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Measurement and evaluation of noise immissions from agriculture

Conflicts due to noise immissions from agriculture are not new. Increased machinery use on farms or approaching residential buildings often aggravate the situation in villages. Therefore, the question arises how these immissions must be judged. The Technical Regulations Concerning Noise Protection provide a basis for evaluation which can also be used for agriculture because special regulations do not exist. However, the special characteristics of agricultural facilities must be taken into consideration in the assessment.

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Keywords

Noise immission, noise measurement, immission evaluation

Literatur

Literature references can be called up on the internet under LT 06121 http://www.landwirtschaftsverlag.com/landtech/local/literatur.htm.

If one speaks of noise, this term usually describes sounds which are subjectively found annoying and disturbing. Thus, noise cannot be measured using physical measuring techniques because it is the result of the cognitive evaluation of sounds. The pressure, however, which sound waves of different frequencies exert on the ear can be measured. Pressure fluctuations are caused by one air particle moving the next one like in a domino effect. This results in a so-called longitudinal wave, which swings in the direction of sound propagation. The human ear has the ability to perceive sound pressure fluctuations in a range of ~ $20 \cdot 10^{-6}$ to $1 \cdot 10^{2}$ Pascal. Given a ratio of more than one to one million and with regard to the fact that the ear tendetially reacts in a logarithmic manner to stimuli, it is sensible to express acoustic parameters as a logarithmic ratio of a measurement value to a reference point. One speaks of sound pressure levels, which are given in the unit decibel or dB. The hearing threshold at 0 dB serves as a reference point. Since our ears are less sensitive at very low and high frequencies, a frequency-weighting system which approximately corresponds to the sensitivity of the ear is used for the measurement-technological registration of sounds. The most common frequency-weighting system is the A-system, for which the unit dB (A) is employed [1].

When dealing with sounds and their weighting, the following rules of thumb are useful:

- If the noise emitted by a source doubles, the measured sound level only increases by 3 dB. Ten equal sources result in an increase of 10 dB and 100 sources in a 20 dB increase.
- A level increase by 3 dB(A) is perceived as a level change by the ear.
- A 6 dB(A) level increase is perceived as a significant level alteration by the human ear.
- A level increase by 10 dB(A) is perceived as subjective doubling of the volume.

A generally applicable basis for the weighting of noise is not available. Instead, numerous legal regulations and rules from various fields of law must be observed. In addition, separate noise weighting techniques have been developed for many different kinds of noise, such as road-, rail-, construction-, industrial, or leisure noise. For some sources of noise, such as agriculture, however, no individual regulations exist.

Agricultural noise

The very divergent range of noise from agriculture can comprise sounds from stationary facilities, vehicles, or animals. Often, noise emissions from agriculture are considered usual at certain locations due to the history of their development and the regional structure. Agricultural facilities (even those which do not require approval) are subject to the Federal Immission Protection Act [2], and their operators must observe the obligations stipulated in sections 5 and 22 of the Federal Immission Protection Act. If examinations are carried out in order to determine whether the given protection requirements can be guaranteed, concrete noise measurements may become necessary. Since no special basis for examination in agriculture is available, the Technical Regulations Concerning Noise Protection [3] and the directives

Table 1: Standard immission values (SIV) according to the Technical Regulations Concerning Noise Protection; values in dB(A)

	Evaluation level		Maximum level
	Area utilization	SIV day/night	
Outside	a) industrial area	70/70	day: SIV + 30
	b) business area	65/50	night: SIV + 20
	c) village area	60/45	
	d) general residential area	55/40	
	e) pure residential area	50/35	
	f) cure area	45/35	
Inside	a) to f)	35/25	IRW + 10

Fig. 1 and 2: Raster calculation with marked iso-areas for the ranges < 45 dB(A), 50 dB(A), 55 dB(A), and > 60 dB(A). The source of sounds is a grain ventilation fan having a fictional sound power level of 105 dB(A). The duration of operation corresponds to the period of evaluation (during the day). The figures show noise distribution in the surroundings of the facility at a height of 5.60 m. In Figure 2 (right), the unit is surrounded by a noise protection wall, which allows the daytime standard value of 60 dB(A) for the village area to be kept in the zone near residential areas.

contained therein can be employed. If the evaluation system for the normal case can only be applied to a limited extent, a special case examination departing from the usual procedure is possible. With regard to agricultural noise, in particular animal- and harvest sounds must be mentioned in connection with the examination of special cases.

Sound measurement

For the measurement-technological determination of sound immissions, knowledge about the generation and the occurrence of sound sources is an essential prerequisite. If information about the kind and number of sound sources and their time of occurrence (e.g. during grain- or potato storage) is available, one-time measurement is often sufficient. If, however, only little information exists, immissions may have to be measured several times. In addition, meteorology needs to be taken into consideration. In general, measurements take place under weather conditions which are propitious to the propagation of sound, such as wind blowing from the direction of the sound source and temperature inversion. Sound level measurements should not be carried out during snowfall, heavier rain, while wind speeds are higher, or when the ground is frozen [4].

Depending on the sound situation, the initial sound level as well as the additional and the total sound level must be measured because the approach requires acceptor-related evaluation in order to be better able to assess the actual immission situation at a specific location.

For measurement, it is therefore very helpful if the system can be turned off for the determination of the initial or foreign sound level.

In building areas, the relevant location of measurement is situated at a distance of 0.5 m from the building in front of the centre of the opened window of the room which needs to be protected and is most significantly affected by the sound according to DIN 4109 [5]. In unbuilt areas, the edge of the area most affected by noise immissions where buildings with rooms requiring protection may be built according to the construction- and planning law must be chosen as the location of measurement. If measurement at the relevant location of immission is impossible, a comparable alternative measuring location can be selected.

The most important parameters to be measured for the assessment of immisions are the average level (L_{Aeq}), the maximum sound pressure level (L_{AFmax}), the average maximum cycle level (L_{AFTeq}), and different percentile levels (such as L_{AF95}).

Immission evaluation

Whether or not the sounds determined by the measuring instruments must be considered a significant annoyance in particular depends on protection-worthiness and the protection requirements, which result from the kind of area and the actual conditions. The standard immission values according to number 6.1 of the Technical Regulations Concerning Noise Protection are listed in *Table 1*. Short-term sound peaks may not exceed the standard values by more than 30 dB(A) during the day and more than 20 dB(A) at night. If sound immissions due to the special operation of the facility must only be expected for a short time („rare event“), the standard values may be 70dB(A) during the day and 55 dB(A) at night.

The evaluation level to be compared with the standard values must be developed based on the measurement values and is determined separately for the evaluation times during the day (6:00 a.m. until 10:00 p.m.) and at night (10:00 p.m. until 6:00 a.m., loudest hour). Considering the frequency of occurrence of the sound, supplements for the following characteristics can be given, which may range between 3 and 6 dB or even more:

- tone- and information content
- impulse content
- times of the day characterized by higher sensitivity.

In agriculture, sounds containing tones and information can be caused by quckly running electric motors, such as fans or saws, for example. The manoeuvring of implements or animal sounds, however, often contain impulses. Resting time supplements of 6 dB are given for immission evaluation in residential areas or areas which are even more worthy of protection.

Prognosis calculation

If no reliable data can be collected at the relevant location of immission due to excessively loud foreign sounds, for example, or during a planning procedure, sound immissions can be determined by means of prognosis. In this category, the Technical Regulations Concerning Noise Protection (number A 2.1) distinguish detailed from rough methods of prognosis. If special software is used for immission prognosis, raster calculation for an entire area can be carried out in addition to single-point calculation. The documentation of the data used is of particular importance for prognosis.

Summary

The Technical Regulations Concerning Noise Protection consist of a collection of national and international regulations and decrees which are used as the basis for the acceptor-related evaluation of noise from facilities. In atypical cases, which include most agricultural noise immissions, the individual case must be examined. Thus, weighting elements, such as customary character, social adequacy, and general acceptance, must be considered in order to determine whether immissions cause significant annoyance. In individual cases, deviations from the standard immission values are allowed.