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Lmax of Road Noise According to RTN96

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All Nordic countries except Sweden express limits for the maximum noise level caused by road traffic in terms of the level exceeded by 5% of the vehicles, Lmax5%. On the other hand, Swedish legislation states that the noise level must not exceed the noise limit more than 5 times. For many years it has been common practise for Swedish consultants and authorities to compare the level caused by the 5th noisiest vehicle, Lmax5th, with the noise limit. However, recently it has been argued that this 'more than 5 times' really means that Lmax6th should fulfil the noise limit, see section 2 in 'Beräkning av maximal bullernivå med CNOSSOS – EU from Sahlgrenska Universitetssjukhuset, Arbets- och miljömedicin, written by Mikael Ögren, Anders Genell and Andreas Gustafson, dated January 28, 2021:

Beräkning av maximal bullernivå med CNOSSOS-EU (kunskapscentrumbuller.se)

Since RTN96 was first implemented in SoundPLAN the program has included calculation of Lmax5%. Later (with Ver 7.0 released October 2009) the implementation was amended so it became possible to calculate also Lmax5th. And in the current version, Ver 8.2, it is possible to calculate also Lmax6th, so all 3 relevant values can be obtained.

The rest of this Net Info is addressed mainly to our Swedish customers. Right now (springtime 2021) there is no guideline telling you explicitly to report Lmax6th instead of Lmax5th, but at least you should be aware that good practise is changing right now.

In general, Lmax should be calculated for the noisiest vehicle type, which in RTN96 is named 'heavy vehicles'. Only if there is no heavy vehicle at all, you should calculate Lmax for 'light vehicles'.

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

Finally, in case there is less than 10 vehicles during the time slice in question, Lmax should be set equal to the arithmetic mean value of the maximum levels, Lmax(mean). SoundPLAN does that without your assistance.

A tool to handle the 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 fall near the mean value, and the bigger difference to this value the fewer results. The figure shows the Normal distribution, also named Gaussian distribution.

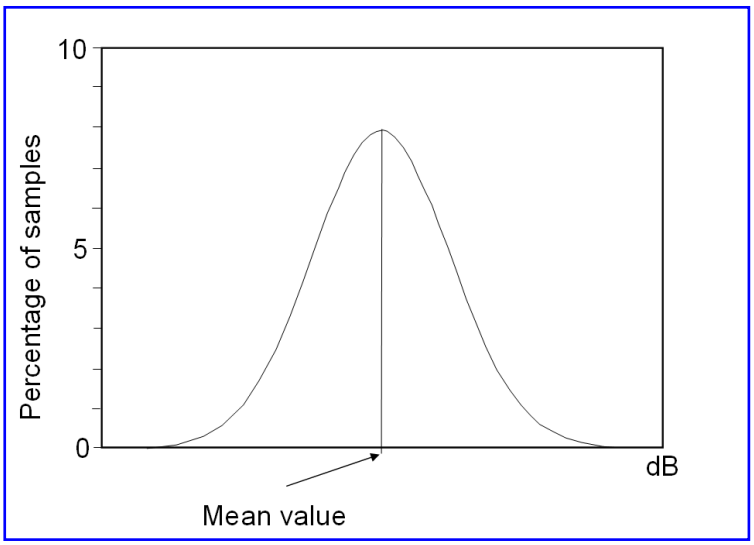


Fig 1 Normal distribution

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.

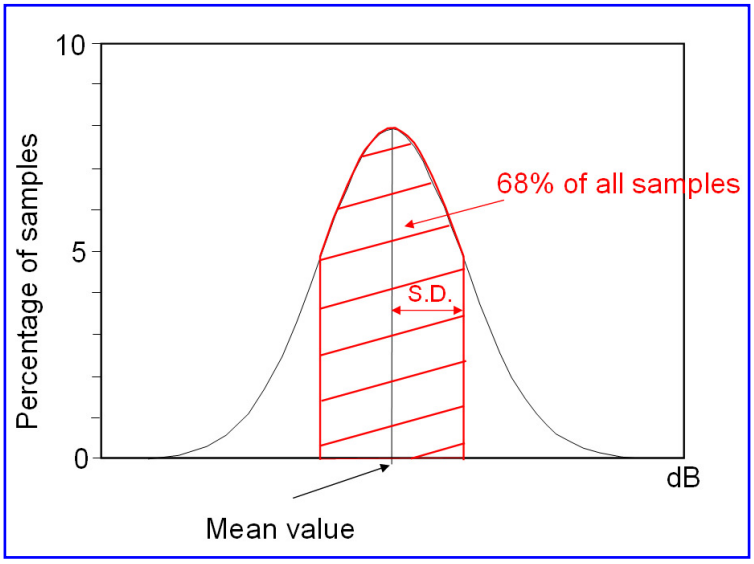


Fig 2 68 % of all samples take values (mean values +/– s.d.).

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

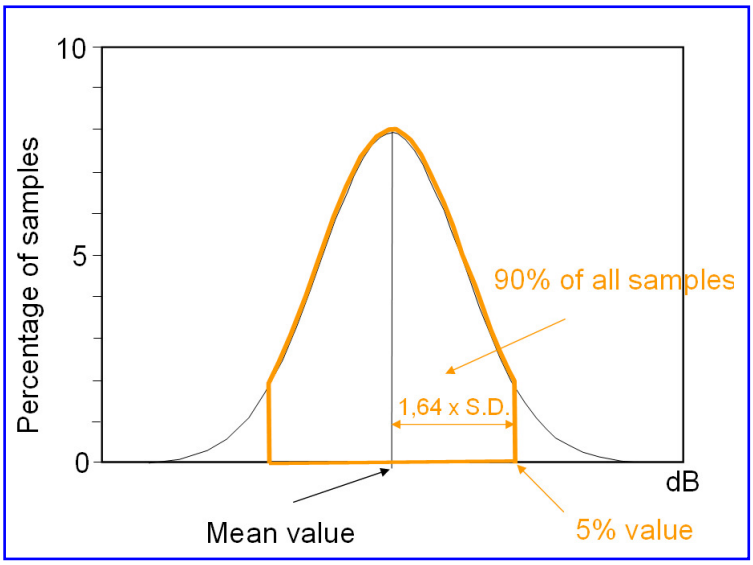


Fig 3 90 % of all samples take values (mean value +/– 1,64 · s.d.)

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 % take values below (mean value – 1,64 · s.d.). Consequently:

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

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

How to derive Lmax6th (or Lmax5th) from Lmax5%? In the first place we need to find what percentage 6 events are relative to the total number of passages. If N vehicles pass by during the time slice in question it is p % = 6·100/N (similar p % = 5·100/N if you are looking for Lmax5th).

Example: if 480 vehicles pass by the level from the 6th noisiest event will be exceeded by 6·100/480 = 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 statistic 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 6th 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

$$Lmax6th = Lmax(mean) + 2{,}2 \cdot s.d. \qquad [2]$$

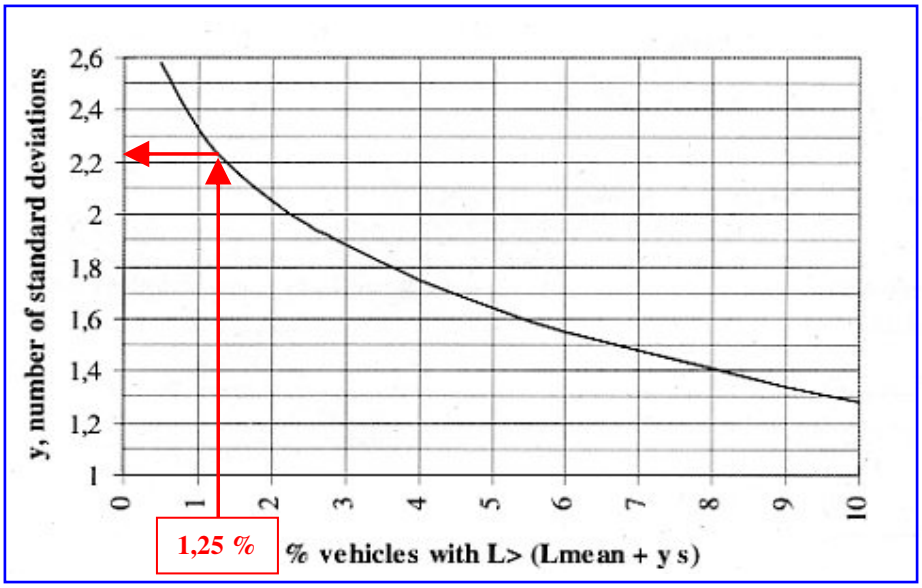


Fig 4 Percentage of vehicles exceeding a certain noise level

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.

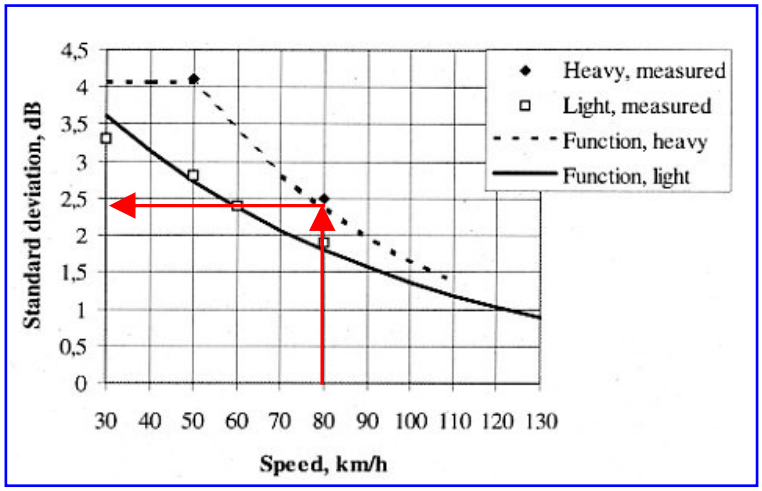


Fig 5 Standard deviation of Lmax for light and heavy vehicles

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 Lmax6th 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 approx. 0,5 % and 10 %. However, the graph can be approximated by a polynomial stated in Boverkets handbook (Boverkets Allmänna råd 2008:1 (AR2008:1), Tabell 4.12). This polynomial y = P(x) is used in SoundPLAN to make it possible to calculate Lmax6th (and 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 Lmax-tool in SoundPLAN

In the standard settings for RTN96 you must choose which value you want the program to return, see Fig 6:

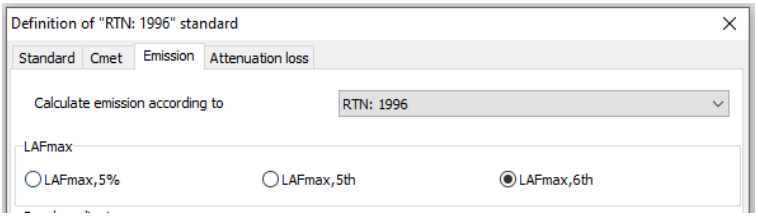


Fig 6 Select the relevant value between the 3 options

Since we are aiming at Lmax results for both rush hour and night-time it is convenient to split the 24 hours into 2 time slices, see Fig 7, combined with an assessment record that includes Lmax for the 2 time slides, see Fig 8

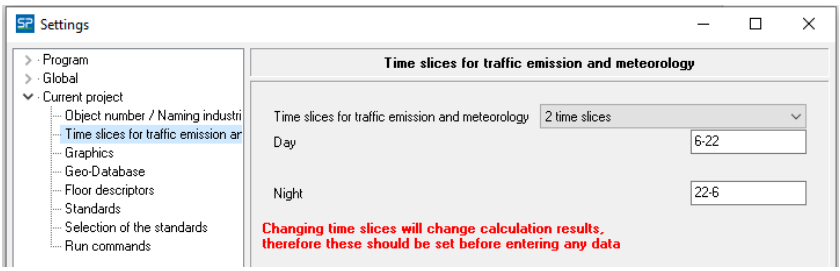


Fig 7 Relevant time slices for calculating Lmax

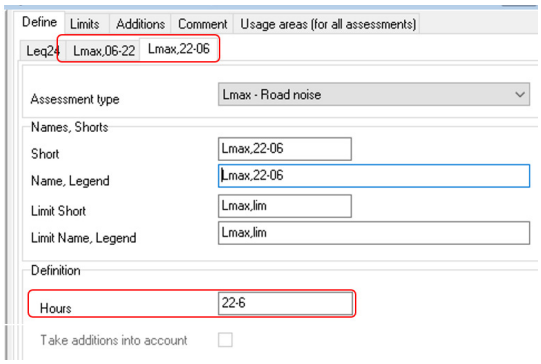
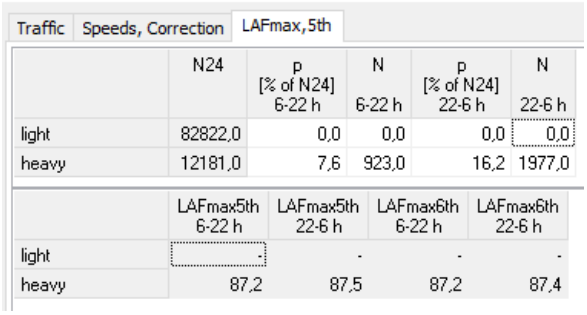


Fig 8 Assessment record with two time slice dependant Lmax, Lmax 06-22 and Lmax 22-06

In the emission calculation mask in the road property window, you should for each road key in the percentage of the noisiest vehicle type. This is done on the index card LAFmax,5th, see Fig. 9 (hopefully the name of the index card will change to something like LAFmax in a future version of SoundPLAN since the table accounts for both Lmax5th and Lmax6th).



	N24	p [% of N24] 6-22 h	N 6-22 h	p [% of N24] 22-6 h	N 22-6 h
light	82822,0	0,0	0,0	0,0	0,0
heavy	12181,0	7,6	923,0	16,2	1977,0

	LAFmax5th 6-22 h	LAFmax5th 22-6 h	LAFmax6th 6-22 h	LAFmax6th 22-6 h
light		-	-	-
heavy	87,2	87,5	87,2	87,4

Fig 9 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 the number under N24. 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:

Vehicles type	0-1h	1-2h	2-3h	3-4h	4-5h	5-6h	6-7h	7-8h	8-9h	9-10h	10-11h	11-12h	12-13h	13-14h	14-15h	15-16h	16-17h	17-18h	18-19h	19-20h	20-21h	21-22h	22-23h	23-24h	Sum	Max day	Max 22-06
Light vehicles	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 vehicles	**151**	**155**	**141**	**175**	**260**	**654**	757	688	685	764	747	776	729	780	**923**	778	602	554	410	336	368	307	**240**	**201**	**12181**	923	1977

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 % (22-06) = 1977*100/12179 = 16,2 %.

The Lmax-tool is designed to work also in those (still rather common) cases where only ADT is available, but the distribution of vehicles per hour is not known. Consequently, the Lmax-tool needs your (manual) input for p or N. In these cases, you can lean on appendix D, section D1 in Svensk Standard SS 25267 edition 3, published 2004. Here it is recommended to use p = 13 % for heavy traffic during the night period.

The standard does not say explicit what percentage to use for the noisiest hour during 06-22, but fortunately it will often turn out that the same percentage is relevant for the rush hour. If calculation results based on this general recommendation is critical relative to the noise limit, there is no 'shortcut' to more reliable results than to get hold on the hourly distribution.

If LAFmax < LAeq

No matter the type of Lmax – Lmax5% or Lmax6th/Lmax5th – the maximum level is generated by a single event/point source whereas the road is considered a line source when calculating Leq. Since the level decreases 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 from a certain distance on (depending on ADT and speed), see Fig 10.

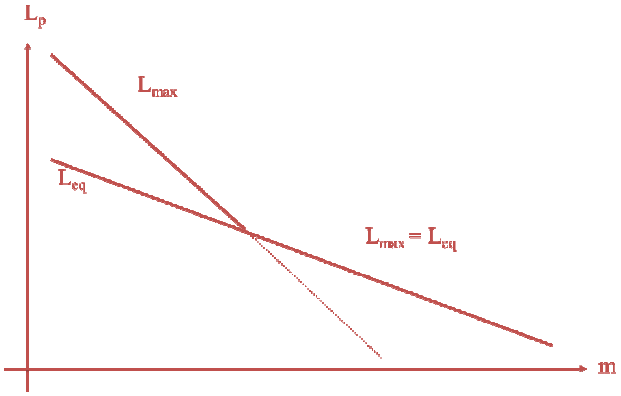


Fig 10 For big distances Lmax < Leq

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 or is it Lden that includes penalties? Or maybe Lnight? The report on RTN96 did not foresee this question. For this reason, SoundPLAN can no longer decide which value Lmax cannot exceed. **It is left to the user not to report Lmax lower than Leq**. 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 contributions from the last reflection were 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 and in back yards.