DETERMINATION OF AIRBORNE SOUND POWER LEVELS EMITTED BY GEAR UNITS

CONTENTS .... PAGE

ANNEXES

DETERMINATION OF AIRBORNE SOUND POWER LEVELS EMITTED BY GEAR UNITS

0 SCOPE

This standard specifies the conditions in accordance with which sound emitted from gear units shall be determined by a common procedure such that the levels so determined will be comparable. This standard applies to all power transmission gearing other than gears for fine mechanisms.

This document uses as a basis the standards ISO 3744 (1981) "Acoustics – Determination of sound power levels of noise sources–Engineering methods for free field conditions over a reflecting plane", and ISO 3746 (1979) "Acoustics – Determination of sound power levels of noise sources – survey method".

The gear unit is only part of the total acoustic system which includes, in addition to the gear unit, the prime mover, driven equipment, gear unit mounting, foundation and acoustic environment. Each of these might effect the measured level of sound emitted from the gear unit. Unless otherwise agreed, the gear manufacturer's responsibility is to ensure that the level of noise emitted from a gear unit under the test conditions in his factory is within contractually specified or negotiated limits.

The measurement method prescribed in this standard is valid for determining "A" weighted sound power level of sound radiated over a reflective surface, for example, in an anechoic room with a reflective floor. Correction values are provided so that within specified limits the procedure can be applied in factory test areas commonly used by a manufacturer.

In some instances it may be necessary to determine sound power levels in octave or 1/3 octave bands; procedures are included in this standard for that purpose. However, the use of those procedures must be agreed between manufacturer and purchaser.

NOTE: This standard does not include a method for substitution of a reference source in a reverberation room for determining sound power level. For this method refer to ISO 3743 (1976).

1. REFERENCES

ISO 31/7	Quantities and Units of Acoustics
ISO 131	Expression of physical and subjective magnitudes of sound or noise in air
ISO 3743	Acoustics – Determination of sound power levels of noise sources – Engineering methods for special reverberation test rooms
ISO 3744	Acoustics – Determination of sound power levels of noise sources – Engineering methods for essentially free-field conditions over a reflecting plane
ISO 3746	Acoustics – Determination of sound power levels of noise sources – Survey method
IEC 225	Recommendations for Octave and 1/3 Octave Band Filters intended for the analysis of sound and vibrations
IEC 651	Sound level meters

2. TERMS, DEFINITIONS AND UNITS

2.1 Background Noise

Any sound at the points of measurement which does not originate from or is not directly emitted by the gear unit for which the sound level is to be determined.

2.2 Band Pressure Level

For a specified frequency band, the effective sound pressure level corresponding to the sound energy contained within the band.

2.3 Measurement-Surface

An imaginary surface enveloping the gear unit, on which the measurement points lie, see Clause 4.4.1.

2.4 Measurement-Surface Area, S

The area of the measurement surface (m^2).

2.5 Measurement-Surface Quantity, L_S

This quantity, which accounts for different measurement surface areas, is expressed as:

$$L_S = 10 \log_{10}\left(\frac{S}{S_o}\right) \text{ dB}$$

where

$S_o = 1 \text{ m}^2$

2.6 Nearfield

The zone of the nearfield is recognized by the distance r_n from the geometric center of the sound source beyond which the sound pressure level decreases in proportion to 1/r. Beyond this zone, if the distance is doubled, the sound pressure reduction shall be 6 dB with a permissible deviation of 1 dB. The nearfield depends upon the frequencies of interest.

2.7 Noise Spectrum

A spectrum showing the sound pressure level distribution throughout the frequency range. The appearance of the spectrum depends on the band width characteristics of the analyzer used.

2.8 Sound Level, L_{pA}

It is defined as the "A" weighted sound pressure level reading given by a sound level meter complying with IEC 651 - "Sound Level Meters."

2.9 Sound Pressure Level, L_p

It is expressed by the formula:

$$L_p = 20 \log\left(\frac{p}{p_o}\right)$$ in decibels, see ISO 131 (1979)

where

p = is the measured sound pressure

p_o = is the reference sound pressure expressed in the same units as p

$p_o = 20\ \mu\text{ Pa } (20 \times 10^{-6} \text{ N/m}^2)$

2.10 Sound Power Level, L_W

It is expressed as:

$$L_W = 10 \log_{10}\left(\frac{P}{P_o}\right) \text{ in decibels}$$

where

P = is the measured sound power

P_o = is the referenced sound power expressed in the same units as P

$P_o = 10^{-12}$ watt (1 picowatt, 1 pW)

NOTE: L_{WA} is a weighted sound power level determined in such a manner that the acoustic power level in each of the frequency bands is weighted according to the "A" scale.

3. INSTRUMENTATION

3.1 Grade

The sound level meter should comply with IEC 651, "Sound Level Meters," Class 1.

The instructions in the use of the equipment are to be complied with to ensure that the intended degree of precision is realized.

Any filters used for noise analyses should comply with IEC 225, "Recommendations for Octave and 1/3 Octave Band Filters Intended for the Anaysis of Sound and Vibrations." Narrow band or Fourier Transform equipment may also be used for analysis.

NOTE: Octave or 1/3 Octave band levels determined by recombining narrow band or discrete frequency levels, may not be accurate.

3.2 Calibration of Measuring Equipment

The overall acoustical performance of the instrumentation should be checked, and any specified adjustments made immediately before and rechecked immediately after, each series of machine noise measurements.

These site checks should be augmented by more detailed calibrations of all the instrumentation carried out at least once every two (2) years.

3.3 Location of Instruments and Observer

Any measuring amplifiers, filters, or observers should be positioned to minimize errors due to reflections.

4. TEST REQUIREMENTS

4.1 Test Objective

In principle, only that noise emitted from the gear unit should be measured. However, such equipment as is integral with or nearby and essential to the function of the gear unit in service (such as pumps, fans, etc.) is to be included. It is to be exactly stated in the test report the type of additional equipment used and under which condition it was operated.

If a gear unit is mounted in a set of machinery in such a way that its individual level of noise emission cannot be measured, and the level of noise emitted from the set is not of interest, measurement in accordance with other negotiated procedures should be used (such as acoustic intensity, cross correlation, or structural vibration measurements).

4.2 Test Conditions of the Gear Unit

For the purposes of noise tests in accordance with this standard, the following conditions will apply, unless otherwise agreed between the gear manufacturer and the purchaser:

(a) A gear unit shall be tested at its intended operating speed or, if intended for variable speed service, at the arithmetic mean of its speed range.

(b) A gear unit shall be tested in its intended direction of rotation or if reversible in both directions.

(c) Gear units may be operated with or without load, at the gear manufacturer's discretion.

(d) The test measurements shall be conducted using the operating lubricating system and the lubricant viscosity equivalent to the operating viscosity.

(e) Noise measurement shall be conducted when the machinery is operating within its design temperature range.

4.3 Installation and Coupling of the Gear Unit

The test set-up and coupling arrangements can have significant influence on sound radiation from gear units.

The gear unit should be so installed for sound measurement operation, such that the influence of the test environment, including the driving machine, loading device, and foundation, will be minimized to the greatest practicable extent. Some of the measures which can help to achieve this objective are given in Clause 5.3. Noises radiated from driving machines, loading devices or foundations are to be regarded as background noises. If necessary, background noises are to be determined in accordance with the provisions of Clause 5.3.

Details of test set-up and operating conditions must be carefully stated in the test report.

4.4 Measurement Surfaces, Measurement Distance, Position and Number of Measurement Points

4.4.1 Measurement Surfaces

A reference surface in the simple form of a parallelepiped is to be set out as a hypothetical boundry around the gear unit. In laying out this boundary, individual projecting construction features which do not make significant contribution to sound radiation are neglected. The measurement surface conforms to this enclosing reference parallelepiped at distance "d" (see Figures 1 to 8) and ends at a sound reflecting boundary surface of the installation site, for example, at the floor or walls.

The distance from the measurement surface to all other surfaces, such as walls of the room or other machine panels, must be at least twice the distance from the measurement surface to the surface of the reference parallelepiped. If any part of the measurement surface does not meet this condition, that part is disregarded and the remaining measurement surface can be extended to the corresponding wall or panel, if that surface is reflective (see Figure 3).

4.4.2 Measurement Distance

In general the measurement distance "d" is equal to one (1) meter. It can also be chosen at a distance less than one (1) meter, but there is a danger of entering a nearfield zone where sound power determination is not allowed from simple pressure measurements. Measurement at very small distance (minimum 0.25 m) offers possibilities only for comparison with gear units of the same type which have been measured in the same way.

Measurement distances other than one (1) meter are to be stated in the test report.

4.4.3 Position and Number of Measurement Points

The Measurement Point Arrangement can be one of the following:

(a) Complete measurement point arrangement.
The measurement points are to be chosen with regard to the size of the reference parallelepiped and the arrangements shown in Figures 2, 4, 6 and 8. The number of measurement points should be increased if the horizontal distance between adjacent points exceeds two (2) meters, or if the difference in dB between the highest and lowest value of sound pressure level exceeds the number of measurement points. Care is to be taken to ensure that the measurement points are evenly spaced. The measurement points are to be so arranged that the microphone is not placed in air currents streaming from exhaust openings or rotating parts.

Figure 6 shows the measurement point arrangement for the special case of a gear unit installed in a pit.

(b) Simplified measurement point arrangement.
The basic arrangements of measurement points shown in Figures 2, 4, 6 and 8 or even more simple arrangements may suffice, if it has been established by test measurements of the gear unit type that the sound field is sufficiently even to the extent that the sound level determined from the measured values will be equal to, or higher, than that which would be determined by a full compliment of measured values.

(c) Single point measurement for acceptance testing.
A standard production test for a gear unit, considering the economic effect of sound power testing, may be conducted using a single point sound pressure measurement. This single point measurement shall only be used with the consideration that: a single point cannot be used to obtain a true sound power level; the test area and unit type must be qualified by prior sound power determination in accordance with Clause 4.4.3 a; the point of sound pressure measurement should be selected as the surface measuring point of least perturbation established by the sound power determination. This single point sound pressure method shall only apply when agreed between manufacturer and purchaser.

4.5 Test Room

Gear unit sound can be measured to this standard if the influence of room acoustic reaction (reverberation) on the sound field in the vicinity of the measurement points is not more than 3 dB. This requirement is met if the correction factor for room influence, K_2, is $\leq$ 3 dB as given in Clause 6.1.4 or $\leq$ 3 dB/Octave as given in Clause 7.1.4. The level of $K_2 \leq$ 3 dB is the appropriate level for gear unit measurements as an intermediate value between those of ISO 3744 and ISO 3746.

When the distance from the measurement surface to the nearest flat surface, including room walls and other machines, is at least twice the measurement distance, it can be assumed that the test room is suitable if the interior volume of the room is nearly numerically equal to, or greater than, the area of the measurement surface in square meters multiplied by 100. If the test room does not meet these volumetric requirements, room suitability may be determined as follows:

Place a small broad band noise source at the position to be occupied by the geometric center of the gear unit under test. Using this noise source, determine the mean sound pressure levels at two sets of measurement points. These two sets of measurement points are: (a) the pre-selected measurement points, and (b) corresponding points half or twice the distance from the source (provided that the points are not in the nearfield). The difference between the two means must be at least 4 dB for room suitability.

Measurements are then correct in accordance with Clauses 6.1.4 or 7.1.4.

If the room correction factor, K_2, exceeds 3 dB, then measurements cannot be corrected in accordance with the procedure of Clause 6.1.4 because incremental pressures included in the measured levels are excessive. In such cases, recalibration with smaller measurement distances can be tried, free-hanging absorbers or additional sound absorption material can be installed, or a more suitable room should be chosen.

5. PROCEDURE FOR OBTAINING SOUND PRESSURE DATA

Before carrying out measurements, the conditions set out in Section 4 are to be reviewed to establish such corrections as are necessary.

It must be noted that the meter can be influenced when measuring under difficult conditions (such as vibrations, electrical and magnetic fields, wind or gas streams, abnormal temperature).

5.1 Obtaining "A" Weighted Sound Pressure Levels

At each measurement point, using the "A" weighted frequency scale and "slow" meter response characteristic, the sound level, L_{pAS}, should be observed on the sound level meter. From the observed levels, the time related mean level, L_{pASm}, should be recorded. The measurement time for this mean level, L_{pASm}, should be chosen such that the sound level recorded will be representative of normal operating conditions.

5.2 Obtaining Sound Pressure Level Spectra

Sound pressure level spectra are in general to be determined without weighting in frequency bands. Measurements at each measurement point, in octave band frequency range will suffice and are recommended, unless pure tones are present in which case third octave, narrow band spectra or Fourier Transform analysis may be necessary.

5.3 Concerning Background Noise

With only the gear unit and essential auxiliaries, see Clause 4.1, at a standstill, background noise levels are to be observed at each measurement point and recorded as described in Clauses 5.1 and 5.2. These levels should preferably be so low as not to influence measurements of gear noise. This is assured if "A" weighted background noise levels are lower than levels observed during the tests by 10 or more dB. If this is not the case, measures such as are described below might help to reduce background noise.

5.3.1 As many of the background noise sources as is practicable should be moved out of the test area, or as far away as safety (because of extended shafts) and the area will allow.

5.3.2 Background noise sources can, if practicable, be acoustically screened. Possible reflection of gear noise from screens must be considered.

5.3.3 Subject to agreement, operating conditions might be altered to avoid, for example, structural resonances in the test area.

5.3.4 If the above measures do not sufficiently reduce background noise, a correction in accordance with Clause 6.1.2 is to be applied when background levels are from 3 dB to 9 dB below observed levels according to Clauses 5.1 and 5.2.

5.4 Calculation of the Measurement Surface Area, S, and the Measurement Surface Quality, L_S

The measurement surface area, S, in m² is calculated from Figures 2, 4, 6 and 8 as follows:

$S = 4\ (ab + ac + bc)$ (Figure 2)

$S = 2\ (2ab + 2ac + bc)$ (Figure 4)

$S = 4\ ab$ (Figure 6)

$S = 4\ (2ab + ac + bc)$ (Figure 8)

The measurement surface quantity is obtained therefore as:

$$L_S = 10 \log_{10} \left(\frac{S}{S_o} \right) \text{ dB or from Table 1}$$

where

The reference surface area $S_o = 1\ m^2$

Only an approximate value of the measurement surface area needs be determined since an error of −20 percent to +25 percent will only result in a measurement surface value change of 1dB.

6. PROCESSING OBSERVED SOUND PRESSURE FOR DETERMINING "A" WEIGHTED SOUND POWER

6.1 Determination of the Surface Sound Pressure Level Mean Value, $\bar{L}_{pAm}$

$\bar{L}_{pAm}$ is to be determined in accordance with Clauses 6.1.1 to 6.1.3 from values of sound pressure measured at the measurement surface.

6.1.1 Time Related Mean Values

Values obtained in accordance with Clauses 5.1 and 5.2 are time related mean values.

6.1.2 Corrections for Background Noise

If it is necessary to take account of background noise, correction values K_1 at each measurement point (i) which depend on the difference in dB between measurements, in accordance with Clauses 5.1 and 5.2 respectively, and background noise measurements, are to be chosen from Table 2.

If at any point the difference is less than 3 dB, the sound pressure level so corrected is not accurate.

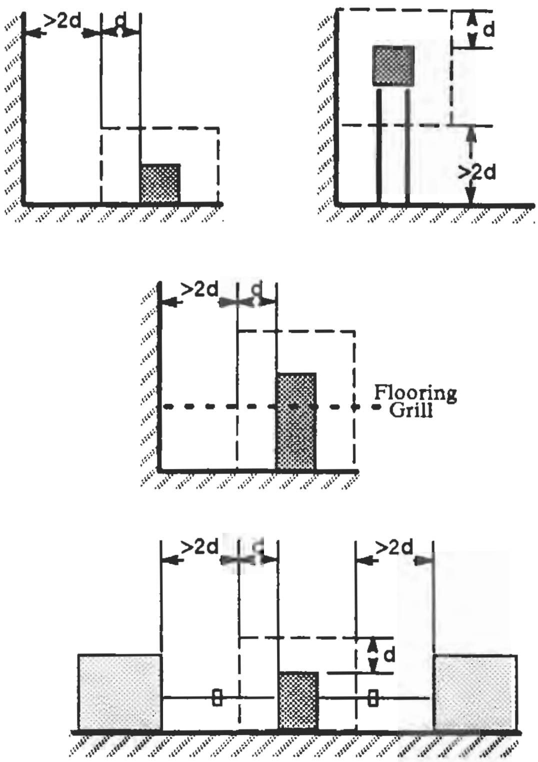

Fig 1 Example of Machinery Mounted on the Floor or by a Wall

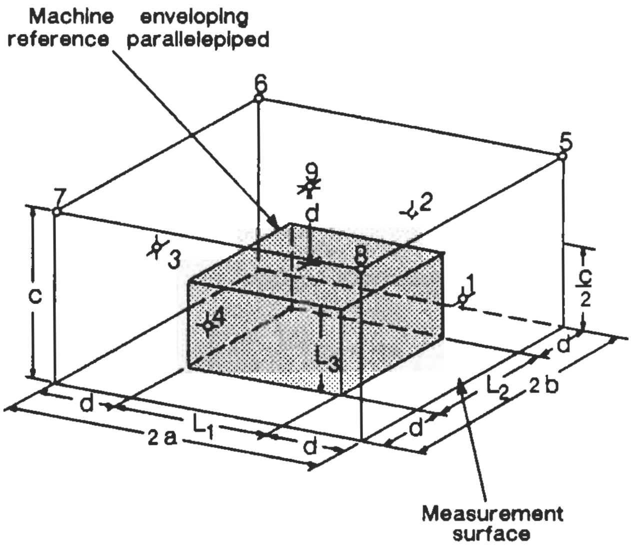

Fig 2 Measurement Point Arrangemwnt According to Fig 1

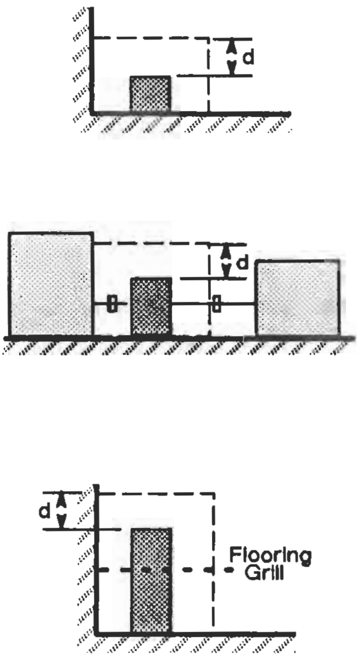

Fig 3 Example of Machinery Mounted on the Floor or Near to a Wall

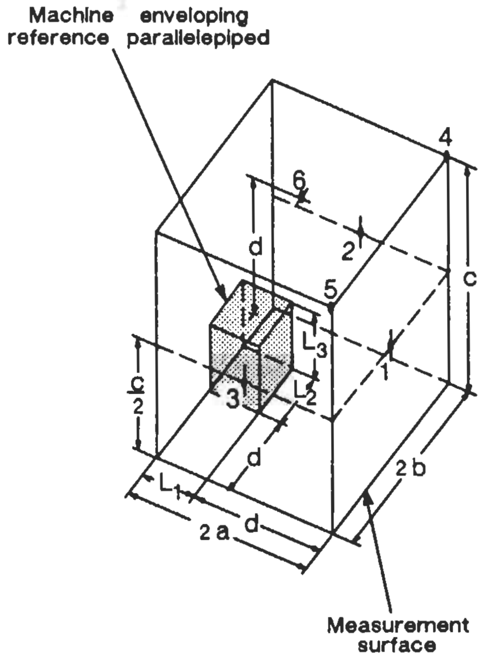

Fig 4 Measurement Point Arrangement According to Fig 3

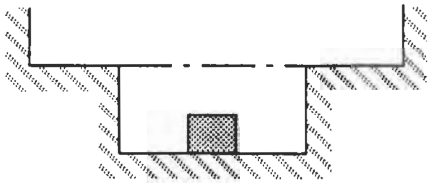

Fig 5 Example of Machinery Mounted in Pits with Hard Sound-Reflecting Walls

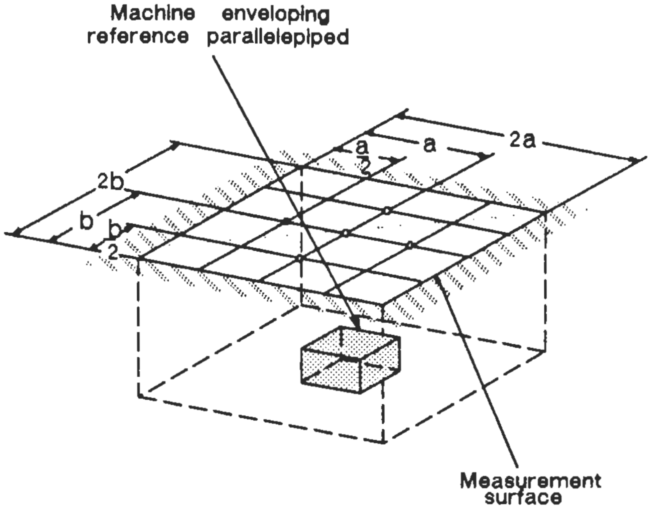

Fig 6 Measurement Point Arrangement According to Fig 5

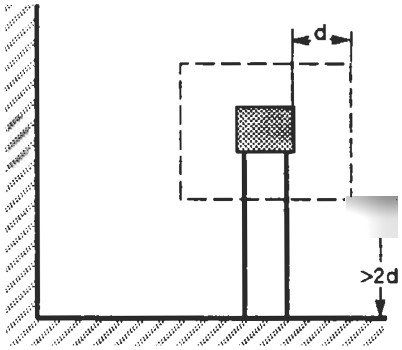

Fig 7 Example of Machinery Mounted at a Considerable Distance from Sound-Reflecting

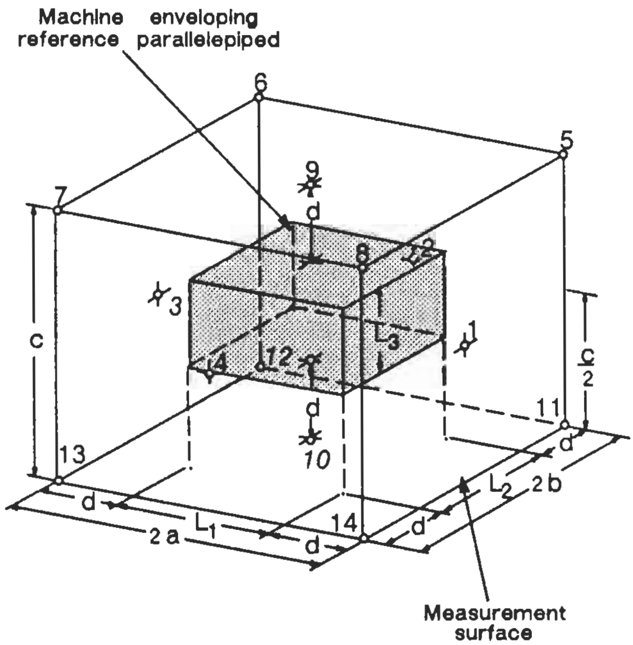

Fig 8 Surface Measurement Point Arrangement According to Fig 7

TABLE 1

Measurement Surface Quantity Relative to Measurement Surface Area based on $S_o = 1\ m^2$

Measurement Surface Area S m^2	Measurement Surface Quantity L_S dB
0.63	-2
0.80	-1
1.0	0
1.25	+1
1.60	+2
2.0	+3
2.5	+4
3.2	+5
4.0	+6
5.0	+7
6.3	+8
8.0	+9
10.0	+10
12.5	+11
16	+12
20	+13
25	+14
32	+15
40	+16
50	+17
63	+18
80	+19
100	+20
125	+21
160	+22
200	+23
250	+24
320	+25
400	+26
500	+27
630	+28

TABLE 2

Correction Values K_1 for Taking Account of Background Noise

Difference between the values obtained in accordance with Clauses 5.1 and 5.3 in dB	3	4 to 5	6 to 9
Correction values K_1 in dB to be subtracted from values obtained in accordance with Clause 5.1	3	2	1

6.1.3 Surface Sound Pressure Level Mean Value

The surface sound pressure level mean value, $\bar{L}_{pAm}$, is to be evaluated from all the time related mean values determined at all measurement points, and corrected if necessary in accordance with Clause 6.1.2. If the difference between the highest and lowest values does not exceed 6 dB, the arithmetic mean can be taken.

$$\bar{L}_{pAm} = \frac{1}{n} \sum_{i=1}^{n} (L_{pASmi} - K_{1i})$$

Where: K_{1i} is the K_1, correction at each point if neccessary.

If the difference exceeds 6 dB(A), the mean of the nth individual sound pressure levels is to be determined on the energy basis. The formula that then must be used is:

$$\bar{L}_{pAm} = 10 \log_{10} \frac{1}{n} \sum_{j=1}^{n} 10^{(L_{pASmj} - K_{1j})/10}$$

6.1.4 Determination of the Room Factor, K_2

The effect of acoustic reaction of the test area on the surface sound pressure levels in accordance with Clause 6.1.3 is above all dependent on the absorption characteristics of the test room, and the quotient of its volume, V, and the measurement surface, S.

The acoustic reaction (0 to 3 dB) can be dealt with by subtracting an integer number correction factorfor room influence, K_2, from the surface sound pressure level mean value. The correction factor can be determined directly by:

(a) Use of a reference sound source (see Annex C)
or
(b) Use of Table 3

6.1.5 Calculation of Corrected Mean Sound Pressure Level, $\bar{L}_{pAf}$

The factor K_2 is to be used as necessary to calculate the corrected mean sound pressure level $\bar{L}_{pAf}$.

$$\bar{L}_{pAf} = \bar{L}_{pAm} - K_2$$

6.2 Calculation of a "A" Weighted Sound Power Level, L_{WA}

The "A" weighted sound power level is usually approximated as the sum of the corrected mean pressure level, $\bar{L}_{pAf}$, and the measurement surface quantity, L_S, in accordance with Clause 5.4.

$$L_{WA} = \bar{L}_{pAf} + L_S$$

6.3 Measurement Uncertainty

Because of characteristic tolerances of instruments, disturbances during measurement and uncertainties inherent in the above correction procedure, the measurement uncertainty for the sound power determination would have a standard deviation of 1 dB.

NOTE: If the distribution is "normal" and the standard deviation s = 1 dB, then in 70 percent of all cases uncertainties are less than ± 1 dB, and in 95 percent of all cases uncertainties will be less than ± 2 dB.

TABLE 3

CORRECTION ROOM FACTOR VALUES, K_2, IN dB FOR USUAL MACHINE AND TESTING ROOM, DEPENDENT ON THE MEASUREMENT SURFACE

Measurement Surface Area, S (m^2), Room Characteristics and Volume, V (m^3), are Known

Quotient room volume by measurement surface area V/S: 25 32 40 50 63 80 100 125 160 200 250 320 400 500 630 800 1000

Room Furnishings and Fittings	Hatched zones (values greater than 3 dB)	$K_2 = 3$	$K_2 = 2$	$K_2 = 1$	$K_2 = 0$
(a) Room with strongly reflecting walls (e.g. tiles, flat concrete or plaster)	25 – 100	100 – 160	160 – 320	320 – 800	800 – 1000
(b) Room without features according to (a) or (c)	25 – 63	63 – 100	100 – 200	200 – 500	500 – 1000
(c) Room with weakly reflecting surface with some sound absorbing areas	25 – 40	40 – 63	63 – 125	125 – 320	320 – 1000

NOTE: Table 3 provides help towards estimating room factor values of K_2 without frequent recourse to sound source measurements (see Clause 4.5 and Annex C). The qualification test by direct measurement is, however, essential in cases where application of Table 3 raises doubts or provides values greater than 3 dB (hatched zones).

7. EVALUATION OF OCTAVE AND 1/3 OCTAVE SOUND POWER

NOTE: All considerations developed for "octave" can be applied to "1/3 octave".

7.1 Determination of the Surface Sound Pressure Level Mean Value for Octave (1/3 Octave) Band Pressure Levels, $\bar{L}_{oct}$ ($\bar{L}_{1/3\ oct}$)

The surface sound pressure level mean values, $\bar{L}_{oct}$ ($\bar{L}_{1/3oct}$), are to be determined in each octave (1/3 octave) band (125 Hz to 8kHz) from values of octave (1/3 octave) band pressure levels at each point of the measurement surface.

7.1.1 Time Related Mean

See Clause 6.1.1.

7.1.2 Correction for Background Noise in Octave (1/3 Octave) Bands

If it is necessary to take account of background noise, correction values, K_{1octi}, for each octave (1/3 octave) band, and at each point which depend on the difference in dB in each octave (1/3 octave) band, are to be chosen from Table 2.

If at **any point** the difference is less than 3dB in an **octave (1/3 octave)** band, the sound pressure in that octave (1/3 octave) band is not accurate.

7.1.3 Surface Sound Pressure Level Mean for Octave (1/3 Octave) Band Evaluation

The surface sound pressure level mean values, $\bar{L}_{oct}$, for each octave (1/3 octave) band are to be evaluated from all the time related mean values determined at all measurement points and corrected separately for background noise.

If in any octave (1/3 octave) band the difference between the highest and lowest values does not exceed 6dB, the arithmetic mean can be taken.

If this difference exceeds 6dB, the mean of the individual sound pressure levels is to be determined on the energy basis, see Clause 6.1.3.

7.1.4 Determination of the Octave (1/3 Octave) Band Room Factors, K_{2oct}

The factor for each octave (1/3 octave) band is to be determined by:

(a) Use of reference sound source (see Annex C)

or

(b) Use of Method A in Table 3 (K_2 + K_{2oct})

7.1.5 Calculation of Corrected Mean Octave (1/3 Octave) Band Pressure Levels, $\bar{L}_{oct.c}$

Factors determined in accordance with Clause 7.1.4 are used to calculate corrected octave (1/3 octave) band mean pressure levels:

$$\bar{L}_{oct.c} = \bar{L}_{oct} - K_{2oct}$$

7.2 Calculation of Octave (1/3 Octave) Band Power Levels, L_{Woct}

The octave (1/3 octave) band power level, L_{Woct}, are calculated as the sum of the corrected mean octave (1/3 octave) band pressure levels, $L_{oct.c}$, and the measurement surface quantity, L_S.

$$L_{Woct} = \bar{L}_{oct.c} + L_S$$

7.3 Octave (1/3 Octave) Power Level Measurement Uncertainty

Band levels determined in conformance with this standard will be accurate within confidence limits indicated by standard deviations given in Table 4.

NOTE: If the distribution is "normal" and the standard deviation is equal to "s", then in 70 percent of all cases uncertainties are less than ± 1, s and in 95 percent of all cases uncertainties will be less than ± 2 s.

TABLE 4

Band Power Levels - Measurement Uncertainty Standard Deviations

Octave Band Center Frequencies (Hz)	One Third Octave Band Center Frequencies (Hz)	Standard Deviation (dB)
125	100 to 160	3.0
250 to 500	200 to 630	2.0
1000 to 4000	800 to 5000	1.5
8000	6300 to 10,000	2.5

8. TEST REPORT

The test report shall include:

8.1 Type and Definition of Gear Unit. Manufacturer, type and definition of the gear unit investigated, see Clause 4.1.

8.2 Operating Data. The test operating data conditions for setting-up and running of the gear unit.

Special attention is to be drawn to any deviations from the conditions specified in Clause 4.2.

8.3 Description of Arrangement. Descriptions, including dimensional sketch of the test room, arrangement of the gear unit, position of measurement points, distance of measurement points from the gear unit surfaces, data from individual measurement points in accordance with Clause 4.2.

8.4 List of Measuring Equipment. A list of the measuring equipment used, by make and type.

8.5 Description of Noise. Characteristics of the noise, especially: distinctly perceptible individual tones, surges, pulse content, etc.

8.6 Test Measurements and Results

8.6.1 "A" weighted measurements and results shall include:

(a) "A" weighted sound pressure level, L_{pASm}, at each measurement point, see Clause 5.1.

(b) Background noise level and correction factors, K_1, at each measurement point, see Clause 6.1.2.

(c) Calculated mean value of sound pressure level, L_{pAm}, from L_{pAS} and K_1 at each measurement point, see Clause 6.1.3.

(d) Applied room factor, K_2, (Clause 6.1.4).

(e) The measurement surface quantity, L_S, corresponding to the measurement surface area, S, see Clause 5.4.

(f) The sound power level, L_{WA}, see Clause 6.2.

(g) Measurements at additionally chosen point (s) may be made, if requested, and are to be precisely reported.

8.6.2 Octave or 1/3 Octave Band measurements and results shall include:

(a) Octave (or 1/3 octave) band sound pressure level, L_{oct}, at each measurement point, see Clause 5.2.

(b) Background noise levels and correction factors, K_1, at each measurement point, and in each octave (or 1/3 octave) band.

(c) Calculated mean value of sound pressure levels L_{oct} in each octave (or 1/3 octave) band, and at each measurement point from L_{oct} and K_1, see Clause 7.1.3.

(d) Applied room factor, K_{2oct}, in each octave (or 1/3 octave) band, see Clause 7.1.4.

(e) The measurement surface quantity, L_S, corresponding to the measurement surface area, S, see Clause 5.4.

(f) The sound power level, L_{Woct}, in each octave (1/3 octave) band, see Clauses 7.2 and 7.3.

(g) Unless separately measured, the "A" weighted sound power level, L_{WA}, shall be calculated on the energy basis, see Clause 6.1.3 from the "A" weighted sound power levels, L_{Woct}, in each octave (or 1/3 octave) band (see Annex A).

(h) Measurements at additionally chosen point (s) may be made, if requested, and are to be precisely reported.

ANNEX A
COMPUTATION PROCEDURES FOR CALCULATING "A" WEIGHTED SOUND PRESSURE OR POWER LEVELS FROM OCTAVE OR 1/3 OCTAVE BAND SPECTRA

A1 Compute the "A" weighted sound pressure level mean, L_A, in decibles from the formula:

$$\bar{L}_A = 10 \log_{10} \sum_{j=1}^{j\,max.} 10^{0.1(\bar{L}_{oct\,j} + C_j)}$$

Where: C_j = the correction factor in the j octave or 1/3 octave band, see Clauses A2 or A3

NOTE: The same formula may be used for sound power level using L_{WA} for $\bar{L}_A$ and L_{Woct} for $\bar{L}_{Woct}$

A2 For computations with octave band data, j_{max} = 7 and C_j is given in the following table:

J	Octave band centre frequency (H_z)	C_J
1	125	-16.1
2	250	-8.6
3	500	-3.2
4	1000	0
5	2000	+1.2
6	4000	+1.0
7	8000	-1.1

A3 For computations with third-octave band data, j_{max}= 21 and C_j is given in the following table:

J	One-third octave band centre frequency (H_z)	C_J
1	100	-19.1
2	125	-16.1
3	160	-13.4
4	200	-10.9
5	250	-8.6
6	315	-6.6
7	400	-4.8
8	500	-3.2
9	630	-1.9
10	800	-0.8
11	1000	0
12	1250	0.6
13	1600	1.0
14	2000	1.2
15	2500	1.3
16	3150	1.2
17	4000	1.0
18	5000	0.5
19	6300	-0.1
20	8000	-1.1
21	10,000	-2.5

ANNEX B
PRACTICAL MEASUREMENT APPLICATIONS

B 1 Characteristic Parameters for Gear Unit Sound Acceptance

Normally one of the following characteristics is applied to gear units as a sound acceptance parameter:

(a) Sound Power Level, L_{WA}.

(b) Measurement of "sound pressure level", L_A, together with the measurement distance.

(c) Sound pressure spectra at designated measurement points.

B 2 Assignment of Practical Acceptance Criteria

B 2.1 In most cases for gear units of similar type, and with the same operating conditions, when the measurement quantity is within 2 dB it is sufficient for acceptance to directly compare their measurement surface sound pressure levels.

B 2.2 When the conditions of B.2.1 are not met, acceptance should be by sound power levels.

B 2.3 The noise influence at working areas near machinery may be assigned acceptance levels derived from "A" weighted sound pressure measurements made in those areas. These may be complemented by "A" weighted sound pressure level measurements in the fast meter operating mode or sound spectra or both.

For evaluation of expected sound around a gear unit at a particular point, it may be necessary to provide a statement of sound power level with information on directional characteristics of the sound spectrum.

NOTE: For evaluation of sound level at a specified distance, the pattern of spreading of sound over the radiation paths of the site of installation must be known. This pattern can be determined at the site by taking measurements at two distances, d_1 and $2d_1$.

If people work in areas near the machines, room influence on those areas can be determined by means of additional independent measurements at the work stations. The results of these measurements must not be used for evaluating the mean level of sound emitted by the machines unless the measurement points lie on the measurement surface.

B 2.4 In general, to solve problems of noise reduction requires knowledge of the noise spectrum.

NOTE: To this end, more detailed measurements such as structureborne noise and measurements under various operating conditions may be necessary.

B 3 The use of other methods of sound power determination, such as sound intensity measurements, may be used for acceptance if the method is agreed upon between the manufacturer and the purchaser.

ANNEX C
DETERMINATION OF THE CORRECTION FACTOR K_2 FOR ROOM ACOUSTIC REACTION WITH THE AID OF A REFERENCE SOUND-SOURCE

C 1 Requirements for the Reference Sound-Source

The reference sound-source is to be able to radiate without significant directivity or pure tone content, broad band sound covering the frequency range of interest.

The requirement for constancy of level can be deemed adequate if the sound pressure level measured in the slow mode at a fixed position does not vary by more than 0.5 dB in one hour.

The nearfield zone of the reference sound source must be known over the entire frequency range of interest.

NOTE: Smaller sound-sources have in general less extensive nearfield zones. Small fans driven at high rotational speeds of which those speeds, are variable and controlled, are especially suitable, for example the motor/fan assembly of a vacuum cleaner.

C 2 Making the Measurements and Determination of K_2

The reference sound-source shall be installed in the measurement room to occupy the position to be occupied by the geometric center of the gear unit, for which the noise is to be measured. For all measurement points chosen for measurement of gear unit noise, the sound power level, L_{W1}, and octave band power levels for all frequency bands of interest are to be determined in accordance with Section 6 and Section 7.

The determination of sound power level, L_W, of the reference sound-source is to be repeated for another set of measurement points nearer to the source but remaining outside the nearfield zone. It is recommended that for this purpose the original measurement distance should be at least halved. The result of the second determination of sound power level is to be designated L_{W2}.

Thence the correction value, K_2, for unfiltered or band sound power levels, is calculated from the difference in sound power determinations.

$$K_2 = L_{W1} - L_{W2}$$