KTH Engineering Sciences

MEASUREMENTS OF INSERTION LOSS OF EARMUFFS FOR FLOW-INDUCED NOISE

Technical Note no.:	1003
Client:	Dag Nordström Praktisk Reklam Ånghammargatan 1d 721 33 Västerås
Carried out by:	Leping Feng
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Report complied by:	Leping Feng
Signature:	
Measurements carried out:	2010-04-19
Report compiled:	2010-04-19

1. Method of measurements

There are no standards available at the moment for the measurements of the insertion loss of flow-induced noise. Hence the measurements are performed, when applicable, in reference to standard ISO 4869-3:2007 Acoustics - Hearing protectors - Part 3: Measurement of insertion loss of ear-muff type protectors using an acoustic test fixture. The main difference is that in our measurements the noise is flow-induced noise instead of an external reverberant sound source as described in the standard.

A duct, with size 0.6 m x 0.6 m, is mounted in between the reverberation room and the anechoic room in MWL with the anechoic room serves as an air tank. When the anechoic room is in overpressure, airflow is produced in the duct. A *Head and Torso Simulator* is placed inside the duct to measure the flow-induced noise with and without the earmuffs under test positioned. The difference of the sound pressure levels detected is the insertion of the earmuff for the flow-induced noise.

Two measurement channels, corresponding to the signal in the left and in the right ear, are used. The average of the two signals is taken to calculate the average insertion loss of the earmuffs under test.

2. Environment

Temperature:	19 °C	Relative humidity:	58%
Ambient pressure:	1001 mbar	Background noise:	25.5 dBA

3. Instrumentation

Analyzer LD 2900B, series number 2900B0710
Head and Torso Simulator, B&K type 4218, series number 1877681
Sound Quality Conditioning Amplifier, B&K type 2672, series number 1838629

4. Test samples and test conditions

Three pairs of earmuffs are tested. The mounting conditions of the earmuffs are controlled by the customer.

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5. Results

All results listed below are average insertion loss of flow-induced noise for both ears.

5.1 A-weighted insertion loss

Wind speed km/h	Mean insertion loss, dBA		
	Sample 1	Sample 2	Sample 3
7	**10.7**	**7.1**	**7.9**
12	**20.0**	**14.0**	**11.1**
15	**22.5**	**13.6**	**11.1**
20	**19.2**	**11.3**	**10.1**
25	**19.7**	**12.9**	**11.0**
30	**19.9**	**15.4**	**10.5**
35	**19.4**	**13.8**	**10.5**
40	**18.5**	**14.5**	**10.6**
45	**17.8**	**14.5**	**10.3**
50	**18.4**	**15.4**	**11.0**

A British earmuff is also tested at the air speed of 30 km/h. The average insertion loss of flow-induced noise is then 10.1 dBA.

Mean sound pressure levels during the test (the pressure levels when the earmuffs are not on), or the wind-induced sound pressure levels at different air speeds, are listed below:

Freq., Hz	Air speed, km/h									
	7	**12**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
100	55.1	69.7	74.2	77.9	83.4	88.3	90.1	91.2	93.7	95.1
125	50.1	69.6	74.6	77.5	82.5	87.1	90.8	92.8	93.9	94.5
160	44.5	68.3	74.8	77.8	81.9	86.2	89.2	92	94.5	96.4
200	39.4	64.8	73.1	78	83	85.7	88.5	90.5	92.7	95.7
250	33.9	60.4	70.2	76.3	83.3	86.7	88.8	90.3	92.1	94.4
315	29.6	56.9	66.1	74.5	81.1	86.5	90.1	91.6	92.8	94.4
400	23.9	52.5	62.8	71.6	79.6	84.2	88.3	92.1	93.8	95.7
500	21.8	47.4	59	68.4	76.8	82.5	86.2	89.5	92.1	96.1
630	22.6	42.2	54.9	65.1	73.5	79.6	84.2	87.6	89.7	93.5
800	22.9	37.4	50.3	61	70.5	76.5	80.9	84.9	87.3	91.4
1000	23.4	32.9	46.6	57.2	66.8	73.3	78.3	82.1	84.4	88.6
1250	21.6	28.6	42.9	53.9	63.4	70.1	75.3	79.2	81.6	85.8
1600	21	24.8	39.4	51	60.7	67.3	72.2	76.2	78.8	83.1
2000	18.8	21.3	34.7	48.2	58.4	65	70	73.8	76.2	80.4
2500	18.2	20.2	27.9	44.8	56.1	63.2	68	72.1	74.5	78.4
3150	17.2	19.5	22	39.4	53.1	61.1	66.3	70.5	73	77.2
4000	17.3	19.5	20.5	33	48	58.4	64.4	68.8	71.4	75.9
5000	17.2	19.6	20.3	26.5	41.1	52.7	60.4	65.8	68.8	73.6
A-weighted	**43**	**61.3**	**69**	**75.4**	**82.5**	**87.4**	**91.3**	**94.2**	**96.3**	**99.6**

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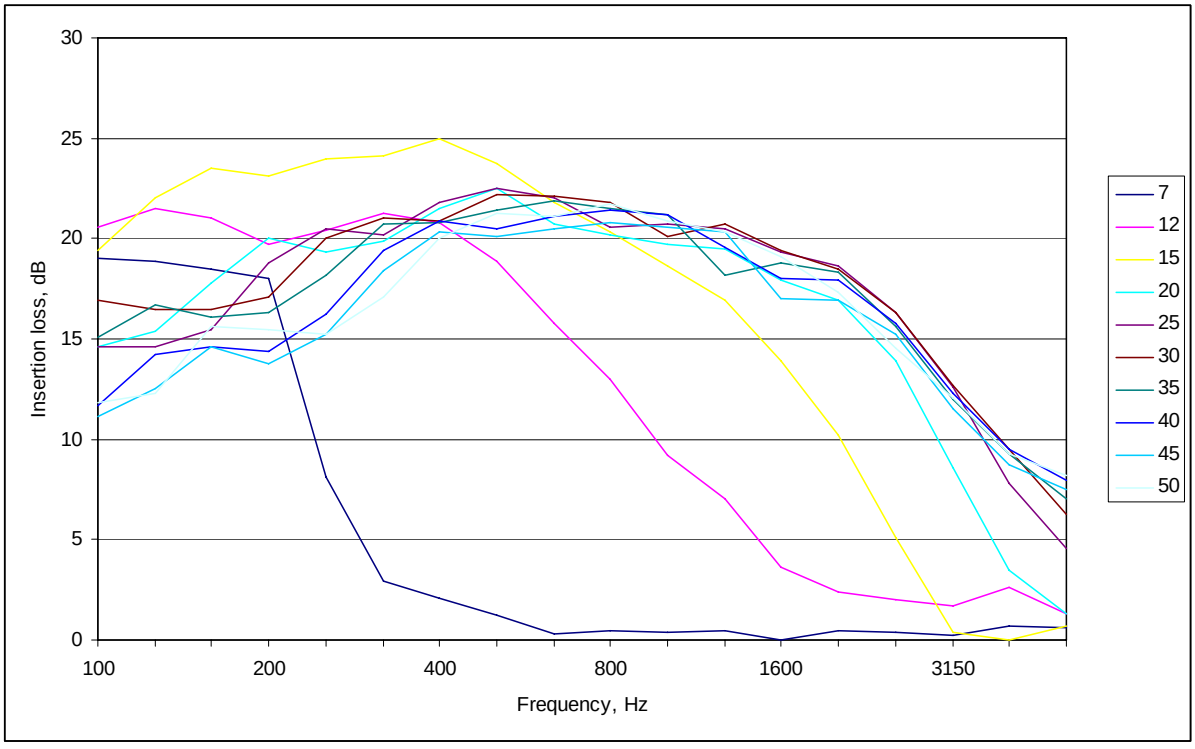
5.2 In 1/3 octave band

Sample 1

Freq.	Air speed, km/h									
Hz	7	12	15	20	25	30	35	40	45	50
100	19	20.6	19.4	14.6	14.6	16.9	15.1	11.7	11.1	11.8
125	18.9	21.5	22	15.4	14.6	16.5	16.7	14.2	12.5	12.3
160	18.5	21	23.5	17.8	15.5	16.5	16.1	14.6	14.6	15.6
200	18	19.7	23.1	20	18.8	17.1	16.3	14.4	13.8	15.5
250	8.1	20.4	24	19.3	20.5	20	18.2	16.2	15.2	15.2
315	2.9	21.3	24.1	19.9	20.2	21	20.7	19.4	18.4	17.1
400	2.1	20.8	25	21.5	21.8	20.9	20.8	20.9	20.3	20
500	1.2	18.9	23.7	22.5	22.5	22.2	21.4	20.5	20.1	21.3
630	0.3	15.8	21.8	20.7	22	22.1	21.9	21.1	20.5	21.1
800	0.5	13	20.3	20.2	20.6	21.8	21.5	21.4	20.8	21.7
1000	0.4	9.2	18.6	19.7	20.7	20.1	21.2	21.2	20.6	20.9
1250	0.5	7	16.9	19.5	20.5	20.7	18.2	19.6	20.3	20.3
1600	0	3.6	13.9	17.9	19.3	19.4	18.8	18	17	19.1
2000	0.5	2.4	10.2	16.9	18.6	18.5	18.3	17.9	16.9	17.3
2500	0.4	2	5.1	13.9	16.3	16.3	15.6	15.8	15.2	14.5
3150	0.2	1.7	0.4	8.6	12.6	12.7	12	12.3	11.5	12.1
4000	0.7	2.6	0.1	3.5	7.8	9.5	9.3	9.5	8.7	9.3
5000	0.6	1.3	0.7	1.3	4.6	6.3	7	8	7.5	8.2

The results are also depictured in the figure below. When the speed is low, the flow-induced noise is only at low frequencies. That explains why the insertion losses for low speed cases are low at high frequencies since the signal at high frequency is at the same level as the background noise.



1/3 octave band insertion loss for sample 1

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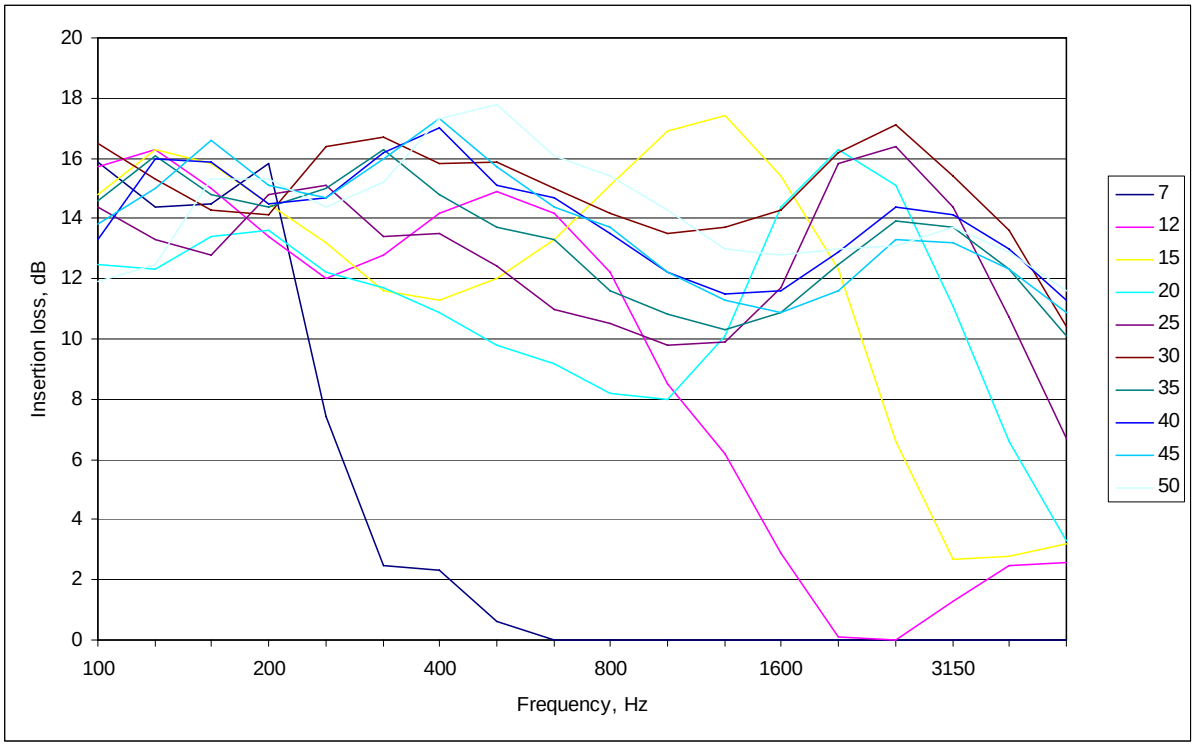
Sample 2

Freq.	Air speed, km/h									
Hz	7	12	15	20	25	30	35	40	45	50
100	15.9	15.7	14.8	12.5	14.4	16.5	14.6	13.3	13.8	11.9
125	14.4	16.3	16.3	12.3	13.3	15.3	16.1	16	15	12.5
160	14.5	15	15.8	13.4	12.8	14.3	14.8	15.9	16.6	15.3
200	15.8	13.4	14.5	13.6	14.8	14.1	14.4	14.5	15.1	15.3
250	7.4	12	13.2	12.2	15.1	16.4	15	14.7	14.7	14.4
315	2.5	12.8	11.6	11.7	13.4	16.7	16.3	16.2	16	15.2
400	2.3	14.2	11.3	10.9	13.5	15.8	14.8	17	17.3	17.3
500	0.6	14.9	12	9.8	12.4	15.9	13.7	15.1	15.7	17.8
630	0	14.2	13.3	9.2	11	15	13.3	14.7	14.4	16.1
800	0	12.2	15.1	8.2	10.5	14.2	11.6	13.5	13.7	15.4
1000	0	8.5	16.9	8	9.8	13.5	10.8	12.2	12.2	14.3
1250	0	6.2	17.4	10.1	9.9	13.7	10.3	11.5	11.3	13
1600	0	2.9	15.4	14.4	11.7	14.3	10.9	11.6	10.9	12.8
2000	0	0.1	12.3	16.3	15.8	16.2	12.5	12.9	11.6	13
2500	0	0	6.6	15.1	16.4	17.1	13.9	14.4	13.3	13.1
3150	0	1.3	2.7	11.1	14.4	15.4	13.7	14.1	13.2	13.7
4000	0	2.5	2.8	6.6	10.7	13.6	12.3	13	12.3	12.9
5000	0	2.6	3.2	3.3	6.7	10.4	10.1	11.3	10.9	11.6



1/3 octave band insertion loss for sample 2

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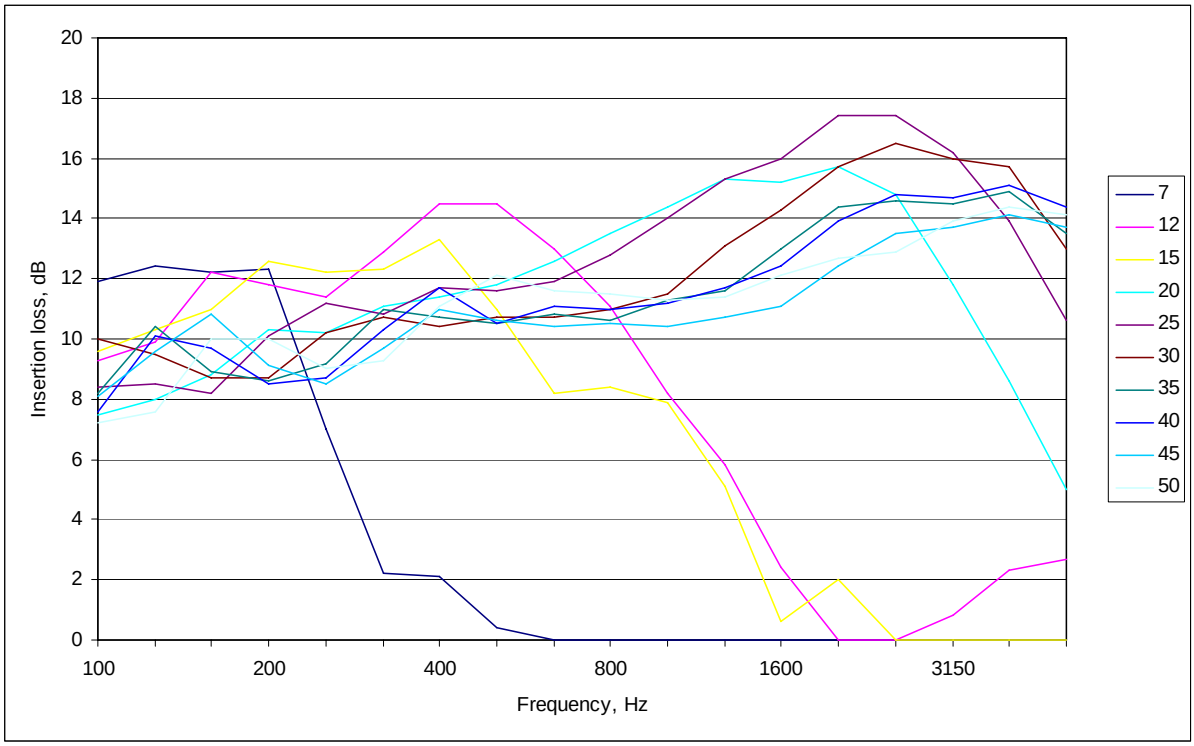
Sample 3

Freq.	Air speed, km/h									
Hz	7	12	15	20	25	30	35	40	45	50
100	11.9	9.3	9.6	7.5	8.4	10	8.2	7.6	8.1	7.2
125	12.4	9.9	10.3	8	8.5	9.5	10.4	10.1	9.6	7.6
160	12.2	12.2	11	8.8	8.2	8.7	8.9	9.7	10.8	10
200	12.3	11.8	12.6	10.3	10.1	8.7	8.6	8.5	9.1	10
250	7	11.4	12.2	10.2	11.2	10.2	9.2	8.7	8.5	9
315	2.2	12.9	12.3	11.1	10.8	10.7	11	10.3	9.7	9.3
400	2.1	14.5	13.3	11.4	11.7	10.4	10.7	11.7	11	11.1
500	0.4	14.5	11	11.8	11.6	10.7	10.5	10.5	10.6	12.1
630	0	13	8.2	12.6	11.9	10.7	10.8	11.1	10.4	11.6
800	0	11.1	8.4	13.5	12.8	11	10.6	11	10.5	11.5
1000	0	8.2	7.9	14.4	14	11.5	11.3	11.2	10.4	11.3
1250	0	5.8	5.1	15.3	15.3	13.1	11.6	11.7	10.7	11.4
1600	0	2.4	0.6	15.2	16	14.3	13	12.4	11.1	12.1
2000	0	0	2	15.7	17.4	15.7	14.4	13.9	12.4	12.7
2500	0	0	0	14.8	17.4	16.5	14.6	14.8	13.5	12.9
3150	0	0.8	0	11.8	16.2	16	14.5	14.7	13.7	13.9
4000	0	2.3	0	8.6	13.9	15.7	14.9	15.1	14.1	14.4
5000	0	2.7	0	5	10.6	13	13.5	14.4	13.7	14.1



1/3 octave band insertion loss for sample 3

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