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1. INTRODUCTION

Athens Tram has performed during last years an extended Noise &Vibration Study including both airborne & ground borne noise & vibration levels calculations. This N&V study suggested the implementation of various anti noise/vibration mitigation measures. The originally performed calculations within this study for the design of the Tram networks suggested that in some urban areas the use of adequate noise barriers in order to achieve both improvement of the acoustic environment and aesthetic integration of the relevant construction to the urban environment. TTE has conducted the above study on improvement of the urban acoustic environment that revealed of a transparent barrier of a max. height of approx. 1,5 meters, in a suitable distance from the external rail of the tramway, could decrease dramatically the equivalent sound levels (depending also to tram type & relevant noise emissions) for the majority of nearby residents even though the relevant noise criterion in Greece was set to 67 dB(A) for the index Leq (18hours) based on the total daily operation of the system. This highly aesthetical medium height transparent barrier was then ordered and installed on October 2005 in a site area with dense urban characteristics in the front side at Glyfada Athens (Diadohou Pavlou str.). Furthermore within Qcity project Acoustic Control & Zblock suggested also to test a prototype low platform barrier of a limited height of some 32cm suitable for installation near platforms in the network. Zblock has produced the relevant prototype that was arrived in Athens end 2005 and Installed by Tram S.A. in a test site in Tram Depot at Hellinikon Athens. Both prototypes barriers were then tested and measured within Qcity's relevant subproject SP4 and the relevant results were already presented in the relevant deliverable 4.3

Additionally to the above deliverable findings - in the framework of WP5.2 - TTE has also conducted a relevant measurement campaign in order to evaluate also the insertion loss of a prototype rubber low height CDM noise barrier in Athens Tram depot for both setups "WITH" & "WITHOUT" noise barrier, with the goal to evaluate the overall noise attenuation in the view of reducing further down the noise index from tramway operation in European urban areas.

The present report describes the setup of the relevant additional measurement campaign, the relevant results and the relevant concluding remarks & recommendations.

2. CDM NOISE BARRIER TEST SITE & INSTRUMENTATION

In this chapter the tested rubber barrier type & test site evaluated in the measurement campaign is described in detail. As presented before an approx 50m length, low height (approx 45 cm) absorbing rubber noise barrier from CDM in a min. distance of approx. 4 to 12cm from the Tram "gabarit" (according to Athens Tram relevant dimensioning in platform area respectively at upper edge & base of barrier) This prototype low barrier was installed in Athens Tram Depot in order to evaluate the relevant insertion loss at various speed conditions (from 10 up to 40 Km/h). The same vehicle was used during all measurements as per the Zblock barrier measurements presented in D4.3.

As per D4.3 two distinct measurement scenario were executed involving measurements "WITH" & "WITHOUT" the barrier according to the EN ISO 3095:2005(E) and the provisions of the recent 2002/49/CE directive introducing a height for noise recording purposes of H = 4 m (+/- 0.2). The measured campaign was designed especially to obtain reproducible and comparable measurement results of levels and spectra of noise emitted by tramway vehicles operating on rails or fixed track.

The Standard EN ISO 3095:2005 has been prepared by Technical Committee CEN/TC 256 "Railway applications", the secretariat of which is held by DIN, in collaboration with Technical Committee ISO/TC 43 "Acoustics". This standard is applicable for type testing & periodic monitoring testing and the results may be used,:

- to characterize the noise emitted by these trains;
- to compare the noise emission of various vehicles on a particular track section;
- to collect basic source data for trains.

According to the standard and in view of the particularities of the Athens Tram depot test site the noise quantities suggested to be measured at all microphone positions are :

- For whole trams moving at constant speed the Transit Exposure Level, TEL, or the A-Weighted equivalent continuous sound pressure level on the pass by time, LpAeq.
- The measurement quantity for accelerating or braking tests the maximum AF-weighted sound pressure LpAFmax.
- For the present campaign a frequency analysis was also required, made at least in one third octave bands according to EN ISO 266: at least from 31,5 Hz to 8 kHz. ensuring that the lower frequency limit is chosen to ensure that the product of the lowest bandwidth and signal duration exceeds unity. For this campaign a frequency range from 20 Hz to 20 KHz was introduced.

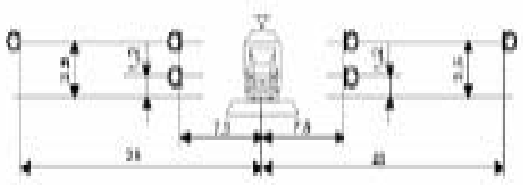
The instrumentation system, including the microphones, cables and recording devices was in accordance with the requirements for a type 1 instrument specified in EN 61672-1. Both 01dB's Harmonie & Symphonie noise recording and 1/3 octave band analysis systems from 01dB (FR) were used ensuring two sets of :

- 4 synchronized micros &
- 2 synchronized micros (for add. locations in Tram depot site all with suitable windscreens

The microphones have an essentially flat frequency response in a free sound field. The 1/3 octave band filters met the requirements of class 1 according to EN 61260. Before and after each series of measurements a sound calibrator meeting the requirements of class 1 according to EN 60942 was applied to the microphone(s) for verifying the calibration of the entire measuring system. The compliance of the instrumentation system with the requirements of EN 61672-1 and EN 61672-2 was recently verified

General Depot test site conditions

The necessary conditions were ensured for the test site, including additionally a microphone height of 4m was also introduced according to 2002/49/CE directive. In this case as per the Zblock low platform barrier tests add. measurement's locations were introduced in order to evaluate more aspects of the screening and diffusion effect. The Athens tram Depot test site ensures free sound propagation with a ground essentially flat (with a max level variation from 0 m to -0,20 m, relative to the top of rail). The free field area around the microphones has a radius more that 3 times the measurement distance on both sides free of large reflecting objects like barriers, hills, rocks, bridges or buildings. In the vicinity of the microphones, no obstacles disturbing the sound field were permitted including persons. Furthermore the area between the tram vehicle and the microphones was completely free as possible of sound absorbing matter (e.g. snow, tall vegetation, other tracks) or reflective covering (e.g. water, ice). The ground cover in both test sites was an asphalt (tarmac) coverage. Regarding the meteorological conditions during the test the wind speed measured at the microphone height was below 1 m/s and there was no falling rain or snow. Temperature was between 8 & 12o C and humidity, in normal levels (some 70 to 80%).



The microphone positions axis was always horizontal and directed perpendicularly to the track. The microphone positions as per the relevant Standard EN ISO 3095:2005 are shown in the adjacent schematic.

The microphone positions were selected were in one side (opposite site not available due to topographic conditions and the depot building set up) ensuring the basic

distance of 7,5 m from the track axis, at a height of 1,2 m above the top of rail, and also the distance of 25 m from the track axis, at a height of both 1,20 & 4,0 m, above the top of rail. as described above. The Athens Tram vehicle measured in the Depot site was in its normal operating conditions and already run in normal conditions at least 1 000 km on track with normal traffic. During all measurements, the doors and windows of the vehicle were kept closed, and all auxiliary equipment on the test vehicles that normally operates during the run was in action. The embedded track with elastic encapsulation (CDM Prefarail system) was laid in both sites without rail joints (welded rail) and free of visible surface defects such as rail burns or pits and spikes caused by the compression of external material between wheel and rail: no audible impact noise due to welds was present. The photographic / schematic presentation of the site and the relevant measurement's setup is presented hereafter

CDM Rubber Low height Absorbing Noise barrier

In the figure 1 here below we present the conceptual sketch showing the test site and the relevant basic distances of the various locations of measurement points for the Low Platform Absorbing Barrier test site at Athens Tram Depot. In figure 2 a general view of the site for "with"& "without barrier" setups is presented. In figure 3 a general view of the CDM's prototype is presented along with figure 4 of a general overview of the positioning of the barrier at the test site at Athens Tram depot. In table 1 detailed geometrical data for all microphones locations are also presented. In the relevant figures 5 to 7 hereafter the test site location both for "with"& "without barriers" setups are presented including general views of tram pass byes with & without the barrier.

Low Platform Absorbing Barrier Test site MICROPHONE LOCATION 4 channel HARMONIE system	Hor. Dist.	Height	Description
Ch. 1 (H1)	**3,75**	**0,6**	Reference point
Ch. 2 (H2)	**7,50**	**1,2**	ISO 3095/2005
Ch. 3 (H3)	**10,00**	**1,2**	NORDIC Prediction Model
Ch. 4 (H4)	**10,00**	**4,0**	2002/49/EU

Low Platform Absorbing Barrier Test site MICROPHONE LOCATION 2 channel SYMPHONIE system	Hor. Dist.	Height	Description
Ch. 1 (S1)	**1,0**	**1,2**	Reference point (Hor. Distance from external rail)
Ch. 2 (S2)	**25,0**	**1,2**	ISO 3095/2005

Table 1

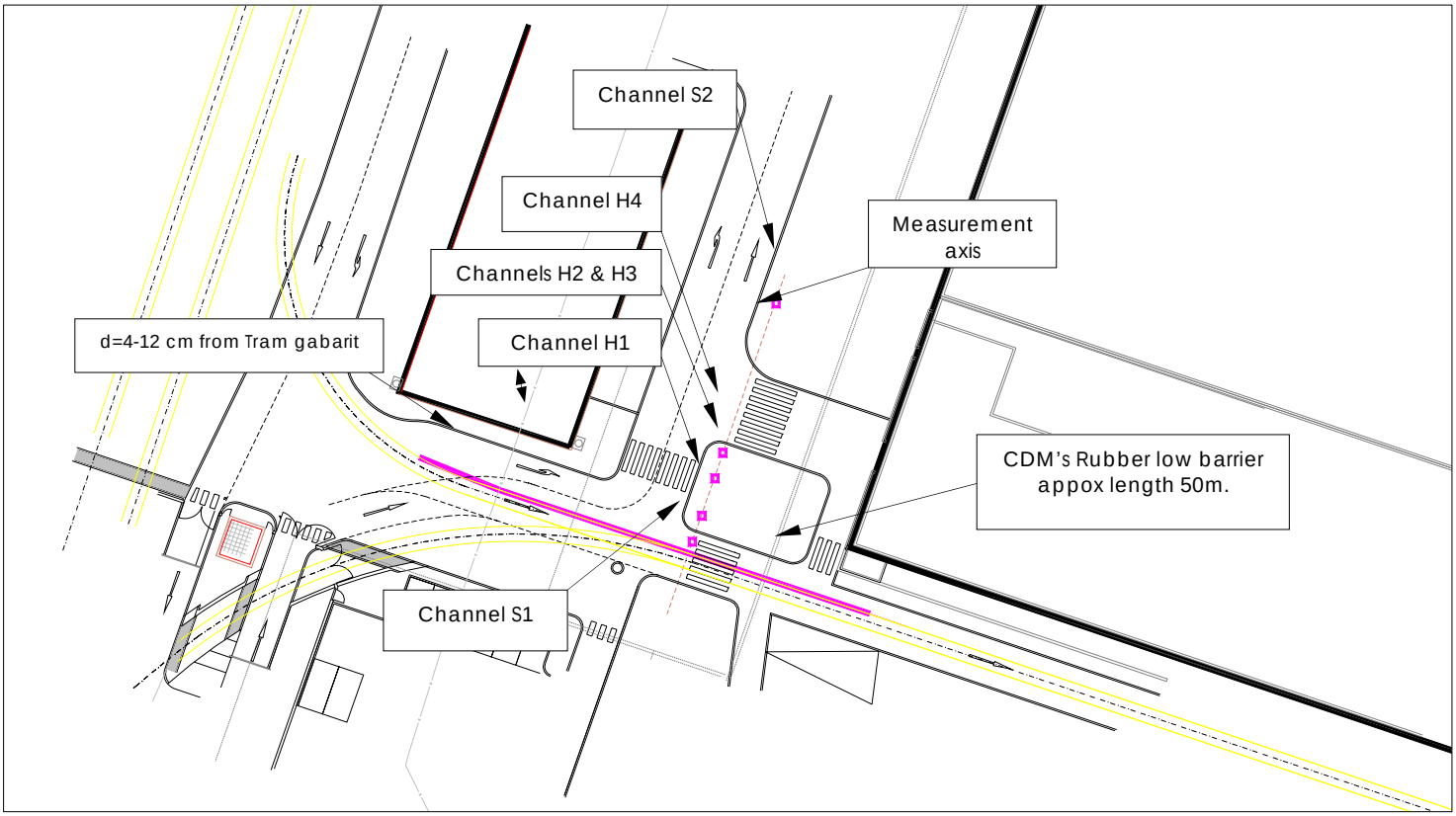


Fig. 1. Conceptual sketch showing the CDM's Rubber Low Absorbing Noise barrier test site at Athens Tram Depot

"without barrier"

"with barrier"

Fig. 2 General view of the CDM's Rubber low height Noise barrier test site at Athens Tram Depot for both "with"& "without barrier" setups

Fig. 3 General view of the CDM's prototype

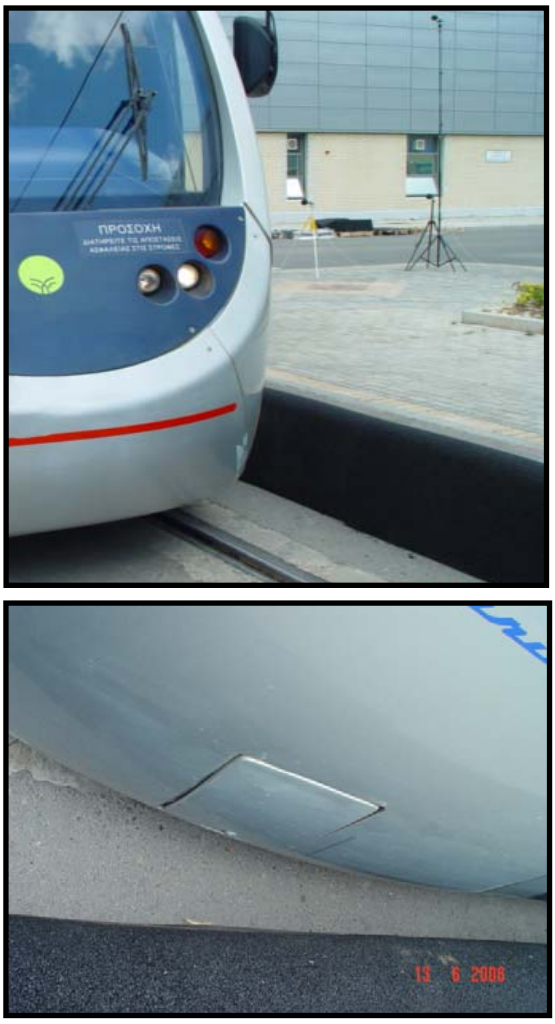


Fig. 4 Positioning f the CDM's barrier at Athens Tram Depot (at approx. 4-12cm from vehicle ext. gabarit)

Fig. 5 Measurement's location setup for both "With" & "Without barrier" tests

Fig. 6 Tram pass by at "Without barrier" test

Fig. 7 Tram pass by at "With barrier" test

3. FIELD MEASUREMENTS RESULTS 2006 AT ATHENS TRAM DEPOT - HELLINIKON GREECE

A total of 2X12=24 tram pass byes of the same vehicle (as per D4.3 setting) were recorded and analysed in this test site according to the setup described above for various speeds i.e 10,20,30 & 37 to 40 Km/h (3 pass bys per speed and per test). The analytical results per pass by are presented (including full 1/3 octave band analysis) in Annex 1 hereafter for both "With" & "Without" the CDM barrier tests. The main results for both descriptors Leq (tram passage) and Lmax are presented in the tables and relevant graphs hereafter. In order to evaluate the noise attenuation in various measurement locations, separate calculations were made in both tests and the relevant attenuation was established by 2 separate statistical approaches (called approach 1 & 2 respectively as per D 4.3 relevant analysis) in chapters 3.1 & 3.2 as presented here after.

3.1 Approach 1

By comparison of each speed level pass bys for "with" & "without barrier" tests the **Average Leq attenuation per measurement point** was calculated and the average insertion loss for each point was calculated for all speeds. These results are presented in the following tables and figures. including the **average LAmax** values for each independent vehicle speed/barrier scenario (8 in total)**.** This approach method (as per D4.3 relevant analysis) has the obvious advantage of calculating the IL including both duct attenuation effects and screening effects, but has the drawback of not getting a full normalization of the source strength for each passage (despite the fact that during the measurements we have ensured same tram vehicle & operator, same track and three pass byes for each speed limit so it is expected that the average reflects an appropriate approach of the IL values).

Based on the above approach **an average insertion loss of approx. 7,3 dB(A) ± 0,7 dB(A)** was calculated for the measurement points H1,H2,H3,H4 & S2 by the use of this type of rubber low height barrier.

Table 2
Average Leq attenuation per measurement point/speed for
"Without" & "WITH barrier" tests

Measurement points	Vehicle Speed (Km/h)				**Average attenuation for all speeds**
	10 Km/h	20 Km/h	30 Km/h	37-40 Km/h	
S1	3,7	1,8	1,6	2,7	2,5
H1	7,5	8,2	8,6	10,0	8,6
H2	6,0	7,1	7,8	8,7	7,4
H3	5,9	7,0	7,5	8,5	7,2
H4	4,6	5,2	6,6	7,0	5,9
S2	3,8	5,4	5,8	6,1	5,3

Table 3
Average Lmax fluctuation per measurement point for all speeds for
"Without" & "WITH barrier" tests

Measurement points	Vehicle Speed (Km/h)							
	10 Km/h Without barrier	**20 Km/h Without barrier**	**30 Km/h Without barrier**	**37-40 Km/h Without barrier**	**10 Km/h With barrier**	**20 Km/h With barrier**	**30 Km/h With barrier**	**37-40 Km/h With barrier**
S1	77,0	83,6	86,1	87,5	73,2	82,8	85,4	87,3
H1	74,8	82,1	85,6	87,1	65,1	72,6	76,5	78,1
H2	69,2	76,2	80,6	81,5	61,4	67,8	71,9	73,3
H3	68,7	75,2	79,8	81,1	61,0	67,1	71,8	73,6
H4	66,4	73,7	78,1	79,8	61,8	69,3	71,0	72,9
S2	64,1	70,0	73,2	75,7	59,1	64,7	67,8	69,8

Table 4
Average Lmax attenuation per measurement point for all speeds for
"Without" & "WITH barrier" tests

Measurement points	Vehicle Speed (Km/h)				Average & st. deviation for all speeds	
	10 Km/h	20 Km/h	30 Km/h	37-40 Km/h		
S1	3,8	0,8	0,7	0,2	1,4	1,7
H1	9,7	9,5	9,1	9,0	9,3	0,3
H2	7,8	8,4	8,6	8,3	8,3	0,4
H3	7,7	8,1	8,0	7,6	7,8	0,2
H4	4,6	4,4	7,0	6,9	5,7	1,5
S2	5,0	5,3	5,5	5,9	5,4	0,7
Average H2/H3/H4 points/all speeds					**7,3**	**0,7**

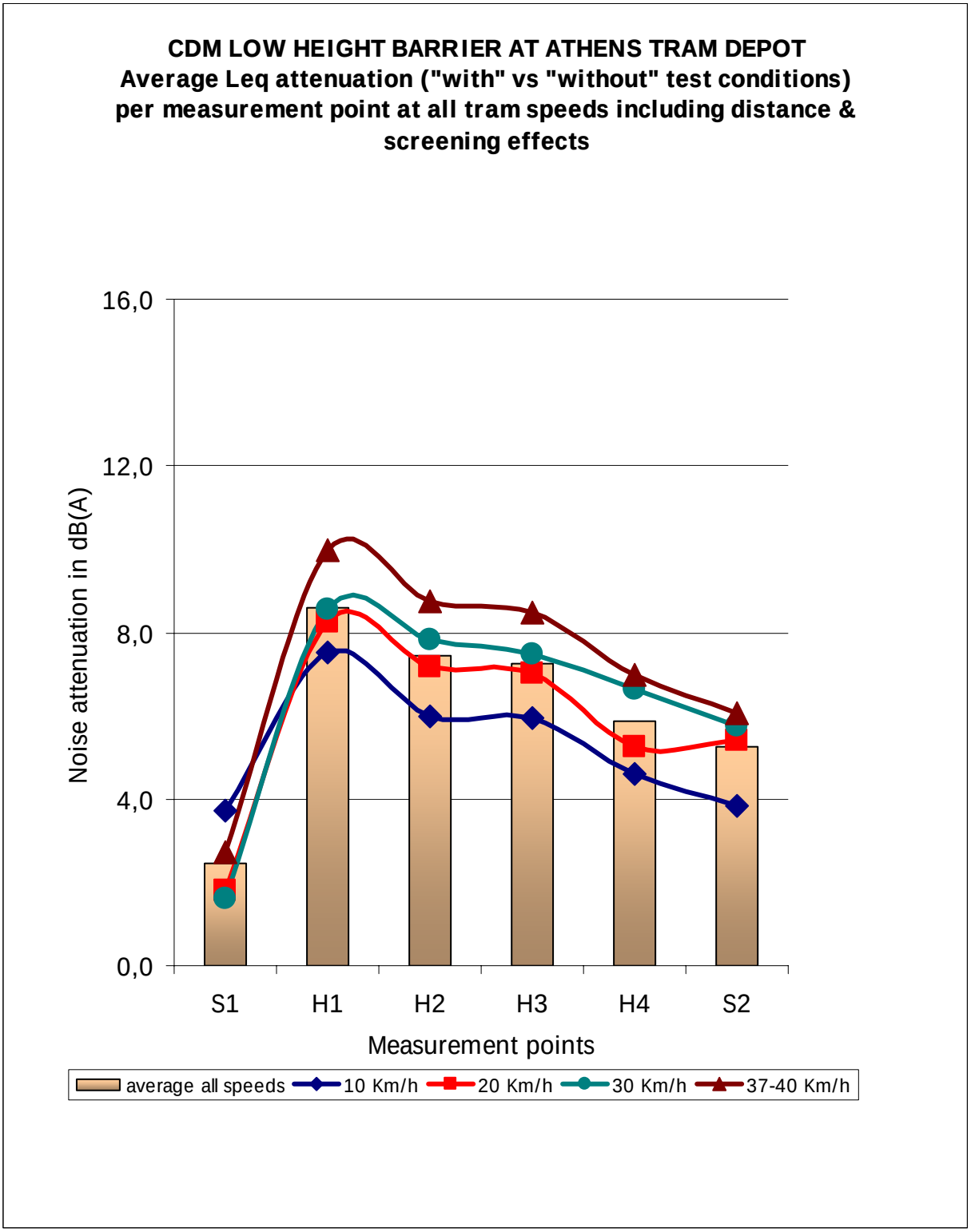

CDM LOW HEIGHT BARRIER AT ATHENS TRAM DEPOT
Average Leq attenuation ("with" vs "without" test conditions)
per measurement point at all tram speeds including distance &
screening effects
16,0
12,0
8,0
4,0
0,0
Noise attenuation in dB(A)
S1
H1
H2
H3
H4
S2
Measurement points
average all speeds
10 Km/h
20 Km/h
30 Km/h
37-40 Km/h

Fig. 8

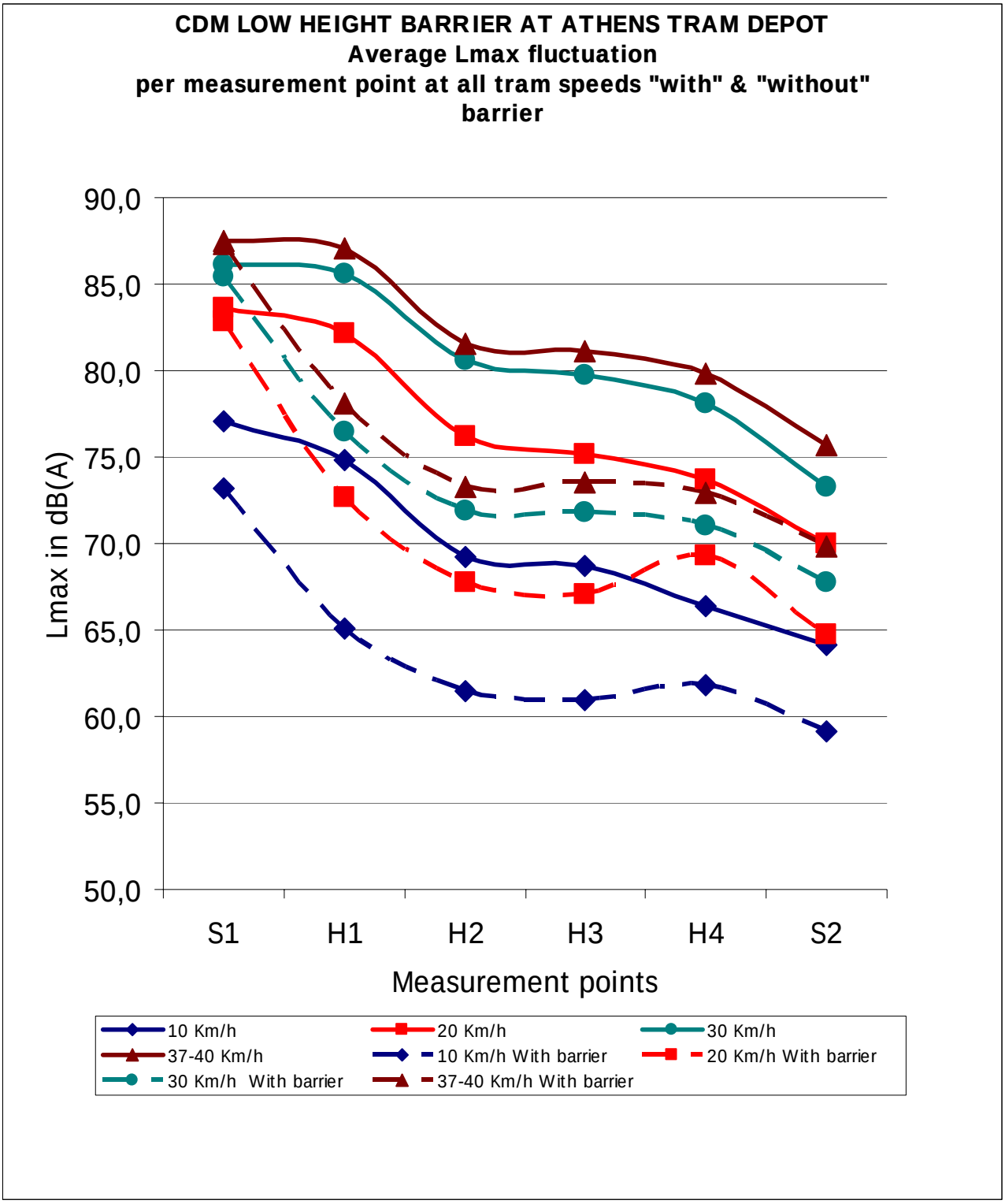

CDM LOW HEIGHT BARRIER AT ATHENS TRAM DEPOT
Average Lmax fluctuation
per measurement point at all tram speeds "with" & "without" barrier
Lmax in dB(A)
90,0
85,0
80,0
75,0
70,0
65,0
60,0
55,0
50,0
S1
H1
H2
H3
H4
S2
Measurement points
10 Km/h
20 Km/h
30 Km/h
37-40 Km/h
10 Km/h With barrier
20 Km/h With barrier
30 Km/h With barrier
37-40 Km/h With barrier

Fig. 9

3.2 Approach 2

By this approach – as also per D 4.3 - the differences of average Lmax values between all points vs the reference point S1 were calculated for each speed level and for both "with" & "without barrier" tests (see tables & figures hereafter). By this approach and given to the fact that reference point S1 reflects for both tests the source emission with no distance interference, the results of the relevant tables hereafter reflects the noise attenuation at all measurement locations including both source absorption/screening effect and distance attenuation. By abstracting the attenuation values of "with barrier" test from the relative values of the "without barrier" test, the insertion loss of the barrier it self is then calculated. The relevant approach is presented in the figures hereafter. This approach has the advantage of normalizing the source strength of the tram (see relevant negative point in approach 1 above) to account for effects from deviations in speed etc., but has also the possible drawback of underestimating the insertion loss (IL) of the barrier due to duct attenuation effects.

Based on the above approach **an average insertion loss of approx. 5,9 dB(A) ± 2,2 dB(A)** was calculated for the measurement points H1,H2,H3,H4 & S2 by the use of this type of low absorbing platform barrier.

Table 5
Average Lmax attenuation for CDM low height barrier per measurement point vs reference point S1 for "Without" & "WITH " tests including distance effect

Attenuation from S1 reference point to all measurement points	Vehicle Speed (Km/h) for "Without" – "With" tests							
	10 Km/h Without barrier	**20 Km/h Without barrier**	**30 Km/h Without barrier**	**37-40 Km/h Without barrier**	**10 Km/h With barrier**	**20 Km/h With barrier**	**30 Km/h With barrier**	**37-40 Km/h With barrier**
S1-H1	2,2	1,5	0,6	0,4	8,1	10,2	9,0	9,3
S1-H2	7,8	7,4	5,6	6,0	11,8	15,1	13,5	14,1
S1-H3	8,3	8,5	6,4	6,4	12,2	15,7	13,6	13,8
S1-H4	10,6	9,9	8,1	7,7	11,4	13,5	14,4	14,4
S1-S2	12,9	13,7	12,9	11,8	14,1	18,1	17,7	17,5

Table 6
Lmax index average insertion loss for the CDM Low height barrier per measurement point for "Without" & "WITH" tests

Measurement point	10 Km/h	20 Km/h	30 Km/h	37-40 Km/h	Averages & st.deviation for all speeds	
H1 (d=3,75 H=0,6)	5,9	8,7	8,4	8,8	**8,0**	1,4
H2 (d=7,5 H=1,2)	3,9	7,6	7,9	8,1	**6,9**	2,0
H3 (d=10 H=1,2)	3,9	7,3	7,3	7,4	**6,5**	1,7
H4 (d=10 H=4,0)	0,7	3,6	6,3	5,1	**4,4**	2,8
S2 (d=25 H=1,2)	1,2	4,5	4,8	5,7	**4,0**	2,0
Average H2/H3/H4 points/all speeds					**5,9**	**2,2**

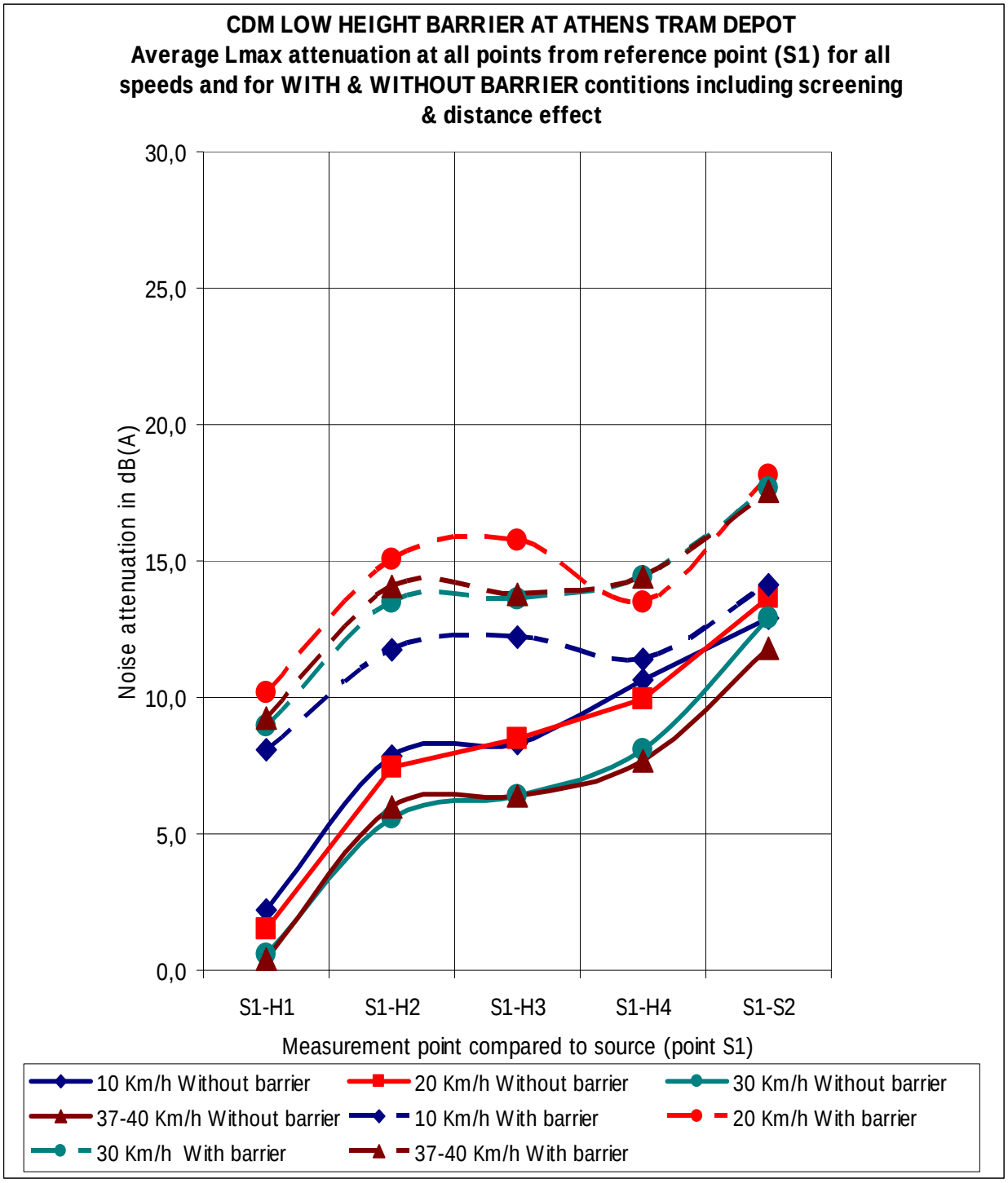

CDM LOW HEIGHT BARRIER AT ATHENS TRAM DEPOT
Average Lmax attenuation at all points from reference point (S1) for all speeds and for WITH & WITHOUT BARRIER contitions including screening & distance effect
30,0
25,0
20,0
15,0
10,0
5,0
0,0
Noise attenuation in dB(A)
S1-H1
S1-H2
S1-H3
S1-H4
S1-S2
Measurement point compared to source (point S1)
10 Km/h Without barrier
20 Km/h Without barrier
30 Km/h Without barrier
37-40 Km/h Without barrier
10 Km/h With barrier
20 Km/h With barrier
30 Km/h With barrier
37-40 Km/h With barrier

Fig. 10

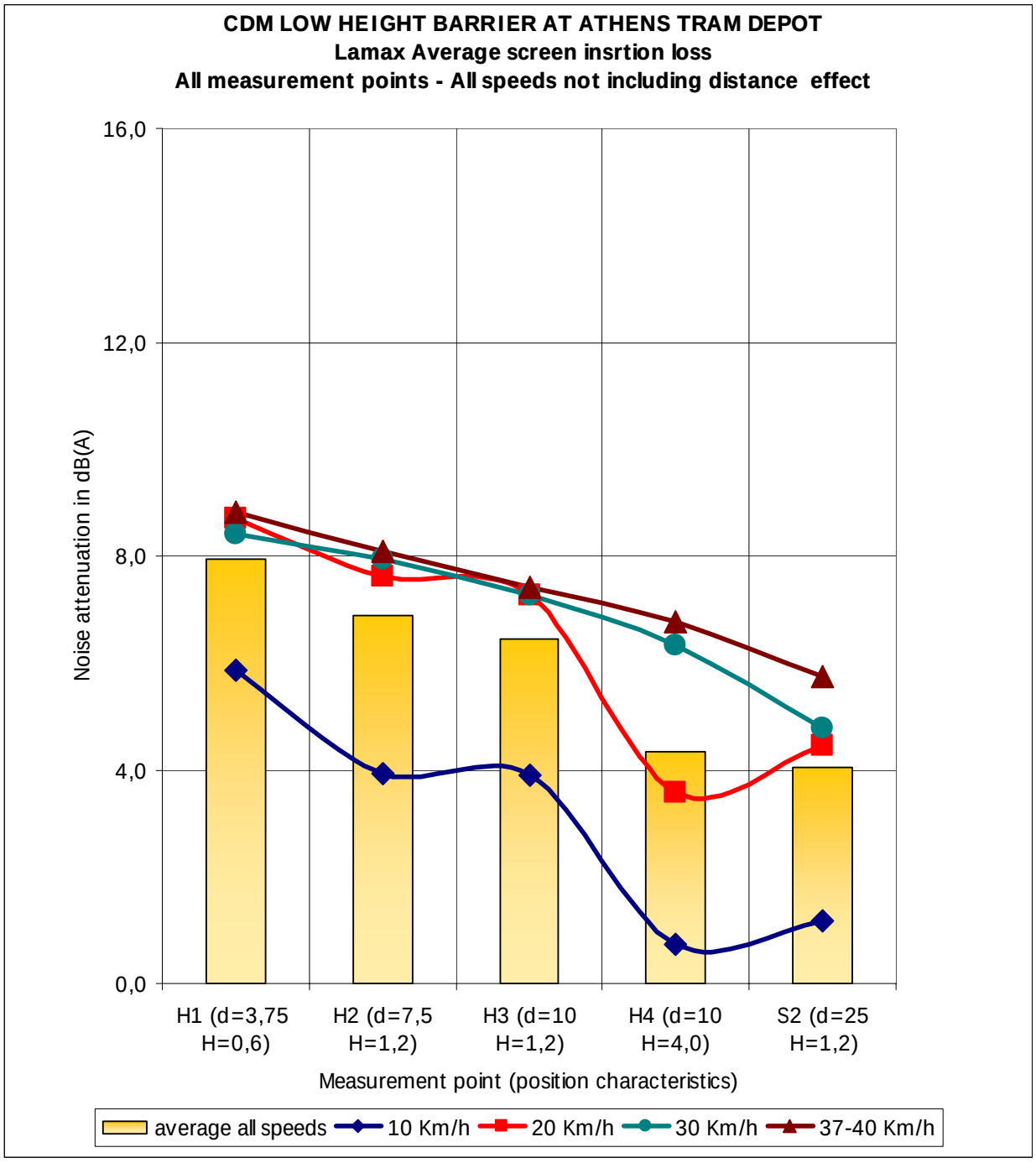

CDM LOW HEIGHT BARRIER AT ATHENS TRAM DEPOT
Lamax Average screen insrtion loss
All measurement points - All speeds not including distance effect
16,0
12,0
8,0
4,0
0,0
Noise attenuation in dB(A)
H1 (d=3,75 H=0,6)
H2 (d=7,5 H=1,2)
H3 (d=10 H=1,2)
H4 (d=10 H=4,0)
S2 (d=25 H=1,2)
Measurement point (position characteristics)
average all speeds
10 Km/h
20 Km/h
30 Km/h
37-40 Km/h

Fig. 11

4. DISCUSSION AND CONCLUDING REMARKS

Based on the above results we can conclude the following remarks & conclusions regarding the noise attenuation that can be achieved from the tested CDM Low height barrier for trams and trains. This rubber low height noise barrier can also ensure an important insertion los both on noise source & screening effect due to his absorbing capabilities. It was establish that **an average insertion loss varying from 7,3 dB(A) ± 0,7 dB(A) to 5,9 ± 2,2 dB(A)** (as per the presented approaches 3.1 & 3.2 above) for a speed range from 10 up to 40 Km/h is ensured by the use of this type of low absorbing platform barrier. However the tested prototype needs to be upgraded on the aesthetical & rubber crumb quality & cohesion level in order to facilitate the integration in the urban context and not creating adverse population reactions.

ANNEX 1 CDM's rubber low height platform barrier noise measurement results per pass by/speed with & without barrier

"WITHOUT" CDM BARRIER

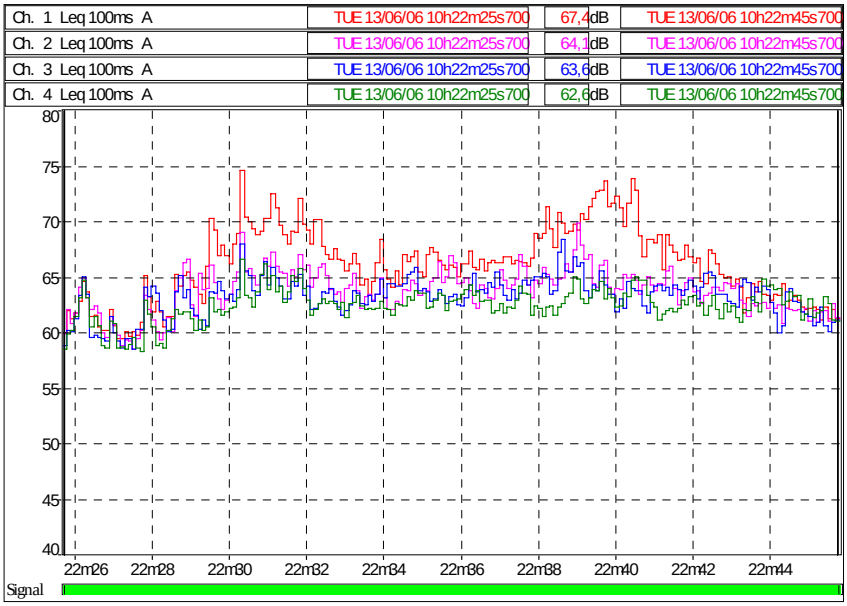
4 CHANNEL SYSTEM			
MICROPHONE LOCATION	Hor. Dist.	Height	Description
Ch. 1 (H1)	3,75	0,6	**Reference point**
Ch. 2 (H2)	7,50	1,2	**ISO 3095/2005**
Ch. 3 (H3)	10,00	1,2	**NORDIC Prediction Model**
Ch. 4 (H4)	10,00	4,0	**2002/49/EU**

2 CHANNEL SYSTEM			
MICROPHONE LOCATION	Hor. Dist.	Height	Description
Ch. 1 (S1)	1,0	1,2	**Reference point**
Ch. 2 (S2)	25,0	1,2	**ISO 3095/2005**

SPEED =10 km/h

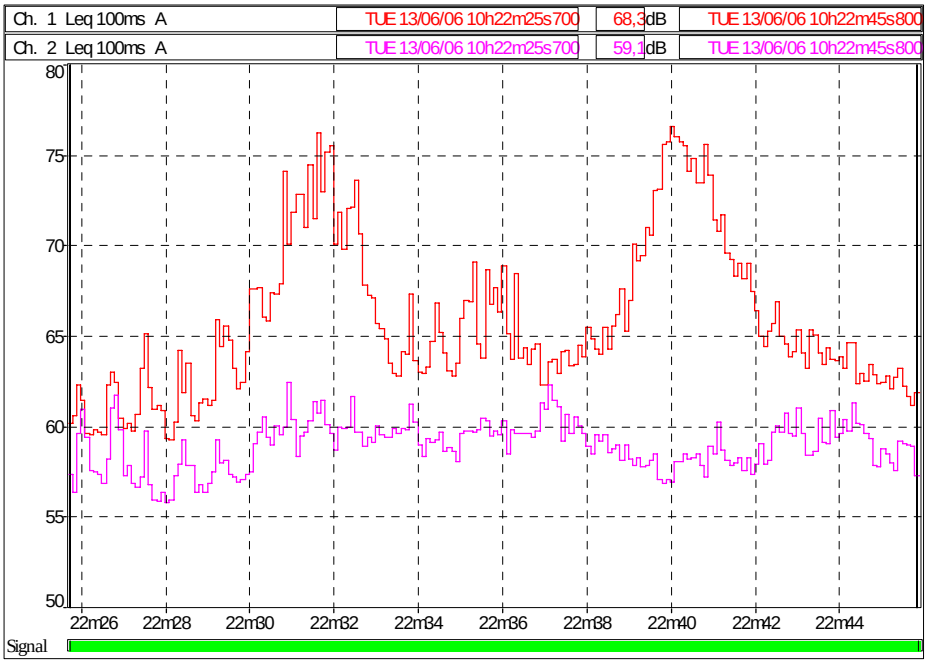
Passby1

4 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	67,4	59,4	74,6	59,5	60,4	66,2	70,2	73,5
Ch. 2	Leq	A	dB	64,1	58,4	69,9	59,1	59,9	63,8	65,9	67,7
Ch. 3	Leq	A	dB	63,6	58,5	68,4	58,7	59,6	63,4	65,1	67,1
Ch. 4	Leq	A	dB	62,6	58,3	67,0	58,4	58,8	62,4	64,0	65,7

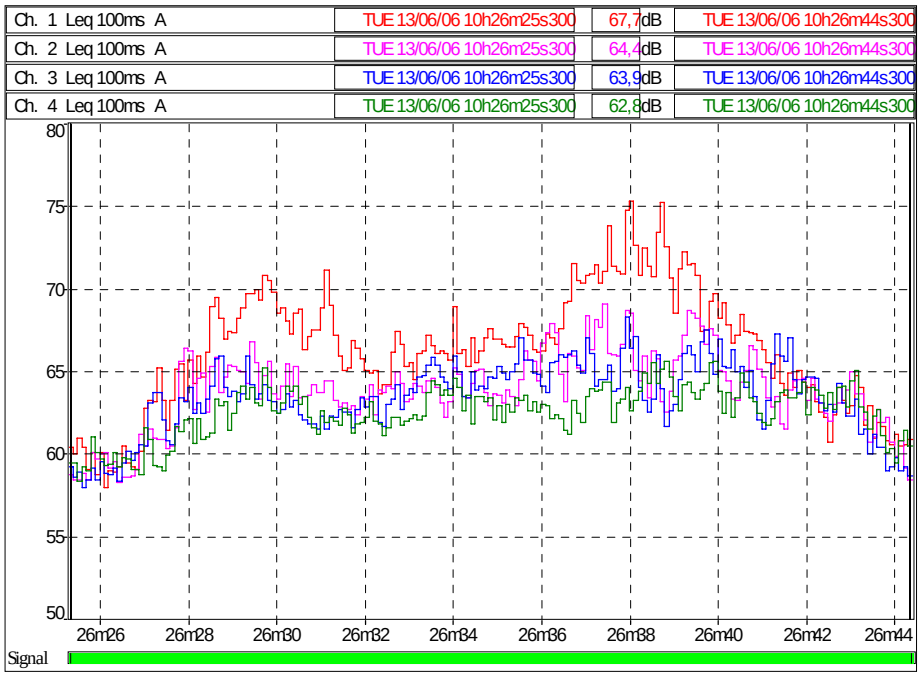
2 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	68,3	59,2	76,6	59,4	60,1	64,5	72,8	75,9
Ch. 2	Leq	A	dB	59,1	55,8	63,4	55,8	56,7	59,0	60,4	61,6

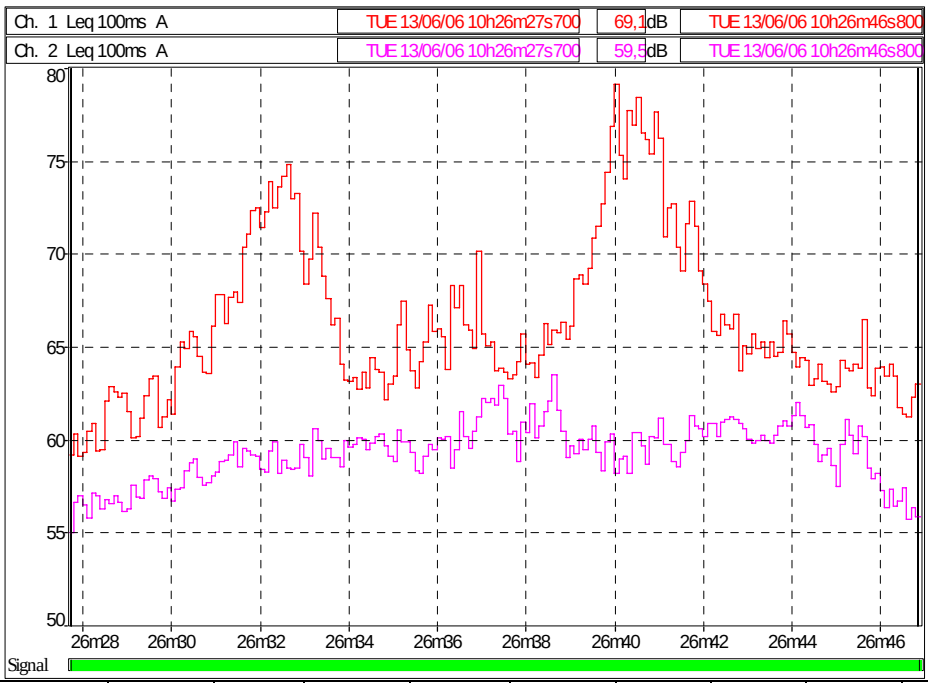
Passby2

4 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	67,7	58,0	75,3	58,6	59,9	66,3	70,8	75,1
Ch. 2	Leq	A	dB	64,4	58,3	69,0	58,3	58,7	63,7	66,5	68,6
Ch. 3	Leq	A	dB	63,9	57,9	68,3	58,2	58,9	63,5	65,9	67,4
Ch. 4	Leq	A	dB	62,8	58,3	66,2	58,6	59,2	62,5	64,2	65,5

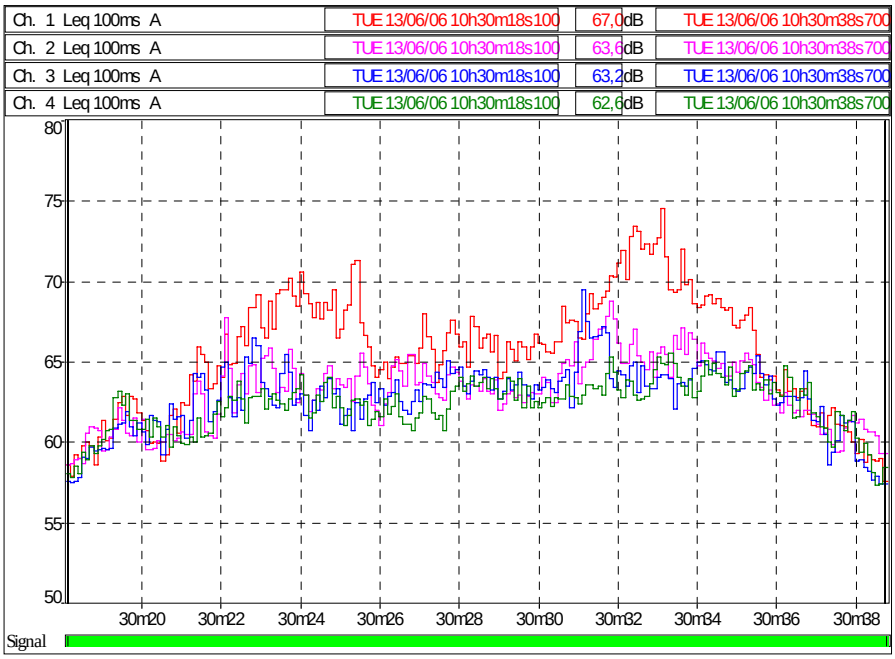
2 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	69,1	59,1	79,1	59,1	60,6	65,2	72,7	78,3
Ch. 2	Leq	A	dB	59,5	55,0	64,5	55,6	56,3	59,4	61,0	62,8

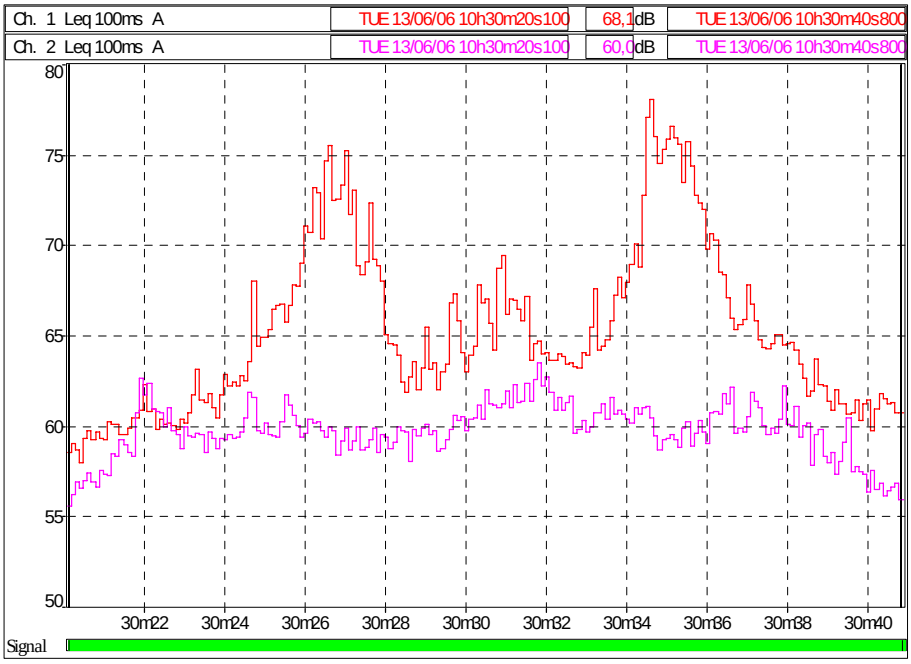
Passby3

4 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	67,0	57,6	74,5	58,5	59,1	65,8	70,0	73,0
Ch. 2	Leq	A	dB	63,6	58,5	68,7	58,6	59,4	63,1	65,5	67,7
Ch. 3	Leq	A	dB	63,2	57,4	69,4	57,4	58,5	63,0	64,8	67,0
Ch. 4	Leq	A	dB	62,6	57,3	66,0	57,7	59,2	62,6	64,0	65,1

2 CHANNEL SYSTEM

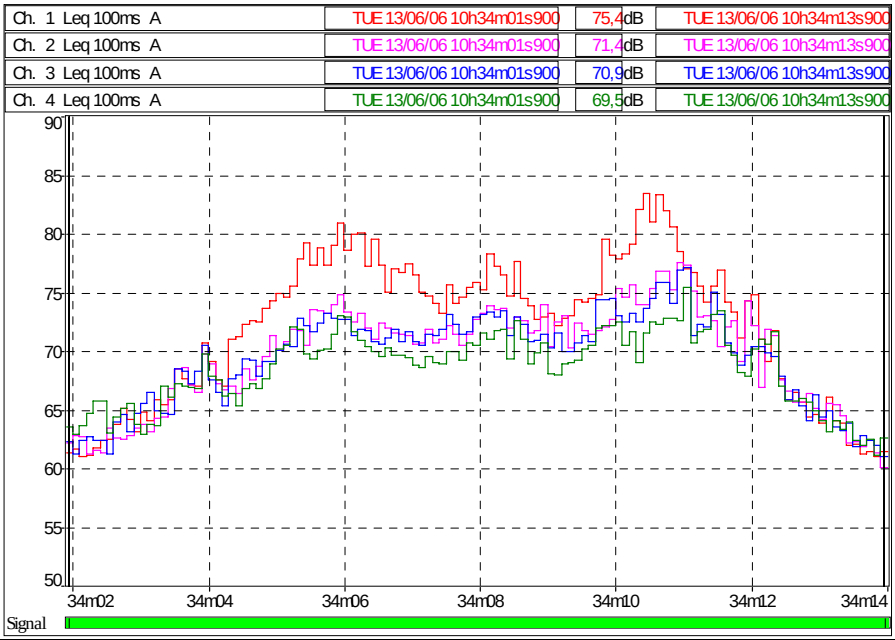


Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	68,1	58,0	78,0	58,6	59,6	64,2	72,7	76,5
Ch. 2	Leq	A	dB	60,0	55,6	64,4	56,0	56,7	59,7	61,5	62,5

SPEED =20 km/h

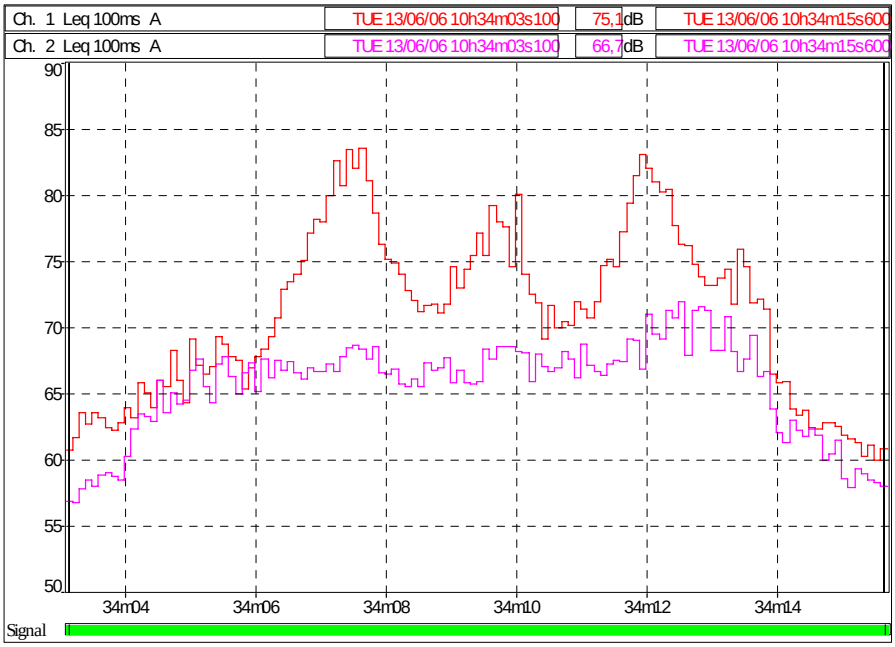
Passby1

4 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	75,4	60,4	83,4	60,8	61,0	73,7	79,0	83,3
Ch. 2	Leq	A	dB	71,4	60,0	77,6	60,0	61,2	70,9	73,8	77,2
Ch. 3	Leq	A	dB	70,9	60,9	77,1	61,1	61,9	70,3	73,2	76,8
Ch. 4	Leq	A	dB	69,5	61,1	75,4	61,8	62,8	69,1	72,1	73,3

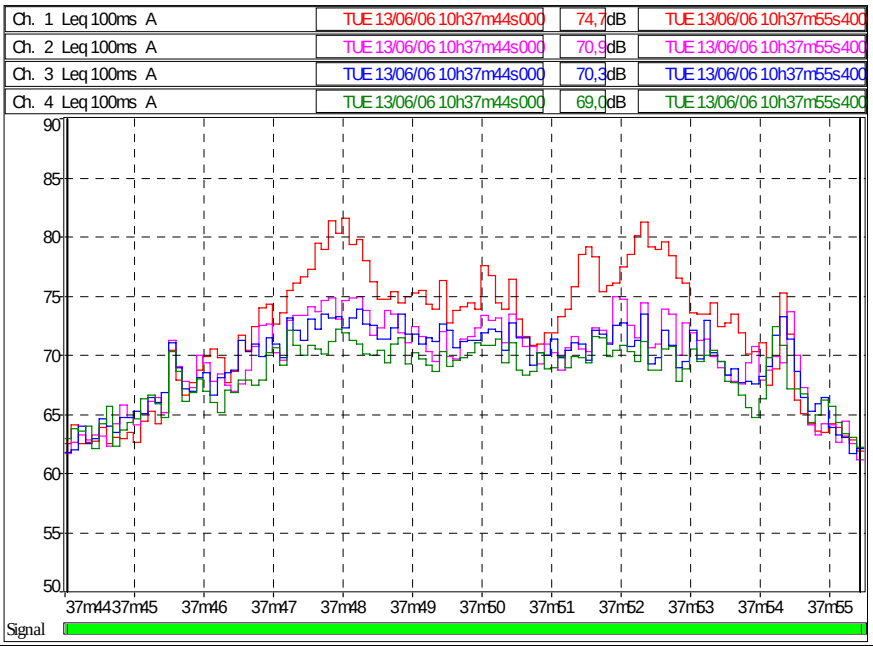
2 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	75,1	59,9	83,5	60,2	61,4	71,7	79,9	83,4
Ch. 2	Leq	A	dB	66,7	56,7	71,9	56,8	58,2	66,6	68,9	71,4

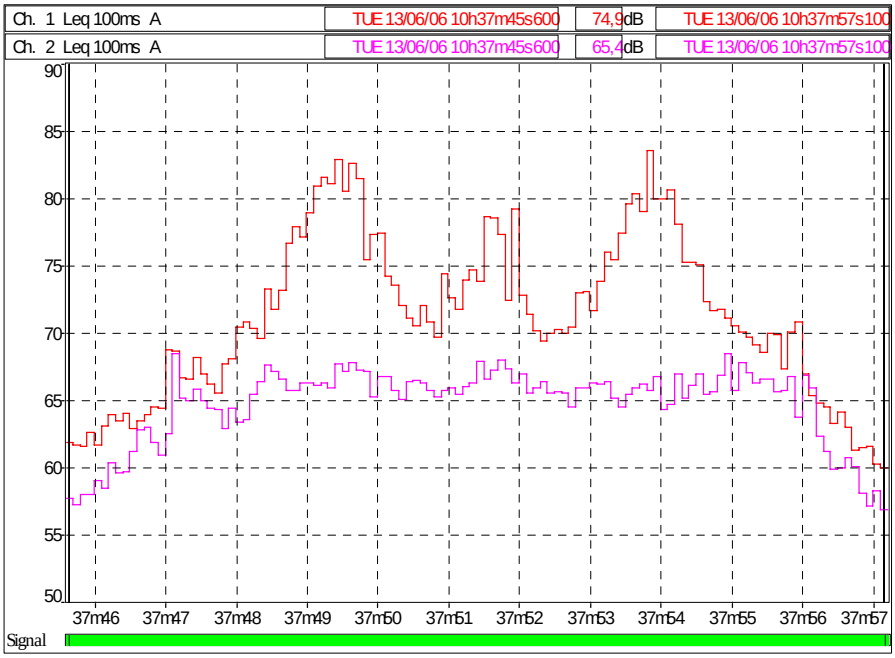
Passby2

4 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	74,7	61,8	81,5	62,3	62,5	73,3	78,8	81,2
Ch. 2	Leq	A	dB	70,9	61,1	74,9	61,6	62,5	70,4	73,6	74,8
Ch. 3	Leq	A	dB	70,3	61,6	73,8	61,6	62,8	70,3	72,6	73,3
Ch. 4	Leq	A	dB	69,0	62,1	72,4	62,1	63,2	69,0	70,9	72,1

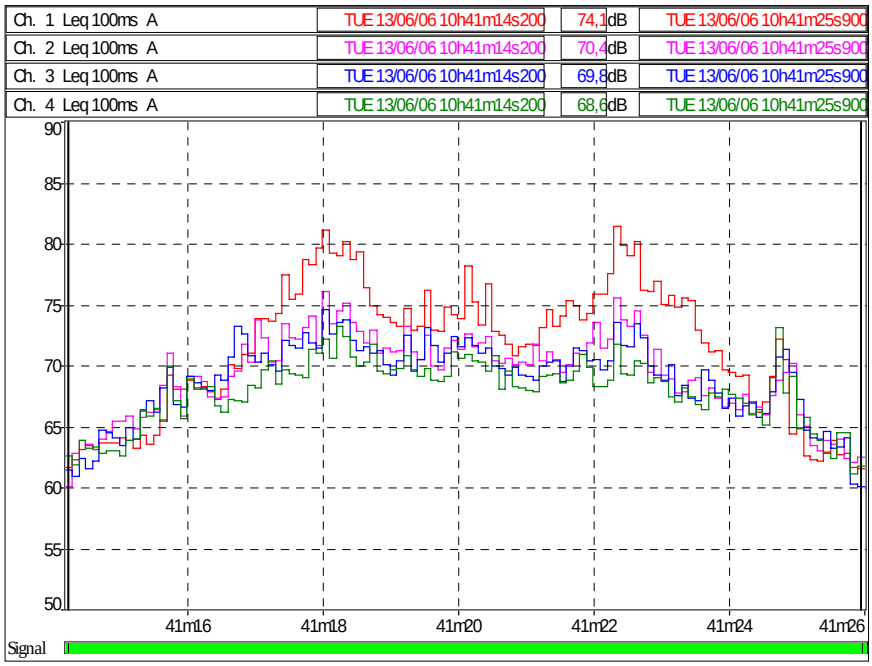
2 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	74,9	60,0	83,5	60,1	61,5	70,7	79,8	82,8
Ch. 2	Leq	A	dB	65,4	56,8	68,5	57,0	57,9	65,6	67,0	68,3

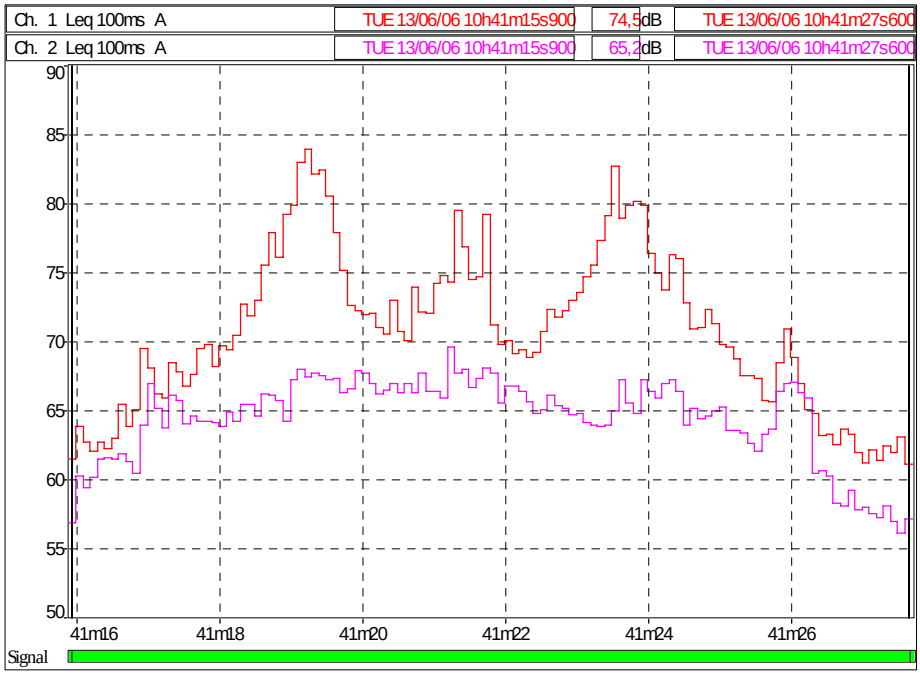
Passby3

4 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	74,1	61,5	81,5	61,5	62,2	72,7	78,6	81,0
Ch. 2	Leq	A	dB	70,4	60,1	76,1	61,9	62,9	69,9	73,3	75,4
Ch. 3	Leq	A	dB	69,8	60,1	74,6	60,2	62,0	69,6	72,3	73,7
Ch. 4	Leq	A	dB	68,6	61,1	73,3	61,6	62,5	68,3	70,7	73,0

2 CHANNEL SYSTEM

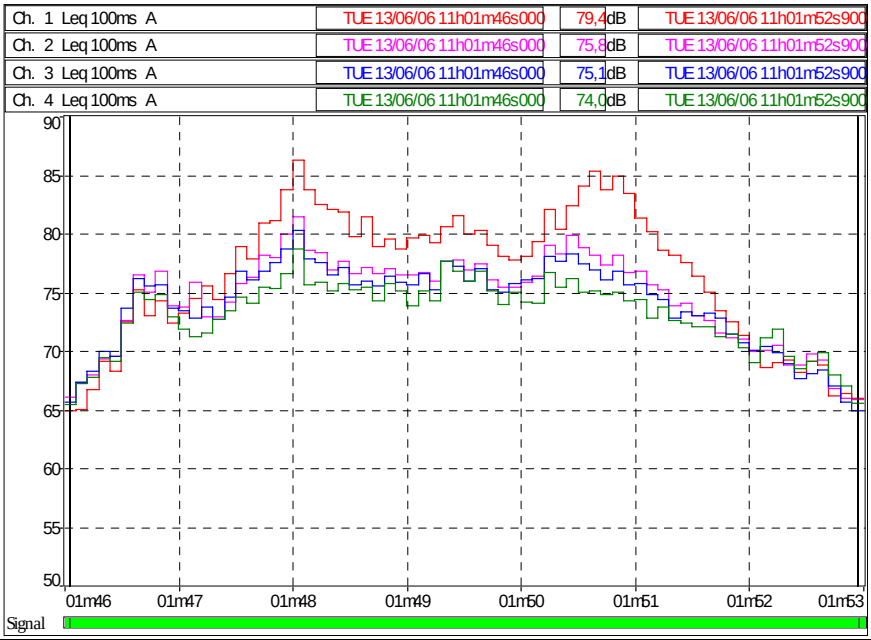


Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	74,5	61,1	83,9	61,1	61,8	70,7	79,1	82,8
Ch. 2	Leq	A	dB	65,2	56,0	69,5	56,7	57,4	65,0	67,3	67,9

SPEED =30 km/h

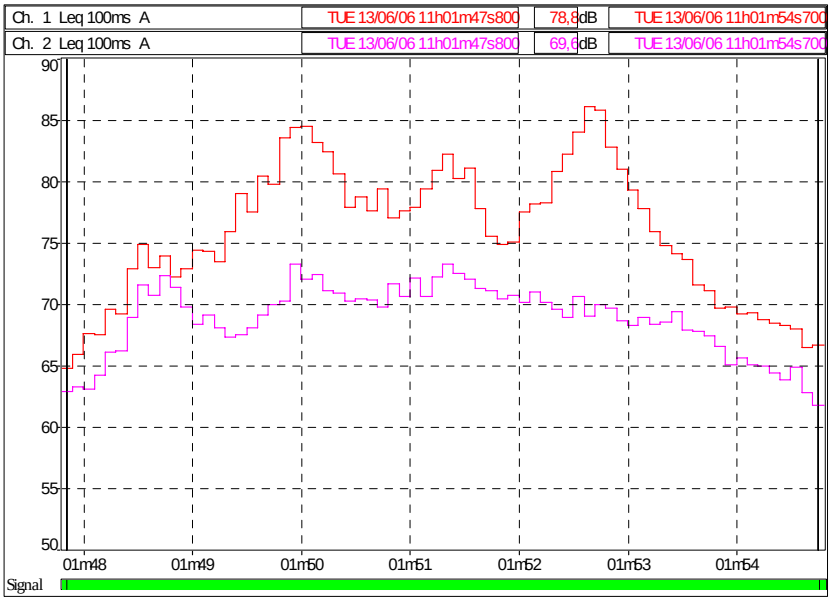
Passby1

4 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	79,4	64,9	86,3	64,8	66,1	78,1	83,6	86,2
Ch. 2	Leq	A	dB	75,8	65,9	81,4	65,8	66,7	75,8	78,2	81,3
Ch. 3	Leq	A	dB	75,1	64,9	80,3	64,8	66,9	75,4	77,5	80,2
Ch. 4	Leq	A	dB	74,0	65,4	78,7	65,3	67,1	74,0	76,1	78,6

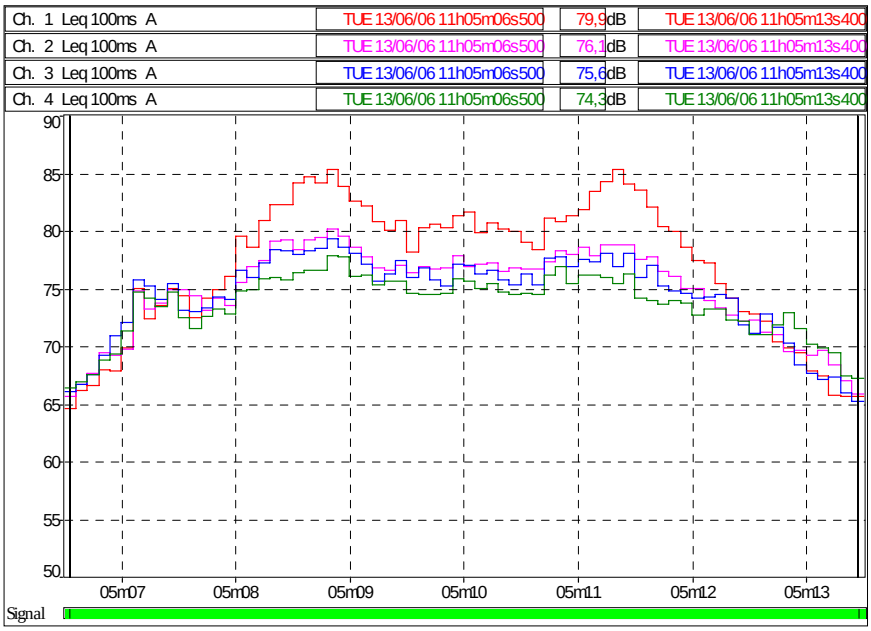
2 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	78,8	64,8	86,1	64,7	66,5	76,9	83,0	86,0
Ch. 2	Leq	A	dB	69,6	61,8	73,2	61,7	63,0	69,5	72,1	73,1

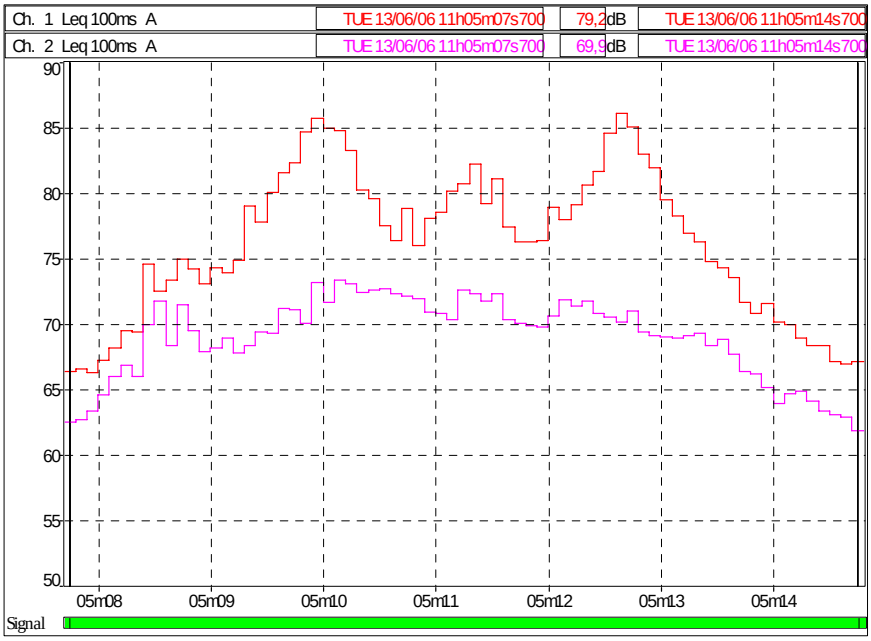
Passby2

4 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	79,9	64,6	85,3	64,5	65,7	79,4	83,9	85,2
Ch. 2	Leq	A	dB	76,1	65,6	80,2	65,5	66,9	76,4	78,7	80,1
Ch. 3	Leq	A	dB	75,6	65,2	79,3	65,1	66,6	75,5	77,9	79,3
Ch. 4	Leq	A	dB	74,3	66,3	77,8	66,2	67,3	74,4	76,1	77,7

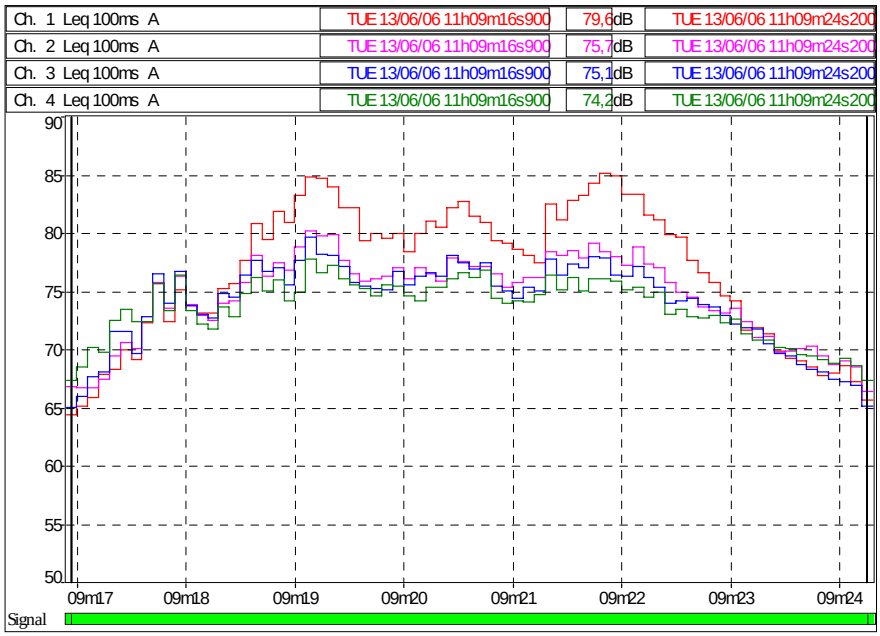
2 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	79,2	66,3	86,1	66,2	66,8	76,3	83,2	86,0
Ch. 2	Leq	A	dB	69,9	61,8	73,3	61,7	62,8	69,4	72,3	73,2

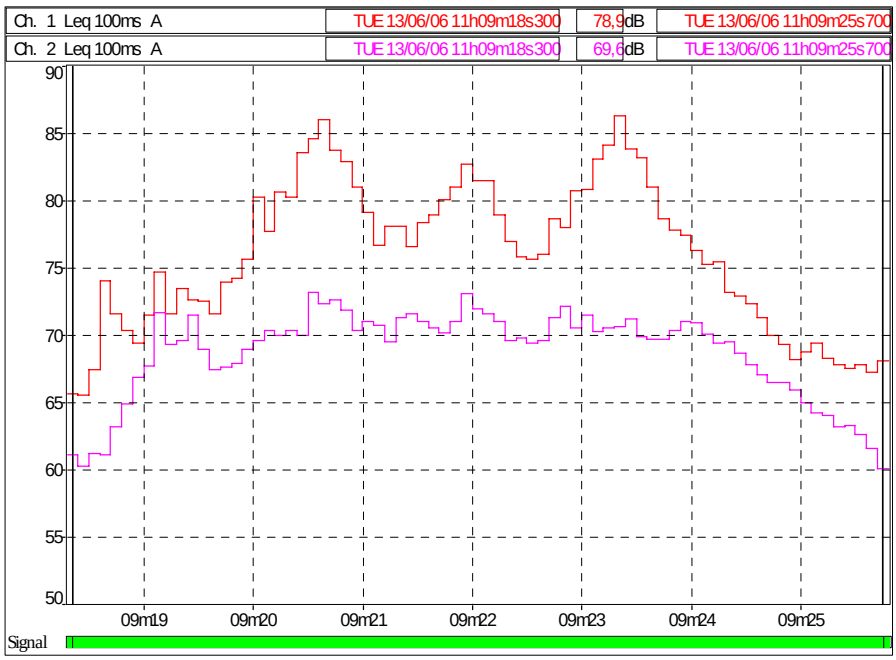
Passby3

4 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	79,6	64,4	85,1	64,3	65,8	78,5	83,2	85,0
Ch. 2	Leq	A	dB	75,7	66,4	80,1	66,3	66,7	75,7	78,3	80,0
Ch. 3	Leq	A	dB	75,1	65,0	79,7	64,9	66,8	75,2	77,5	79,6
Ch. 4	Leq	A	dB	74,2	67,3	77,7	67,2	68,4	74,1	76,1	77,6

2 CHANNEL SYSTEM

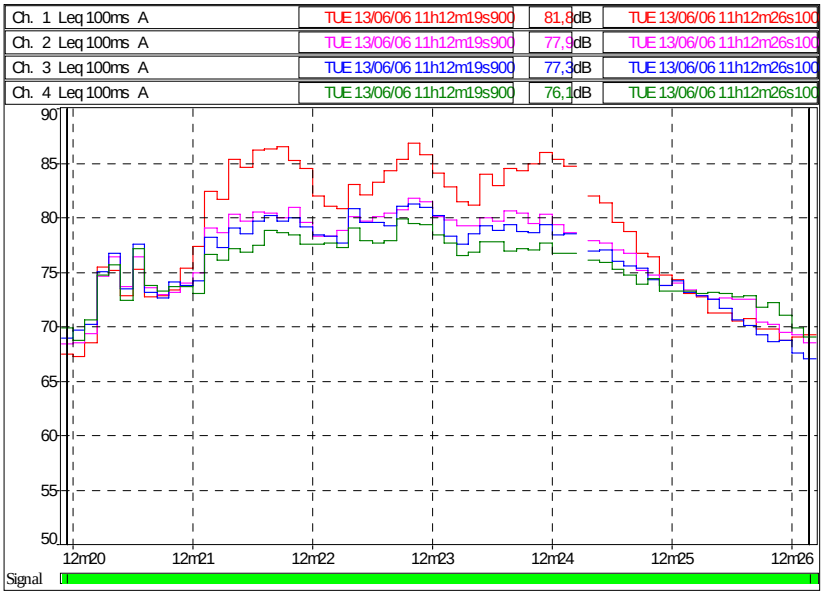


Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	78,9	65,5	86,2	65,4	67,3	76,2	83,1	86,1
Ch. 2	Leq	A	dB	69,6	60,1	73,2	60,0	61,0	69,6	71,6	73,1

SPEED =30+ km/h

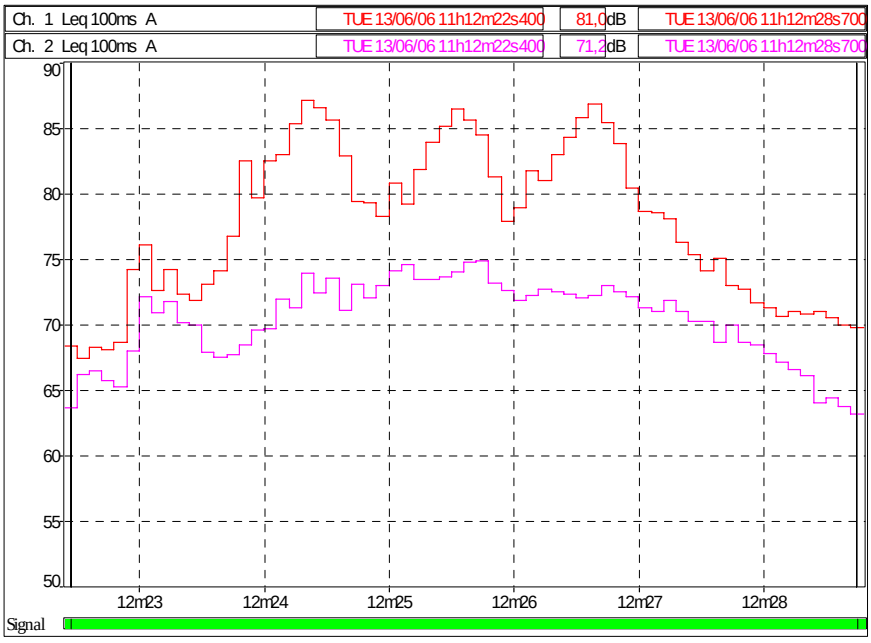
Passby1

4 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	81,8	67,2	86,8	67,1	68,6	81,0	85,3	86,7
Ch. 2	Leq	A	dB	77,9	68,3	81,7	68,3	69,1	78,2	80,3	81,6
Ch. 3	Leq	A	dB	77,3	67,0	81,3	66,9	68,6	77,4	79,9	81,2
Ch. 4	Leq	A	dB	76,1	68,7	79,8	68,6	69,8	76,4	78,3	79,7

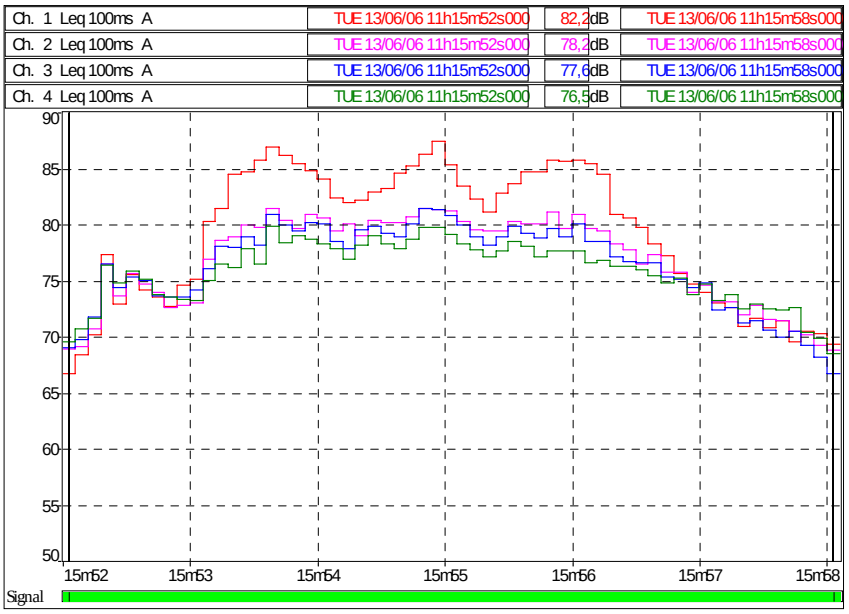
2 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	81,0	67,4	87,1	67,3	68,3	78,4	85,5	87,0
Ch. 2	Leq	A	dB	71,2	63,2	74,9	63,1	63,9	71,1	73,5	74,8

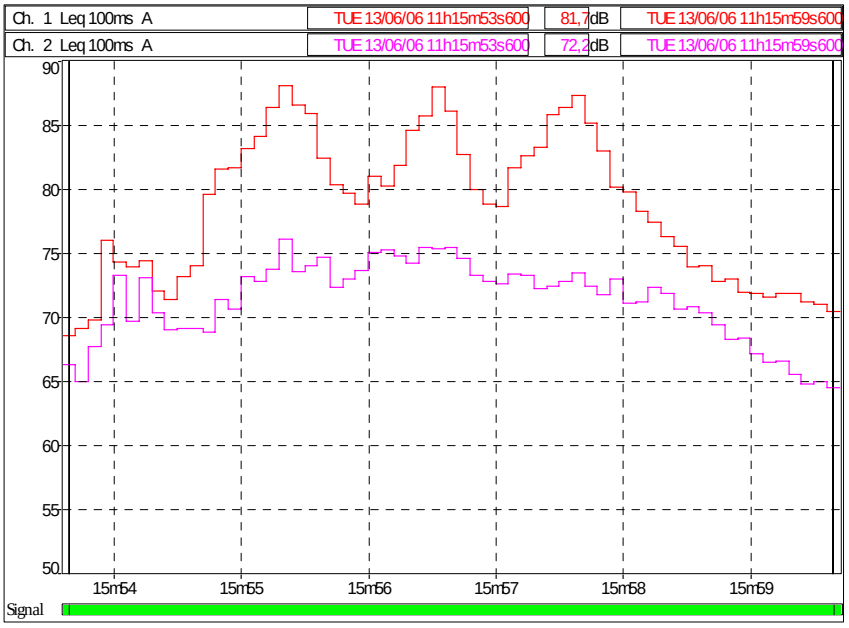
Passby2

4 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	82,2	66,7	87,4	66,6	69,4	81,0	85,6	87,3
Ch. 2	Leq	A	dB	78,2	68,8	81,5	68,7	69,2	78,4	80,8	81,4
Ch. 3	Leq	A	dB	77,6	66,7	81,5	66,6	69,1	77,8	80,0	81,4
Ch. 4	Leq	A	dB	76,5	68,5	79,9	68,4	70,3	76,3	78,6	79,8

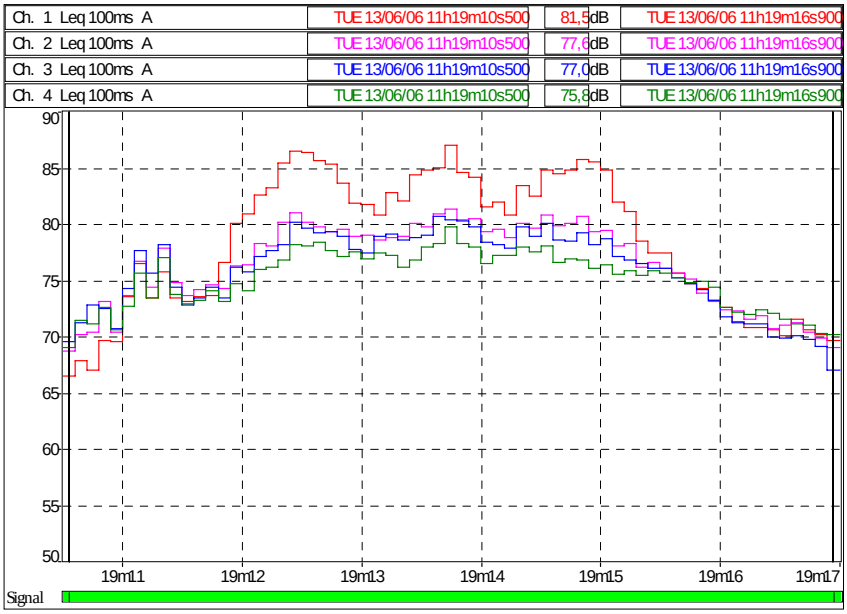
2 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	81,7	68,5	88,0	68,4	70,3	79,5	86,0	88,0
Ch. 2	Leq	A	dB	72,2	64,5	76,1	64,4	64,9	72,2	74,7	76,0

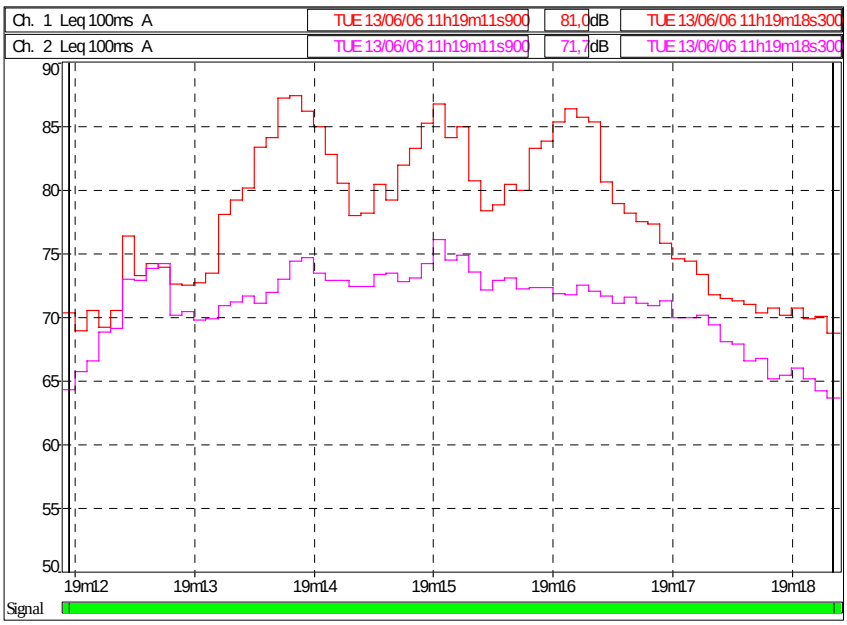
Passby3

4 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	81,5	66,5	87,0	66,4	69,4	80,7	85,4	86,9
Ch. 2	Leq	A	dB	77,6	68,7	81,4	68,6	70,1	77,7	80,2	81,3
Ch. 3	Leq	A	dB	77,0	67,0	80,6	67,0	69,7	77,0	79,6	80,6
Ch. 4	Leq	A	dB	75,8	69,0	79,8	68,9	70,5	75,8	77,9	79,7

2 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	81,0	68,7	87,4	68,6	69,8	78,0	85,2	87,3
Ch. 2	Leq	A	dB	71,7	63,6	76,1	63,6	65,0	71,6	74,1	76,0

"WITH" CDM BARRIER

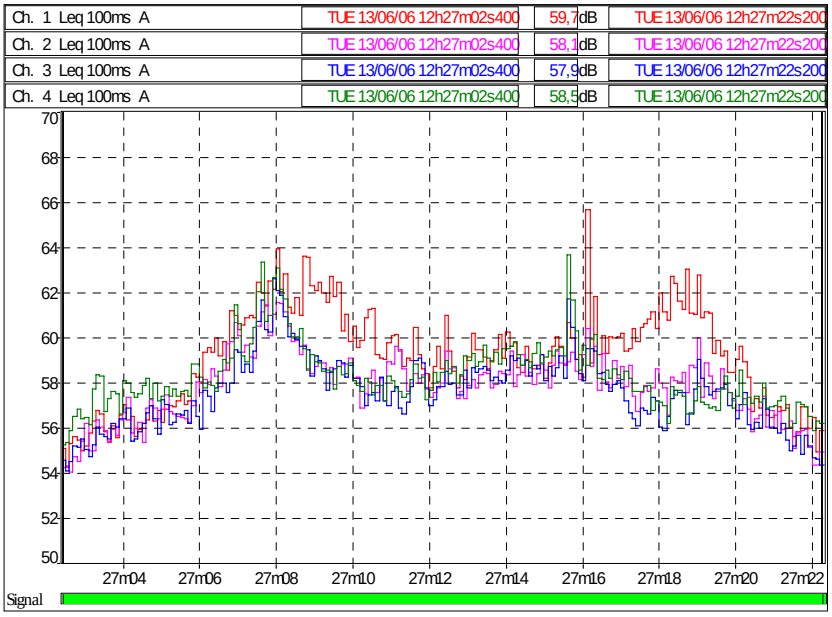
4 CHANNEL SYSTEM			
MICROPHONE LOCATION	Hor. Dist.	Height	Description
Ch. 1 (H1)	3,75	0,6	**Reference point**
Ch. 2 (H2)	7,50	1,2	**ISO 3095/2005**
Ch. 3 (H3)	10,00	1,2	**NORDIC Prediction Model**
Ch. 4 (H4)	10,00	4,0	**2002/49/EU**

2 CHANNEL SYSTEM			
MICROPHONE LOCATION	Hor. Dist.	Height	Description
Ch. 1 (S1)	1,0	1,2	**Reference point**
Ch. 2 (S2)	25,0	1,2	**ISO 3095/2005**

SPEED =10 km/h

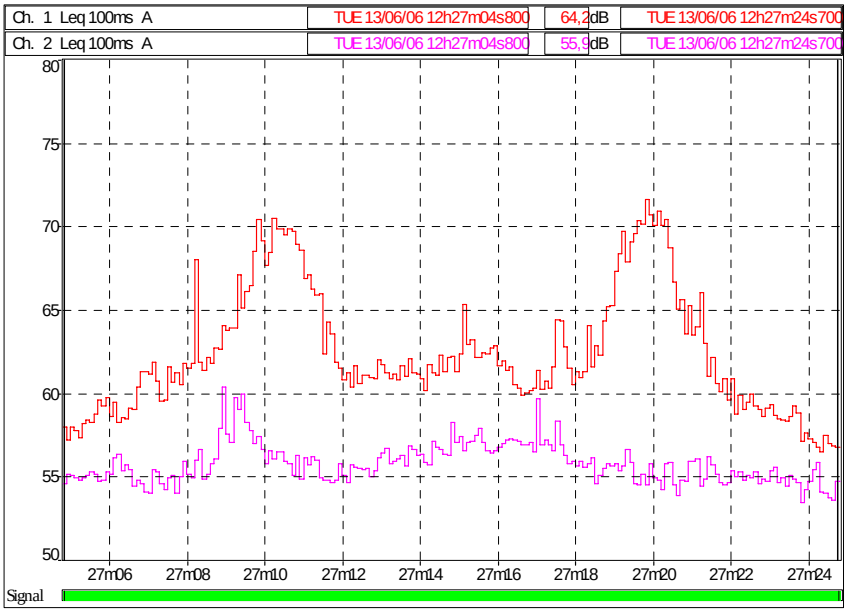
Passby1

4 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	59,7	54,3	65,7	54,8	55,5	59,2	61,9	63,8
Ch. 2	Leq	A	dB	58,1	54,0	61,5	54,1	54,9	57,9	59,5	61,4
Ch. 3	Leq	A	dB	57,9	54,1	62,6	54,3	55,0	57,6	59,3	62,0
Ch. 4	Leq	A	dB	58,5	55,3	63,7	55,2	56,2	58,0	59,8	63,2

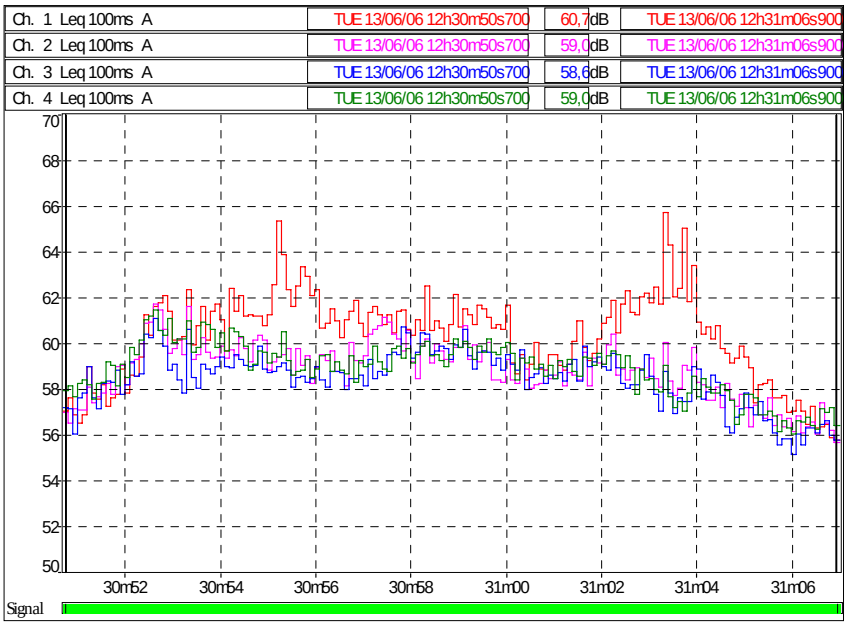
2 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	64,2	56,5	71,6	56,7	57,3	61,4	68,8	70,8
Ch. 2	Leq	A	dB	55,9	53,4	60,4	53,6	54,1	55,6	57,0	59,9

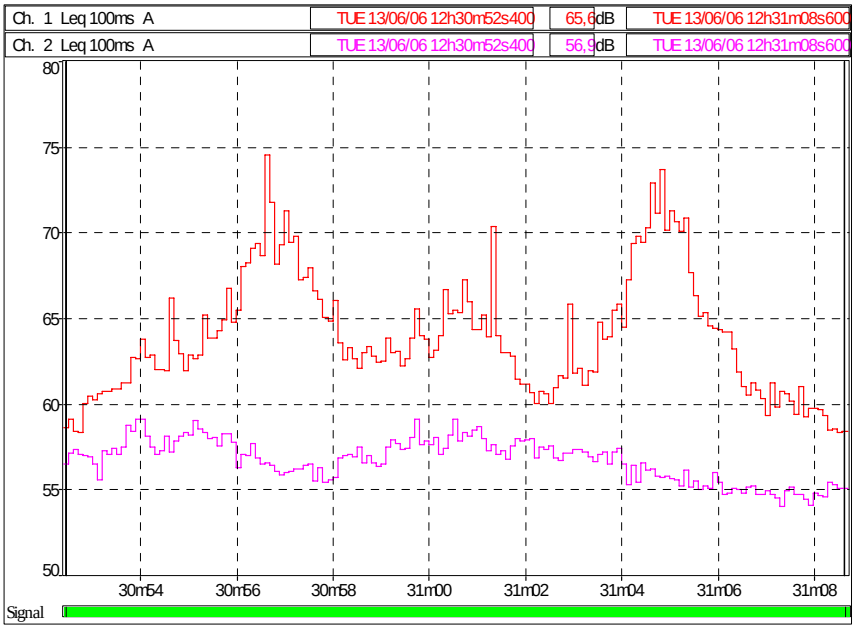
Passby2

4 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	60,7	55,8	65,7	55,8	56,8	60,6	62,2	65,3
Ch. 2	Leq	A	dB	59,0	55,6	61,7	55,9	56,3	58,9	60,2	61,5
Ch. 3	Leq	A	dB	58,6	55,1	61,1	55,5	55,9	58,6	59,6	60,6
Ch. 4	Leq	A	dB	59,0	56,0	61,5	56,0	56,5	59,0	60,1	61,1

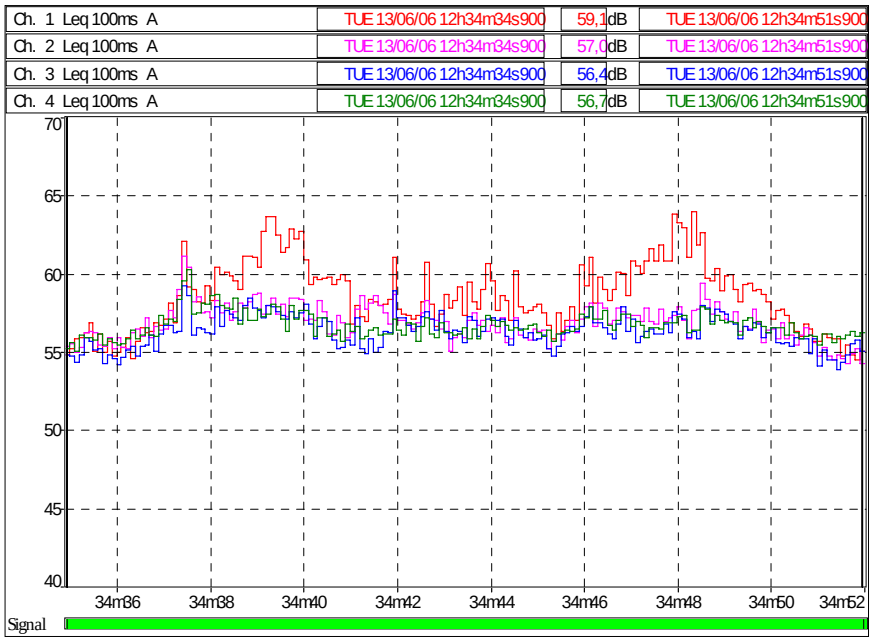
2 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	65,6	58,3	74,5	58,2	59,1	63,1	69,3	73,6
Ch. 2	Leq	A	dB	56,9	54,0	59,1	54,0	54,6	56,8	58,0	59,0

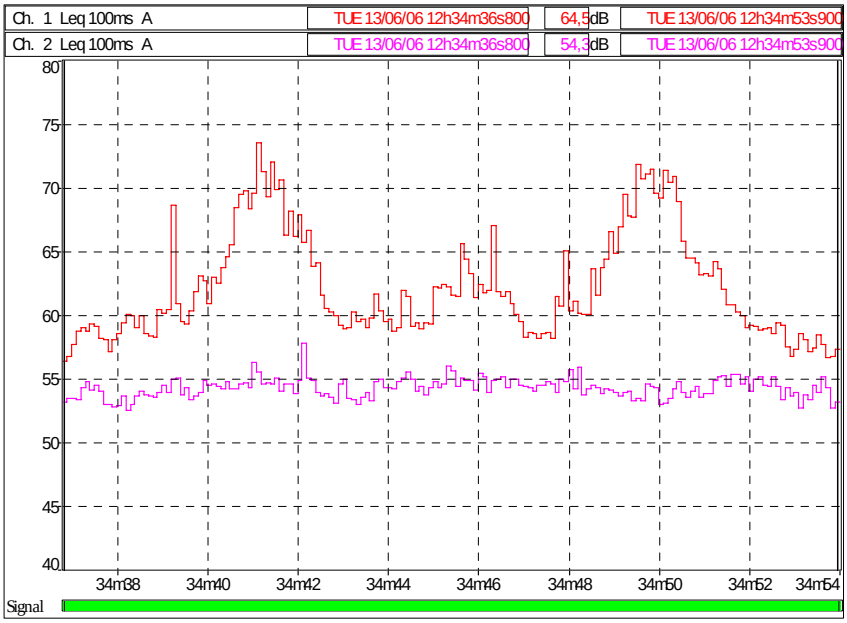
Passby3

4 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	59,1	54,5	63,9	54,5	54,9	58,2	61,3	63,7
Ch. 2	Leq	A	dB	57,0	54,3	61,1	54,2	54,9	56,9	58,2	60,3
Ch. 3	Leq	A	dB	56,4	53,9	59,2	54,0	54,4	56,2	57,5	58,8
Ch. 4	Leq	A	dB	56,7	55,0	60,3	55,1	55,5	56,5	57,6	59,4

2 CHANNEL SYSTEM

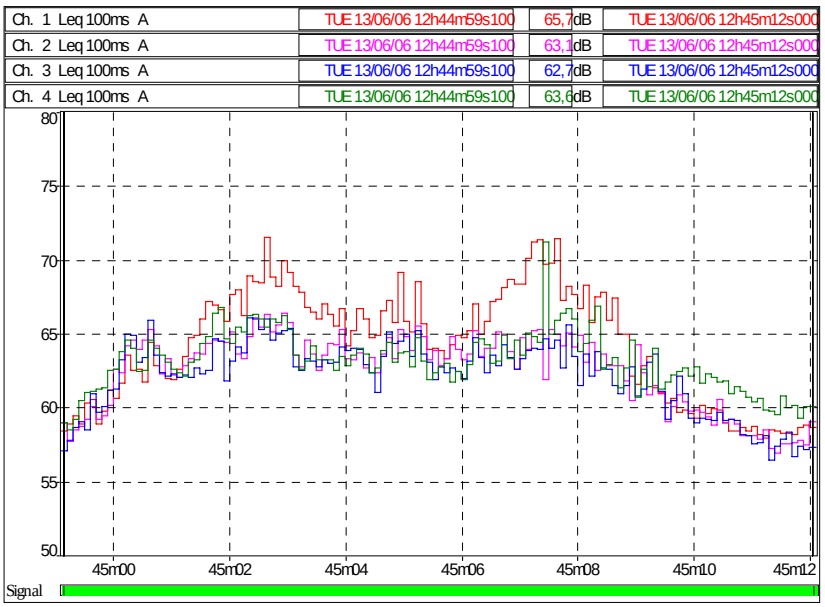


Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	64,5	56,3	73,5	56,5	57,3	60,7	69,2	72,0
Ch. 2	Leq	A	dB	54,3	52,5	57,8	52,6	52,9	54,2	55,0	56,2

SPEED =20 km/h

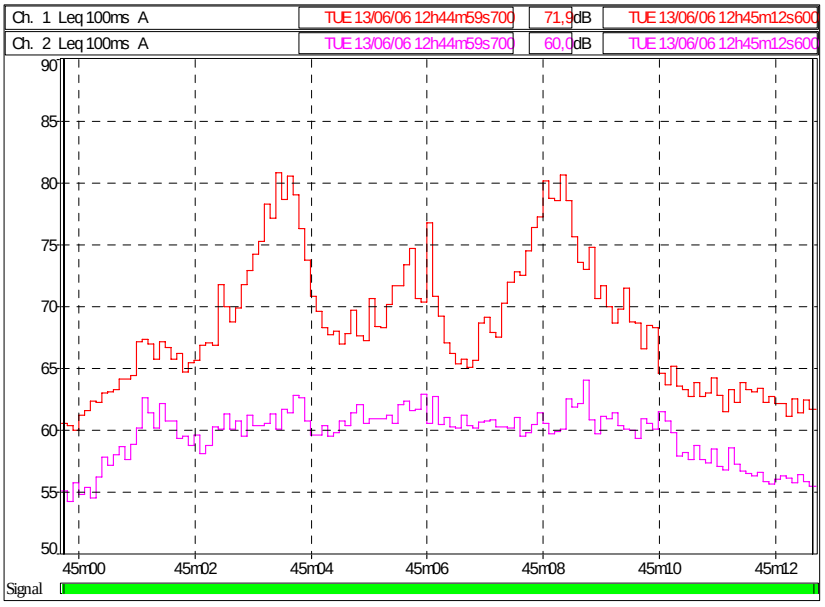
Passby1

4 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	65,7	57,9	71,5	58,0	58,3	64,8	68,6	71,4
Ch. 2	Leq	A	dB	63,1	56,9	66,4	57,1	57,6	63,2	65,1	66,2
Ch. 3	Leq	A	dB	62,7	56,5	66,0	56,6	57,3	62,6	64,9	65,9
Ch. 4	Leq	A	dB	63,6	58,5	71,2	58,9	59,7	63,0	65,8	66,7

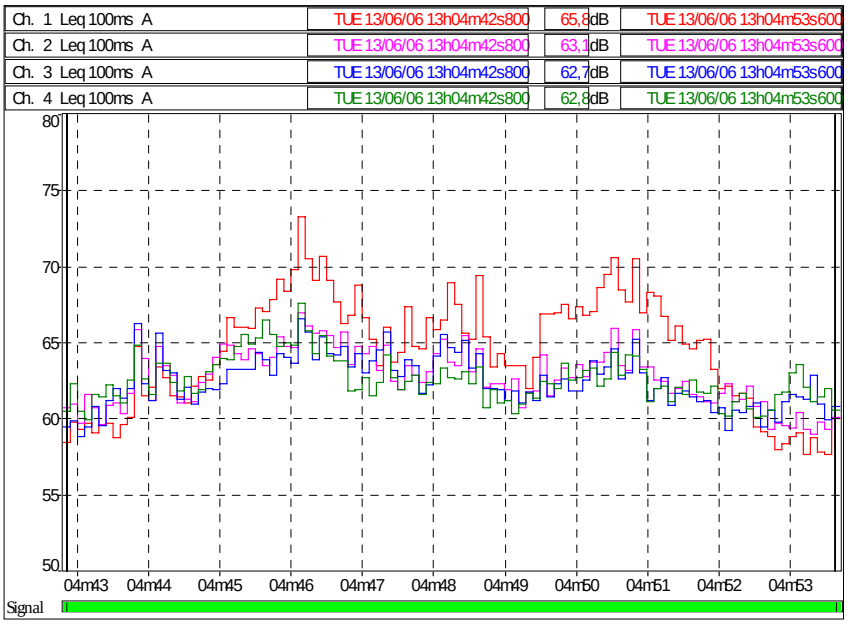
2 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	71,9	60,0	80,8	60,2	61,4	67,6	76,7	80,5
Ch. 2	Leq	A	dB	60,0	54,2	64,0	54,4	55,6	60,0	61,7	62,8

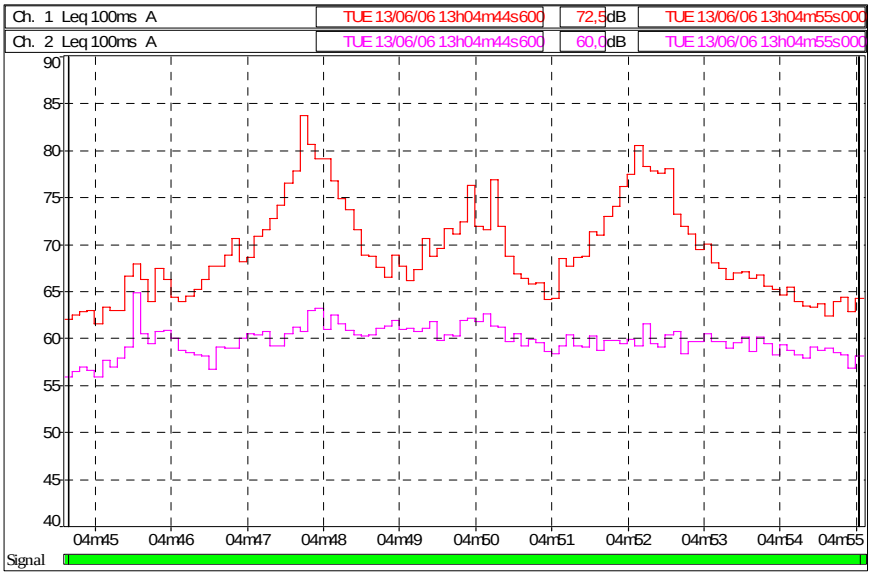
Passby2

4 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	65,8	57,6	73,3	57,5	58,3	64,8	69,0	70,5
Ch. 2	Leq	A	dB	63,1	59,0	67,0	59,2	59,4	62,6	65,3	66,0
Ch. 3	Leq	A	dB	62,7	58,8	66,6	59,1	59,4	62,1	64,5	66,1
Ch. 4	Leq	A	dB	62,8	59,9	67,6	60,0	60,2	62,2	64,7	66,3

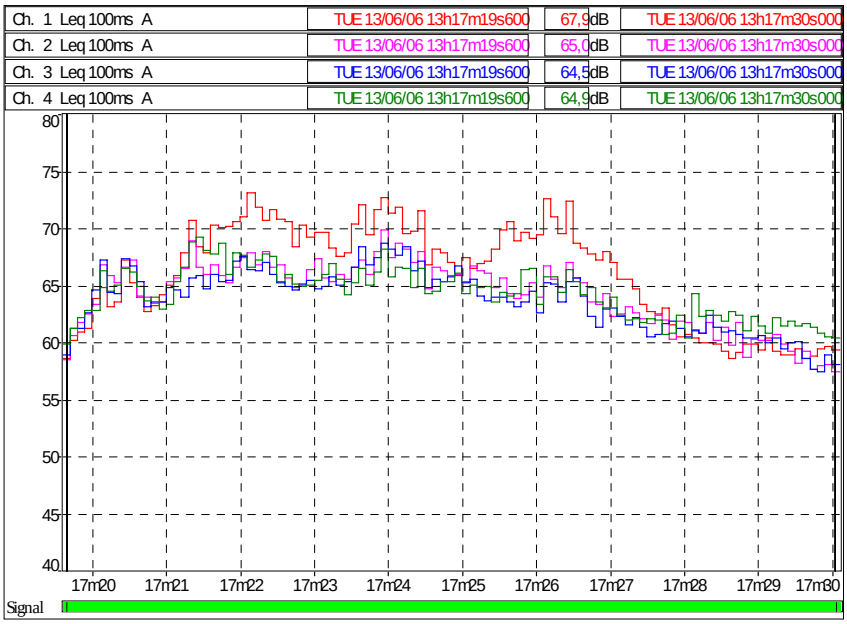
2 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	72,5	61,5	83,6	61,9	62,8	67,9	77,3	80,5
Ch. 2	Leq	A	dB	60,0	55,8	64,8	55,7	56,7	59,6	61,5	63,1

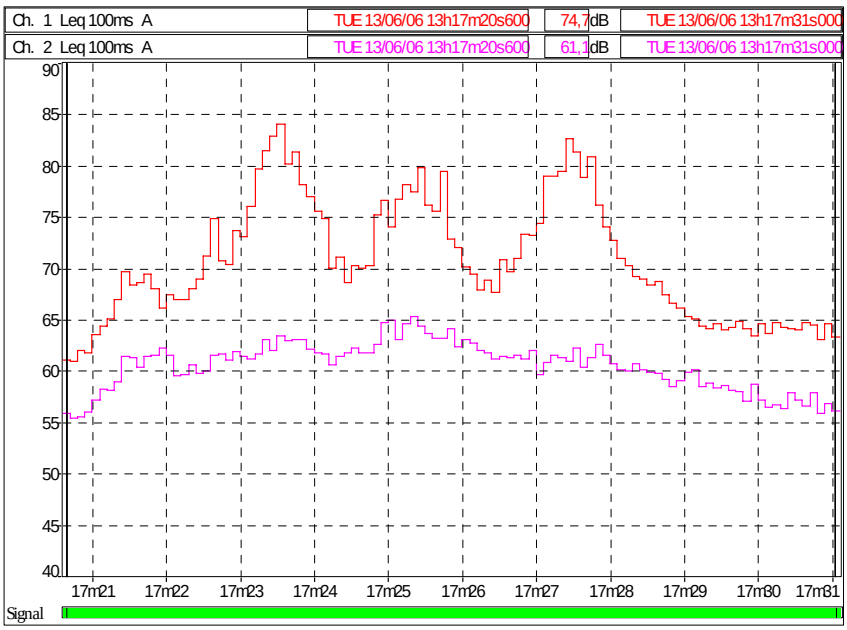
Passby3

4 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	67,9	58,6	73,1	58,5	58,8	67,1	71,2	72,6
Ch. 2	Leq	A	dB	65,0	57,4	69,9	57,6	58,4	65,1	67,3	68,8
Ch. 3	Leq	A	dB	64,5	57,4	68,7	57,5	58,8	64,1	67,0	68,3
Ch. 4	Leq	A	dB	64,9	59,8	69,2	60,3	60,6	64,4	67,1	68,7

2 CHANNEL SYSTEM

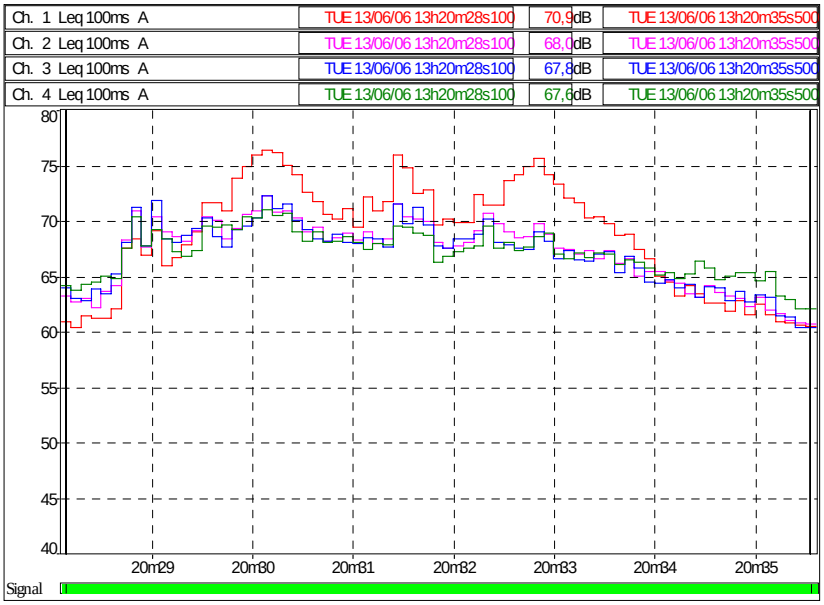


Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	74,7	60,9	84,1	60,9	63,2	69,6	79,3	82,8
Ch. 2	Leq	A	dB	61,1	55,4	65,3	55,4	56,0	61,1	63,0	64,8

SPEED =30 km/h

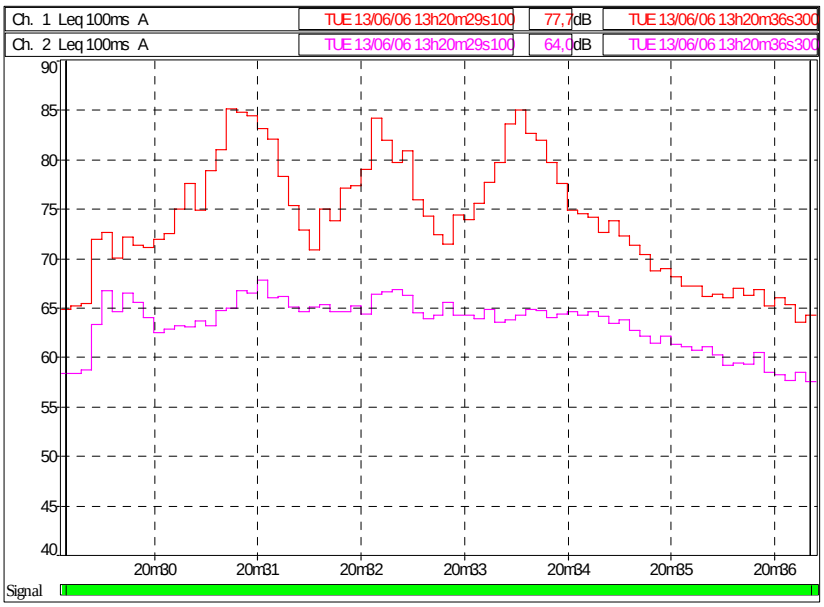
Passby1

4 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	70,9	60,4	76,3	60,3	60,7	69,7	74,8	76,2
Ch. 2	Leq	A	dB	68,0	60,7	72,3	60,6	61,6	68,0	70,5	72,2
Ch. 3	Leq	A	dB	67,8	60,3	72,3	60,2	61,3	67,6	70,1	72,2
Ch. 4	Leq	A	dB	67,6	62,0	71,1	61,9	63,2	67,2	69,5	71,0

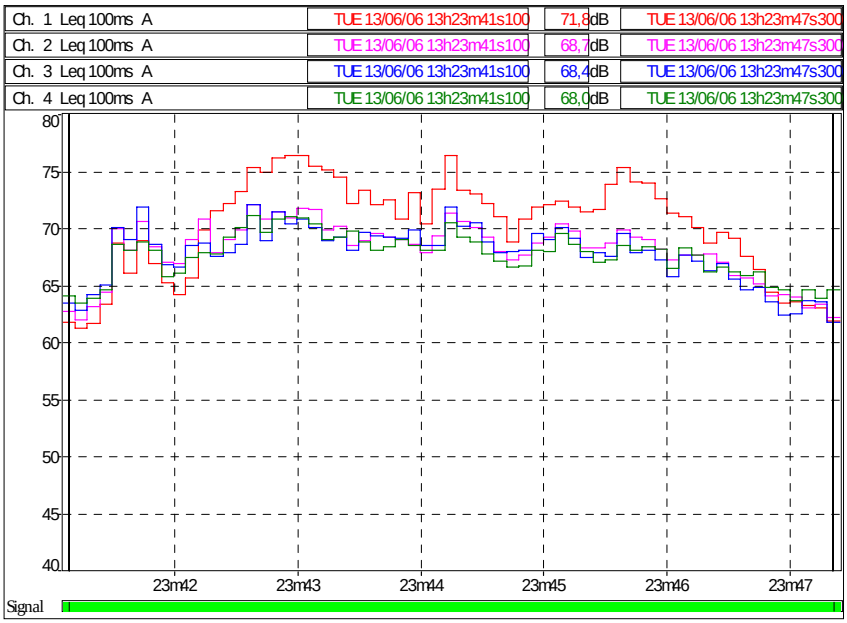
2 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	77,7	63,5	85,1	63,4	65,1	73,7	82,6	85,0
Ch. 2	Leq	A	dB	64,0	57,5	67,8	57,4	58,3	64,0	66,3	67,7

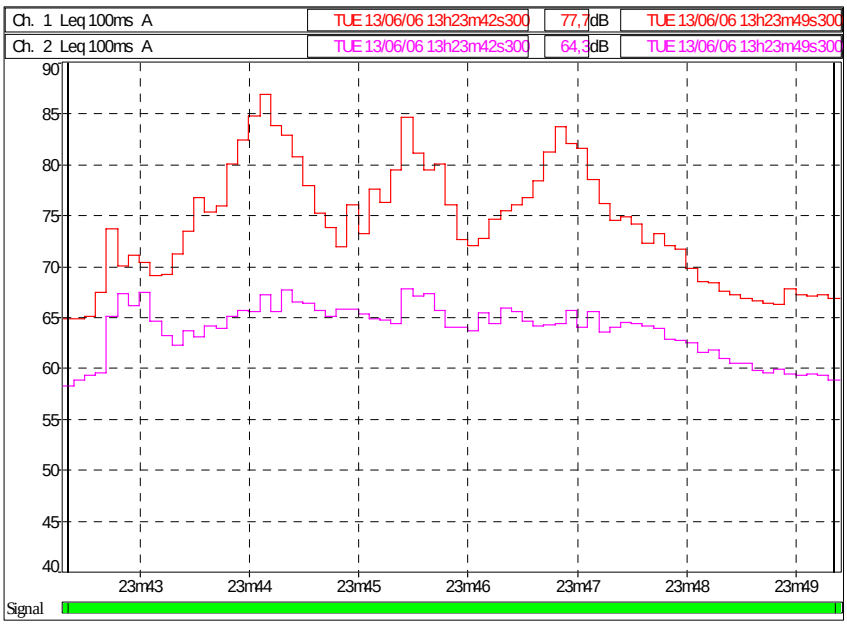
Passby2

4 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	71,8	61,2	76,4	61,2	61,7	71,4	75,2	76,3
Ch. 2	Leq	A	dB	68,7	62,0	72,1	61,9	62,9	68,5	70,7	72,0
Ch. 3	Leq	A	dB	68,4	61,7	72,0	61,6	62,7	67,9	70,3	71,9
Ch. 4	Leq	A	dB	68,0	63,4	71,1	63,3	63,8	68,0	69,9	71,0

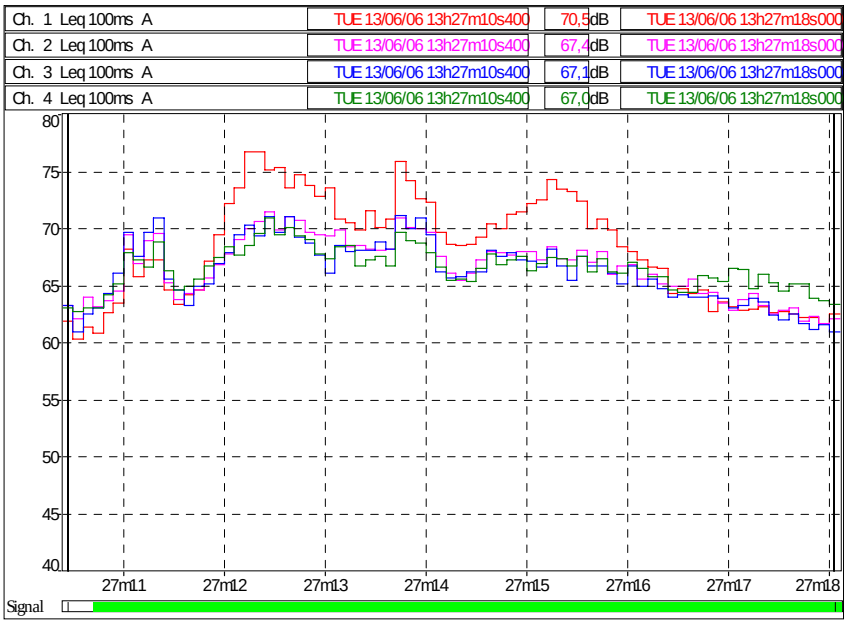
2 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	77,7	64,8	86,9	64,7	66,1	73,6	82,0	86,8
Ch. 2	Leq	A	dB	64,3	58,3	67,8	58,2	59,1	64,1	66,3	67,7

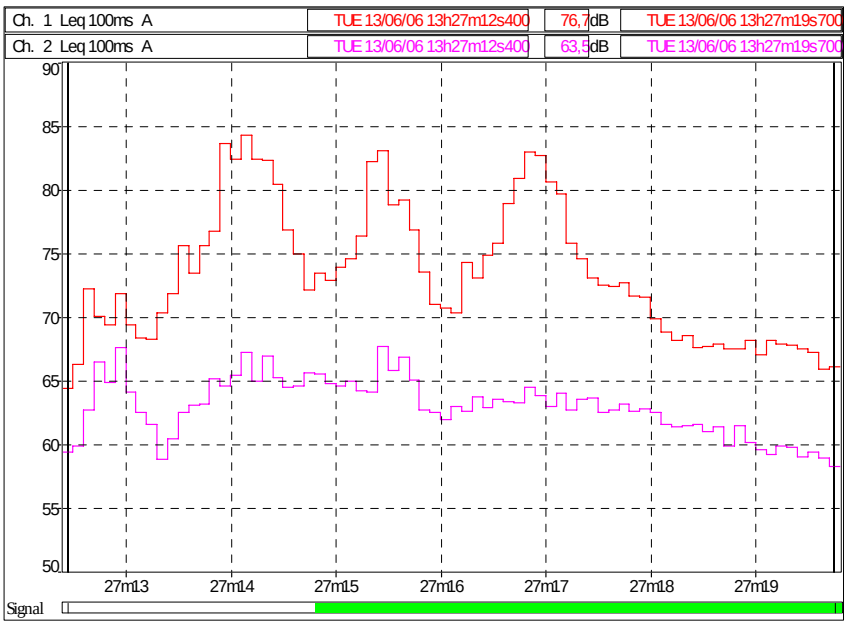
Passby3

4 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	70,5	60,8	76,7	60,7	62,1	69,1	74,0	76,6
Ch. 2	Leq	A	dB	67,4	61,6	71,4	61,5	62,2	67,1	69,8	71,3
Ch. 3	Leq	A	dB	67,1	60,9	71,1	60,8	61,5	66,5	69,5	71,0
Ch. 4	Leq	A	dB	67,0	63,0	70,9	62,9	63,8	66,5	68,8	70,8

2 CHANNEL SYSTEM

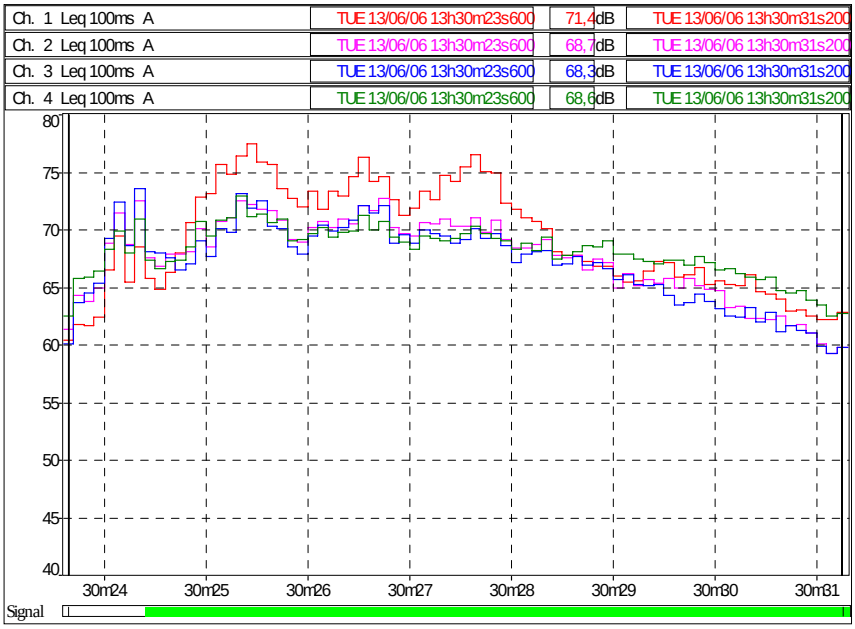


Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	76,7	64,3	84,3	64,2	66,2	72,6	82,2	84,2
Ch. 2	Leq	A	dB	63,5	58,3	67,7	58,2	58,9	62,9	65,5	67,6

SPEED =30+ km/h

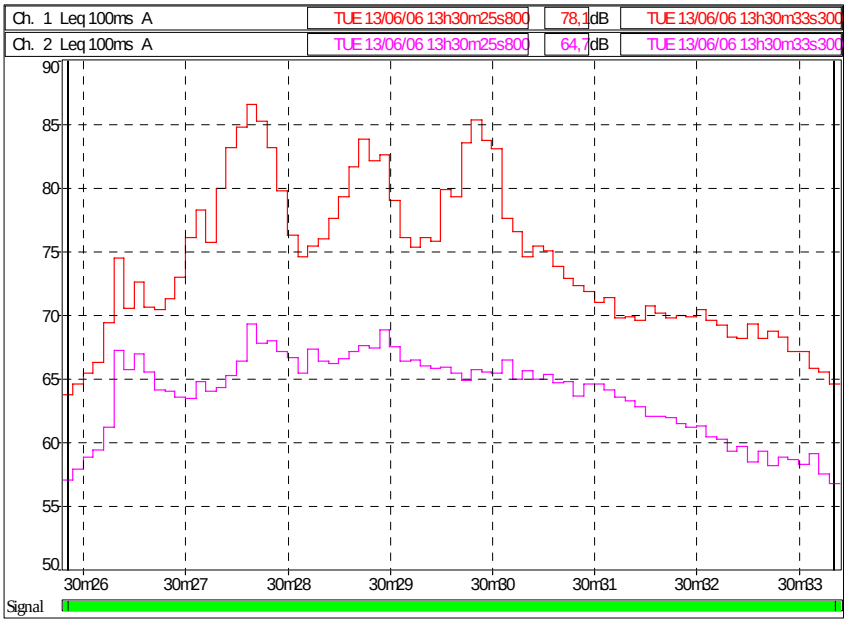
Passby1

4 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	71,4	60,4	77,4	60,3	62,0	68,0	75,4	77,3
Ch. 2	Leq	A	dB	68,7	59,2	72,7	59,1	60,9	68,2	71,6	72,6
Ch. 3	Leq	A	dB	68,3	59,2	73,5	59,1	60,0	67,7	71,3	73,4
Ch. 4	Leq	A	dB	68,6	62,5	72,9	62,4	63,3	68,2	70,7	72,8

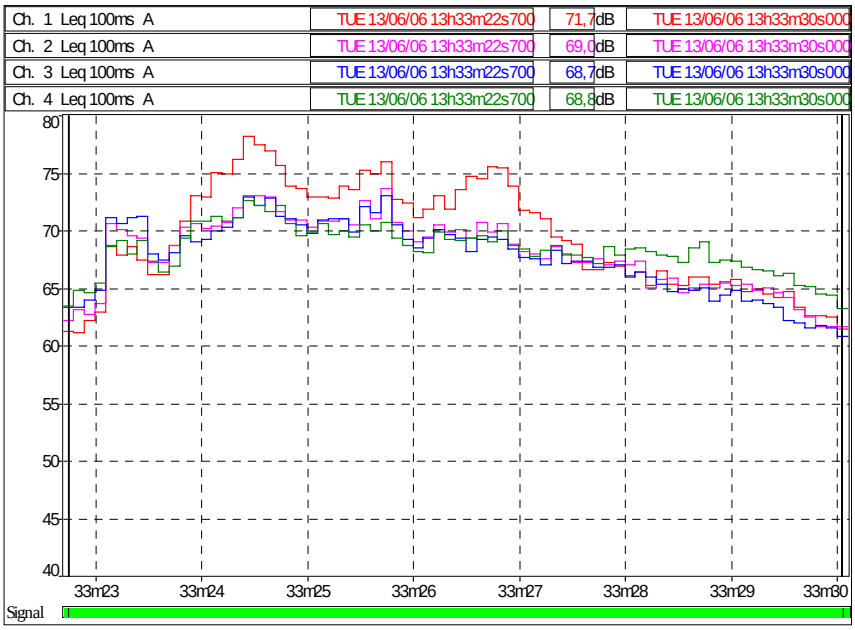
2 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	78,1	63,7	86,6	63,6	65,3	73,7	83,1	86,5
Ch. 2	Leq	A	dB	64,7	56,7	69,3	56,6	57,8	64,7	67,2	69,2

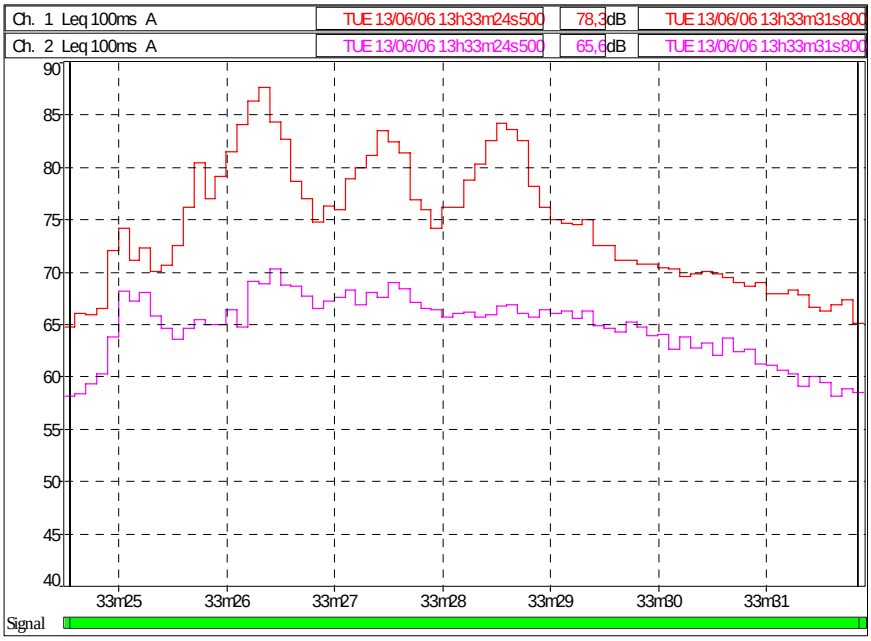
Passby2

4 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	71,7	61,2	78,1	61,1	62,1	69,0	75,4	78,0
Ch. 2	Leq	A	dB	69,0	61,6	73,6	61,5	62,0	68,6	70,9	73,5
Ch. 3	Leq	A	dB	68,7	60,8	73,0	60,7	61,7	68,1	71,1	72,9
Ch. 4	Leq	A	dB	68,8	63,2	72,6	63,1	64,4	68,4	70,7	72,5

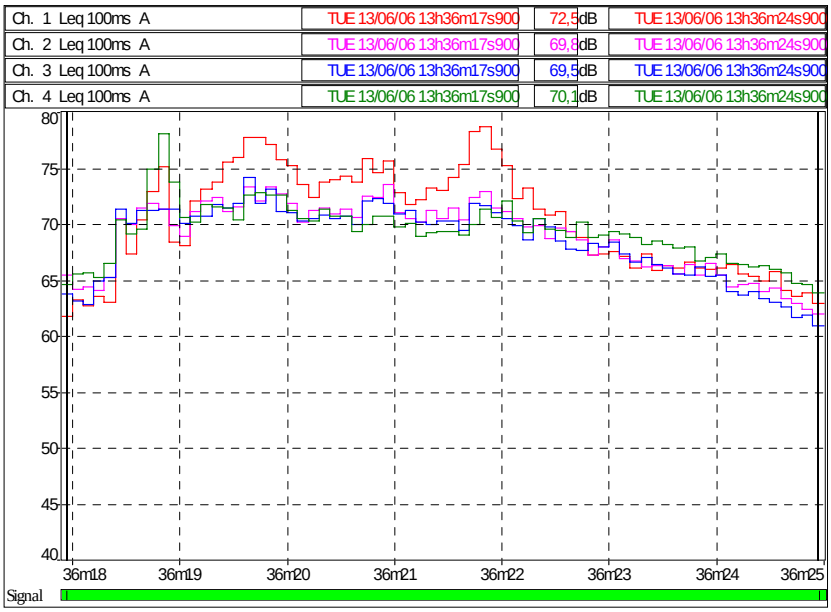
2 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	78,3	64,7	87,5	64,6	65,9	74,4	82,5	87,4
Ch. 2	Leq	A	dB	65,6	58,1	70,2	58,0	58,4	65,5	68,2	70,1

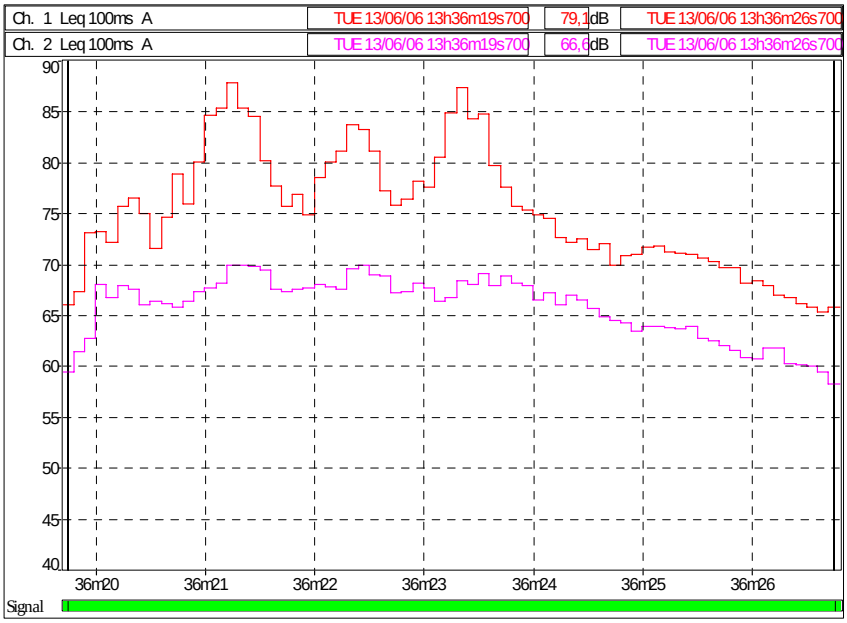
Passby3

4 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	72,5	61,7	78,7	61,6	63,0	71,0	75,8	78,6
Ch. 2	Leq	A	dB	69,8	61,9	73,5	61,8	63,2	69,8	72,3	73,4
Ch. 3	Leq	A	dB	69,5	60,9	74,2	60,8	62,5	69,9	71,7	74,1
Ch. 4	Leq	A	dB	70,1	63,9	73,2	63,8	64,6	69,3	71,9	78,0

2 CHANNEL SYSTEM



Channel	Type	Wght	Unit	Leq	Lmin	Lmax	L99	L95	L50	L10	L1
Ch. 1	Leq	A	dB	79,1	65,3	87,9	65,2	65,9	74,8	84,5	87,8
Ch. 2	Leq	A	dB	66,6	58,2	69,9	58,1	59,8	66,6	68,9	69,8

ANNEX 2 Technical specifications of CDM's rubber barrier