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Maximum noise levels from terminals and industrial plants

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Norwegian regulations on maximum noise levels from transport terminals and industrial plants are not (and have not) been well defined. According to practice from 1984, the maximum level is the highest occurring level. The maximum level was considered relevant for the night period only, and the control was to be made from the arithmetic mean of repeated measurements. From 2005, a new comprehensive regulation on most types of external noise has introduced two new definitions of maximum levels. The definitions may yield quite different results and have not been assessed for relevance. This gives rise to confusion in legal and nuisance judgments. The presentation includes examples from noise situations in freight train and harbour terminals.

1 Introduction

External noise from industry has been regulated in Norway from the late 70's. Regulations mainly use equivalent levels for day, evening and night. In addition, maximum levels are also used as a supplement for the night period. Protection of sleep, especially awakenings has been the rationale for this supplement.

The maximum level is sensitive to the definition of the measurement unit. At the top end of the distribution the uncertainty is large. It is thus necessary to specify a sufficient number of noise events to obtain a given accuracy. Admittedly, a single, very high level noise event may cause a distinct probability for awakening[1]. However, for reasons of consistency and repeatability, you never specify this single top level value, but rather a practical and relevant statistic or average is used.

At the moment no less than five different metrics are in use in Norway for maximum level from external industrial noise during the night period, see Table 1. Which metric to be used is sometimes a question of history and legal requirements (three different laws might have been used).

$L_{A,max,avg}$,the average value from at least five independent measurement comes from the joint Nordic Nordforsk project "Eksternt industriburner [2]. It is used in most cases before 2005, both for transport terminals and traditional industry. The key question is: What types of events should be the basis, high level events of one specific type only or a variety of different events? A restricted basis gives a higher average level than a large one.

L_{5AF}, the 5% most noisy events, was introduced in 2005 with the new #Guideline for management of noise in area planning", T-1442[5]. The metric comes from the joint Nordic calculation method for road traffic noise[3] (1996), and the basis is Heavy Vehicles. In the guideline L_{5AF} was also used for other types of noise, also industrial types, with a remark that L_{5AF} was best suited for uniform type of noise events.

L_{A1}, the level exceeded 1% of the time, comes from T-1442[5] as an alternative metric in case of several different types of events. The metric has not been assessed for different situations, and there is also no instruction on how to judge a result L_{A1} compared to L_{5AF}. In most cases, the L_{A1} description gives a significantly lower value than the L_{5AF} – value.

$L_{AFmax,PPR}$ from Prevention of Pollution Regulation. This applies for three different types of industry (asphalt works, maintenance of metal structures - including shipyards, and stone chrushing plants)[6]. The regulation have some

differences compared to T-1442. The $L_{AFmax,PPR}$ is defined as an average of the 5-10 most noisy events during the night period. The regulation will possibly be used for other industries as well.

N45+ , the number of events above L_{Amax}=45 dB indoors, comes from building regulation[7], and determine the necessary sound insulation to be made (type of ventilation, window and outer wall) in a house exposed to external noise. The number must be below 10 for an average night.

Table 1: Different metrics for Maximum noise levels in use for external industrial noise in the night period in Norway.

Metric	Definition	Activity	Reference
$L_{A,max,avg}$	Averaged value from at least five measurements in the (night) period, separated by at least 2 min. To be able to assess uncertainty it is advised to make more independent measurements (separated by at least 24 h). FAST response.	"industry"	Measurement guide T-590, 1984[4]
L_{5AF}	Level exceeded by 5% of the events in the (night) period. FAST response.	Uniform type of events, for instance heavy vehicles in road traffic.	Planning guide T-1442, 2005[5]
L_{A1}	Level exceeded 1% of the time in the (night) period.	Different types of events.	Planning guide T-1442, 2005[5]
$L_{AFmax,PPR}$	Average from the 5-10 highest levels L_{AF} occuring at night period	Three specified types of industries, for instance: shipyards	Prevention of Pollution Regulation (PPR), 2010[6].
N above Level (N45+)	Number of events above a running level: 10 events above L_{pAFmax}=45 dB indoor level in sleeping room during night at sufficient ventilation.	All types of external noises.	Building regulation / NS8175:2008[7]

2 Three different transport terminals

2.1 Ganddal railway freight terminal, Sandnes

The new Ganddal railway freight terminal south of Stavanger was put into service in 2008, following more than 10 years of planning. The noisy activity of such terminals comprises a variety of events: rail movements, impulsiv blows and action from diesel container handling trucks. For noise, equivalent criterion levels were used with a supplementary maximum level for the night period.

A number of measurements, most of them unattended, were performed outdoors at a specific neighbour house, located 100-200 m from the nearest activities of the terminal. The measurements were made due to the house owners claiming a full redemption of their house due to excessive noise. The owner of the terminal was thus required to document and assess the noise impact as well as remedial actions.

The assessment of the measurements, were made both to the old planning criteria and the new T-1442 criteriona from 2005[8]. Concerning maximum levels at night, three different metrices were used. From the unattended measurements:

- the averaged L_{AFmax} reached the highest value,
- the L_{5AF} was a few dB lower, and
- the L_{A1} still 5-6 dB below.

A proper assessment of the three different metrices was not made, but the actual house was eventually not considered heavily impacted by noise. The house was considered easy protectable and was not allowed to be redempted. Consequently, the claim for redemption was rejected [9].

Figure 1: Ganddal railway freight terminal

2.2 Ormsund harbour terminal, Oslo

Here, a living area overlooks an existing container harbour terminal at a 200-400 m distance. A large national road and a railway line is also close to the living area, and influence the noise climate in the living area during day-time. The nightly activity at the terminal has given rise to noise complaints. The noise requirements for the terminal at night time is specified as indoor levels in a ventilated sleeping room, both as an equivalent level (30 dB) and as a maximum level L_{AFmax}=45 dB during a night (no additional requirement to number of events, but to average maximum level only). The site has an automatic acoustic monitoring system. In addition, a lot of attended observations have been performed to differentiate harbour events from local events in the living area. The type of dominating nightly noise events at the harbour is impulsive blows from container handling.

At the actual stage of assessment, the typical noise level difference outdoor(freefield)-indoor in a sufficient ventilated room with closed windows (ventilation outlet or mechanical ventilation) is considered to be about 25 dB. With the actual averaged maximum level of typically around 70 dB, some dwellings will probably need mechanical ventilation while others will satisfy the requirements without further actions.

Figure 3 shows a cumulative distribution of 1308 events above L_{AFmax}=63 dB, obtained over a period of 4 months. The distribution gives $L_{AFmax,average}$ = 67.5 dB and L_{5AF}=72.5 dB[10]. The definition of the basis choise to include events above a limit of 63 dB only is based on two considerations:

- Each event should be distinctly audible
- a sufficient number of events must be retained to provide sufficient statistics.

At a lower limit (57 dB, $L_{AFmax,average}$ = 64 dB) the less noisy events would not be distinctly audible. At a higher level (67 dB, $L_{AFmax,average}$ = 69.5 dB) the actual average number of events per night with harbour activity (about 6) would be too low.

Figure 4 shows the time distribution of 84 events during one particular active night.

Figure 2: Ormsund harbour terminal

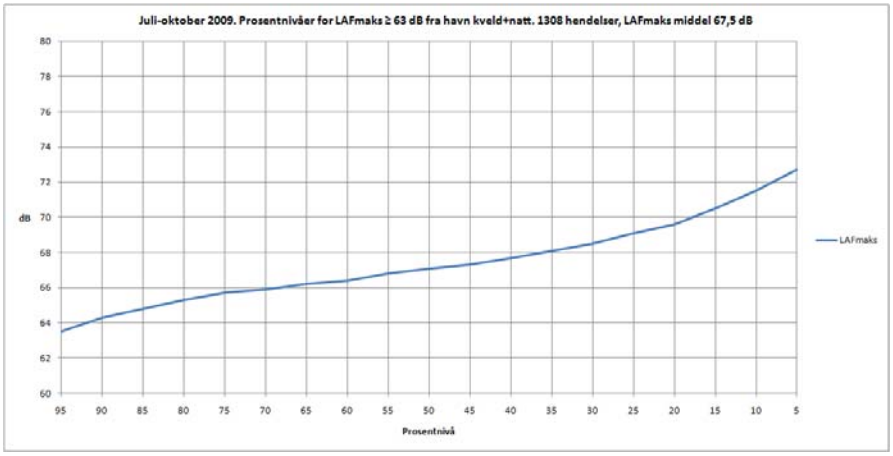

Figure 3: Ormsund. Cumulative distribution of 1308 events above L_{AFmax}=63 dB.

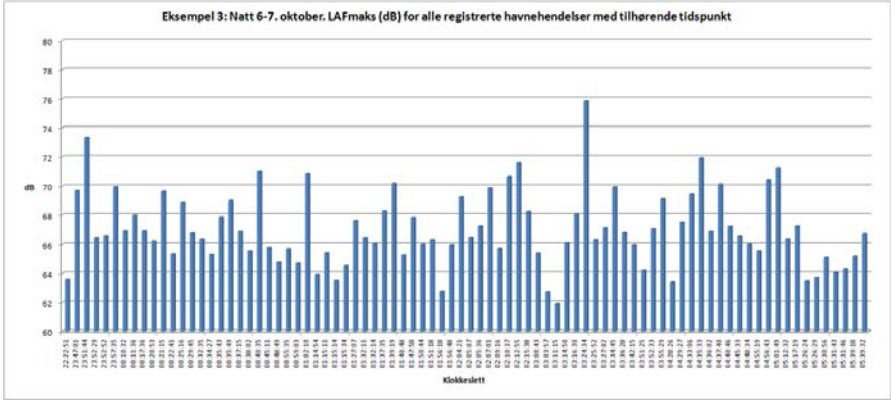

Figure 4: Ormsund. Time distribution from harbour activity above L_{AFmax}=63 dB during one night.

2.3 Bergen railway freight terminal

A living area overlooks an existing railway freight terminal at a 50-200 m distance. The nightly activity at the terminal has given rise to noise complaints. The noisy activity is dominated by two different types of events:

- impulsive blows from handling of containers and trailers and
- lifting- and transport-movement by heavy trucks and reachstackers.

A noise assessment is undertaken at the moment, and some results could possibly be shown in the presentation. Several day- and night time noise criteria will be used, among them the number of events exceeding indoor level 45 dB.

Figure 5: Bergen railway freight terminal

2.4 Discussion

Nordic vs European Community

While the Nordic countries are using L_{max}-metrices in addition to the equivalent L_{night}, the EC have chosen the equivalent L_{night} only for its regulatory and descriptive purposes on night time noise. Thus, the large organisations, for example WHO have dedicated their recommendation mainly to this metric. The large night noise guideline from WHO[11] nevertheless decribes thresholds for different observed adverse effects on sleep both in L_{Amax}- and L_{night}-metrices, and present them as outdoor level for a common assumption of a 21 dB level difference outdoor (freefield)-indoor, correspond to a window slightly open. For L_{night} the recommended level start at outdoor level 40 dB, where the lowest observed adverse effects occur. For $L_{A,max}$ the first effects occur at 56 dB (EEG awakening) or 63 dB (Sleep quality: wake up too early). All these recommendations are non-compromised levels, at lowest observed adverse effects.

New or existing situation

For planning purposes the recommended noise levels have a more or less pronounced basis that aim to a satisfactory indoor level with the ventilation quality of a semi-opened window. The outdoor-criterion of L_{5AF}=60 dB and L_{night}=45 dB (T-1442[5] and PPR[6]) thus have a roughly 15 dB difference (freefield outdoor to indoor) to recommended indoor levels (NS8175[7]). These recommendations are compromised, planning levels, set where about 10-15% of a normal population experience to be highly annoyed by the noise (or 20-25% annoyed, all degrees of annoyance). Thus, this outdoor criterion is good for both outdoor and indoor quality. There is no need for extra noise insulation or ventilation actions if these outdoor noise criteria are fulfilled.

For existing situations things are different. In this case there is no "half-way-open-window" aspect, and insulation and ventilation are crucial points. The indoor criteria rule the game.

Critical aspects of the different metrics

The L_{A1}-metric give significantly lower values for actual terminals than the other outdoor metrices. The total time window seems to be too wide (almost 5 min for a full 8 hour night), letting the few, most noisy events escape unnoticed. If any time-based statistics should be used, the window should be smaller, probably in the range of 0.2-0.5%.

When considering the other outdoor metrices, one should assess what kind of events should be the basis. Do we have one dominating type or several types? How large do the basis need to be (larger than the minimum number for measurement, but limited to events that are easily perceived at actual immission points, see the case of the Ormsund experiences). If there is one type of events only, the L_{5AF} could possibly be used for new (planning) situations.

In an existing situation some kind of indoor criterion should be used. The question of outdoor-indoor level difference and possible insulation actions may be influenced by the spectrum of the actual noise events. The spectrum could be very different from typical LF-diesel-engine-sounds to HF-rich impulses from twistlockers (part of lifting device at reachstackers).

For all metrices there is a need to define what is the time limit for an event? Impulsive events could have a duration of 0.1-2 seconds, a lifting or transporting movement could have duration of 2-20 seconds, a passing train or airplane could be even longer. Should there be a separation in time, for instance 10 seconds or 2 minutes, before we are allowed to count a new event?

2.5 Summary and conclusions

- Unlike most of Europe, Norway continues to use maximum levels as an important night time criterion for noise. For industry and terminals, the current night time limits for planning purposes are set so that fairly satisfactory results in living houses may be expected with semi-open windows.
- Several definitions exist for the outdoor maximum noise level. Unfortunately, potentially large differences can arise depending on the metric being used and/or what events are included in the statistical handling. Evidence from transport terminals suggest that the difference between different "versions" of the maximum level could be as large as 5-10 dB. It is not obvious which version is "correct" in each specific case.
- The actual metrics and criterions could be well defined from the supposition in the project, like in the Ormsund case. Here, the $L_{Amax,avg}$ was defined. Still there is a need to examine and assess the limitations for how to applicate the metric (right selection of what basis events are used in the statistical analysis).

- The L_{A1}- has the advantage of being easy to measure. This metric is recommended where several types of noisy events occur, producing rather different maximum levels. However, the effective measurement time (1% of the total night period, almost 5 minutes) seems in many cases to be too large, leading to a fairly low maximum level compared to other metrics. Do not use the L_{A1}-metric or other time-based statistic before a proper assessment has been made.
- In some planning situations neither L_{5AF} should be used (limited relevance if several types of events occur).
- For existing situations and in new situations where the defined metric can be found not relevant, we recommend to select an indoor metric and assess necessary insulation actions and relevant ventilation standard. Noise spectrum type for the noise should be taken in to account.

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