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Determination of microphone data

(8 appendices)

Task

SP has been requested to purchase four microphones from each of four manufacturers according to table 1 and do independent tests on them according to table 2. All microphones have similar specifications, ½" IEPE microphones with nominal sensitivity 50 mV/Pa.

Measurement objects

The microphones were all purchased from their respective Swedish representative without letting them know the purpose. The B&K microphones were delivered in 3 working days, the G.R.A.S. microphones 5 working days, the PCB microphones 2 working days and the BSWA microphones three weeks after order.

Microphone model	Ser.no.	Denoted in the report
Brüel & Kjaer type 4189-A-021	2857973	B&K 1
	2857974	B&K 2
	2857975	B&K 3
	2857976	B&K 4
BSWA type MPA201	491153	BSWA 1
	491154	BSWA 2
	491155	BSWA 3
	491156	BSWA 4
G.R.A.S. type 46AE	175021	GRAS 1
	175022	GRAS 2
	175023	GRAS 3
	175024	GRAS 4
PCB type 378B02	LW111307	PCB 1
	LW111308	PCB 2
	LW111309	PCB 3
	LW111310	PCB 4

Table 1. The test objects.

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Test scope

Tests have been performed on the IEPE microphone kits and on the microphone cartridges according to table 2 below.

Test	IEPE kit	Cartridge alone	Appendix
Sensitivity at 250 Hz	Yes	Yes	1
Sensitivity frequency response	Yes	Yes	2
Phase frequency response	Yes	No	3
A-weighted noise floor	Yes	Yes	4
Dynamic range upper limit	Yes	No	5
Low frequency limit	Yes	No	6
Temperature coefficient	Yes	No	7
Humidity coefficient	Yes	No	8

Table 2. The test scope.

Method

The measurement methods are described in appendix 1 to 8.

Result

The results are given in appendix 1 to 8.

Traceability

The measurements are traceable to national and international standards if not other stated.

Reference equipment used

Reference microphone B&K 4192 ser.no. 2670898

Low frequency reference microphone B&K 4193 ser.no. 2151209

High sound pressure monitoring microphone B&K 4939 ser.no. 2478632

Pistonphone B&K 4228 ser.no. 1818796

Temp/humidity meter Testo 645 ser.no. 344901/006

Barometer Druck DPI 160 ser.no. 434/91-9

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Appendices

Appendix 1

Determination of microphone sensitivity at 250 Hz

Objects

Microphones denoted B&K 1 to B&K 4, BSWA 1 to BSWA 4, GRAS 1 to GRAS 4 and PCB 1 to PCB 4 as described in the main part of this report.

Task

The task was to determine the sensitivity of the IEPE microphone kits when they were delivered to SP compared to the results after the extended exposure to changes of temperature and humidity as defined by the IEC 61094-4 temperature and humidity coefficient test as described (appendix 7 and 8) later in this report. This will show stability after exposure to changes in the environmental elements.

Method

The sensitivity of the IEPE microphone kits has been determined by use of a calibrated pistonphone type B&K 4228.

The open circuit sensitivity of the microphone cartridges has been determined by sequential comparison to a calibrated reference microphone type B&K 4192 using the insert voltage technique as described in IEC 61094-5. A pistonphone type B&K 4228 was used as a transfer standard.

Environmental conditions

The sensitivity determinations were all conducted within the following environmental conditions.

Air pressure	995±3 hPa
Temperature	23±1°C
Humidity	45±7 % RH

Result

The sensitivities of the IEPE microphone kits at 250 Hz measured in chronological order

1. before any other tests were conducted
2. between the temperature and humidity coefficient determination tests as described in appendix 7 and 8.
3. after the temperature and humidity coefficient determination tests as described in appendix 7 and 8.

are given in table 1 below. The absolute value of the total sensitivity shift is also given under "Deviation".

The initial open circuit sensitivities of the microphone cartridges at 250 Hz are given in table 2.

Appendix 1

Test object	Measurement 1	Measurement 2	Measurement 3	Deviation (dB)
B&K 1	-25,95	-26,00	-26,00	0,05
B&K 2	-26,22	-26,36	-26,38	0,16
B&K 3	-26,38	-26,43	-26,34	0,04
B&K 4	-25,68	-25,77	-25,71	0,03
BSWA 1	-25,27	- *)	- *)	- *)
BSWA 2	-25,08	-22,16	-21,83	3,25
BSWA 3	-25,36	-22,51	-21,95	3,41
BSWA 4	-24,82	-23,30	-22,92	1,90
GRAS 1	-27,15	-27,32	-27,50	0,35
GRAS 2	-26,09	-26,23	-26,13	0,04
GRAS 3	-27,21	-27,36	-27,68	0,47
GRAS 4	-26,76	-26,97	-26,92	0,16
PCB 1	-25,47	-25,59	-25,45	0,02
PCB 2	-26,51	-26,68	-26,28	0,23
PCB 3	-26,48	-26,64	-26,44	0,04
PCB 4	-25,69	-25,87	-25,79	0,10

Table 1. Sensitivity at 250 Hz of the IEPE microphone kits (dB re. 1 V/Pa).

*) No result given as the microphone broke during the temperature coefficient determination tests.

Test object	Sensitivity
B&K 1	-25,80
B&K 2	-26,21
B&K 3	-26,20
B&K 4	-25,55
BSWA 1	-25,31
BSWA 2	-26,01
BSWA 3	-25,46
BSWA 4	-25,37
GRAS 1	-26,92
GRAS 2	-25,89
GRAS 3	-26,99
GRAS 4	-26,53
PCB 1	-25,41
PCB 2	-26,48
PCB 3	-26,43
PCB 4	-25,66

Table 2. Initial open circuit sensitivity at 250 Hz of the microphone cartridges (dB re. 1 V/Pa).

The measurement uncertainty is 0,15 dB including a coverage factor $k=2$.

Appendix 1

Comparison to specifications and standard

IEC 61094-4 is defining specifications for working standard microphones. The requirement for a WS2F microphone is a minimum sensitivity level -40 dB re 1 V/Pa. No requirements are given for IEPE kits.

The manufacturers have stated sensitivity levels as given in table 3.

Microphone type	Stated sensitivity level (dB re 1 V/Pa)	
	IEPE microphone kit	Microphone cartridge
B&K 4189-A-021	-26 (no tolerance)	-26±1,5
BSWA MPA201	-28 (no tolerance)	-26±2
G.R.A.S. 46AE	-26±2	-26±2
PCB 378B02	No specification given	-26±1,5

Table 3. Sensitivity level specified by the manufacturers.

A summary of how the measurement results initially meets the specifications given by the manufacturers and IEC standard is given in table 4a and 4b.

In case of specification without tolerance is given for IEPE microphone kits, the tolerance given for microphone cartridges is applied.

If the result is within the specifications the indication is “Yes”. If the result is outside the specifications but within the specification expanded by the measurement uncertainty the indication is “Indeterminable”. If the result is outside the specification expanded by the measurement uncertainty the indication is “No”.

Test object (IEPE microphone kit)	Meets IEC 61094-4	Meets manufacturers specification
B&K 1	No specification given	Yes
B&K 2	No specification given	Yes
B&K 3	No specification given	Yes
B&K 4	No specification given	Yes
BSWA 1	No specification given	Yes
BSWA 2	No specification given	Yes
BSWA 3	No specification given	Yes
BSWA 4	No specification given	Yes
GRAS 1	No specification given	Yes
GRAS 2	No specification given	Yes
GRAS 3	No specification given	Yes
GRAS 4	No specification given	Yes
PCB 1	No specification given	No specification given
PCB 2	No specification given	No specification given
PCB 3	No specification given	No specification given
PCB 4	No specification given	No specification given

Table 4a. Initially determined sensitivity level for the IEPE microphone kits compared to IEC standard and manufacturers specifications.

Appendix 1

Test object (Microphone cartridge)	Meets IEC 61094-4	Meets manufacturers specification
B&K 1	Yes	Yes
B&K 2	Yes	Yes
B&K 3	Yes	Yes
B&K 4	Yes	Yes
BSWA 1	Yes	Yes
BSWA 2	Yes	Yes
BSWA 3	Yes	Yes
BSWA 4	Yes	Yes
GRAS 1	Yes	Yes
GRAS 2	Yes	Yes
GRAS 3	Yes	Yes
GRAS 4	Yes	Yes
PCB 1	Yes	Yes
PCB 2	Yes	Yes
PCB 3	Yes	Yes
PCB 4	Yes	Yes

Table 4b. Initially determined sensitivity level for the microphone cartridges compared to IEC standard and manufacturers specifications.

Appendix 2

Determination of microphone sensitivity frequency response

Objects

Microphones denoted B&K 1 to B&K 4, BSWA 1 to BSWA 4, GRAS 1 to GRAS 4 and PCB 1 to PCB 4 as described in the main part of this report.

Task

The task was to determine the sensitivity frequency response of the microphones cartridges and IEPE microphone kits when they were delivered to SP.

Method

The sensitivity frequency response of the test objects was determined by the electrostatic actuator method, described in IEC 61094-6. A ½” actuator type GRAS RA0014 was used. Free field corrections given by the manufacturers were applied and are presented in table 1.

Frequency (Hz)	Free field correction (dB)			
	B&K 4189	BSWA MP201	GRAS 46AE	PCB 378B02
<315	0	0	0	0
315	0,01	0	0	0,01
400	0,01	0	0	0,01
500	0,02	0	0	0,04
630	0,04	0	0,03	0,04
800	0,07	0,1	0,08	0,09
1k	0,10	0,2	0,18	0,12
1,25k	0,15	0,3	0,28	0,16
1,6k	0,22	0,4	0,37	0,21
2k	0,32	0,5	0,46	0,31
2,5k	0,48	0,6	0,58	0,46
3,15k	0,71	0,8	0,82	0,68
4k	1,07	1,0	1,10	1,01
5k	1,57	1,5	1,58	1,52
6,3k	2,28	2,2	2,26	2,28
8k	3,38	3,3	3,27	3,43
10k	5,12	4,6	4,63	4,95
12,5k	7,19	6,5	6,42	6,71
16k	8,59	8	8,02	8,41
20k	10,05	9	9,05	9,95

Table 1. Free field corrections applied.

Appendix 2

Environmental conditions

The sensitivity frequency response determinations were conducted within the following environmental conditions.

Air pressure 995±3 hPa
 Temperature 23±1°C
 Humidity 45±7 % RH

Result

The sensitivity frequency response re. 250 Hz of the IEPE microphone kits are given in the figure 1 to 4 and table 2 to 5.

The sensitivity frequency response re. 250 Hz of the microphone cartridges are given in the figure 5 to 8 and table 6 to 9.

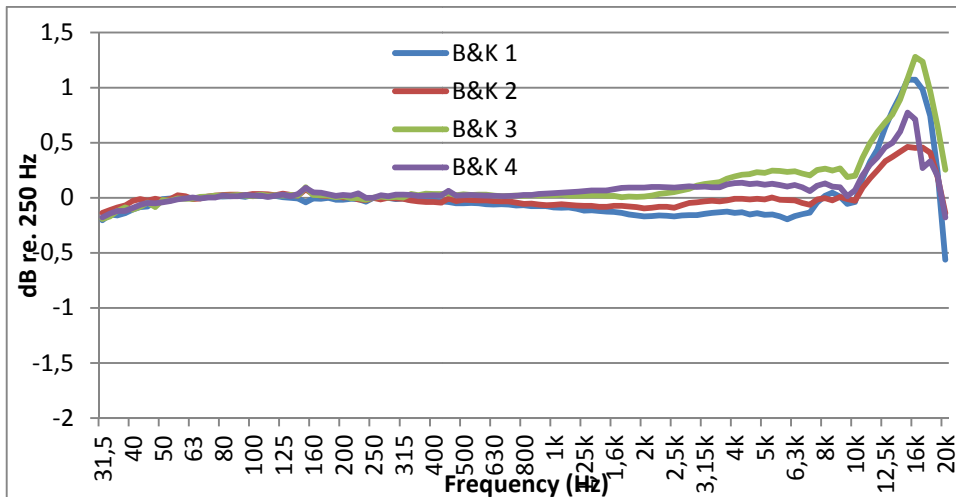


Figure 1. Frequency response of the B&K 4189-A-021 microphone kits.

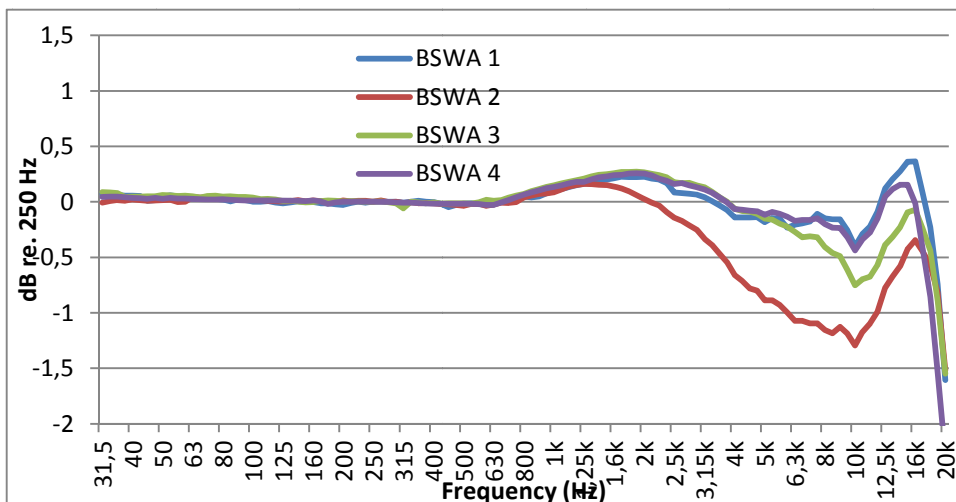


Figure 2. Frequency response of the BSWA MPA201 microphone kits.

Appendix 2

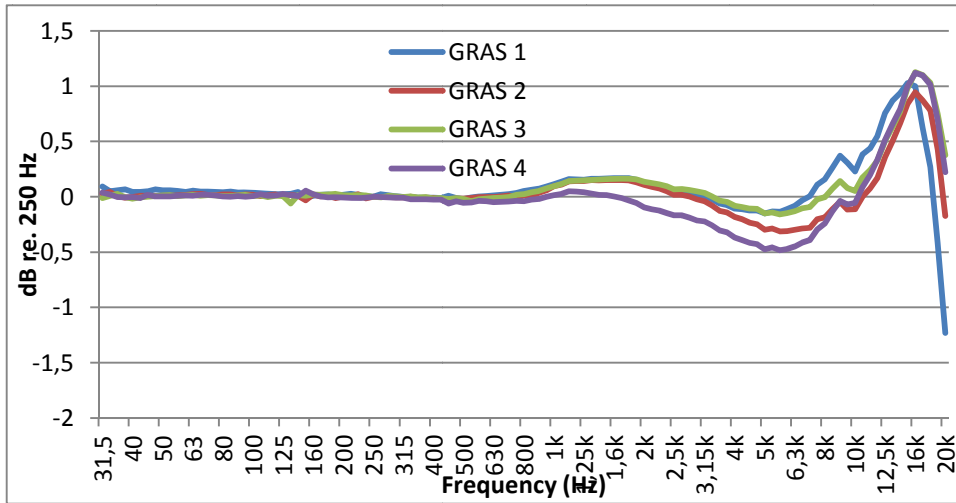


Figure 3. Frequency response of the G.R.A.S. 46AE microphone kits.

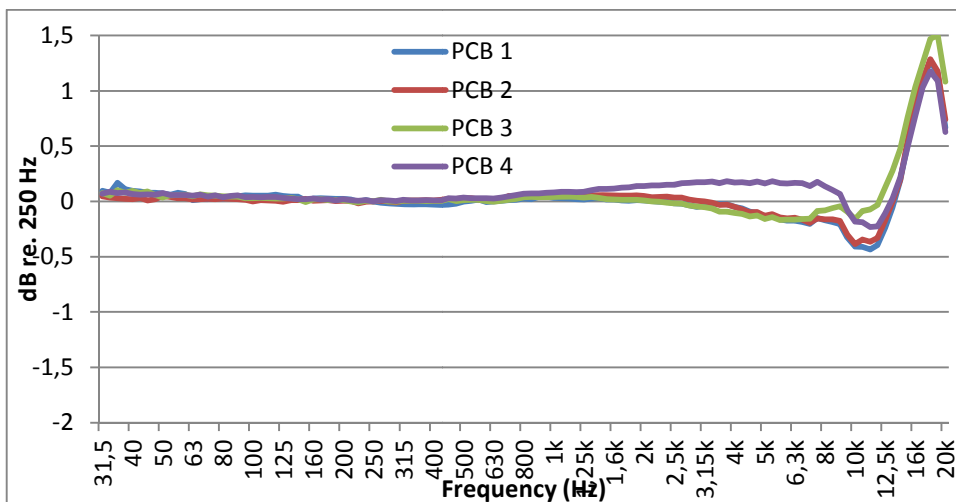


Figure 4. Frequency response of the PCB 378B02 microphone kits.

Appendix 2

Frequency	Frequency response re. 250 Hz			
	B&K 1	B&K 2	B&K 3	B&K 4
31,5	-0,2	-0,1	-0,2	-0,2
40	-0,1	0,0	-0,1	-0,1
50	0,0	0,0	0,0	0,0
63	0,0	0,0	0,0	0,0
80	0,0	0,0	0,0	0,0
100	0,0	0,0	0,0	0,0
125	0,0	0,0	0,0	0,0
160	0,0	0,0	0,0	0,0
200	0,0	0,0	0,0	0,0
250	0,0	0,0	0,0	0,0
315	0,0	0,0	0,0	0,0
400	0,0	0,0	0,0	0,0
500	-0,1	0,0	0,0	0,0
630	-0,1	0,0	0,0	0,0
800	-0,1	-0,1	0,0	0,0
1k	-0,1	-0,1	0,0	0,0
1,25k	-0,1	-0,1	0,0	0,1
1,6k	-0,1	-0,1	0,0	0,1
2k	-0,2	-0,1	0,0	0,1
2,5k	-0,2	-0,1	0,1	0,1
3,15k	-0,1	0,0	0,1	0,1
4k	-0,1	0,0	0,2	0,1
5k	-0,2	0,0	0,2	0,1
6,3k	-0,2	0,0	0,2	0,1
8k	0,0	0,0	0,3	0,1
10k	0,0	0,0	0,2	0,1
12,5k	0,6	0,3	0,7	0,5
16k	1,1	0,5	1,3	0,7
20k	-0,6	-0,1	0,3	-0,2

Table 2. Sensitivity frequency response of the B&K 4189-A-021 microphone kits.

Appendix 2

Frequency	Frequency response re. 250 Hz			
	BSWA1	BSWA2	BSWA3	BSWA4
31,5	0,1	0,0	0,1	0,0
40	0,1	0,0	0,0	0,0
50	0,0	0,0	0,1	0,0
63	0,0	0,0	0,0	0,0
80	0,0	0,0	0,0	0,0
100	0,0	0,0	0,0	0,0
125	0,0	0,0	0,0	0,0
160	0,0	0,0	0,0	0,0
200	0,0	0,0	0,0	0,0
250	0,0	0,0	0,0	0,0
315	0,0	0,0	-0,1	0,0
400	0,0	0,0	0,0	0,0
500	0,0	0,0	0,0	0,0
630	0,0	0,0	0,0	0,0
800	0,0	0,0	0,1	0,1
1k	0,1	0,1	0,1	0,1
1,25k	0,2	0,2	0,2	0,2
1,6k	0,2	0,1	0,3	0,2
2k	0,2	0,0	0,3	0,3
2,5k	0,1	-0,1	0,2	0,2
3,15k	0,0	-0,3	0,1	0,1
4k	-0,1	-0,7	-0,1	-0,1
5k	-0,2	-0,9	-0,2	-0,1
6,3k	-0,2	-1,1	-0,3	-0,2
8k	-0,1	-1,2	-0,4	-0,2
10k	-0,4	-1,3	-0,8	-0,4
12,5k	0,1	-0,8	-0,4	0,0
16k	0,4	-0,3	-0,1	0,0
20k	-1,6	-1,5	-1,5	-2,3

Table 3. Sensitivity frequency response of the BSWA MPA201 microphone kits.

Appendix 2

Frequency	Frequency response re. 250 Hz			
	GRAS1	GRAS2	GRAS3	GRAS4
31,5	0,1	0,0	0,0	0,0
40	0,0	0,0	0,0	0,0
50	0,1	0,0	0,0	0,0
63	0,1	0,0	0,0	0,0
80	0,0	0,0	0,0	0,0
100	0,0	0,0	0,0	0,0
125	0,0	0,0	0,0	0,0
160	0,0	0,0	0,0	0,0
200	0,0	0,0	0,0	0,0
250	0,0	0,0	0,0	0,0
315	0,0	0,0	0,0	0,0
400	0,0	0,0	0,0	0,0
500	0,0	0,0	0,0	-0,1
630	0,0	0,0	0,0	0,0
800	0,1	0,0	0,0	0,0
1k	0,1	0,1	0,1	0,0
1,25k	0,2	0,1	0,1	0,0
1,6k	0,2	0,2	0,2	0,0
2k	0,1	0,1	0,1	-0,1
2,5k	0,1	0,0	0,1	-0,2
3,15k	0,0	0,0	0,0	-0,2
4k	-0,1	-0,2	-0,1	-0,4
5k	-0,2	-0,3	-0,2	-0,5
6,3k	-0,1	-0,3	-0,1	-0,4
8k	0,2	-0,2	0,0	-0,2
10k	0,2	-0,1	0,1	-0,1
12,5k	0,8	0,4	0,5	0,5
16k	1,0	0,9	1,1	1,1
20k	-1,2	-0,2	0,4	0,2

Table 4. Sensitivity frequency response of the G.R.A.S. 46AE microphone kits.

Appendix 2

Frequency	Frequency response re. 250 Hz			
	PCB 1	PCB 2	PCB 3	PCB 4
31,5	0,1	0,0	0,1	0,1
40	0,1	0,0	0,1	0,1
50	0,1	0,0	0,0	0,1
63	0,0	0,0	0,0	0,1
80	0,0	0,0	0,0	0,0
100	0,1	0,0	0,0	0,0
125	0,0	0,0	0,0	0,0
160	0,0	0,0	0,0	0,0
200	0,0	0,0	0,0	0,0
250	0,0	0,0	0,0	0,0
315	0,0	0,0	0,0	0,0
400	0,0	0,0	0,0	0,0
500	0,0	0,0	0,0	0,0
630	0,0	0,0	0,0	0,0
800	0,0	0,1	0,0	0,1
1k	0,0	0,1	0,0	0,1
1,25k	0,0	0,1	0,0	0,1
1,6k	0,0	0,1	0,0	0,1
2k	0,0	0,0	0,0	0,1
2,5k	0,0	0,0	0,0	0,2
3,15k	0,0	0,0	-0,1	0,2
4k	-0,1	-0,1	-0,1	0,2
5k	-0,1	-0,1	-0,2	0,2
6,3k	-0,2	-0,1	-0,2	0,2
8k	-0,2	-0,2	-0,1	0,1
10k	-0,4	-0,4	-0,2	-0,2
12,5k	-0,2	-0,2	0,1	-0,1
16k	0,8	0,9	1,0	0,8
20k	0,7	0,7	1,1	0,6

Table 5. Sensitivity frequency response of the PCB 378B02 microphone kits.

Appendix 2

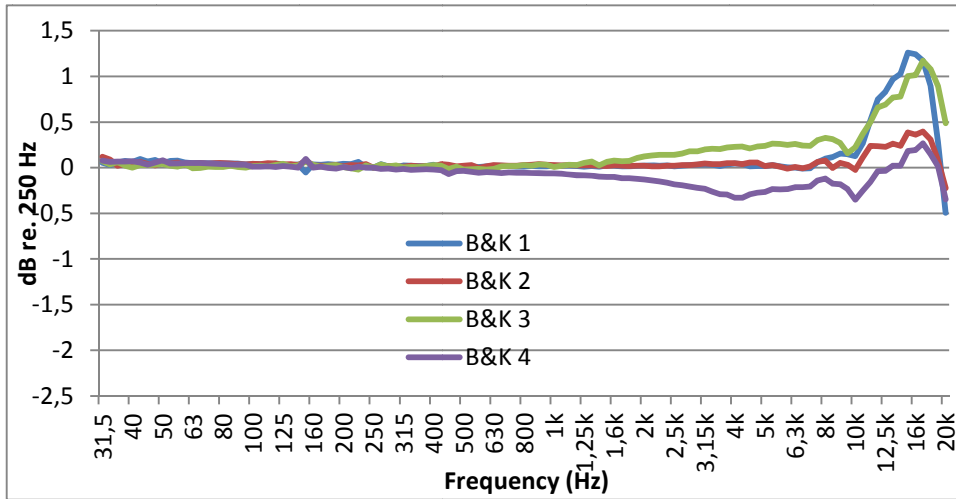


Figure 5. Frequency response of the B&K 4189 microphone cartridge.

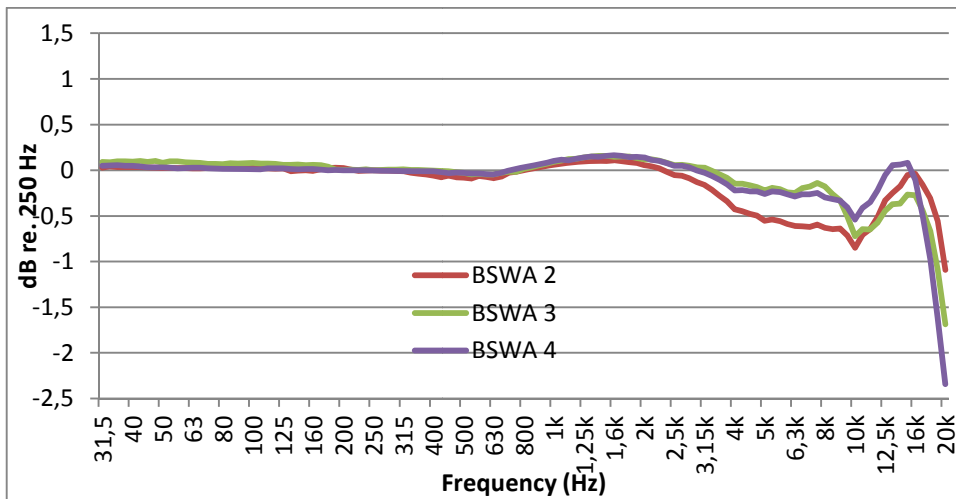


Figure 6. Frequency response of the BSWA MP201 microphone cartridge.

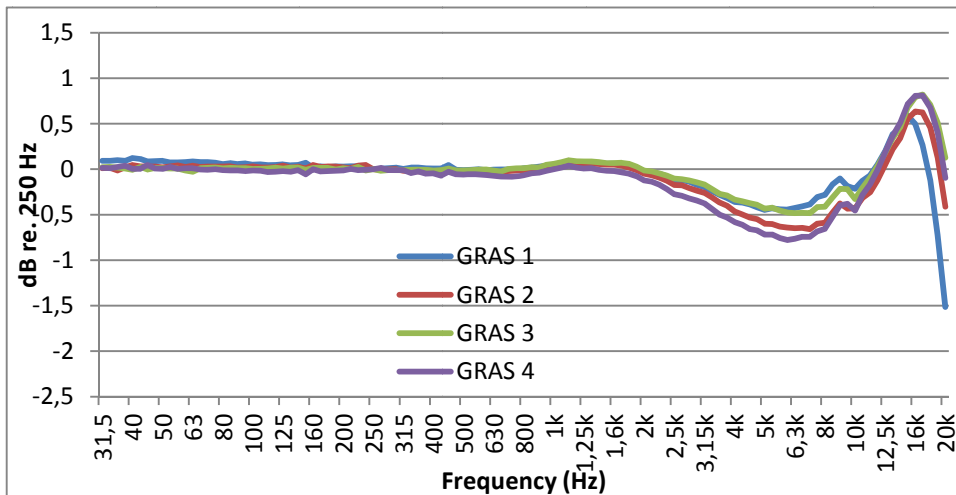


Figure 7. Frequency response of the G.R.A.S. 40AE microphone cartridge.

Appendix 2

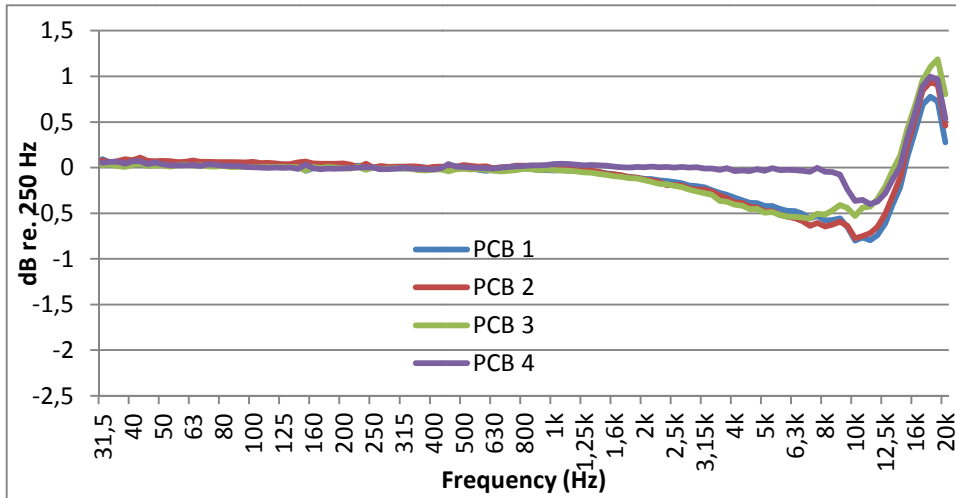


Figure 8. Frequency response of the PCB 377B02 microphone cartridge.

Frequency	Frequency response re. 250 Hz			
	B&K 1	B&K 2	B&K 3	B&K 4
31,5	0,1	0,1	0,1	0,1
40	0,1	0,0	0,0	0,1
50	0,0	0,1	0,0	0,1
63	0,0	0,0	0,0	0,1
80	0,0	0,0	0,0	0,0
100	0,0	0,0	0,0	0,0
125	0,0	0,0	0,0	0,0
160	0,0	0,0	0,0	0,0
200	0,0	0,0	0,0	0,0
250	0,0	0,0	0,0	0,0
315	0,0	0,0	0,0	0,0
400	0,0	0,0	0,0	0,0
500	0,0	0,0	0,0	0,0
630	0,0	0,0	0,0	-0,1
800	0,0	0,0	0,0	-0,1
1k	0,0	0,0	0,0	-0,1
1,25k	0,0	0,0	0,1	-0,1
1,6k	0,0	0,0	0,1	-0,1
2k	0,0	0,0	0,1	-0,1
2,5k	0,0	0,0	0,1	-0,2
3,15k	0,0	0,0	0,2	-0,2
4k	0,0	0,0	0,2	-0,3
5k	0,0	0,0	0,2	-0,3
6,3k	0,0	0,0	0,3	-0,2
8k	0,1	0,1	0,3	-0,1
10k	0,1	0,0	0,2	-0,4
12,5k	0,8	0,2	0,7	0,0
16k	1,2	0,4	1,0	0,2
20k	-0,5	-0,2	0,5	-0,3

Table 6. Sensitivity frequency response of the B&K 4189 microphone cartridge.

Appendix 2

Frequency	Frequency response re. 250 Hz			
	BSWA1	BSWA2	BSWA3	BSWA4
31,5	0,1	0,0	0,1	0,1
40	0,1	0,0	0,1	0,1
50	0,1	0,0	0,1	0,0
63	0,1	0,0	0,1	0,0
80	0,1	0,0	0,1	0,0
100	0,1	0,0	0,1	0,0
125	0,0	0,0	0,1	0,0
160	0,0	0,0	0,1	0,0
200	0,0	0,0	0,0	0,0
250	0,0	0,0	0,0	0,0
315	0,0	0,0	0,0	0,0
400	0,0	-0,1	0,0	0,0
500	0,0	-0,1	0,0	0,0
630	-0,1	-0,1	0,0	0,0
800	0,0	0,0	0,0	0,0
1k	0,1	0,1	0,1	0,1
1,25k	0,1	0,1	0,1	0,1
1,6k	0,1	0,1	0,1	0,2
2k	0,1	0,1	0,1	0,1
2,5k	0,1	-0,1	0,1	0,0
3,15k	0,0	-0,2	0,0	0,0
4k	-0,1	-0,4	-0,1	-0,2
5k	-0,1	-0,6	-0,2	-0,3
6,3k	0,0	-0,6	-0,2	-0,3
8k	0,1	-0,6	-0,2	-0,3
10k	-0,1	-0,8	-0,7	-0,5
12,5k	0,4	-0,3	-0,4	-0,1
16k	0,6	0,0	-0,3	-0,1
20k	-1,2	-1,1	-1,7	-2,3

Table 7. Sensitivity frequency response of the BSWA MP201 microphone cartridge.

Appendix 2

Frequency	Frequency response re. 250 Hz			
	GRAS1	GRAS2	GRAS3	GRAS4
31,5	0,1	0,0	0,0	0,0
40	0,1	0,0	0,0	0,0
50	0,1	0,0	0,0	0,0
63	0,1	0,0	0,0	0,0
80	0,1	0,0	0,0	0,0
100	0,0	0,0	0,0	0,0
125	0,1	0,0	0,0	0,0
160	0,0	0,0	0,0	0,0
200	0,0	0,0	0,0	0,0
250	0,0	0,0	0,0	0,0
315	0,0	0,0	0,0	0,0
400	0,0	0,0	0,0	0,0
500	0,0	-0,1	0,0	-0,1
630	0,0	0,0	0,0	-0,1
800	0,0	0,0	0,0	-0,1
1k	0,1	0,0	0,1	0,0
1,25k	0,1	0,1	0,1	0,0
1,6k	0,1	0,0	0,1	0,0
2k	0,0	-0,1	0,0	-0,1
2,5k	-0,1	-0,2	-0,1	-0,3
3,15k	-0,2	-0,3	-0,2	-0,4
4k	-0,4	-0,5	-0,3	-0,6
5k	-0,4	-0,6	-0,4	-0,7
6,3k	-0,4	-0,6	-0,5	-0,8
8k	-0,3	-0,6	-0,4	-0,7
10k	-0,2	-0,4	-0,3	-0,5
12,5k	0,2	0,0	0,2	0,2
16k	0,5	0,6	0,8	0,8
20k	-1,5	-0,4	0,1	-0,1

Table 8. Sensitivity frequency response of the G.R.A.S. 40AE microphone cartridge.

Appendix 2

Frequency	Frequency response re. 250 Hz			
	PCB 1	PCB 2	PCB 3	PCB 4
31,5	0,1	0,1	0,0	0,1
40	0,1	0,1	0,0	0,1
50	0,1	0,1	0,0	0,0
63	0,0	0,1	0,0	0,0
80	0,0	0,1	0,0	0,0
100	0,0	0,1	0,0	0,0
125	0,0	0,0	0,0	0,0
160	0,0	0,0	0,0	0,0
200	0,0	0,0	0,0	0,0
250	0,0	0,0	0,0	0,0
315	0,0	0,0	0,0	0,0
400	0,0	0,0	0,0	0,0
500	0,0	0,0	0,0	0,0
630	0,0	0,0	0,0	0,0
800	0,0	0,0	0,0	0,0
1k	0,0	0,0	0,0	0,0
1,25k	0,0	0,0	-0,1	0,0
1,6k	-0,1	-0,1	-0,1	0,0
2k	-0,1	-0,1	-0,1	0,0
2,5k	-0,2	-0,2	-0,2	0,0
3,15k	-0,2	-0,2	-0,3	0,0
4k	-0,3	-0,4	-0,4	0,0
5k	-0,4	-0,5	-0,5	0,0
6,3k	-0,5	-0,6	-0,5	0,0
8k	-0,6	-0,6	-0,5	0,0
10k	-0,8	-0,8	-0,5	-0,4
12,5k	-0,6	-0,5	-0,2	-0,3
16k	0,4	0,5	0,7	0,6
20k	0,3	0,5	0,8	0,5

Table 9. Sensitivity frequency response of the PCB 377B02 microphone cartridge.

The expanded measurement uncertainty with a coverage factor $k=2$ is given in table 10.

Frequency (Hz)	Expanded uncertainty (dB)
31,5-100	0,3
125-630	0,2
800-8k	0,3
10k-12,5k	0,5
16k-20k	1,0

Table 10. Expanded uncertainty of sensitivity frequency response determination.

Appendix 2

Comparison to specifications and standard

IEC 61094-4 is defining specifications for working standard microphones. The frequency response requirement given for a WS2F microphone is $\pm 0,5$ dB within 20 to 4000 Hz, with increasing tolerance with 0,25 dB/1/3 octave up to ± 2 dB at 16 kHz. At 20 kHz the tolerance is +2,0/-6,0 dB. No requirements are given for IEPE kits.

The manufacturers have stated frequency range as given in table 11.

Microphone type	Stated frequency response	
	IEPE kit	Microphone cartridge
B&K 4189-A-021	± 2 dB within 20 to 20000 Hz	± 1 dB within 10 to 8000 Hz ± 2 dB within 6,3 to 20000 Hz
BSWA MPA201	± 2 dB within 20 to 20000 Hz	± 2 dB within 6,3 to 20000 Hz
G.R.A.S. 46AE	± 1 dB within 5 to 10000 Hz ± 2 dB within 3,15 to 20000 Hz	± 1 dB within 5 to 10000 Hz ± 2 dB within 3,15 to 20000 Hz
PCB 378B02	No specification given	± 1 dB within 5 to 10000 Hz ± 2 dB within 3,15 to 20000 Hz

Table 11. Frequency response specified by the manufacturers.

A summary of how the measurement results meets the specifications given by the manufacturers and IEC standard is given in table 12a and 12b.

If the result is within the specifications the indication is “Yes”. If the result is outside the specifications but within the specification expanded by the measurement uncertainty the indication is “Indeterminable”. If the result is outside the specification expanded by the measurement uncertainty the indication is “No”.

Test object (IEPE microphone kit)	Meets IEC 61094-4	Meets manufacturers specification
B&K 1	No specification given	Yes
B&K 2	No specification given	Yes
B&K 3	No specification given	Yes
B&K 4	No specification given	Yes
BSWA 1	No specification given	Yes
BSWA 2	No specification given	Yes
BSWA 3	No specification given	Yes
BSWA 4	No specification given	Indeterminable
GRAS 1	No specification given	Yes
GRAS 2	No specification given	Yes
GRAS 3	No specification given	Yes
GRAS 4	No specification given	Yes
PCB 1	No specification given	No specification given
PCB 2	No specification given	No specification given
PCB 3	No specification given	No specification given
PCB 4	No specification given	No specification given

Table 12a. Frequency response for the IEPE microphone kits compared to IEC standard and manufacturers specifications.

Appendix 2

Test object (Microphone cartridge)	Meets IEC 61094-4	Meets manufacturers specification
B&K 1	Yes	Yes
B&K 2	Yes	Yes
B&K 3	Yes	Yes
B&K 4	Yes	Yes
BSWA 1	Yes	Yes
BSWA 2	Yes	Yes
BSWA 3	Yes	Yes
BSWA 4	Yes	Indeterminable
GRAS 1	Yes	Yes
GRAS 2	Yes	Yes
GRAS 3	Yes	Yes
GRAS 4	Indeterminable	Yes
PCB 1	Yes	Yes
PCB 2	Yes	Yes
PCB 3	Yes	Yes
PCB 4	Yes	Yes

Table 12b. Frequency response for the microphone cartridges compared to IEC standard and manufacturers specifications.

Appendix 3

Determination of microphone phase response

Objects

Microphones denoted B&K 1 to B&K 4, BSWA 1 to BSWA 4, GRAS 1 to GRAS 4 and PCB 1 to PCB 4 as described in the main part of this report.

Task

The task was to determine the relative phase response between the IEPE microphone kits.

Method

The phase response of the test objects was determined by the electrostatic actuator method, described in IEC 61094-6. A 1/2" actuator type GRAS RA0014 was used. No corrections were applied. All results were normalized to 250 Hz.

The measurements were conducted before any environmental tests.

Result

The uncorrected phase response re. 250 Hz of the IEPE microphone kits are given in the figure 1 to 4 and table 1 to 4.

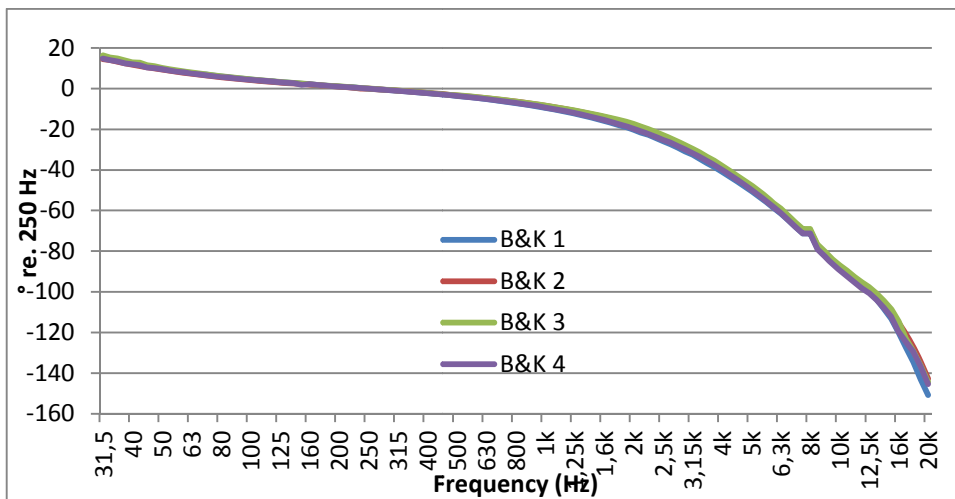


Figure 1. The uncorrected phase response of the B&K 4189-A-021 microphone kits.

Appendix 3

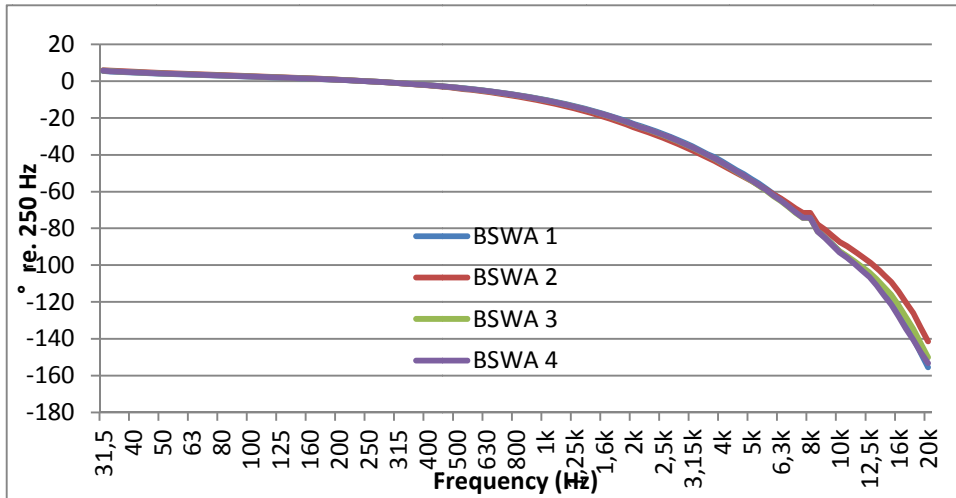


Figure 2. The uncorrected phase response of the BSWA MPA201 microphone kits.

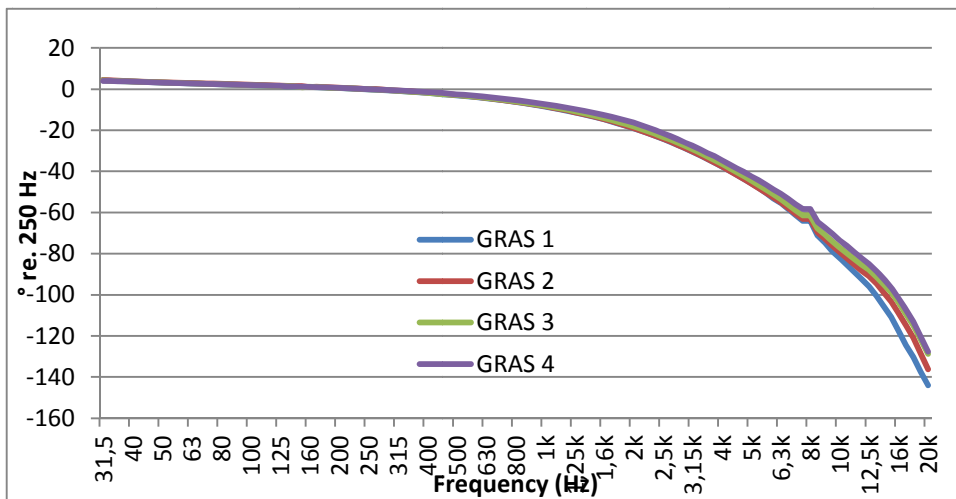


Figure 3. The uncorrected phase response of the G.R.A.S. 46AE microphone kits.

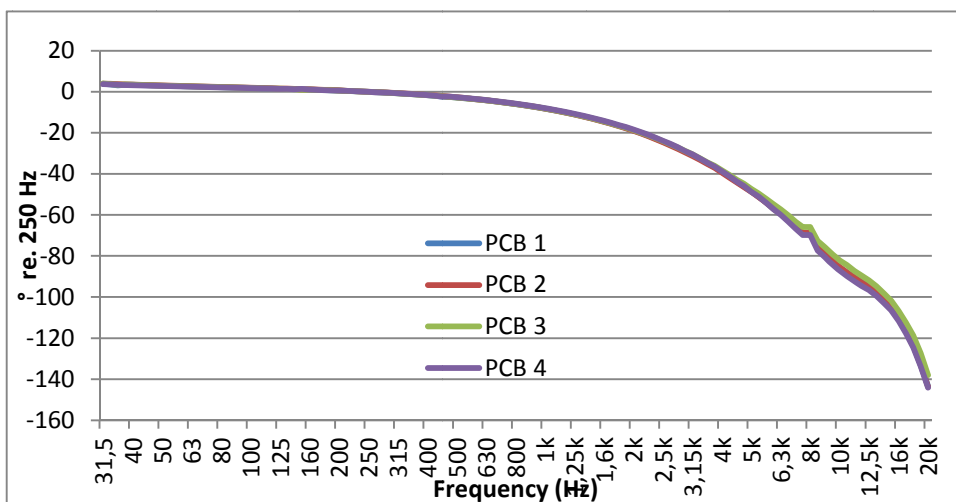


Figure 4. The uncorrected phase response of the PCB 378B02 microphone kits.

Appendix 3

Frequency (Hz)	Phase response re. 250 Hz (°)			
	B&K 1	B&K 2	B&K 3	B&K 4
31,5	15	15	16	15
40	12	12	13	12
50	10	9	10	10
63	8	7	8	7
80	6	6	6	6
100	5	4	5	4
125	3	3	3	3
160	2	2	2	2
200	1	1	1	1
250	0	0	0	0
315	-1	-1	-1	-1
400	-2	-2	-2	-2
500	-4	-3	-3	-4
630	-5	-5	-5	-5
800	-7	-6	-6	-7
1k	-9	-8	-8	-9
1,25k	-12	-11	-11	-12
1,6k	-16	-14	-14	-15
2k	-20	-18	-17	-20
2,5k	-26	-23	-23	-25
3,15k	-33	-30	-29	-32
4k	-41	-39	-38	-40
5k	-51	-48	-48	-50
6,3k	-61	-60	-59	-61
8k	-71	-70	-69	-71
10k	-89	-88	-87	-89
12,5k	-100	-99	-98	-101
16k	-120	-115	-115	-120
20k	-151	-143	-144	-145

Table 1. The uncorrected phase response of the B&K 4189-A-021 microphone kits

Appendix 3

Frequency (Hz)	Phase response re. 250 Hz (°)			
	BSWA 1	BSWA 2	BSWA 3	BSWA 4
31,5	6	6	6	6
40	5	5	5	5
50	4	5	4	4
63	4	4	4	4
80	3	3	3	3
100	2	3	3	3
125	2	2	2	2
160	1	2	1	1
200	1	1	1	1
250	0	0	0	0
315	-1	-1	-1	-1
400	-2	-2	-2	-2
500	-3	-4	-4	-4
630	-5	-6	-5	-5
800	-7	-8	-8	-8
1k	-10	-11	-10	-10
1,25k	-14	-15	-14	-14
1,6k	-18	-19	-18	-18
2k	-23	-25	-24	-24
2,5k	-29	-31	-29	-29
3,15k	-35	-38	-36	-36
4k	-44	-45	-44	-44
5k	-53	-54	-54	-54
6,3k	-64	-64	-65	-65
8k	-73	-71	-74	-74
10k	-93	-87	-92	-93
12,5k	-106	-98	-104	-106
16k	-126	-114	-122	-128
20k	-156	-141	-150	-153

Table 2. The uncorrected phase response of the BSWA MPA201 microphone kits

Appendix 3

Frequency (Hz)	Phase response re. 250 Hz (°)			
	GRAS 1	GRAS 2	GRAS 3	GRAS 4
31,5	4	4	4	4
40	4	4	4	4
50	3	3	3	3
63	3	3	3	3
80	2	3	2	2
100	2	2	2	2
125	1	2	2	2
160	1	1	1	1
200	0	1	1	1
250	0	0	0	0
315	-1	-1	-1	-1
400	-2	-2	-2	-1
500	-3	-3	-3	-2
630	-4	-4	-4	-4
800	-6	-6	-6	-5
1k	-8	-8	-8	-7
1,25k	-11	-11	-11	-10
1,6k	-15	-15	-14	-13
2k	-19	-19	-18	-16
2,5k	-24	-24	-23	-22
3,15k	-30	-30	-29	-27
4k	-38	-38	-36	-35
5k	-46	-46	-44	-42
6,3k	-55	-55	-54	-51
8k	-64	-63	-61	-58
10k	-82	-79	-77	-74
12,5k	-96	-91	-88	-85
16k	-117	-109	-104	-102
20k	-144	-136	-129	-128

Table 3. The uncorrected phase response of the G.R.A.S. 46AE microphone kits

Appendix 3

Frequency (Hz)	Phase response re. 250 Hz (°)			
	PCB 1	PCB 2	PCB 3	PCB 4
31,5	4	4	4	4
40	3	3	3	3
50	3	3	3	3
63	3	3	3	2
80	2	2	2	2
100	2	2	2	2
125	1	2	2	1
160	1	1	1	1
200	1	1	1	1
250	0	0	0	0
315	-1	-1	-1	-1
400	-2	-2	-2	-2
500	-3	-3	-3	-3
630	-4	-4	-4	-4
800	-6	-6	-6	-6
1k	-8	-8	-8	-8
1,25k	-11	-11	-11	-11
1,6k	-14	-15	-14	-14
2k	-19	-19	-19	-18
2,5k	-24	-25	-24	-24
3,15k	-31	-31	-30	-30
4k	-39	-39	-38	-39
5k	-49	-49	-47	-49
6,3k	-60	-60	-57	-60
8k	-69	-69	-66	-70
10k	-86	-85	-82	-87
12,5k	-95	-95	-92	-97
16k	-110	-111	-107	-112
20k	-143	-144	-138	-144

Table 4. The uncorrected phase response of the PCB 378B02 microphone kits

No phase requirements are given in IEC 61094-4.

No phase information is given in the manufacturers specifications for the IEPE microphone kits.

Appendix 4

Determination of A-weighted noise floor of microphones

Objects

Microphones denoted B&K 1 to B&K 4, BSWA 1 to BSWA 4, GRAS 1 to GRAS 4 and PCB 1 to PCB 4 as described in the main part of this report.

Task

The task was to determine the A-weighted noise floor of the microphone cartridges and IEPE microphone kits

Method

The microphones were placed in a silent environment with $L_{pA} \leq 7$ dB and the A-weighted output level was recorded.

Environmental noise and electrical noise from the measurement equipment have been corrected for.

Environmental conditions

The A-weighted noise floor determinations were conducted within the following environmental conditions.

Air pressure	984±2 hPa (IEPE microphone kits)
Air pressure	1000±2 hPa (microphone cartridges)
Temperature	23±1°C
Humidity	45±7 % RH

Result

The A-weighted noise floor is given in table 1.

Test object	IEPE microphone kit	Microphone cartridge
B&K 1	14,8 dB	13,2 dB
B&K 2	14,9 dB	13,6 dB
B&K 3	15,0 dB	13,2 dB
B&K 4	15,0 dB	13,7 dB
BSWA 1	15,8 dB	15,0 dB
BSWA 2	16,1 dB	15,7 dB
BSWA 3	15,9 dB	15,1 dB
BSWA 4	16,0 dB	15,5 dB
GRAS 1	14,3 dB	13,8 dB
GRAS 2	15,1 dB	14,7 dB
GRAS 3	15,6 dB	15,1 dB
GRAS 4	15,1 dB	14,6 dB
PCB 1	14,0 dB	13,4 dB
PCB 2	14,5 dB	13,8 dB
PCB 3	14,7 dB	14,0 dB
PCB 4	14,2 dB	13,6 dB

Table 1. A-weighted noise floor of the IEPE microphone kits and the microphone cartridges.

Appendix 4

The expanded uncertainty ($k=2$) of the determined A-weighted noise floor is estimated to be 1 dB.

Comparison to specifications and standard

IEC 61094-4 is defining specifications for working standard microphones. However no requirement for A-weighted noise floor is given.

The manufacturers have stated A-weighted noise floor as given in table 2.

Microphone type	Stated A-weighted noise floor (dB)	
	IEPE kit	Microphone cartridge
B&K 4189-A-021	16,5	14,6
BSWA MPA201	18	16
G.R.A.S. 46AE	17	15
PCB 378B02	No specification given	15

Table 2. A-weighted noise floor specified by the manufacturers.

A summary of how the measurement results meets the specifications given by the manufacturers and IEC standard is given in table 3a and 3b.

If the result is within the specifications the indication is “Yes”. If the result is outside the specifications but within the specification expanded by the measurement uncertainty the indication is “Indeterminable”. If the result is outside the specification expanded by the measurement uncertainty the indication is “No”.

Test object (IEPE microphone kit)	Meets IEC 61094-4	Meets manufacturers specification
B&K 1	No specification given	Yes
B&K 2	No specification given	Yes
B&K 3	No specification given	Yes
B&K 4	No specification given	Yes
BSWA 1	No specification given	Yes
BSWA 2	No specification given	Yes
BSWA 3	No specification given	Yes
BSWA 4	No specification given	Yes
GRAS 1	No specification given	Yes
GRAS 2	No specification given	Yes
GRAS 3	No specification given	Yes
GRAS 4	No specification given	Yes
PCB 1	No specification given	No specification given
PCB 2	No specification given	No specification given
PCB 3	No specification given	No specification given
PCB 4	No specification given	No specification given

Table 3a. Determined A-weighted noise floor for the IEPE microphone kits compared to IEC standard and manufacturers specifications.

Appendix 4

Test object (Microphone cartridge)	Meets IEC 61094-4	Meets manufacturers specification
B&K 1	No specification given	Yes
B&K 2	No specification given	Yes
B&K 3	No specification given	Yes
B&K 4	No specification given	Yes
BSWA 1	No specification given	Yes
BSWA 2	No specification given	Yes
BSWA 3	No specification given	Yes
BSWA 4	No specification given	Yes
GRAS 1	No specification given	Yes
GRAS 2	No specification given	Yes
GRAS 3	No specification given	Indeterminable
GRAS 4	No specification given	Yes
PCB 1	No specification given	Yes
PCB 2	No specification given	Yes
PCB 3	No specification given	Yes
PCB 4	No specification given	Yes

Table 3b. Determined A-weighted noise floor for the microphone cartridges compared to IEC standard and manufacturers specifications.

Appendix 5

Determination of dynamic range upper limit of microphones

Objects

Microphones denoted B&K 1 to B&K 4, BSWA 1 to BSWA 4, GRAS 1 to GRAS 4 and PCB 1 to PCB 4 as described in the main part of this report.

Task

The task was to determine the upper dynamic range of the IEPE microphone kits by finding the 3 % distortion sound pressure level.

Method

The test objects were mounted in a hard termination of a Ø100 mm metal tube. A ¼” monitoring microphone type B&K 4939 with specified upper dynamic limit 164 dB was mounted in the same termination. The other end was terminated by a loudspeaker emitting a sine tone. The frequency of the tone was tuned to maximum level measured by the microphones. The level was increased until the distortion of the test microphone reached 3 %. The level and distortion in the tube was then read by the monitoring microphone.

At the test of the IEPE microphone kits the distortion in the tube was kept low.

Environmental conditions

The upper dynamic range determinations were conducted within the following environmental conditions.

Air pressure	994±3 hPa
Temperature	23±1°C
Humidity	45±7 % RH

Appendix 5

Result

The sound pressure levels where the microphone induced distortion reaches 3 % are given in table 1 below. Test frequency 350 Hz.

Test object	IEPE microphone kit
B&K 1	138 dB
B&K 2	138 dB
B&K 3	138 dB
B&K 4	138 dB
BSWA 1 ¹⁾	-
BSWA 2 ²⁾	133 dB
BSWA 3 ²⁾	133 dB
BSWA 4 ²⁾	133 dB
GRAS 1	139 dB
GRAS 2	138 dB
GRAS 3	139 dB
GRAS 4	139 dB
PCB 1	136 dB
PCB 2	137 dB
PCB 3	137 dB
PCB 4	137 dB

Table 1. Dynamic range upper limit

- 1) No result given as the microphone broke during the temperature coefficient determination tests.
- 2) The result may be affected by a sensitivity shift after the temperature coefficient determination test.

The expanded uncertainty ($k=2$) of the determined upper limit of dynamic range is estimated to be 1 dB. Potential instability of the BSWA microphones is not taken into account.

Comparison to specifications and standard

IEC 61094-4 is defining specifications for working standard microphones. The requirement given for upper limit of dynamic range is >140 dB for a WS2F microphone. No requirements are given for IEPE kits.

The manufacturers have stated upper limits of dynamic range as given in table 2.

Microphone type	Stated upper limit of dynamic range (dB)	
	IEPE microphone kit	Microphone cartridge
B&K 4189-A-021	134	>146
BSWA MPA201	130	>146
G.R.A.S. 46AE	134	144
PCB 378B02	No specification given	146

Table 2. Upper limit of dynamic range specified by the manufacturers.

Appendix 5

A summary of how the measurement results meets the specifications given by the manufacturers and IEC standard is given in table 3.

If the result is within the specifications the indication is “Yes”. If the result is outside the specifications but within the specification expanded by the measurement uncertainty the indication is “Indeterminable”. If the result is outside the specification expanded by the measurement uncertainty the indication is “No”.

Test object (IEPE microphone kit)	Meets IEC 61094-4	Meets manufacturers specification
B&K 1	No specification given	Yes
B&K 2	No specification given	Yes
B&K 3	No specification given	Yes
B&K 4	No specification given	Yes
BSWA 1 ¹⁾	No specification given	-
BSWA 2	No specification given	Yes
BSWA 3	No specification given	Yes
BSWA 4	No specification given	Yes
GRAS 1	No specification given	Yes
GRAS 2	No specification given	Yes
GRAS 3	No specification given	Yes
GRAS 4	No specification given	Yes
PCB 1	No specification given	No specification given
PCB 2	No specification given	No specification given
PCB 3	No specification given	No specification given
PCB 4	No specification given	No specification given

Table 3. Determined upper limit of dynamic range for the IEPE microphone kits compared to IEC standard and manufacturers specifications.

1) No result given as the microphone broke during the temperature coefficient determination tests.

Appendix 6

Determination of low frequency limit of microphones

Objects

Microphones denoted B&K 1 to B&K 4, BSWA 1 to BSWA 4, GRAS 1 to GRAS 4 and PCB 1 to PCB 4 as described in the main part of this report.

Task

The task was to determine the low frequency limit of the IEPE microphone kits by finding the -3 dB frequency.

Method

The microphone under test, including the entire preamplifier, was placed in a 3 dm³ closed coupler face-to-face to a monitoring microphone B&K 4193 with a specified lower limiting frequency 0,014 Hz. However the monitoring microphone has no valid traceable calibration at the frequency of interest.

A reference reading was taken at 250 Hz. The frequency in the coupler was then decreased until the output level of the test microphone had decreased 3 dB compared to the output level of the monitoring microphone.

The lower limiting frequency of the measuring amplifier was set to 0,1 Hz and the IEPE power supply is shown to not influence the result.

Environmental conditions

The low frequency limit determinations were conducted within the following environmental conditions.

Air pressure	998±2 hPa
Temperature	23±1°C
Humidity	45±7 % RH

Appendix 6

Result

The lower limiting frequencies for the IEPE microphone kits and their associated uncertainties are given in table 1 below. The expanded uncertainty is stated with a coverage factor $k=2$.

Test object	-3 dB frequency (Hz)	Expanded uncertainty (Hz)
B&K 1	10,4	0,6
B&K 2	9,6	0,6
B&K 3	11,6	0,6
B&K 4	10,4	0,6
BSWA 1	1,2	0,1
BSWA 2	1,2	0,1
BSWA 3	1,3	0,1
BSWA 4	1,2	0,1
GRAS 1	0,7	0,1
GRAS 2	0,8	0,1
GRAS 3	0,7	0,1
GRAS 4	0,7	0,1
PCB 1	2,1	0,2
PCB 2	2,0	0,2
PCB 3	1,9	0,2
PCB 4	2,4	0,2

Table 1. The -3 dB frequencies for the IEPE microphone kits.

Comparison to specifications

The manufacturers have stated -3 dB frequencies as given in table 2.

Microphone type	Stated -3 dB frequency (Hz)
B&K 4189-A-021	12 Hz
BSWA MPA201	No specification given
G.R.A.S. 46AE	No specification given
PCB 378B02	1-2,4 Hz

Table 2. Lower limiting frequency specified by the manufacturers.

A summary of how the measurement results meets the specifications given by the manufacturers is given in table 3.

Appendix 6

Test object	Meets manufacturers specification
B&K 1	Yes
B&K 2	Yes
B&K 3	Yes
B&K 4	Yes
BSWA 1	No specification given
BSWA 2	No specification given
BSWA 3	No specification given
BSWA 4	No specification given
GRAS 1	No specification given
GRAS 2	No specification given
GRAS 3	No specification given
GRAS 4	No specification given
PCB 1	Yes
PCB 2	Yes
PCB 3	Yes
PCB 4	Yes

Table 3. Determined -3 dB frequencies compared to manufacturers specifications.

Appendix 7

Determination of temperature coefficient of microphones

Objects

Microphones denoted B&K 1 to B&K 4, BSWA 1 to BSWA 4, GRAS 1 to GRAS 4 and PCB 1 to PCB 4 as described in the main part of this report.

Task

The task was to determine the temperature coefficient of the IEPE microphone kits.

Method

The IEPE microphone kits were placed in a climate chamber. After at least 12 h in stable climate the sensitivity at 250 Hz was determined by a pistonphone. The test was repeated at -10°C, +5°C/50 %RH and +50°C/50 %RH. The static air pressure was constant during the tests.

The temperature coefficient was determined by linear regression.

Result

At -10°C the BSWA 1 microphone broke. The diaphragm tensioning ring went loose.

The temperature coefficients for the other IEPE microphone kits are given in table 1.

Test object	Temperature coefficient at 250 Hz (dB/°C)
B&K 1	-0,007
B&K 2	-0,007
B&K 3	-0,007
B&K 4	-0,007
BSWA 1	-
BSWA 2	+0,025 ^{*)}
BSWA 3	+0,028 ^{*)}
BSWA 4	+0,022 ^{*)}
GRAS 1	-0,014
GRAS 2	-0,013
GRAS 3	-0,008
GRAS 4	-0,012
PCB 1	+0,009
PCB 2	+0,009
PCB 3	+0,010
PCB 4	+0,010

Table 1. The temperature coefficients at 250 Hz for the IEPE microphone kits. No result is given for the BSWA 1 as it broke during the test.

*) As the BSWA microphones was noted to be instable after the temperature coefficient determination tests the test result may be affected also.

The expanded uncertainty ($k=2$) of the determined temperature coefficients at 250 Hz is estimated to be 0,0015 dB/°C. Potential instability of the BSWA microphones is not taken into account.

Appendix 7

Comparison to specifications and standard

IEC 61094-4 is defining specifications for working standard microphones. The requirement given for temperature dependence is that the temperature coefficient shall be within $\pm 0,03$ dB/°C.

The manufacturers have stated temperature coefficient as given in table 2.

Microphone type	Stated temperature coefficient (dB/°C)
B&K 4189-A-021	-0,006
BSWA MPA201	-0,005
G.R.A.S. 46AE	-0,01
PCB 378B02	+0,009

Table 2. Temperature coefficients at 250 Hz specified by the manufacturers.

A summary of how the measurement results meets the specifications given by the manufacturers and IEC standard is given in table 3.

Test object	Meets IEC 61094-4	Meets manufacturers specification
B&K 1	Yes	Yes
B&K 2	Yes	Yes
B&K 3	Yes	Yes
B&K 4	Yes	Yes
BSWA 1 ¹⁾	-	-
BSWA 2 ²⁾	Yes	No
BSWA 3 ²⁾	Yes	No
BSWA 4 ²⁾	Yes	No
GRAS 1	Yes	Yes
GRAS 2	Yes	Yes
GRAS 3	Yes	Yes
GRAS 4	Yes	Yes
PCB 1	Yes	Yes
PCB 2	Yes	Yes
PCB 3	Yes	Yes
PCB 4	Yes	Yes

Table 3. Determined temperature coefficients compared to IEC standard and manufacturers specifications.

1) No result given as the microphone broke during the temperature coefficient determination tests.

2) The result may be affected by the fact that the microphones were possible instable during the test.

Appendix 8

Determination of humidity coefficient of microphones

Objects

Microphones denoted B&K 1 to B&K 4, BSWA 1 to BSWA 4, GRAS 1 to GRAS 4 and PCB 1 to PCB 4 as described in the main part of this report.

Task

The task was to determine the humidity coefficient of the IEPE microphone kits.

Method

The IEPE microphone kits were placed in a climate chamber. After at least 24 h in stable climate the sensitivity at 250 Hz was determined by a pistonphone. The test was repeated at 10 % RH/23°C, 40 % RH/23°C and 90 % RH/23°C.

The static air pressure varied within a span of 10 hPa during the measurements. All results were corrected to the same static air pressure by use of the static pressure coefficients given by the manufacturers. The corrections used are given in table 1.

The humidity coefficient was determined by linear regression.

Microphone type	Static pressure coefficient (dB/hPa)
B&K 4189-A-021	-0,001
G.R.A.S. 46AE	-0,0007
PCB 378B02	-0,0013

Table 1. Static pressure coefficients used for correction.

Result

The humidity coefficients for the IEPE microphone kits are given in table 2.

No results are given for the BSWA MPA201 microphone as they became instable during the climatic coefficient determination tests.

Appendix 8

Test object	Humidity coefficient at 250 Hz (dB/% RH)
B&K 1	0,000
B&K 2	-0,002
B&K 3	-0,001
B&K 4	-0,001
BSWA 1	-
BSWA 2	-
BSWA 3	-
BSWA 4	-
GRAS 1	-0,001
GRAS 2	-0,002
GRAS 3	0,000
GRAS 4	-0,002
PCB 1	0,000
PCB 2	+0,001
PCB 3	0,000
PCB 4	0,000

Table 2. The humidity coefficients at 250 Hz for the IEPE microphone kits. No results are given for the BSWA MPA201 microphone as they were instable.

The expanded uncertainty ($k=2$) of the determined humidity coefficients at 250 Hz is estimated to be 0,001 dB/%RH.

Comparison to specifications and standard

IEC 61094-4 is defining specifications for working standard microphones. The requirement given for humidity dependence is that the humidity coefficient shall be within $\pm 0,001$ dB/%RH.

The manufacturers have stated humidity coefficient as given in table 3.

Appendix 8

Microphone type	Stated humidity coefficient (dB/%RH)
B&K 4189-A-021	<0,1 dB influence within 0-100 % RH
BSWA MPA201	-0,003
G.R.A.S. 46AE	-0,001
PCB 378B02	<0,1 dB influence within 0-100 % RH

Table 3. Humidity coefficients at 250 Hz specified by the manufacturers.

A summary of how the measurement results at 250 Hz meets the specifications given by the manufacturers and IEC standard is given in table 4.

If the result is within the specifications the indication is “Yes”. If the result is outside the specifications but within the specification expanded by the measurement uncertainty the indication is “Indeterminable”. If the result is outside the specification expanded by the measurement uncertainty the indication is “No”.

Test object	Meets IEC 61094-4	Meets manufacturers specification
B&K 1	Yes	Yes
B&K 2	Indeterminable	Yes
B&K 3	Yes	Yes
B&K 4	Yes	Yes
BSWA 1 ¹⁾	-	-
BSWA 2 ¹⁾	-	-
BSWA 3 ¹⁾	-	-
BSWA 4 ¹⁾	-	-
GRAS 1	Yes	Yes
GRAS 2	Indeterminable	Yes
GRAS 3	Yes	Yes
GRAS 4	Indeterminable	Yes
PCB 1	Yes	Yes
PCB 2	Yes	Yes
PCB 3	Yes	Yes
PCB 4	Yes	Yes

Table 4. Determined humidity coefficients compared to IEC standard and manufacturers specifications.

1) No result given as the microphones are broken or instable.