.	30.2	*	
5000	27.4	**		36.4	*		23.9	**		26.7	**	
6300	27.2	*		30.1	*		24.0	**		30.3	*	
8000	26.6	**		31.5	*		22.3	**		30.4	*	
10000	26.8	**		30.5	*		23.1	**		27.9	**	

Table C.3. Test Nrs.9 to 12 (test certificates Appendix A, pages 9 to 12):
Determined sound power levels L_W in third-octave bands in dB(A).

Frequency	Test No. 9			Test No. 10			Test No. 11			Test No. 12		
	L_W	Corr.	Crit.	L_W	Corr.	Crit.	L_W	Corr.	Crit.	L_W	Corr.	Crit.
100	17.1	**		14.9	**		20.6	**		37.3	*	
125	14.6	**		10.8	**		30.0	*		40.9		
160	21.6	*		13.8	**		38.3			27.0	*	
200	29.6	*		18.1	**		37.4			37.7		
250	50.0			28.0	*		36.6			46.2		
315	44.6			34.4	*		40.8			51.1		
400	34.4			44.7			36.2			48.6		
500	48.0			44.4			33.6			41.3		
630	44.3			43.3			36.6			40.5		
800	44.2			45.2			39.1			42.1		
1000	44.7			46.7			42.3			46.1		
1250	51.5			49.3			38.8			42.4		
1600	44.8			44.9			33.8			39.3		
2000	33.4	*		40.7			35.1			41.3		
2500	35.4			34.7			31.8	*		43.3		
3150	33.8	*		35.1			34.9			41.4		
4000	30.2	*		38.9			36.9			38.4		
5000	27.7	**		35.5	*		31.9	*		39.5		
6300	28.3	*		29.0	*		27.1	*		40.2	*	
8000	27.8	*		31.7	*		27.2	*		35.3	*	
10000	28.7	*		29.1	*		25.9	**		35.9	*	

Description of the test procedure for the determination of the sound power level

1 Measurand

The measurement of the sound power level was performed following the direct procedure according to DIN EN ISO 3741 [2]. The sound power level was determined in one third-octave bands. The calculation of the sound power level L_W was calculated using the following equation:

$$L_W = \overline{L_{p(ST)}} + \left\{ 10\lg\frac{A}{A_0} dB + 4{,}34\frac{A}{S} dB + 10\lg\left(1 + \frac{S \cdot c}{8 \cdot V \cdot f}\right) dB + C_1 + C_2 - 6dB \right\}$$

With:

$\overline{L_{p(ST)}}$	mean value of the corrected time-averaged one third-octave band sound pressure levels of the sound sources to be examined in operation in the reverberation room in dB
A	equivalent sound absorption area in the reverberation room in m^2
A_0	1 m^2
S	total surface of the reverberation room in m^2
c	sound-propagation velocity at the air temperature prevailing in the reverberation room at the time of measurement in m/s
V	volume of the reverberation room in m^3
f	one third-octave band centre frequency in Hz
C_1	correction to take account of the different reference parameters of the sound pressure and sound power levels in function of the characteristic acoustic impedance of the air in the reverberation room at the time of measurements in dB
C_2	correction of the radiation impedance in dB

Information regarding the measurement uncertainty of the measurement procedure is given in DIN EN ISO 3740 [1] and DIN EN ISO 3741 [2].

2 Description of the reverberation room

The reverberation room of Müller-BBM GmbH in Planegg complies with the requirements defined in DIN ISO 3741 [2].

The reverberation room has a volume of V = 199.6 m^3 and a surface area of S = 216 m^2. Thus it is possible according to section 5.2 of DIN ISO 3741 [2] to perform measurements starting from and including the one third-octave band of the centre frequency 100 Hz. In order to increase diffusivity, six composite sheet metal

S:\MProj\112\M112237\M112237_01_PBE_2E.DOC : 31. 07. 2014 boards dimensioned 1.2 m x 2.4 m and six composite sheet metal boards dimensioned 1.2 m x 1.2 m were suspended curved and irregularly

Figure D.1 shows drawings of the reverberation room.

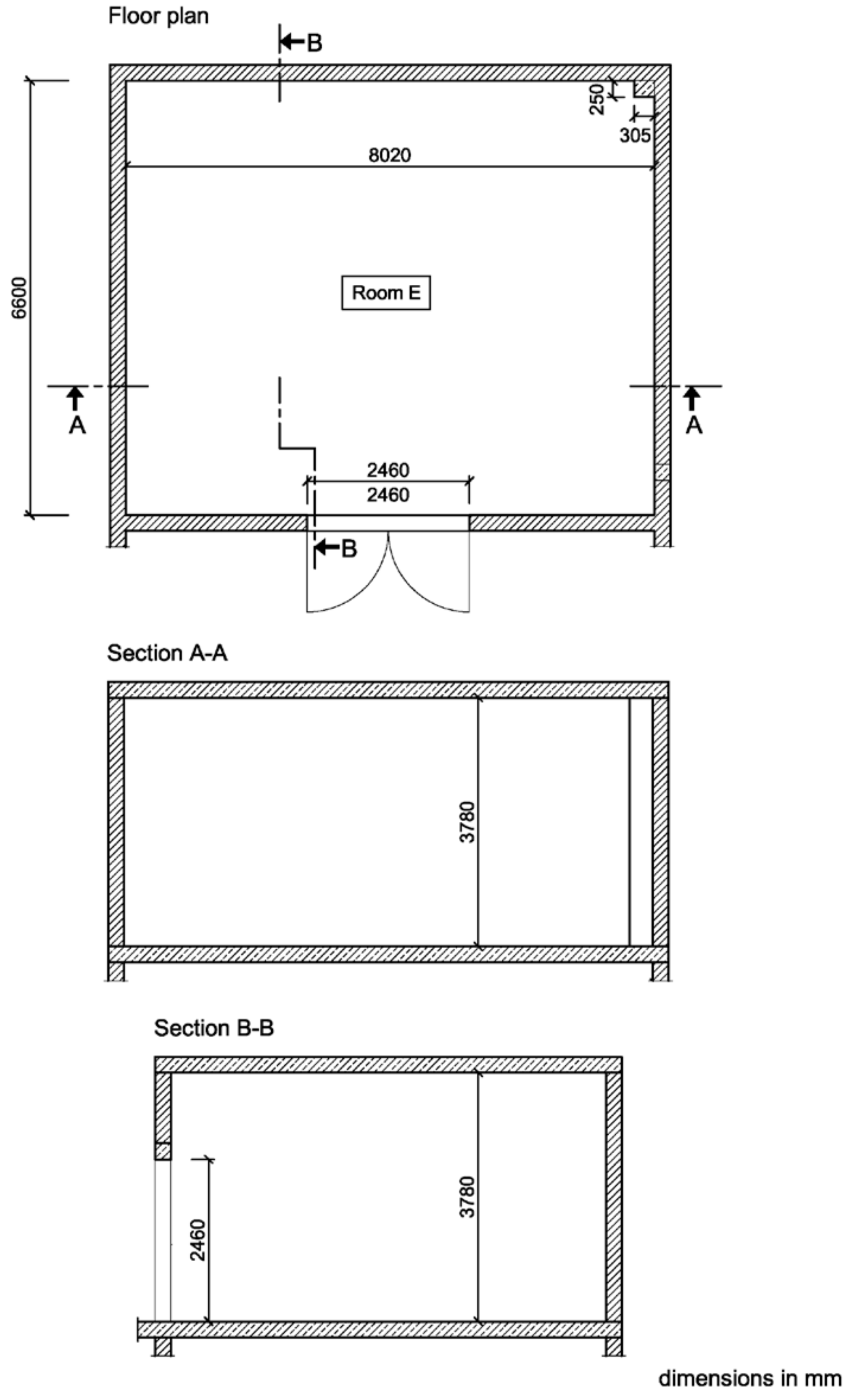

Figure D.1. Plan view and sections of the reverberation room.

3 Measurement of the sound pressure level

The measurement of the average sound pressure level $L'_{pi(ST)}$ was performed with i = 2 single microphones by continuous scanning using moved microphones on circular paths. The path radius of the microphones was 1.0 m. The minimum distances between the microphone positions were as follows:

- 1.5 m between each microphone position and the test object;
- 1.0 m between each microphone position and the surfaces of the reverberation room;
- 0.5 m between each microphone position and the diffusors.

The path levels were inclined by at least 10° compared to all room surfaces.

The chosen measurement duration of 45 s corresponds to two complete circuits of the measurement paths.

The sound pressure level was registered in one third-octave bands (100 Hz…10000 Hz).

The test was performed for one source position at a time (position of the test object on the floor of the reverberation room).

The required minimum path length of the microphone paths and the necessary number of source positions were qualified acc. to section 8.4.2, DIN EN ISO 3741 [2].

4 Background noise correction

The time-averaged sound pressure level of the background noise was determined on the same microphone paths and with the same measurement duration as in the measurements with sound source.

The background noise correction $K_{1,i}$ was determined according to section 9.1 of DIN EN ISO 3741 [2]. In the result tables in Appendix C and in the test certificates in Appendix A, the results are marked if a correction due to background noise was done.

5 Absorption area in the reverberation room

The equivalent sound absorption area *A* of the reverberation room was determined by measuring the reverberation time *T* following the indirect procedure according to DIN EN ISO 3382-2 [3] using the following equation:

$$A = \frac{55{,}26}{c}\left(\frac{V}{T}\right)$$

With

A	equivalent sound absorption area in the reverberation room in m^2
c	sound-propagation velocity in m/s at the air temperature prevailing in the reverberation room at the time of measurement
V	volume of the reverberation room in m^3

The determination of the impulse responses was carried out following the indirect procedure in the reverberation room without test object. In terms of test signal, a sine-sweep with a pink spectrum was used. 24 independent loudspeaker-microphone combinations were registered. The evaluation of the reverberation time was carried out acc. to DIN EN ISO 3382-2 [3], whereby a linear regression was used to calculate the reverberation time *T* from the level of the inverse impulse response.

6 Test equipment

The calibration of the measurement instruments used was controlled by means of the pistonphone at the beginning of the measurements. At the end of measurement, the constancy of the calibration was checked and confirmed. Within the scope of our own quality assurance system, the equipment is additionally inspected and controlled in regular intervals.

In Table D.1 the test equipment used is listed.

Table D.1. Test equipment.

Name	Manufacturer	Type	Serial-No.
Reverberation time measurement			
Sound card	RME	Multiface II	22460388
Amplifier	APart	Champ One	09070394
Dodecahedron	Müller-BBM	DOD130B	265201
Dodecahedron	Müller-BBM	DOD130B	265202
Dodecahedron	Müller-BBM	DOD130B	265203
Dodecahedron	Müller-BBM	DOD130B	265204
Microphone	Microtech	M360	1783
Microphone	Microtech	M360	1785
Microphone	Microtech	M360	1786
Microphone	Microtech	M360	1787
Microphone	Microtech	M360	1788
Microphone	Microtech	M360	1789
Sound pressure level measurements			
Measuring system	Norsonic	121	26342
Microphone swivel facility	Norsonic	212	12986
Microphone swivel facility	Norsonic	212	12987
Pre-amplifier microphone with free-field microphone	Norsonic Norsonic	1201 1220	26145 25160
Pre-amplifier microphone with free-field microphone	Norsonic Norsonic	1201 1220	30588 26071
Pistonphon	Brüel & Kjaer	4228	1651956
Measurement of the climatic conditions			
Hygro-/thermometer	Testo	Saveris H1E	01554624
Barometer	Lufft	Opus 10	030.0910.0003.9. 4.1.30
Software			
Software for measurement and evaluation	Müller-BBM	Bau 4	Version 1.7