Performance of the ducted silencers
FVS 100-1000
FVS 100-600
FVS 100-300

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 100-1000/600/300
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 26.-28.1.2022.
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 tappings. 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

Measurement results are presented in appendix 3-5. Measurement results are valid only for the tested samples.

Instruments used in measurements are presented in appendix 6.

References

/1/ ISO 7235:2003. Acoustics - Laboratory measurement procedures for ducted silencers and air-terminal units - Insertion loss, flow noise and total pressure loss.

/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.

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.

Espoo, 1.2.2022

Pekka Kettunen
Expert

Mika Hurme
Expert

Appendices 6

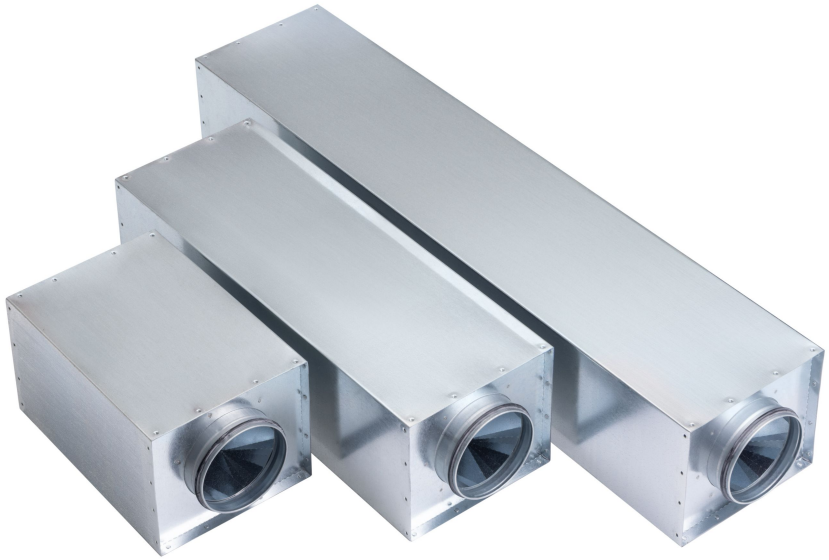
Distribution Customer, electronically approved

Ducted silencer: FVS 100-1000/600/300

Description of the sample

ISO 7235:2003

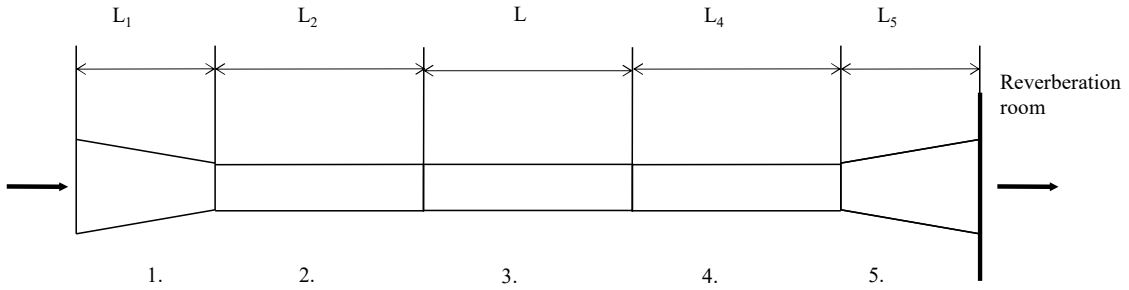
Symbols and units	FVS 100-1000	FVS 100-600	FVS 100-300	Substitution duct
Type	Ducted silencer			Spiral duct
Diameter of the inlet and outlet sections Ød, mm	100			100
Width a, mm	215			-
Height b, mm	155			-
Length L, mm	1000	600	300	1000 / 600 / 300
Mass, kg	6.27	4.07	2.29	-
Thickness of steel duct material, mm	0.7			0.7
Direction of flow determined	no			no
Direction of insertion loss	no			no



Ducted silencer: FVS 100-1000/600/300

Test facility

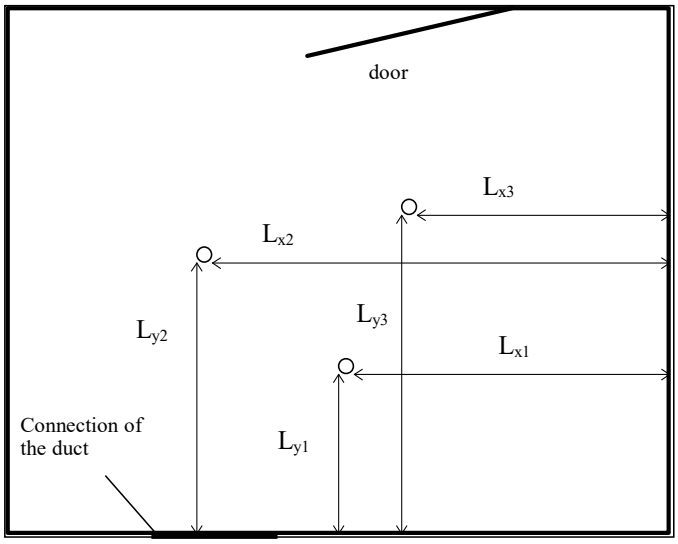
ISO 7235:2003



Components:	Symbols and units	Length
1. Transition Ø1600 / Ø100	L_1, mm	5805
2. Duct Ø100	L_2, mm	1500
3. Silencer	L, mm	1000/600/300
4. Duct Ø100	L_4, mm	2500
5. Transition Ø100 / Ø1250	L_5, mm	4485
Total lenght of measurement duct		15290 / 14890 / 14590

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 100-1000/600/300

Test facility

ISO 7235:2003

Volume of the reverberation room: 298 m³

Reverberation time T of the reverberation room and the transmission coefficient t of the measurement duct transmission element Ø 100.

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

Symbol	Unit	τ
τ_{50}	-	0.472
τ_{63}	-	0.854
τ_{80}	-	0.730
τ_{100}	-	0.773
τ_{125}	-	0.922
τ_{160}	-	0.971
τ_{200}	-	0.949
τ_{250}	-	0.987
τ_{315}	-	0.987
τ_{400}	-	0.997
τ_{500}	-	0.997
τ_{630}	-	0.997
τ_{800}	-	0.997
τ_{1000}	-	0.997
τ_{1250}	-	0.997
τ_{1600}	-	0.997
τ_{2000}	-	0.997
τ_{2500}	-	0.997
τ_{3150}	-	1.000
τ_{4000}	-	1.000
τ_{5000}	-	1.000
τ_{6300}	-	1.000
τ_{8000}	-	1.000
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

Ducted silencer: FVS 100-1000/600/300

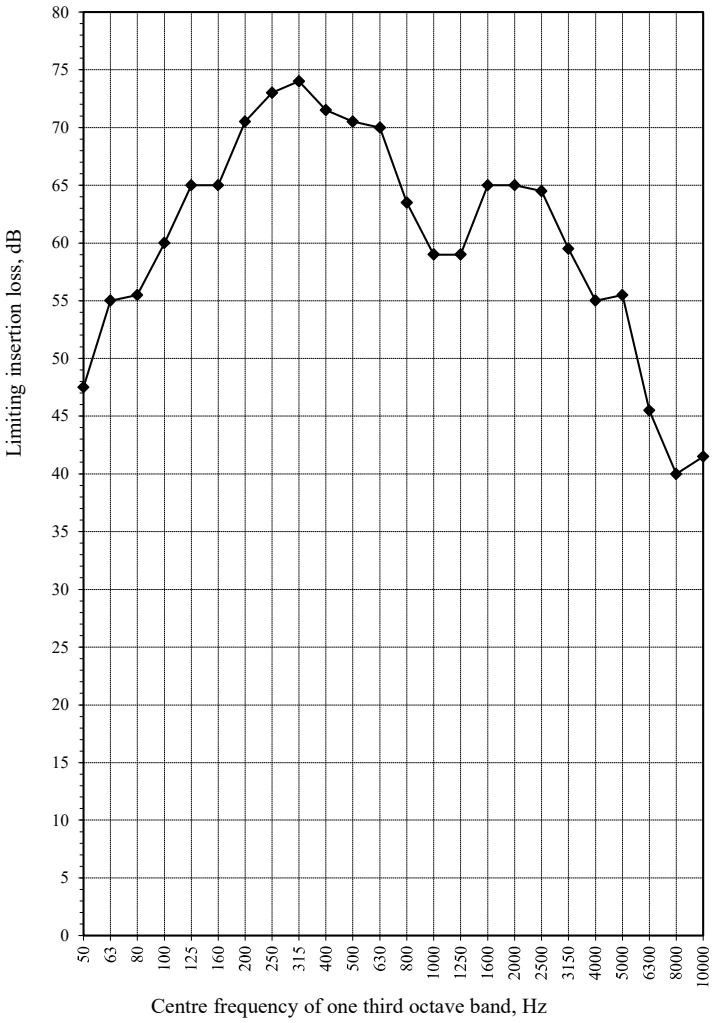
Limiting insertion loss of the test facility

ISO 7235:2003

Diameter of the inlet and outlet sections: 100 mm

Length: 15290 mm

Symbol	Unit	D
$D_{1/3oct50}$	dB	47.5
$D_{1/3oct63}$	dB	55.0
$D_{1/3oct80}$	dB	55.5
$D_{1/3oct100}$	dB	60.0
$D_{1/3oct125}$	dB	65.0
$D_{1/3oct160}$	dB	65.0
$D_{1/3oct200}$	dB	70.5
$D_{1/3oct250}$	dB	73.0
$D_{1/3oct315}$	dB	74.0
$D_{1/3oct400}$	dB	71.5
$D_{1/3oct500}$	dB	70.5
$D_{1/3oct630}$	dB	70.0
$D_{1/3oct800}$	dB	63.5
$D_{1/3oct1000}$	dB	59.0
$D_{1/3oct1250}$	dB	59.0
$D_{1/3oct1600}$	dB	65.0
$D_{1/3oct2000}$	dB	65.0
$D_{1/30ct2500}$	dB	64.5
$D_{1/3oct3150}$	dB	59.5
$D_{1/3oct4000}$	dB	55.0
$D_{1/3oct5000}$	dB	55.5
$D_{1/3oct6300}$	dB	45.5
$D_{1/3oct8000}$	dB	40.0
$D_{1/3oct10000}$	dB	41.5



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

Ducted silencer: FVS 100-1000/600/300

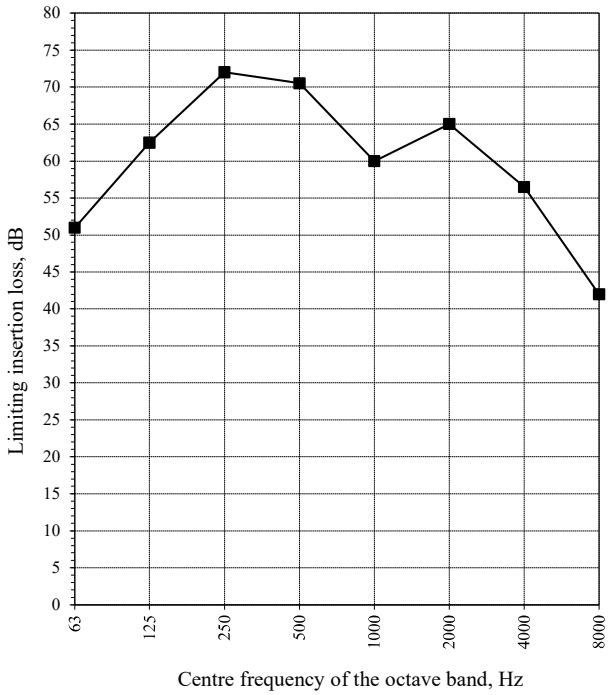
Limiting insertion loss of the test facility

ISO 7235:2003

Diameter of the inlet and outlet sections: 100 mm

Length: 15290 mm

Symbol	Unit	D
D_{oct63}	dB	51
D_{oct125}	dB	63
D_{oct250}	dB	72
D_{oct500}	dB	71
$D_{oct1000}$	dB	60
$D_{oct2000}$	dB	65
$D_{oct4000}$	dB	57
$D_{oct8000}$	dB	42



Symbols and units

$D_{oct63...8000}$ Insertion loss in octave bands, dB

$_{63...8000}$ Centre frequency of octave band, Hz

Ducted silencer: FVS 100-1000

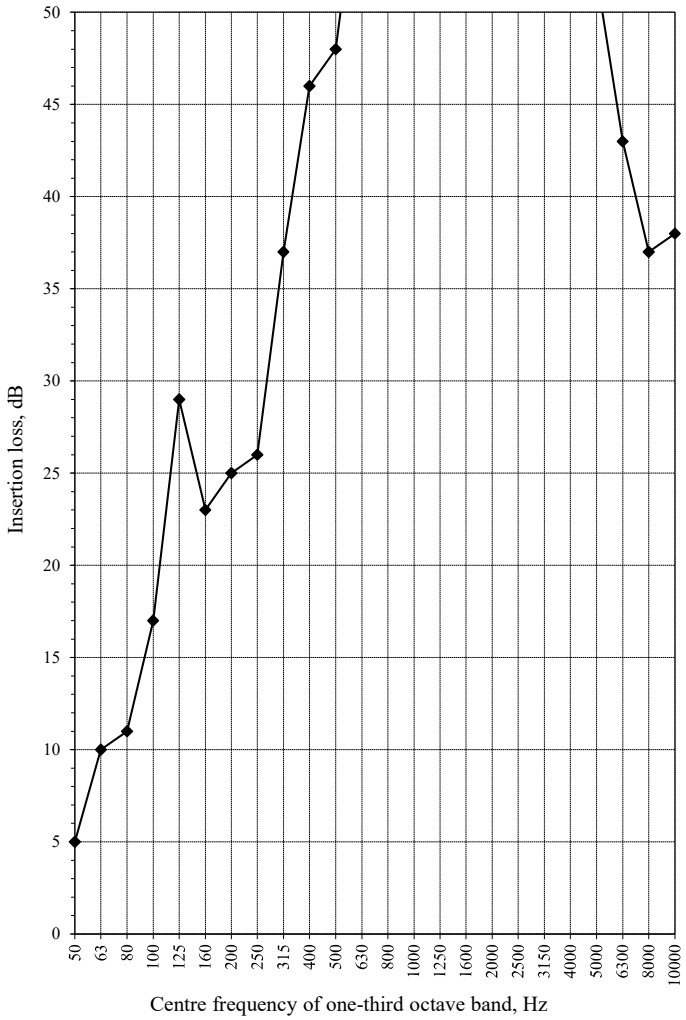
Insertion loss in one-third octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 100 mm

Length: 1000 mm

Symbol	Unit	Di
$D_{1/3oct50}$	dB	5
$D_{1/3oct63}$	dB	10
$D_{1/3oct80}$	dB	11
$D_{1/3oct100}$	dB	17
$D_{1/3oct125}$	dB	29
$D_{1/3oct160}$	dB	23
$D_{1/3oct200}$	dB	25
$D_{1/3oct250}$	dB	26
$D_{1/3oct315}$	dB	37
$D_{1/3oct400}$	dB	46
$D_{1/3oct500}$	dB	48
$D_{1/3oct630}$	dB	>50
$D_{1/3oct800}$	dB	>50
$D_{1/3oct1000}$	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	43
$D_{1/3oct8000}$	dB	37
$D_{1/3oct10000}$	dB	38



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

Ducted silencer: FVS 100-1000

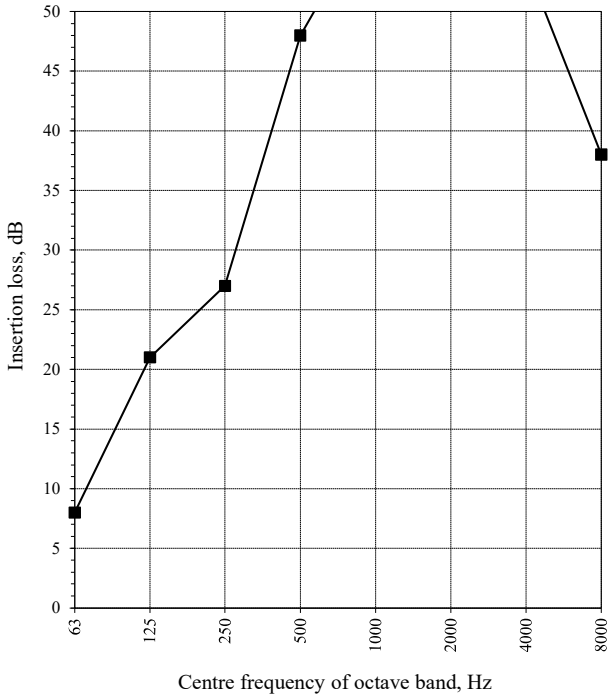
Insertion loss in octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 100 mm

Length: 1000 mm

Symbol	Unit	Di
D_{oct63}	dB	8
D_{oct125}	dB	21
D_{oct250}	dB	27
D_{oct500}	dB	48
$D_{oct1000}$	dB	>50
$D_{oct2000}$	dB	>50
$D_{oct4000}$	dB	>50
$D_{oct8000}$	dB	38



Symbols and units

Di	Insertion loss, dB
$D_{oct63...8000}$	Insertion loss in octave bands, dB
$_{63...8000}$	Centre frequency of octave band, Hz

Ducted silencer: FVS 100-1000

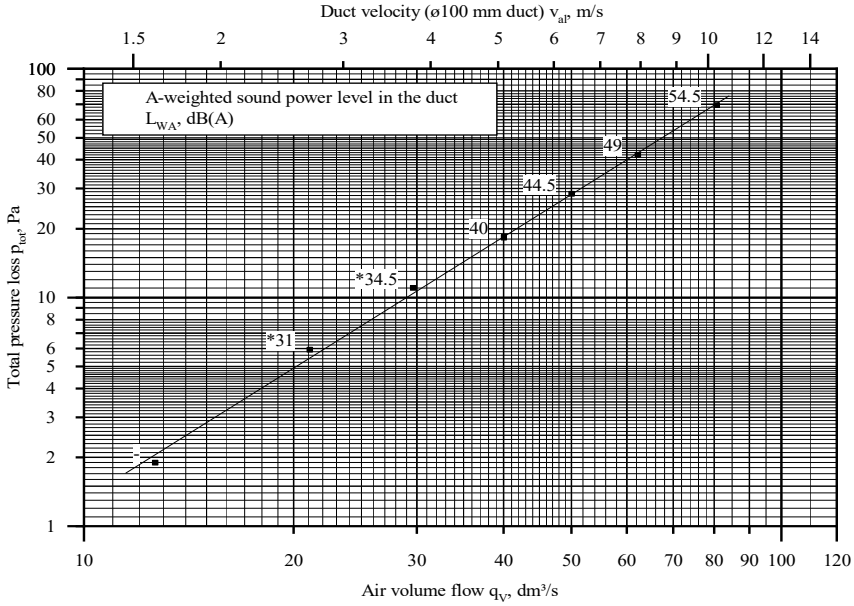
Pressure loss and flow noise in octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 100 mm

Length: 1000 mm

Air density 1,20 kg/m³



Symbol	Unit	1	2	3	4	5	6	7
q_V	dm³/s	12.7	21.1	29.7	40.0	50.0	62.3	80.8
v_{a1}	m/s	1.6	2.7	3.8	5.1	6.4	7.9	10.3
p_{tot}	Pa	1.9	5.9	11.0	18.3	28.4	42.0	69.4
ζ_{tot}	-	1.21	1.37	1.28	1.17	1.17	1.11	1.09
L_{W63}	dB	*	*34.7	*41.4	45.3	47.7	49.9	53.5
L_{W125}	dB	*	*32	39.9	46.0	50.3	54.3	57.7
L_{W250}	dB	*	*28.3	36.6	42.8	47.3	52.0	56.7
L_{W500}	dB	*	*22.5	32.3	39.5	44.5	48.8	53.6
L_{W1000}	dB	*	*13.7	*22.2	31.1	37.0	42.3	48.1
L_{W2000}	dB	*	*14.3	*15.1	*21.1	*28.4	35.1	42.3
L_{W4000}	dB	*	*22.4	*22.5	*22.7	*24.1	*28.8	37.3
L_{W8000}	dB	*	*30.5	*30.5	*30.5	*30.6	*30.5	*31.2
L_W	dB	*	*38.3	*45	50.2	54.1	57.9	62.0
L_{WA}	dB(A)	*	*30.8	*34.4	39.9	44.6	49.2	54.4

*) 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_{a1}	Duct velocity (ø100 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)

Ducted silencer: FVS 100-600

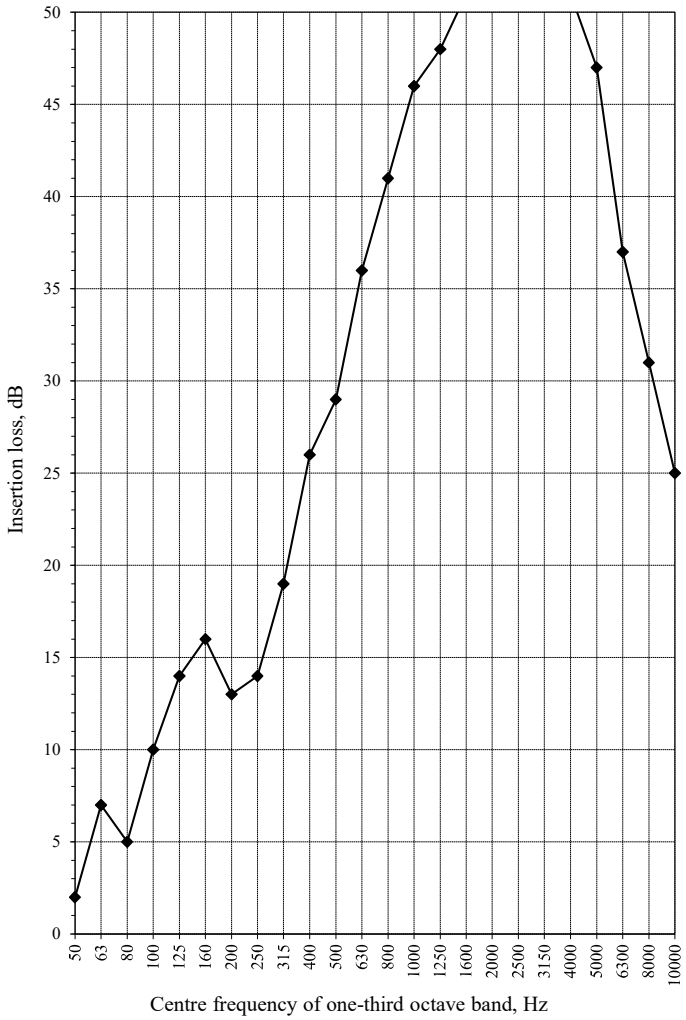
Insertion loss in one-third octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 100 mm

Length: 600 mm

Symbol	Unit	Di
$D_{1/3oct50}$	dB	2
$D_{1/3oct63}$	dB	7
$D_{1/3oct80}$	dB	5
$D_{1/3oct100}$	dB	10
$D_{1/3oct125}$	dB	14
$D_{1/3oct160}$	dB	16
$D_{1/3oct200}$	dB	13
$D_{1/3oct250}$	dB	14
$D_{1/3oct315}$	dB	19
$D_{1/3oct400}$	dB	26
$D_{1/3oct500}$	dB	29
$D_{1/3oct630}$	dB	36
$D_{1/3oct800}$	dB	41
$D_{1/3oct1000}$	dB	46
$D_{1/3oct1250}$	dB	48
$D_{1/3oct1600}$	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	47
$D_{1/3oct6300}$	dB	37
$D_{1/3oct8000}$	dB	31
$D_{1/3oct10000}$	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

Ducted silencer: FVS 100-600

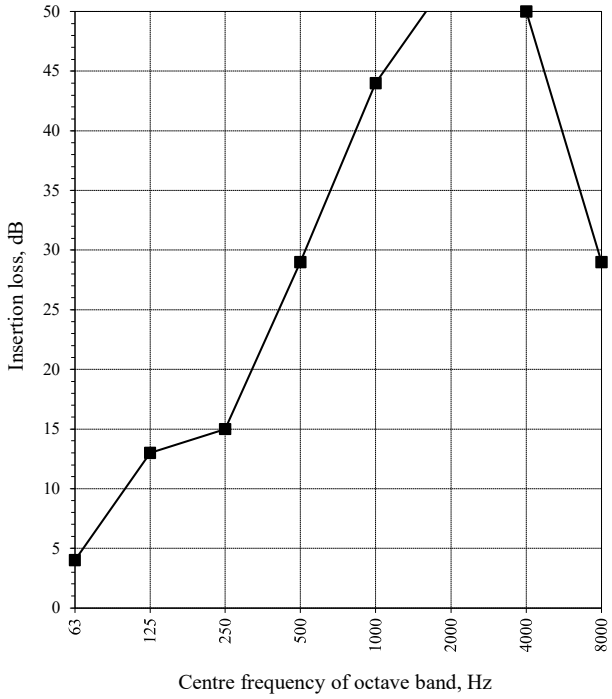
Insertion loss in octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 100 mm

Length: 600 mm

Symbol	Unit	Di
D_{oct63}	dB	4
D_{oct125}	dB	13
D_{oct250}	dB	15
D_{oct500}	dB	29
$D_{oct1000}$	dB	44
$D_{oct2000}$	dB	>50
$D_{oct4000}$	dB	50
$D_{oct8000}$	dB	29



Symbols and units

Di	Insertion loss, dB
$D_{oct63…8000}$	Insertion loss in octave bands, dB
$_{63…8000}$	Centre frequency of octave band, Hz

Ducted silencer: FVS 100-600

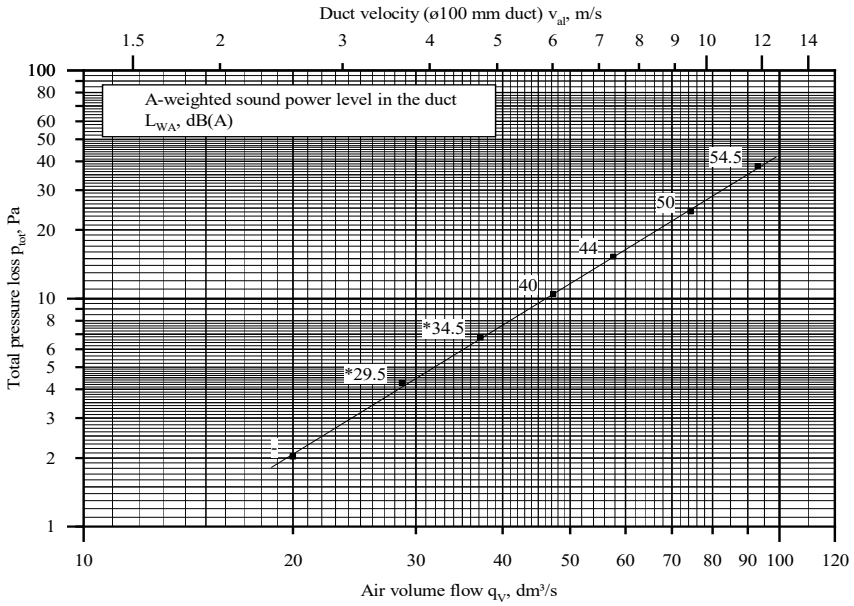
Pressure loss and flow noise in octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 100 mm

Length: 600 mm

Air density 1,20 kg/m³



Symbol	Unit	1	2	3	4	5	6	7
q_V	dm³/s	20.0	28.7	37.2	47.3	57.7	74.6	93.1
v_{a1}	m/s	2.5	3.7	4.7	6.0	7.3	9.5	11.9
p_{tot}	Pa	2.0	4.3	6.7	10.4	15.2	24.1	38.0
ζ_{tot}	-	0.52	0.53	0.50	0.48	0.47	0.44	0.45
L_{W63}	dB	*	*37.9	42.8	46.8	47.9	51.1	54.0
L_{W125}	dB	*	*34.2	39.6	44.9	48.9	54.5	58.1
L_{W250}	dB	*	30.7	36.9	41.9	45.7	50.1	54.6
L_{W500}	dB	*	26.0	33.5	39.4	43.6	48.7	52.6
L_{W1000}	dB	*	*16.3	25.4	33.0	38.2	44.3	48.8
L_{W2000}	dB	*	*14.1	*16.2	*23.9	31.1	39.1	45.1
L_{W4000}	dB	*	*19.9	*19.9	*20.7	*24.3	33.2	41.1
L_{W8000}	dB	*	*26.3	*26.2	*26.2	*26.2	*26.6	*29.8
L_W	dB	*	*40.4	45.6	50.2	53.2	58.0	61.7
L_{WA}	dB(A)	*	*29.5	*34.3	39.8	44.1	49.8	54.4

*) 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_{a1}	Duct velocity (ø100 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)

Ducted silencer: FVS 100-300

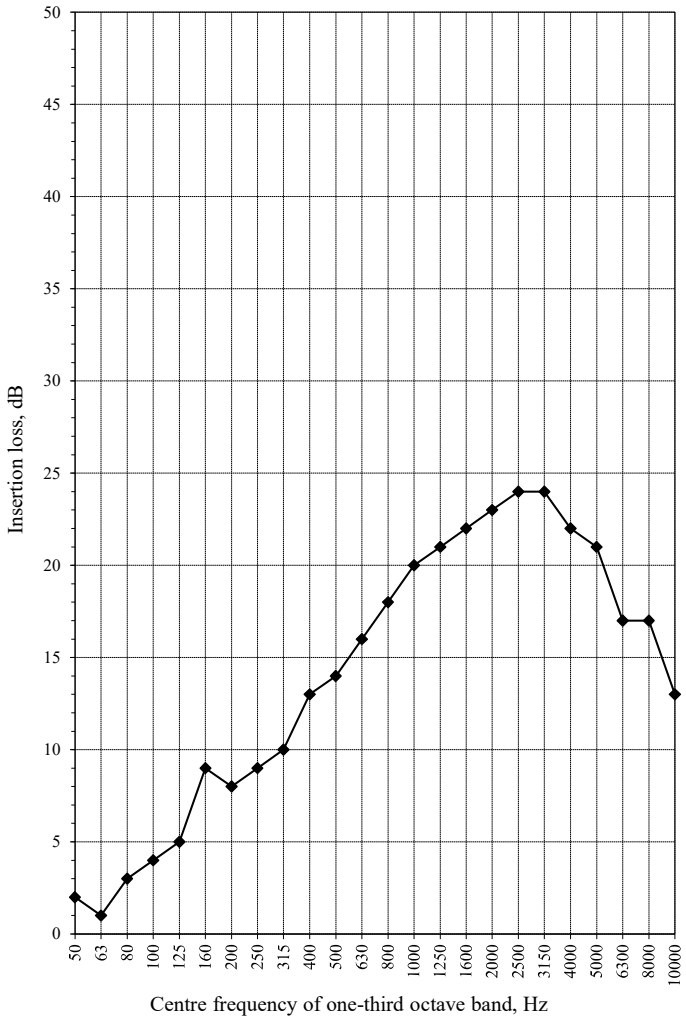
Insertion loss in one-third octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 100 mm

Length: 300 mm

Symbol	Unit	Di
$D_{1/3oct50}$	dB	2
$D_{1/3oct63}$	dB	1
$D_{1/3oct80}$	dB	3
$D_{1/3oct100}$	dB	4
$D_{1/3oct125}$	dB	5
$D_{1/3oct160}$	dB	9
$D_{1/3oct200}$	dB	8
$D_{1/3oct250}$	dB	9
$D_{1/3oct315}$	dB	10
$D_{1/3oct400}$	dB	13
$D_{1/3oct500}$	dB	14
$D_{1/3oct630}$	dB	16
$D_{1/3oct800}$	dB	18
$D_{1/3oct1000}$	dB	20
$D_{1/3oct1250}$	dB	21
$D_{1/3oct1600}$	dB	22
$D_{1/3oct2000}$	dB	23
$D_{1/3oct2500}$	dB	24
$D_{1/3oct3150}$	dB	24
$D_{1/3oct4000}$	dB	22
$D_{1/3oct5000}$	dB	21
$D_{1/3oct6300}$	dB	17
$D_{1/3oct8000}$	dB	17
$D_{1/3oct10000}$	dB	13



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

Ducted silencer: FVS 100-300

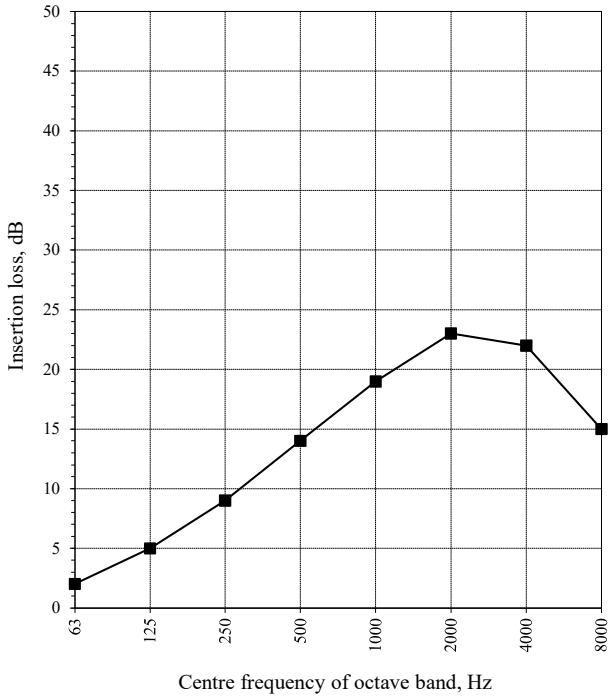
Insertion loss in octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 100 mm

Length: 300 mm

Symbol	Unit	Di
D_{oct63}	dB	2
D_{oct125}	dB	5
D_{oct250}	dB	9
D_{oct500}	dB	14
$D_{oct1000}$	dB	19
$D_{oct2000}$	dB	23
$D_{oct4000}$	dB	22
$D_{oct8000}$	dB	15



Symbols and units

Di	Insertion loss, dB
$D_{oct63…8000}$	Insertion loss in octave bands, dB
$_{63…8000}$	Centre frequency of octave band, Hz

Ducted silencer: FVS 100-300

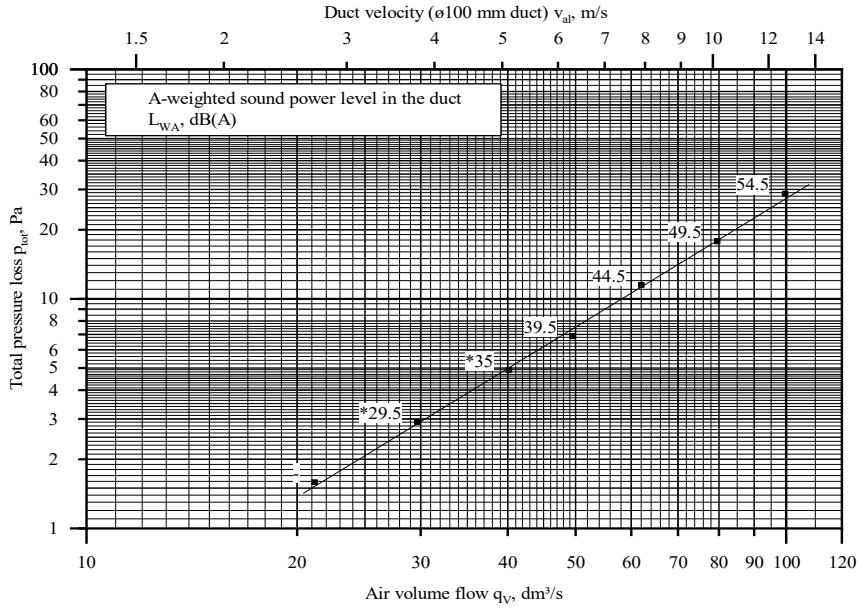
Pressure loss and flow noise in octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 100 mm

Length: 300 mm

Air density 1,20 kg/m³



Symbol	Unit	1	2	3	4	5	6	7
q_V	dm³/s	21.2	29.7	40.2	49.5	62.1	79.7	99.6
v_{a1}	m/s	2.7	3.8	5.1	6.3	7.9	10.1	12.7
p_{tot}	Pa	1.6	2.9	4.9	6.9	11.5	17.7	28.6
ζ_{tot}	-	0.36	0.34	0.31	0.29	0.31	0.29	0.30
L_{W63}	dB	*	*38	44.0	46.7	49.5	50.6	56.2
L_{W125}	dB	*	37.6	40.6	45.3	50.5	55.0	57.9
L_{W250}	dB	*	31.3	37.2	41.2	45.6	50.6	55.5
L_{W500}	dB	*	26.1	34.1	38.6	43.4	48.0	52.0
L_{W1000}	dB	*	*16.7	27.0	33.0	38.7	44.1	48.6
L_{W2000}	dB	*	*13.7	*17.7	*24.9	32.6	39.8	45.5
L_{W4000}	dB	*	*19.8	*19.9	*21.2	*25.9	*34.6	42.1
L_{W8000}	dB	*	*26.1	*26.1	*26.2	*26.2	*27.1	*31.4
L_W	dB	*	41.6	46.6	50.2	54.3	58.1	62.2
L_{WA}	dB(A)	*	*29.7	*34.9	39.4	44.5	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_{a1}	Duct velocity (ø100 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)

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 m³		