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Measurement of noise emitted by machines

Airborne noise emission
Enveloping surface method
Basic method, divided into 3 grades of accuracy

DIN 45 635 Part 1

Geräuschmessung an Maschinen; Luftschallemission; Hüllflächen-Verfahren; Rahmenverfahren für 3 Genauigkeitsklassen

Supersedes January 1972 edition

In keeping with current practice in standards published by the International Organization for Standardization (ISO), a comma has been used throughout as the decimal marker.

See Explanatory notes for connection with International Standards ISO 3740 – 1980, ISO 3744 – 1981, ISO 3745 – 1977, ISO 3746 – 1979, ISO/DIS 3748 – 1983 and ISO/DIS 6081.2 – 1984, published by the International Organization for Standardization (ISO).

The January 1972 edition of this standard forms the basis of numerous other parts of DIN 45 635 dealing with specific families of machines. These parts retain their validity except when superseded by revised editions.

Supplement 3 to DIN 45 635 contains a list of the families of machines already covered.

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Table 1. **Survey of features and criteria regarding the 3 grades of accuracy of the acoustic measurement method**

Table 1a. **Basic allocations to the 3 grades of accuracy**

	Clause	Grade 1 accuracy		Grade 2 accuracy	Grade 3 accuracy
Connection with International Standards	Explanatory notes	ISO 3745 - 1977 Precision method		ISO 3744 - 1981, ISO/DIS 3748 - 1983, ISO/DIS 6081.2 - 1984 Engineering method	ISO 3746 - 1979 Survey method
Direct method	3.2	Yes		Yes	Yes
Comparison method	3.2, 3.14	Not possible		Possible (implicitly covered by the method for determining K_2 by means of reference sound source).	
Precision of method for determining L_W, expressed as reproducibility standard deviation σ_R^*	3.21, 8	(Without considering dispersions of the emission of the machine, e.g. when reproducing the specified operating conditions, $\sigma_B = 0$)			
— for determining L_{WA}		$\sigma_R^* \leq 1$ dB		$\sigma_R^* \leq 2$ dB	$\sigma_R^* \leq 4$ dB $\sigma_R^* \leq 5$ dB for distinctly audible discrete tones
— for determining L_W in frequency bands					
Octave band Hz / One-third octave band Hz		Free field	Free field over a reflecting plane		
125 / 100 to 160		$\sigma_R^* \leq 1$ dB	$\sigma_R^* \leq 1{,}5$ dB	$\sigma_R^* \leq 3$ dB	
250, 500 / 200 to 630		$\sigma_R^* \leq 1$ dB	$\sigma_R^* \leq 1{,}5$ dB	$\sigma_R^* \leq 2$ dB	
1000 to 4000 / 800 to 5 000		$\sigma_R^* \leq 0{,}5$ dB	$\sigma_R^* \leq 1$ dB	$\sigma_R^* \leq 1{,}5$ dB	
8000 / 6300 to 10 000		$\sigma_R^* \leq 1$ dB	$\sigma_R^* \leq 1{,}5$ dB	$\sigma_R^* \leq 2{,}5$ dB	

Table 1b. **Requirements to be met by the acoustic test conditions and the sound source (machine) for the 3 grades of accuracy**

	Clause	Grade 1 accuracy	Grade 2 accuracy	Grade 3 accuracy
Test environment (in rooms or in the open)	5.5, Appendix B	Acoustic free field or free field over a reflecting plane (laboratory conditions; low-reflection room)	Essentially acoustic free field over a reflecting plane (e.g. large plant room, small damped room, in the open)	No special environment (e.g. plant room with strongly reflecting walls)
Criterion for suitability of test environment; environmental correction K_2	3.14, 5.5.1, 7.1.4, Appendix B, subclauses B.1 and B.2	See Appendix B, subclause B.1, for criterion	$K_{2A} \leq 2$ dB	$K_{2A} \leq 7$ dB
Sound source (machine)	5.1	Volume preferably smaller than 0,5 % of room volume, i.e. only suitable for small sources	Largest dimension preferably less than 15 m	No limitation
Type of noise produced by sound source (machine)	—	Any type (e.g. broad-band, narrow-band, tonal, steady, non-steady, impulsive content)		
Criterion for background noise including wind effect Difference ΔL (level with machine operating minus level with machine stopped) Background noise correction K_1	3.12, 3.13, 5.5.2, 7.1.3	$\Delta L \geq 6$ dB (if possible, exceeding 12 dB) $K_1 \leq 1{,}3$ dB	$\Delta L \geq 6$ dB (if possible, exceeding 10 dB) $K_{1A} \leq 1{,}3$ dB	$\Delta L \geq 3$ dB $K_{1A} \leq 1{,}3$ dB
Allowance for barometric pressure and temperature	3.11, 5.5.3, 7.1.4	By means of correction K_0	Generally not necessary	Not necessary
Measurement surface	3.8, 5.4, 5.4.1	Spherical surface with free field, hemispherical surface with free field over a reflecting plane	Rectangular parallelepiped surface; alternatively: (hemi-)sphere	Rectangular parallelepiped surface, combination of several rectangular parallelepiped surfaces; alternatively: (hemi-)sphere
Measurement distance d	3.9, 5.4.2	$d \geq r/2$, with r ((hemi-)sphere radius) not less than 1 m	For rectangular parallelepiped measurement surface: $d \geq 0{,}25$ m, preferably 1 m; for (hemi-)spherical measurement surface: $d \geq r/2$, with $r \geq 1$ m	For rectangular parallelepiped measurement surface: $d \geq 0{,}15$ m, preferably 1 m; for (hemi-)spherical measurement surface: $d \geq r/2$, with $r \geq 1$ m
Minimum number of measuring points for free field over a reflecting plane	5.4	≥ 10	≥ 9	≥ 5
Instrumentation: Sound level meter at least complying with Integrating sound level meter at least complying with	4	a) class 1 as in DIN IEC 651, December 1981 edition b) class 1 as in DIN 45 655, December 1978 edition *)	a) class 1 as in DIN IEC 651, December 1981 edition b) class 1 as in DIN 45 655, December 1978 edition *)	c) class 2 as in DIN IEC 651, December 1981 edition d) class 2 as in DIN 45 655, December 1978 edition *)
Filter	4	Octave band filter complying with DIN 45 651; one-third octave band filter complying with DIN 45 652		
Checking of instrumentation	4	By means of acoustic calibrator complying with DIN 45 656 *) before and after each test series; sound level meter to be verified for compliance with standard at maximum interval of 2 years (unless subject to mandatory verification)		

*) At present at the stage of draft.

Table 1c. **Noise emission parameters and application of data with regard to the 3 grades of accuracy**

		Clause	Grade 1 accuracy	Grade 2 accuracy	Grade 3 accuracy
Noise emission parameters					
	A-weighted sound power level L_{WA}	3.2 7.2	Determinable in every case	Determinable in every case	Determinable in every case
Supplementary data	Sound power spectrum $L_{W\,oct}$ or $L_{W\,1/3\,oct}$	3.19 6.2 7.3	Determinable	Determinable	Determinable
	Sound pressure spectrum at operator's position or at loudest position	3.19 6.2 7.3	Determinable	Determinable	Determinable
	Emission value related to operator's position	3.16 6.1.1 7.3 Appendix D	Determinable	Determinable	Determinable
	Impulsive noise content ΔL_I at operator's position or at loudest position	3.17 6.1.2 7.3	Determinable	Determinable	Determinable
	Tonal content	3.18, 7.3	Generally only subjectively determinable		
	Directivity index DI	3.20, 7.3 Appendix C	Determinable	Only determinable with (hemi-) spherical measurement surface	Only determinable with (hemi-) spherical measurement surface
	Level variation with time	7.3	Determinable	Determinable	Determinable
Application of data		1			
	Comparison of machines of the same family or of different families	1	Suitable, but requiring much effort	Suitable	Less suitable, but applicable if grade 2 accuracy not attainable
	Comparison with specified values (e.g. with limiting values, labelled values, contractually agreed values)	1 8	Suitable, but requiring much effort	Suitable	Less suitable, but applicable if grade 2 accuracy not attainable
	Metrological basis for noise abatement measures	1	Suitable	Suitable	Less suitable
	Determining emission parameters of reference sound sources	1	Suitable	Less suitable	Not suitable
	Acoustic planning tasks (e.g. including noise immission estimates)	1	Suitable, but requiring much effort	Suitable	Less suitable

1 Scope and field of application

This standard is applicable to industrial noise sources such as equipment, machines, machine components, subassemblies and plant, which are referred to in this standard as machines. It does not apply to vehicles for transporting persons and goods on public roads. It is applicable in certain circumstances to industrial noise sources constituting a unit together with a vehicle.

This standard established the basis for determining the noise (noise emission, airborne noise emission) radiated by machines direct to the surrounding air by standard methods, so that the results are comparable (see Supplement 2 of DIN 45 635 for explanations relating to the noise emission parameters).

Noise measurements on machines may serve various purposes (see table 1c), e.g. comparison of the noise emission of machines of identical or differing family, comparison with specified emission values (e.g. limiting values, labelled values or agreed values), implementation of noise abatement measures or estimation of noise immission (see Supplement 2 of DIN 45 635).

The principal noise emission parameter is the sound power level. The sound power level of a machine is a measure of the sound power radiated by the machine; for this purpose, the sound power is the sound energy passing in unit time through a surface enveloping the machine. The sound energy related to 1 s is designated as the sound power of an isolated noise event (see subclauses 3.1.4 and 7.2).

This standard describes the basic method for determining the sound power level of a machine with the aid of the enveloping surface method. Other basic methods (reverberation room method, in-duct method) are described in DIN 45 635 Part 2 and Part 3 (at present at the stage of draft) and in DIN 45 635 Part 9 (at present at the stage of draft). In the enveloping surface method, measuring points are located on the enveloping surface (measurement surface) and the sound pressure levels are measured at these points where the radiated sound power passes through. From these sound pressure levels with the necessary corrections made (pri-

marily for mathematically eliminating the influence of background noise and reflections from the environment) and from the area of the measurement surface the sound power level is calculated. For determining partial sound power levels (by means of parts of the enveloping surface) this standard shall be applied as appropriate (see also Appendix F and if necessary DIN 45635 Part 9, at present at the stage of draft).

In addition to the enveloping surface method for determining the sound power level, this standard also describes methods of determining further noise emission parameters (emission value related to operator's position, impulsive noise content, noise spectrum and others) (see table 1c).

The measurement method is divided into three grades, according to accuracy. Of these grades of accuracy, grade 2 will be the one normally applicable. If the test conditions are too unfavourable for it, grade 3 accuracy shall be applied. Under exceptionally favourable conditions, as in laboratories, grade 1 accuracy may be adopted for maximum accuracy. Table 1 gives a survey of the features and criteria of the three grades of accuracy. Reference is made to this each time in the relevant subclauses of this standard.

The grades of accuracy and the information on the precision of the method (see clause 8) relate in this standard to the determining of the sound power level. For other noise emission parameters the grade indicated is only for guidance.

When selecting the grade of accuracy consideration should be given not only to the acoustic conditions, but also to the dispersion of the noise emission of the machine (e.g. when reproducing the operating conditions). If this dispersion is so great that the uncertainty of the test results (see clause 8) significantly depends on it, it may be desirable to lower the demands made on the acoustic test conditions accordingly, because of their diminished influence on the uncertainty of the test results, in other words to choose the lower-accuracy grade. As an alternative to this, the Part of DIN 45635 dealing with an individual family of machines may specify that instead of one measurement several measurements shall be made in order to reduce the uncertainty of the final result (see subclause 8.2).

A given grade of accuracy is deemed to be complied with if the requirements for this grade or for a higher grade of accuracy are met.

Since this standard lays down the general acoustic principles for noise emission measurement on machines of different families in the context of a basic method without, however, being able to concern itself with the conditions applicable to the individual family of machines (in particular the operating conditions) provisions relating to this are specified in the Parts (multi-digit Parts) of DIN 45635 dealing with the individual families of machines which, however, are not intended to be contradictory to this standard. Where such a Part does not (yet) exist, the direct application of this standard is possible in cases in which the basic principles of this standard, particularly with regard to clause 5, are sufficient for obtaining results fulfilling the purpose of the measurement concerned.

Parts of this standard series dealing with the individual families of machines generally give details on the following points, whilst relevant clauses of the present standard are simply referred to (the exception being the verbatim quoting of an international standard dealing with an individual family of machines):

- the grade(s) of accuracy specified for the individual family of machines with regard to the method of measurement used and the acoustical characteristics of the machines;
- noise emission parameters to be determined additionally to the A-weighted sound power level;
- specifications relating to the individual family of machines regarding scope and field of application, object under test, mounting and operating conditions, arrangement of measuring points, precision of method, test report, report on results.

Appendix E makes it possible to specify, for the individual family of machines, simple test methods for inspection purposes.

2 Designation

The method shall be designated giving the grade of accuracy used. The designation shall include the term "noise measurement", the DIN number and the grade of accuracy (KL) used, 1, 2 or 3.

Example:

The method of noise measurement as specified in this standard (01) for grade 2 accuracy (KL 2) shall be designated:

Noise measurement DIN 45635 – 01 – KL 2

In Parts of DIN 45635 dealing with the individual families of machines the number of grades of accuracy may be restricted.

The designation in these Parts is specified accordingly. If, however, such Parts allow the use of several basic methods (e.g. reverberation room method as specified in DIN 45635 Part 2), the Part number XX is followed by the number of the Part of the basic standard applied (example: noise measurement DIN 45635 – XX – 01 – KL 2). If the noise measurement can only be uniquely defined by quoting the relevant appendix of the specialized standard, the capital letter symbol (e.g. B) denoting the appendix shall be additionally quoted behind the Part number XX (example: noise measurement DIN 45635 – XX – B – KL 3).

3 Terminology, quantities

See Appendix I for a survey of the principal symbols used.

3.1 Sound pressure level L_p

3.1.1 The sound pressure level L_p is given by the equation

$$L_p = 10 \lg \frac{p^2}{p_0^2} \text{ dB} = 20 \lg \frac{p}{p_0} \text{ dB} \qquad (1)$$

where

p is the sound pressure;

$p_0 = 20\ \mu\text{Pa}$ is the reference sound pressure.

3.1.2 The frequency weighting or width of a restricted frequency band and the time weighting (S, F or I, see DIN IEC 651) shall be stated, for example, as follows:

- A-weighted sound pressure level: L_{pA};
- octave band sound pressure level: L_{poct};
- one-third octave band sound pressure level: $L_{p\,1/3\,oct}$;
- A-weighted sound pressure level measured with time weighting S: L_{pAS} (AS-weighted sound pressure level);
- A-weighted sound pressure level measured with time weighting I: L_{pAI} (AI-weighted sound pressure level, A-weighted impulse sound pressure level).

3.1.3 The time-averaged sound pressure level (averaged over the specified time interval T) as laid down in DIN 45641 is denoted by the subscript "m" and termed "averaged level"

$$L_{pm} = 10 \lg \left[\frac{1}{T} \int_0^T 10^{0{,}1\, L_p(t)}\, dt \right] \text{dB} = 10 \lg \left[\frac{1}{T} \int_0^T \frac{p^2}{p_0^2}\, dt \right],$$

with $L_p(t)$ in dB.

Example: L_{pAIm}.