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**Acoustics — Rating of sound  
insulation in buildings and of building  
elements —**

**Part 1:  
Airborne sound insulation**

*Acoustique — Évaluation de l'isolement acoustique des immeubles et  
des éléments de construction —*

*Partie 1: Isolement aux bruits aériens*

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Published in Switzerland

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 2, *Building acoustics*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 126, *Acoustic properties of building elements and of buildings*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This fourth edition cancels and replaces the third edition (ISO 717-1:2013), which has been technically revised.

The main changes compared to the previous edition are as follows:

- ISO 10140-1:2016, G.6 relocated into this document;
- ISO 10140-5:2010, Annex B relocated into this document;
- references updated.

A list of all parts in the ISO 717 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

## Introduction

Methods of measurement of airborne sound insulation of building elements and in buildings have been standardized e.g. in ISO 10140-2 and ISO 16283-1. The purpose of this document is to standardize a method whereby the frequency-dependent values of airborne sound insulation can be converted into a single number characterizing the acoustical performance.

References to standards which provide data for single-number evaluation are meant to be examples and therefore are not complete.

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# Acoustics — Rating of sound insulation in buildings and of building elements —

## Part 1: Airborne sound insulation

### 1 Scope

This document

- a) defines single-number quantities for airborne sound insulation in buildings and of building elements such as walls, floors, doors, and windows,
- b) takes into consideration the different sound level spectra of various noise sources such as noise sources inside a building and traffic outside a building, and
- c) gives rules for determining these quantities from the results of measurements carried out in one-third-octave or octave bands for example in accordance with ISO 10140-2 and ISO 16283-1.

The single-number quantities in accordance with this document are intended for rating airborne sound insulation and for simplifying the formulation of acoustical requirements in building codes. An additional single-number evaluation in steps of 0,1 dB is indicated for the expression of uncertainty (except for spectrum adaptation terms). The required numerical values of the single-number quantities are specified according to varying needs. The single-number quantities are based on results of measurements in one-third-octave bands or octave bands.

For laboratory measurements made in accordance with ISO 10140-2, single-number quantities are calculated using one-third-octave bands only.

The rating of results of measurements carried out over an enlarged frequency range is dealt with in [Annex B](#).

### 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 10140-1:2016, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 1: Application rules for specific products*

ISO 10140-2:2010, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 2: Measurement of airborne sound insulation*

ISO 10140-5:2010, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 5: Requirements for test facilities and equipment*

ISO 10848-2:2017, *Acoustics — Laboratory and field measurement of flanking transmission for airborne, impact and building service equipment sound between adjoining rooms — Part 2: Application to Type B elements when the junction has a small influence*

ISO 15186-1:2000, *Acoustics — Measurement of sound insulation in buildings and of building elements using sound intensity — Part 1: Laboratory measurements*

ISO 16283-1:2014, *Acoustics — Field measurement of sound insulation in buildings and of building elements — Part 1: Airborne sound insulation*

ISO 16283-1:2014/Amd 1:2017, *Acoustics — Field measurement of sound insulation in buildings and of building elements — Part 1: Airborne sound insulation — Amendment 1*

ISO 16283-3:2016, *Acoustics — Field measurement of sound insulation in buildings and of building elements — Part 3: Façade sound insulation*

### 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

**3.1**  
**single-number quantity**  
<for airborne sound insulation rating> value, in decibels, of the reference curve at 500 Hz after shifting it in accordance with the method specified in this document

Note 1 to entry: Terms and symbols for the single-number quantity used depend on the type of measurement. Examples are listed in [Table 1](#) for airborne sound insulation properties of building elements and in [Table 2](#) for airborne sound insulation in buildings. In general, new single-number quantities are derived in a similar way.

**3.2**  
**spectrum adaptation term**  
value, in decibels, to be added to the single-number rating (e.g.  $R_w$ ) to take account of the characteristics of particular sound spectra

Note 1 to entry: Two sound spectra are defined (in one-third-octave bands and in octave bands) in this document.

Note 2 to entry: [Annex A](#) gives information on the purpose of introducing these two spectrum adaptation terms  $C$  and  $C_{tr}$ .

### 4 Procedure for evaluating single-number quantities

#### 4.1 General

The values obtained in accordance with e.g. ISO 10140-2 and ISO 16283-1 are compared with reference values (see [4.2](#)) at the frequencies of measurement within the range 100 Hz to 3 150 Hz for one-third-octave bands and 125 Hz to 2 000 Hz for octave bands.

The comparison shall be carried out as specified in [4.4](#).

Furthermore, two spectrum adaptation terms shall be calculated (see [4.5](#)) based on two typical spectra within the frequency range as quoted above. These two terms may optionally be supplemented by additional spectrum adaptation terms covering (if need be and if measured data are available) a wider frequency range between 50 Hz and 5 000 Hz.

**Table 1 — Single-number quantities of airborne sound insulation properties of building elements**

| Derived from one-third-octave band values                  |                                                 | Defined in                |                |
|------------------------------------------------------------|-------------------------------------------------|---------------------------|----------------|
| Single-number quantity                                     | Term and symbol                                 |                           |                |
| Weighted sound reduction index, $R_w$                      | Sound reduction index, $R$                      | ISO 10140-2:2010          | Formula (2)    |
| Weighted normalized flanking level difference, $D_{n,f,w}$ | Normalized flanking level difference, $D_{n,f}$ | ISO 10848-2:2017          | 3.1            |
| Weighted element-normalized level difference, $D_{n,e,w}$  | Element-normalized level difference, $D_{n,e}$  | ISO 10140-2:2010          | Formula (5)    |
| Weighted joint sound insulation index, $R_{s,w}$           | Joint sound insulation index, $R_s$             | ISO 10140-1:2016, Annex J | Formula (J.1). |
| Weighted intensity sound insulation index, $R_{I,w}$       | Intensity sound insulation index, $R_I$         | ISO 15186-1:2000          | Formula (7)    |

**Table 2 — Single-number quantities of airborne sound insulation in buildings**

| Derived from one third octave band values or octave band values              |                                                                 | Defined in                   |             |
|------------------------------------------------------------------------------|-----------------------------------------------------------------|------------------------------|-------------|
| Single-number quantity                                                       | Term and symbol                                                 |                              |             |
| Weighted apparent sound reduction index, $R'_w$                              | Apparent sound reduction index, $R'$                            | ISO 16283-1:2014/ Amd 1:2017 | Formula (4) |
| Weighted apparent sound reduction index, $R'_{45^\circ,w}$                   | Apparent sound reduction index, $R'_{45^\circ}$                 | ISO 16283-3: 2016            | 3.12        |
| Weighted apparent sound reduction index, $R'_{tr,s,w}$                       | Apparent sound reduction index, $R'_{tr,s}$                     | ISO 16283-3: 2016            | 3.13        |
| Weighted normalized level difference, $D_{n,w}$                              | Normalized level difference, $D_n$                              | ISO 10140-2:2010             | Formula (5) |
| Weighted standardized level difference, $D_{nT,w}$                           | Standardized level difference, $D_{nT}$                         | ISO 16283-1:2014             | Formula (2) |
| Weighted standardized level difference, $D_{ls,2m,nT,w}$ or $D_{tr,2m,nT,w}$ | Standardized level difference, $D_{ls,2m,nT}$ or $D_{tr,2m,nT}$ | ISO 16283-3:2016             | 3.15        |
| Weighted normalized level difference, $D_{ls,2m,n,w}$ or $D_{tr,2m,n,w}$     | Normalized level difference, $D_{ls,2m,n}$ or $D_{tr,2m,n}$     | ISO 16283-3:2016             | 3.16        |

## 4.2 Reference values

The set of reference values used for comparison with measurement results shall be as given in [Table 3](#). The reference curves are shown in [Figure 1](#) and [Figure 2](#).

**Table 3 — Reference values for airborne sound**

| Frequency | Reference values       |              |
|-----------|------------------------|--------------|
|           | dB                     |              |
| Hz        | One-third-octave bands | Octave bands |
| 100       | 33                     | 36           |
| 125       | 36                     |              |
| 160       | 39                     |              |
| 200       | 42                     | 45           |
| 250       | 45                     |              |
| 315       | 48                     |              |
| 400       | 51                     | 52           |
| 500       | 52                     |              |
| 630       | 53                     |              |
| 800       | 54                     | 55           |
| 1 000     | 55                     |              |
| 1 250     | 56                     |              |
| 1 600     | 56                     | 56           |
| 2 000     | 56                     |              |
| 2 500     | 56                     |              |
| 3 150     | 56                     |              |

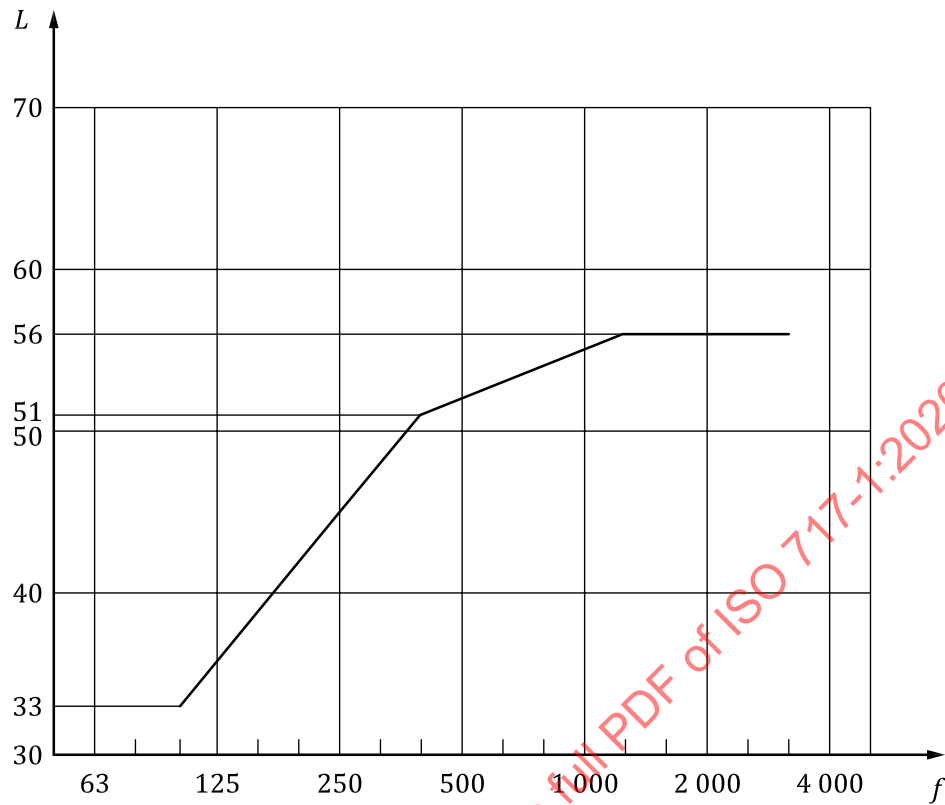
## 4.3 Sound spectra

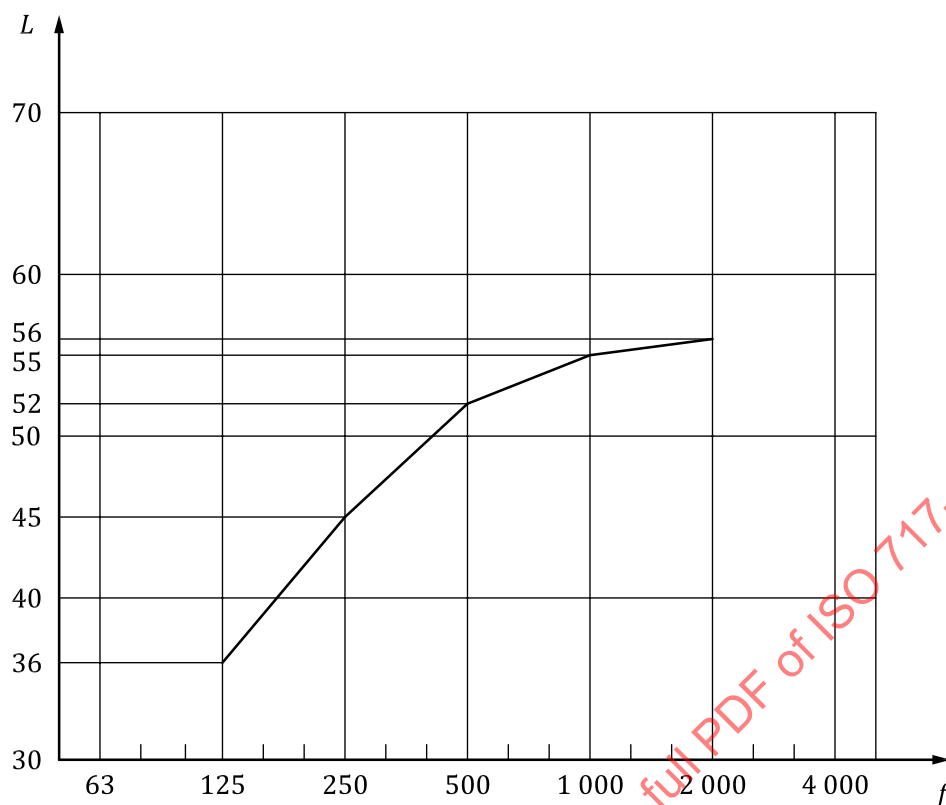
The set of sound spectra in one-third-octave bands and octave bands to calculate the spectrum adaptation terms shall be as given in [Table 4](#) and shown in [Figure 3](#) and [Figure 4](#). The spectra are A-weighted and the overall spectrum level is normalized to 0 dB.

## 4.4 Method of comparison

To evaluate the results of a sound insulation measurement in one-third-octave bands (or octave bands), the measurement data shall be given to one decimal place<sup>1)</sup>. Shift the relevant reference curve in increments of 1 dB (0,1 dB for the expression of uncertainty) towards the measured curve until the sum of unfavourable deviations is as large as possible, but not more than 32,0 dB (measurement in 16 one-third-octave bands) or 10,0 dB (measurement in 5 octave bands).

1) ISO 10140-2 and ISO 16283-1 state that the results shall be reported “to one decimal place”. However, if the octave or one-third-octave values have been reported with more than one decimal digit, the values should be reduced to one decimal place before use in the calculation of the single number rating. This is done by taking the value in tenths of a decibel closest to the reported values: XX,XYZ ZZ ... is rounded to XX,X if Y is less than 5 and to XX,X + 0,1 if Y is equal to or greater than 5. Software developers should ensure that this reduction applies to the true input values and not only to the displayed precision (as shown on the screen or printed on paper). Generally this can be implemented by the following sequence of instructions: multiply the (positive) number XX,XYZ ZZ ... by 10 and add 0,5, take the integer part and then divide the result by 10. For further details see ISO 80000-1<sup>[1]</sup>.

**Key** $f$  frequency, in Hz $L$  reference value, in dB**Figure 1 — Curve of reference values for airborne sound, one-third-octave bands**

**Key** $f$  frequency, in Hz $L$  reference value, in dB**Figure 2 — Curve of reference values for airborne sound, octave bands****Table 4 — Sound level spectra to calculate the adaptation terms**

| Frequency<br>Hz | Sound levels, $L_{i,j}$<br>dB   |        |                                      |        |
|-----------------|---------------------------------|--------|--------------------------------------|--------|
|                 | Spectrum No. 1 to calculate $C$ |        | Spectrum No. 2 to calculate $C_{tr}$ |        |
|                 | One-third octave                | Octave | One-third octave                     | Octave |
| 100             | -29                             |        | -20                                  |        |
| 125             | -26                             | -21    | -20                                  | -14    |
| 160             | -23                             |        | -18                                  |        |
| 200             | -21                             |        | -16                                  |        |
| 250             | -19                             | -14    | -15                                  | -10    |
| 315             | -17                             |        | -14                                  |        |
| 400             | -15                             |        | -13                                  |        |
| 500             | -13                             | -8     | -12                                  | -7     |
| 630             | -12                             |        | -11                                  |        |
| 800             | -11                             |        | -9                                   |        |
| 1 000           | -10                             | -5     | -8                                   | -4     |
| 1 250           | -9                              |        | -9                                   |        |

NOTE All levels are A weighted and the overall spectrum level is normalized to 0 dB.

Table 4 (continued)

| Frequency | Sound levels, $L_{ij}$          |        |                                      |        |
|-----------|---------------------------------|--------|--------------------------------------|--------|
|           | dB                              |        |                                      |        |
|           | Spectrum No. 1 to calculate $C$ |        | Spectrum No. 2 to calculate $C_{tr}$ |        |
| Hz        | One-third octave                | Octave | One-third octave                     | Octave |
| 1 600     | -9                              | -4     | -10                                  | -6     |
| 2 000     | -9                              |        | -11                                  |        |
| 2 500     | -9                              |        | -13                                  |        |
| 3 150     | -9                              |        | -15                                  |        |

NOTE All levels are A weighted and the overall spectrum level is normalized to 0 dB.

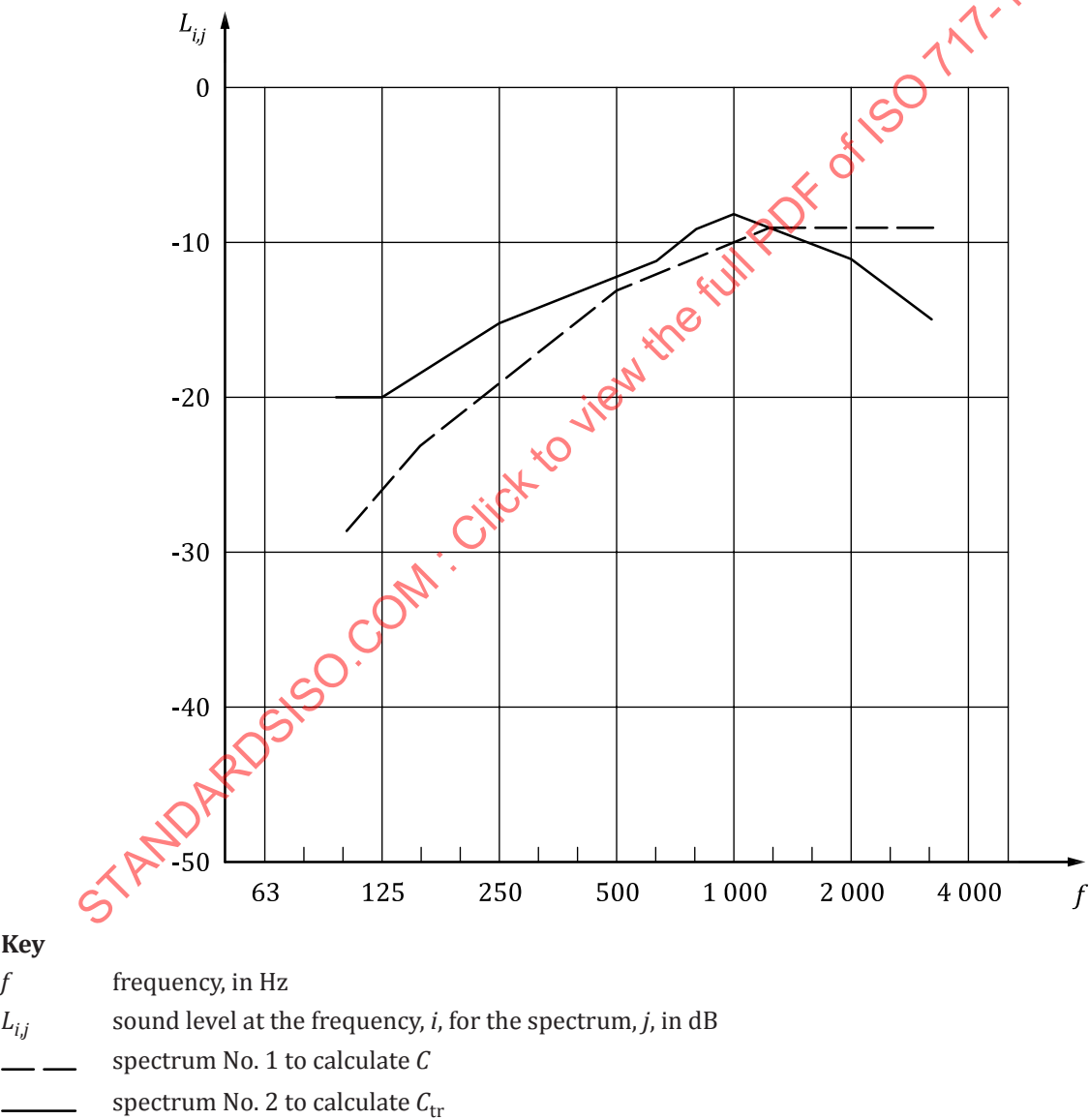


Figure 3 — Sound level spectra to calculate the spectrum adaptation terms for one-third-octave band values

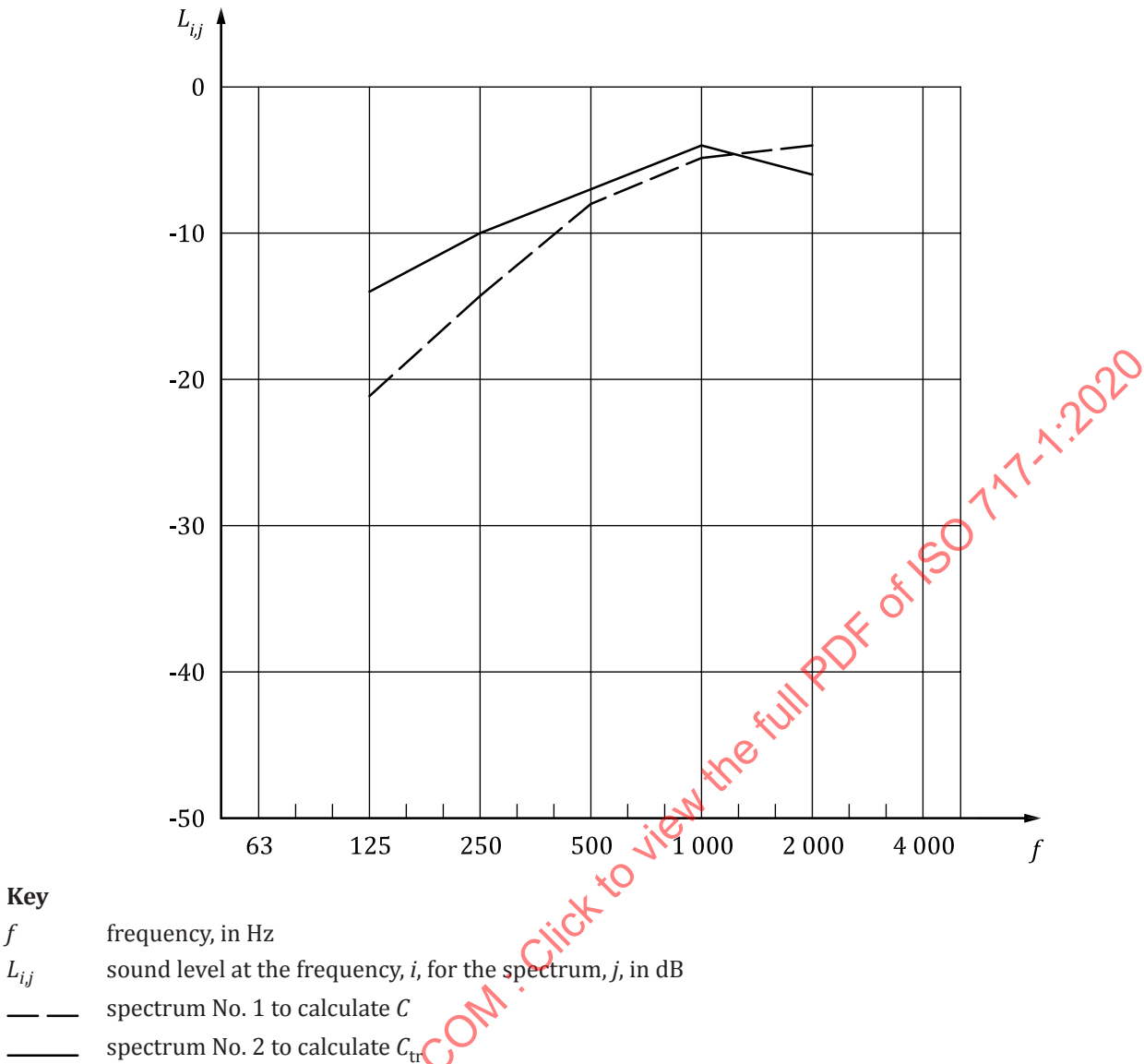


**Figure 4 — Sound level spectra to calculate the spectrum adaptation terms for octave band measurements**

An unfavourable deviation at a particular frequency occurs when the result of measurements is less than the reference value. Only the unfavourable deviations shall be taken into account.

The value, in decibels (or 1/10 dB for the expression of uncertainty), of the reference curve at 500 Hz, after shifting it in accordance with this procedure, is  $R_w$ ,  $R'_w$ ,  $D_{n,w}$  or  $D_{nT,w}$  etc. (see [Table 1](#) and [Table 2](#)).

Only reference values in octave bands shall be used for comparison with results of measurements in octave bands in the field.

**4.5 Calculation of spectrum adaptation terms**

The spectrum adaptation terms,  $C_j$ , in decibels, shall be calculated with the sound spectra given in [4.3](#) from the following formula:

$$C_j = X_{Aj} - X_w \tag{1}$$

where

$j$  is the subscript for the sound spectra No. 1 and No.2;

$X_w$  is the single-number quantity calculated according to 4.4 from  $R$ ,  $R'$ ,  $D_n$  or  $D_{nT}$  values;

$X_{Aj}$  is calculated from

$$X_{Aj} = -10 \lg \sum 10^{(L_{i,j} - X_i)/10} \text{ dB} \quad (2)$$

in which

$i$  is the subscript for the one-third-octave bands 100 Hz to 3 150 Hz or the octave bands 125 Hz to 2 000 Hz;

$L_{i,j}$  are the levels as given in 4.3 at the frequency,  $i$ , for the spectrum,  $j$ ;

$X_i$  is the sound reduction index,  $R_i$ , or apparent sound reduction index,  $R'_i$ , or normalized sound level difference,  $D_{n,i}$ , or standardized sound level difference,  $D_{nT,i}$ , at the measuring frequency  $i$ , given to one decimal place.

Calculate the quantity,  $X_{Aj}$ , with sufficient accuracy and round the result to an integer (to one decimal digit for the expression of uncertainty)<sup>2)</sup>. The resulting spectrum adaptation term is an integer by definition and shall be identified in accordance with the spectrum used, as follows:

- $C$  when calculated with spectrum No. 1 (A-weighted pink noise);
- $C_{tr}$  when calculated with spectrum No. 2 (A-weighted urban traffic noise).

NOTE 1 The spectra of most of the usual prevailing indoor and outdoor noise sources lie in the range of spectra Nos. 1 and 2; the spectrum adaptation terms  $C$  and  $C_{tr}$  can therefore be used to characterize the sound insulation with respect to many types of noise. Guidelines for the relevant spectrum adaptation terms are given in Annex A.

NOTE 2 Supplementary calculations of the spectrum adaptation terms can also be carried out for the enlarged frequency range (including 50 Hz + 63 Hz + 80 Hz and/or 4 000 Hz + 5 000 Hz one-third-octave bands or 63 Hz and/or 4 000 Hz octave bands). The relevant terms and spectra are given in Annex B. An example of the calculation of the single-number quantity and the adaptation terms is given in Annex C.

## 5 Statement of results

### 5.1 General

The appropriate single-number quantity  $R_w$ ,  $R'_w$ ,  $D_{n,w}$  or  $D_{nT,w}$  and both adaptation terms shall be given with reference to this document. The single number rating for improvement of sound reduction index by linings shall be done as given in Annex D.

### 5.2 Statement of performance of building elements

Calculate the single-number quantity from one-third-octave bands only. State the two spectrum adaptation terms in parentheses after the single-number quantity, separated by a semicolon.

2) XX,YYY Z ... is rounded to XX if Y is less than 5 and to XX + 1 if Y is greater than or equal to 5. For further details, see ISO 80000-1<sup>[1]</sup>. Software implementers should be aware that calculation of the spectrum adaptation terms involves floating-point calculations that are never exact and may incur rounding errors. In some rare cases, this can lead to a difference of +1 dB or -1 dB in the final result. In order to avoid rounding errors, it is strongly recommended that the highest possible machine accuracy available be used for floating-point representation and mathematical operations.

EXAMPLE 1

$$R_w(C;C_{tr})=41(0;-5)\text{ dB}$$

The uncertainty of the weighted single-number quantities may also be stated. In this case, the numbers shall be given to one decimal place.

EXAMPLE 2

$$R_w=40,9\text{ dB}\pm 1,2\text{ dB}$$

Spectrum adaptation terms do not have uncertainty values of their own.

### 5.3 Statement of requirements and of performance of buildings

Requirements shall be given with the single-number quantity according to 4.2 and 4.4 or be based on the sum of this value and the relevant spectrum adaptation term.

EXAMPLE

$$R'_w+C_{tr}\geq 45\text{ dB}$$

(e.g. for façades) or

$$D_{nT,w}+C\geq 54\text{ dB}$$

(e.g. between dwellings).

The acoustic performance of buildings shall be given in the relevant terms according to the requirements (see [Annex A](#)).

For field measurements in accordance with ISO 16283-1 or ISO 16283-3, it shall be stated whether the single-number quantity is calculated from measuring results in one-third-octave bands or octave bands. In general, there can be differences between single-number quantities calculated from one-third-octave or octave band measurements of about  $\pm 1$  dB.

## Annex A (informative)

### Use of spectrum adaptation terms

NOTE The spectrum adaptation terms  $C$  and  $C_{tr}$  were introduced into ISO 717-1:1996 (which also incorporated ISO 717-2:1982) to take into account different spectra of noise sources (such as pink noise and road traffic noise) and to assess sound insulation curves with very low values in a single frequency band. (The validity of the rating obtained with the reference curve alone is limited for such cases.) The spectrum adaptation term in this sense replaces the 8 dB rule used in ISO 717-1:1982.  $C$  and  $C_{tr}$  have not been included as one single-number quantity, but have been included as separate numbers. This is to ensure continuity with the reference curve system and to avoid the danger of confusion of different single-number quantities of about the same magnitude. Furthermore, interlaboratory tests have shown that the reproducibility of the single-number quantity based on the reference curve is somewhat better.

#### A.1 Spectrum adaptation term, $C$

The spectrum adaptation term  $C$  is defined in 4.5 as

$$C = X_{A,1} - X_w \quad (A.1)$$

where

$X_{A,1}$  characterizes the difference between the A-weighted sound levels in the source room and the receiving room, for pink noise (spectrum No.1) in the source room;

$X_w$  is the relevant single-number quantity based on the reference curve.

NOTE In several countries, when using pink noise as a sound source,

$$R_{A,1} = R_w + C \quad (A.2)$$

is used as  $R_A$  (the sound reduction index) and

$$D_{nT,A,1} = D_{nT,w} + C \quad (A.3)$$

is used as  $D_{nT,A}$  (the standardized level difference).

Generally,  $C$  is approximately  $-1$ ; however, when there is a dip in the sound insulation curve in a single frequency band,  $C$  becomes less than  $-1$ . When comparing constructions, it can therefore be appropriate to consider both  $R_w$  and  $C$ .

In setting requirements, it can be appropriate to base these on the sum of  $X_w$  and  $C$ , as stated in 5.3.

#### A.2 Spectrum adaptation term, $C_{tr}$

The spectrum adaptation term  $C_{tr}$  is defined in 4.5 as

$$C_{tr} = X_{A,2} - X_w \quad (A.4)$$

where

$X_{A,2}$  characterizes the difference between the A-weighted levels in the source room (or open air in front of the façade) and in the receiving room, for road traffic noise (spectrum No. 2);

$X_w$  is the relevant single-number quantity based on the reference curve.

NOTE In several countries, when using traffic noise as a source signal,

$$R_{A,2} = R_w + C_{tr} \quad (A.5)$$

is used instead of  $R_{A,tr}$  (the sound reduction index) and

$$D_{nT,A,2} = D_{nT,w} + C_{tr} \quad (A.6)$$

is used instead of  $D_{nT,A,tr}$  (the sound insulation).

Generally, for different makes of windows having the same basic construction, the numerical value of the term  $C_{tr}$  will be almost the same; in such cases it can be appropriate to use  $R_w$  for rating purposes. However, when comparing very different types of constructions, both  $R_w$  and  $C_{tr}$  should be considered.

Requirements may be based on the sum of  $X_w$  and  $C_{tr}$  as stated in 5.3. An estimation of the A-weighted indoor level from the known A-weighted traffic noise level in front of the façade should be based on  $X_w + C_{tr}$ .

### A.3 Application of the spectrum adaption terms to additional types of noise

In Table A.1, a number of different noise sources is attached to the spectrum adaptation terms  $C$  and  $C_{tr}$ . Table A.1 may be used as a guideline for the application of the spectrum adaptation terms to assess the sound insulation with respect to these noise sources. If the A-weighted spectrum of a certain type of noise is known, it can be compared with the data in Table 4 and Figure 3 and Figure 4 and the relevant adaptation term may be chosen.

**Table A.1 — Relevant spectrum adaptation term for different types of noise source**

| Type of noise source                                                                                                                                                                                                                                                      | Relevant spectrum adaptation term |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|
| Living activities (talking, music, radio, TV)<br>Children playing<br>Railway traffic at medium and high speed <sup>a</sup><br>Highway road traffic at >80 km/h <sup>a</sup><br>Jet aircraft, short distance<br>Factories emitting mainly medium- and high-frequency noise | $C$<br>(spectrum No. 1)           |
| Urban road traffic<br>Railway traffic at low speeds <sup>a</sup><br>Aircraft, propeller driven<br>Jet aircraft, large distance<br>Disco music<br>Factories emitting mainly low and medium frequency noise                                                                 | $C_{tr}$<br>(spectrum No. 2)      |

<sup>a</sup> In several European countries, calculation models for highway road traffic noise and railway noise exist, which define octave band levels; these could be used for comparison with spectra Nos. 1 and 2

## Annex B (informative)

### Terms and spectra for an enlarged frequency range

When measurements have been carried out for an enlarged frequency range, additional spectrum adaptation terms may be calculated and stated for this frequency range. The frequency range shall be stated as a subscript to  $C$  or  $C_{tr}$ .

EXAMPLE 1  $C_{50-3150}$  or  $C_{50-5000}$  or  $C_{100-5000}$

EXAMPLE 2  $C_{tr,50-3150}$  or  $C_{tr,50-5000}$  or  $C_{tr,100-5000}$

In the statement of results, these additional adaptation terms may be given as follows:

$$R_w(C; C_{tr}; C_{50-3150}; C_{tr,50-3150}) = 41 \text{ (0; -5; -1; -4) dB} \quad (\text{B.1})$$

The sound spectra in one-third-octave bands and in octave bands for the enlarged frequency range are specified in [Table B.1](#) and shown in [Figure B.1](#) and [Figure B.2](#). The spectra, like those in [Table 4](#), are A weighted and the overall spectrum level is normalized to 0 dB.

NOTE Because of the normalization to 0 dB, the absolute values for the enlarged frequency ranges 50 Hz to 5 000 Hz and 100 Hz to 5 000 Hz for spectrum No.1 differ by 1 dB from those given for the frequency range 100 Hz to 3 150 Hz in [Table 4](#).

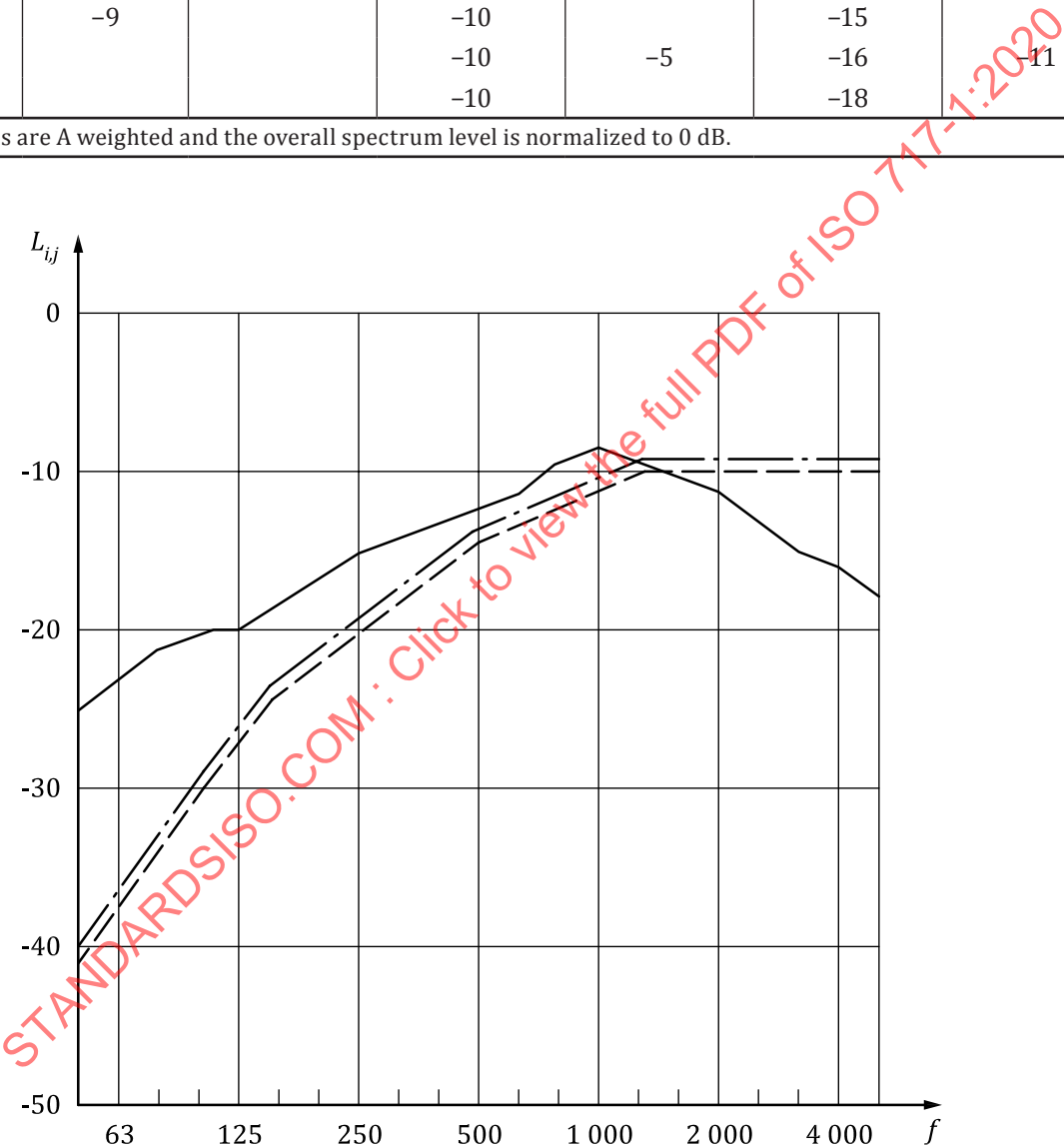
**Table B.1 — Sound level spectra to calculate the adaptation terms for enlarged frequency range**

| Frequency<br>Hz | Sound levels, $L_{ij}$ , dB |        |                                  |        |                                                                |        |
|-----------------|-----------------------------|--------|----------------------------------|--------|----------------------------------------------------------------|--------|
|                 | Spectrum No.1 to calculate  |        |                                  |        | Spectrum No.2 to calculate<br>$C_{tr}$ for any frequency range |        |
|                 | $C_{50-3150}$               |        | $C_{50-5000}$ and $C_{100-5000}$ |        |                                                                |        |
|                 | One-third octave            | Octave | One-third octave                 | Octave | One-third octave                                               | Octave |
| 50              | -40                         |        | -41                              |        | -25                                                            |        |
| 63              | -36                         |        | -37                              |        | -23                                                            |        |
| 80              | -33                         | -31    | -34                              | -32    | -21                                                            | -18    |
| 100             | -29                         |        | -30                              |        | -20                                                            |        |
| 125             | -26                         |        | -27                              |        | -20                                                            |        |
| 160             | -23                         | -21    | -24                              | -22    | -18                                                            | -14    |
| 200             | -21                         |        | -22                              |        | -16                                                            |        |
| 250             | -19                         | -14    | -20                              | -15    | -15                                                            | -10    |
| 315             | -17                         |        | -18                              |        | -14                                                            |        |
| 400             | -15                         |        | -16                              |        | -13                                                            |        |
| 500             | -13                         | -8     | -14                              | -9     | -12                                                            | -7     |
| 630             | -12                         |        | -13                              |        | -11                                                            |        |
| 800             | -11                         |        | -12                              |        | -9                                                             |        |
| 1 000           | -10                         | -5     | -11                              | -6     | -8                                                             | -4     |
| 1 250           | -9                          |        | -10                              |        | -9                                                             |        |

NOTE All levels are A weighted and the overall spectrum level is normalized to 0 dB.

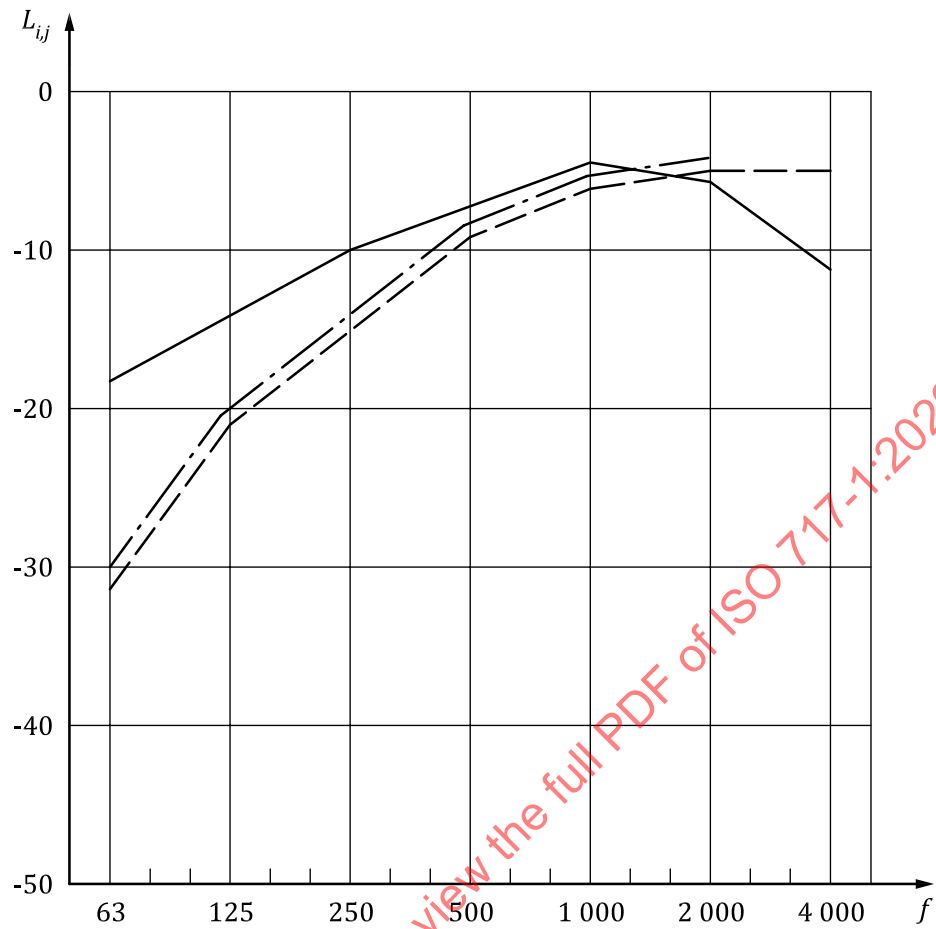
Table B.1 (continued)

| Frequency                                                                            | Sound levels, $L_{ij}$ , dB |        |                                  |        |                                                             |        |
|--------------------------------------------------------------------------------------|-----------------------------|--------|----------------------------------|--------|-------------------------------------------------------------|--------|
| Hz                                                                                   | Spectrum No.1 to calculate  |        |                                  |        | Spectrum No.2 to calculate $C_{tr}$ for any frequency range |        |
|                                                                                      | $C_{50-3150}$               |        | $C_{50-5000}$ and $C_{100-5000}$ |        |                                                             |        |
|                                                                                      | One-third octave            | Octave | One-third octave                 | Octave | One-third octave                                            | Octave |
| 1 600                                                                                | -9                          |        | -10                              |        | -10                                                         |        |
| 2 000                                                                                | -9                          | -4     | -10                              | -5     | -11                                                         | -6     |
| 2 500                                                                                | -9                          |        | -10                              |        | -13                                                         |        |
| 3 150                                                                                | -9                          |        | -10                              |        | -15                                                         |        |
| 4 000                                                                                |                             |        | -10                              | -5     | -16                                                         | -11    |
| 5 000                                                                                |                             |        | -10                              |        | -18                                                         |        |
| NOTE All levels are A weighted and the overall spectrum level is normalized to 0 dB. |                             |        |                                  |        |                                                             |        |



- Key**
- $f$  frequency, in Hz
  - $L_{ij}$  sound level at the frequency,  $i$ , for the spectrum,  $j$ , in dB
  - — spectrum No. 1 to calculate  $C$ : 50 Hz to 5 000 Hz and 100 Hz to 5 000 Hz
  - . — spectrum No. 1 to calculate  $C$ : 50 Hz to 3 150 Hz
  - spectrum No. 2 to calculate  $C_{tr}$

Figure B.1 — Sound level spectra to calculate the spectrum adaptation terms for measurements using one-third octave bands

**Key**

- $f$  frequency, in Hz
- $L_{ij}$  sound level at the frequency,  $i$ , for the spectrum,  $j$ , in dB
- — spectrum No. 1 to calculate  $G$ ; 63 Hz to 4 000 Hz and 125 Hz to 4 000 Hz
- . — spectrum No. 1 to calculate  $C$ ; 63 Hz to 2 000 Hz
- spectrum No. 2 to calculate  $C_{tr}$

**Figure B.2 — Sound level spectra to calculate the spectrum adaption terms for measurements using octave bands**

## Annex C

(informative)

### Examples of the calculation of single-number quantities and spectrum adaptation terms

[Table C.1](#) and [Table C.2](#) show examples of the evaluation of the single-number quantities and spectrum adaptation terms based on the results of the measurement of the sound reduction index of a building element in a laboratory. The results may be stated as

$$R_w(C;C_{tr}) = 30(-2; -3) \text{ dB} \quad (\text{C.1})$$

or

$$R_w(C;C_{tr};C_{50-5000};C_{tr,50-5000}) = 30(-2; -3; -2; -4) \text{ dB} \quad (\text{C.2})$$

Table C.1 — Calculation example — Measurements in the specified frequency range 100 Hz to 3 150 Hz

| Frequency                                                                | $R_i$<br>dB | Reference values<br>shifted by -22 dB | Unfavourable<br>deviation | Spectrum No. 1                                                                                              | $L_{i1} - R_i$<br>dB | $10^{(L_{i1}-R_i)/10}$<br>/10 <sup>-5</sup> | Spectrum No. 2 | $L_{i2} - R_i$<br>dB | $10^{(L_{i2}-R_i)/10}$<br>/10 <sup>-5</sup> |
|--------------------------------------------------------------------------|-------------|---------------------------------------|---------------------------|-------------------------------------------------------------------------------------------------------------|----------------------|---------------------------------------------|----------------|----------------------|---------------------------------------------|
| Hz                                                                       |             | dB                                    | dB                        | dB                                                                                                          | dB                   | /10 <sup>-5</sup>                           | dB             | dB                   | /10 <sup>-5</sup>                           |
| 100                                                                      | 20,4        | 11                                    | —                         | -29                                                                                                         | -49,4                | 1,148...                                    | -20            | -40,4                | 9,120...                                    |
| 125                                                                      | 16,3        | 14                                    | —                         | -26                                                                                                         | -42,3                | 5,888...                                    | -20            | -36,3                | 23,442...                                   |
| 160                                                                      | 17,7        | 17                                    | —                         | -23                                                                                                         | -40,7                | 8,511...                                    | -18            | -35,7                | 26,915...                                   |
| 200                                                                      | 22,6        | 20                                    | —                         | -21                                                                                                         | -43,6                | 4,365...                                    | -16            | -38,6                | 13,803...                                   |
| 250                                                                      | 22,4        | 23                                    | 0,6                       | -19                                                                                                         | -41,4                | 7,244...                                    | -15            | -37,4                | 18,197...                                   |
| 315                                                                      | 22,7        | 26                                    | 3,3                       | -17                                                                                                         | -39,7                | 10,715...                                   | -14            | -36,7                | 21,379...                                   |
| 400                                                                      | 24,8        | 29                                    | 4,2                       | -15                                                                                                         | -39,8                | 10,471...                                   | -13            | -37,8                | 16,595...                                   |
| 500                                                                      | 26,6        | 30                                    | 3,4                       | -13                                                                                                         | -39,6                | 10,964...                                   | -12            | -38,6                | 13,803...                                   |
| 630                                                                      | 28,0        | 31                                    | 3,0                       | -12                                                                                                         | -40,0                | 10,000                                      | -11            | -39,0                | 12,589...                                   |
| 800                                                                      | 30,5        | 32                                    | 1,5                       | -11                                                                                                         | -41,5                | 7,079...                                    | -9             | -39,5                | 11,220...                                   |
| 1 000                                                                    | 31,8        | 33                                    | 1,2                       | -10                                                                                                         | -41,8                | 6,606...                                    | -8             | -39,8                | 10,471...                                   |
| 1 250                                                                    | 32,5        | 34                                    | 1,5                       | -9                                                                                                          | -41,5                | 7,079...                                    | -9             | -41,5                | 7,079...                                    |
| 1 600                                                                    | 33,4        | 34                                    | 0,6                       | -9                                                                                                          | -42,4                | 5,754...                                    | -10            | -43,4                | 4,570...                                    |
| 2 000                                                                    | 33,0        | 34                                    | 1,0                       | -9                                                                                                          | -42,0                | 6,309...                                    | -11            | -44,0                | 3,981...                                    |
| 2 500                                                                    | 31,0        | 34                                    | 3,0                       | -9                                                                                                          | -40,0                | 10,000                                      | -13            | -44,0                | 3,981...                                    |
| 3 150                                                                    | 25,5        | 34                                    | 8,5                       | -9                                                                                                          | -34,5                | 35,481...                                   | -15            | -40,5                | 8,912...                                    |
| sum = 31,8 < 32<br>$R_w = 52 \text{ dB} - 22 \text{ dB} = 30 \text{ dB}$ |             |                                       |                           |                                                                                                             |                      |                                             |                |                      |                                             |
|                                                                          |             |                                       |                           | sum = 147,619 9 ... × 10 <sup>-5</sup><br>-10 lg sum = 28,308...<br>C = 28 dB - 30 dB = -2 dB               |                      |                                             |                |                      |                                             |
|                                                                          |             |                                       |                           | sum = 206,063 6 ... × 10 <sup>-5</sup><br>-10 lg sum = 26,859...<br>C <sub>tr</sub> = 27 dB - 30 dB = -3 dB |                      |                                             |                |                      |                                             |

Table C.2 — Calculation example — Measurements in the enlarged frequency range 50 Hz to 5 000 Hz

| Frequency | $R_i$<br>dB                                           | Reference values<br>shifted by -22 dB | Unfavourable<br>deviation | Spectrum No. 1                                      | $L_{i1} - R_i$<br>dB | $10^{(L_{i1} - R_i)/10}$<br>/10 <sup>-5</sup> | Spectrum No. 2                                           | $L_{i2} - R_i$<br>dB | $10^{(L_{i2} - R_i)/10}$<br>/10 <sup>-5</sup> |
|-----------|-------------------------------------------------------|---------------------------------------|---------------------------|-----------------------------------------------------|----------------------|-----------------------------------------------|----------------------------------------------------------|----------------------|-----------------------------------------------|
| Hz        |                                                       | dB                                    | dB                        | dB                                                  | dB                   | /10 <sup>-5</sup>                             | dB                                                       | dB                   | /10 <sup>-5</sup>                             |
| 50        | 18,7                                                  |                                       |                           | -41                                                 | -59,7                | 0,107...                                      | -25                                                      | -43,7                | 4,265...                                      |
| 63        | 19,2                                                  |                                       |                           | -37                                                 | -56,2                | 0,239...                                      | -23                                                      | -42,2                | 6,025...                                      |
| 80        | 20,0                                                  |                                       |                           | -34                                                 | -54,0                | 0,398...                                      | -21                                                      | -41,0                | 7,943...                                      |
| 100       | 20,4                                                  | 11                                    |                           | -30                                                 | -50,4                | 0,912...                                      | -20                                                      | -40,4                | 9,120...                                      |
| 125       | 16,3                                                  | 14                                    |                           | -27                                                 | -43,3                | 4,677...                                      | -20                                                      | -36,3                | 23,442...                                     |
| 160       | 17,7                                                  | 17                                    |                           | -24                                                 | -41,7                | 6,760...                                      | -18                                                      | -35,7                | 26,915...                                     |
| 200       | 22,6                                                  | 20                                    |                           | -22                                                 | -44,6                | 3,467...                                      | -16                                                      | -38,6                | 13,803...                                     |
| 250       | 22,4                                                  | 23                                    | 0,6                       | -20                                                 | -42,4                | 5,754...                                      | -15                                                      | -37,4                | 18,197...                                     |
| 315       | 22,7                                                  | 26                                    | 3,3                       | -18                                                 | -40,7                | 8,511...                                      | -14                                                      | -36,7                | 21,379...                                     |
| 400       | 24,8                                                  | 29                                    | 4,2                       | -16                                                 | -40,8                | 8,317...                                      | -13                                                      | -37,8                | 16,595...                                     |
| 500       | 26,6                                                  | 30                                    | 3,4                       | -14                                                 | -40,6                | 8,709...                                      | -12                                                      | -38,6                | 13,803...                                     |
| 630       | 28,0                                                  | 31                                    | 3,0                       | -13                                                 | -41,0                | 7,943...                                      | -11                                                      | -39,0                | 12,589...                                     |
| 800       | 30,5                                                  | 32                                    | 1,5                       | -12                                                 | -42,5                | 5,623...                                      | -9                                                       | -39,5                | 11,220...                                     |
| 1 000     | 31,8                                                  | 33                                    | 1,2                       | -11                                                 | -42,8                | 5,248...                                      | -8                                                       | -39,8                | 10,471...                                     |
| 1 250     | 32,5                                                  | 34                                    | 1,5                       | -10                                                 | -42,5                | 5,623...                                      | -9                                                       | -41,5                | 7,079...                                      |
| 1 600     | 33,4                                                  | 34                                    | 0,6                       | -10                                                 | -43,4                | 4,570...                                      | -10                                                      | -43,4                | 4,570...                                      |
| 2 000     | 33,0                                                  | 34                                    | 1,0                       | -10                                                 | -43,0                | 5,011...                                      | -11                                                      | -44,0                | 3,981...                                      |
| 2 500     | 31,0                                                  | 34                                    | 3,0                       | -10                                                 | -41,0                | 7,943...                                      | -13                                                      | -44,0                | 3,981...                                      |
| 3 150     | 25,5                                                  | 34                                    | 8,5                       | -10                                                 | -35,5                | 28,183...                                     | -15                                                      | -40,5                | 8,912...                                      |
| 4 000     | 26,8                                                  |                                       |                           | -10                                                 | -36,8                | 20,893...                                     | -16                                                      | -42,8                | 5,248...                                      |
| 5 000     | 29,2                                                  |                                       |                           | -10                                                 | -39,2                | 12,022...                                     | -18                                                      | -47,2                | 1,905...                                      |
|           | sum = 31,8 < 32                                       |                                       |                           | sum = 150,919 4... × 10 <sup>-5</sup>               |                      |                                               | sum = 231,451 8... × 10 <sup>-5</sup>                    |                      |                                               |
|           | $R_w = 52 \text{ dB} - 22 \text{ dB} = 30 \text{ dB}$ |                                       |                           | -10 lg sum = 28,212...                              |                      |                                               | -10 lg sum = 26,355...                                   |                      |                                               |
|           |                                                       |                                       |                           | $C = 28 \text{ dB} - 30 \text{ dB} = -2 \text{ dB}$ |                      |                                               | $C_{tr} = 26 \text{ dB} - 30 \text{ dB} = -4 \text{ dB}$ |                      |                                               |

## Annex D (normative)

### Single-number rating for improvement of sound reduction index by linings

#### D.1 General

All results of  $R_{\text{with}}$ ,  $R_{\text{without}}$  and  $\Delta R$  shall be given as one-third octave band levels to one decimal place. If required, octave band values  $\Delta R_{\text{oct}}$ , in decibels, shall be calculated from the corresponding one-third octave band values,  $\Delta R_n$ , using [Formula \(D.1\)](#):

$$\Delta R_{\text{oct}} = -10 \lg \left( \sum_{n=1}^3 \frac{10^{\left( \frac{\Delta R_n}{10} \right)}}{3} \right) \text{ dB} \quad (\text{D.1})$$

$R_{\text{without}}$  is the sound reduction value without the lining and  $R_{\text{with}}$  is the sound reduction with the lining.  $R_{\text{with}}$ ,  $R_{\text{without}}$  and  $\Delta R$  shall be given as frequency spectra in a table as follows:

- $R_{\text{with}}$  and  $R_{\text{without}}$  as one-third octave band level spectra;
- $\Delta R$  as one-third octave and as octave band level spectra.

To evaluate the single-number rating,  $\Delta R_w$ , from the one-third octave band  $\Delta R$  values given to one decimal place, the measured values of the sound reduction improvement are used in conjunction with standard reference curves for the standard basic elements by calculation (see [Annex E](#)). The difference between the weighted sound reduction indices of the reference standard basic element with and without lining yields the weighted improvement of sound reduction index,  $\Delta R_w$ , of the lining. A similar procedure is used for the A-weighted improvement of sound reduction indices of the lining,  $\Delta(R_w + C)$  and  $\Delta(R_w + C_{\text{tr}})$ . To calculate the A-weighted sound reduction indices, with and without the lining, sound level spectra in accordance with [Table 4](#) or [Table B.1](#) (extended frequency range) shall be used.

**NOTE** To evaluate the single-number rating,  $\Delta R_w$ , from the one-third octave band  $\Delta R$  values, the same procedure is used as when evaluating the weighted improvement of impact sound insulation  $\Delta L_w$  from the normalized impact sound pressure levels  $L_n$  according to ISO 717-2.

#### D.2 Quantities determined

The single-number ratings determined in accordance with this subclause are as given below.

- The weighted sound reduction improvement index,  $\Delta R_w$ . The single-number rating calculated from the sound reduction improvement index,  $\Delta R$ . An additional index indicates the standard basic element used: “heavy” for the heavyweight wall or floor and “light” for the lightweight wall in accordance with ISO 10140-5:2010, Annex B. For example,  $\Delta R_{w,\text{heavy}}$ .
- The direct difference of the weighted sound reduction indices,  $\Delta R_{w,\text{direct}}$ , in decibels: the difference of the weighted sound reduction indices of the basic element with and without lining under the particular conditions of the measurement (without generalization by means of a reference curve for the sound reduction of the basic element) as given by [Formula \(D.2\)](#):

$$\Delta R_{w,\text{direct}} = R_{w,\text{with}} - R_{w,\text{without}} \quad (\text{D.2})$$

### D.3 Rating procedures

Take the one-third octave band sound reduction improvement index  $\Delta R$  values, as measured. Add them to the reference values of the sound insulation index,  $R_{\text{ref,without}}$ , of the matching standard basic element as given in [Annex E](#).

$$R_{\text{ref,with}} = R_{\text{ref,without}} + \Delta R \quad (\text{D.3})$$

Determine the weighted sound reduction indices  $R_{\text{w,ref,with}}$  and  $R_{\text{w,ref,without}}$  and the corresponding spectrum adaptation terms. The weighted improvement of sound reduction index is then given by [Formula \(D.4\)](#):

$$\Delta R_{\text{w}} = R_{\text{w,ref,with}} - R_{\text{w,ref,without}} \quad (\text{D.4})$$

The A-weighted improvement of sound reduction indices  $\Delta(R_{\text{w}} + C)$ , respectively,  $\Delta(R_{\text{w}} + C_{\text{tr}})$ , are calculated in an equivalent way.

An additional index indicates the reference basic element used: “heavy” for the heavyweight wall and floor and “light” for the lightweight wall in accordance with [Annex E](#). For example,  $\Delta(R_{\text{w}} + C)_{\text{heavy}}$ .

If basic elements besides the standard basic elements are used, the single-number ratings follow directly from the single-number ratings for that basic element with and without the tested acoustical lining.

## Annex E (normative)

### Standard basic elements for measuring the improvement of airborne sound insulation by linings

#### E.1 Standard basic elements

The constructions described in this annex can be used as standard basic elements for the application of linings. This annex also gives the standardized values of the sound reduction indices,  $R$ , for the standard basic elements. These are given in figures and in a table, together with the corresponding weighted sound reduction indices,  $R_w$ , and spectrum adaptation terms,  $C$  and  $C_{tr}$ , in accordance with this document.

NOTE [Figures E.1](#), [E.2](#) and [E.3](#) as well as [Table E.1](#) give typical smoothed values for the sound reduction index of these basic elements used in the determination of the single-number rating; the measured values of the actual basic element are used to evaluate the improvement by a lining.

#### E.2 Standard wall with low critical frequency ("heavy wall")

This is constructed of masonry, homogeneous concrete or concrete blocks with a surface density,  $\rho_A$ , of  $(350 \pm 50) \text{ kg/m}^2$ . The material and thickness shall be chosen such that the critical frequency is located in the 125 Hz octave band. This may be calculated or measured. No cavities are allowed and there shall be no thickness resonances below 3150 Hz. The density of the blocks or bricks shall be at least  $1\,600 \text{ kg/m}^3$ . If the wall is not airtight, it shall be plastered on the side facing the lining.

For the reference curve of this wall, see [Figure E.1](#) and [Table E.1](#).

EXAMPLE Calcium silicate blocks with density  $1\,700 \text{ kg/m}^3 \leq \rho < 1\,800 \text{ kg/m}^3$ . Thickness of the blocks: 175 mm. 10 mm gypsum plaster on one side of the wall.