ORIENTERING FRA MILJØSTYRELSENS
REFERENCELABORATORIUM FOR STØJMÅLINGER

Environmental noise regulation in Denmark

Orientering nr. 45 JEL/PFI/ilk 17. januar 2012

This paper gives an overview of the Danish legislation in dealing with environmental noise. It also introduces the most important guidelines and directions needed to avoid noise problems when installing potential noisy equipment or processes in Denmark.

Content

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1. Authorities

The Danish noise legislation is handled by the Danish Environmental Protection Agency (EPA) under the Danish Ministry of the Environment, who sets up overall guidelines for noise administration practice, noise limits and methods for practicing noise measurements and calculations [www.mst.dk].

In Denmark several types of industry and installations must seek and obtain an environmental permit prior to going into operation. The permit sets specific limits for the pollution, including noise limits. For most industries and installations the permit is obtained from the municipality, who is also responsible for subsequently checking that the conditions of the permit are respected. Larger industries, including IPPC-industries, are handled by the Environmental Protection Agency situated in three local departments in Aarhus, Odense and Roskilde.

Noise from smaller industries, which are not subject to approval, and from workshops, commerce, restaurants etc. is handled by the municipality. In these cases the municipality assesses the noise and decides if the noise can be regarded as a nuisance and a ban or other kind of control is necessary.

General guidelines about administration of external noise can be found in [2] and [12], and links to relevant homepages are listed in chapter 6.

2. Reference Laboratory for Noise Measurements

The Danish Environmental Protection Agency has a Reference Laboratory for Noise Measurements that on its behalf gives technical and practical advice on noise and vibration matters. Another objective of the Reference Laboratory is to help ensure a high quality of noise and vibration measurements in Denmark; by arranging Round Robin tests for acoustical laboratories, performing studies on new methods and publishing their results and other EPA guidelines on their homepage: www.referencelaboratoriet.dk.

3. Acoustical laboratories

The local authorities in Denmark often require noise reports of high standard from laboratories that are accredited or hold persons that are certified to perform environmental noise measurements. A list of Danish certified and accredited laboratories can be found at www.referencelaboratoriet.dk. As a part of the approval these laboratories are regularly monitored to ensure a sufficient quality level of performance regarding instrumentation, software, measurements and reporting practice. Every 18 month the laboratories are obliged to participate in round robin tests held by the Reference Laboratory.

The approval requirements are described in document RL 20/96 [1] which can be found at the homepage mentioned above. The reports made in accordance with RL 20/96 are labelled “Miljømåling - ekstern støj” or Miljømåling - trafikstøj” (English: “Environmental measurement - external noise” or “Environmental measurement - traffic noise”).

4. Report quality

To ensure that the authorities have a sufficient basis for making decisions within environmental matters, it is important that noise reports contain all relevant information. The requirements for the issues that should be covered in the reports are written in document RL 20/96 [1], and the reports are labelled "Miljømåling - ekstern støj". The most important issues that should be considered are outlined in Annex A. They are explained in further detail in [1]. Since the reports are intended for the Danish authorities and the public, they are to be written in Danish.

5. Guidelines and directions

5.1 Environmental noise from industry

The definition of noise parameters, recommended noise limits and administrative guidelines are found in The Environment Protection Agency (EPA) guideline No 5/1984 [2]. In Denmark noise limits are set according to the area types and their actual usage. Table 1 shows the recommended limits for environmental noise in 8 types of areas [2]. Environmental noise is expressed by the measured "Noise rating level" (Danish: Støjbelastning (L_r)). The Danish definition of Noise Rating Level is the A-weighted energy equivalent sound pressure level corrected for duration and for presence of clearly audible tones or impulses. The noise is normally measured in practical free field conditions at height 1.5 m above local terrain.

Time periods: **Recommended noise limits, L_r** **Area type (usage)**	**Monday - Friday:** 07-18 hrs. **Saturday:** 07-14 hrs.	**Monday - Friday:** 06-22 hrs. **Saturday:** 14-22 hrs. **Sunday:** 07-22 hrs.	**All week:** 22-07 hrs.
Industrial area	70	70	70
Business and industry area with restrictions	60	60	60
Areas with mixed residences and businesses, city centre	55	45	40*
Multi storey dwellings	50	45	40*
Areas for open and low residential dwellings	45	40	35*
Summer house areas and public recreational areas. Special natural areas	40	35	35*
Allotment gardens	Refer to paragraph 2.2.3. in [2]	Refer to paragraph 2.2.3. in [2]	Refer to paragraph 2.2.3. in [2]
Open country (including villages and agricultural areas)	Refer to paragraph 2.2.3. in [2]	Refer to paragraph 2.2.3. in [2]	Refer to paragraph 2.2.3. in [2]

Table 1
*Recommended limits for Noise Rating Level (L_r) applied to outdoor noise in free field (from [2]). *See paragraph 5.1.4 regarding noise limits for maximum noise levels.*

5.1.1 Time periods and reference time

In Table 1 the top row generally shows the time period (day, evening and night) of the week. Within these time periods the noise is averaged over shorter periods called Reference Time Periods which are: 8 hours for the day period, 1 hour for the evening period (18 - 22), and ½ hour for the night period (22 - 07) to obtain the equivalent A-weighted sound pressure level, L_{Aeq}.

At weekdays the noise shall be calculated for each of the three time periods: Day (averaged over the worst 8 hour period), Evening (worst 1 hour period) and Night (worst half hour period). Saturdays differs by having the day period divided into two: morning (worst 7 hours) and afternoon (worst 4 hours).

5.1.2 Correction for clearly audible tonal and impulse sounds

If the perceived noise contains either clearly audible tones or clearly audible impulses, a 5 dB annoyance penalty shall be added to the measured equivalent sound pressure level, L_{Aeq} thereby yielding the Noise Rating Level L_r, thus $L_r = L_{Aeq}$ + penalty.

An objective analysing method to detect the presence of audible tonal content in noise is described in [4].

Regarding sound impulses there is no generally accepted public Danish method to evaluate the audibility of impulses. It is up to the measurement technician to subjectively decide, whether the impulses from the noise sources are clearly audible at the receiver position.

5.1.3 Equivalent A-weighted sound pressure level, L_{Aeq} and noise rating level L_r

The equivalent A-weighted sound pressure level L_{Aeq} is measured (or calculated) at the receiver and averaged over the reference time of both the day-, evening- and night periods, respectively. The duration of the noise source is corrected for duration as follows:

$$L_{Aeq} = L_{Aeq,T} + 10 \log (\text{noise duration T / Reference Time})$$

The noise rating level L_r (Danish: støjbelastning) is derived from L_{Aeq} by adding 5 dB annoyance penalty in the cases, where the noise contains clearly audible tones or impulses.

5.1.4 Maximum levels at night, L_{pAmax}

In Denmark noise limits are recommended for the maximum sound pressure level occurring during the night period (22-07 hrs.) in areas with dwellings. The analysis time constant is F (Fast) (exponential time weighting 0.125 second). These noise limits only apply to area type 3-6 in Table 1, and they are identical to the normal night noise limits for L_r plus 15 dB.

5.1.5 Noise rating level (L_r) measured indoor

Environmental noise from industry, located in the same building as the receiver, is assessed by the indoors noise level. The recommended indoor noise limits are stated in [2] (section 2.3) for three types of usage, as shown in Table 2.

Time periods: **Recommended limits for indoor noise rating level , L_r , measured indoor** **Room type (usage)**	**All week** **Day and evening** **07-22 hrs.**	**All week** **Night** **22-07 hrs.**
1. Business and industry (except offices)	50	50
2. Offices	40	40
3. Habitable rooms in dwellings	30	25

Table 2
Recommended limits for indoor noise rating level (L_r) applied to indoor noise measurements made with closed windows [2]. It is assumed that the reverberation time in area type 1-3 is 1.0 s, 0.8 s and 0.5 s respectively.

The recommended limit for maximum indoor noise level $L_{pA,max}$ is only applied to room type 3 (habitable rooms) in the night period (40 dB(A)).

The method of indoor measurements is described in EPA No 6/1984 [4] and in more detail in [13] and in EPA No 9/1997 [7] for low frequency noise.

5.2 Measurement of environmental noise from industry

The most important Danish guideline about noise immission measurements is the EPA guideline No 6/1984 [4]. It covers many different aspects of noise measurements, such as noise categories and characteristics (i.e. stationary, fluctuating and intermittent), measurement accuracy, ensuring the proper weather conditions (i.e. wind direction and speed, cloud cover), locating the proper microphone position, alternative choices of microphone placements, where free field conditions are not obtainable, ensuring the right sound propagation conditions depending on weather parameters and correcting for the influence of background noise. The guideline shows in detail how to make corrections for noise duration, audible tones and impulses.

5.3 Calculating external noise from industrial plants

When calculating noise propagation the most important guideline is EPA guideline No 5/1993 [5], which is a supplement to the above mentioned EPA guideline No 5/1984 and No 6/1984, and it covers circumstances, where it is difficult to measure the noise at the receiver directly, e.g. because of disturbances from other noise sources and traffic lines and because of the difficulties getting the proper weather conditions (e.g. downwind from the noise source to the receiver). The guideline also deals with the general situation of predicting noise from a planned industry or installation, and in this context the principle of noise calculation - contrary to noise measurement - reveals in detail, which of the noise sources that are the most important to control.

The calculation method is the Nordic General Prediction Method [6], which is implemented and described in this guideline. This method is in general agreement with the international standard ISO 9613-2. The principle of the calculation method is that the noise emission from all sound sources is measured at close range. The resulting sound power levels are inserted in a suitable sound propagation / noise prediction software program, where the general prediction method is implemented. The guideline describes in particular the different sound power measuring methods that can be applied, depending on the type of sound source (e.g. stationary or moving) and its placement (e.g. in a free field or near to walls or corners). The noise is calculated in eight octave frequency bands from 63 Hz to 8000 Hz.

5.4 Low frequency noise and infrasound

When dealing with low frequency noise, there are specific noise limits and measuring methods as described in EPA information guideline No 9/1997 [7]. Section 3.4.1 regarding microphone positions has been adjusted in 2010. The low frequency noise is defined as the A-weighted equivalent noise level $L_{pA,LF}$ from 10 Hz to 160 Hz, whereas the infrasound is the G-weighted equivalent noise level from ca. 5 Hz to 20 Hz. The suggested noise limits

apply to environmental noise received indoor. In contrast to measurements of "ordinary" indoor noise, there is no correction for reverberation time or tonal content in the noise. The microphone positions are chosen carefully to avoid positions, where the level is atypically low due to standing waves. Often the occupant can identify areas of the room, where the noise is most annoying. At least three measurement positions shall be used, where two shall represent normal use of the room and the third is located near a corner; however, at least 0.5 m from any wall, floor or ceiling.

The recommended noise limits from [7] are presented in Table 3.

Recommended noise limits Room usage		**A-weighted sound pressure level, $L_{pA,LF}$ (10-160 Hz)**	**G-weighted infra-sound level, L_{pG} (ca. 5-20 Hz)**
Habitable room, child institutions etc.	Evening /night (18-07 hrs.)	20	85
	Day (07-18 hrs.)	25	85
Offices, classrooms and similar noise sensitive rooms		30	85
Other rooms in industrial facilities		35	90

Table 3
Recommended limits for low frequency noise and infrasound measured indoors. The limits apply to 10 minutes equivalent time periods, where the noise is strongest [7].

5.5 Noise from motorsport ranges

EPA guidelines No 2/2005 [20]. The noise prediction method for calculation noise emission from motorsport ranges is the same as for noise from industrial plants (Nordic General Prediction Method), but in contrast to noise limits for industrial plants the noise limits for motorsport ranges apply to the noisiest one hour period during the day. Furthermore the recommended noise limits are lowered with increasing number of training days per week. The guideline provides A-weighted sound power levels in octave bands 63-8000 Hz for 33 motor vehicles.

5.6 Noise from shooting ranges

EPA guidelines No 1 and 2/1995 [16] and [17] deal with noise from shooting ranges. Predicting noise from shooting ranges is done by using an adapted version of the Nordic General Prediction Method. Noise from shooting ranges is not assessed with the equivalent levels but with the maximum A-weighted sound pressure level $L_{pA,I}$ of single shots calculated or measured at the receiver position (Time weighting: I, Impulse). The recommended noise limits are lowered with increasing number of shooting days per week. For the calculation of noise from shooting ranges parameters like weapon type, weapon directivity, vegetation and firing sheds have to be taken into account. The method only applies to hand

weapon (calibres up to 10 mm). The calculation method in EPA guideline No. 2/1995 has been refined and extended in the Nordic standard, Nordtest NT ACOU 099.

Noise from military training areas is regulated in a statutory order No. 468 from 13. June 2002. A noise zone is defined around every training area expressed as the C-weighted average noise level over one year, L_{Cden}. EPA Guideline No. 8/1997 describes calculation of these noise zones [19].

5.7 Noise from wind turbines

Statutory Order No 1284 [21] from 2011 describes the measurement method, the calculation method and the noise limits for wind turbines. The sound power level of the wind turbine is to be measured on a plate on the ground at a distance of 1.5 times the hub height on the downwind side, and the sound power level is to be calculated at two wind speeds: 6 m and 8 m per second. The noise propagation is calculated according to the formulas stated in the statutory order.

Specific limits for low frequency noise are included in this statutory order. They apply to wind turbines erected after 1 January 2012. This method is also based upon the power level of the wind turbine. The noise contribution is calculated in third-octave bands at a receiver point at the façade of the nearest dwelling using the noise prediction method Nord2000. The corresponding indoor sound level is calculated by subtracting specified sound insulation values.

5.8 Comparing noise levels to noise limits

When a new industry or installation is planned, the expected noise should be compared to the recommended noise limits. If the noise level exceeds these, the industry will normally have to be redesigned or arranged so that the expected noise is below the recommended limits. The noise limits for wind turbines are mandatory, so a new wind turbine is not allowed, if the noise exceeds the limit values in the statutory order. Similar procedures are used when planning for new dwellings or other noise sensitive use of a noise impacted area, where noise screens or other measures are planned to secure that the recommended noise limits are not violated.

When an industry or an installation has an environmental permit setting specific noise limits, or a workshop has a noise ban with a set of noise limits, it is the task of the environmental authorities to control that the conditions are not violated. The actual noise level is then compared to the noise limits, and further action can be taken, if the noise level is significantly higher than the limits. The measurement or calculation uncertainty is taken into account in the favour of the noise polluter. Uncertainty calculations are descripted in [10] and [11]. A spread sheet with recommended standard deviation values and several calculating sheets [22] can help facilitate the calculations and the decision process of compliance with noise limits.

5.9 Urban planning and urban transformation

EPA guidelines No 3 / 2003 [14] deals with urban planning especially in cases, where an area formerly laid out for noisy industry is converted into a residential area or a mixed commercial / residential area.

A comprehensive environmental planning guidebook has been published by EPA and The National Forest and Nature Agency [15]. One of the main principles is to separate noisy industry from dwelling areas by appointing an "environmental classification" to different types of industry or installation. A set of recommended minimum separation distances is given as a function of the environmental classification. The guidebook includes a tool for predicting the traffic volume generated by different types of industry or commerce. This can be very relevant, when an industrial area is transformed to offices or commerce.

6. Links

List of publications of guidelines and directions:

- http://www.mst.dk/Virksomhed_og_myndighed/Stoej/regler_vejledninger/Oversigt_vejledninger/vejledningeroganvisninger.htm
- http://referencelaboratoriet.dk/information/

List of certified and accredited laboratories:

- http://referencelaboratoriet.dk/godkendte-laboratorier/samlet-oversigt/

7. References

[1] RL 20/96: Kvalitetskrav til "Miljømåling - ekstern støj" og "Miljømåling - trafikstøj".

[2] Miljøstyrelsens vejledning nr. 5/1984: "Ekstern støj fra virksomheder".

[3] Tillæg til vejledning nr. 5/1984: "Ekstern støj fra virksomheder" 2007.

[4] Miljøstyrelsens vejledning nr. 6/1984: "Måling af ekstern støj fra virksomheder".

[5] Miljøstyrelsens vejledning nr. 5/1993: "Beregning af ekstern støj fra virksomheder".

[6] Report No 32: "Environmental Noise from Industrial Plants. General Prediction Method". Lydteknisk Institut 1982.

[7] Miljøstyrelsens Orientering nr. 9/1997: "Lavfrekvent støj, infralyd og vibrationer i eksternt miljø".

[8] Orientering nr. 13: Måling af hørbare toner i støj, Referencelaboratoriet 1991.

[9] Orientering nr. 32: Beregning af impulser, Referencelaboratoriet 2001.

[10] Orientering nr. 36: Usikkerhed på beregnede niveauer af ekstern støj fra virksomheder, Referencelaboratoriet 2005.

[11] Orientering nr. 38: "Miljømåling" eller "orienterende støjmåling" – hvad kan de bruges til, og hvad er forskellen? Referencelaboratoriet 2007.

[12] Orientering nr. 40: "Hvilke spilleregler gælder der for støjen", Referencelaboratoriet 2009.

[13] Orientering nr. 43: Valg af måle- og beregningspositioner, Referencelaboratoriet 2010.

[14] Miljøstyrelsens vejledning nr. 3/2003: "Ekstern støj i byomdannelsesområder".

[15] Håndbog om Miljø og Planlægning - boliger og erhverv i byerne, Miljøstyrelsen / Skov- og Naturstyrelsen 2004.

[16] Miljøstyrelsens vejledning nr. 1/1995: "Skydebaner".

[17] Miljøstyrelsens vejledning nr. 2/1995: "Beregning og måling af støj fra skydebaner".

[18] Nordtest Method NT ACOU 099. Shooting Ranges: Prediction of Noise.

[19] Miljøstyrelsens vejledning nr. 8/1997: "Beregning af støjkonsekvensområder omkring Forsvarets øvelsesområder".

[20] Miljøstyrelsens vejledning nr. 2/2005: "Støj fra motorsportsbaner".

[21] Miljøministeriets bekendtgørelse nr. 1284 af 15. december 2011: "Bekendtgørelse om støj fra vindmøller".

[22] Spread Sheet: "Usikkerhedsberegningsark - RL 0608.xls", Referencelaboratoriet 2008.

Annex A - Outline of report type: ”Miljømåling - ekstern støj”

Front page

Name and address of the institution/laboratory performing the measurements, document ID, accreditation number

Measurement type: ”Miljømåling - ekstern støj”

Name and address of the institution that has requested the measurements

Guidelines that have been followed during the measurements/calculations

Summary that describes purpose of measurements/calculations and conclusion, and possibly the most important results

Signature and date

Terms of reproduction of the report

Background

Reason for making the measurements/calculations

Involved parties

Purpose for making the measurements/calculations

Task description

Measurement object

Industry noise: The facility, noise sources, character of the noise from the facility, surroundings.

Sound propagation

Permanent conditions, temporary conditions

Background noise

The main sources of background noise and the character of the background noise

Method for measurements and calculations

Measurement instruments

Calculation software

Measurement procedures

Measurement positions

Technical problems

Noise model assumptions

Calculation assumptions

Operating circumstances

Facility operating modes, operation of noise sources, the parties' assessment of the noise

Meteorology

The speed and direction of the wind, the temperature gradient

Measurement results

Measured values

Calculated values

Noise maps

Noise character

Corrections

Measurement results

Measurement uncertainty

Conclusion

Conforming to noise limits

Conclusion regarding noise limit exceedance or compliance

Signature and date (alternatively on front page)

Possibly: Potential for noise damping and the magnitude of associated expenses