

MORE THAN ONE INSERTION LOSS, THROUGHOUT THE DAY, FOR THE SAME OUTDOOR NOISE BARRIER

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ISO 10847:1997 establishes a method for determining the insertion loss of noise barriers, assuming the existence of only one insertion loss for the same outdoor noise barrier. Since during the day distinct vertical gradients of sound speed may occur, different curved path radius of the sound rays can be formed, which leads to a different insertion loss throughout the day, for the same noise barrier. This article examines the influence of atmospheric conditions on the insertion loss of noise barriers and suggests how to complement the ISO 10847:1997.

1. Introduction

In short ISO 10847^{1, 2} defines 2 methods for *in situ* determination of insertion loss of outdoor noise barriers of all types, for any source type:

1. Direct method: Measurement Before and After the installation of the barrier, at the same point.
2. Indirect method: Measurement After the installation of the barrier, at the desired point and at another point considered equivalent to desired point without the influence of the barrier.

ISO 10847^{1, 2} states that in the direct method, it must be ensured equivalence of the weather conditions.

In terms of wind the measurements, before and after the installation of the barrier, are considered equivalent if Wind Class of Table 1 remains the same.

Table 1. Wind Class (ISO10847).

Wind Class		Vector component of wind velocity
All distances	Downwind	+1 a +5 m/s
	Calm	-1 a +1 m/s*
Short distances	Downwind	+1 a +5 m/s
	Calm	-1 a +1 m/s
	Upwind	+1 a -5 m/s

* Only with the case of temperature inversion.

Short distances conditions are as follows (h_s : source height in metres; h_r : receiver height in metres; h : barrier height in metres; d_1 : distance between source and barrier in metres; d_2 : distance between barrier and receiver in metres):

- Before measurement:
 - $(h_s+h_r)/(d_1+d_2)>0,1$.
- After measurement:
 - $(h_s+h)/(d_1)>0,1$;
 - $(h+h_r)/(d_2)>0,1$.

In terms of temperature the measurements, before and after the installation of the barrier, are considered equivalent if the difference does not exceed 10 °C, and the vertical temperature gradient is similar.

In terms of humidity is not stated any threshold, but it indicated the need for similar conditions.

In terms of cloudiness the measurements, before and after the installation of the barrier, are considered equivalent if the Class of Cloudiness of Table 2 remains the same.

Table 2. Cloud Cover Class (ISO10847).

Class	Description
1	Heavily overcast day or night (80 % cloud cover or more, for 100% of the measurement time)
2	Moderately overcast day or night (50% to 80% cloud cover for at least 80% of the measurement time)
3	Lightly overcast or sunny day or night (either with continuous sun or less than 50% cloud cover for at least 80% of the measurement time)
4	Clear night

Considering the foregoing, it appears that ISO 10847^{1, 2} does not recommend that ensures representativeness of the Insertion-Loss of noise barriers, for example on annual average (may be also in terms of average in a critical month or day, depending on the requirement of law or otherwise), since are given guarantees of meteorological equivalence, in Before and After measurements, but no guarantees are given that these weather conditions are truly representative of the situation.

2. Favorable and unfavorable conditions of sound propagation

In accordance with Annex B of NF S31-133³, we have that a measurement during day period with strong solar radiation, dry surface and downwind medium to weak, or strong wind little favorable (45°) – such configuration is allowed by ISO 10847^{1, 2}, as explained above, for any distance – corresponds to an Unfavorable/Homogeneous sound propagation situation. A measurement at night – which is also allowed under ISO 10847^{1, 2}, as explained above – corresponds, in accordance with Annex B of NF S31-133³, to a Favorable sound propagation situation.

In the circumstances described, are summarized in Figure 1 and Figure 2, for comparison, the Cross Section Noise Maps (mesh calculation of 1×1 m²), obtained in the software Cadna A/NMPB '96⁴ for a traffic road, with and without the effect of 4 meters height noise barrier,

respectively for Homogeneous and Favorable conditions of sound propagation, on flat terrain with 0.8 sound absorption coefficient, up to a distance of 20 meters.

The results for 1 m and 4 m height above ground, extended to a distance of 200 meters, are presented in Table 3.

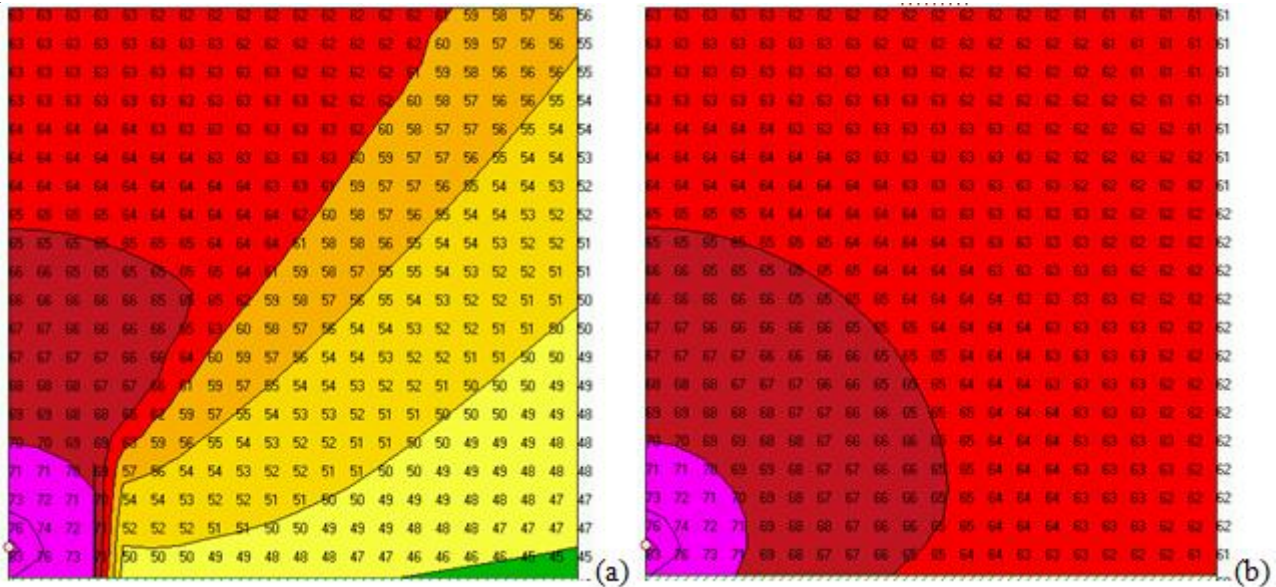


Figure 1. Cross Section Noise Maps With (a) and Without (b) noise barrier, for favorable conditions (up to 20 metres) (NMPB'96).

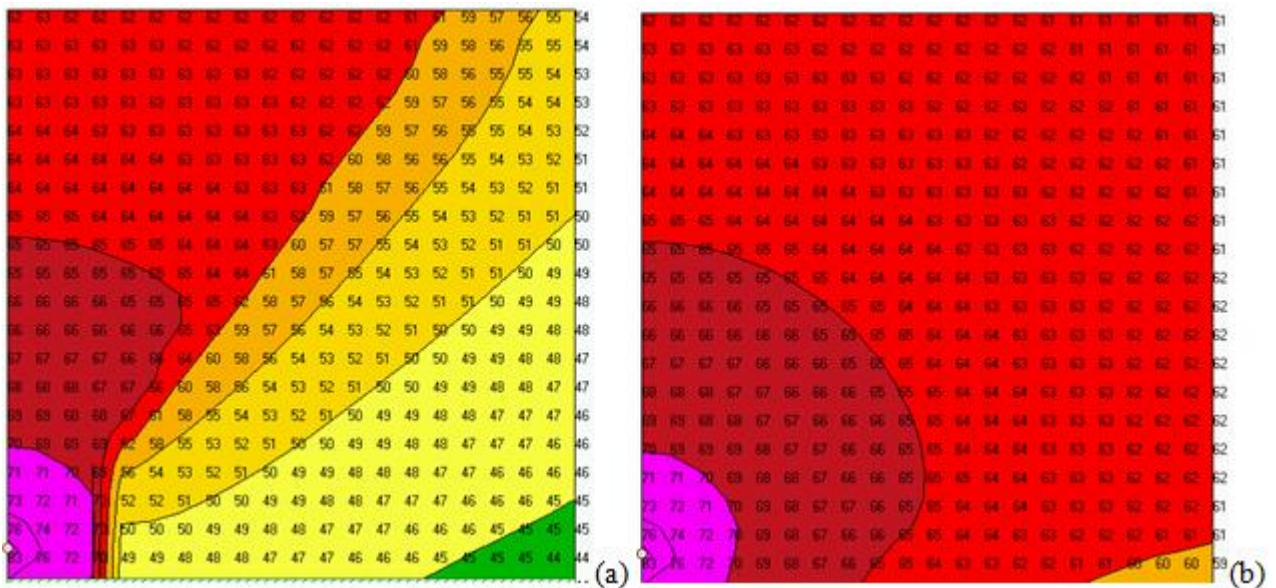


Figure 2. Cross Section Noise Maps With (a) and Without (b) noise barrier, for homogeneous conditions (up to 20 metres) (NMPB'96).

Table 3. : Example of different insertion-loss for the same noise barrier (up to 200 metres) (NMPB'96).

Distance to road [m]	Levels Without Barrier Favorable Conditions [dB(A)]		Levels With Barrier Favorable Conditions [dB(A)]		Insertion-loss Favorable Conditions [dB]		Levels Without Barrier Homogen. Conditions [dB(A)]		Levels With Barrier Homogen. Conditions [dB(A)]		Insertion-loss Homogen. Conditions [dB]		Insertion-loss difference [dB]	
	1	4	1	4	1	4	1	4	1	4	1	4	1	4
	Height above ground [m]													
1	83	71	83	71	0	0	83	71	83	71	0	0	0	0
2	76	71	76	71	0	0	76	71	76	71	0	0	0	0
3	73	70	73	70	0	0	72	70	72	70	0	0	0	0
4	71	69	71	68	0	1	70	69	70	69	0	0	0	-1
5	69	69	50	57	19	12	69	68	49	56	20	12	1	0
6	68	68	50	56	18	12	68	68	49	54	19	14	1	2
7	67	67	50	54	17	13	67	67	48	53	19	14	2	1
8	67	67	49	54	18	13	66	66	48	52	18	14	0	1
9	66	66	49	53	17	13	65	66	48	51	17	15	0	2
10	65	66	48	52	17	14	65	65	47	50	18	15	1	1
11	65	65	48	52	17	13	64	65	47	49	17	16	0	3
12	64	65	48	51	16	14	63	65	47	49	16	16	0	2
13	64	64	47	51	17	13	63	64	46	48	17	16	0	3
14	63	64	47	50	16	14	62	64	46	48	16	16	0	2
15	63	64	46	50	17	14	62	63	46	48	16	15	-1	1
16	63	63	46	49	17	14	61	63	45	47	16	16	-1	2
17	62	63	46	49	16	14	61	63	45	47	16	16	0	2
18	62	63	46	49	16	14	60	62	45	46	15	16	-1	2
19	62	63	45	48	17	15	60	62	45	46	15	16	-2	1
20	61	62	45	48	16	14	60	62	44	46	16	16	0	2
21	61	62	45	48	16	14	59	62	44	46	15	16	-1	2
22	61	62	44	47	17	15	59	61	44	45	15	16	-2	1
23	62	62	44	47	18	15	58	61	44	45	14	16	-4	1
24	60	61	44	47	16	14	58	61	43	45	15	16	-1	2
25	60	61	44	47	16	14	58	61	43	45	15	16	-1	2
26	60	61	43	46	17	15	58	60	43	44	15	16	-2	1
27	60	61	43	46	17	15	57	60	43	44	14	16	-3	1
28	59	61	43	46	16	15	57	60	43	44	14	16	-2	1
29	59	60	43	46	16	14	57	60	42	44	15	16	-1	2
30	59	60	43	45	16	15	56	60	42	43	14	17	-2	2
31	59	60	42	45	17	15	56	59	42	43	14	16	-3	1
32	58	60	42	45	16	15	56	59	42	43	14	16	-2	1
33	58	60	42	45	16	15	56	59	42	43	14	16	-2	1
34	58	60	42	45	16	15	55	59	42	43	13	16	-3	1
35	58	59	42	44	16	15	55	59	41	43	14	16	-2	1
36	58	59	41	44	17	15	55	58	41	42	14	16	-3	1
37	57	59	41	44	16	15	55	58	41	42	14	16	-2	1
38	57	59	41	44	16	15	55	58	41	42	14	16	-2	1
39	57	59	41	44	16	15	54	58	41	42	13	16	-3	1
40	57	59	41	44	16	15	54	58	41	42	13	16	-3	1
41	57	59	41	43	16	16	54	58	41	42	13	16	-3	0
42	57	58	41	43	16	15	54	58	40	42	14	16	-2	1
43	57	58	40	43	17	15	54	57	40	41	14	16	-3	1
44	56	58	40	43	16	15	53	57	40	41	13	16	-3	1
45	56	58	40	43	16	15	53	57	40	41	13	16	-3	1
46	56	58	40	43	16	15	53	57	40	41	13	16	-3	1
47	56	58	40	43	16	15	53	57	40	41	13	16	-3	1
48	56	58	40	42	16	16	53	57	40	41	13	16	-3	0

Distance to road [m]	Levels Without Barrier Favorable Conditions [dB(A)]		Levels With Barrier Favorable Conditions [dB(A)]		Insertion-loss Favorable Conditions [dB]		Levels Without Barrier Homogen. Conditions [dB(A)]		Levels With Barrier Homogen. Conditions [dB(A)]		Insertion-loss Homogen. Conditions [dB]		Insertion-loss difference [dB]	
	Height above ground [m]													
	1	4	1	4	1	4	1	4	1	4	1	4	1	4
49	56	58	39	42	17	16	52	57	40	41	12	16	-5	0
50	56	57	39	42	17	15	52	56	40	41	12	15	-5	0
51	55	57	39	42	16	15	52	56	39	40	13	16	-3	1
52	55	57	39	42	16	15	52	56	39	40	13	16	-3	1
53	55	57	39	42	16	15	52	56	39	40	13	16	-3	1
54	55	57	39	42	16	15	52	56	39	40	13	16	-3	1
55	55	57	39	42	16	15	51	56	39	40	12	16	-4	1
56	55	57	39	41	16	16	51	56	39	40	12	16	-4	0
57	55	57	38	41	17	16	51	55	39	40	12	15	-5	-1
58	55	57	38	41	17	16	51	55	39	40	12	15	-5	-1
59	54	57	38	41	16	16	51	55	39	40	12	15	-4	-1
60	54	56	38	41	16	15	51	55	38	39	13	16	-3	1
61	54	56	38	41	16	15	51	55	38	39	13	16	-3	1
62	54	56	38	41	16	15	50	55	38	39	12	16	-4	1
63	54	56	38	41	16	15	50	55	38	39	12	16	-4	1
64	54	56	38	41	16	15	50	55	38	39	12	16	-4	1
65	54	56	38	41	16	15	50	55	38	39	12	16	-4	1
66	54	56	37	40	17	16	50	54	38	39	12	15	-5	-1
67	54	56	37	40	17	16	50	54	38	39	12	15	-5	-1
68	54	56	37	40	17	16	50	54	38	39	12	15	-5	-1
69	54	56	37	40	17	16	50	54	38	39	12	15	-5	-1
70	54	56	37	40	17	16	49	54	38	39	11	15	-6	-1
71	53	56	37	40	16	16	49	54	37	38	12	16	-4	0
72	53	55	37	40	16	15	49	54	37	38	12	16	-4	1
73	53	55	37	40	16	15	49	54	37	38	12	16	-4	1
74	53	55	37	40	16	15	49	54	37	38	12	16	-4	1
75	53	55	37	40	16	15	49	53	37	38	12	15	-4	0
76	53	55	37	39	16	16	49	53	37	38	12	15	-4	-1
77	53	55	36	39	17	16	49	53	37	38	12	15	-5	-1
78	53	55	36	39	17	16	48	53	37	38	11	15	-6	-1
79	53	55	36	39	17	16	48	53	37	38	11	15	-6	-1
80	53	55	36	39	17	16	48	53	37	38	11	15	-6	-1
81	53	55	36	39	17	16	48	53	37	38	11	15	-6	-1
82	53	55	36	39	17	16	48	53	36	38	12	15	-5	-1
83	53	55	36	39	17	16	48	53	36	38	12	15	-5	-1
84	53	55	36	39	17	16	48	52	36	37	12	15	-5	-1
85	53	55	36	39	17	16	48	52	36	37	12	15	-5	-1
86	52	54	36	39	16	15	48	52	36	37	12	15	-4	0
87	52	54	36	39	16	15	48	52	36	37	12	15	-4	0
88	52	54	36	39	16	15	47	52	36	37	11	15	-5	0
89	52	54	36	39	16	15	47	52	36	37	11	15	-5	0
90	52	54	36	38	16	16	47	52	36	37	11	15	-5	-1
91	52	54	35	38	17	16	47	52	36	37	11	15	-6	-1
92	52	54	35	38	17	16	47	52	36	37	11	15	-6	-1
93	52	54	35	38	17	16	47	51	36	37	11	14	-6	-2
94	52	54	35	38	17	16	47	51	35	37	12	14	-5	-2
95	52	54	35	38	17	16	47	51	35	37	12	14	-5	-2
96	52	54	35	38	17	16	47	51	35	37	12	14	-5	-2
97	52	54	35	38	17	16	47	51	35	37	12	14	-5	-2
98	52	54	35	38	17	16	47	51	35	36	12	15	-5	-1
99	52	54	35	38	17	16	47	51	35	36	12	15	-5	-1

Distance to road [m]	Levels Without Barrier Favorable Conditions [dB(A)]		Levels With Barrier Favorable Conditions [dB(A)]		Insertion-loss Favorable Conditions [dB]		Levels Without Barrier Homogen. Conditions [dB(A)]		Levels With Barrier Homogen. Conditions [dB(A)]		Insertion-loss Homogen. Conditions [dB]		Insertion-loss difference [dB]	
	Height above ground [m]													
	1	4	1	4	1	4	1	4	1	4	1	4	1	4
100	52	54	35	38	17	16	46	51	35	36	11	15	-6	-1
101	52	54	35	38	17	16	46	51	35	36	11	15	-6	-1
102	52	53	34	38	18	15	46	51	35	36	11	15	-7	0
103	51	53	34	37	17	16	46	50	35	36	11	14	-6	-2
104	51	53	34	37	17	16	46	50	35	36	11	14	-6	-2
105	51	53	34	37	17	16	46	50	35	36	11	14	-6	-2
106	51	53	34	37	17	16	46	50	35	36	11	14	-6	-2
107	51	53	34	37	17	16	46	50	34	36	12	14	-5	-2
108	51	53	34	37	17	16	46	50	34	36	12	14	-5	-2
109	51	53	34	37	17	16	46	50	34	36	12	14	-5	-2
110	51	53	34	37	17	16	46	50	34	36	12	14	-5	-2
111	51	53	34	37	17	16	46	50	34	36	12	14	-5	-2
112	51	53	34	37	17	16	46	50	34	36	12	14	-5	-2
113	51	53	34	37	17	16	45	49	34	36	11	13	-6	-3
114	51	53	34	37	17	16	45	49	34	35	11	14	-6	-2
115	51	53	34	37	17	16	45	49	34	35	11	14	-6	-2
116	51	53	34	37	17	16	45	49	34	35	11	14	-6	-2
117	51	53	34	37	17	16	45	49	34	35	11	14	-6	-2
118	51	53	34	37	17	16	45	49	34	35	11	14	-6	-2
119	51	53	33	37	18	16	45	49	34	35	11	14	-7	-2
120	51	52	33	36	18	16	45	49	34	35	11	14	-7	-2
121	51	52	33	36	18	16	45	49	34	35	11	14	-7	-2
122	51	52	33	36	18	16	45	49	34	35	11	14	-7	-2
123	50	52	33	36	17	16	45	49	33	35	12	14	-5	-2
124	50	52	33	36	17	16	45	49	33	35	12	14	-5	-2
125	50	52	33	36	17	16	45	49	33	35	12	14	-5	-2
126	50	52	33	36	17	16	45	48	33	35	12	13	-5	-3
127	50	52	33	36	17	16	45	48	33	35	12	13	-5	-3
128	50	52	33	36	17	16	45	48	33	35	12	13	-5	-3
129	50	52	33	36	17	16	44	48	33	35	11	13	-6	-3
130	50	52	33	36	17	16	44	48	33	35	11	13	-6	-3
131	50	52	33	36	17	16	44	48	33	35	11	13	-6	-3
132	50	52	33	36	17	16	44	48	33	34	11	14	-6	-2
133	50	52	33	36	17	16	44	48	33	34	11	14	-6	-2
134	50	52	33	36	17	16	44	48	33	34	11	14	-6	-2
135	50	52	33	36	17	16	44	48	33	34	11	14	-6	-2
136	50	52	33	36	17	16	44	48	33	34	11	14	-6	-2
137	50	52	32	36	18	16	44	48	33	34	11	14	-7	-2
138	50	52	32	36	18	16	44	48	33	34	11	14	-7	-2
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140	50	52	32	35	18	17	44	47	33	34	11	13	-7	-4
141	50	52	32	35	18	17	44	47	32	34	12	13	-6	-4
142	50	52	32	35	18	17	44	47	32	34	12	13	-6	-4
143	50	51	32	35	18	16	44	47	32	34	12	13	-6	-3
144	50	51	32	35	18	16	44	47	32	34	12	13	-6	-3
145	50	51	32	35	18	16	44	47	32	34	12	13	-6	-3
146	49	51	32	35	17	16	44	47	32	34	12	13	-5	-3
147	49	51	32	35	17	16	43	47	32	34	11	13	-6	-3
148	49	51	32	35	17	16	43	47	32	34	11	13	-6	-3
149	49	51	32	35	17	16	43	47	32	34	11	13	-6	-3
150	49	51	32	35	17	16	43	47	32	34	11	13	-6	-3

Distance to road [m]	Levels Without Barrier Favorable Conditions [dB(A)]		Levels With Barrier Favorable Conditions [dB(A)]		Insertion-loss Favorable Conditions [dB]		Levels Without Barrier Homogen. Conditions [dB(A)]		Levels With Barrier Homogen. Conditions [dB(A)]		Insertion-loss Homogen. Conditions [dB]		Insertion-loss difference [dB]	
	Height above ground [m]													
	1	4	1	4	1	4	1	4	1	4	1	4	1	4
151	49	51	32	35	17	16	43	47	32	34	11	13	-6	-3
152	49	51	32	35	17	16	43	47	32	33	11	14	-6	-2
153	49	51	32	35	17	16	43	47	32	33	11	14	-6	-2
154	49	51	32	35	17	16	43	47	32	33	11	14	-6	-2
155	49	51	32	35	17	16	43	47	32	33	11	14	-6	-2
156	49	51	32	35	17	16	43	46	32	33	11	13	-6	-3
157	49	51	32	35	17	16	43	46	32	33	11	13	-6	-3
158	49	51	32	35	17	16	43	46	32	33	11	13	-6	-3
159	49	51	32	35	17	16	43	46	32	33	11	13	-6	-3
160	49	51	31	35	18	16	43	46	32	33	11	13	-7	-3
161	49	51	31	35	18	16	43	46	32	33	11	13	-7	-3
162	49	51	31	34	18	17	43	46	32	33	11	13	-7	-4
163	49	51	31	34	18	17	43	46	31	33	12	13	-6	-4
164	49	51	31	34	18	17	43	46	31	33	12	13	-6	-4
165	49	51	31	34	18	17	43	46	31	33	12	13	-6	-4
166	49	51	31	34	18	17	43	46	31	33	12	13	-6	-4
167	49	51	31	34	18	17	43	46	31	33	12	13	-6	-4
168	49	51	31	34	18	17	43	46	31	33	12	13	-6	-4
169	49	51	31	34	18	17	42	46	31	33	11	13	-7	-4
170	49	51	31	34	18	17	42	46	31	33	11	13	-7	-4
171	49	51	31	34	18	17	42	46	31	33	11	13	-7	-4
172	49	51	31	34	18	17	42	46	31	33	11	13	-7	-4
173	49	50	31	34	18	16	42	46	31	33	11	13	-7	-3
174	48	50	31	34	17	16	42	45	31	32	11	13	-6	-3
175	48	50	31	34	17	16	42	45	31	32	11	13	-6	-3
176	48	50	31	34	17	16	42	45	31	32	11	13	-6	-3
177	48	50	31	34	17	16	42	45	31	32	11	13	-6	-3
178	48	50	31	34	17	16	42	45	31	32	11	13	-6	-3
179	48	50	31	34	17	16	42	45	31	32	11	13	-6	-3
180	48	50	31	34	17	16	42	45	31	32	11	13	-6	-3
181	48	50	31	34	17	16	42	45	31	32	11	13	-6	-3
182	48	50	31	34	17	16	42	45	31	32	11	13	-6	-3
183	48	50	31	34	17	16	42	45	31	32	11	13	-6	-3
184	48	50	31	34	17	16	42	45	31	32	11	13	-6	-3
185	48	50	31	34	17	16	42	45	31	32	11	13	-6	-3
186	48	50	30	34	18	16	42	45	31	32	11	13	-7	-3
187	48	50	30	34	18	16	42	45	30	32	12	13	-6	-3
188	48	50	30	33	18	17	42	45	30	32	12	13	-6	-4
189	48	50	30	33	18	17	42	45	30	32	12	13	-6	-4
190	48	50	30	33	18	17	42	45	30	32	12	13	-6	-4
191	48	50	30	33	18	17	42	45	30	32	12	13	-6	-4
192	48	50	30	33	18	17	42	45	30	32	12	13	-6	-4
193	48	50	30	33	18	17	42	45	30	32	12	13	-6	-4
194	48	50	30	33	18	17	42	44	30	32	12	12	-6	-5
195	48	50	30	33	18	17	41	44	30	32	11	12	-7	-5
196	48	50	30	33	18	17	41	44	30	32	11	12	-7	-5
197	48	50	30	33	18	17	41	44	30	32	11	12	-7	-5
198	48	50	30	33	18	17	41	44	30	31	11	13	-7	-4
199	48	50	30	33	18	17	41	44	30	31	11	13	-7	-4
200	48	50	30	33	18	17	41	44	30	31	11	13	-7	-4

3. Analysis of results and conclusions

The analysis of Table 3 shows that there may be differences in insertion-loss of noise barriers, in the example, for Homogeneous and Favorable Conditions, between -7 dB and 2 dB for 1 m height above ground (up to 20 metres the differential is only ± 2 dB), and between -5 dB and 3 dB for 4 m above ground (up to 130 metres the differential is only ± 3 dB), which means that if the insertion-loss of the noise barrier meet the legal limits near the limit at $\pm 2 / 3$ dB – which often happens – must be taken some caution in determining the average insertion-loss, or minimum insertion-loss, because it is not even guaranteed that measurements at night lead to insertion-loss safer (lower) because, as shown on Table 3, the insertion-loss for Favorable Conditions may be higher or lower than the insertion-loss for Homogeneous Conditions, though, for greater distances the insertion-loss tends to be higher in Favorable Conditions, contrary to common sense. According to the results, the highest insertion-loss for Favorable Conditions are due to the fact that, under the influence of the Noise Barrier, noise levels are virtually equal for Homogeneous and Favorable Conditions, and without the influence of the Noise Barrier noise levels are higher for Favorable Conditions.

These results show how the same noise barrier may have more than one insertion-loss throughout the day, due to daily variation of the vertical gradient of sound speed, consequently is important not only to ensure, as expressed in ISO 10847^{1, 2}, an equivalence of weather conditions in measurements Before and After implementation of noise barriers, but also ensure that weather conditions characterized are representative of the legal period, or otherwise, that we pretend to characterize, otherwise we might have deviations, according to Table 3, up to 7 dB.

4. Suggestions for amendments to ISO 10847

It is suggested therefore that the ISO 10847^{1, 2} becomes to include a chapter about the representativeness of insertion-loss characterized, according to the information available for the atmospheric conditions representative of the site, for the legal periods, or others concerned, and should be well considered for inclusion the Annex A of ISO 1996-2⁵, because it relies largely on the recommendation of performing measurements under favorable conditions, because they are more stable, however, as shown in Table 3, for further distances the insertion-loss tends to be higher in favorable conditions, and may be of interest to characterize the minimum insertion-loss (or at least other insertion-loss than the maximum) of Noise Barrier.

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