International Standard ISO 7574/4

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Acoustics — Statistical methods for determining and verifying stated noise emission values of machinery and equipment — Part 4 : Methods for stated values for batches of machines

Acoustique — Méthodes statistiques pour la détermination et le contrôle des valeurs déclarées d'émission acoustique des machines et équipements — Partie 4 : Méthodes pour valeurs déclarées de lots de machines

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Foreword

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Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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0 Introduction

A general introduction to the four-part series of ISO 7574 is given in ISO 7574/1.

For the purposes of this part of ISO 7574, the term "labelled value" stands for all kinds of stated value (e.g. information on a label, the upper noise limit set by an authority, the agreed contract value) for which the methods may be applied.

This part of ISO 7574 contains statistical sampling methods for checking the stated noise emission values for batches (lots) of machines. The labelled value for all machines in a batch is checked by sampling procedures. A reference standard deviation is required when testing the compliance of a batch of a specific family of machines. In addition, information on the type of sampling to be used (single, double or sequential) and the sample size is required. The procedures specified in this part of ISO 7574 assume that the noise emission values of a batch (lot) of machines will follow a normal distribution. The statistical parameters upon which this part of ISO 7574 is based assume that there is a 95 % probability of acceptance if no more than 6,5 % of the noise emission values in a batch exceed the labelled value. Information is included to assist the labeller in determining a labelled value based on these statistical parameters.

The methods given in this part of ISO 7574 ensure that a batch (lot) of machines labelled in accordance with the specifications for the verification procedure have a predetermined probability of acceptance.

1 Scope and field of application

This part of ISO 7574 provides guidelines for determining the labelled value, L_c, by the labeller and specifies statistical sampling procedures for verifying compliance of the noise emissions of a batch (lot) of machinery and equipment with its labelled value.

This part of ISO 7574 is intended to assist those parties responsible for drawing up specific labelling codes for specific families of machines. It is also intended to be of use to labellers who want their batches of machines to conform with verification procedures that are in accordance with the specifications given in the specific labelling codes based on clause 7.

This part of ISO 7574 does not deal with the consequences that ensue if the stated value is not confirmed as verified for a batch (lot) of machines.

2 References

ISO 3951, *Sampling procedures and charts for inspection by variables for percent defective.*

ISO 4871, *Acoustics — Noise labelling of machinery and equipment.*

ISO 7574/1, *Acoustics — Statistical methods for determining and verifying stated noise emission values of machinery and equipment — Part 1: General considerations and definitions.*

3 Definitions

For the purposes of this part of ISO 7574, the definitions given in ISO 7574/1 apply.

4 General

For a batch of machines, the noise emission values will cover a certain range due to the variability between the machines (relevant measure: standard deviation of production, σ_p) and due to measurement errors occurring under reproducibility conditions (relevant measure: standard deviation of reproducibility, σ_R — see 3.17 in ISO 7574/1). The measure for the overall variability is the total standard deviation, σ_t.

The aim of labelling a batch of machines is to indicate as labelled value, L_c, a limit below which a specified large proportion of the noise emission values of the batch shall lie. L_c is expressed as an integer in decibels.

When used for checking the compliance of a batch of machines with the labelled value, this part ISO 7574 works on the principle that only a sample from the batch is measured. This principle is appropriate for mass-produced machines. This part of ISO 7574 considers the need to control machines which are too noisy compared with the labelled value; therefore, it applies to one-sided cases for checking an upper limit, not to two-sided cases which would also exclude machines which are too quiet. The principle is based on balancing risks which are expressed by a pair of values: a specified proportion, $p_{1-\alpha}$, of noise emission values of the batch exceeding the labelled value and a specified probability of rejection, α, for a lot with this proportion $p_{1-\alpha}$.

Verifying compliance of the lot with the labelled value is based on the following assumptions:

a) that the noise emission values of the batch approximate to a normal distribution, characterized by the mean value μ and the specified reference standard deviation σ_M; and

b) that the rejection probability for a batch is equal to a specified value α if the labelled value L_c is chosen so that the proportion of noise emission values of the batch exceeding L_c is equal to the specified value $p_{1-\alpha}$.

Procedures in this part of ISO 7574 are based on α = 5 % and $p_{1-\alpha}$ = 6,5 %.

NOTE — The fixed value of 6,5 % was chosen in order

- to comply with the definition for L_c;
- to make sure that the difference between L_c and the mean for the batch is reasonably limited; and
- to achieve a common understanding, comparability and compatibility of different L_c values for different machines from different families of machines.

If the batch and the labelled value, L_c, conform with these values, the sampling inspection procedures are set in such a way that the batch will be accepted with the probability of 1 − α = 95 % and the mean value will be expected to lie approximately 1,5 σ_M below the labelled value.

NOTES

1 If it is explicitly known that a stated value is not an upper value as L_c but represents a mean value (which is not in accordance with ISO 4871), the checking procedure might also be used by adding 1,5 σ_M to this mean value to obtain L_c.

2 Methods for estimating risk factors are given in annexes A and B; they may be replaced by repeated, simulated application of the checking procedure using actual measurement data, if the assumption that the noise emission values of the batch approximate to a normal distribution is uncertain. Normality tests will be described in a future International Standard.

3 The sampling inspection by variables for isolated batches of machines, as described in this part of ISO 7574, broadly conforms to ISO 3951 which is, however, designed for the inspection of batches from continuous production. ISO 3951 does not provide for double and sequential sampling inspection, and the operating characteristic curves do not intersect exactly at the producer's risk point; this is, however, the aim of this part of ISO 7574 with the view to establishing the meaning of L_c unambiguously.

It should be noted that fixing α and $p_{1-\alpha}$ results in all operating characteristic curves (OCs) intersecting at the producer's risk point.

If the actual total standard deviation is different from the reference standard deviation σ_M, guidance for the labeller is given in clause 5 and annex B.

NOTE — In the application of this part of ISO 7574, it is assumed that all measurements will be performed by a testing laboratory which has appropriate test facilities and trained staff.

5 Guidelines for the determination of the labelled value, L_c, by the labeller

As the determination of the labelled value for a batch of machines is the sole responsibility of the labeller, this clause is given for guidance only to provide a predictable probability of acceptance.

L_c can only be determined in accordance with this part of ISO 7574 if a specific labelling code in conformity with clause 7 exists [see, in particular, 7 c) to f)].

A reasonably large number of measured values of individual machines, L_i^*, are determined in accordance with the specific measurement test code for the specific family of machines. (The asterisk in the symbols is used here to differentiate between measurements in conformity with this clause and those in conformity with clause 6.)

The mean value, $\bar{L}^*$, and the total standard deviation, s_t^* are calculated from the measured values, L_i^*, of the individual machines in a sample (see also clause B.2).

$\bar{L}^*$ and s_t^* are estimates of the mean value μ and the total standard deviation, σ_t, of the batch to be labelled.

In accordance with clause B.3, equation (16), the following equations will provide guidance for the labeller who wants to have a probability of acceptance, P_a, defined by himself:

$$L_c = \mu + \left(k + \frac{u_{P_a}}{\sqrt{n}}\right)\sigma_M \qquad \text{for } \sigma_t = \sigma_M \qquad \dots (1)$$

$$L_c = \mu + k\sigma_M + \frac{u_{P_a}}{\sqrt{n}}\sigma_t \qquad \text{for } \sigma_t \neq \sigma_M \qquad \dots (2)$$

where

μ is the mean value of the batch;

n is the specified verification sample size for single sampling inspection (6.2) or the equivalent single sample size in the case of double sampling inspection (see 6.3) or sequential sampling inspection (see 6.4);

k is a function of n, in accordance with table 1;

u_{P_a} is the quantile of the normal distribution for the value P_a (see table 7);

σ_M is the specified reference standard deviation for verification;

σ_t is the actual total standard deviation.

If the labeller accepts a risk of rejection of 5 % (i.e. he wants to have a probability of acceptance, P_a, of 95 %), the above equations result in the following 1) :

$$L_c = \mu + 1{,}5\,\sigma_M \qquad \text{for } \sigma_t = \sigma_M \qquad \dots (3)$$

$$L_c = \mu + 1{,}5\,\sigma_t + k(\sigma_M - \sigma_t) \qquad \text{for } \sigma_t \neq \sigma_M \qquad \dots (4)$$

For examples, see clause B.3.

NOTE — Testing may be necessary from time to time in order to ensure that the labelled value continues to be correct. Testing is also required whenever physical changes are made to the production machines that may affect their noise emissions.

6 Verifying the labelled value for a batch of machines

6.1 General

Three equivalent procedures for verifying the labelled value of the batch are described in this part of ISO 7574: single sampling, double sampling and sequential sampling. The results obtained from any one of the three procedures will generally be the same if the assumption that the emission values are distributed approximately as a normal distribution is valid.

One and only one of the three procedures shall be chosen and specified in the labelling code for each specific family of machines (see clause 7). All three procedures require a specified reference standard deviation, σ_M, for each specific family of machines.

The sample size, n, in the case of single sampling (or equivalent sample sizes n_1 and n_2 in the case of double sampling or equivalent maximum sample size n_{max} in the case of sequential sampling) shall also be specified for each specific family of machines (see annex A). In general, double or sequential sampling results in a somewhat smaller number of machines being tested.

NOTE — The reason for applying only one of the three procedures for a specific family of machines is that the procedures are only equivalent provided that the assumption of normality is absolutely valid.

The procedures outlined in 6.2 to 6.4 are applicable for reproducibility conditions (see 3.17 in ISO 7574/1), and for repeatability conditions (see 3.16 in ISO 7574/1). It shall be ascertained that no outstanding systematic error of measurement results is connected with relevant laboratories.

For each of the procedures outlined in 6.2 to 6.4, the measured values, L_i, shall be determined in accordance with the specific measurement test code for the specific family of machines [see clause 7 c) and d)]. The measured values shall not be rounded prior to statistical calculations.

6.2 Single sampling inspection

In accordance with 6.1 and clause 7, n and σ_M have been specified for the relevant family of machines.

Take at random a sample of size n from the batch under consideration.

The measured values are L_i ($i = 1, \dots, n$) and their mean value is

$$\bar{L} = \frac{1}{n}\sum_{i=1}^{n} L_i \qquad \dots (5)$$

Determine the value

$$A = L_c - k\sigma_M \qquad \dots (6)$$

using the acceptability constant k calculated from the formula

$$k = u_{1-p_{1-\alpha}} - \frac{u_{1-\alpha}}{\sqrt{n}} \qquad \dots (7)$$

where

$u_{1-p_{1-\alpha}} = 1{,}514$

$u_{1-\alpha} = 1{,}645$

are the quantiles of the standardized normal distribution for the values $1 - p_{1-\alpha} = 93{,}5$ % and $1 - \alpha = 95$ % respectively.

Table 1 gives the values for k for different sample sizes n.

Table 1 — Acceptability constant k for different sample sizes n

n	1	2	3	4	5	6	7	8	9	10
k	−0,131	0,351	0,564	0,692	0,778	0,842	0,892	0,932	0,966	0,994

1) Use equation (1) or (2), by replacing $\frac{u_{P_a}}{\sqrt{n}}$ with $\frac{u_{1-\alpha}}{\sqrt{n}} = u_{1-p_{1-\alpha}} - k$ [see equation (7)]

where $u_{1-p_{1-\alpha}} \approx 1{,}5$.

Make the decision on the acceptability of the labelled value using the following rules:

if $\bar{L} < A$, the labelled value is confirmed as verified for the batch;

if $\bar{L} > A$, the labelled value is not confirmed as verified for the batch.

NOTE — See example in A.4.1.

6.3 Double sampling inspection

In accordance with 6.1 and clause 7, n_1, n_2 and σ_M have been specified for the relevant family of machines.

Take at random a sample of specified size n_1 from the batch under consideration.

The measured values are L_i ($i = 1, ..., n_1$) and their mean value is $\bar{L}$.

Determine the values

$$A = L_c - k_a \sigma_M \qquad ... (8)$$

$$B = L_c - k_r \sigma_M \qquad ... (9)$$

using the acceptability constants k_a and k_r given in table 2.

Table 2 — Acceptability constants k_a, k_r and k_d for double sampling and equivalent sample sizes (single/double)

Double sampling					Equivalent single sampling
n_1	n_2	k_a	k_r	k_d	n
1	1	0,863	– 0,210	0,191	2
1	2	1,194	– 0,201	0,533	3
1	3	2,834	0,235	0,632	4
2	3	1,649	– 0,130	0,774	5
2	4	1,553	– 0,228	0,848	6
3	4	1,750	0,057	0,892	7
3	5	1,504	0,302	0,938	8
3	6	2,083	0,018	0,962	9

NOTE — The only double sampling plans given are those whose operating characteristic curves are nearest to the operating characteristic curves for the equivalent single sampling plans.

Make the decision on the acceptability of the labelled value using the following rules:

if $\bar{L} < A$, the labelled value is confirmed as verified for the batch;

if $\bar{L} > B$, the labelled value is not confirmed as verified for the batch;

if $A < \bar{L} < B$, take a second sample of specified size n_2. The measurement values of both samples are L_i ($i = 1, ..., n_1 + n_2$) and their total mean is $\bar{L}_t$.

Determine the value

$$C = L_c - k_d \sigma_M \qquad ... (10)$$

using k_d from table 2.

If $\bar{L}_t < C$, the labelled value is confirmed as verified for the batch.

If $\bar{L}_t > C$, the labelled value is not confirmed as verified for the batch.

NOTE — See example in A.4.2.

6.4 Sequential sampling inspection

In accordance with 6.1 and clause 7, n_{max} and σ_m have been specified for the relevant family of machines.

Start with the first item taken from the batch under consideration.

After each test, calculate the following summation from the n^* results L_i that have been obtained:

$$S_{n^*} = \sum_{i=1}^{n^*} (L_i - b) \qquad ... (11)$$

where b is taken from the appropriate column in table 3.

Table 3 — Acceptability values a, b and r for sequential sampling and equivalent sample sizes (single/sequential)

Sequential sampling				Equivalent single sampling
n_{max}	a	b	r	n
3	$-1,267\ \sigma_M$	$L_c - 0,351\sigma_M$	$1,267\ \sigma_M$	2
5	$-1,552\ \sigma_M$	$L_c - 0,564\sigma_M$	$1,552\ \sigma_M$	3
6	$-1,791\ \sigma_M$	$L_c - 0,692\sigma_M$	$1,791\ \sigma_M$	4
8	$-2,000\ \sigma_M$	$L_c - 0,778\sigma_M$	$2,000\ \sigma_M$	5
9	$-2,188\ \sigma_M$	$L_c - 0,842\sigma_M$	$2,188\ \sigma_M$	6
11	$-2,362\ \sigma_M$	$L_c - 0,892\sigma_M$	$2,362\ \sigma_M$	7
12	$-2,524\ \sigma_M$	$L_c - 0,932\sigma_M$	$2,524\ \sigma_M$	8
14	$-2,680\ \sigma_M$	$L_c - 0,966\sigma_M$	$2,680\ \sigma_M$	9
15	$-2,823\ \sigma_M$	$L_c - 0,994\sigma_M$	$2,823\ \sigma_M$	10

NOTE — The only sequential plans given are those whose operating characteristic curves are nearest to the operating characteristic curves for the equivalent single sampling plans.

Make the decision (using a and r from table 3) on the acceptability of the labelled value using the following rules:

if $S_{n^*} < a$, the labelled value is confirmed as verified for the batch;

if $S_{n^*}, > r$, the labelled value is not confirmed as verified for the batch;

if $a < S_{n^*} < r$, take the next item at random from the batch and apply the rules again.

Stop the sampling if n^* equals the specified maximum sample size n_{max} by applying the following decisions[1]:

if $S_{n\,max} < 0$, the labelled value is confirmed as verified for the batch;

if $S_{n\,max} > 0$, the labelled value is not confirmed as verified for the batch.

NOTE — See example in A.4.3.

7 Information to be given in a specific labelling code for a specific family of machines

In order to draw up a document (specific labelling code) for verifying compliance of batches of a specific family of machines, consideration shall be given to the following:

- economic aspects of the verification;
- relative magnitude of the consumer's risk (β, p_β, ΔL, see clause A.3);
- measurement data variability.

The result of these considerations shall be given in the specific labelling code for the specific family of machines in accordance with the list which appears below. These labelling specifications should preferably be included as an annex to the specific measurement test code for the specific family of machines.

The labelling specification shall include the following information :

a) a statement that the specific labelling code is based on this part of ISO 7574;

b) a definition of the family of machines to which this test code applies;

c) identification of the specific measurement test code for the specific family of machines;

d) the mounting, loading and operating conditions to be used during noise measurements, if the measurement test code specifies several options;

e) the sampling procedure to be used (single, double or sequential) and relevant sample size (n or n_1 and n_2 or n_{max}) to be used when verifying conformity of a batch of a specific family;

f) the reference standard deviation, σ_M, to be used when verifying conformity of a batch of a specific family;

g) a reference to the relevant operating characteristic curve (OC) in accordance with annex A which is determined by the information provided in e) above.

If a specific labelling code for the specific family of machines does not (yet) exist, yet the methods of this part of ISO 7574 are intended to be applied, the specifications listed above should be agreed upon (e.g. by contract). Thus σ_M might be agreed upon on the basis of the information on the actual total standard deviation, σ_t, for the relevant batches of machines, as provided by the manufacturer of these machines.

1) The truncation of the procedure which is made for practical reasons alters the operating characteristic curve in an undefined way. The truncation error is ignored in this part of ISO 7574.

Annex A

Operating characteristic curves and examples of single, double and sequential sampling

(This annex forms an integral part of the standard.)

A.1 General

This annex provides information on the meaning of operating characteristic curves and gives guidelines for the use of the operating characteristic curves for selecting the appropriate sample size when specifying a sampling plan in a specific labelling code for a specific family of machines.

A.2 Operating characteristic curves (OCs)

The values for k given in table 1 are based on a producer's risk of α = 5 %. When the proportion of noise emission values of the batch exceeding the labelled value equals $p_{1-\alpha}$ = 6,5 %, the probability that a batch has been wrongly rejected is therefore 5 % [producer's risk point on the operating characteristic curve (OC)]. As, in addition to the fixed producer's risk point ($p_{1-\alpha}$, $1-\alpha$), the sample size n is specified in a specific labelling code for each specific family of machines, the relevant OC curve is therefore fixed. An OC curve shows the probability of acceptance P_a of the batch as a function of the proportion p of the noise emission values of the batch exceeding the labelled value. The OC curves for different specified sample sizes, n, are given in figure 1.

NOTE — The curves in figure 1 are derived from

$$u_{P_a} = (u_{1-p} - k)\sqrt{n}$$

which is the general form of equation (7) given in 6.2.

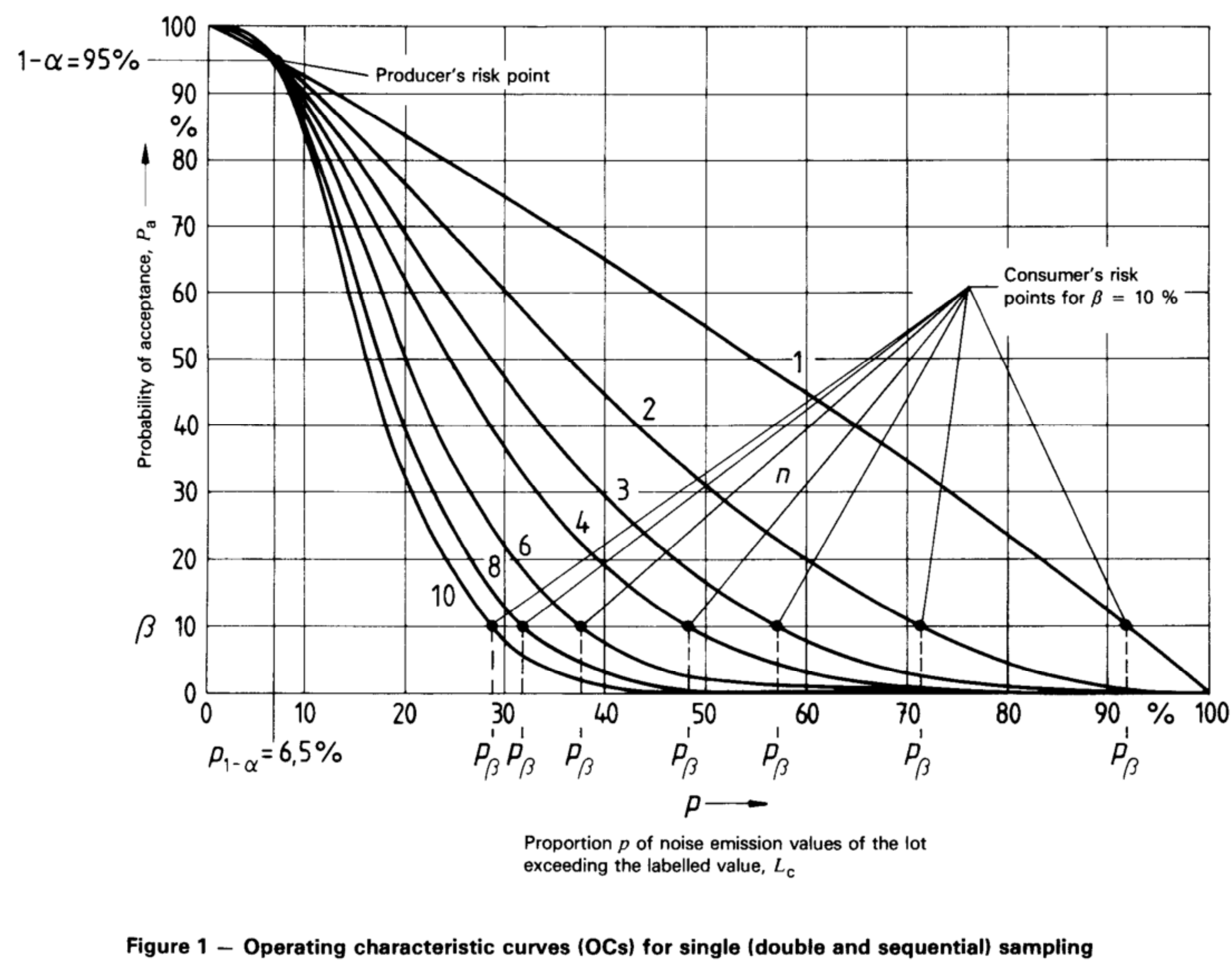

Figure 1 — Operating characteristic curves (OCs) for single (double and sequential) sampling

On the basis of the operating characteristic curves (derived for single sampling inspection), the equivalent double sampling and sequential sampling plans, in accordance with 6.3 and 6.4, were constructed. These OC curves are substantially similar to the OC curves for the single sampling.

A.3 Guidelines for the selection of an appropriate sample size

In conformity with clauses 6 and 7, the sample size n (together with σ_M) shall be specified for each specific family of machines in a specific labelling code by those drawing up the labelling code. When deciding how to select n, it may help to calculate an assumed labelled value $L_c' = L_c - \Delta L$ with such a high proportion p_β of noise emission values exceeding L_c' that acceptance would only be possible with a very low probability of only 10 % (β = 10 % consumer's risk) instead of 95 % connected with the value L_c (producer's risk α = 5 %). The lower ΔL is, the larger is the sample size n and the smaller is the proportion p_β of noise emission values exceeding L_c' at the consumer's risk point (for the value of u, see table 7).

$$\Delta L = L_c - L_c' = (u_{1-\alpha} - u_\beta)\frac{\sigma_M}{\sqrt{n}} \qquad \ldots (12)$$

$$= (1{,}645 + 1{,}282)\frac{\sigma_M}{\sqrt{n}} \approx 2{,}93\frac{\sigma_M}{\sqrt{n}}$$

For a given ΔL, the sample size n is established after a rounding up to the next integer

$$n = \left(\frac{2{,}93\,\sigma_M}{\Delta L}\right)^2 \qquad \ldots (13)$$

Figure 2 gives this relation in graph form.

The operating characteristic curve is now fixed by n (see figure 1).

Example

Given

σ_M = 2 dB

ΔL = 3 dB

Then

$$n = \left(\frac{2{,}93 \times 2}{3}\right)^2 = 3{,}83 \approx 4$$

A.4 Examples of single, double and sequential sampling inspection

A.4.1 Example of single sampling inspection (see 6.2)

The following specifications are laid down for batches of a specific family of machines:

σ_M = 2 dB

n = 3

Labelled value is L_c = 87 dB

From table 1:

k = 0,564

$A = L_c - k\,\sigma_M$ = 87 − (0,564 × 2) = 85,9 dB

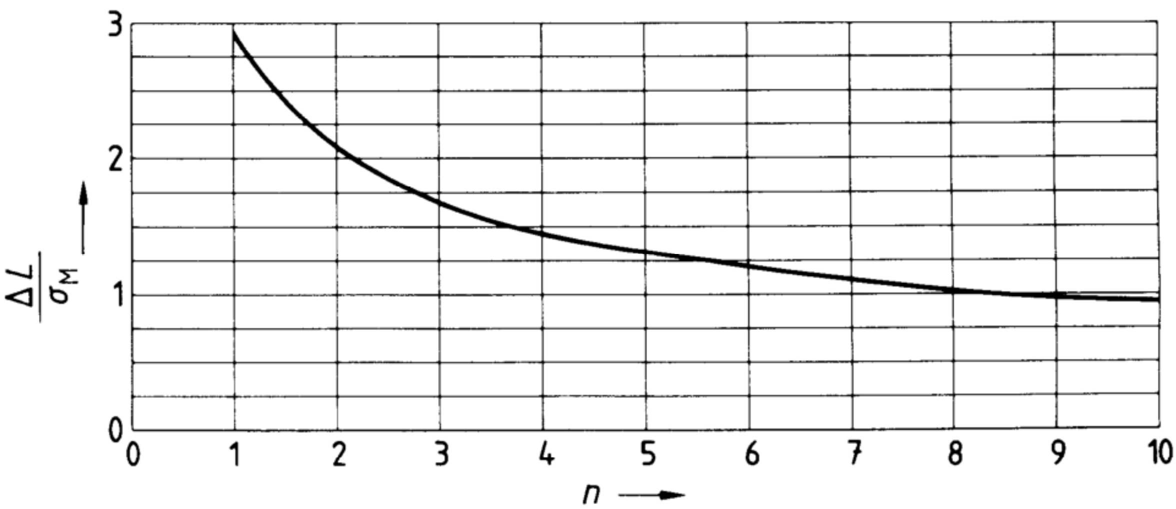

Figure 2 — Relation between $\frac{\Delta L}{\sigma_M}$ and sample size n

Measured values

$L_1 = 84{,}6$ dB

$L_2 = 85{,}4$ dB

$L_3 = 87{,}0$ dB

$\overline{L} = 85{,}67$ dB

$\overline{L} < A$

The labelled value is confirmed as verified for the batch.

A.4.2 Example of double sampling inspection (see 6.3)

The following specifications are laid down for a batch from a specific family of machines:

$\sigma_M = 2$ dB

$n_1 = 2$

$n_2 = 3$ ($n = 5$)

Labelled value is $L_c = 87$ dB

From table 2:

$k_a = 1{,}649$

$k_r = -0{,}130$

$k_d = 0{,}774$

$A = L_c - k_a \sigma_M = 87 - (1{,}649 \times 2) = 83{,}702$ dB

$B = L_c - k_r \sigma_M = 87 + (0{,}130 \times 2) = 87{,}26$ dB

Measured values for the first sample ($n_1 = 2$)

$L_1 = 85{,}3$ dB

$L_2 = 86{,}7$ dB

$\overline{L} = 86{,}0$ dB

$A < \overline{L} < B$

Take a second sample of size $n_2 = 3$.

Measured values for the second sample

$L_3 = 84{,}4$ dB

$L_4 = 88{,}0$ dB

$L_5 = 83{,}6$ dB

$$\overline{L}_t = \frac{1}{n_1 + n_2} \sum_i L_i = 85{,}6 \text{ dB}$$

$C = L_c - k_d \sigma_M = 87 - (0{,}774 \times 2) = 85{,}452$ dB

$\overline{L}_t > C$

The labelled value is not confirmed as verified for the batch.

A.4.3 Example of sequential sampling inspection (see 6.4)

The following specifications are laid down for a batch from a specific family of machines:

$\sigma_M = 2$ dB

$n_{max} = 5$ ($n = 3$)

Labelled value is $L_c = 87$ dB ($L_{WA} = 87$ dB)

From table 3:

$a = -1{,}552 \times \sigma_M = -3{,}104$ dB

$b = L_c - 0{,}564 \times \sigma_M = 85{,}87$ dB

$r = -1{,}552 \times \sigma_M = 3{,}104$ dB

First measured value ($n^* = 1$)

$L_1 = 83{,}0$ dB

$S_{n^*} = 83{,}0 - 85{,}87 = -2{,}87$ dB

Decision: continue since $\alpha < S_{n^*} < r$

Second measured value ($n^* = 2$)

$L_2 = 85{,}0$ dB

$S_{n^*} = (83{,}0 - 85{,}87) + (85{,}0 - 85{,}87) = -3{,}74$ dB

Decision: since $S_{n^*} < a$, the labelled value is confirmed as verified for the batch.

Annex B

Guidelines for estimating standard deviations and for the use of operating characteristic curves

(This annex does not form part of the standard.)

B.1 General

Acoustic labelling of products usually needs extensive preliminary investigation of the parameters which potentially influence the labelled value.

Acoustic measurements are generally expensive. Therefore, the sample size for compliance testing should be as small as possible. This part of ISO 7574 enables small sample sizes to be used.

Small sample sizes make statistical sense only if the standard deviation of the population is known. For many reasons this may not be available. It is therefore necessary for the standard deviation to be otherwise specified before the procedures in this part of ISO 7574 can be used. It should be noted that the value σ_M takes into account the dispersion of the measurement values caused by both the errors inherent in the specific measurement method (see standard deviation of reproducibility) and the unavoidable differences of the noise emission of the different machines in the batch (see standard deviation of production).

The more measured values from different machines that are available to a manufacturer, the better he can estimate the mean, μ, and the total standard deviation, σ_t, of the noise emission values of his products. He is able, therefore, to compare his values with the specified value σ_M. He should, however, remember that σ_M can be influenced significantly by the standard deviation of reproducibility. If the actual total standard deviation, σ_t, differs from σ_M, the consequences that ensue are discussed in clauses 5 and B.3.

The sample sizes for inspection by variables are smaller than for inspection by attributes, because measurement values contain more information than the yes/no-decisions obtained when testing by attributes. To enable small samples to be used this part of ISO 7574 therefore adopts inspection by variables.

B.2 Example of the estimation of the standard deviation of reproducibility, the standard deviation of production and the total standard deviation in order to specify the reference standard deviation of the family of machines under consideration

To illustrate the use of the different standard deviations, the following practical example is given.

B.2.1 Determination of the standard deviation of reproducibility

If given, the standard deviation of reproducibility given in the specific test code for the family of machines being considered shall be used. If not, the standard deviation which may be given in the basic measurement test code (see ISO 3741, ISO 3742, ISO 3743, ISO 3744 and ISO 3745) can be used. If these are not available or acceptable, the following method for the determination of the standard deviation of reproducibility may be used.

Measurements on one machine are to be carried out in accordance with the specific measurement test code in four different laboratories under repeatability conditions (two determinations within each laboratory) and under reproducibility conditions (two determinations in each of four laboratories).

Example

(See 14.8 in ISO 5725.)

Table 4 — Measured values, L_i, and original data

Laboratory i	Measured values, L_i (L_{WA} in dB) First determination	Second determination	Original data w_i	$\bar{y}_i$	w_i^2	$\bar{y}_i^2$
1	70	70,5	0,5	70,25	0,25	4 935,06
2	69	69,5	0,5	69,25	0,25	4 795,56
3	70,5	70	0,5	70,25	0,25	4 935,06
4	68	69	1	68,50	1	4 692,25

In table 4

w_i is the absolute value of the difference between the first and second determinations;

$\bar{y}_i$ is the mean value of the first and second determinations.

Table 5 — Computational formulae and numerical results

Number of laboratories: p	$p = 4$
Number of measurements in each laboratory: n	$n = 2$
$S_1 = \sum \bar{y}_i$	$S_1 = 278,25$
$S_2 = \sum \bar{y}_i^2$	$S_2 = 19\ 357,938$
$S_3 = \sum w_i^2$	$S_3 = 1,75$
$s_r^2 = \frac{S_3}{2p}$	$s_r^2 = 0,219$
$s_L^2 = \frac{pS_2 - S_1^2}{p(p-1)} - \frac{s_r^2}{2}$	$s_L^2 = 0,614$
$s_R = \sqrt{s_r^2 + s_L^2}$	$s_R = 0,91 \approx 1$

The standard deviation of reproducibility is $s_R = 1$ dB.

In table 5

s_r is the standard deviation of repeatability;

s_L is the inter-laboratory standard deviation.

B.2.2 Determination of the standard deviation of production

Measurements of seven machines from one batch are carried out in accordance with the specific measurement test code in one laboratory under conditions as identical as possible (repeatability conditions).

NOTE — Each value given in table 6 is a mean value for the same machine from measurements made under repeatability conditions.

Example

Table 6 — Measured values

Machine j	$L_{WA,j}$, in dB
1	81,0
2	80,0
3	79,5
4	82,0
5	79,5
6	82,0
7	81,5

According to 3.18 in ISO 7574/4, the standard deviation of production for these data given in table 6 is $s_p = 1,1$ dB.

B.2.3 Determination of the overall standard deviation

The overall standard deviation, s_t, is given by

$$s_t = \sqrt{s_R^2 + s_p^2} \quad \text{... (14)}$$

For the data given in B.2.1 and B.2.2, s_t is approximately 1,5 dB. After further investigation on many products in the family of machines, a reference standard deviation, σ_M, could be specified, for example $\sigma_M = 2$ dB.

B.3 Example of the use of the operating characteristic curves (OCs) when labelling (see figure 3)

The distribution function of the noise emission values of three batches of vacuum cleaners from different manufacturers may be given as cumulative frequency curves on probability paper. The mean noise emission value of all three batches may be identical (μ = 84 dB), while the total standard deviations σ_t may have the three different values: 1 dB, 2 dB and 4 dB. The specified reference standard deviation is σ_M = 2 dB.

Let the specified sample size for the inspection of batches taken from this family of machines be n = 3 ($\Delta L \approx$ 3,4 dB, in accordance with clause A.3). The operating characteristic curve ⓑ (taken from figure 1, for n = 3) therefore applies. This operating characteristic curve is only valid for $\sigma_t = \sigma_M$.

From the probability paper, the relevant sound power levels for the different proportions p are entered as abcissae in figure 3 for the operating characteristic curves.

The operating characteristic curve in the case where the total standard deviation, σ_t, is known from the manufacturer, but is not the same as the specified reference standard deviation σ_M ($\sigma_t \neq \sigma_M$), can be computed by the following equation:

$$u_{P_a} = (u_{1-p}\,\sigma_t - k\,\sigma_M)\,\frac{\sqrt{n}}{\sigma_t} \qquad \text{... (15)}$$

where P_a is computed for different p values [all other parameters are either known or specified: σ_t, σ_M = 2 dB, n = 3, k = 0,564 (see table 1)] using the quantiles, u, of the standardized normal distribution given in table 7.

Table 7 — Quantiles of the standardized normal distribution

$1-p$ or P_a	1 %	2,5 %	5 %	10 %	20 %	30 %	40 %	50 %	60 %	70 %	80 %	90 %	93,5 %	95 %	97,5 %	99 %	99,9 %
u	−2,326	−1,96	−1,645	−1,282	−0,842	−0,524	−0,253	0	0,253	0,524	0,842	1,282	1,514	1,645	1,96	2,326	3,090

A manufacturer who has a known mean, μ, and a known standard deviation, σ_t, which is not the same as the specified reference standard deviation σ_M ($\sigma_t \neq \sigma_M$), and who wants to run a risk which may deviate from the specified value α = 5 %, will label his product as follows:

$$L_c = \mu + k\,\sigma_M + \frac{u_{P_a}}{\sqrt{n}}\,\sigma_t \qquad \text{... (16)}$$

where L_c is given as a function of P_a (u_{P_a} from table 7), and where all the other parameters are either known or specified:

μ, σ_t, n = 3, $k \doteq$ 0,564 (see table 1), σ_M = 2 dB

NOTE — Equation (15) is derived from the following three equations, equation (16) is derived from the first and the third of the following equations:

$A = L_c - k\,\sigma_M$ (test criterion in accordance with 6.2)

$L_c = \mu + u_{1-p}\,\sigma_t$

$\mu + \frac{u_{P_a}}{\sqrt{n}}\,\sigma_t = A$

The three different cases can now be compared.

i) Case ⓑ : $\sigma_t = \sigma_M$ = 2 dB

The manufacturer of the batch ⓑ has a total standard deviation σ_t which is equal to the specified reference standard deviation σ_M. The appropriate OC curve is curve ⓑ . When labelling with L_c = 87 dB [see equation (2)], the acceptance probability, P_a, is equal to the specified value 1 − α = 95 %.

ii) Case ⓐ : $\sigma_t < \sigma_M$ (σ_t = 1 dB)

The manufacturer of batch ⓐ has a total standard deviation (σ_t = 1 dB) which is lower than the reference standard deviation σ_M = 2 dB.

From equation (15), the appropriate OC curve (curve ⓐ) is derived. In accordance with equation (16), he should label his product with

$$L_c = 84 + 0{,}563\,4 \times 2 + \frac{1{,}645}{\sqrt{3}} \times 1$$
$$= 86{,}08 \approx 86 \text{ dB}$$

if he accepts a risk of $1 - P_a$ of $\alpha = 5\ \%$.

iii) Case ⓒ : $\sigma_t > \sigma_M$ ($\sigma_t = 4$ dB)

The manufacturer of batch ⓒ has a higher total standard deviation ($\sigma_t = 4$ dB).

From equation (1), the appropriate OC curve (curve ⓒ) is derived. In accordance with equation (2), he should label his product with

$$L_c = 84 + 0{,}564 \times 2 + \frac{1{,}645}{\sqrt{3}} \times 4$$
$$= 88{,}93 \approx 89 \text{ dB}$$

if he accepts a risk of $1 - P_a$ of $\alpha = 5\ \%$.

The operating characteristic curves can also be used to check the effect of

— a constant labelled value L_c on the probabilities of acceptance and/or the proportions p of noise emission values of the batch exceeding the labelled value, or

— a constant proportion p of noise emission values of the batch exceeding the labelled value on the probabilities of acceptance and/or the labelled values.

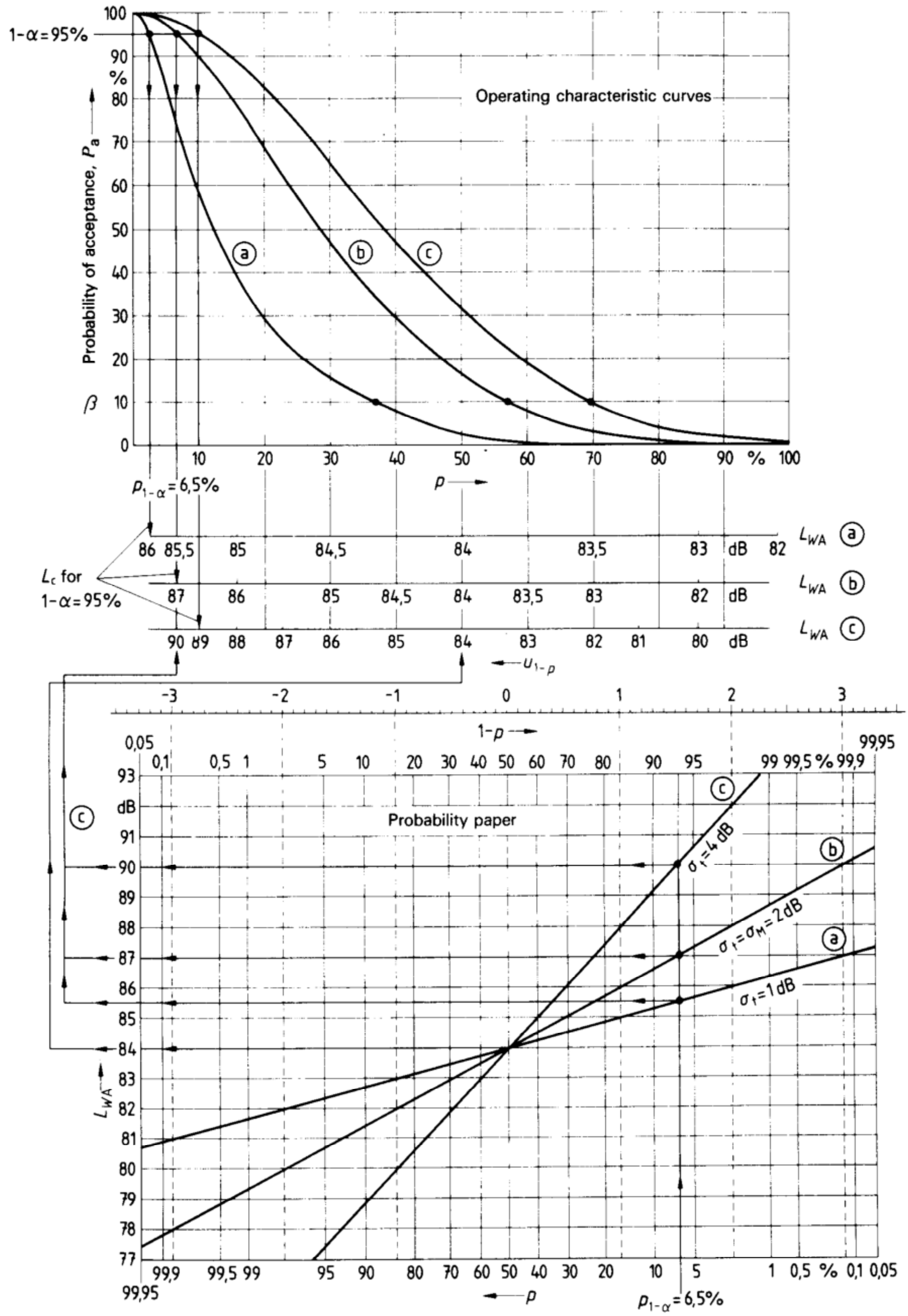

Figure 3 — Change of the operating characteristic curve for $\sigma_t \neq \sigma_M$

Annex C

List of symbols

(This annex forms an integral part of the standard.)

L_W	Sound power level
L_{WA}	A-weighted sound power level
L_i, L_i^*	Measured values (L_1, L_2, ...)
$\overline{L}$, $\overline{L}_t$, $\overline{L}^*$	Arithmetic mean of the L_i values
μ	Arithmetic mean of the population
L_c	Labelled value
ΔL	Level difference for the two acceptance probabilities $1-\alpha$ and β
N	Size of the batch/population
n	Size of the sample
n_{max}	Maximum sample size (sequential sampling)
n_1	Size of the first sample (double sampling)
n_2	Size of the second sample (double sampling)
n^*	Size of the sample already tested (sequential sampling)
s	Standard deviation of the sample
σ	Standard deviation of the population
σ_r	Standard deviation of repeatability
σ_R	Standard deviation of reproducibility
σ_p	Standard deviation of production
σ_t	Total standard deviation
σ_M	Reference standard deviation
k	Acceptability constant (single sampling)
k_a	Acceptability constant (double sampling)
k_r	Acceptability constant (double sampling)
k_d	Acceptability constant (double sampling)
K	Correction used in ISO 7574/3
a	Acceptability value (sequential sampling)
b	Acceptability value (sequential sampling)
r	Acceptability value (sequential sampling)
p	Proportion of noise emission values of the batch exceeding the labelled value.
$p_{1-\alpha}$	Specified proportion of noise emission values of the batch exceeding the labelled value for the specified probability of rejection α
p_β	Proportion of noise emission values of the batch exceeding the labelled value for the consumer's risk β
P_a	Probability of acceptance
α	Specified probability of rejection (producer's risk); $1-\alpha$ equivalent acceptance probability
β	Special low probability of acceptance (consumer's risk)
OC	Operating characteristic curve
u_{P_a}, u_β, $u_{1-\alpha}$, u_{1-p}	Quantiles of the standardized normal distribution for the subscribed values
S_{n^*}, $S_{n\,max}$	Special quantities for sequential sampling

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