Performance of the ducted silencers
FVS 160-1000
FVS 160-600
FVS 160-300

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 160-1000/600/300
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 31.1-1.2.2022.
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 160-1000/600/300

Description of the sample

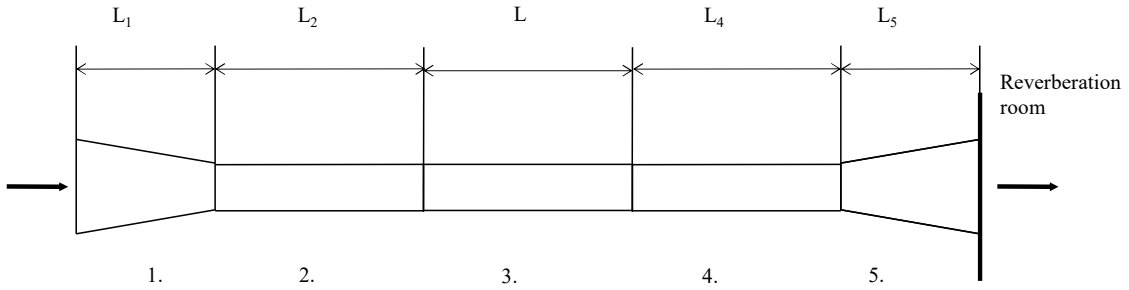
ISO 7235:2003

Symbols and units	FVS 160-1000	FVS 160-600	FVS 160-300	Substitution duct
Type	Ducted silencer			Spiral duct
Diameter of the inlet and outlet sections Ød, mm	160			160
Width a, mm	240			-
Height b, mm	215			-
Length L, mm	1000	600	300	1000 / 600 / 300
Mass, kg	8.22	5.25	3.26	-
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 160-1000/600/300

Test facility

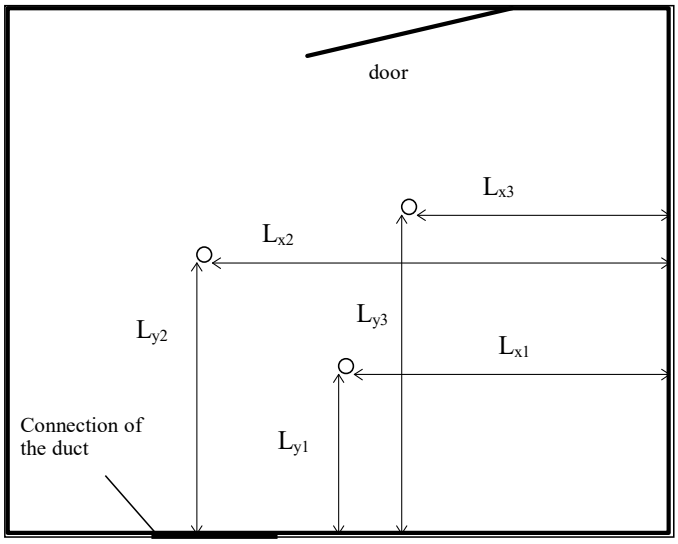
ISO 7235:2003



Components:	Symbols and units	Length
1. Transition Ø1600 / Ø160	L_1, mm	5580
2. Duct Ø160	L_2, mm	2000/2000/1500
3. Silencer	L, mm	300/600/1000
4. Duct Ø160	L_4, mm	2500
5. Transition Ø160 / Ø1250	L_5, mm	4260
Total lenght of measurement duct		14640 / 14940 / 14840

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 160-1000/600/300

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 160.

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}	-	0.730
τ_{63}	-	0.730
τ_{80}	-	0.971
τ_{100}	-	0.922
τ_{125}	-	0.949
τ_{160}	-	0.987
τ_{200}	-	0.997
τ_{250}	-	0.997
τ_{315}	-	0.997
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}	-	1.000
τ_{2000}	-	1.000
τ_{2500}	-	1.000
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 160-1000/600/300

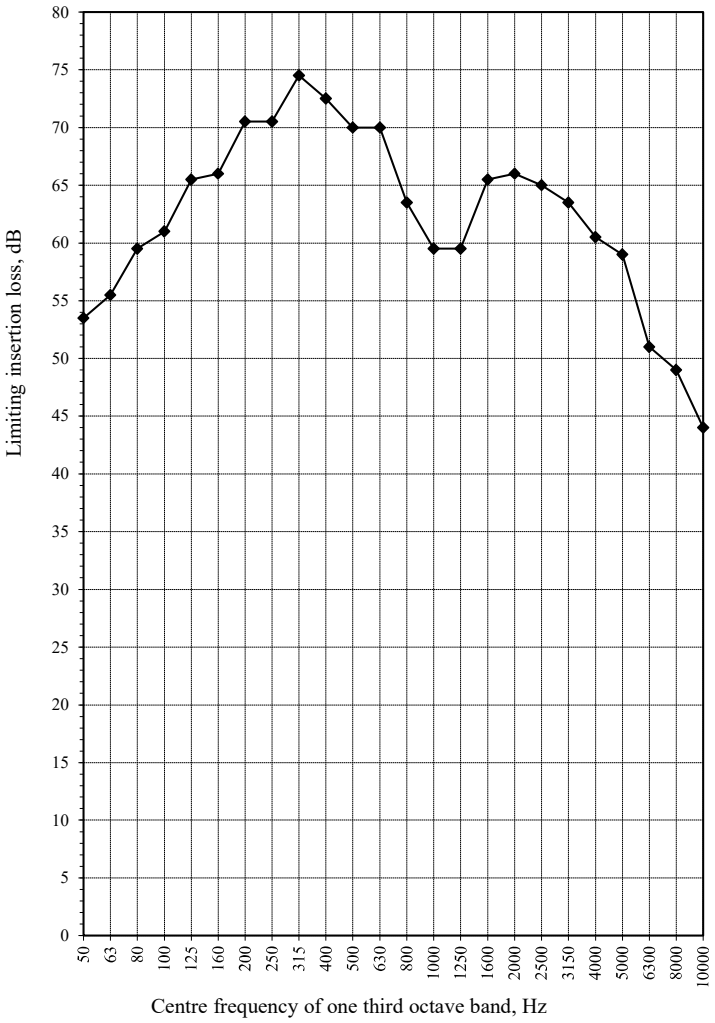
Limiting insertion loss of the test facility

ISO 7235:2003

Diameter of the inlet and outlet sections: 160 mm

Length: 14840 mm

Symbol	Unit	D
$D_{1/3oct50}$	dB	53.5
$D_{1/3oct63}$	dB	55.5
$D_{1/3oct80}$	dB	59.5
$D_{1/3oct100}$	dB	61.0
$D_{1/3oct125}$	dB	65.5
$D_{1/3oct160}$	dB	66.0
$D_{1/3oct200}$	dB	70.5
$D_{1/3oct250}$	dB	70.5
$D_{1/3oct315}$	dB	74.5
$D_{1/3oct400}$	dB	72.5
$D_{1/3oct500}$	dB	70.0
$D_{1/3oct630}$	dB	70.0
$D_{1/3oct800}$	dB	63.5
$D_{1/3oct1000}$	dB	59.5
$D_{1/3oct1250}$	dB	59.5
$D_{1/3oct1600}$	dB	65.5
$D_{1/3oct2000}$	dB	66.0
$D_{1/30ct2500}$	dB	65.0
$D_{1/3oct3150}$	dB	63.5
$D_{1/3oct4000}$	dB	60.5
$D_{1/3oct5000}$	dB	59.0
$D_{1/3oct6300}$	dB	51.0
$D_{1/3oct8000}$	dB	49.0
$D_{1/3oct10000}$	dB	44.0



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

Ducted silencer: FVS 160-1000/600/300

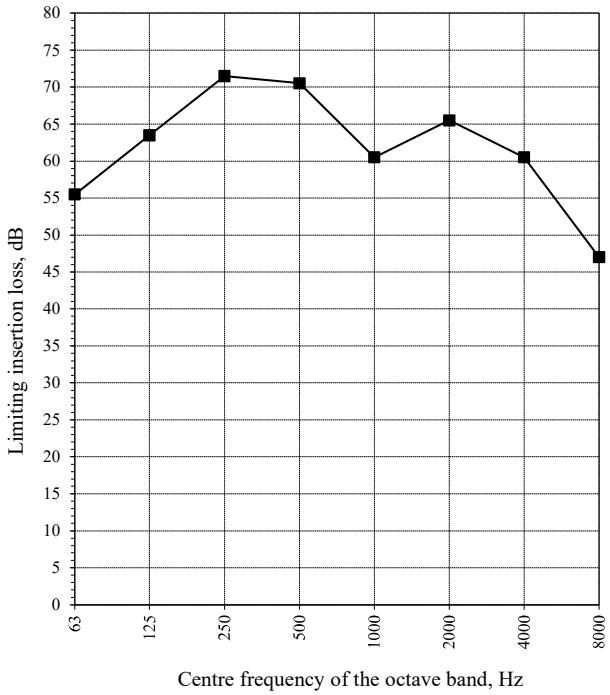
Limiting insertion loss of the test facility

ISO 7235:2003

Diameter of the inlet and outlet sections: 160 mm

Length: 14840 mm

Symbol	Unit	D
D_{oct63}	dB	56
D_{oct125}	dB	64
D_{oct250}	dB	72
D_{oct500}	dB	71
$D_{oct1000}$	dB	61
$D_{oct2000}$	dB	66
$D_{oct4000}$	dB	61
$D_{oct8000}$	dB	47



Symbols and units

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

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

Ducted silencer: FVS 160-1000

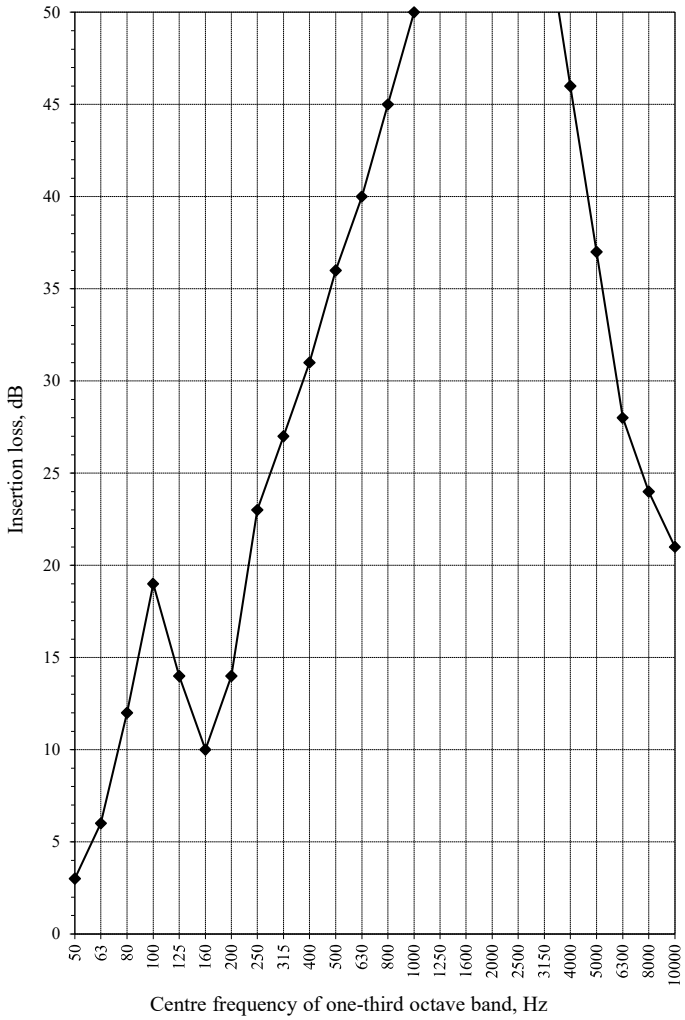
Insertion loss in one-third octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 160 mm

Length: 1000 mm

Symbol	Unit	Di
$D_{1/3oct50}$	dB	3
$D_{1/3oct63}$	dB	6
$D_{1/3oct80}$	dB	12
$D_{1/3oct100}$	dB	19
$D_{1/3oct125}$	dB	14
$D_{1/3oct160}$	dB	10
$D_{1/3oct200}$	dB	14
$D_{1/3oct250}$	dB	23
$D_{1/3oct315}$	dB	27
$D_{1/3oct400}$	dB	31
$D_{1/3oct500}$	dB	36
$D_{1/3oct630}$	dB	40
$D_{1/3oct800}$	dB	45
$D_{1/3oct1000}$	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	46
$D_{1/3oct5000}$	dB	37
$D_{1/3oct6300}$	dB	28
$D_{1/3oct8000}$	dB	24
$D_{1/3oct10000}$	dB	21



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 160-1000

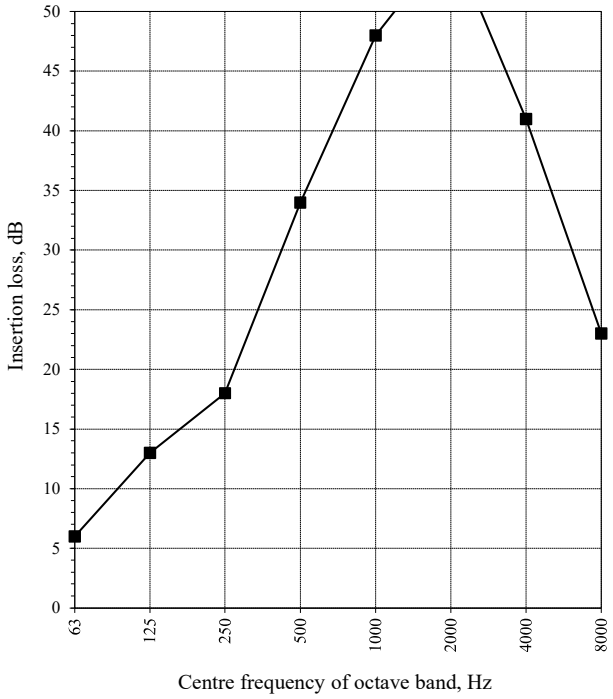
Insertion loss in octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 160 mm

Length: 1000 mm

Symbol	Unit	Di
D_{oct63}	dB	6
D_{oct125}	dB	13
D_{oct250}	dB	18
D_{oct500}	dB	34
$D_{oct1000}$	dB	48
$D_{oct2000}$	dB	>50
$D_{oct4000}$	dB	41
$D_{oct8000}$	dB	23



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 160-1000

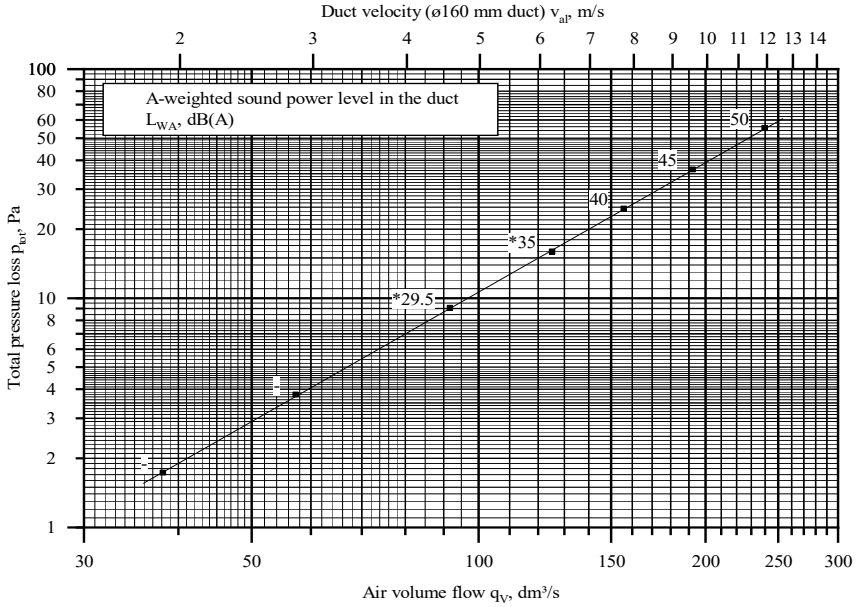
Pressure loss and flow noise in octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 160 mm

Length: 1000 mm

Air density 1,20 kg/m³



Symbol	Unit	1	2	3	4	5	6	7
q_V	dm³/s	38.2	57.2	91.7	125	156	193	240
v_{a1}	m/s	1.9	2.8	4.6	6.2	7.8	9.6	11.9
p_{tot}	Pa	1.7	3.8	9.0	16.0	24.6	36.4	55.2
ζ_{tot}	-	0.80	0.78	0.72	0.69	0.68	0.66	0.65
L_{W63}	dB	*	*	*37.1	43.5	47.7	50.5	54.7
L_{W125}	dB	*	*	36.1	41.6	46.3	51.2	55.6
L_{W250}	dB	*	*	31.5	37.8	41.8	46.1	50.9
L_{W500}	dB	*	*	25.3	33.2	38.2	42.5	46.9
L_{W1000}	dB	*	*	*17	26.3	32.5	37.8	42.9
L_{W2000}	dB	*	*	*14.5	*22.5	30.0	36.3	42.2
L_{W4000}	dB	*	*	*19.8	*20.5	*24.5	*31.2	38.4
L_{W8000}	dB	*	*	*26.4	*26.4	*26.4	*27	*30.1
L_W	dB	*	*	*40.6	46.7	51.0	55.0	59.4
L_{WA}	dB(A)	*	*	*29.6	*35	39.9	44.8	49.9

*) 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 (ø160 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 160-600

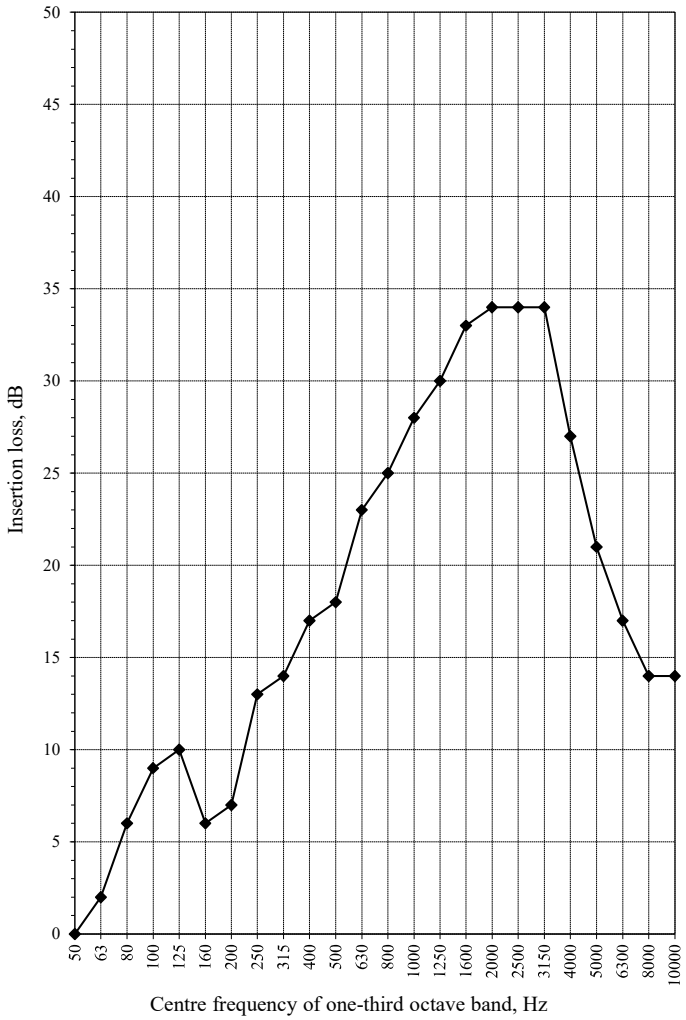
Insertion loss in one-third octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 160 mm

Length: 600 mm

Symbol	Unit	Di
$D_{1/3oct50}$	dB	0
$D_{1/3oct63}$	dB	2
$D_{1/3oct80}$	dB	6
$D_{1/3oct100}$	dB	9
$D_{1/3oct125}$	dB	10
$D_{1/3oct160}$	dB	6
$D_{1/3oct200}$	dB	7
$D_{1/3oct250}$	dB	13
$D_{1/3oct315}$	dB	14
$D_{1/3oct400}$	dB	17
$D_{1/3oct500}$	dB	18
$D_{1/3oct630}$	dB	23
$D_{1/3oct800}$	dB	25
$D_{1/3oct1000}$	dB	28
$D_{1/3oct1250}$	dB	30
$D_{1/3oct1600}$	dB	33
$D_{1/3oct2000}$	dB	34
$D_{1/3oct2500}$	dB	34
$D_{1/3oct3150}$	dB	34
$D_{1/3oct4000}$	dB	27
$D_{1/3oct5000}$	dB	21
$D_{1/3oct6300}$	dB	17
$D_{1/3oct8000}$	dB	14
$D_{1/3oct10000}$	dB	14



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 160-600

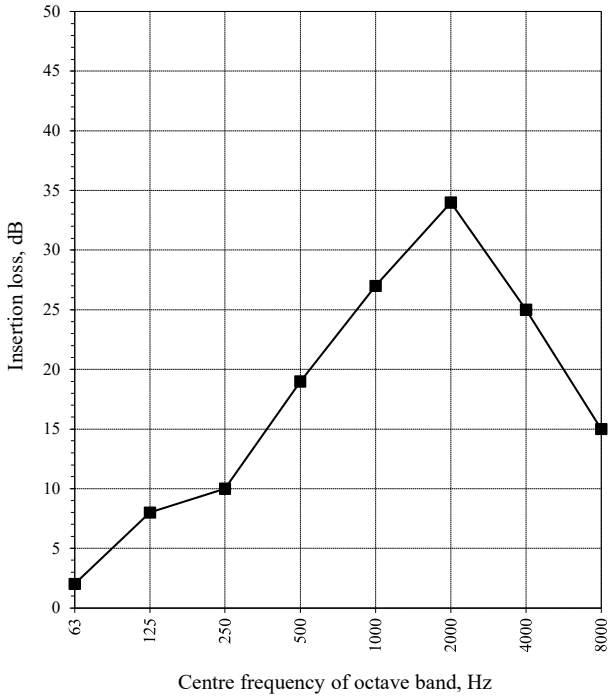
Insertion loss in octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 160 mm

Length: 600 mm

Symbol	Unit	Di
D_{oct63}	dB	2
D_{oct125}	dB	8
D_{oct250}	dB	10
D_{oct500}	dB	19
$D_{oct1000}$	dB	27
$D_{oct2000}$	dB	34
$D_{oct4000}$	dB	25
$D_{oct8000}$	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 160-600

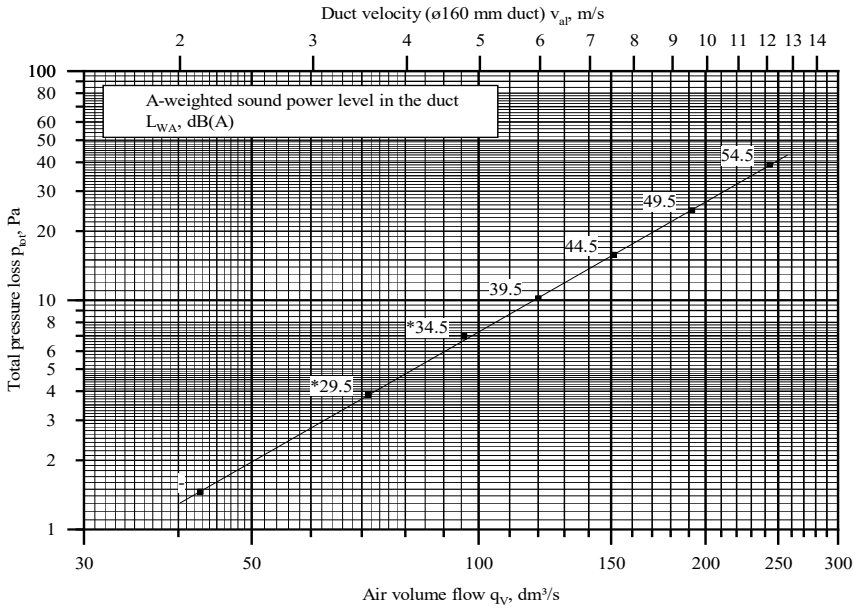
Pressure loss and flow noise in octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 160 mm

Length: 600 mm

Air density 1,20 kg/m³



Symbol	Unit	1	2	3	4	5	6	7
q_V	dm³/s	42.8	71.5	95.8	120	151	192	244
v_{a1}	m/s	2.1	3.6	4.8	6.0	7.5	9.6	12.1
p_{tot}	Pa	1.5	3.9	6.9	10.2	15.7	24.6	39.0
ζ_{tot}	-	0.53	0.51	0.51	0.48	0.46	0.45	0.44
L_{W63}	dB	*	*36.9	40.8	43.9	48.4	52.5	56.2
L_{W125}	dB	*	36.1	40.3	44.0	47.8	52.3	56.2
L_{W250}	dB	*	31.4	37.8	42.1	46.0	49.9	53.9
L_{W500}	dB	*	25.7	34.1	39.3	44.0	48.5	52.5
L_{W1000}	dB	*	*15.9	24.9	31.7	37.8	43.6	48.7
L_{W2000}	dB	*	*14.5	*18.1	*25.8	33.6	40.8	47.0
L_{W4000}	dB	*	*19.7	*20	*20.9	*25.5	33.5	41.5
L_{W8000}	dB	*	*26	*26.2	*26.2	*26.3	*26.7	*30.2
L_W	dB	*	*40.5	45.1	48.8	53.1	57.4	61.4
L_{WA}	dB(A)	*	*29.6	*34.7	39.5	44.5	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_{a1}	Duct velocity (ø160 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 160-300

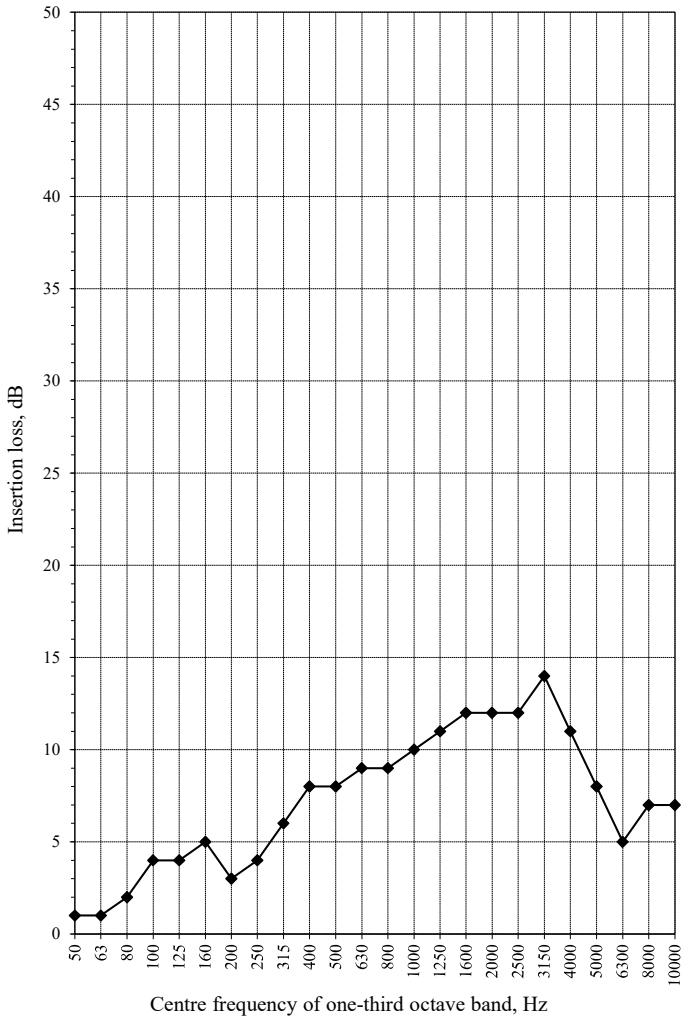
Insertion loss in one-third octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 160 mm

Length: 300 mm

Symbol	Unit	Di
$D_{1/3oct50}$	dB	1
$D_{1/3oct63}$	dB	1
$D_{1/3oct80}$	dB	2
$D_{1/3oct100}$	dB	4
$D_{1/3oct125}$	dB	4
$D_{1/3oct160}$	dB	5
$D_{1/3oct200}$	dB	3
$D_{1/3oct250}$	dB	4
$D_{1/3oct315}$	dB	6
$D_{1/3oct400}$	dB	8
$D_{1/3oct500}$	dB	8
$D_{1/3oct630}$	dB	9
$D_{1/3oct800}$	dB	9
$D_{1/3oct1000}$	dB	10
$D_{1/3oct1250}$	dB	11
$D_{1/3oct1600}$	dB	12
$D_{1/3oct2000}$	dB	12
$D_{1/3oct2500}$	dB	12
$D_{1/3oct3150}$	dB	14
$D_{1/3oct4000}$	dB	11
$D_{1/3oct5000}$	dB	8
$D_{1/3oct6300}$	dB	5
$D_{1/3oct8000}$	dB	7
$D_{1/3oct10000}$	dB	7



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 160-300

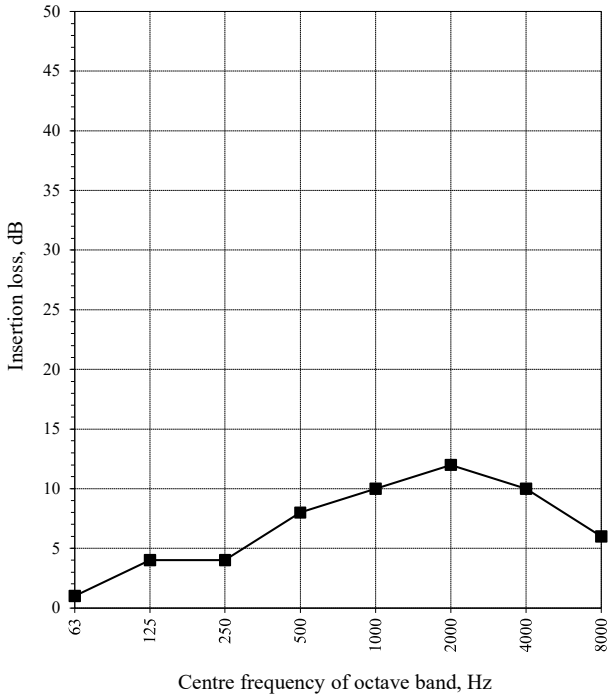
Insertion loss in octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 160 mm

Length: 300 mm

Symbol	Unit	Di
D_{oct63}	dB	1
D_{oct125}	dB	4
D_{oct250}	dB	4
D_{oct500}	dB	8
$D_{oct1000}$	dB	10
$D_{oct2000}$	dB	12
$D_{oct4000}$	dB	10
$D_{oct8000}$	dB	6



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 160-300

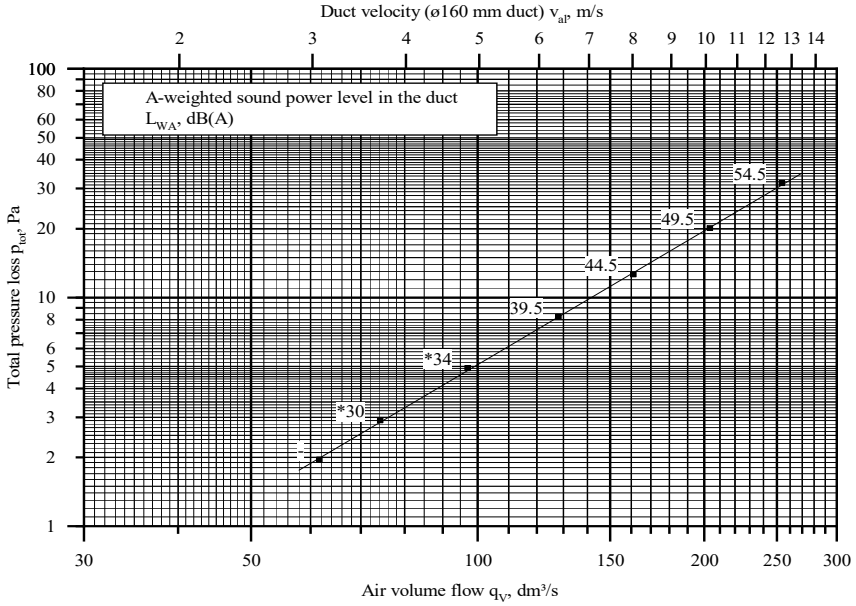
Pressure loss and flow noise in octave bands

ISO 7235:2003

Diameter of the inlet and outlet sections: 160 mm

Length: 300 mm

Air density 1,20 kg/m³



Symbol	Unit	1	2	3	4	5	6	7
q_V	dm³/s	61.7	74.4	97.1	128	161	204	254
v_{a1}	m/s	3.1	3.7	4.8	6.4	8.0	10.1	12.6
p_{tot}	Pa	2.0	2.9	4.9	8.2	12.6	20.1	31.6
ζ_{tot}	-	0.35	0.35	0.35	0.34	0.33	0.33	0.33
L_{W63}	dB	*	*34.8	39.8	45.7	48.4	52.5	57.0
L_{W125}	dB	*	34.2	38.2	43.4	48.1	52.5	56.8
L_{W250}	dB	*	31.2	36.0	40.7	44.8	48.8	53.2
L_{W500}	dB	*	27.7	33.9	39.6	43.8	47.8	51.6
L_{W1000}	dB	*	*15.8	24.7	32.9	38.5	43.8	48.5
L_{W2000}	dB	*	*13.6	*17.2	*27.4	35.3	42.3	47.7
L_{W4000}	dB	*	*19.9	*19.9	*21.2	*26.7	35.5	43.0
L_{W8000}	dB	*	*26.1	*26.1	*26.2	*26.3	*27.4	*31.6
L_W	dB	*	*39.1	43.7	49.2	53.0	57.3	61.7
L_{WA}	dB(A)	*	*29.8	*34.1	39.7	44.6	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 (ø160 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		