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GENERAL REQUIREMENTS FOR THE PREPARATION OF TEST CODES FOR MEASURING THE NOISE EMITTED BY MACHINES

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BRIEF HISTORY

The ISO Recommendation R 495, *General Requirements for the Preparation of Test Codes for Measuring the Noise Emitted by Machines*, was drawn up by Technical Committee ISO/TC 43, *Acoustics*, the Secretariat of which is held by the British Standards Institution (BSI).

Work on this question by the Technical Committee began in 1960 and led, in 1963, to the adoption of a Draft ISO Recommendation.

In December 1963, this Draft ISO Recommendation (No. 695) was circulated to all the ISO Member Bodies for enquiry. It was approved, subject to a few modifications of an editorial nature, by the following Member Bodies:

Australia	Finland	Korea, Rep. of
Austria	France	Netherlands
Belgium	Germany	New Zealand
Brazil	Greece	Sweden
Canada	Hungary	Switzerland
Chile	India	United Kingdom
Colombia	Israel	U.S.A.
Czechoslovakia	Italy	U.S.S.R.
Denmark	Japan	Yugoslavia

No Member Body opposed the approval of the Draft.

The Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided, in August 1966, to accept it as an ISO RECOMMENDATION.

ISO Recommendation R 495 August 1966

GENERAL REQUIREMENTS FOR THE PREPARATION OF TEST CODES FOR MEASURING THE NOISE EMITTED BY MACHINES

1. SCOPE

This ISO Recommendation is concerned with the procedures to be followed in the objective measurement of the noise emitted by machines. These procedures are not necessarily applicable to noise of an impulsive character.

The aim is to indicate the general principles by which specific test codes for noise measurements may be formulated. These general rules give different methods for measuring noise.

The specific codes for the various types of machines will have to select the most suitable method having regard to the size of the machine and its application. The codes themselves should contain all the necessary particulars to enable a result to be obtained with the required accuracy.

2. GENERAL

The measurement of the physical characteristics of the noise of machines has four objects:

(*a*) Verification that the noise of a given machine conforms to a certain standard;

(*b*) To make a comparison between the noise emitted by machines built to the same specification;

(*c*) To make a comparison between the noise emitted by different machines;

(*d*) The determination of the noise received at a distance.

The four aims stated above can be attained through the determination of the radiated sound power and its directivity. Special installation conditions of the machine are however required and these conditions cannot always be met, particularly for large machines. When this is the case, the test code may call for the measurement of sound pressure level near the machine and when appropriate the determination of the sound pressure level at the reference radius. From these sound pressure level measurements it is possible in certain cases to make an approximate determination of the radiated sound power.

3. DEFINITIONS AND TERMS

3.1 *Sound pressure level* is defined by ISO Recommendation R 131, *Expression of the Physical and Subjective Magnitudes of Sound or Noise.*

3.2 *Sound level* is defined as the reading given by a sound level meter complying with specifications of the International Electrotechnical Commission (IEC), Publications No. 123 for sound level meters, or No. 179 for precision sound level meters.

3.3 *Sound power level* is defined as $10 \log_{10} \frac{P}{P_o}$

where P is the sound power and P_o is the reference sound power of 10^{-12} W.

For the purposes of this ISO Recommendation, the following definitions apply:

3.4 *Machine.* Any sound source of which the acoustical characteristics are to be measured.

3.5 *Prescribed surface.* A hypothetical surface surrounding the machine as given in the test code and over which the measurements are assumed to be made. Its area S is calculated as laid down in the test code.

3.6 *Equivalent hemisphere.* A hypothetical hemisphere having the same area S as the prescribed surface.

3.7 *Reference radius.* A radius (measured from the centre of the equivalent hemisphere), as given in the test code, to which all the results of measurements made on machines of the same category (tested according to the same test code) are reduced.

4. INSTALLATION AND OPERATION OF THE MACHINE

The acoustic radiation of the machine can depend on its installation, particularly when the machine is one of small dimensions.

The test code should, therefore, define the conditions of installation of the machine. It should also define the conditions of operation of the machine during the test.

5. QUANTITIES TO BE MEASURED

Depending on the purpose of the measurement, the nature of the noise source, and the character of the sound field, one or both of the following quantities should be measured:

(*a*) Sound level (it is recommended that weighting A be adopted);

(*b*) Sound pressure level in frequency bands of given width (it is recommended that octave bands be used; for narrower bands, the result should always be available, expressed in octave bands).

Since in all cases a pressure microphone will be used, the result of the measurements will be band sound pressure level or sound level values.

NOTES

1. When the spectral distribution of the noise is well known, a measurement of wide band sound pressure level or sound level may suffice.
2. Any determination of the spectral distribution of the noise should be in frequency bands corresponding to those specified in ISO Recommendation R 266, *Preferred Frequencies for Acoustical Measurements.*

6. RECOMMENDED METHODS OF MEASUREMENT

The accurate determination of the acoustic power of a machine has to be performed either as a far-field sound pressure level measurement under hemispherical radiation or free-field conditions, or as a sound pressure level measurement in a reverberant room under diffuse-field conditions.

It is often impossible to take sound pressure level measurements under such ideal conditions. In such cases sound pressure level measurements have to be performed under semi-reverberant conditions, or near-field measurements made.

6.1 Determination of sound power.

The methods available for the determination of the radiated sound power and the directivity are described in Annexes A, B and C.

6.1.1 *Hemispherical radiation and free-field methods.* The determination of the sound power and the directivity requires the siting of measurement points sufficiently remote from the machine for the conditions of propagation of progressive sound waves to be established.

There should be no reflected waves at the measurement points and this requires premises with sufficiently absorbent walls and dimensions large compared with those of the machine (see Annex A).

Any effect of the surroundings or near-field effects will be made apparent by measuring over two surfaces and checking if the sound pressure varies inversely as the square root of the ratio of surface areas. A ratio of areas of 2 or 4 is recommended, corresponding to −3 and −6 dB respectively. The results of such check measurements should be stated.

6.1.2 *Diffuse-field method.* As an alternative to the hemispherical radiation and free-field methods, the use of a highly reverberant enclosure is recommended.

In this case, the sound field tends to become uniform and the relevant theory for sound power determination is described in Annex B.

This method can provide no information on the directivity of the acoustic radiation.

Since the degree of diffusion is dependent upon the nature of the noise source, this method is not recommended for machines the noise from which contains prominent components.

6.1.3 *Semi-reverberant method.* A third method in which semi-reverberant conditions exist is possible (see Annex C).

This method can provide only limited information on the directivity of the acoustic radiation.

6.2 Near-field sound pressure level measurement

6.2.1 *General.* This method consists of carrying out sound pressure level measurements at a number of points suitably distributed around the machine, sufficiently close to the machine so that the measurements are not significantly affected by nearby reflecting surfaces or background noise.

6.2.2 *Prescribed surface.* A surface as simple as possible and whose area can be calculated easily should be marked out round the machine conforming approximately to the external casing. This surface and its average distance from the outer casing should be laid down in each test code.

The number and disposition of the measuring points required depend on the irregularity of the acoustic field.

When it is necessary to carry out measurements closer to the machine than is specified in the test code, or to explore only part of the surface, these limitations should be clearly stated in the test report.

6.2.3 *Evaluation of the result.* In the majority of cases, in particular when the directivity is not pronounced or when for the type of machine under consideration it varies relatively slightly from one machine to another, the arithmetic mean of the decibel readings over the prescribed surface may be a sufficiently accurate measure of the mean square pressure.

NOTE. — For a spread of 5 dB in the decibel readings, the error in taking the mean of the decibels is less than 0.7 dB and for a spread of 10 dB it is less than 2.5 dB. When the spread is greater than 10 dB, this method of averaging is not suitable.

6.2.4 *Effect of environment.* The effect of the surroundings of the machine may be determined by first placing such a machine in a space without reflections and secondly in the test environment so that a direct comparison can be made; every precaution should be taken to ensure constant conditions of machine noise and measuring apparatus.

As accurate determination of the influence of the surroundings is not possible, it is recommended that this influence be kept to a minimum.

6.2.5 *Calculation of the sound pressure level at a reference radius.* The sound pressure level at a reference radius which is laid down in the specific test codes, can be calculated from that measured on the prescribed surface as described in Annex D.

The reference radius should be the same for all machines covered by a given code. One of the values 1, 3 or 10 m should be adopted.

It is recommended that the value chosen should be slightly greater than the radius of the equivalent hemisphere corresponding to the largest machine covered by the test code.

6.2.6 *Approximate evaluation of the sound power.* In certain cases it is possible to arrive at an approximate evaluation of the sound power starting from the sound pressure level at the measuring distance of the reference radius (see Annexes D and A).

NOTE. — In the case of hemispherical radiation at 20 °C and 1000 mb, the numerical value of sound power level (as defined in clause 3.3) would be 8, 18 or 28 dB greater than the sound pressure level at the reference distance for reference distances of 1, 3 and 10 m respectively.

6.3 Background noise

The background noise readings when the machine is not on test should be determined using the same filters and at the same points as for the test. The readings at each point with the machine on test ought to exceed those due to the background noise alone by at least 10 dB.

When the differences are less than 10 dB, corrections as given below should be applied:

dB increase in level produced by the machine dB	dB to be subtracted from the measured value dB
3	3
4–5	2
6–9	1

When corrections are applied, the corrected levels should be reported in brackets.

When the increase is less than 3 dB, measurements in general cease to have any significance.

6.4 Choice of method

The methods of measurement of sound pressure level under conditions that permit the determination of acoustic power are recommended.

The determination of acoustic power and directivity from measurements made under hemispherical radiation or free-field conditions (see clause 6.1.1) makes it possible to calculate the sound pressure level at a distance.

If the directivity is not pronounced or there are no great variations from one machine to another it may be preferable to determine the acoustic power from measurements in a diffuse field (see clause 6.1.2). In this case, since the characteristics of the reverberant enclosure generally vary with frequency, it is usually necessary to analyse the noise in frequency bands.

If the measurements are made under semi-reverberant conditions (see clause 6.1.3) the determination of acoustic power is often less precise.

When measurements according to clauses 6.1.1, 6.1.2 or 6.1.3 are difficult to perform, it may suffice to carry out sound pressure level measurements close to the machine, in accordance with clause 6.2. These may be the only measurements possible when difficulties are encountered with reflecting surfaces or background noise. Such measurements permit correct comparisons to be made between similar machines built to the same specification but make possible only an approximate determination of the acoustic power or the sound pressure level at a distance.

7. PRESENTATION OF RESULTS

The test report should give the following information in all cases:

(*a*) Reference to the test code.

(*b*) Description of the machine and of its conditions of installation and operation.

(*c*) Description of the test environment and location of the machine.

(*d*) Meteorological conditions, if appropriate, e.g. ambient temperature, relative humidity and barometric pressure.

(*e*) Description of measuring apparatus used.

NOTES

1. When a sound level meter is used, the grade employed and the weighting network used should be stated.
2. When a frequency analyser is used, the band width and centre frequencies should be stated.

(*f*) Position of measuring points.

(*g*) Results of sound pressure level measurements.

(*h*) Background noise levels.

(*i*) Sound pressure level values corrected for background noise if necessary.

(*j*) When required, the calculated octave band sound power levels.

(*k*) When required, the sound pressure level at the reference radius or reference surface corrected as for free-field conditions.

(*l*) In the case of measurements in an anechoic environment, when required, the directivity index as calculated by the method of Annex A.

NOTE. — Values of the directivity index at intervals of 30° are generally sufficient.

7.1 Additional information to be given for near-field sound pressure level measurements

(*a*) Description of the prescribed surface and equivalent hemisphere.

(*b*) Results of sound pressure level measurements, either average or individual, as specified in the test code.

(*c*) Effect, if any, of environment.

(*d*) Extrapolation of the results to the reference radius specified in the test code, by the method given in Annex D.