

Performance of the ducted silencers

FVS 125-1000

FVS 125-600

FVS 125-300

Requested by	Flexovent OÜ Mart Petermann Kadaka tee 70a 12618, Tallinn ESTONIA mart.petermann@flexovent.ee
Order ref.	Mart Petermann, 20.12.2021, EF4APT210087-03
Contact person	Eurofins Expert Services Oy Pekka Kettunen Tekniikantie 4B 02150 Espoo tel. +358 40 159 6471 PekkaKettunen@eurofins.fi
Assignment	Determination of the performance of the ducted silencer FVS 125-1000/600/300
Sample details	The customer delivered the silencer, the specifications of which are in appendix 1. Samples were received 5.1.2022. Measurements were carried out 24.-26.1.2022.
Methods	Total pressure loss measurements, flow noise measurements and insertion loss measurements were carried out according to ISO 7235:2003 /1/. Description of the test facility is presented in appendix 2. Air flow rates were measured according to ISO 5167-1:2003 and ISO 5167-2:2003 /2/ using orifice plates with corner tapings. FINAS Finnish Accreditation Service has accredited our laboratory (T001) to perform measurements according to standards ISO 7235:2003, ISO 5167-1:2003 and ISO 5167-2:2003. Other measurements mentioned in this test report do not belong to the field of accreditation.

Results	<p>Measurement results are presented in appendix 3-5. Measurement results are valid only for the tested samples.</p> <p>Instruments used in measurements are presented in appendix 6.</p>
References	<p>/1/ ISO 7235:2003. Acoustics - Laboratory measurement procedures for ducted silencers and air-terminal units - Insertion loss, flow noise and total pressure loss.</p> <p>/2/ ISO 5167-1:2003. Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full. Part 1: General principles and requirements.</p> <p>ISO 5167-2:2003. Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full. Part 2: Orifice plates.</p>

Espoo, 1.2.2022



Pekka Kettunen
Pekka Kettunen
Expert



Mika Hurme
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Expert

Appendices	6
Distribution	Customer, electronically approved

Ducted silencer: FVS 125-1000/600/300

Description of the sample

ISO 7235:2003

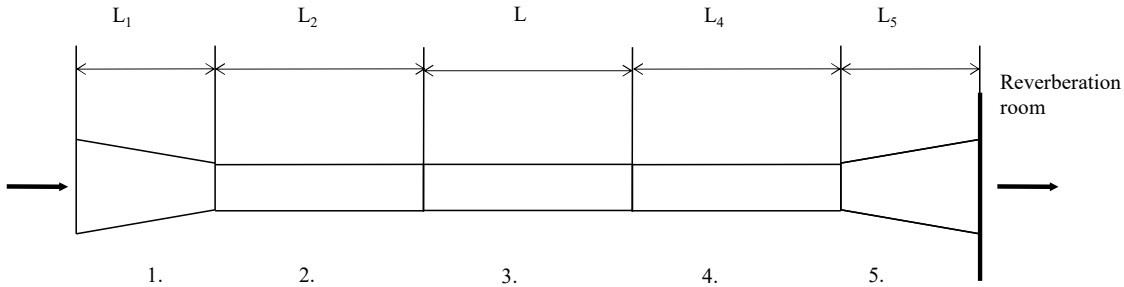
Symbols and units	FVS 125-1000	FVS 125-600	FVS 125-300	Substitution duct
Type	Ducted silencer			Spiral duct
Diameter of the inlet and outlet sections $\varnothing d$, mm	125			125
Width a, mm	225			-
Height b, mm	180			-
Length L, mm	1000	600	300	1000 / 600 / 300
Mass, kg	7.10	4.81	2.66	-
Thickness of steel duct material, mm	0.7			0.7
Direction of flow determined	no			no
Direction of insertion loss	no			no



Ducted silencer: FVS 125-1000/600/300

Test facility

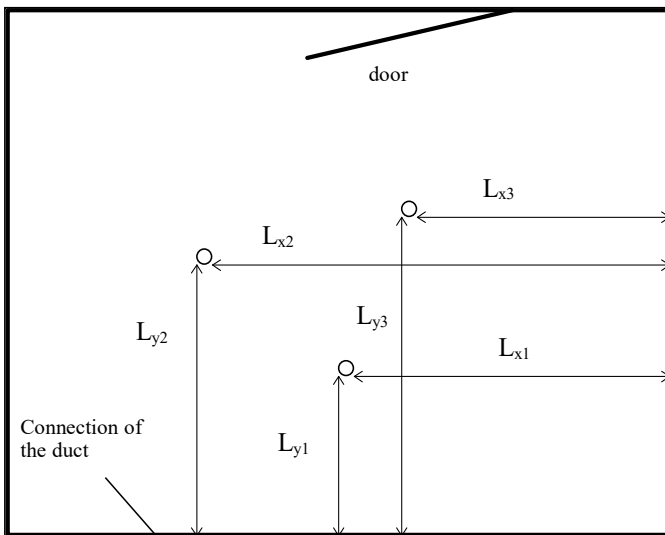
ISO 7235:2003



Components:	Symbols and units	Length
1. Transition $\varnothing 1600 / \varnothing 125$	L_1 , mm	5705
2. Duct $\varnothing 125$	L_2 , mm	2000/2000/1500
3. Silencer	L , mm	300/600/1000
4. Duct $\varnothing 125$	L_4 , mm	2500
5. Transition $\varnothing 125 / \varnothing 1250$	L_5 , mm	4385
Total length of measurement duct		14890 / 15190 / 15090

Volume of the reverberation room is 298 m³.

Microphone location in the reverberation room



Symbol	Unit	Distance
L_{x1}	m	2.0
L_{y1}	m	3.6
h_1	m	2.7
L_{x2}	m	3.7
L_{y2}	m	2.1
h_2	m	2.6
L_{x3}	m	4.0
L_{y3}	m	4.1
h_3	m	3.9

Symbols and units

- L_x Distance from wall, m
- L_y Distance from wall, m
- h Distance from floor, m

Ducted silencer: FVS 125-1000/600/300

Test facility

ISO 7235:2003

Volume of the reverberation room: 298 m³

Reverberation time T of the reverberation room and the transmission coefficient τ of the measurement duct transmission element Ø 125.

Symbol	Unit	T	Symbol	Unit	τ
T ₅₀	s	5.15	τ_{50}	-	0.642
T ₆₃	s	5.51	τ_{63}	-	0.949
T ₈₀	s	3.82	τ_{80}	-	0.686
T ₁₀₀	s	3.85	τ_{100}	-	0.854
T ₁₂₅	s	6.28	τ_{125}	-	0.922
T ₁₆₀	s	5.19	τ_{160}	-	0.987
T ₂₀₀	s	5.72	τ_{200}	-	0.987
T ₂₅₀	s	5.25	τ_{250}	-	0.997
T ₃₁₅	s	5.71	τ_{315}	-	0.997
T ₄₀₀	s	4.21	τ_{400}	-	0.997
T ₅₀₀	s	5.17	τ_{500}	-	0.997
T ₆₃₀	s	4.43	τ_{630}	-	0.997
T ₈₀₀	s	5.44	τ_{800}	-	0.997
T ₁₀₀₀	s	5.68	τ_{1000}	-	0.997
T ₁₂₅₀	s	4.94	τ_{1250}	-	0.997
T ₁₆₀₀	s	4.14	τ_{1600}	-	0.997
T ₂₀₀₀	s	3.91	τ_{2000}	-	1.000
T ₂₅₀₀	s	3.11	τ_{2500}	-	1.000
T ₃₁₅₀	s	2.39	τ_{3150}	-	1.000
T ₄₀₀₀	s	2.06	τ_{4000}	-	1.000
T ₅₀₀₀	s	1.62	τ_{5000}	-	1.000
T ₆₃₀₀	s	1.30	τ_{6300}	-	1.000
T ₈₀₀₀	s	1.03	τ_{8000}	-	1.000
T ₁₀₀₀₀	s	0.69	τ_{10000}	-	1.000

Transmission coefficient τ has not been measured at frequencies below 50 Hz.

Symbols and units

- T_{50...10000} Reverberation time, s
- $\tau_{50...10000}$ Transmission coefficient, -
- 50...10000 Centre frequency of one-third octave band, Hz



The results are only valid for the tested sample(s).
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Ducted silencer: FVS 125-1000/600/300

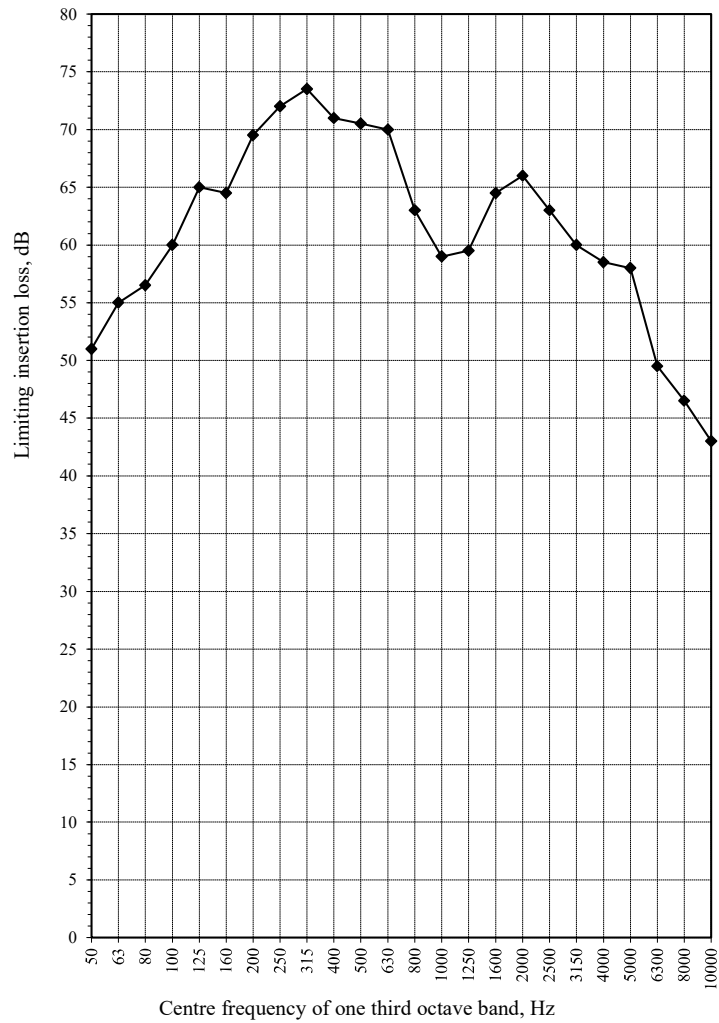
Limiting insertion loss of the test facility

ISO 7235:2003

Diameter of the inlet and outlet sections: 125 mm

Length: 15090 mm

Symbol	Unit	D
D _{1/3oct50}	dB	51.0
D _{1/3oct63}	dB	55.0
D _{1/3oct80}	dB	56.5
D _{1/3oct100}	dB	60.0
D _{1/3oct125}	dB	65.0
D _{1/3oct160}	dB	64.5
D _{1/3oct200}	dB	69.5
D _{1/3oct250}	dB	72.0
D _{1/3oct315}	dB	73.5
D _{1/3oct400}	dB	71.0
D _{1/3oct500}	dB	70.5
D _{1/3oct630}	dB	70.0
D _{1/3oct800}	dB	63.0
D _{1/3oct1000}	dB	59.0
D _{1/3oct1250}	dB	59.5
D _{1/3oct1600}	dB	64.5
D _{1/3oct2000}	dB	66.0
D _{1/3oct2500}	dB	63.0
D _{1/3oct3150}	dB	60.0
D _{1/3oct4000}	dB	58.5
D _{1/3oct5000}	dB	58.0
D _{1/3oct6300}	dB	49.5
D _{1/3oct8000}	dB	46.5
D _{1/3oct10000}	dB	43.0



Symbols and units

D_{1/3oct50...10000} Insertion loss in one-third octave bands, dB
 50...10000 Centre frequency of one third octave band, Hz



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Ducted silencer: FVS 125-1000/600/300

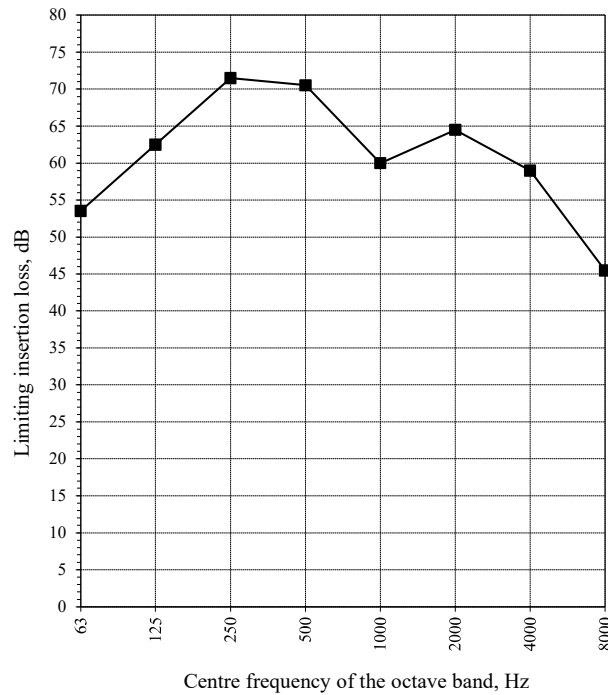
Limiting insertion loss of the test facility

ISO 7235:2003

Diameter of the inlet and outlet sections: 125 mm

Length: 15090 mm

Symbol	Unit	D
$D_{\text{Oct}63}$	dB	54
$D_{\text{Oct}125}$	dB	63
$D_{\text{Oct}250}$	dB	72
$D_{\text{Oct}500}$	dB	71
$D_{\text{Oct}1000}$	dB	60
$D_{\text{Oct}2000}$	dB	65
$D_{\text{Oct}4000}$	dB	59
$D_{\text{Oct}8000}$	dB	46



Symbols and units

$D_{\text{Oct}63 \dots 8000}$ Insertion loss in octave bands, dB
 63...8000 Centre frequency of octave band, Hz

Ducted silencer: FVS 125-1000

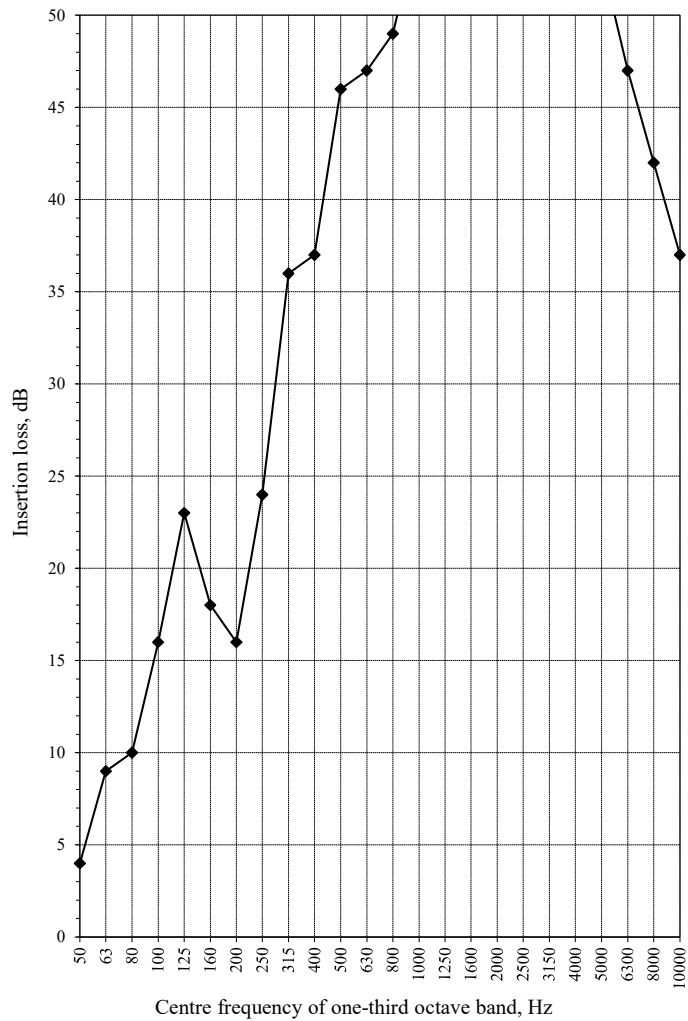
Insertion loss in one-third octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 125 mm

Length: 1000 mm

Symbol	Unit	Di
D _{1/3oct50}	dB	4
D _{1/3oct63}	dB	9
D _{1/3oct80}	dB	10
D _{1/3oct100}	dB	16
D _{1/3oct125}	dB	23
D _{1/3oct160}	dB	18
D _{1/3oct200}	dB	16
D _{1/3oct250}	dB	24
D _{1/3oct315}	dB	36
D _{1/3oct400}	dB	37
D _{1/3oct500}	dB	46
D _{1/3oct630}	dB	47
D _{1/3oct800}	dB	49
D _{1/3oct1000}	dB	>50
D _{1/3oct1250}	dB	>50
D _{1/3oct1600}	dB	>50
D _{1/3oct2000}	dB	>50
D _{1/3oct2500}	dB	>50
D _{1/3oct3150}	dB	>50
D _{1/3oct4000}	dB	>50
D _{1/3oct5000}	dB	>50
D _{1/3oct6300}	dB	47
D _{1/3oct8000}	dB	42
D _{1/3oct10000}	dB	37



Symbols and units

- Di Insertion loss, dB
- D_{1/3oct50...10000} Insertion loss in one-third octave bands, dB
- 50...10000 Centre frequency of one-third octave band, Hz



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Ducted silencer: FVS 125-1000

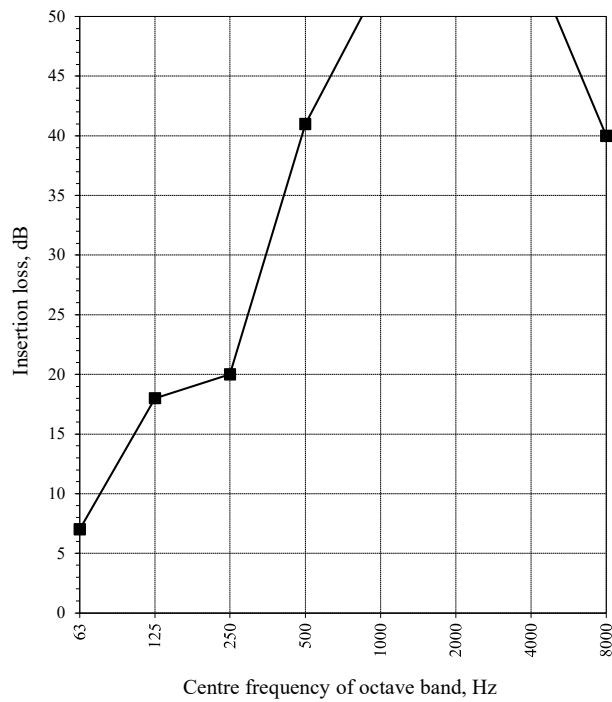
Insertion loss in octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 125 mm

Length: 1000 mm

Symbol	Unit	Di
$D_{\text{oct}63}$	dB	7
$D_{\text{oct}125}$	dB	18
$D_{\text{oct}250}$	dB	20
$D_{\text{oct}500}$	dB	41
$D_{\text{oct}1000}$	dB	>50
$D_{\text{oct}2000}$	dB	>50
$D_{\text{oct}4000}$	dB	>50
$D_{\text{oct}8000}$	dB	40



Symbols and units

- Di Insertion loss, dB
- $D_{\text{oct}63 \dots 8000}$ Insertion loss in octave bands, dB
- 63...8000 Centre frequency of octave band, Hz

Ducted silencer: FVS 125-1000

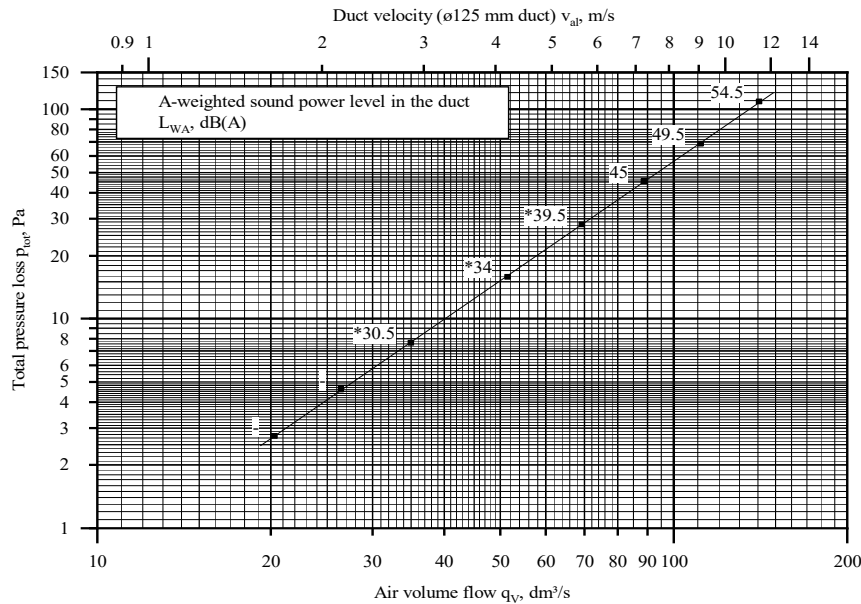
Pressure loss and flow noise in octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 125 mm

Length: 1000 mm

Air density 1,20 kg/m³



Symbol	Unit	1	2	3	4	5	6	7	8
q _v	dm ³ /s	20.3	26.5	35.0	51.5	69.3	88.8	111	141
v _{al}	m/s	1.7	2.2	2.9	4.2	5.6	7.2	9.1	11.5
p _{tot}	Pa	2.8	4.6	7.7	15.9	28.1	45.2	68.6	109
ζ _{tot}	-	1.68	1.65	1.58	1.50	1.47	1.44	1.39	1.38
L _{W63}	dB	*	*	*34.6	*39.2	44.8	49.1	52.4	55.9
L _{W125}	dB	*	*	*31.5	38.9	44.5	49.6	54.0	58.2
L _{W250}	dB	*	*	*27.1	36.0	41.9	47.3	51.5	56.0
L _{W500}	dB	*	*	*22.8	32.3	38.9	44.1	48.5	52.9
L _{W1000}	dB	*	*	*12.7	*22.2	30.9	37.6	42.7	47.6
L _{W2000}	dB	*	*	*13.7	*15.8	*24.4	33.0	39.3	45.4
L _{W4000}	dB	*	*	*22.3	*22.4	*22.8	*26.9	*33.7	41.3
L _{W8000}	dB	*	*	*30.3	*30.4	*30.4	*30.6	*30.8	*33.7
L _W	dB	*	*	*38	*43.7	49.3	54.1	58.3	62.4
L _{WA}	dB(A)	*	*	*30.6	*34.2	*39.5	45.0	49.6	54.5

*) The background noise requirements of standard ISO 3741:2010 have not been met.

Data represent upper bounds to the sound power level of the noise source under test.

Symbols and units

- q_v Air volume flow rate, dm³/s
- v_{al} Duct velocity (ø125 mm duct), m/s
- p_{tot} Total pressure loss, Pa
- ζ_{tot} Total pressure loss coefficient, -
- L_{W63...8000} Sound power level in the duct in octave bands, dB
- 63...8000 Centre frequencies of the octave bands, Hz
- L_W Sound power level in the duct, dB
- L_{WA} A-weighted sound power level in the duct, dB(A)



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Ducted silencer: FVS 125-600

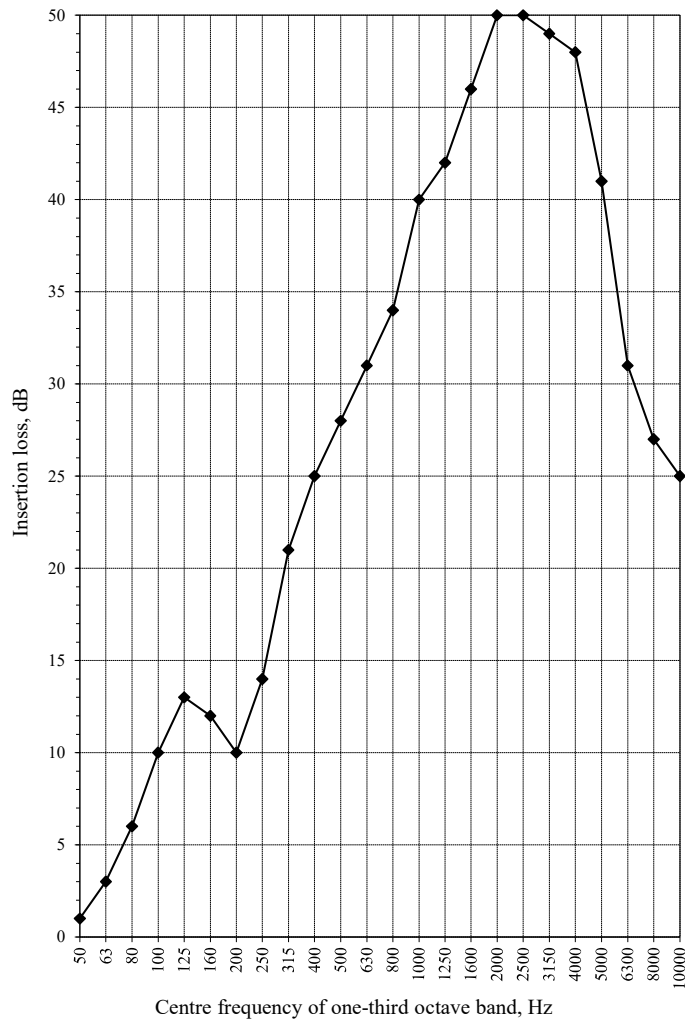
Insertion loss in one-third octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 125 mm

Length: 600 mm

Symbol	Unit	Di
D _{1/3oct50}	dB	1
D _{1/3oct63}	dB	3
D _{1/3oct80}	dB	6
D _{1/3oct100}	dB	10
D _{1/3oct125}	dB	13
D _{1/3oct160}	dB	12
D _{1/3oct200}	dB	10
D _{1/3oct250}	dB	14
D _{1/3oct315}	dB	21
D _{1/3oct400}	dB	25
D _{1/3oct500}	dB	28
D _{1/3oct630}	dB	31
D _{1/3oct800}	dB	34
D _{1/3oct1000}	dB	40
D _{1/3oct1250}	dB	42
D _{1/3oct1600}	dB	46
D _{1/3oct2000}	dB	50
D _{1/3oct2500}	dB	50
D _{1/3oct3150}	dB	49
D _{1/3oct4000}	dB	48
D _{1/3oct5000}	dB	41
D _{1/3oct6300}	dB	31
D _{1/3oct8000}	dB	27
D _{1/3oct10000}	dB	25



Symbols and units

- Di Insertion loss, dB
- D_{1/3oct50...10000} Insertion loss in one-third octave bands, dB
- 50...10000 Centre frequency of one-third octave band, Hz



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Ducted silencer: FVS 125-600

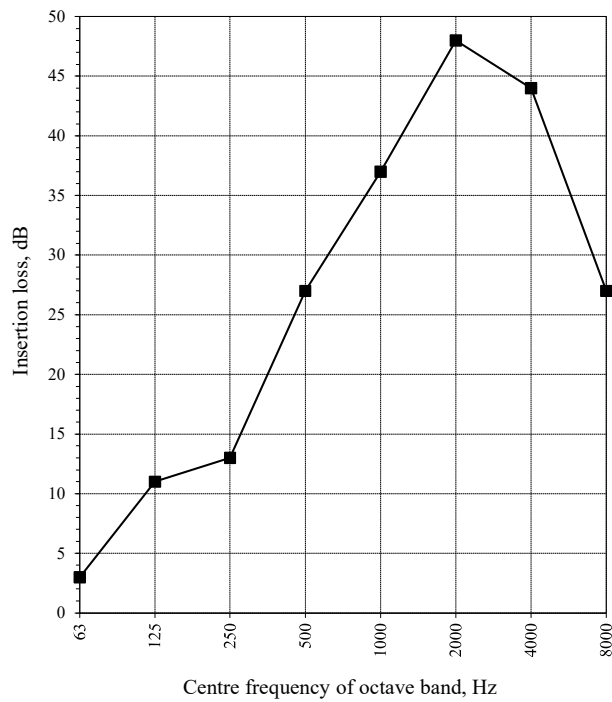
Insertion loss in octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 125 mm

Length: 600 mm

Symbol	Unit	Di
$D_{\text{oct}63}$	dB	3
$D_{\text{oct}125}$	dB	11
$D_{\text{oct}250}$	dB	13
$D_{\text{oct}500}$	dB	27
$D_{\text{oct}1000}$	dB	37
$D_{\text{oct}2000}$	dB	48
$D_{\text{oct}4000}$	dB	44
$D_{\text{oct}8000}$	dB	27



Symbols and units

- Di Insertion loss, dB
- $D_{\text{oct}63 \dots 8000}$ Insertion loss in octave bands, dB
- 63...8000 Centre frequency of octave band, Hz

Ducted silencer: FVS 125-600

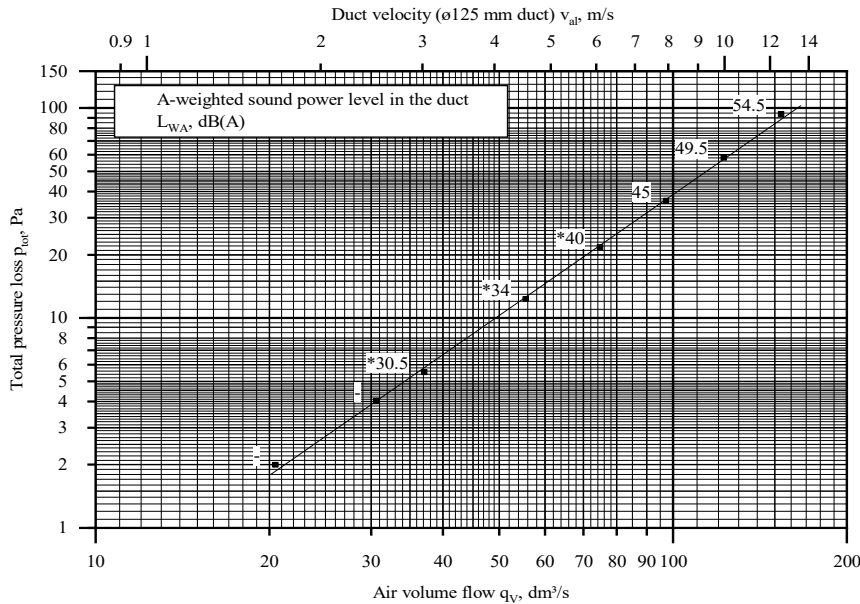
Pressure loss and flow noise in octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 125 mm

Length: 600 mm

Air density 1,20 kg/m³



Symbol	Unit	1	2	3	4	5	6	7	8
q_v	dm ³ /s	20.5	30.6	37.1	55.6	74.8	97.3	123	154
v_{al}	m/s	1.7	2.5	3.0	4.5	6.1	7.9	10.0	12.6
p_{tot}	Pa	2.0	4.0	5.5	12.3	21.7	36.0	57.8	93.5
ζ_{tot}	-	1.19	1.07	1.00	1.00	0.97	0.95	0.97	0.99
L_{W63}	dB	*	*	*36.3	42.8	47.4	51.3	55.0	58.6
L_{W125}	dB	*	*	*33.5	40.8	46.6	52.3	55.9	59.7
L_{W250}	dB	*	*	*27.4	37.0	43.6	47.7	51.9	57.0
L_{W500}	dB	*	*	*20.5	30.6	38.2	43.9	48.1	52.3
L_{W1000}	dB	*	*	*13.7	*22.3	30.8	37.2	42.4	47.3
L_{W2000}	dB	*	*	*14	*16.1	*24.9	32.9	39.3	44.8
L_{W4000}	dB	*	*	*22.3	*22.3	*23.3	*28.4	35.5	41.8
L_{W8000}	dB	*	*	*30.4	*30.4	*30.4	*30.6	*31.9	*36.3
L_W	dB	*	*	*39.3	45.9	51.2	56.0	59.8	63.9
L_{WA}	dB(A)	*	*	*30.6	*34.1	*39.8	45.0	49.7	54.5

*) The background noise requirements of standard ISO 3741:2010 have not been met.

Data represent upper bounds to the sound power level of the noise source under test.

Symbols and units

- q_v Air volume flow rate, dm³/s
- v_{al} Duct velocity (ø125 mm duct), m/s
- p_{tot} Total pressure loss, Pa
- ζ_{tot} Total pressure loss coefficient, -
- $L_{W63...8000}$ Sound power level in the duct in octave bands, dB
- 63...8000 Centre frequencies of the octave bands, Hz
- L_W Sound power level in the duct, dB
- L_{WA} A-weighted sound power level in the duct, dB(A)



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Ducted silencer: FVS 125-300

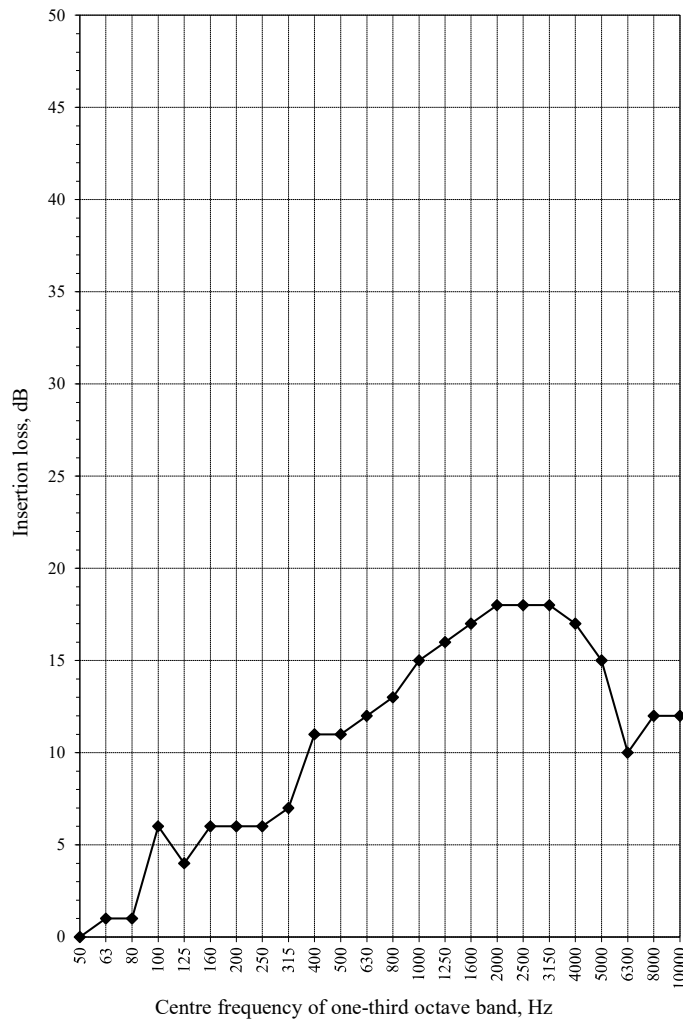
Insertion loss in one-third octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 125 mm

Length: 300 mm

Symbol	Unit	Di
D _{1/3oct50}	dB	0
D _{1/3oct63}	dB	1
D _{1/3oct80}	dB	1
D _{1/3oct100}	dB	6
D _{1/3oct125}	dB	4
D _{1/3oct160}	dB	6
D _{1/3oct200}	dB	6
D _{1/3oct250}	dB	6
D _{1/3oct315}	dB	7
D _{1/3oct400}	dB	11
D _{1/3oct500}	dB	11
D _{1/3oct630}	dB	12
D _{1/3oct800}	dB	13
D _{1/3oct1000}	dB	15
D _{1/3oct1250}	dB	16
D _{1/3oct1600}	dB	17
D _{1/3oct2000}	dB	18
D _{1/3oct2500}	dB	18
D _{1/3oct3150}	dB	18
D _{1/3oct4000}	dB	17
D _{1/3oct5000}	dB	15
D _{1/3oct6300}	dB	10
D _{1/3oct8000}	dB	12
D _{1/3oct10000}	dB	12



Symbols and units

- Di Insertion loss, dB
- D_{1/3oct50...10000} Insertion loss in one-third octave bands, dB
- 50...10000 Centre frequency of one-third octave band, Hz



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Ducted silencer: FVS 125-300

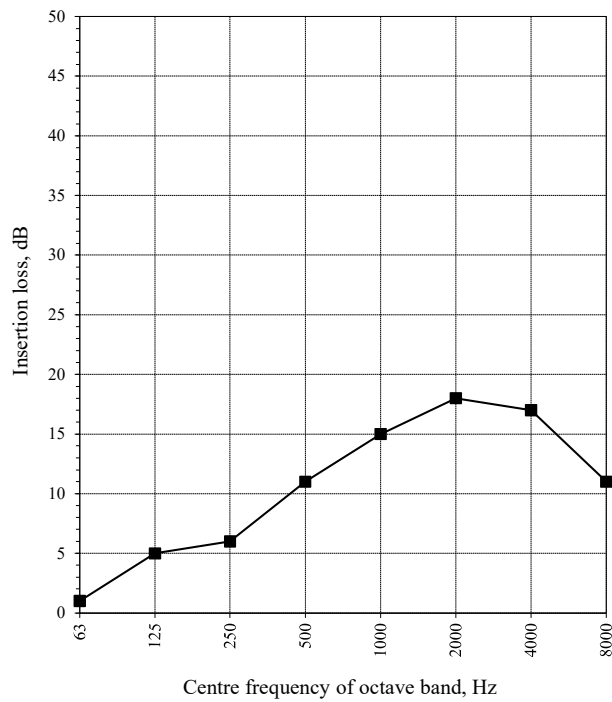
Insertion loss in octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 125 mm

Length: 300 mm

Symbol	Unit	Di
$D_{\text{oct}63}$	dB	1
$D_{\text{oct}125}$	dB	5
$D_{\text{oct}250}$	dB	6
$D_{\text{oct}500}$	dB	11
$D_{\text{oct}1000}$	dB	15
$D_{\text{oct}2000}$	dB	18
$D_{\text{oct}4000}$	dB	17
$D_{\text{oct}8000}$	dB	11



Symbols and units

- Di Insertion loss, dB
- $D_{\text{oct}63 \dots 8000}$ Insertion loss in octave bands, dB
- 63...8000 Centre frequency of octave band, Hz

Ducted silencer: FVS 125-300

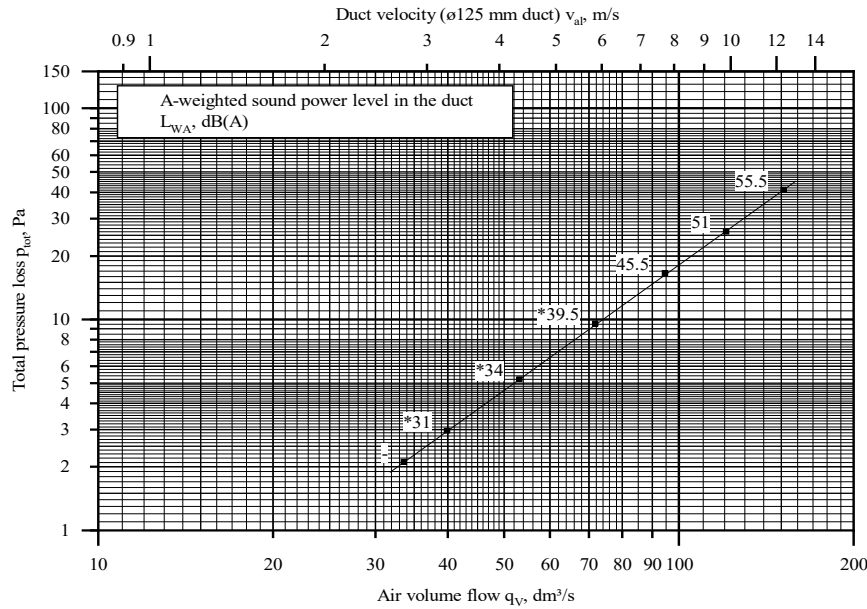
Pressure loss and flow noise in octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 125 mm

Length: 300 mm

Air density 1,20 kg/m³



Symbol	Unit	1	2	3	4	5	6	7
q _v	dm ³ /s	33.6	39.9	53.1	71.8	94.8	121	151
v _{al}	m/s	2.7	3.3	4.3	5.8	7.7	9.8	12.3
p _{tot}	Pa	2.1	3.0	5.2	9.5	16.5	26.1	41.1
ζ _{tot}	-	0.47	0.47	0.46	0.46	0.46	0.45	0.45
L _{W63}	dB	*	*36	*41.3	46.1	49.0	52.4	55.9
L _{W125}	dB	*	*33.5	39.2	44.9	50.4	55.0	58.3
L _{W250}	dB	*	*28.8	35.8	41.3	46.6	51.3	55.6
L _{W500}	dB	*	*22.9	31.6	38.6	44.2	48.7	52.6
L _{W1000}	dB	*	*13.7	*23.4	32.8	39.7	44.7	49.3
L _{W2000}	dB	*	*13.6	*15.8	*25.9	35.8	42.6	48.1
L _{W4000}	dB	*	*22.2	*22.3	*22.9	*28.6	37.4	44.5
L _{W8000}	dB	*	*30.5	*30.5	*30.5	*30.6	*31.5	*36.2
L _W	dB	*	*39.3	44.6	49.8	54.4	58.8	62.5
L _{WA}	dB(A)	*	*30.8	*34	*39.7	45.7	50.8	55.6

*) The background noise requirements of standard ISO 3741:2010 have not been met.

Data represent upper bounds to the sound power level of the noise source under test.

Symbols and units

- q_v Air volume flow rate, dm³/s
- v_{al} Duct velocity (ø125 mm duct), m/s
- p_{tot} Total pressure loss, Pa
- ζ_{tot} Total pressure loss coefficient, -
- L_{W63...8000} Sound power level in the duct in octave bands, dB
- 63...8000 Centre frequencies of the octave bands, Hz
- L_W Sound power level in the duct, dB
- L_{WA} A-weighted sound power level in the duct, dB(A)



The results are only valid for the tested sample(s).
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Instruments used:

Instrument	Type code	Serial number	Calibrated
Micromanometer	Furness FC012	9802124	07/2021
Micromanometer	Furness FC012	110057	07/2021
Micromanometer	Furness FC012	9802125	07/2021
Barometer	Vaisala PTB220BAC2A1	W4230002	07/2021
Hygrometer	Rotronic HTT	8501156	11/2021
Temperature logger	Agilent 34970A	MY44071581	07/2021
Pistonphone	B&K 4228	3063558	01/2021
Microphone	B&K 4943	2415046	before measurements
Microphone preamplifier	B&K 2660	15040598	
Real-time analyser	Norsonic RT 830-2	11504	07/2020
Rotating microphone stand	B&K 3923	1678218	
Reverberation room	298 m ³		