PEUTZ

Laboratory for Acoustics

TESTEN
RvA L 334

Determination of acoustical characteristics of flexible ducted silencers type SILENCERAFS.F PLUS, manufacturer AFS

Report number A 2692-9E-RA-001 d.d. December 16, 2014

Laboratory for Acoustics

Determination of acoustical characteristics of flexible ducted silencers type SILENCERAFS.F PLUS, manufacturer AFS

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1 Introduction

At the request of AFS Boru Sanayi A.S. based in Ankara (Turkey) sound measurements have been carried out in order to determine the acoustical characteristics of

flexible ducted silencers
type SILENCERAFS.F PLUS
manufacturer AFS Boru Sanayi A.S.

The measurements have been carried out in the Laboratory for Acoustics of Peutz bv, at Mook, The Netherlands (see figure 1).

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RvA L 334

For these type of measurements the Laboratory for Acoustics has been accredited by the Dutch Accreditation Council (RvA).

The RvA is member of the EA MLA (**EA MLA**: **E**uropean **A**ccreditation Organisation **M**ulti**L**ateral **A**greement: http://www.european-accreditation.org).

EA: "Certificates and reports issued by bodies accredited by MLA and MRA members are considered to have the same degree of credibility, and are accepted in MLA and MRA countries."

2 Norms and guidelines

The measurements have been carried out according to the Quality Manual of the Laboratory for Acoustics aswell as:

ISO 7235:2003	"Acoustics - Laboratory measurement procedures for ducted silencers and air-terminal units - Insertion loss, flow noise and total pressure loss"
N.A.	*The norm ISO 7235 is within all countries of the European Union accepted as European Standard Norm EN ISO 7235:2003*

Other related norms:

ISO 3741:2010[1]	Acoustics - Determination of sound power levels and sound energy levels of noise sources using sound pressure - Precision methods for reverberation test rooms
ISO 5135:1997	Acoustics - Determination of sound power levels of noise from air-terminal devices, air-terminal units, dampers and valves by measurement in a reverberation room
N.A.	*The norm ISO 5135 is within all countries of the European Union accepted as European Standard Norm EN ISO 5135:1997*

1 According to this norm, the report should include all measured sound pressure levels. Because these figures are not relevant for judging the quality of the product being tested, but merely for judging the accuracy of the calculations, they have been omitted in this report. It is possible of course to reproduce those figures at any time if the principal requests this.

3 Tested constructions

The data presented here have been received from the principal (as thickness foils) or obtained by own observations.

Measurements have been carried out on the following flexible ducted silencers:

SILENCERAFS.F PLUS Composition from inside to outside – micro perforated aluminium polyester laminated foil, thickness 74 µm, reinforced with metal wire – Barrier, thickness 12 µm – 25 mm glasswool – aluminium foil Diameter (inner duct) 160 / 203 / 254 mm Length 1,0 m	

The results as presented here relate only to the tested items and laboratory conditions as described in this report. The laboratory can make no judgement about the representativity of the tested samples. The test report ahead is valid as long as the tested constructions and/or materials are unchanged.

4 Measurements

4.1 Measurement setup

The measurements have been carried according to the reverberation room method as described in the norm ISO 7235.

4.2 Insertion Loss D_i

The specimens are mounted in an measuring duct as shown in figure 2.
Noise is introduced in the measuring duct using a loudspeaker system which is mounted at one and of this duct in ventilation room (6). The other end of the duct leads into the reverberation room (3). The sound pressure level in the reverberation room caused by the loudspeaker is measured in two situations:

- with the specimen to be tested installed in the measuring duct
- without the specimen. Instead of the specimen a substitution duct (dummy) with the same dimensions (length, diameter) is installed in the measuring duct

A microphone on a rotating boom is used in the reverberation room in order to measure the noise radiated from the measurement duct. The reverberation time of the room is also determined. From each set of measurements (sound pressure level and reverberation time) the sound power level L_W radiated into the reverberation room is calculated according to ISO 3741[1]. The insertion loss D_i is now calculated as

$$D_i = L_{wII} - L_{wI} \quad (1)$$

in which:

L_{WI} is the level of the sound power in the frequencyband considered, radiating into the connected reverberation room when the test object is installed;

L_{WII} is the level of the sound power in the frequencyband considered, radiating into the connected reverberation room when the substitution duct replaces the test object.

The insertion loss is determined in third octave bands from 50 Hz to 10 kHz.

4.3 Transmission Loss D_t

The specimens are mounted in an measuring duct as shown in figure 3. Noise is introduced in the measuring duct using a loudspeaker system which is mounted at one and of this duct in ventilation room (6). The test duct is installed crossing the reverberation room, both ends of the pipe penetrating through the walls of the room. The penetrations have been sealed adequately. The opposite end of the pipe is terminated by means of a closed anechoic termination in room (2).

1 For this type of measurements the Laboratory for Acoustics has been accredited by the Dutch Council for Accreditation (RvA) as a test laboratory, registration number L334.

The sound pressure level in the reverberation room caused by the loudspeaker is measured in two situations:

- with the specimen to be tested installed in the measuring duct in the reverberation room;
- without the specimen and a open test duct.

A microphone on a rotating boom is used in the reverberation room in order to measure the noise radiated from the measurement duct. The reverberation time of the room is also determined. From each set of measurements (sound pressure level and reverberation time) the sound power level L_W radiated into the reverberation room is calculated according to ISO 3741. The wall insulation D_t is now calculated as

$$D_t = L_{wII} - L_{wI} + D_{td} \qquad (2)$$

in which:

L_{WI} is the level of the sound power in the frequencyband considered, radiating into the connected reverberation room when the test object is installed;

L_{WII} is the level of the sound power in the frequencyband considered, radiating into the connected reverberation room with the open end of the test duct

D_{td} reflection coefficient at the open end of the duct

The transmission loss at the open end of a straight and rigid duct is calculated from

$$D_{td} = 10\ lg\left[1 + \frac{\Omega}{\left(\frac{4\pi f\sqrt{S}}{c}\right)^2}\right] \text{ dB} \qquad (3)$$

in which:

Ω = the solid angle of radiation at the duct (here: $\Omega = 4\pi$)

c = speed of sound in air (340 m/s)

f = frequency [Hz]

S = cross-sectional area of the duct opening in the measuring room [m^2]

The wall insulation is determined in third octave bands from 50 Hz to 10 kHz.

4.4 Results measurements

4.4.1 Insertion Loss

The results of the measurements are summarized in the tables 4.1 and 4.2 and presented in detail in the figures in Annex 1 of this report.

t4.1 *Insertion loss* ***SILENCERAFS.F PLUS***

INSERTION LOSS [dB]								
AFS nr.	**101**		**102**		**103**		**104**	
diameter	**160 mm**		**160 mm**		**203 mm**		**203 mm**	
length	**1,0 m**		**1,0 m**		**1,0 m**		**1,0 m**	
record nr.	**#960**		**#961**		**#347**		**#348**	
figure nr.	**1.1**		**1.2**		**1.3**		**1.4**	
frequency [Hz]	**1/3 oct.**	**1/1 oct.**	**1/3 oct.**	**1/1 oct.**	**1/3 oct.**	**1/1 oct.**	**1/3 oct.**	**1/1 oct.**
50	17,4		17,7		0,6		3,0	
63	11,7	9,6	12,1	9,7	10,7	4,7	10,8	6,7
80	6,2		6,2		11,7		12,3	
100	10,3		11,1		-2,5		-1,2	
125	5,3	8,3	6,4	9,4	6,2	0,8	7,8	2,2
160	12,9		13,9		3,3		4,8	
200	16,1		15,7		6,3		8,7	
250	19,2	18,8	19,2	18,4	7,2	8,1	10,6	10,9
315	25,1		23,4		14,0		16,4	
400	26,0		25,7		18,0		19,1	
500	28,0	27,0	29,9	27,5	22,3	20,8	22,1	21,1
630	27,2		27,9		25,3		23,4	
800	26,3		26,4		24,0		23,3	
1000	28,3	28,0	27,9	27,9	24,2	23,9	24,3	23,6
1250	30,1		30,3		23,6		23,4	
1600	22,9		22,7		18,2		17,8	
2000	19,3	19,9	18,4	18,9	15,2	15,6	14,2	14,6
2500	18,5		17,2		14,2		13,0	
3150	15,3		14,9		11,5		11,0	
4000	11,0	12,2	10,6	11,7	9,3	9,8	8,2	8,8
5000	11,4		10,7		8,9		7,9	
6300	13,9		12,5		11,0		9,4	
8000	13,7	13,3	12,5	12,1	11,8	10,9	9,1	9,2
10000	12,4		11,5		10,0		9,1	

t4.2 Insertion loss ***SILENCERAFS.F PLUS***

	INSERTION LOSS [dB]			
AFS nr.	**105**		**106**	
diameter	**254 mm**		**254 mm**	
length	**1,0 m**		**1,0 m**	
record nr.	**#970**		**#971**	
figure nr.	**1.5**		**1.6**	
frequency [Hz]	**1/3 oct.**	**1/1 oct.**	**1/3 oct.**	**1/1 oct.**
50	9,6		9,3	
63	2,7	3,2	1,4	2,4
80	1,1		0,5	
100	11,0		12,1	
125	7,9	8,8	9,0	10,1
160	8,2		9,7	
200	11,9		14,2	
250	16,0	14,5	18,0	16,5
315	17,5		18,6	
400	18,6		19,4	
500	18,8	18,0	19,3	18,6
630	16,8		17,4	
800	16,3		17,1	
1000	15,8	15,4	17,0	16,6
1250	14,4		15,7	
1600	11,0		11,9	
2000	10,0	10,0	10,6	10,7
2500	9,2		9,9	
3150	8,5		9,0	
4000	5,8	6,9	6,4	7,6
5000	6,7		7,7	
6300	6,9		8,0	
8000	7,8	7,4	8,8	8,4
10000	7,6		8,4	

4.4.2 Transmission Loss

The results of the measurements are summarized in the tables 4.26 up to and including 4.50 and presented in detail in the figures in Annex 2 of this report.

*t4.3 Transmission loss **SILENCERAFS.F PLUS***

TRANSMISSION LOSS [dB]								
AFS nr.	**101**		**102**		**103**		**104**	
diameter	**160 mm**		**160 mm**		**203 mm**		**203 mm**	
length	**1,0 m**		**1,0 m**		**1,0 m**		**1,0 m**	
record nr.	**#1064**		**#1065**		**#506**		**#507**	
figure nr.	**2.1**		**2.2**		**2.3**		**2.4**	
frequency [Hz]	**1/3 oct.**	**1/1 oct.**	**1/3 oct.**	**1/1 oct.**	**1/3 oct.**	**1/1 oct.**	**1/3 oct.**	**1/1 oct.**
50	28,8		29,2		29,2		29,1	
63	25,8	25,6	26,1	25,4	28,0	27,5	26,0	26,1
80	23,6		23,1		25,9		24,5	
100	22,4		21,9		26,8		25,7	
125	23,9	21,7	23,6	20,8	18,3	21,0	17,2	19,4
160	19,9		18,5		21,6		18,9	
200	20,0		18,9		18,7		16,6	
250	19,3	18,3	18,0	17,4	18,7	17,5	17,2	15,8
315	16,5		15,9		15,8		14,2	
400	15,3		15,2		15,0		14,1	
500	16,2	15,0	16,3	14,7	13,2	13,5	12,3	12,7
630	13,9		13,1		12,6		12,1	
800	12,1		10,9		12,3		12,0	
1000	12,8	12,3	11,6	11,4	12,2	12,2	12,2	12,1
1250	12,1		11,6		12,0		12,1	
1600	13,6		13,1		13,1		13,4	
2000	15,5	14,9	15,2	14,6	14,0	13,5	14,4	13,9
2500	16,0		16,1		13,5		14,1	
3150	16,4		16,7		14,7		14,9	
4000	17,7	17,6	17,8	17,8	16,6	16,4	16,6	16,5
5000	19,3		19,3		19,1		18,8	
6300	21,5		21,6		20,5		19,7	
8000	21,7	20,7	22,4	20,9	22,1	22,0	21,4	21,3
10000	19,3		19,4		24,3		23,9	

t4.4 Transmission loss ***SILENCERAFS.F PLUS***

	TRANSMISSION LOSS [dB]			
AFS nr.	**105**		**106**	
diameter	**254 mm**		**254 mm**	
length	**1,0 m**		**1,0 m**	
record nr.	**#1077**		**#1078**	
figure nr.	**2.5**		**2.6**	
frequency [Hz]	**1/3 oct.**	**1/1 oct.**	**1/3 oct.**	**1/1 oct.**
50	28,1		27,4	
63	24,5	21,9	25,5	22,9
80	18,5		19,7	
100	24,2		24,6	
125	17,0	18,4	17,3	18,2
160	17,1		16,4	
200	15,4		15,8	
250	15,0	13,6	15,7	14,7
315	11,6		13,2	
400	11,5		13,1	
500	10,8	10,6	12,4	12,4
630	9,8		11,7	
800	9,3		11,1	
1000	9,5	9,6	10,8	11,1
1250	10,0		11,4	
1600	11,5		12,5	
2000	12,5	12,5	13,4	13,5
2500	13,7		14,9	
3150	15,0		15,8	
4000	17,5	16,9	18,0	17,5
5000	19,3		19,7	
6300	18,8		19,4	
8000	21,7	20,7	22,4	21,3
10000	22,4		22,9	

The results as presented here relate only to the tested items and laboratory conditions as described in this report. The laboratory can make no judgement about the representativity of the tested samples. The test report ahead is valid as long as the tested constructions and/or materials are unchanged.

Mook,

Th. Scheers
Laboratory Supervisor

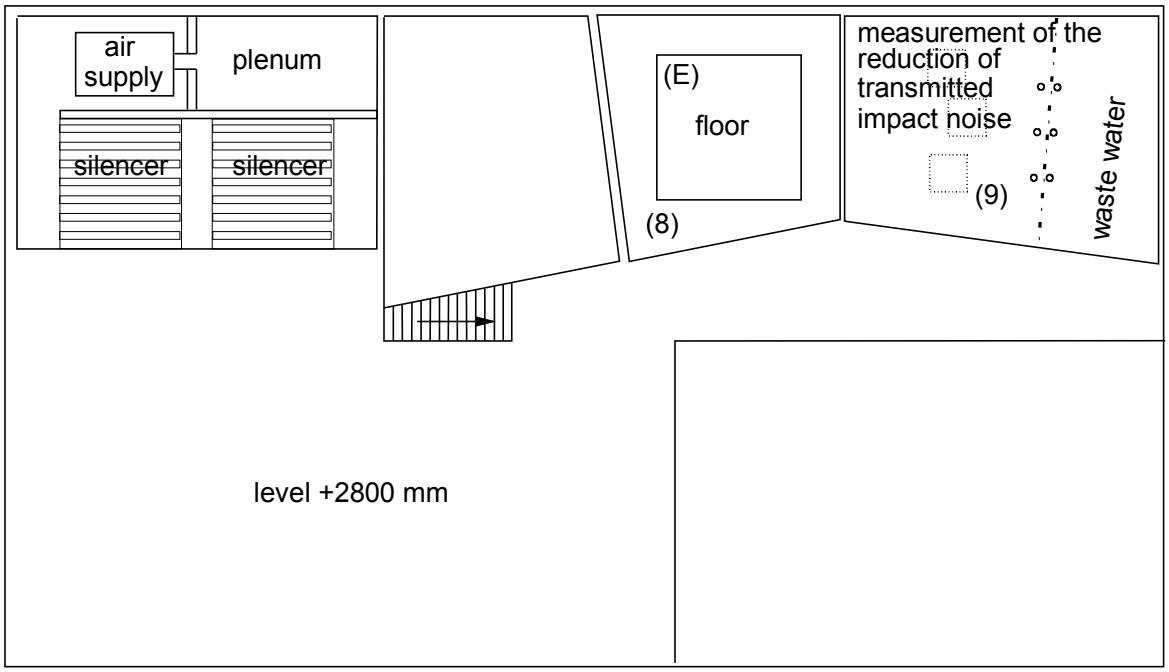
ir. G.M.A. Perquin
Manager

This report contains 13 pages, 3 figures and 2 annexes.

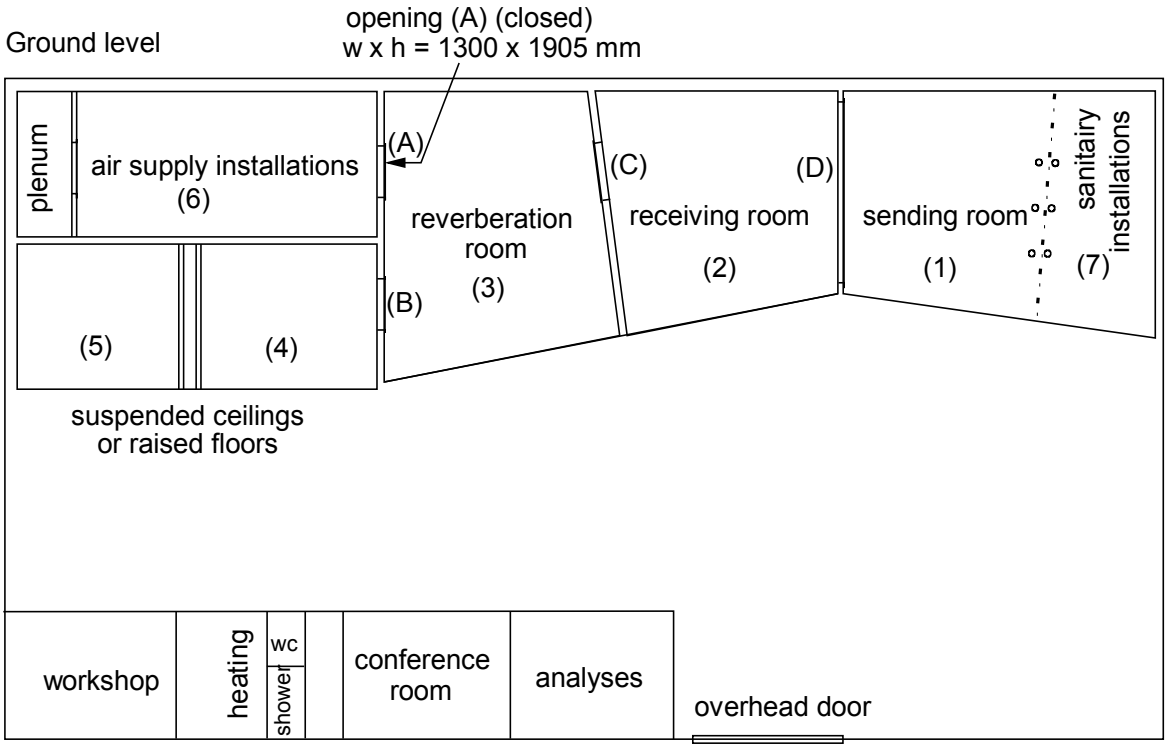
PEUTZ bv
Lindenlaan 41, NL-6584 AC MOLENHOEK (LB), THE NETHERLANDS

OVERVIEW

Story

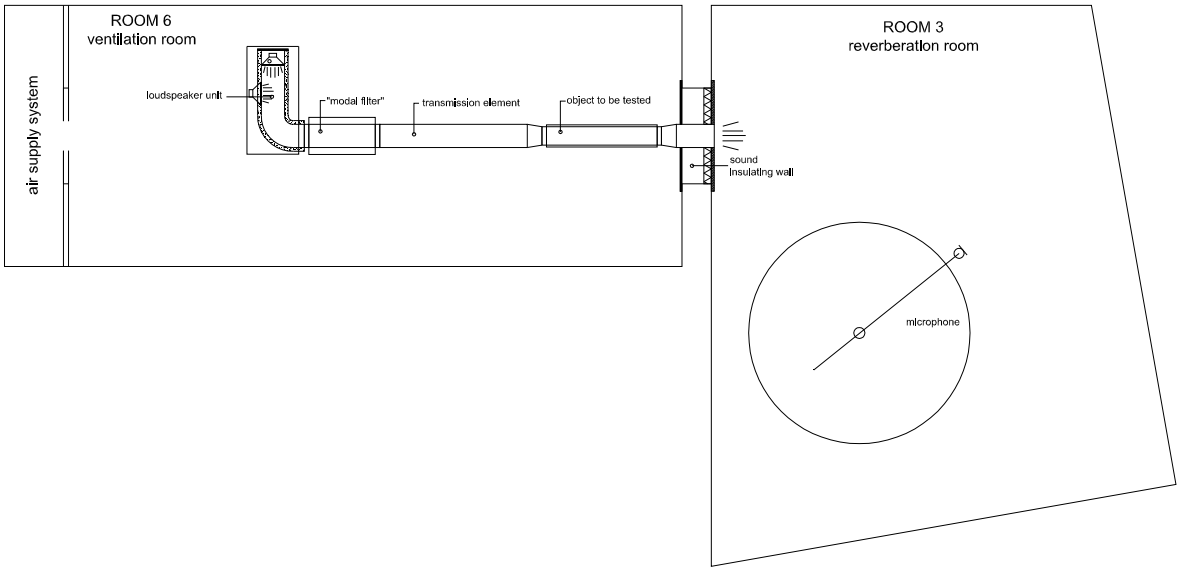


Ground level



TEST OPENINGS (w x h in mm)
(B) 1000 x 2200
(C) 1500 x 1250
(D) 4300 x 2800
(E) 4000 x 4000

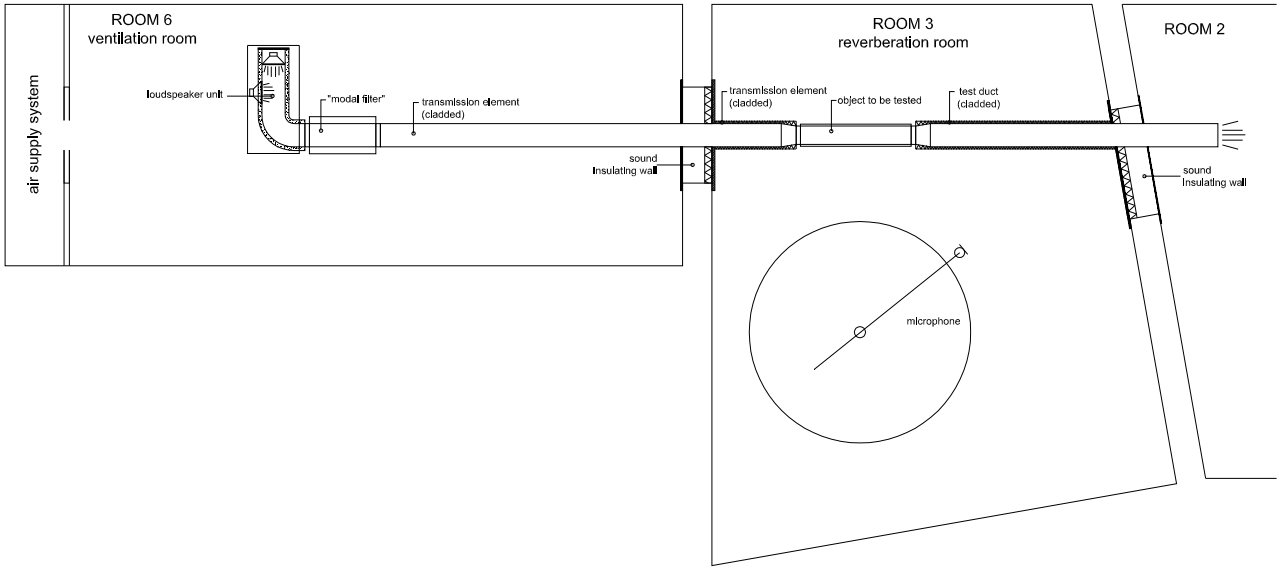
0 1 2 3 4 5 m
scale



Without silencer; L_{wII}

With silencer; L_{wI}

Measurement set-up insertion loss



Open end; L_{wII}

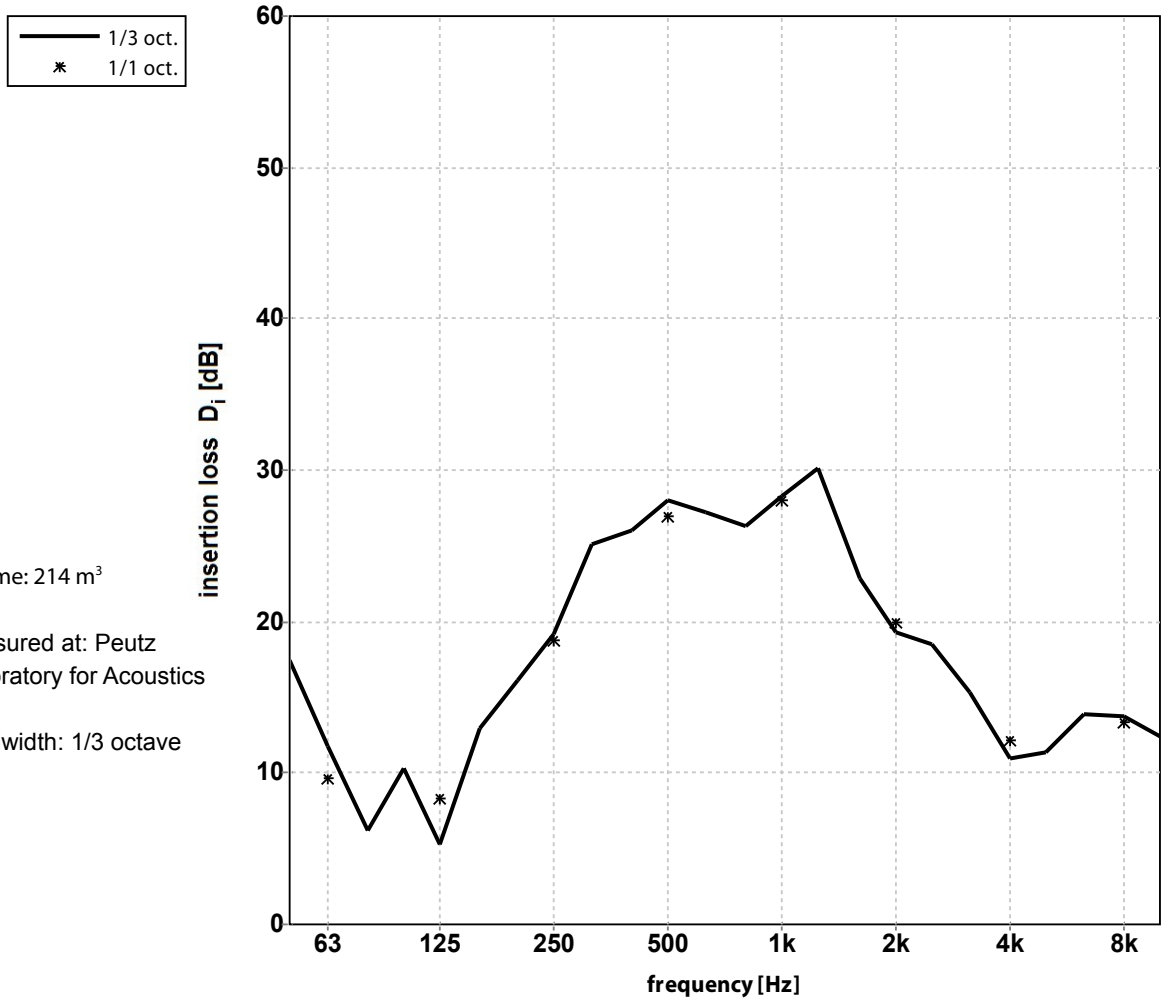
With silencer; L_{wII}

Measurement set-up transmission loss

INSERTION LOSS ACCORDING TO ISO 7235:2003

principal: AFS Boru Sanayi A.S.

construction tested: #101; SILENCERAFS.F PLUS
diameter 160 mm
length 1,0 m



volume: 214 m³

measured at: Peutz
Laboratory for Acoustics

bandwidth: 1/3 octave

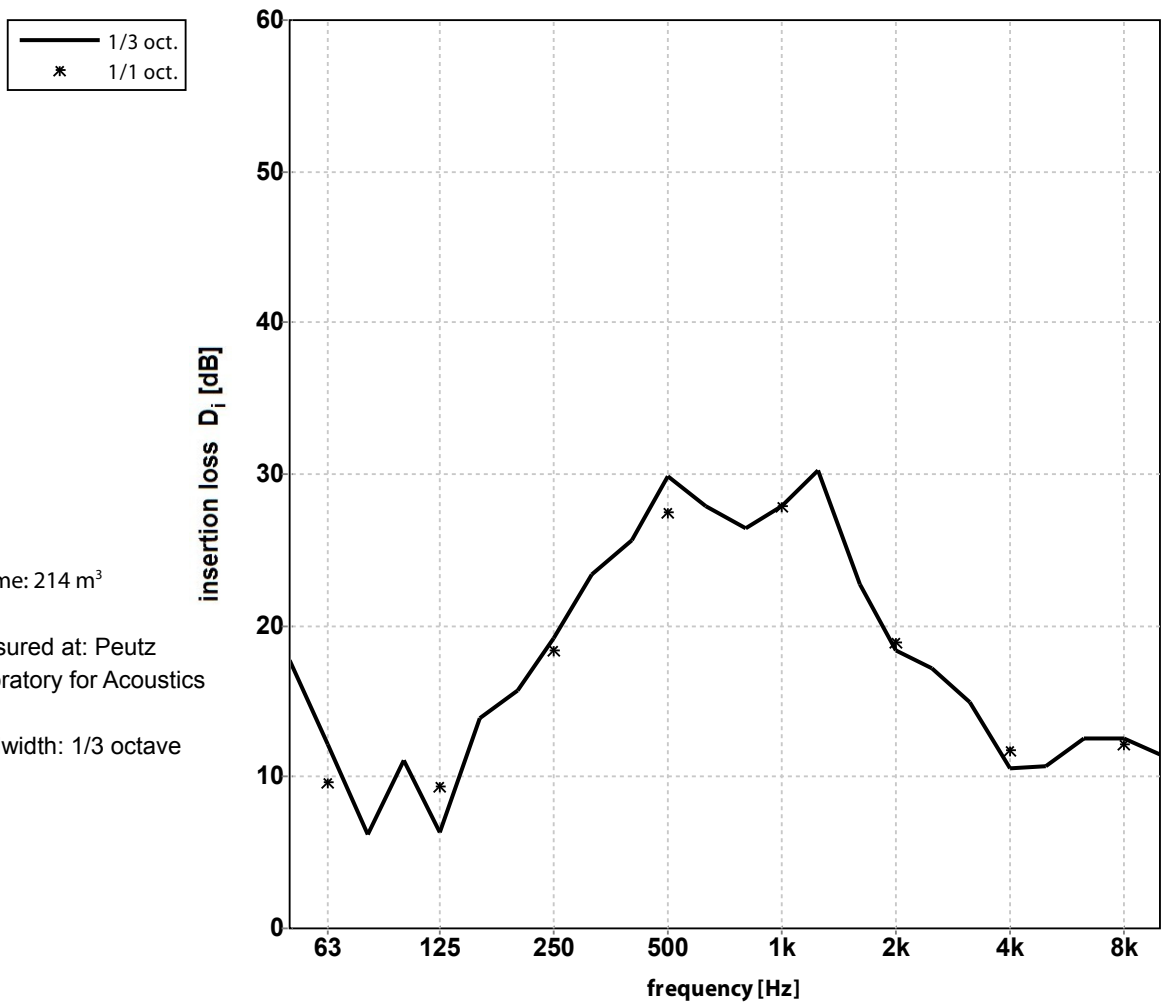
	17,4	10,3	16,1	26,0	26,3	22,9	15,3	13,9	
1/3 oct.	11,7	5,3	19,2	28,0	28,3	19,3	11,0	13,7	dB
	6,2	12,9	25,1	27,2	30,1	18,5	11,4	12,4	
1/1 oct.	**9,6**	**8,3**	**18,8**	**27,0**	**28,0**	**19,9**	**12,2**	**13,3**	**dB**

Mook, 27-08-2014

INSERTION LOSS ACCORDING TO ISO 7235:2003

principal: AFS Boru Sanayi A.S.

construction tested: #102; SILENCERAFS.F PLUS
diameter 160 mm
length 1,0 m



volume: 214 m³

measured at: Peutz
Laboratory for Acoustics

bandwidth: 1/3 octave

	17,7	11,1	15,7	25,7	26,4	22,7	14,9	12,5	
1/3 oct.	12,1	6,4	19,2	29,9	27,9	18,4	10,6	12,5	dB
	6,2	13,9	23,4	27,9	30,3	17,2	10,7	11,5	
1/1 oct.	**9,7**	**9,4**	**18,4**	**27,5**	**27,9**	**18,9**	**11,7**	**12,1**	**dB**

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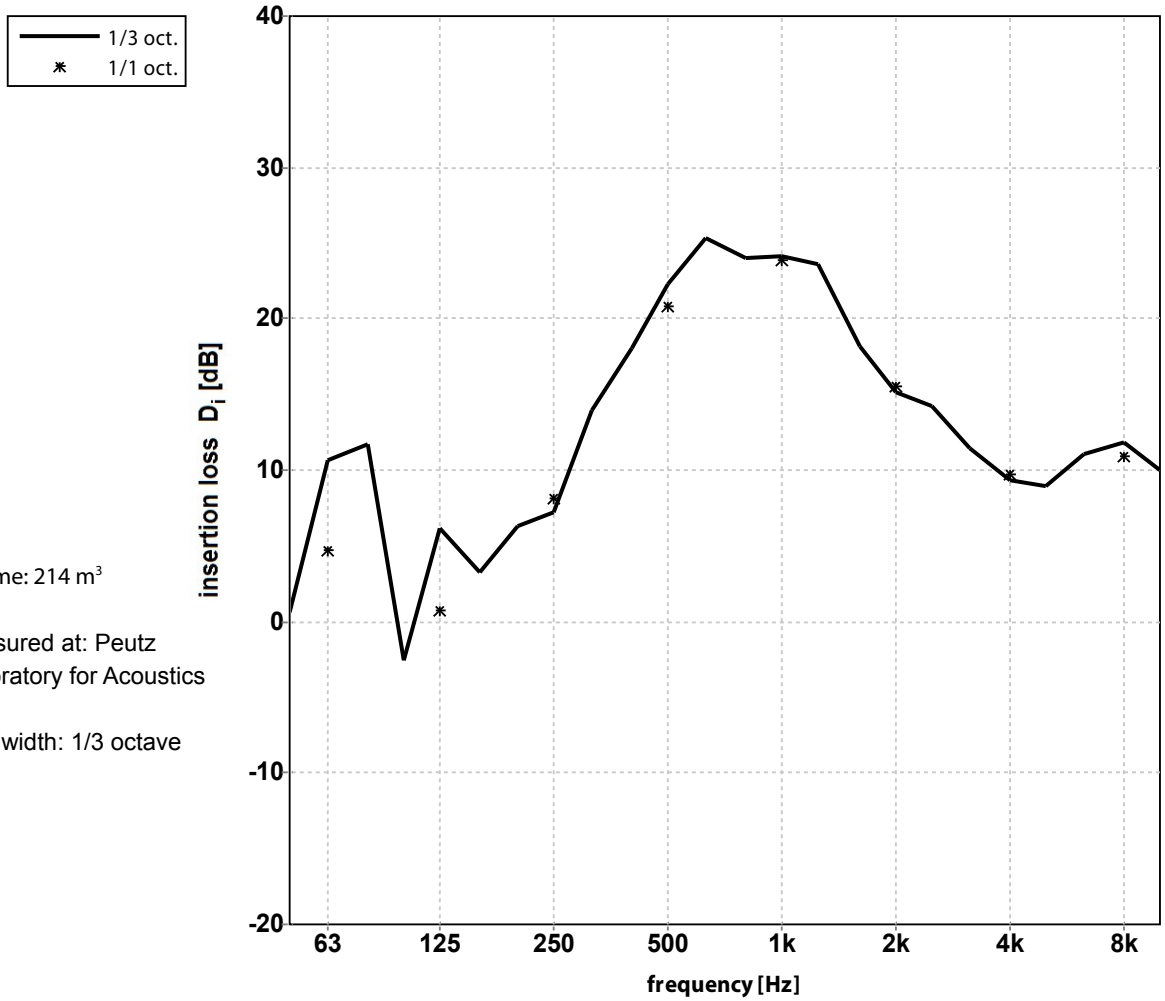
INSERTION LOSS ACCORDING TO ISO 7235:2003

principal: AFS Boru Sanayi A.S.

construction tested: #103; SILENCERAFS.F PLUS
diameter 203 mm
length 1,0 m



volume: 214 m³

measured at: Peutz
Laboratory for Acoustics

bandwidth: 1/3 octave

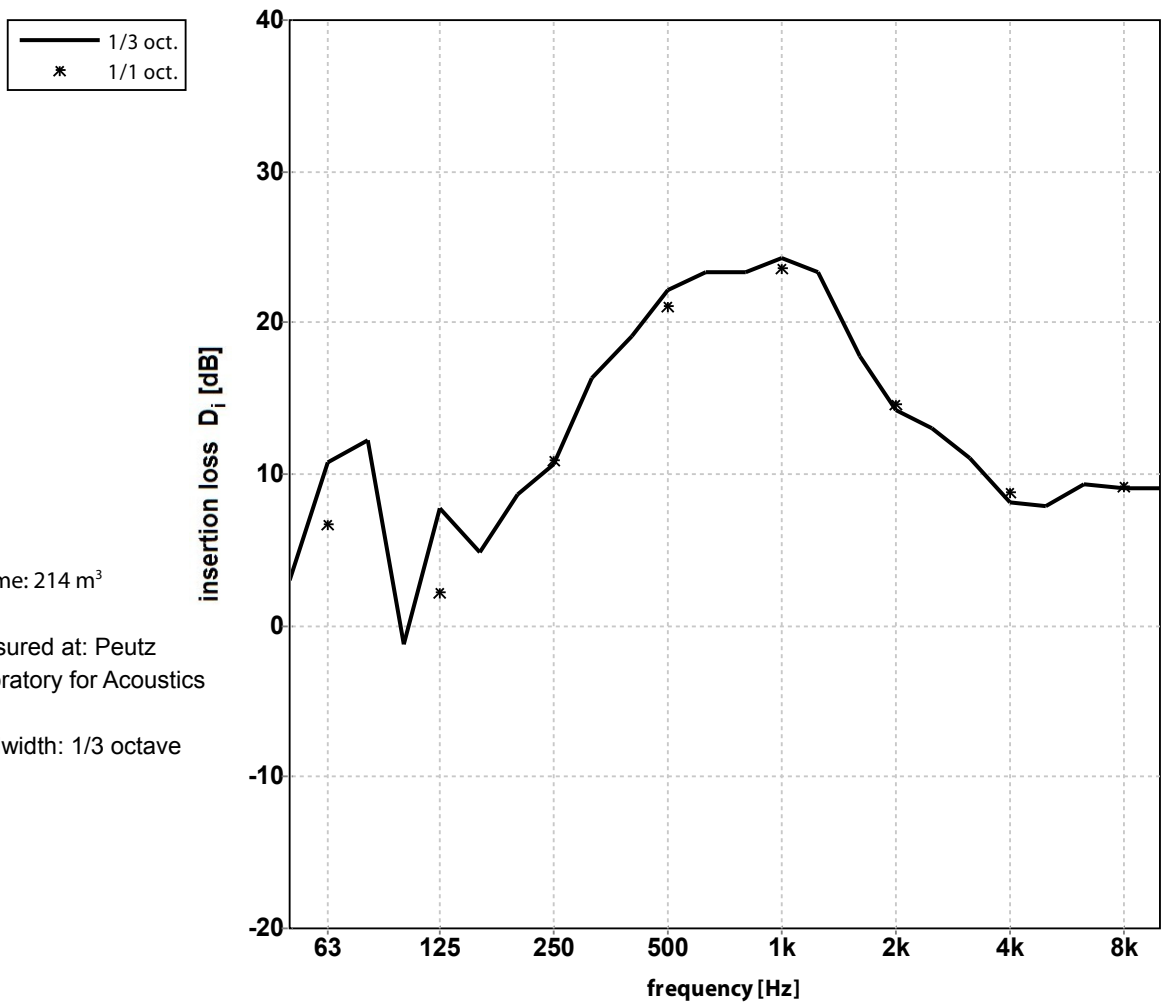
	0,6	-2,5	6,3	18,0	24,0	18,2	11,5	11,0	
1/3 oct.	10,7	6,2	7,2	22,3	24,2	15,2	9,3	11,8	dB
	11,7	3,3	14,0	25,3	23,6	14,2	8,9	10,0	
1/1 oct.	**4,7**	**0,8**	**8,1**	**20,8**	**23,9**	**15,6**	**9,8**	**10,9**	**dB**

Mook, 25-04-2014

INSERTION LOSS ACCORDING TO ISO 7235:2003

principal: AFS Boru Sanayi A.S.

construction tested: #104; SILENCERAFS.F PLUS
diameter 203 mm
length 1,0 m



volume: 214 m³

measured at: Peutz Laboratory for Acoustics

bandwidth: 1/3 octave

	3,0	-1,2	8,7	19,1	23,3	17,8	11,0	9,4	
1/3 oct.	10,8	7,8	10,6	22,1	24,3	14,2	8,2	9,1	dB
	12,3	4,8	16,4	23,4	23,4	13,0	7,9	9,1	
1/1 oct.	**6,7**	**2,2**	**10,9**	**21,1**	**23,6**	**14,6**	**8,8**	**9,2**	**dB**

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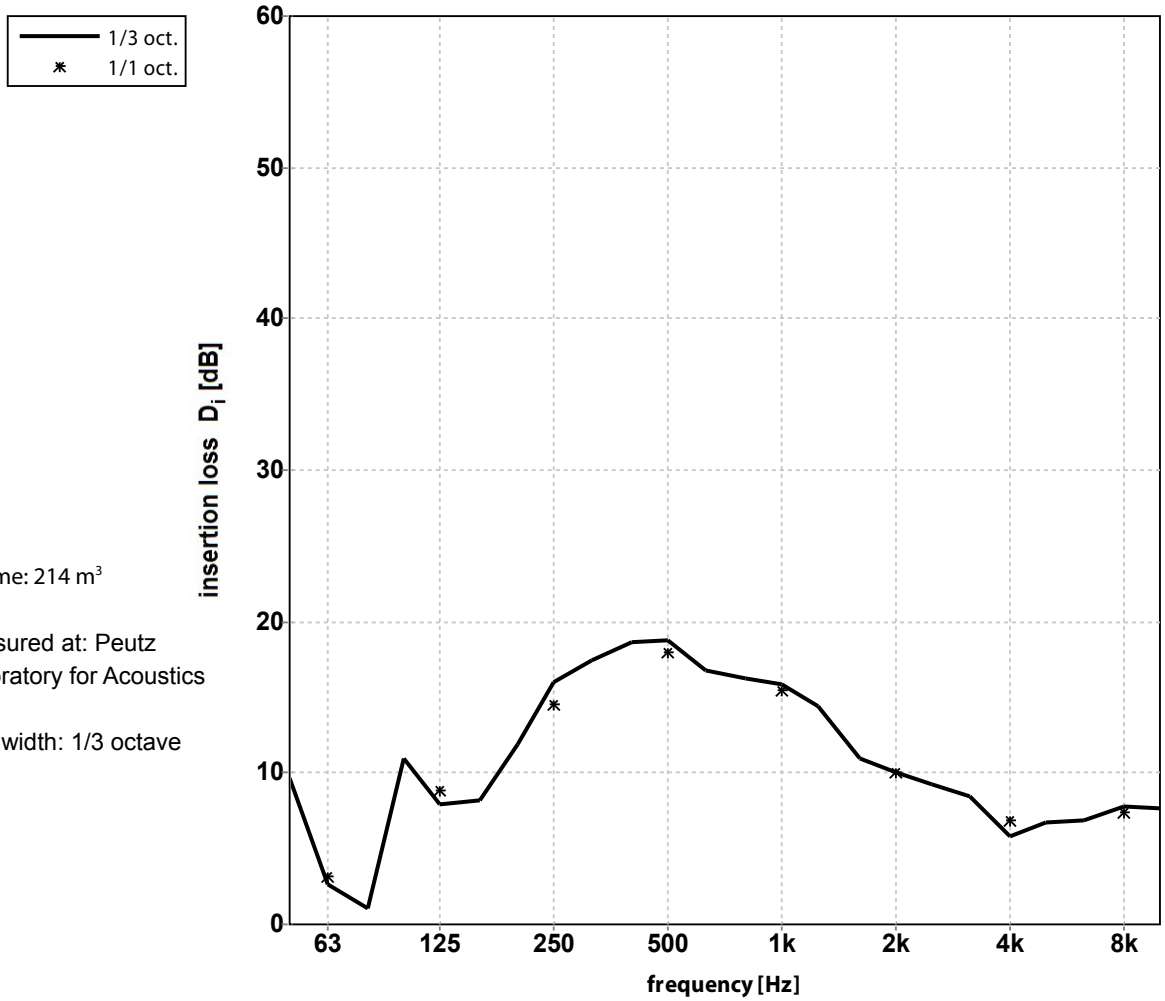
INSERTION LOSS ACCORDING TO ISO 7235:2003

principal: AFS Boru Sanayi A.S.

construction tested: #105; SILENCERAFS.F PLUS
diameter 254 mm
length 1,0 m



volume: 214 m³

measured at: Peutz
Laboratory for Acoustics

bandwidth: 1/3 octave

	9,6	11,0	11,9	18,6	16,3	11,0	8,5	6,9	
1/3 oct.	2,7	7,9	16,0	18,8	15,8	10,0	5,8	7,8	dB
	1,1	8,2	17,5	16,8	14,4	9,2	6,7	7,6	
1/1 oct.	**3,2**	**8,8**	**14,5**	**18,0**	**15,4**	**10,0**	**6,9**	**7,4**	**dB**

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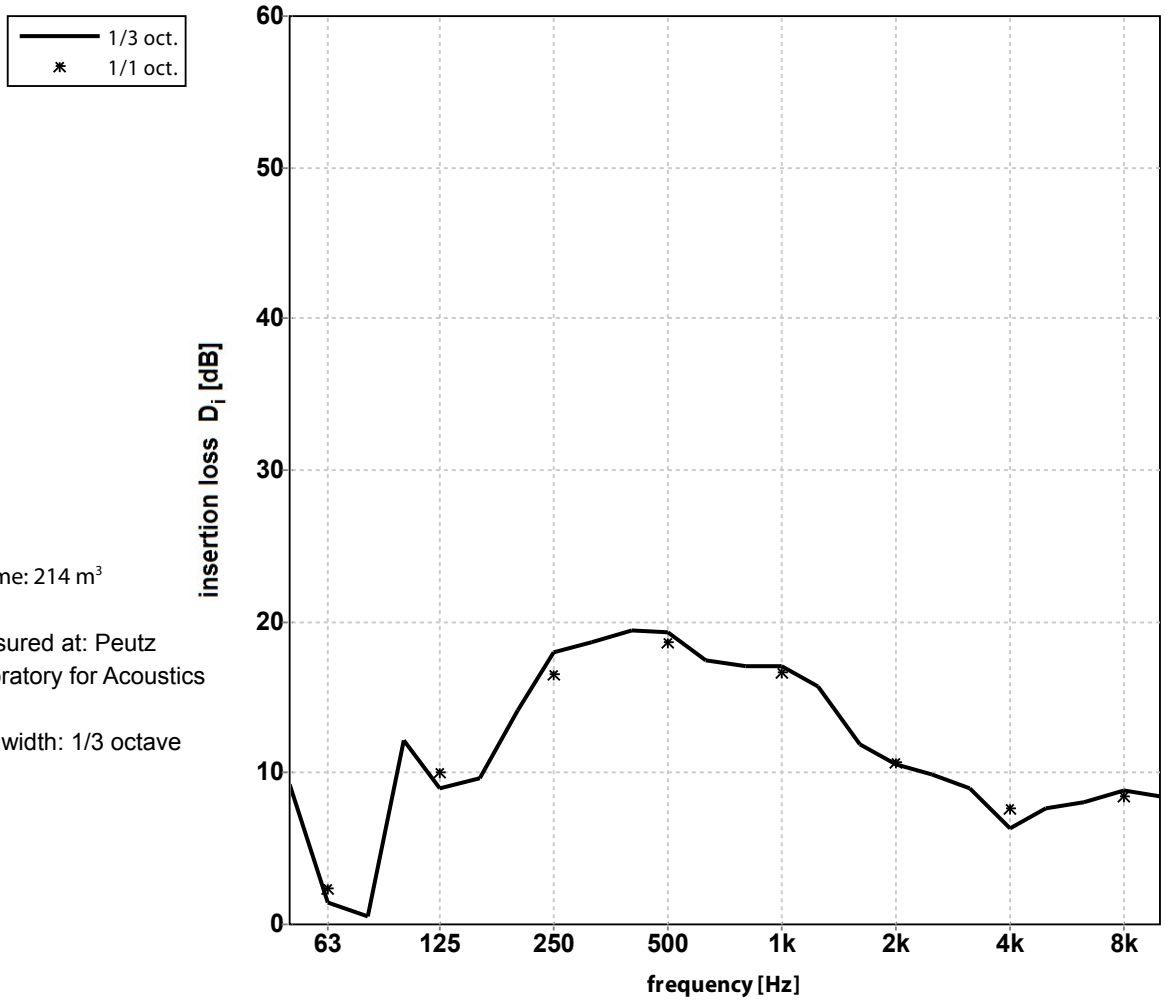
Mook, 27-08-2014

INSERTION LOSS ACCORDING TO ISO 7235:2003

principal: AFS Boru Sanayi A.S.

construction tested: #106; SILENCERAFS.F PLUS
diameter 254 mm
length 1,0 m



volume: 214 m³

measured at: Peutz
Laboratory for Acoustics

bandwidth: 1/3 octave

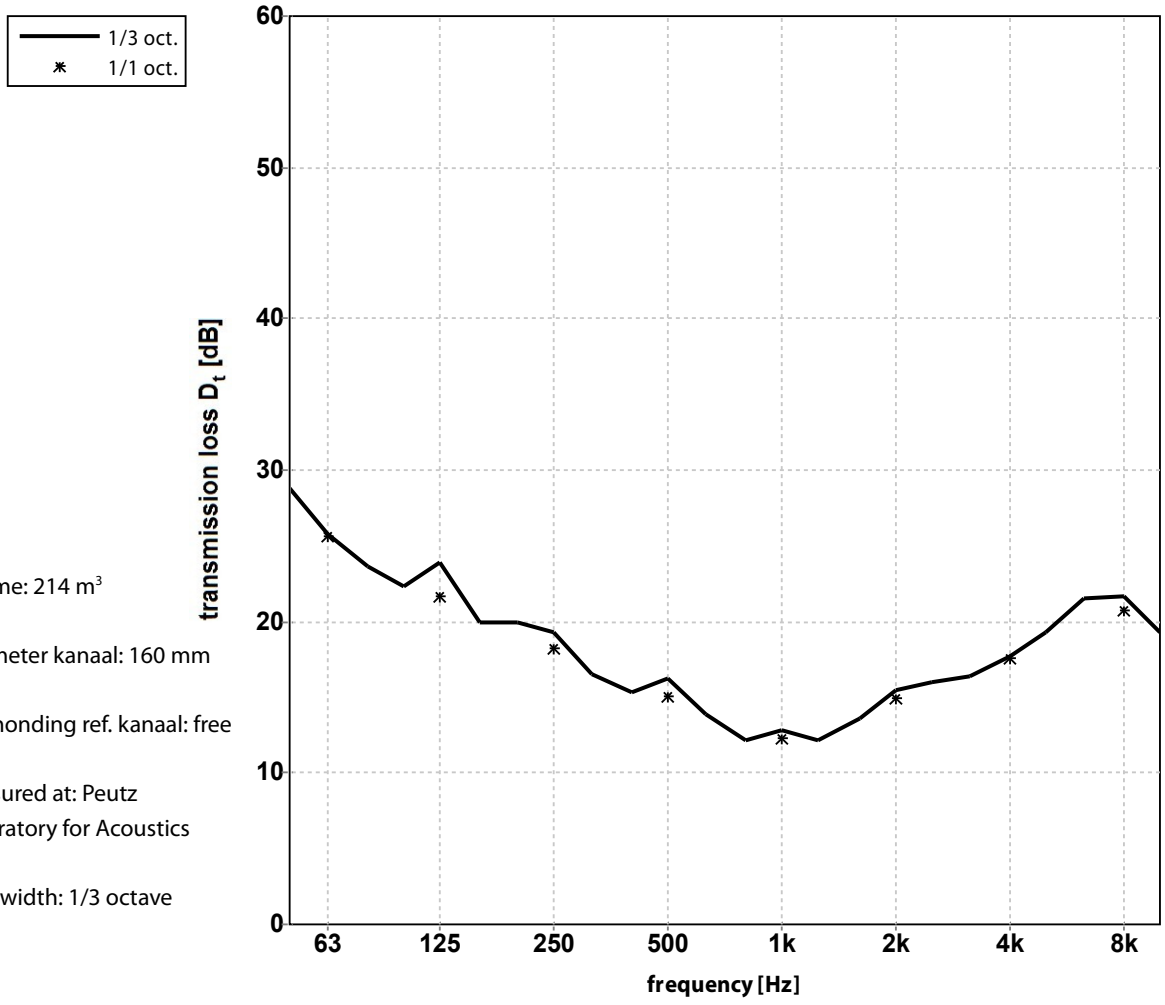
	9,3	12,1	14,2	19,4	17,1	11,9	9,0	8,0	
1/3 oct.	1,4	9,0	18,0	19,3	17,0	10,6	6,4	8,8	dB
	0,5	9,7	18,6	17,4	15,7	9,9	7,7	8,4	
1/1 oct.	**2,4**	**10,1**	**16,5**	**18,6**	**16,6**	**10,7**	**7,6**	**8,4**	**dB**

Mook, 27-08-2014

TRANSMISSION LOSS ACCORDING TO ISO 7235:2003

principal: AFS Boru Sanayi A.S.

construction tested: #101; SILENCERAFS.F PLUS
diameter 160 mm
length 1,0 m



volume: 214 m³

*diameter kanaal: 160 mm

*uitmonding ref. kanaal: free

measured at: Peutz
Laboratory for Acoustics

bandwidth: 1/3 octave

	28,8	22,4	20,0	15,3	12,1	13,6	16,4	21,5	
1/3 oct.	25,8	23,9	19,3	16,2	12,8	15,5	17,7	21,7	dB
	23,6	19,9	16,5	13,9	12,1	16,0	19,3	19,3	
1/1 oct.	**25,6**	**21,7**	**18,3**	**15,0**	**12,3**	**14,9**	**17,6**	**20,7**	**dB**

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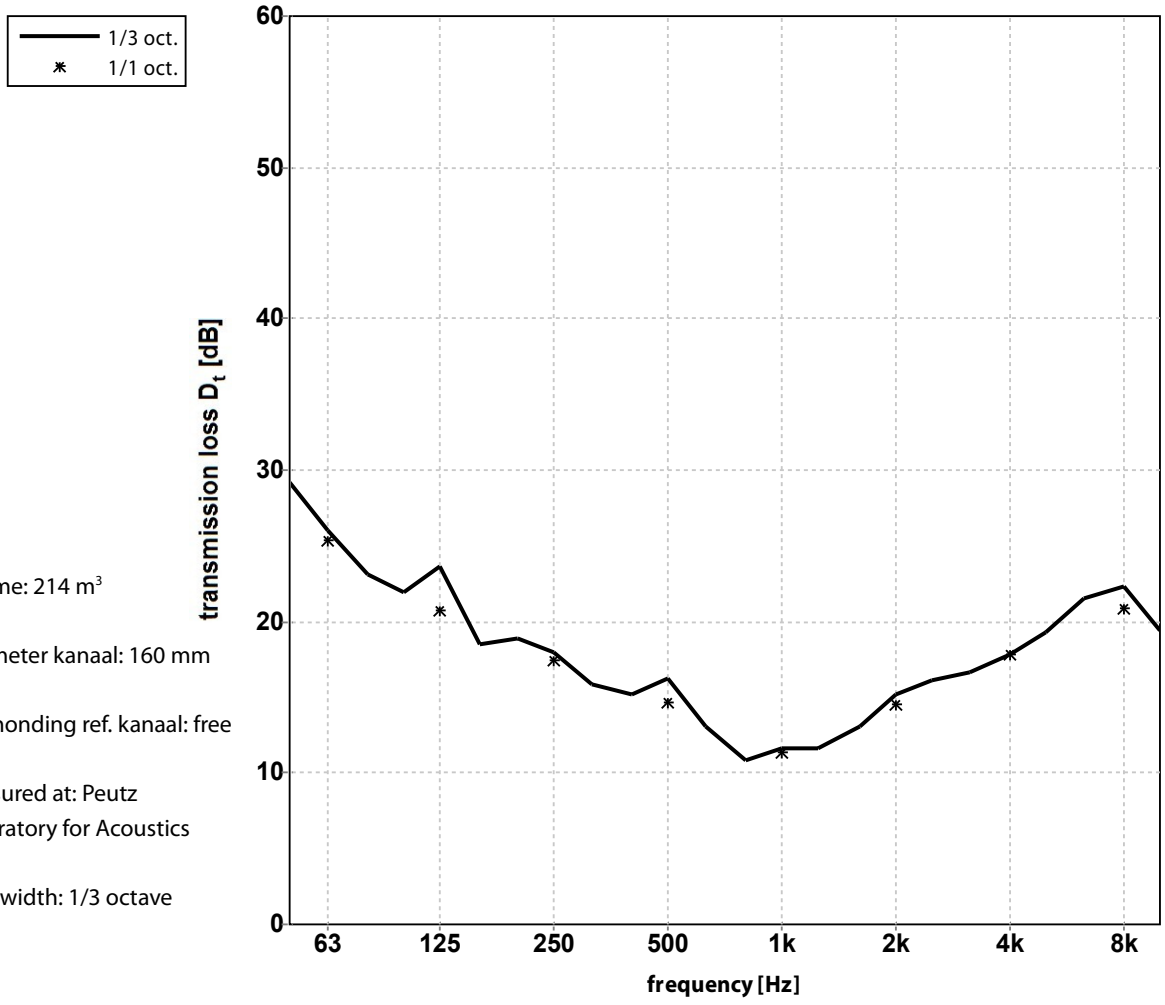
Mook, 11-09-2014

TRANSMISSION LOSS ACCORDING TO ISO 7235:2003

principal: AFS Boru Sanayi A.S.

construction tested: #102; SILENCERAFS.F PLUS
diameter 160 mm
length 1,0 m



volume: 214 m³

*diameter kanaal: 160 mm

*uitmonding ref. kanaal: free

measured at: Peutz
Laboratory for Acoustics

bandwidth: 1/3 octave

	29,2	21,9	18,9	15,2	10,9	13,1	16,7	21,6	
1/3 oct.	26,1	23,6	18,0	16,3	11,6	15,2	17,8	22,4	dB
	23,1	18,5	15,9	13,1	11,6	16,1	19,3	19,4	
1/1 oct.	**25,4**	**20,8**	**17,4**	**14,7**	**11,4**	**14,6**	**17,8**	**20,9**	**dB**

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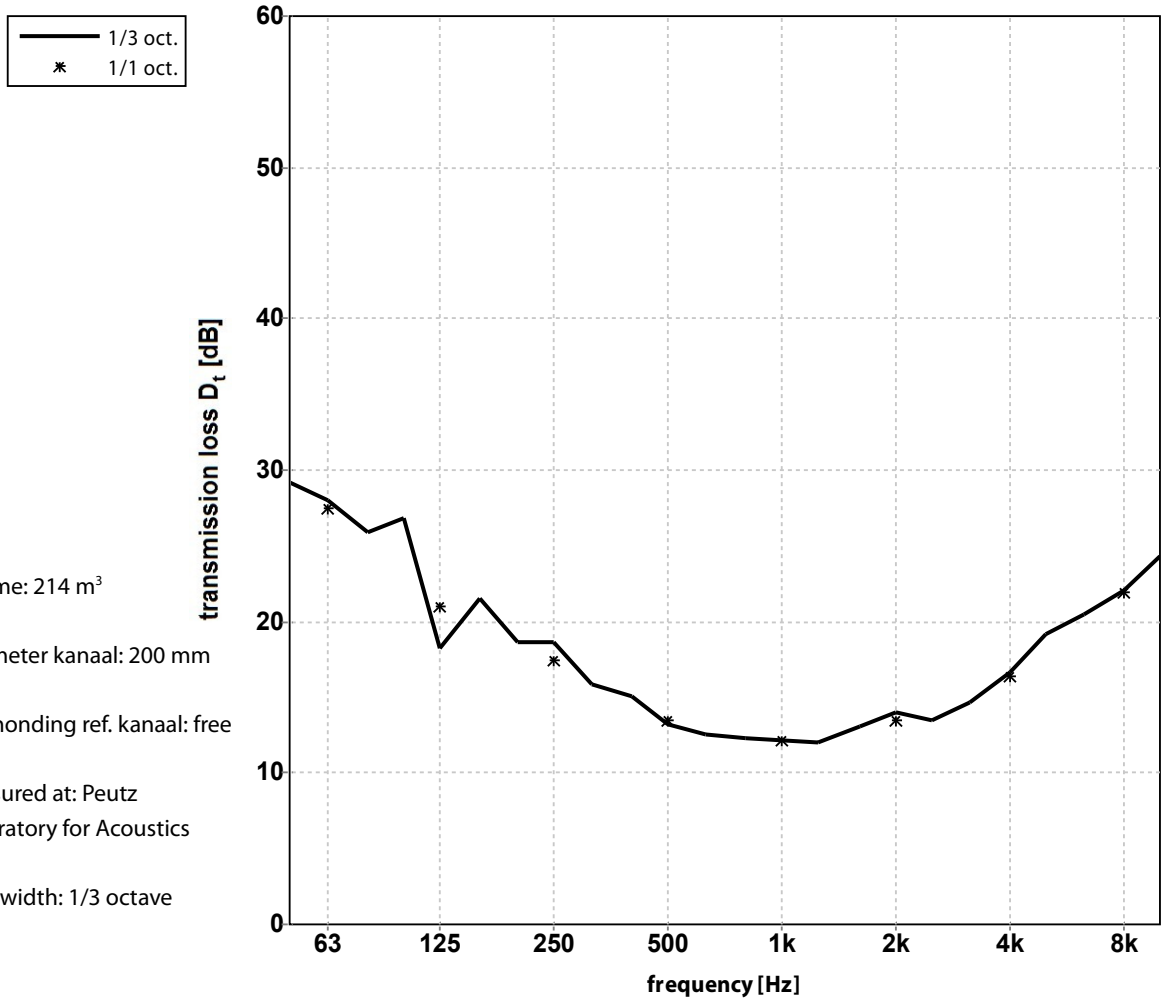
Mook, 11-09-2014

TRANSMISSION LOSS ACCORDING TO ISO 7235:2003

principal: AFS Boru Sanayi A.S.

construction tested: #103; SILENCERAFS.F PLUS
diameter 203 mm
length 1,0 m



volume: 214 m³

*diameter kanaal: 200 mm

*uitmonding ref. kanaal: free

measured at: Peutz
Laboratory for Acoustics

bandwidth: 1/3 octave

	29,2	26,8	18,7	15,0	12,3	13,1	14,7	20,5	
1/3 oct.	28,0	18,3	18,7	13,2	12,2	14,0	16,6	22,1	dB
	25,9	21,6	15,8	12,6	12,0	13,5	19,1	24,3	
1/1 oct.	**27,5**	**21,0**	**17,5**	**13,5**	**12,2**	**13,5**	**16,4**	**22,0**	**dB**

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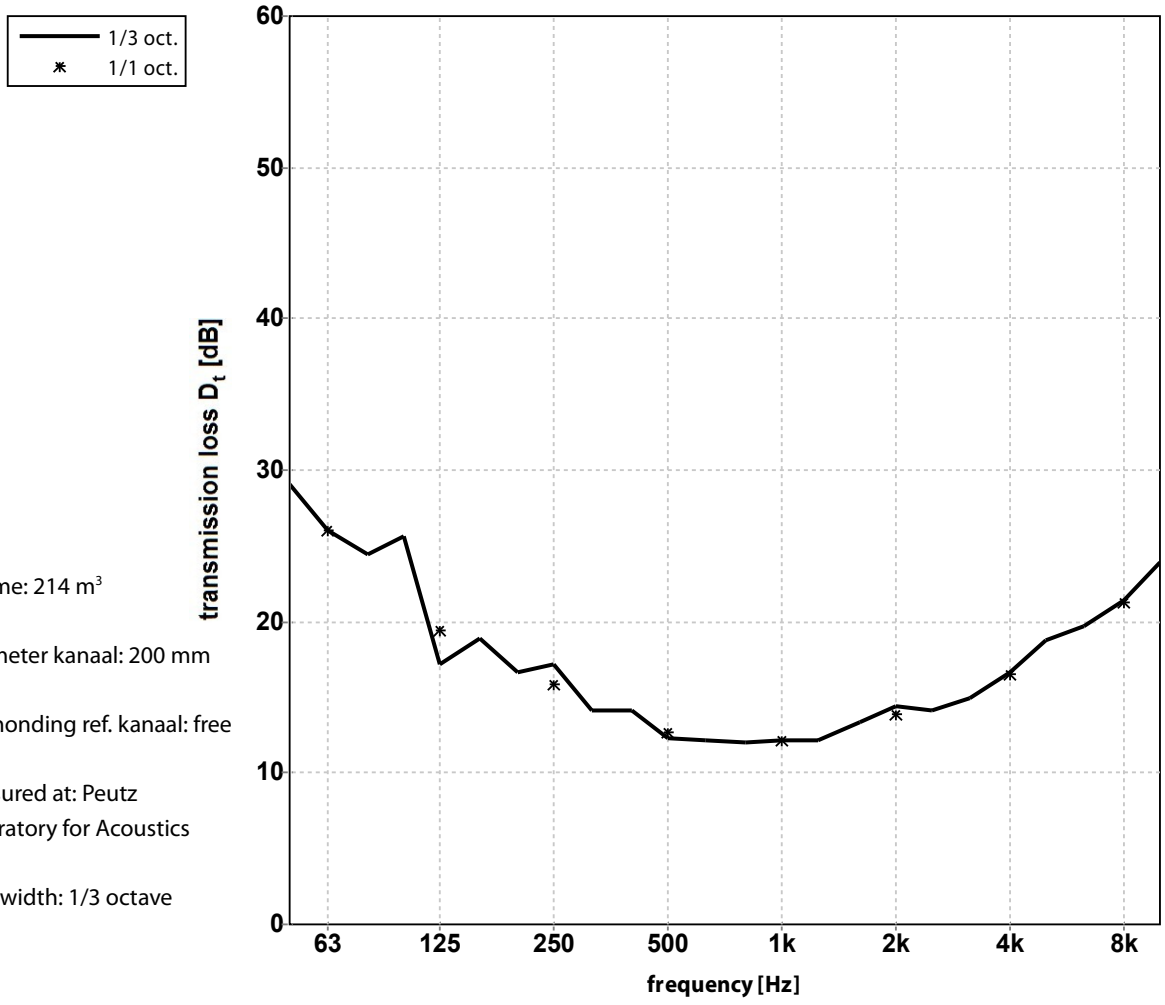
Mook, 23-05-2014

TRANSMISSION LOSS ACCORDING TO ISO 7235:2003

principal: AFS Boru Sanayi A.S.

construction tested: #104; SILENCERAFS.F PLUS
diameter 203 mm
length 1,0 m



volume: 214 m³

*diameter kanaal: 200 mm

*uitmonding ref. kanaal: free

measured at: Peutz Laboratory for Acoustics

bandwidth: 1/3 octave

	29,1	25,7	16,6	14,1	12,0	13,4	14,9	19,7	
1/3 oct.	26,0	17,2	17,2	12,3	12,2	14,4	16,6	21,4	dB
	24,5	18,9	14,2	12,1	12,1	14,1	18,8	23,9	
1/1 oct.	**26,1**	**19,4**	**15,8**	**12,7**	**12,1**	**13,9**	**16,5**	**21,3**	**dB**

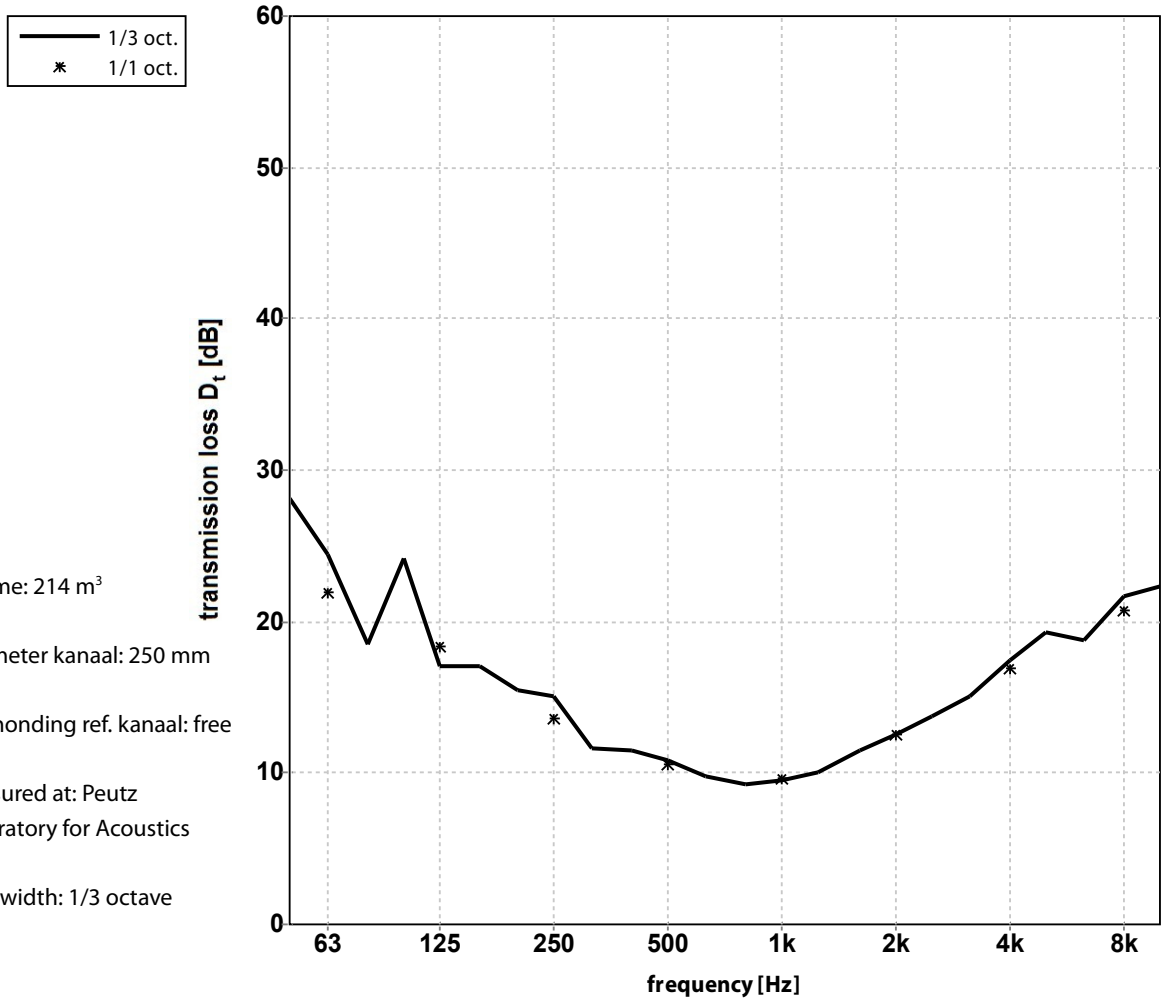
Mook, 23-05-2014

LABORATORY FOR ACOUSTICS

TRANSMISSION LOSS ACCORDING TO ISO 7235:2003

principal: AFS Boru Sanayi A.S.

construction tested: #105; SILENCERAFS.F PLUS
diameter 254 mm
length 1,0 m



volume: 214 m³

*diameter kanaal: 250 mm

*uitmonding ref. kanaal: free

measured at: Peutz
Laboratory for Acoustics

bandwidth: 1/3 octave

	28,1	24,2	15,4	11,5	9,3	11,5	15,0	18,8	
1/3 oct.	24,5	17,0	15,0	10,8	9,5	12,5	17,5	21,7	dB
	18,5	17,1	11,6	9,8	10,0	13,7	19,3	22,4	
1/1 oct.	**21,9**	**18,4**	**13,6**	**10,6**	**9,6**	**12,5**	**16,9**	**20,7**	**dB**

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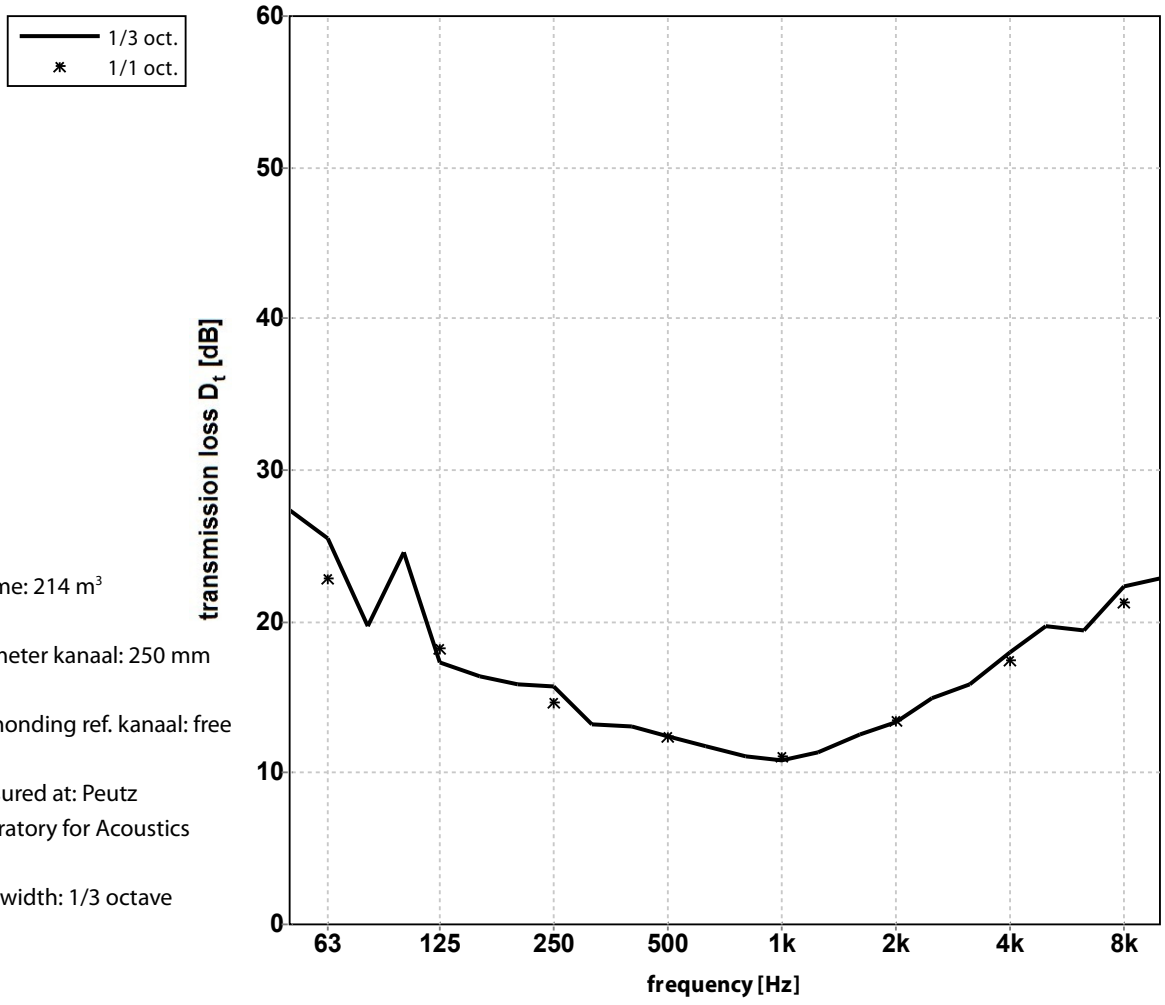
Mook, 11-09-2014

TRANSMISSION LOSS ACCORDING TO ISO 7235:2003

principal: AFS Boru Sanayi A.S.

construction tested: #106; SILENCERAFS.F PLUS
diameter 254 mm
length 1,0 m



volume: 214 m³

*diameter kanaal: 250 mm

*uitmonding ref. kanaal: free

measured at: Peutz Laboratory for Acoustics

bandwidth: 1/3 octave

	27,4	24,6	15,8	13,1	11,1	12,5	15,8	19,4	
1/3 oct.	25,5	17,3	15,7	12,4	10,8	13,4	18,0	22,4	dB
	19,7	16,4	13,2	11,7	11,4	14,9	19,7	22,9	
1/1 oct.	**22,9**	**18,2**	**14,7**	**12,4**	**11,1**	**13,5**	**17,5**	**21,3**	**dB**

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Mook, 11-09-2014