Contact person
Dag Glebe
Sound & Vibration
+46 10 516 57 31
dag.glebe@sp.se

Form The Solution Sthlm AB
Kommendörsgatan 38
114 58 Stockholm

Measurement of wind noise levels on a headset with and without a wind noise reduction unit

(2 appendices)

This document, 6P09044Rev1, replaces document 6P09044, cf. Section Revision information.

Client

Form The Solution Sthlm AB.

Test assignment

Measurement of wind noise levels on a headset in its original state and equipped with a wind noise reduction unit. The test purpose was to establish if, and how much, the wind noise reduction unit would decrease the equivalent wind noise sound pressure level generated in a controlled air flow, at various wind speeds. The test was in applicable parts designed according to the relevant section of the SS-EN 60268-4 (IEC 60268-4:2014) standard, 19.3 “Equivalent sound pressure due to wind”.

Test object

The devices under test, DUT, were an Apple Earpod headset mounted with a wind noise reduction unit denoted xpuff, and the headset without the xpuff, respectively.

Test date

October 27-31, 2016

Results

The wind noise sound pressure levels as functions of various wind speeds are given in Table 1. The results are valid for the tested object only. Caution: The measurement uncertainty is generally high, cf. discussion in the Section *Measurement uncertainty*, below, and notes in the table.

Wind speed (m/s)	Equivalent sound pressure level w/o xpuff L_{Aeq} (dBA)	Equivalent sound pressure level w/ xpuff L_{Aeq} (dBA)	Wind noise sound pressure level reduction (dB)	Approximate wind noise sound pressure difference in %**
2	42,8	39	3,8	35
4	61,4	49,3	12,1	75
6	75,1	63,4	11,7	74
8	83,7*	71,4	12,3	76
10 (IEC Ref value)	88,9*	78,6	10,3	69
12	94*	83,2*	10,8	71

Table 1: Wind speed and corresponding equivalent wind noise sound pressure levels and difference.

*The characteristics of the low frequency content in these measurements indicates that the microphone signal is beginning to overload, and these measurement values are therefore highly uncertain.

**Sound pressure, p (Pa), is calculated from sound pressure level, Lp (dB), as $p = p_{ref} *10^{(Lp/20)}$. *Caution*: Here Lp is A-weighted (dBA), and the differences in p are estimated on assumption of similar frequency distributions.

The Insertion Loss, IL, of xpuff was measured to *IL* = 0.4 dB, which is within the margin of error.

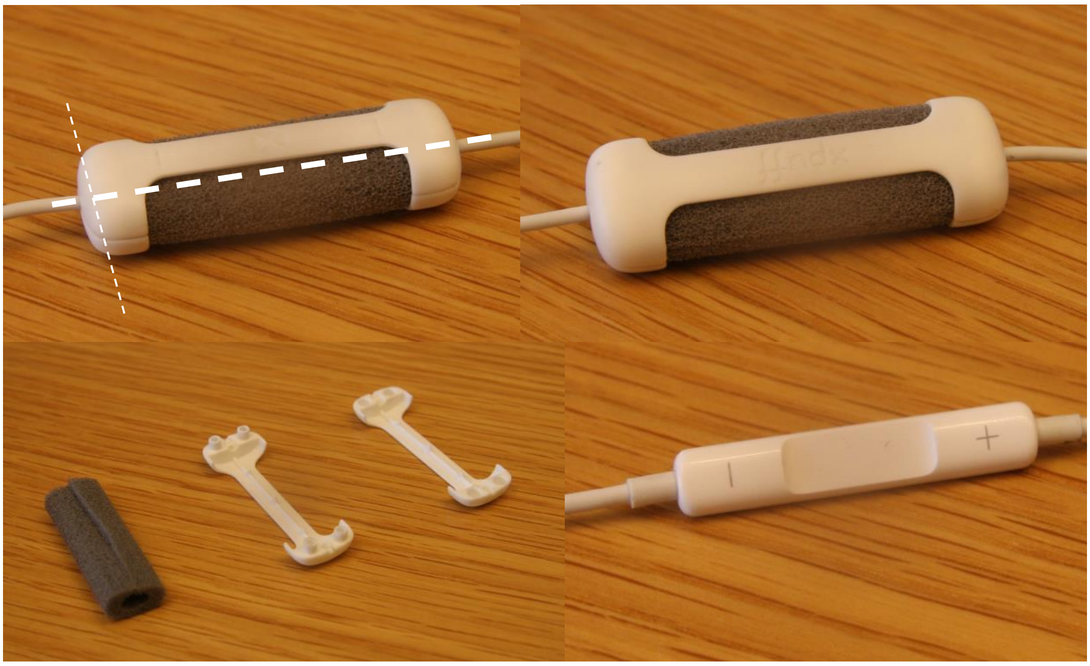

Figure 1: Test objects. xpuff assembled on an Apple Earpod seen from front (top left, with symmetry lines corresponding to Figure A.4), from back side (top right) and disassembled (bottom left) with the Earpod control unit /microphone shown at bottom right.

Methods of measurement

The measurements have, in applicable parts, been carried out according to the guidelines of IEC 60268-4:2014, Section 19.3 Equivalent sound pressure due to wind, in which it is stated that microphones with detachable windscreens shall be measured with and without the windscreen (i.e. a case resembling this assignment).

The measurements were carried out in SPs large (200 m^3) reverberation chamber, with a background noise level ranging from 22 dBA to 24 dBA in the room, and from 22 dBA to 37 dBA at the measurement position by the flow outlet. The higher values were generated by the flow outlet, but were more than 50 dB (ΔL) below the wind noise level generated by the DUT. The margin of the measured signal level to the background level was in each test at least ΔL = 17 dB.

The measurement procedure is summarized below.

Insertion loss

The microphone of the Earpod under test was connected to an iPhone 5 mobile phone, in order to obtain a proper bias voltage, and the signal was tapped to a sound analyser.

A sound field was generated by a reference sound source, and the sound level was measured with the DUT (microphone w/ and w/o xpuff mounted, respectively), and with a reference unit. Thus, the Insertion Loss, IL, of the xpuff unit

$$IL_{xpuff} = L_{Aeq,w/o} - L_{Aeq,w/}$$

could be obtained, as well as the respective DUT sensitivities and frequency responses.

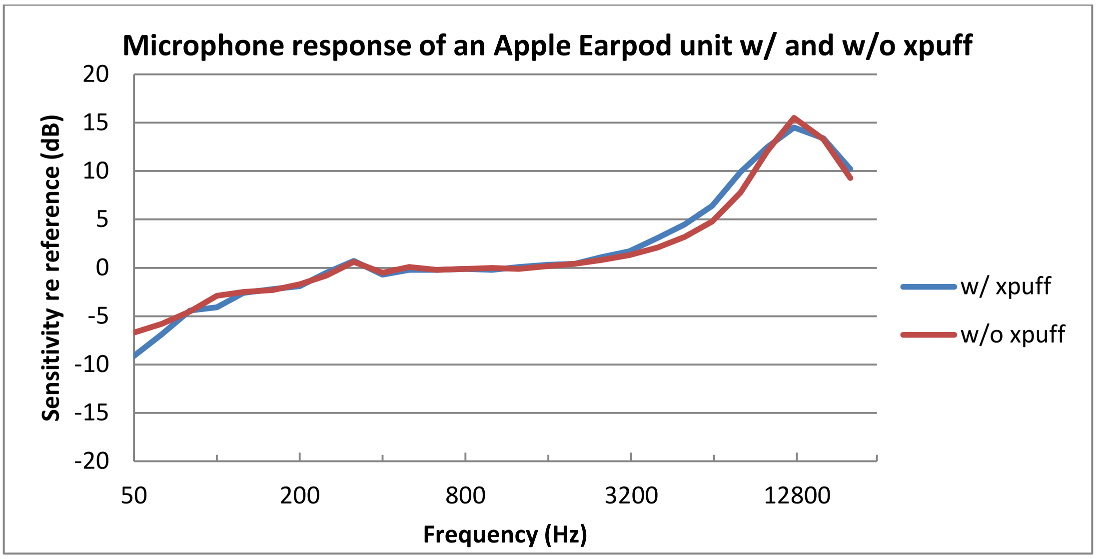

Figure 2: The microphone frequency response of an Apple Earpod unit w/ and w/o xpuff, measured on a reference sound source and adjusted to a reference response measured with a NOR 140 Sound Analyser.

Wind noise

The wind was generated from a source of the machine type 1 in IEC 60268-4. The DUTs were positioned 25 cm from the outlet at the centre of the wind flow in the absence of a sound field. Five positions were evaluated (the DUTs have three symmetry planes), the orientations of maximum and minimum influence were observed (cf Figure 3 and Appendix 2), and the DUT was orientated to the wind direction so that maximum output was obtained. The DUTs were then evaluated for six wind speeds, including the IEC 60268-4 reference velocity, 10 m/s.

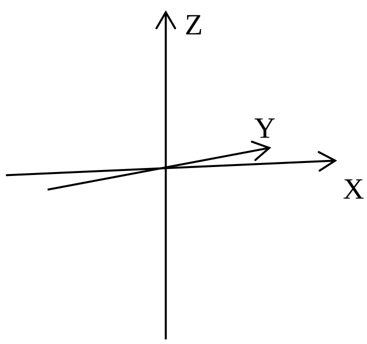

Figure 3: The microphone orientated in the direction with maximum output. This equals position 3 of the evaluated orientations: in the x-y plane with the cord along the x-axis and facing upwards in the z-direction. The minimum output was found in the position with the cord along the Y-axis.

The equivalent sound pressure levels were computed from the output voltage of the microphone with and without the xpuff unit, and are given in Table 1.

Measurement uncertainty

The IEC 60268-4 standard does not state any uncertainty for the wind noise measurements, but suggests that these can be substantial: "After evaluating several methods, the wind tunnel method has proven to give the best matching to natural wind conditions. It is, however, still difficult to measure the nature of the generated wind and to describe it with enough accuracy." The magnitude of these variations cannot be stated, but some comments and indications can be given.

The measurement uncertainty, $u(L_p)$, in decibels, is usually estimated from the standard deviations of reproducibility of the method, σ_{R0}, in decibels, and the standard deviation describing the uncertainty due to the variability in operating and mounting conditions and instability of the source under test, σ_{omc}, in decibels,

$$u(L_p) \cong \sqrt{\sigma_{RO}^2 + \sigma_{omc}^2}$$

Since this is an "*ad hoc*" method, the usual approach for estimating σ_{R0}, using round robin tests, cannot be made. Instead, an estimation of the separate uncertainty sources are needed. Identified known and unknown sources for the measurement uncertainty are listed below:

- Measurement equipment and facility: The accuracy for microphone measurements should be +/- 1 dB or better according to the IEC 60268-4 standard, here it is better than
- Uncertainty caused by fluctuations in the wind flow: $\sigma_{omc} \approx$ 0.3 dB (based on repeated measurements without remounting)
- Variability in the mounting conditions. Two parts can be identified:
  - Remounting the present test configuration seems to yield differences less than +/- 2 dB, and typically around +/- 1 dB.
  - The variability of the hypothetic case that the same test would be reproduced in another facility. It is not possible to give an absolute estimation of this (a round robin test would be needed), but the comments in the IEC-standard, quoted above indicates that this may yield substantial uncertainties, which would be further amplified by the product variability of the microphone, if another sample is selected. An uncertainty in the order of several decibels is not implausible.
- When the absolute level exceeded a certain level, the microphone preamplifier may be overloaded, resulting in saturation of the output level and highly inaccurate results.

To conclude, there are two sides of the problem: These measurements give an indication that relative measurements comparing the cases w/ and w/o wind screen would probably yield a measurement uncertainty in the magnitude within +/- 2 dB. However, the absolute values are subject to larger uncertainties, and the absolute values should be seen as estimations within order of magnitude, since it does not exactly coincides with any standards and the wind noise in real situations will to a large extent vary from the controlled laboratory test results due to differences from the test set-up.

List of instruments

Instrument	Manufacturer	Type	Serial no.
Integrated Sound Analyser (w/ mic Type 4188)	Norsonic	Nor 140	1404569
Sound level calibrator	Brüel & Kjaer	4231	27252520
Wind meter	Reinhardt	WDS 1MV	-
Reference sound source	Brüel & Kjaer	4204	500139

Revision information

This document, 6P09044Rev1, replaces document 6P09044. The revision number increment is caused by the addendum of the right column in Table 1, *Approximate wind noise sound pressure difference in %***, and the associated footnote. The revision is requested by the customer and corresponds to an estimation of what percentage of sound pressure difference (Pa) corresponds to the sound pressure levels (dB) listed in the column *Wind noise sound pressure level reduction (dB)* under the assumptions stated in the footnote.

SP Technical Research Institute of Sweden

Sustainable Built Environment - Sound & Vibration

Performed by

Signed by: Dag Glebe
Reason: I am the author of this document
Date & Time: 2017-01-17 10:52:10 +01:00

Dag Glebe

Examined by

Signed by: Krister Larsson
Reason: I have reviewed this document
Date & Time: 2017-01-17 11:25:22 +01:00

Krister Larsson

Appendices

Appendix 1

Client: Form the solution AB
Jochen Laveno Mangelsdorff
Test object: Xpuff
Date of test: October 27, 2016

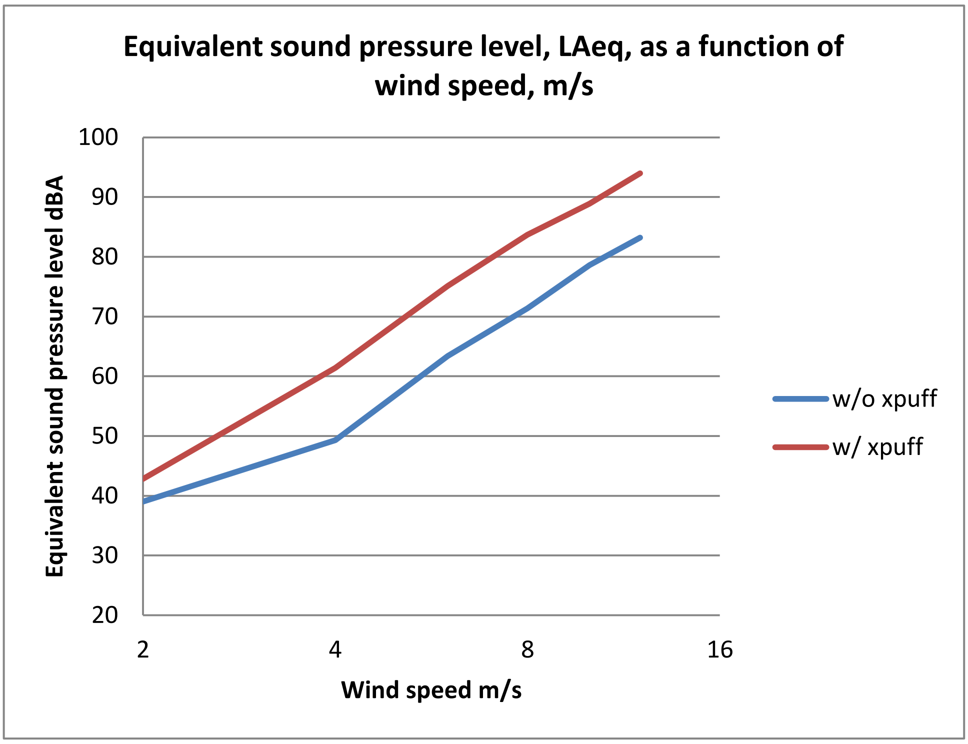

Figure A.1: Equivalent sound pressure level, L_{Aeq}, as a function of wind speed, m/s. The measured difference in sound pressure levels exceeds 10 dB for wind speeds of 4 m/s and upwards, which corresponds to a reduction of sound pressure levels exceeding approximately 70 %.

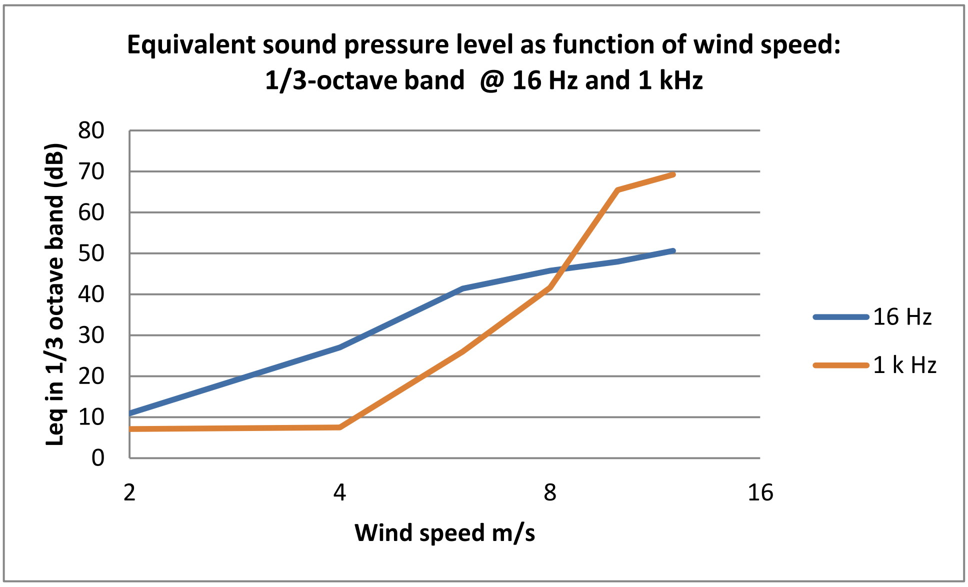

Figure A.2: Equivalent sound pressure level as function of wind speed: 1/3-octave band @ 16 Hz and 1 kHz

Appendix 1

Client: Form the solution AB
Jochen Laveno Mangelsdorff
Test object: xpuff
Date of test: October 27, 2016

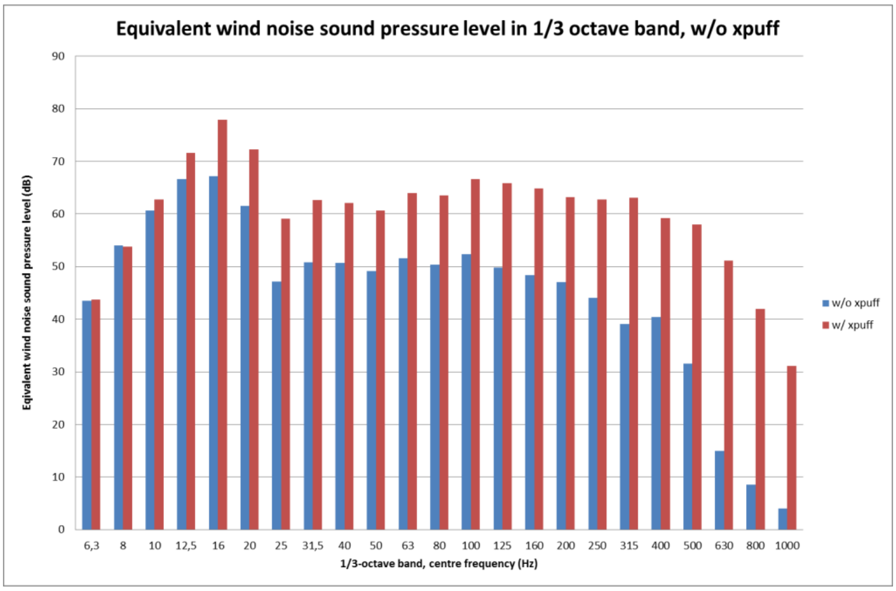

Figure A.3: Equivalent wind noise sound pressure level in 1/3-octave band, w/ and w/o xpuff, which indicates a tendency of pre-stage low frequency overload in the microphone amplifier.

Appendix 2

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Jochen Laveno Mangelsdorff
Test object: xpuff
Date of test: October 27, 2016

Orientations of DUT

Table A.1: Test of orientation with the maximum (**) and minimum (*) influence at 3.5 m/s and 6 m/s. As can be seen, the influence does not vary very much depending on orientation in comparison with the influence from the flow velocity and from xpuff.

Position	1*	2	3**	4	5	Average
w/ xpuff, low flow	42,4*	49,3	50,5	50,8**	47	**48,9**
w/o xpuff, low flow	55,6*	55,7	59,8**	58,3	59,1	**58,0**
w/ xpuff, high flow	51,2*	54,2	58,3**	56,1	56,8	**55,9**
w/o xpuff, high flow	64,9	63,4*	69,8**	68,1	67,7	**67,4**

Figure A.4: Evaluated orientations corresponding to Table A.1., cf coordinate system in Figure 3 and symmetry lines in Figure 1. According to guidelines of IEC 60268-4:2014, position 3 was chosen for evaluation of wind noise properties, since it had maximum influence on the wind noise levels.