SoundPLAN Nord ApS, Bakkevej 26A, DK-5210 Odense NV, Denmark
phone: +45 2946 1030
www.soundplan.dk
support@soundplan.dk
CVR no.: 27 92 34 88

Lmax of Road Noise According to RTN96 **SP Net info 89**

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All Nordic countries except Sweden express limits for the maximum noise level from road traffic in terms of Lmax5%, meaning the level exceeded by 5% of the vehicles. Sweden has instead chosen to use the level caused by the 5th noisiest vehicle, Lmax5th. Since RTN96 was implemented in SoundPLAN the program has included calculation of Lmax5%. Lately the program was amended so the user now can select between Lmax5th and Lmax5%.

This Net Info sums up the Swedish guidelines and explains how to make SoundPLAN return the value relevant for Swedish users. Consequently this Net Info is mainly addressed to our Swedish customers.

Boverket handbok – Bullerskydd i bostäder och lokaler

This document is where you find the relevant guidelines on how to calculate Lmax5th so that you fulfil Boverkets Allmänna råd 2008:1 (AR2008:1). 'Guidelines' means that we are not dealing with mandatory legislation, but you must have really strong arguments if you want to deviate from these recommendations.

While AR2008:1 is unambiguous on that Lmax indoors during night should be calculated as Lmax5th, Lmax at 'uteplats' is unfortunately not defined in the same explicit way. However, in preparatory work to AR2008:1 Lmax at uteplats is defined as Lmax5th.

According to Boverkets handbok you should state Lmax5th for the noisiest vehicle type. This means in general the type 'heavy vehicle' defined in RTN96. Only if there are no heavy vehicles you should calculate Lmax5th for 'light vehicles'.

Lmax5th should be calculated for the noisiest 60 minutes during daytime 06 – 22 ('rush hour'), and for the entire night 22 – 06.

Finally in case there are less than 10 vehicles during the time slice in question, Lmax5th should be set equal to the arithmetic mean value of the maximum level, Lmax(mean).

Statistics

By definition the max level is caused by a single individual vehicle and not by a combination of vehicles (this approach is also relevant for the other Nordic countries). The max level caused by passages of single vehicles is assumed to spread around a mean value like illustrated below, Fig 1. A high percentage of the samples falls near the mean value, and the further away from this value the fewer results. The figure shows the Normal distribution, also named Gaussian distribution.

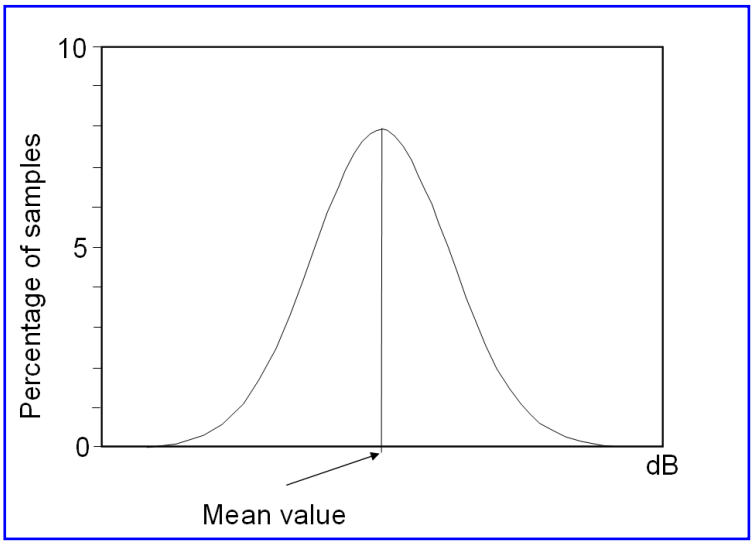

Fig 1 Normal distribution

The Normal distribution is fully described by the mean value and the standard deviation (s.d.). One characteristic thing about the Normal distribution is that 68 % of all samples fall inside the interval

[mean value – s.d.; mean value + s.d.], see Fig 2.

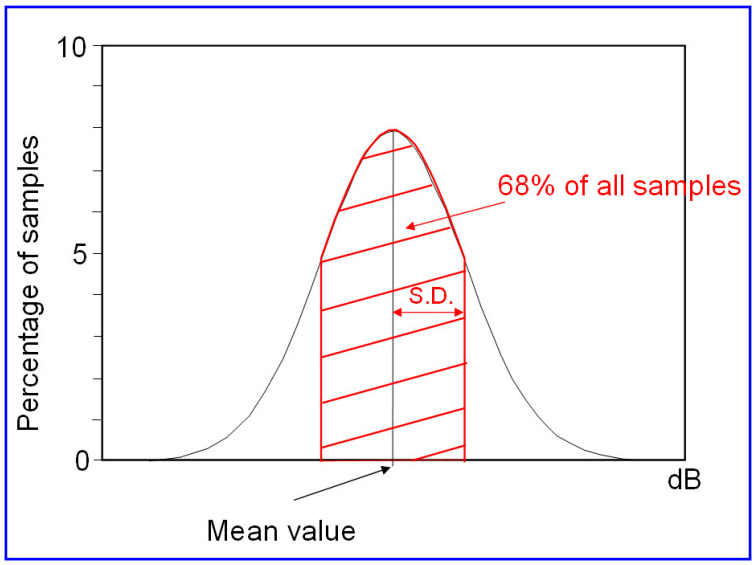

Fig 2 68 % of all samples take values (mean values +/– s.d.).

If the interval is increased to 1,64 times the standard deviation 90 % of all samples will be included, see Fig 3

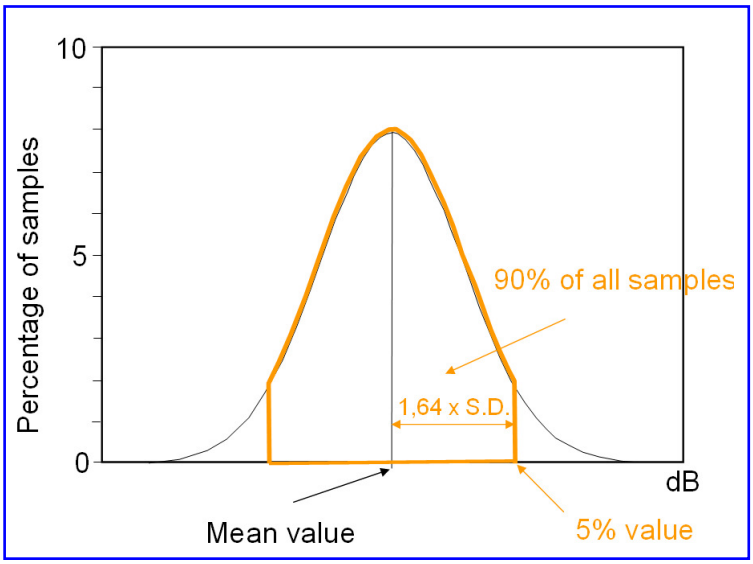

Fig 3 90 % of all samples take values (mean value +/– 1,64 · s.d.)

This interval is of special interest because it means that only 5 % of all samples take values higher than (mean value + 1,64 · s.d.). In the same way only 5 % takes values below (mean value – 1,64 · s.d.). Consequently:

$Lmax5\% = Lmax(mean) + 1{,}64 \cdot s.d.$ [1]

Lmax5% is the value for Lmax that SoundPLAN has calculated since RTN96 was first implemented.

How to derive Lmax5th from Lmax5%? In the first place we need to find what percentage 5 events are relative to the total number of passages. If N vehicles pass by it is p % = 5·100/N.

Example: if 400 vehicles pass by, the level from the 5th noisiest event will be exceeded by 5·100/400 = 1,25 % of all passages. In other words: in this example we need to find the width of the interval around Lmax(mean) that will include 97,5 % of all samples (leaving 2,5 % outside the interval with 1,25 % at higher values and 1,25 % at lower values). From standard statistical math it is possible to work out the width of the interval. Or to be more precise: to work out the number of standard deviations causing the level Lmaxp% to be equal to the 5th highest level.

In the basic report on RTN96 you will see a graph (Figure 2.7) that can be used to find the width of the interval. The graph is shown in Fig 4. The graph indicates the number of standard deviations should be approx. 2,2 in the example above. This gives us

Lmax5th = Lmax(mean) + 2,2 · s.d. [2]

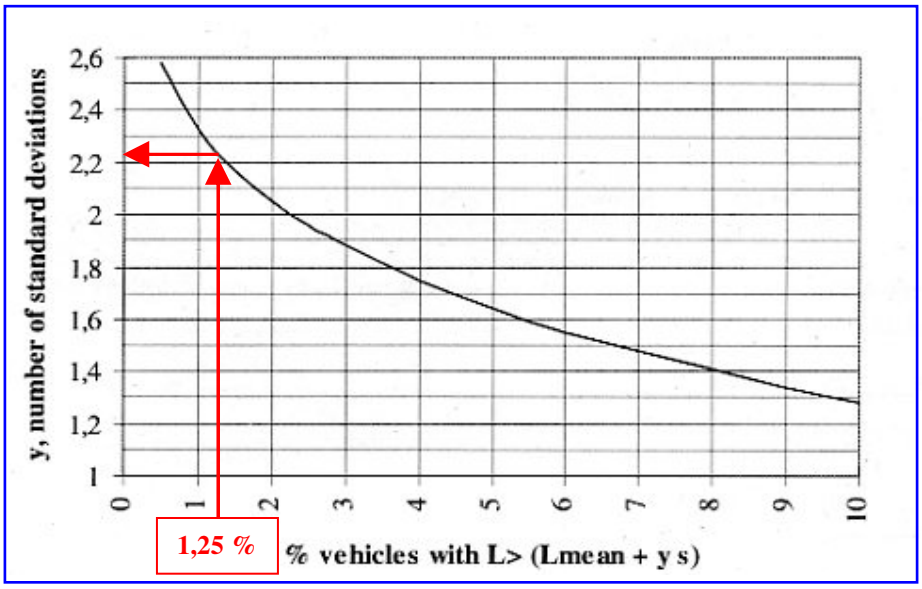

Fig 4 Percentage of vehicles exceeding a certain noise level

The only thing now left to be done is to find the standard deviation itself. This parameter varies depending on vehicle type and speed. According to the basic report on RTN96 the standard deviation can be read from Fig. 5 below (Figure 2.6 in the report) or calculated from the formulas (2.29)/(2.30) in the report.

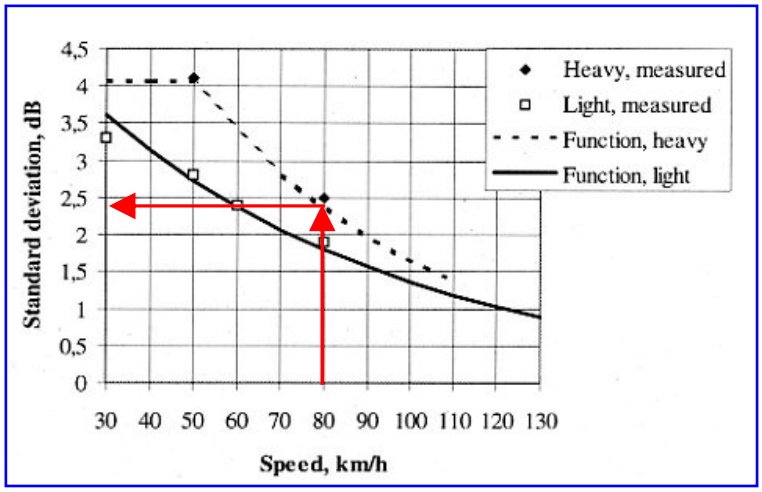

Fig 5 Standard deviation of Lmax for light and heavy vehicles

Suppose the speed is 80 km/h for the heavy vehicles mentioned in the example above, Fig 5 gives s.d. = 2,4 dB.

Combining formula [1] and [2] finally gives us that Lmax5th is 1,3 dB higher than Lmax5% with the specific data stated in the example above.

Graphs are difficult to work with when it comes to implementation in software. Besides that the graph in Fig 4 can only be used for percentages of heavy vehicles between 0,5 % and 10 %. However, the graph can be approximated by a polynomial stated in Boverkets handbook (Tabell 4.12) This polynomial y = P(x) is used in SoundPLAN to make it possible to calculate Lmax5th:

$$y = -0{,}00000000001130 \cdot x^7 + 0{,}00000000395695 \cdot x^6 - 0{,}00000055493824 \cdot x^5 + 0{,}00003978754303 \cdot x^4 - 0{,}00154675475318 \cdot x^3 + 0{,}03207776088465 \cdot x^2 - 0{,}35743879311349 \cdot x + 2{,}76935096017743$$

How to use the tool in SoundPLAN Version 7.0

In the emission calculation mask you should for each road key in the percentage of the noisiest vehicle type, see Fig. 6

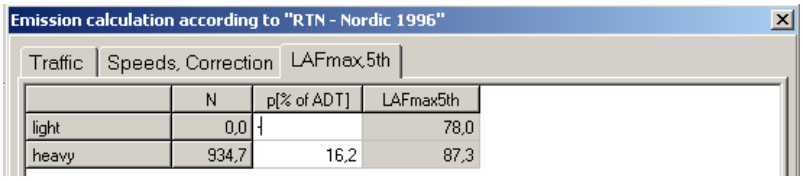

Fig 6 Emission calculation window with index card LAFmax,5th

As soon as a percentage has been keyed in the total number of vehicles of that type is calculated from the data on the 'Traffic' index card. You can read that number under N. In case you happen to know the number of vehicles instead of the percentage you can key in percentages until you by trail and error reach the correct value for N. Or of course work out N by hand. Another thing to notice is that only if there are no heavy vehicles, it is relevant to key in a percentage for light cars.

Example:

The distribution of vehicles over the 24 hours is like this:

time	00:00	01:00	02:00	03:00	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	sum 0-0	sum 22-6
light	497	230	171	251	524	2834	5940	6607	5673	4522	3434	3332	3681	4242	5778	7513	7291	6465	4015	2672	2208	2088	1726	1128		
heavy	151	155	141	175	260	654	757	688	685	764	747	776	729	780	**923**	778	602	554	410	336	368	307	240	201	**12179**	1975

The number of heavy vehicles during rush hour (14-15) is 923 and therefore p % (rush hour) = 923*100/12179 = 7,6 %.

In the same way the night period gives p % (22-6) = 1975*100/12179 = 16,2 %.

To get Lmax5th at night you have to do a calculation with p % = 16,2 %, and to get Lmax5th during rush hour you must do a second calculation (with p % = 7,6 %). In general you have to do two calculations, one for the rush hour and one for the night. This is maybe done most convenient by producing two geofiles with the roads, one valid for the rush hour and one for the night.

How to use the tool in SoundPLAN Version 7.1

In SoundPLAN 7.1 the assessment record has been amended with an important feature: the possibility to calculate Lmax for a specific time slice, see Fig 7. This is especially useful when it comes to calculation of Lmax5th. With this improvement you can leave it with only one geofile and one calculation.

The input mask for Lmax5th has been amended too. Now it is possible to key in either p % or the number of vehicles N during the time slices. With the data from the example above you end up with an input mask like shown in Fig 8.

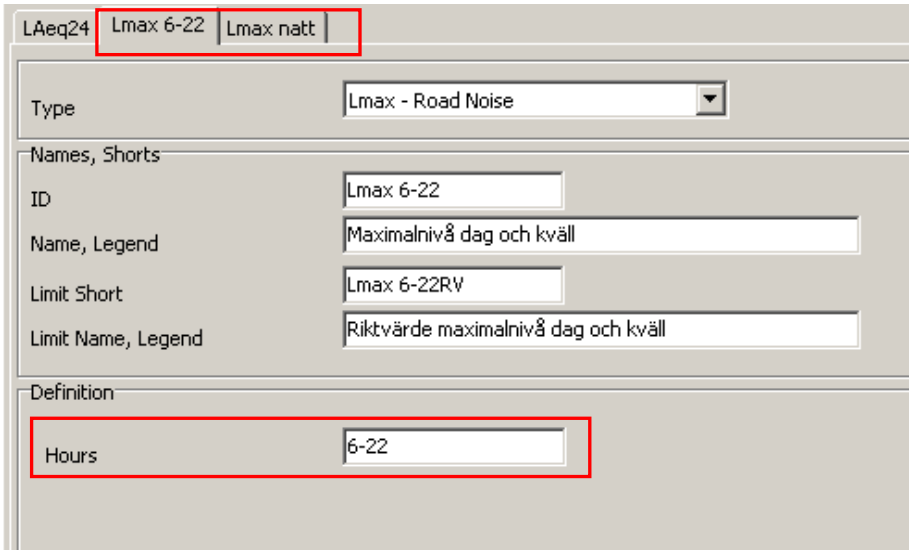

Fig 7 Assessment record with two time slice dependant Lmax, Lmax 6-22 and Lmax night

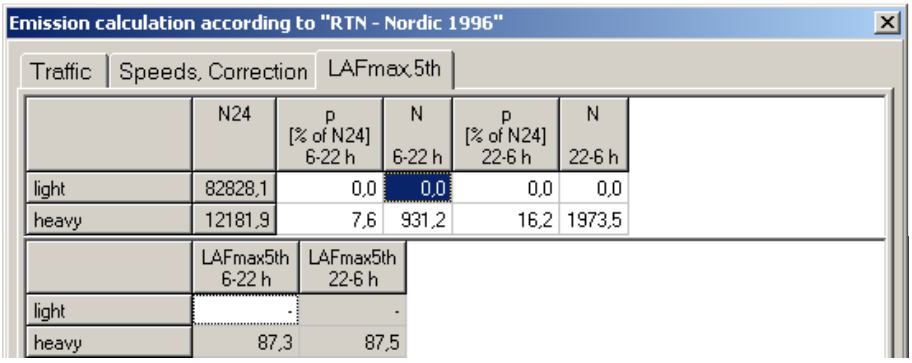

Fig 8 Emission calculation window with index card LAFmax5th in Version 7.1

Both versions

Finally, you need to tell SoundPLAN that you want to calculate Lmax5th and not Lmax5%. This you do under Settings-Standards, click on the button with two dots next to the Road standard, go to the tab Emission and select LAFmax,5th, see fig 9.

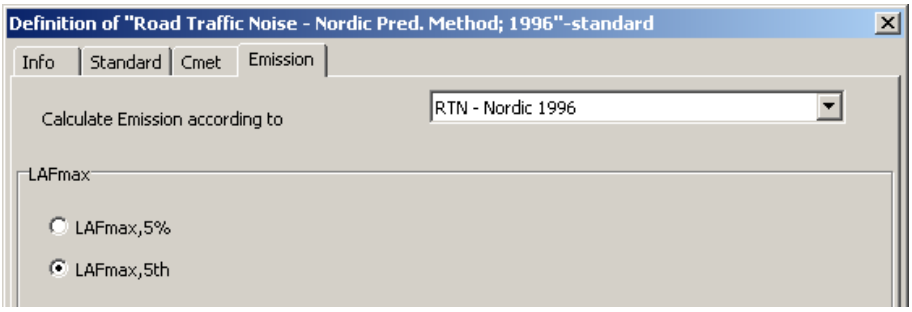

Fig 9 Emission tab of the standards setting

If LAFmax < LAeq

No matter the type of Lmax – Lmax5% or Lmax5th – the maximum level is generated by a single event/point source whereas the road is considered as a line source when calculating Leq. Since the level changes by 6 dB per distance

doubling for the point source but only 3 dB for a line source, it cannot be avoided that Lmax becomes lower than Leq at a certain distance (depending on ADT and speed), see Fig 10.

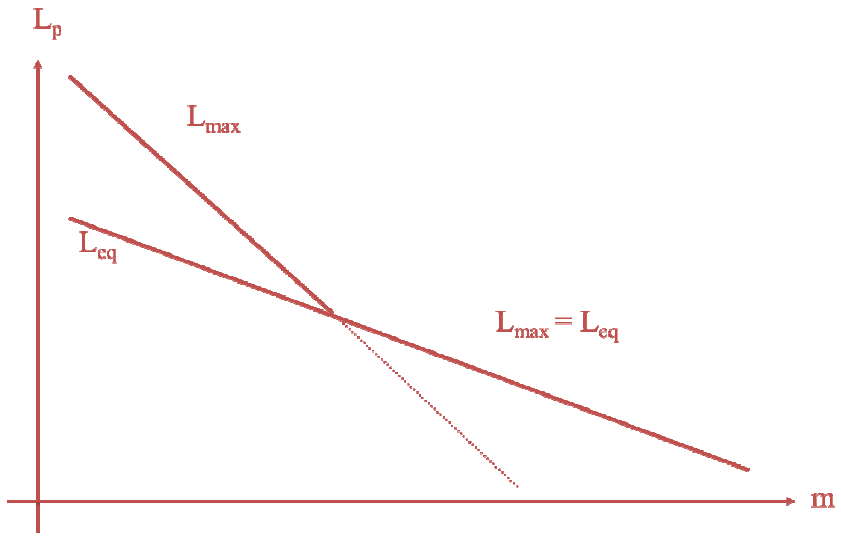

Fig 10 For big distances Lmax < Leq

However, the basic report on RTN96 (TemaNord 1996:525) states: "If LAFmax < LAeq then put LAFmax = LAeq". Originally SoundPLAN took care of that, the program never reported a max value lower than Leq. But since Lden and the three time slices were introduced in our assessment system it is no longer obvious which Leq-value we are talking about; is it Leq24, is it Lden or Lnight? The report on RTN96 did not foresee this question. For this reason SoundPLAN can no longer decide which value Lmax cannot exceed. **This is left to the user**. In case of a facade noise map this can easily be done in the SoundPLAN Spreadsheet, whereas a grid operation can be used to present Lmax in a contour map.

Lmax road in SoundPLAN 7.3, update 27.11.2013

The way RTN96 takes care of multiple reflections in street environments – not to mention branch streets and court yards – contradicts totally with the basic SoundPLAN approach. In few words RTN96 states a tabular correction to the free field level which depends on the size and position of the buildings. In general SoundPLAN takes care of multiple reflections by introducing mirror sources.

Direct and reflected noise never arrive simultaneously at the receiver. For short term events Lmax will therefore not include the last reflection. SoundPLAN used to consider the pass by of a vehicle as such a 'short term event' and consequently the last reflection was omitted. With this approach it was impossible for the program to fulfil the official test cases for Lmax. The producer of SoundPLAN therefore looked for a solution.

With the update from November 27, 2013 the calculation procedure was changed. Now the program finds the position of the point source – in general representing a heavy truck – for which the noise level is highest and the reported level includes reflections from facades and barriers. This change made levels in main streets fall inside the official tolerance, but we still have problems in branch streets with little traffic and in back yards.