

English Version

**Analogue audio disk records and reproducing equipment  
(IEC 60098:2020)**

Disques audio analogiques et appareils de lecture  
(IEC 60098:2020)

Analoge Schallplatten und Abspielgeräte  
(IEC 60098:2020)

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

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European Committee for Electrotechnical Standardization  
Comité Européen de Normalisation Electrotechnique  
Europäisches Komitee für Elektrotechnische Normung

**CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels**

## **European foreword**

The text of document 100/3261/CDV, future edition 4 of IEC 60098, prepared by IEC/TC 100 "Audio, video and multimedia systems and equipment" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 60098:2020.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2020-11-14
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2023-02-14

This document supersedes HD 337 S3:1989 and all of its amendments and corrigenda (if any).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

## **Endorsement notice**

The text of the International Standard IEC 60098:2020 was approved by CENELEC as a European Standard without any modification.

## Annex ZA

(normative)

### Normative references to international publications with their corresponding European publications

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.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: [www.cenelec.eu](http://www.cenelec.eu).

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60050-806	1996	International Electrotechnical Vocabulary - Chapter 806: Recording and reproduction of audio and video	-	-
+ A1	2001		-	-
+ A2	2018		-	-
IEC 60263	1982	Scales and sizes for plotting frequency characteristics and polar diagrams	-	-
IEC 60386	1972	Method of measurement of speed fluctuations in sound recording and reproducing equipment	-	-
IEC 60417	-	Graphical symbols for use on equipment. Index, survey and compilation of the single sheets.	-	-
IEC 61672-1	2013	Electroacoustics - Sound level meters - Part 1: Specifications	EN 61672-1	2013
IEC 62368-1	2018	Audio/video, information and communication technology equipment - Part 1: Safety requirements	EN IEC 62368-1	2020



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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ANALOGUE AUDIO DISK RECORDS AND REPRODUCING EQUIPMENT**

## FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60098 has been prepared by IEC technical committee 100: Audio, video and multimedia systems and equipment.

This fourth edition cancels and replaces the third edition published in 1987. This edition constitutes a full revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) addition of a tolerance on groove width.

The text of this International Standard is based on the following documents:

CDV	Report on voting
100/3261/CDV	100/3331/RVC

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.



## ANALOGUE AUDIO DISK RECORDS AND REPRODUCING EQUIPMENT

### 1 Scope

This document applies to analogue audio disk records and the corresponding professional and domestic reproducing equipment. It excludes amplifiers and loudspeakers, methods of measurement for which can be found in IEC 60268-3, IEC 60268-5, IEC 60268-21 and IEC 60268-22<sup>1</sup>.

This document specifies the characteristics that are necessary to ensure compatibility between analogue audio disk records and the corresponding reproducing equipment.

It also lists and defines the most important characteristics affecting the performance of reproducing equipment, and establishes agreed methods of measurement for these characteristics

### 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.

IEC 60050-806:1996, *International Electrotechnical Vocabulary (IEV) – Part 806: Recording and reproduction of audio and video*

IEC 60050-806:1996/AMD1:2001

IEC 60050-806:1996/AMD2:2018

IEC 60263:1982, *Scales and sizes for plotting frequency characteristics and polar diagrams*

IEC 60386:1972, *Method of measurement of speed fluctuations in sound recording and reproducing equipment*

IEC 60417, *Graphical symbols for use on equipment* (available at <http://www.graphical-symbols.info/equipment>)

IEC 61672-1:2013, *Electroacoustics – Sound level meters – Part 1: Specifications*

IEC 62368-1:2018, *Audio/video, information and communication technology equipment – Part 1: Safety requirements*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-806 and the following 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>

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<sup>1</sup> Under preparation. Stage at the time of publication: IEC CDV 60268-22:2019.

- IEC Electropedia: available at <http://www.electropedia.org/>

### 3.1

#### **rated value**

value of a quantity used for specification purposes, established for a specified set of operating conditions of a component, device, equipment, or system

Note 1 to entry: The rated value is normally the value stated by the manufacturer.

[SOURCE: IEC 60050-151:2001, 151-16-08, modified – Note 1 to entry has been added.]

### 3.2

#### **terminated**, adj

<of a circuit or connection port> connected to a specified impedance required for correct operation or for specified test conditions

Note 1 to entry: 'Specified test conditions' can include open-circuit and short-circuit.

## 4 General

### 4.1 Scales for graphical presentation of data

Linear or logarithmic scales are recommended for graphical presentation. Linear decibel scales are equivalent to logarithmic scales. Other kinds of scale, such as double logarithmic, should be avoided. When using decibel scales, the zero reference should, if possible, be the rated value. In those cases, where each of the scales refers directly to physical units, it is recommended to avoid a combination of linear and logarithmic scales.

Where quantities represented by the axes are of the same kind, it is recommended that the same unit length be used for both.

Linear scales with remote zero point should be avoided as far as possible. For further information, see IEC 60263.

### 4.2 Scales for frequency characteristics

Graphs should be drawn with frequency in Hz on the  $x$ -axis with a logarithmic scale, and the level expressed in dB on the  $y$ -axis with a linear scale. The scale ratio should be such that the length representing one decade of frequency is the same as the length representing a 25 dB or a 50 dB difference in level. The preferred length per decade is 50 mm. If the size of the graph is changed, the scale ratio should be left unaltered.

## 5 The disk

### 5.1 Types of disk records

The types of disk record given in Table 1 shall be standard.

**Table 1 – Standard types of disk**

Type designation	Nominal diameter (cm)	Nominal speed (rev/min)
3033	30	33 $\frac{1}{3}$
2533	25	33 $\frac{1}{3}$
1733	17	33 $\frac{1}{3}$
3045	30	45

Type designation	Nominal diameter (cm)	Nominal speed (rev/min)
2545	25	45
1745	17	45

## 5.2 Dimensions of disks

The dimensions for types 30xx and 25xx are shown in Figure 1.

Dimensions in millimetres

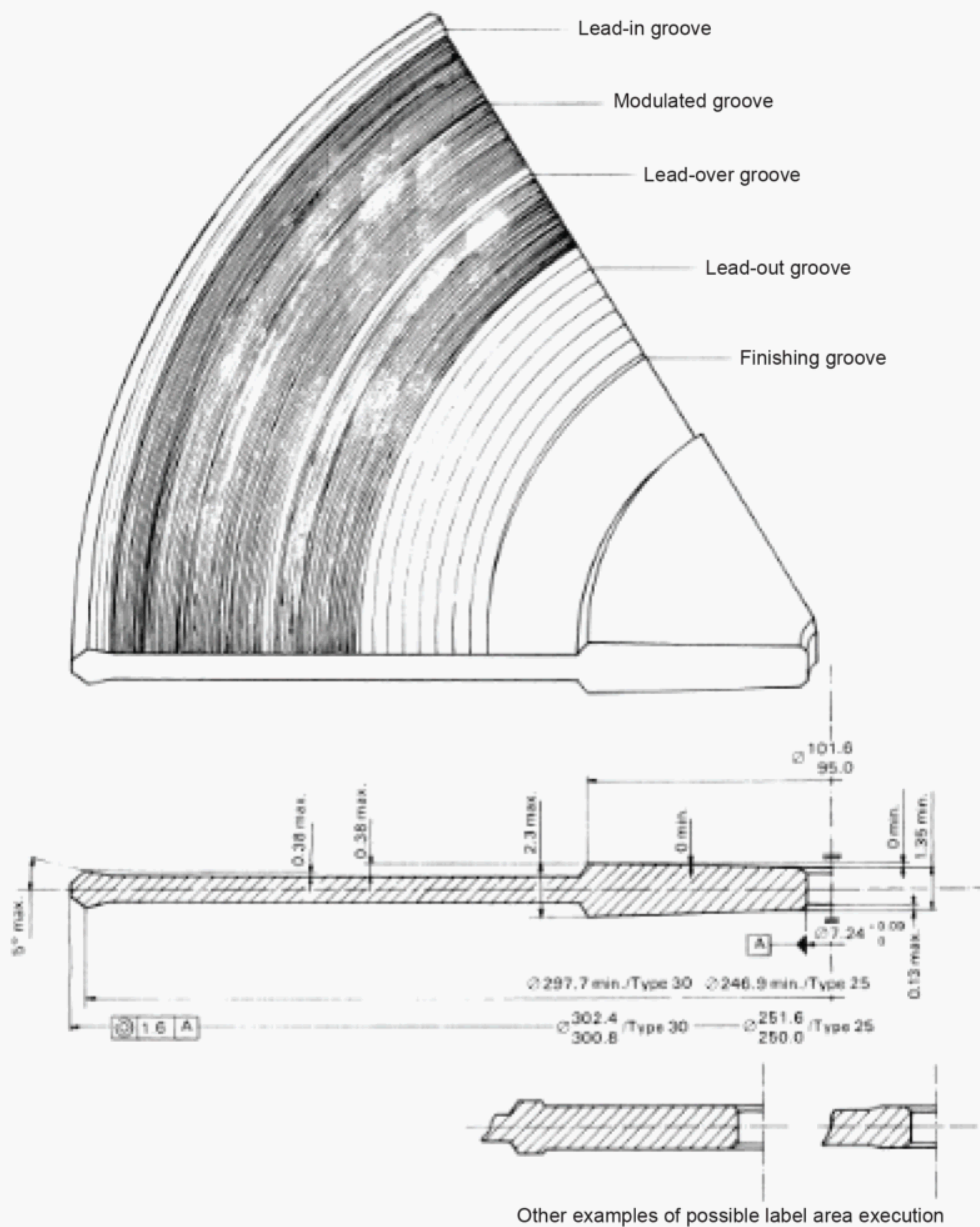
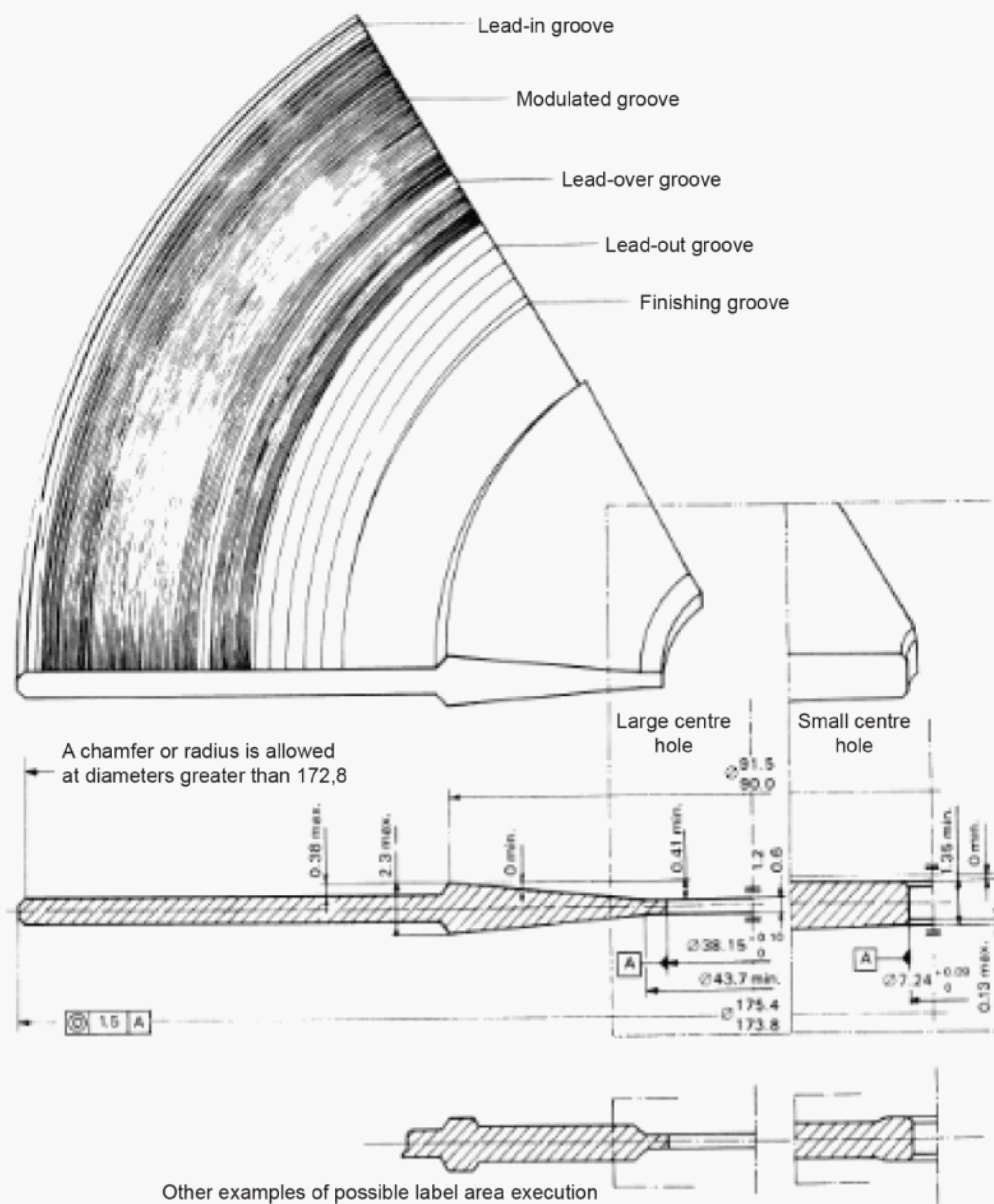


Figure 1 – Dimensions for record types 30xx and 25xx



The dimensions for type 17xx are shown in Figure 2.

Dimensions in millimetres



IEC

A small centre hole click may have an optional push-out centre that, when removed, leaves the large centre hole dimensions. Both configurations should fulfil the requirements of the diagram.

An optional push-out centre should have a closed structure within a diameter of 16 mm concentric with the centre hole.

**Figure 2 – Dimensions for record type 17xx**

### 5.3 Unbalance of disks

The centre of gravity of disks having a small centre hole shall lie within an 8 mm diameter circle concentric with the centre of the centre hole.



## 5.4 Direction of rotation

The direction of rotation of the disk shall be clockwise when viewed from the side being reproduced.

## 5.5 Direction of recording

The direction of recording shall be such that, on reproduction, the pickup shall travel as closely as possible along a straight radial line towards the centre of the disk.

## 5.6 Speed of rotation

The speed of rotation during recording shall be within  $\pm 0,5\%$  of the rated recording speed, the rated recording speed being such as to give the intended musical pitch at one of the following rated reproducing speeds:

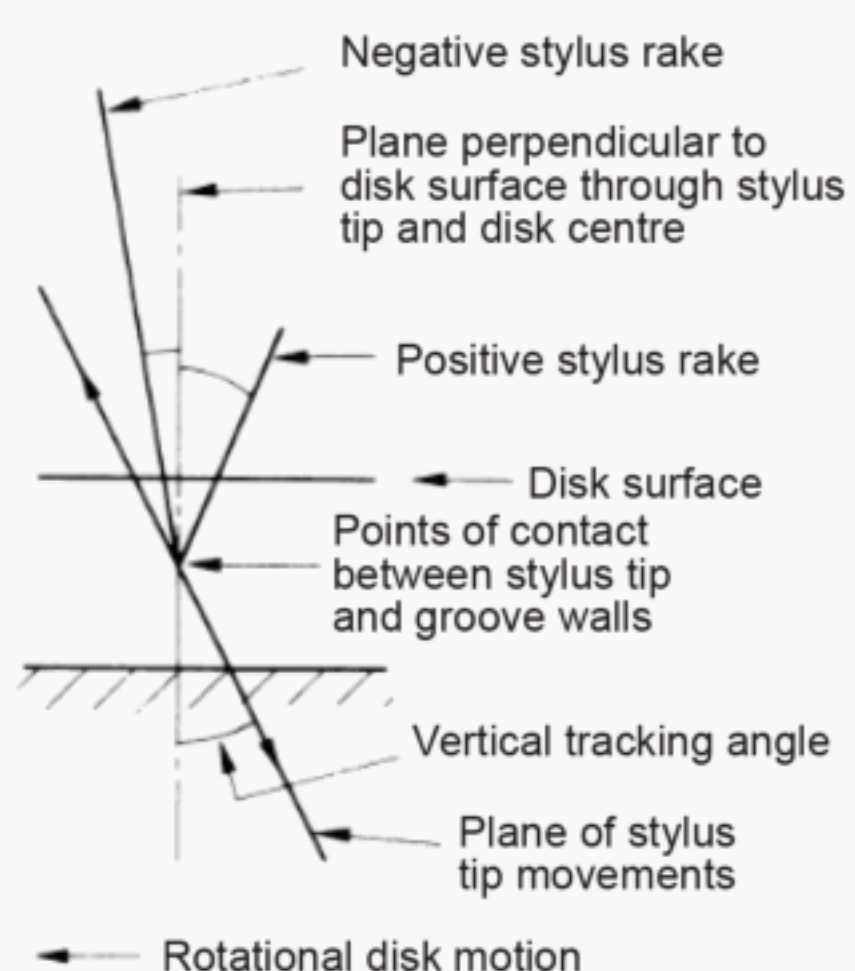
- $33\frac{1}{3}$  r/min: for disk record types 3033, 2533 and 1733,
- 45 r/min: for disk record types 3045, 2545 and 1745.

NOTE Verification of reproducing speed by means of stationary stroboscopic bars in countries employing 50 Hz electric supplies can be made at 45,112 r/min only.

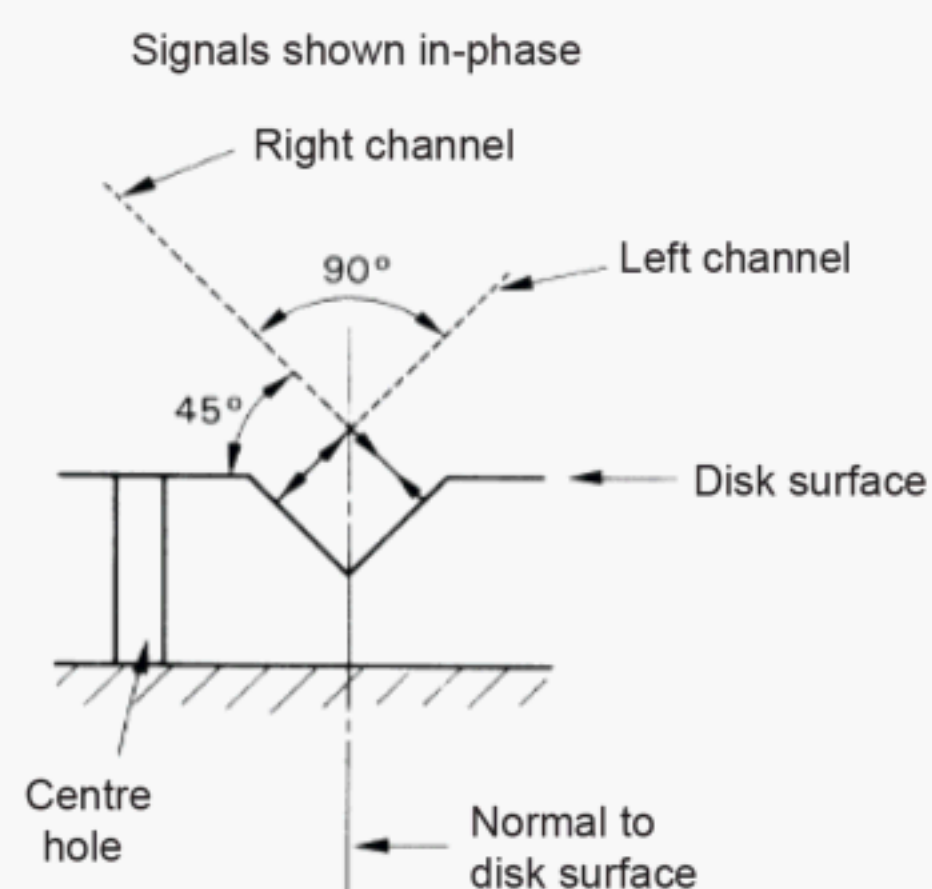
# 6 The groove

## 6.1 Direction of groove modulation

The stereophonic groove shall carry two channels of information. The two channels shall be recorded in such a manner that they can be reproduced by movements of a reproducing stylus tip in two directions at  $90^\circ$  to each other, and at  $45^\circ$  to a radial line through the stylus tip and the centre of the record; these movements shall be tangential to, or lie in a plane through the stylus tip and the record centre, inclined at an angle of  $20^{+5}_0^\circ$  anticlockwise to the normal to the record surface through the stylus tip as viewed towards the record centre (vertical tracking angle). The resulting modulation shall be optimum for reproducing styli having a rake angle of between  $0^\circ$  and  $-5^\circ$  (for detail, see Figure 3).



a) View of groove in direction from stylus tip to disk centre (see 8.1)



b) View of groove in plane of stylus tip movements (see 8.1)

Figure 3 – Groove

The monophonic groove shall carry one channel of information. It shall be recorded on both groove walls in such a manner that it can be reproduced by lateral movements of a stylus tip as described above.

## **6.2 Arrangement of stereophonic channels**

### **6.2.1 Channel orientation**

The right-hand channel, as viewed by the audience, shall be recorded on the outer groove wall, the left-hand channel on the inner groove wall.

### **6.2.2 Channel phasing**

The phasing of the two recorded signals shall be suitable for reproduction on two-channel equipment so connected that movement of the reproducing stylus tip along the radial line through stylus tip and disk centre (as with a monophonic record) produces in-phase sound pressures at the left-hand and right-hand loudspeakers.

### **6.2.3 Channel levels**

The levels of the two recorded signals shall be suitable for reproduction on two-channel equipment, of identical channel gain, so connected that movement of the reproducing stylus along the radial line through the stylus tip and disk centre (as with a monophonic record) produces equal sound pressures at the left-hand and right-hand loudspeakers.

### **6.2.4 Channel polarity**

The polarity of the two recorded signals should preferably be suitable for reproduction on two-channel equipment so connected that movement of the reproducing stylus tip along the radial line through stylus tip and disk centre in a direction away from the disk centre shall produce compression in front of the left and right-hand loudspeakers similar to that produced by the live programme source.

## **6.3 Groove dimensions**

Instantaneous top width: 30  $\mu\text{m}$  (0,012 in) minimum

Bottom radius: 8  $\mu\text{m}$  (0,000 32 in) maximum

Included angle:  $(90 \pm 5)^\circ$

## **6.4 Lead-in groove**

The pitch of the lead-in groove shall be  $(1,2 \pm 0,4)$  mm. The groove width shall be  $(60 \pm 10)$   $\mu\text{m}$ .

## **6.5 Outer diameter of recorded surface**

The recorded surface shall start with at least one turn of plain groove and have a maximum outer diameter of:

- 292,6 mm for types 3033 and 3045;
- 241,8 mm for types 2545 and 2533;
- 168,3 mm for types 1733 and 1745.

## **6.6 Eccentricity of groove spiral**

The distance of the centre of the groove spiral to the centre of the centre hole shall be not more than 0,2 mm.

## 6.7 Marker space

The pitch of the lead-over groove in a marker space shall be not greater than 1,6 mm. A marker space shall not occur at a diameter of less than 127 mm.

## 6.8 Lead-out groove

The pitch of the lead-out groove shall be  $6,4 \text{ mm} \pm 3,2 \text{ mm}$ .

The top width of the lead-out groove shall increase to a minimum of 0,075 mm when the pitch exceeds 6,4 mm.

The lead-out groove shall have at least one turn.

## 6.9 Finishing groove

The diameter of the finishing groove shall be:

- $106,4 \text{ mm} \pm 0,8 \text{ mm}$  for types 3033, 2545 and 2533 and 3045;
- $97,4 \text{ mm} \pm 1,0 \text{ mm}$  for types 1733 and 1745.

## 7 Label information

The label shall give at least the following information:

- a) catalogue number;
- b) if there is more than one record, side number and total number of sides, for example "Side 5 of 8";
- c) programme title;
- d) nominal speed of rotation;
- e) type of recording.

If stereophonic, it shall be clearly marked with either the word "STEREO" or with the symbol specified by IEC 60417-5071:2002-10. Word and symbol may be used simultaneously. If monophonic, it shall be clearly marked with either the word "MONO" or with the symbol specified by IEC 60417-5070:2002-10. Word and symbol may be used simultaneously.

## 8 Recording and reproducing characteristics

### 8.1 Recording characteristic

#### 8.1.1 Standard recording characteristic

The standard recording characteristic shall be a combination of the following three curves:

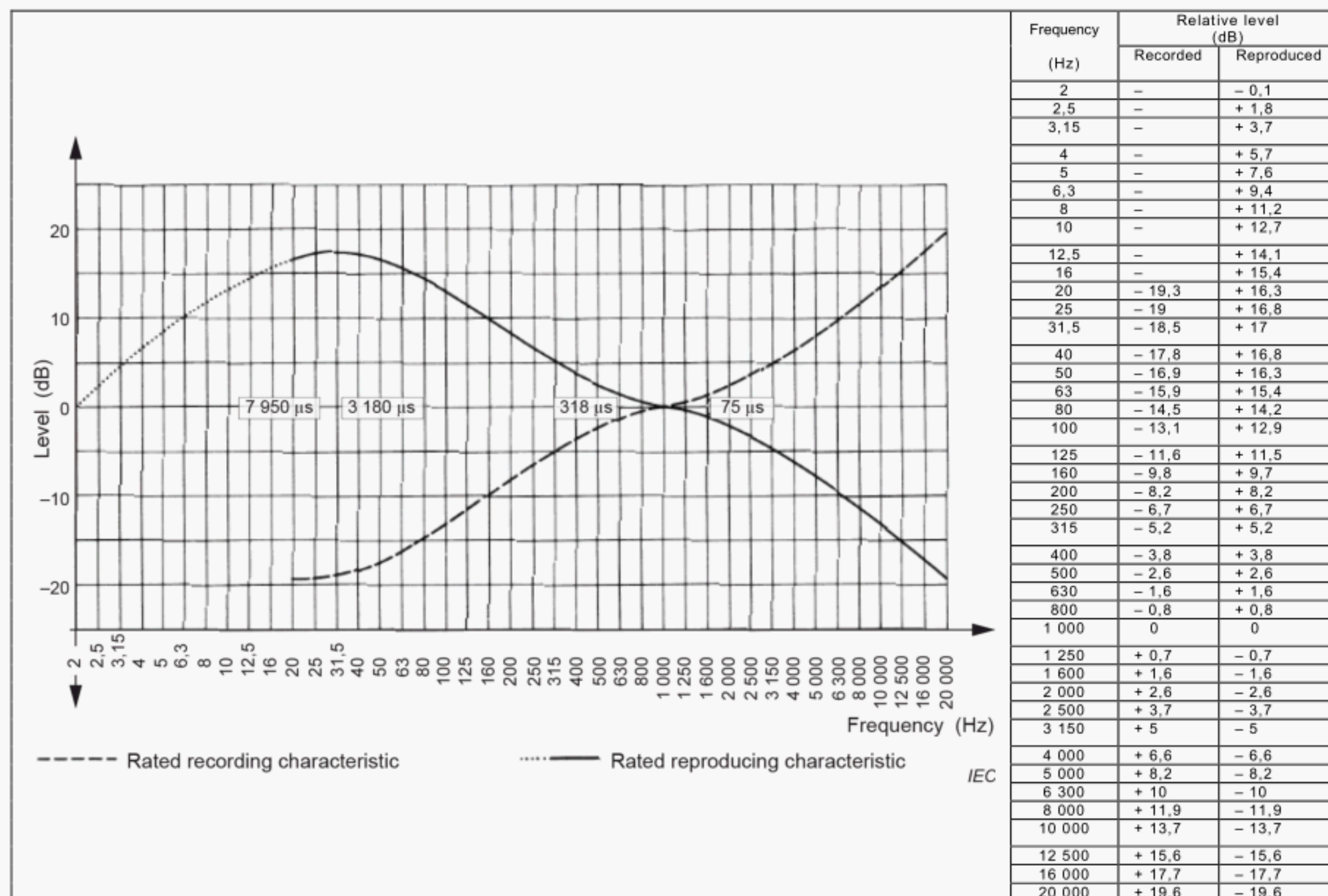
- one rising with increasing frequency in conformity with the admittance of a parallel combination of a capacitance and a resistance having a time constant of  $t_1 = 75 \text{ } \mu\text{s}$ ;
- one falling with decreasing frequency in conformity with the admittance of a series combination of a capacitance and a resistance having a time constant of  $t_2 = 318 \text{ } \mu\text{s}$ ;
- one rising with decreasing frequency in conformity with the impedance of a series combination of a capacitance and a resistance having a time constant of  $t_s = 3\,180 \text{ } \mu\text{s}$ .

If  $N$  is the recorded level in decibels and  $f$  is the frequency, the combined curve is defined by:



$$N = 10 \log_{10} \left( 1 + 4\pi^2 f^2 t_1^2 \right) - 10 \log_{10} \left( 1 + \frac{1}{4\pi^2 f^2 t_2^2} \right) + 10 \log_{10} \left( 1 + \frac{1}{4\pi^2 f^2 t_3^2} \right)$$

This curve and the approximate relative values of recorded levels are shown in Figure 4.



NOTE 1 For recording chain tolerances, see 8.1.2.

NOTE 2 For reproducing chain tolerances, see 8.2.2.

NOTE 3 Corrections of approximately +0,1 dB and –0,1 dB have been applied to the recording and reproducing characteristics, respectively, in order to obtain zero reference at 1 kHz.

**Figure 4 – Recording and reproducing characteristics**

### 8.1.2 Recording chain tolerances

The frequency characteristic of the recording chain shall be a smooth curve lying within  $\pm 2$  dB of the standard recording characteristic in the frequency range from 50 Hz to 10 kHz, taking as reference point the value at 1 kHz.

NOTE When measuring the frequency characteristic of the recording chain by means of a rated reproducing chain, the rated reproducing characteristic is not a mirror image of the rated recording characteristic at frequencies below 200 Hz.

On a stereophonic record, the unbalance between stereo channels at 1 kHz should not exceed 1 dB, while the unbalance at all other frequencies between 50 Hz and 10 kHz should not exceed 2 dB.

## 8.2 Reproducing characteristic

### 8.2.1 Standard reproducing characteristic

The standard reproducing characteristic shall be a combination of the following four curves:



- one falling with increasing frequency in conformity with the impedance of a parallel combination of a capacitance and a resistance having a time constant of  $t_1 = 75 \mu\text{s}$ ;
- one rising with decreasing frequency in conformity with the impedance of a series combination of a capacitance and a resistance having a time constant of  $t_2 = 318 \mu\text{s}$ ;
- one falling with decreasing frequency in conformity with the admittance of a series combination of a capacitance and a resistance having a time constant of  $t_3 = 3\,180 \mu\text{s}$ ;
- one falling with decreasing frequency in conformity with the admittance of a series combination of a capacitance and a resistance having a time constant of  $t_4 = 7\,950 \mu\text{s}$ .

If  $N$  is the output level in decibels and  $f$  is the frequency, the combined curve is defined by:

$$N = -10 \log_{10} \left( 1 + 4\pi^2 f^2 t_1^2 \right) + 10 \log_{10} \left( 1 + \frac{1}{4\pi^2 f^2 t_2^2} \right) - 10 \log_{10} \left( 1 + \frac{1}{4\pi^2 f^2 t_3^2} \right) - 10 \log_{10} \left( 1 + \frac{1}{4\pi^2 f^2 t_4^2} \right)$$

This curve and the approximate relative values of reproduced (output) levels are shown in Figure 4.

## 8.2.2 Reproducing chain tolerances

### a) 2 Hz to 20 Hz:

The frequency characteristic of the reproducing chain shall be a curve which shall always lie at or below the standard reproducing characteristic, taking as reference point the value at 1 kHz.

### b) 20 Hz to 20 kHz:

No tolerances are specified for the frequency characteristic of the reproducing chain.

## 9 Reproducing equipment

### 9.1 Speed of rotation

The speed of rotation during reproduction shall be within  $\pm 2\%$  of the rated reproducing speeds of  $33\frac{1}{3}$  r/min and 45 r/min.

NOTE Verification of the reproducing speed of 45 r/min by means of stationary stroboscopic bars in countries employing 50 Hz electric supplies can be made at 45,112 r/min only.

### 9.2 Automatic pickup lifting

When the pickup is in the playing position, the automatic pickup lifting mechanism of a record player shall not become operative at a diameter of more than 127 mm.

### 9.3 Reproducing stylus

#### 9.3.1 Clearances

The clearance between the stylus tip and the bottom of the groove shall be 0,002 mm minimum, and the stylus tip shall not touch the groove's edges.

#### 9.3.2 Included angle (spherical styli only)

The included angle of the reproducing stylus shall not exceed  $55^\circ$ .

### **9.3.3 Stylus rake (non-spherical styli only)**

The stylus rake in the direction of groove travel shall lie between  $+4^\circ$  and  $-8^\circ$  when playing at the stylus force recommended by the manufacturer (see Figure 3).

## **9.4 Arrangement of stereophonic channels**

### **9.4.1 Channel orientation**

Stereophonic reproducing equipment shall have two channels, and shall be so connected that the right-hand loudspeaker(s), as viewed from the audience, shall be actuated by the outer wall of the groove, and the left-hand loudspeaker(s) by the inner wall of the groove.

### **9.4.2 Channel phasing**

Stereophonic reproducing equipment shall be so connected that movement of the reproducing stylus tip along the radial line through stylus tip and disk centre (as with a monophonic record) produces in-phase sound pressures at the left-hand and right-hand loudspeakers.

### **9.4.3 Channel gain**

The gains of the two channels of stereophonic reproducing equipment shall be so adjusted that movement of the reproducing stylus tip along the radial line through stylus tip and disk centre (as with a monophonic record) produces equal sound pressures at the left-hand and right-hand loudspeakers.

### **9.4.4 Channel polarity**

Stereophonic reproducing equipment should preferably be so connected that movement of the reproducing stylus tip along the radial line through stylus tip and disk centre in a direction away from the disk centre shall produce compression in front of the left-hand and right-hand loudspeakers similar to that produced by the live programme source.

## **9.5 Interchangeability of pickup cartridges**

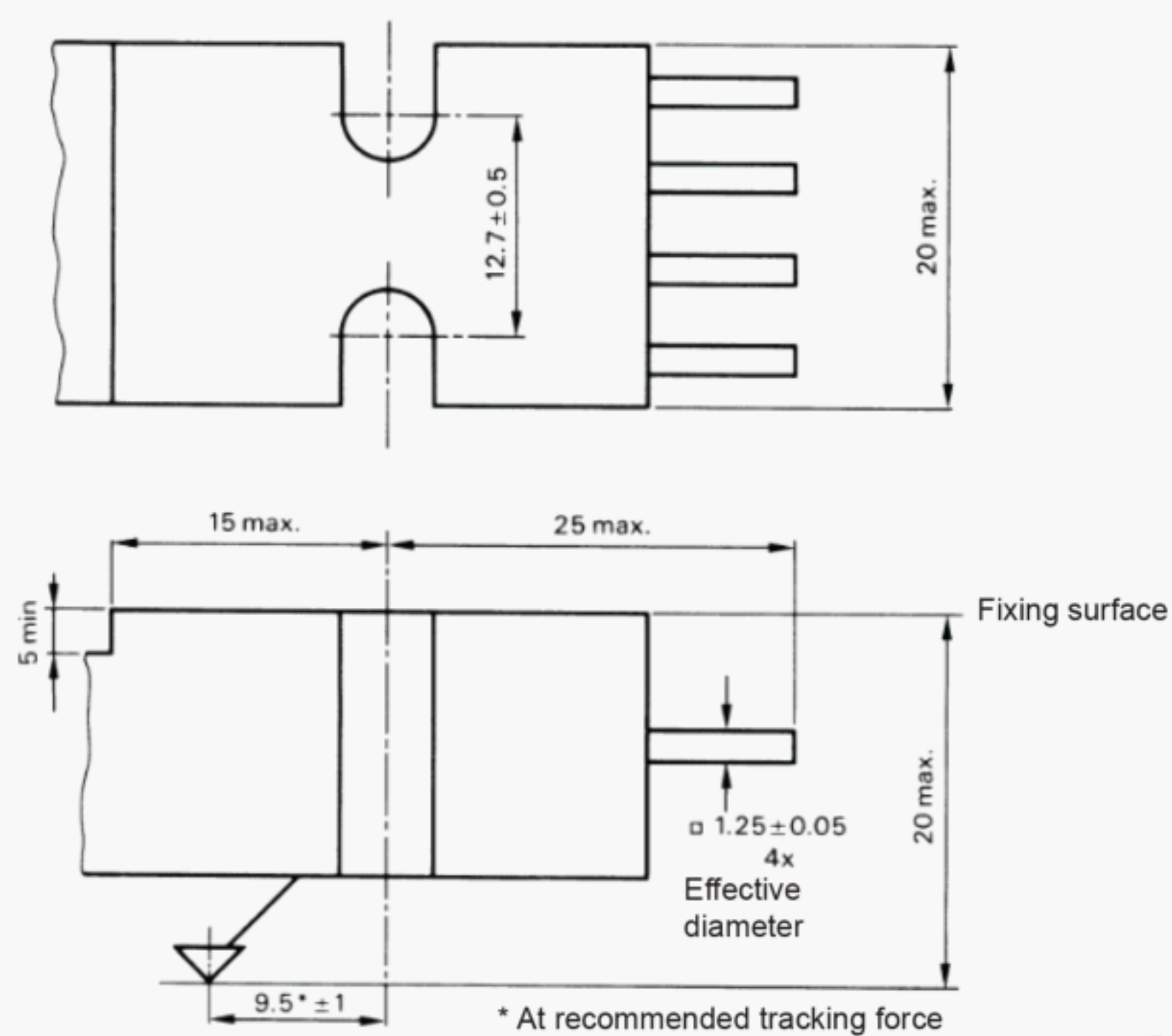
### **9.5.1 Dimensions**

Pickup cartridges intended for fixing to pickup arms by means of screws shall have the dimensions shown in Figure 5. The screws shall be of size M2,5. The mass of such a pickup cartridge shall not exceed 12 g.

NOTE 1 The spatial arrangement of the connecting pins is left to the designer of the pickup cartridge.

NOTE 2 Formerly, M2,6 screws were permitted, and these can still be found in the field.

Dimensions in millimetres



IEC

**Figure 5 – Pickup cartridge****9.5.2 Colour coding of connecting wires between pickup cartridge and pickup arm**

The colour coding for the connecting wires between the pickup cartridge and the pickup arm shall be as shown in Table 2.

**Table 2 – Colour coding of connecting wires**

Colour	Purpose	Pickup cartridge with		
		3 wires	4 wires	5 wires
Red	Right-hand channel	X	X	X
Green	Right return connection		X	X
White	Left-hand channel	X	X	X
Blue	Left return connection		X	X
Black	Return or ground	X		X

**9.5.3 Colour coding or marking of pickup cartridge terminals**

Pickup cartridge terminals shall be marked by means of the colour coding given in Table 2, or by means of suitable letters.

**10 Measurements****10.1 Standard measurement conditions****10.1.1 General**

The manufacturer shall specify the values of the characteristics listed in 10.1.2 to 10.2.2.

### 10.1.2 Environment

The following information shall be provided:

- a) ambient temperature (preferred range: 20 °C to 25 °C);
- b) relative humidity (preferred range: 45 % to 75 %);
- c) air pressure (preferred range: 86 kPa to 106 kPa);
- d) stabilization time of unit after switching on from ambient temperature in min (preferred maximum 30 min).

### 10.1.3 Electric power supply

For information and marking requirements, refer to the applicable IEC safety standard, usually IEC 62368-1.

### 10.1.4 Pickup operation

The following information shall be provided:

- a) stylus force in mN; statement in gm-force may be added;
- b) load impedance per channel, expressed as a parallel combination of resistance in k $\Omega$  and capacitance in pF;
- c) external correction network (if required);
- d) external equalization network (if required).

Before any measurements are taken, the unit shall operate for at least the recommended time for stabilization and all measuring equipment shall have reached temperature stability.

The output of the unit shall be taken from the correction or equalization network (if any) i.e. the measurement shall be made at that point where the signal has the characteristic that is to be reproduced. For stereo pickups, both channels shall be terminated in accordance with item b) above. Apart from that load, the measuring equipment shall not introduce an additional load that would significantly affect the characteristics to be measured.

### 10.1.5 Test records

If a test record is used for any measurement, it shall be identified by catalogue number, name of manufacturer and country of manufacture.

Information on test records is given in Annex A, Annex B, Annex C, Annex D and Annex E.

**NOTE** In order to achieve comparable results, test records for a particular purpose should be derived from the same original recording. However, even given this condition, variations in record manufacture, such as record material and pressing conditions, can give rise to variations in characteristics such as high-frequency characteristics, separation characteristics, wow, flutter and rumble.

## 10.2 Methods of measurement

### 10.2.1 General

The methods of measurement apply to complete record playing units only. If measurements are made on components of record playing units (e.g. turntables, pickup cartridges), the precise details of the remaining parts of the record playing unit used for measurement shall be stated in the test report.

The sensitivity of the measuring equipment shall be sufficiently independent of frequency to achieve the required accuracy of measurement.



### 10.2.2 Maximum apparent power consumption

Specification: the maximum apparent power consumption occurs when it operates at rated voltage and under maximum mechanical load.

Method: the current,  $I$  (in A), taken from the supply source shall be measured to an accuracy of  $\pm 3\%$  while the unit is operated under standard measurement conditions.

Statement of result: maximum power consumption =  $(I \times V_R)$  VA, where  $V_R$  is the rated voltage.

NOTE In addition, the above measurements can be made at maximum voltage and maximum mechanical load conditions.

### 10.2.3 Mean deviation from rated speed

Specification: mean deviation from rated speed, as a signed percentage of rated speed.

Method A: a stroboscope ( $n$  bars) rotating with a record being played is illuminated by a neon lamp operated at power supply frequency  $f$  Hz. The power supply frequency shall be checked, as tolerances vary between systems, and any necessary correction taken into account in the result.

Viewing from above the record, the number of apparent bars passing a fixed point per second ( $N$ ) is counted, clockwise movement being regarded as positive ( $+N$ ), anticlockwise movement as negative ( $-N$ ).

The relations of rated speed and measured speed to  $n$ ,  $f$  and  $N$  are given in Table 3.

**Table 3 – Rated and measured speeds**

Rated speed rev/min	Rated power supply frequency Hz			
	50 Hz		60 Hz	
	$n$	Speed if $N = 0$	$n$	Speed if $N = 0$
45	113	45,11 <sup>a</sup>	160	45,00
33⅓	180	33,33	216	33,33
<sup>a</sup> See the note in 5.6.				

Result: for record playing units with rated parameters of 33⅓ r/min (60 Hz), 33⅓ r/min (50 Hz) and 45 r/min (60 Hz):

- mean deviation from rated speed =  $\left( \frac{N}{2f} \times 100 + E \right) \%$ .

For record playing units with rated parameters of 45 r/min (50 Hz):

- mean deviation from rated speed =  $\left( \frac{N}{2f} \times 100 + E + 0,25 \right) \%$ .

Where  $E = \left( \frac{f - f_r}{f_r} \times 100 \right) \%$  and  $f_r$  is the rated supply frequency.

Method B: while being played, 120 revolutions of a record are timed as  $t$  s. The relation between  $t$  and the actual speed is given in Table 4.

NOTE  $t$  is the measured time,  $T$  is the time that would be measured at rated speed.

**Table 4 – Relation of time  $t$  to actual speed**

Rated speed r/min	Time $T$ for 120 revolutions at rated speed s
45	160
33⅓	216

Result: mean deviation from rated speed =  $\left( \frac{T-t}{t} \times 100 \right) \%$ .

NOTE This formula is valid only for small deviations. Large values of deviation are not expected to occur.

#### 10.2.4 Wow and flutter

Specification: see IEC 60386 for full details.

Method: a test record (see Annex B) containing a lateral signal of 3 150 Hz is centred with respect to the rotational axis of the unit by means of a concentric groove situated near the edge of the record. The 3 150 Hz band is played, and the output is fed to a measuring instrument, in accordance with IEC 60386.

Units without speed adjustment are measured at the actual speed; those with speed adjustment are measured at the rated speed.

Result: weighted wow and flutter = arithmetic mean of at least three meter readings.

#### 10.2.5 Maximum start time to reach actual or rated speed

Specification: the maximum time that has elapsed between the operation of the starting device and the disk speed being increased from zero to the speed that gives a wow and flutter value which is twice the steady state value.

Method:

A test record (see Annex B) containing a signal of 3 150 Hz is played with the pickup at the beginning of the recording. The reproduced test signals shall be fed to a frequency discriminator centred on 3 150 Hz and the output from the discriminator fed to a graphic recorder or storage oscilloscope. The time taken from the operation of the starting device to when the trace on the recorder reaches twice the steady-state wow and flutter value is noted. The measurement is repeated several times.

Result: the maximum time shall be stated in s.

#### 10.2.6 Signal/rumble ratio

For all measurements in this subclause, the frequency characteristic of any correction and/or equalization network external to the unit under test shall, between 2 Hz and 2 kHz, not deviate by more than –1 dB from the rated reproducing characteristic, taking as a reference point the value at 1 kHz.

Specifications:

a) Signal/rumble ratio:

If  $U$  is the maximum voltage derived from low-frequency vibration within the unit measured at a given output, and  $U_0$  is the voltage derived from the reference signal intended for and measured at the same output:

$$\text{signal/rumble ratio} = 20 \log_{10} \frac{U_0}{U} \text{ dB.}$$

b) Signal/rumble ratio – unweighted:

Signal/rumble ratio when  $U$  and  $U_0$  are measured via a low-pass filter network resulting in the attenuation curve X in Figure C.1. It is a measure of the very low-frequency rumble, which is heard mainly as intermodulation with the wanted recording.

c) Signal/rumble ratio – weighted:

Signal/rumble ratio when  $U$  and  $U_0$  are measured via a weighting network resulting in the attenuation curve Y in Figure C.1. It is a measure of the rumble, which is heard mainly as an independent signal.

Method: (for general use, where a simple result is required)

A test record (see Annex C) containing unmodulated grooves as well as reference signals intended for the left, right and lateral measuring planes is played. By means of a measuring instrument (see Annex C), the maximum output voltage derived from the unmodulated grooves is compared with the output voltage derived from the reference signal corresponding to the plane of measurement, both readings being taken via a network resulting in attenuation curves:

- 1) X in Figure C.1 for signal/rumble ratio – unweighted;
- 2) Y in Figure C.1 for signal/rumble ratio – weighted.

For stereo use, the signal/rumble ratios – unweighted and weighted – are determined for the left and right measuring planes. For mono use, the signal/rumble ratios – unweighted and weighted – are determined for the lateral measuring plane.

For stereo use:

- Signal/rumble ratio – unweighted = smallest of left and right signal/rumble ratios, unweighted.
- Signal/rumble ratio – weighted = smallest of left and right signal/rumble ratios, weighted.

For mono use:

- Signal/rumble ratio – unweighted = lateral signal/rumble ratio, unweighted.
- Signal/rumble ratio – weighted = lateral signal/rumble ratio, weighted.

### 10.2.7 Signal/hum ratio

Specification: if  $U$  is the maximum voltage at a given output derived from stray fields when the reproducing stylus tip is 2,5 mm above the rotating turntable, and at a distance of between 50 mm and 150 mm from its centre of rotation, and  $U_0$  is the voltage derived from the reference signal intended for and measured at the same output,

$$\text{signal/hum ratio} = 20 \log_{10} \frac{U_0}{U} \text{ (dB).}$$

A test record (see Annex C) containing reference signals intended for the left, right and lateral measuring planes is played, and the voltage is measured from the respective outputs:

$$U_{0L}; \quad U_{0R}; \quad U_{0H}$$

The reproducing stylus is then placed 2,5 mm above the surface of the rotating turntable and in a radial position between 50 mm and 150 mm to give maximum voltage for each output:

$$U_L; \quad U_R; \quad U_H$$

Three signal/hum ratios are obtained:

$$\text{Left signal/hum ratio} = 20 \log_{10} \frac{U_{0L}}{U_L}$$

$$\text{Right signal/hum ratio} = 20 \log_{10} \frac{U_{0R}}{U_R}$$

$$\text{Lateral signal/hum ratio} = 20 \log_{10} \frac{U_{0H}}{U_H}$$

Result:

For stereo use: signal/hum ratio = smallest of left and right signal/hum ratios.

For mono use: signal/hum ratio = lateral signal/hum ratio.

#### 10.2.8 Channel sensitivity at 1 000 Hz

Specification: if  $U$  mV is the voltage at a given output derived from playing a reference signal of 1 000 Hz recorded at a velocity of  $v$  cm/s intended for that output,

$$\text{channel sensitivity at 1 000 Hz} = \frac{U}{v} \text{ mV/(cm/s)}$$

where  $U$  and  $v$  are both RMS, or both peak values.

Method: a test record (see Annex D) containing left, right and lateral reference signals (1 000 Hz at  $v$  cm/s) is played, and the voltage  $U$  mV is measured from the respective outputs.

Results:

Let  $U_L$ ,  $U_R$  and  $U_H$  denote left, right and lateral output voltages respectively.

$$\text{For stereo use: channel sensitivity} = \frac{U_L + U_R}{2v} \text{ mV/(cm/s)}.$$

$$\text{For mono use: channel sensitivity} = \frac{U_H}{v} \text{ mV/(cm/s)}.$$

#### 10.2.9 Channel unbalance at 1 000 Hz (stereo use only)

Specification:

- $U_L$  is the left output voltage derived from left 1 000 Hz signal
- $U_R$  is the right output voltage derived from identical right 1 000 Hz signal
- Channel unbalance at 1 000 Hz =  $20 \left| \log_{10} \frac{U_R}{U_L} \right|$  dB



Method:  $U_L$  and  $U_R$  are determined as in 10.2.8.

Result: Channel unbalance at 1 000 Hz =  $20 \left| \log_{10} \frac{U_R}{U_L} \right|$  dB

#### 10.2.10 Separation at 1 000 Hz (stereo use only)

Specification: if  $X_L$  and  $X_R$  are two signals of identical recorded velocity and of frequency 1 000 Hz intended for the left and right outputs, respectively,

separation on left channel =  $20 \log_{10} \left( \frac{X_{L,L}}{X_{L,R}} \right)$

where

$X_{L,L}$  is the left-channel output due to  $X_L$

$X_{L,R}$  is the left-channel output due to  $X_R$

separation on right channel =  $20 \log_{10} \left( \frac{X_{R,R}}{X_{R,L}} \right)$

$X_{R,R}$  is the right-channel output due to  $X_R$

$X_{R,L}$  is the right-channel output due to  $X_L$

The separation at 1 000 Hz is the smaller of these ratios.

NOTE Separation is chosen in preference to crosstalk, because it is independent of channel sensitivity.

Method: the voltages are measured from the left output when activated by  $X_L$ , followed by  $X_R$ . The voltages are measured from the right output when activated by  $X_R$ , followed by  $X_L$ .

Result: the separation at 1 000 Hz is calculated in accordance with the above specification.

#### 10.2.11 Frequency response

##### 10.2.11.1 Frequency response to wanted signals (signal response)

Specification: the relative output levels (in dB) as a function of frequency of any given channel activated by signals intended for that channel, when the relative signal levels are in accordance with the standard recording characteristic.

Method: a standard test record (see Annex D) is played, which carries either fixed or swept frequencies intended for the channel to be measured. The variations of output level (in dB) as a function of frequency are plotted on a graph.

Result: for stereo use, the response of left and right channels to the respective left and right signals is quoted in graph form. For mono use, the response of the mono channel to lateral signals is quoted in graph form.

##### 10.2.11.2 Frequency response to unwanted signals (separation response)

Specification: the relative output levels (in dB) as a function of frequency of any given channel activated by signals intended for the opposite channel, when the relative signal levels are in accordance with the standard recording characteristic.

Method: a standard test record (see Annex D) is played, which carries either fixed or swept frequencies intended for the channel opposite to that which is to be measured. The variations in output level (in dB) as a function of frequency are plotted on a graph.

Result: for stereo use only, the response of left and right channels to the respective right and left signals is quoted in graph form, preferably on the same graph as the signal response.

### 10.2.12 Tracking ability

Specification: the ability to maintain contact between the reproducing stylus and both walls of the groove when playing a specified test record at the recommended stylus force.

Method A: low-frequency tracking ability:

The relevant bands of a specified test record (see Annex E) are played at the recommended stylus force, and the output is monitored via an amplifier by means of a loudspeaker and an oscilloscope. Poor tracking is indicated by a buzz-like audible distortion and a visible discontinuity of waveform on the oscilloscope. The maximum recorded amplitude that can be played without distortion is noted for left and right channels.

Result: low-frequency tracking ability = smallest of left and right recorded amplitudes.

Method B: low to middle frequency sweep tracking ability:

The relevant bands of a specified test record (see Annex E) are played at recommended tracking force, and the output is monitored via an amplifier with rated reproducing characteristic on a loudspeaker, an oscilloscope and a level recorder. Poor tracking is indicated by a buzz-like audible distortion, a clearly visible discontinuity of waveform on the oscilloscope and a clearly visible discontinuity in the frequency characteristic curve from the level recorder. The maximum recorded velocity at 315 Hz giving satisfactory tracking is noted for each channel.

This method also exposes partial resonances of head-shells, cartridge connectors and arm pivots, and is particularly effective for low compliance pickups.

Result: low to middle frequency sweep tracking ability = smallest of left and right recorded velocities at 315 Hz.

Method C: high-frequency tracking ability:

The relevant bands of a specified test record (see Annex E) are played at recommended stylus force, and the output voltage is measured for each band and for each channel, via:

- i) a 250 Hz one-third octave band filter, resulting in output voltage  $U_{250}$  using an RMS meter with time-response S (slow), in accordance with IEC 61672-1;
- ii) a 10 kHz one-third octave band filter resulting in output voltage  $U_{10\ 000}$  using an RMS meter. The distortion factor  $D_H$  is given by:

$$D_H = \left( \frac{U_{250}}{U_{10\ 000}} \times 100 \right) \%$$

is plotted as a function of recorded velocity for each channel.

Result: high frequency tracking ability = smaller of the left and right recorded velocities at which the distortion factor is less than the value stated by the manufacturer.

## 11 Information required from manufacturers of record playing units

### 11.1 General

The information required falls into two distinct categories:

- a) mandatory information, which shall be clearly shown on the unit – this is indicated by an "A" in the right-hand column;
- b) optional information, which may be given separately, as, for example, in an instruction manual relating to and supplied with the product.

It is essential that mandatory information outside the scope of this document (e.g. aspects of safety, see IEC 62368-1) shall also be given in the correct location.

Where applicable, the rated value of the characteristic shall be stated first, followed by the tolerance quoted in the same unit (e.g. 230 V ± 10 V).

### 11.2 Identification

The information in Table 5 shall be provided.

**Table 5 – Identification**

Name of manufacturer and/or trademark	A
Model or type number (variants, if any, to be stated)	A

### 11.3 Structure

#### 11.3.1 Pickup cartridge

The information in Table 6 shall be provided.

**Table 6 – Pickup cartridge data**

Feature	Example	
Type of transducer	ceramic	
Type of reproduction	stereo	A
Reproducing stylus material	diamond	
Shape of reproducing stylus	spherical	
Changeable reproducing stylus	yes	
Changeable pickup cartridge	no	

#### 11.3.2 Drive system

The information in Table 7 shall be provided.

**Table 7 – Drive system data**

Feature	Example	
Type of motor	synchronous	
Speeds of rotation of turntable	33⅓ r/min	A
Speed adjustment	no	

Feature	Example	
Speed indicator	no	
Type of drive system	belt drive	

### 11.3.3 Space requirements for unmounted units

- a) Minimum length of mounting board in mm
- b) Minimum width of mounting board in mm

NOTE These can be provided as a template.

- c) Minimum clearance below top of mounting board in mm
- d) Minimum clearance above top of mounting board in mm

### 11.3.4 Operational modes

The information in Table 8 shall be provided.

**Table 8 – Operational modes**

Feature	Availability
Aid to manual pickup lowering	yes/no
Aid to manual pickup lifting	yes/no
Cueing device for programme location	yes/no
Automatic pickup lowering	yes/no
Automatic pickup lifting	yes/no
Automatic pickup return	yes/no
Automatic motor stop	yes/no
Suitable for playing records of diameter(s)	Example: all
Automatic record change	yes/no
Automatic size selection	yes/no
Maximum stack height of records or maximum number of records of effective thickness 2,3 mm	Example: 8

## 12 Performance claims

### 12.1 General

Performance claims shall relate to the product when operating under the recommended operating conditions for testing. The least favourable figure shall be quoted.

### 12.2 Maximum apparent power consumption of the unit

This shall be stated in VA.

### 12.3 Speed of rotation

- a) For units without speed adjustment:
  - Mean deviation from each rated speed, as  $\pm\%$ ;
  - Weighted wow and flutter at each actual speed, as %;
  - Maximum start time for each actual speed, in s.
- b) For units with speed adjustment:



- Range of adjustment for each rated speed, as  $\pm\%$ ;
- Weighted wow and flutter at each rated speed, as  $\pm\%$ ;
- Maximum start time for each rated speed in s.

#### **12.4 Signal/rumble ratio**

- a) Unweighted, in dB
- b) Weighted, in dB

#### **12.5 Signal/hum ratio**

This shall be expressed in dB.

#### **12.6 Channel sensitivity at 1 000 Hz**

The value shall be stated first, followed by the tolerance quoted in the same units:

- a) for stereo use: arithmetic mean of left and right channels, in mV/(cm/s);
- b) for mono use: lateral channel, in mV/(cm/s).

#### **12.7 Channel unbalance at 1 000 Hz (stereo use only)**

This shall be expressed in dB.

#### **12.8 Separation at 1 000 Hz (stereo use only)**

This shall be expressed in dB.

#### **12.9 Frequency response**

- a) Frequency response to wanted signal (signal response);
- b) frequency response to unwanted signal (separation response).

These shall be expressed graphically.

#### **12.10 Tracking ability**

- a) Low-frequency tracking ability, in mm;
- b) low to middle frequency sweep tracking ability, in cm/s;
- c) high-frequency tracking ability, in cm/s.

## **Annex A** (informative)

### **Multipurpose test records**

#### **A.1 Available multi-purpose test record**

Supplier: Japan Audio Society<sup>2</sup>

AD-1 Audio test record

Disc type: 30 cm LP analogue record (33⅓ r/min turntables)

This is an audio test record that contains typical test signals that are essential for measuring cartridges, tone arms, and turntables.

AD-1 Recording signal contents:

SIDE 1:

- Band 1: frequency slow sweep signal, 20 Hz to 20 kHz, left channel
- Band 2: frequency slow sweep signal, 20 Hz to 20 kHz, right channel
- Band 3: signal band for mechanical impedance measurement
- Band 4: low-frequency sweep signal for low resonance measurement, 4 Hz to 100 Hz, left and right channels
- Band 5: signal for measuring wow and flutter, 3 kHz, for about 100 s

NOTE IEC 60386 specifies a frequency of 3,15 kHz.

SIDE 2:

- Band 1: 1/3 octave band noise, centre frequency 25 Hz to 16 kHz, left channel
- Band 2: 1/3 octave band noise, centre frequency 25 Hz to 16 kHz, right channel
- In the middle part of right channel bands 1 and 2 is a silence groove for inside force measurement
- Band 3: phase check signal, right and left in-phase, reverse phase,  $\pm 45^\circ$ ,  $\pm 90^\circ$ ,  $\pm 135^\circ$
- Band 4: reference level, 1 kHz, 3,54 cm/sec (peak value), left channel
- Band 5: Reference level, 1 kHz, 3,54 cm/sec (peak value), right channel
- Band 6: Silence groove

#### **A.2 Multi-purpose test record no longer available new but which may still be used**

Original supplier: United States National Association of Broadcasters

RL-1677, RL-1678

Disc type: 30 cm LP analogue record (33⅓ r/min turntables)

<sup>2</sup> AD-1 is the trade name of a product supplied by Japan Audio Society. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

This is an audio test record that contains typical test signals that are essential for measuring cartridges, tone arms, and turntables.

Recording signal contents:

a) SIDE A Mono:

- Band 1 Level check 1 kHz tone, 20 s. 7 cm/s peak velocity.
- Band 2 Wow and flutter 3 kHz tone, 2 min, 7 cm/s peak
- Band 3 Frequency response 23 tones from 15 kHz to 30 Hz. 14 dB below 7 cm/s Recording characteristic NAB Standard
- Band 4 Rumble reference level 100 Hz tone, 20 s 1,4 cm/s

b) SIDE B Stereo

- Band 1 Phase and balance Lateral 1 kHz tone 7 cm/s peak, right-channel 1 kHz tone, 5 cm/s peak, left-channel 1 kHz tone, 5 cm/s peak, vertical 1 kHz tone, 7 cm/s peak.
- Band 2 Spot frequency test Lateral tones 100 Hz, 1 kHz, 10 kHz, 1 kHz, 3 s each, repeated for 60 s.
- Band 3 Separation test Right- and left-channel tones, 10 kHz, 7 kHz, 3 kHz, 1 kHz, 100 Hz and 50 Hz.
- Band 4 Level check 1 kHz tone, 3,25 min, 7 cm/s peak.



## Annex B (normative)

### Test records for wow and flutter

The dimensions shall comply with those for Type 3033 or Type 1745 records (see Clause 5).

The record shall have a closed groove concentric with the recorded groove spiral for the purpose of centring the recorded spiral with respect to the axis of rotation during reproduction.

The frequency of the recorded signal during reproduction shall be 3 150 Hz. The weighted wow and flutter of the recording, measured in accordance with IEC 60386, shall be less than 0,06 %. Vertical movement of the recorded area shall be less than 0,3 mm.

Test records are listed in Table B.1.

**Table B.1 – Examples of test records that may be used**

Catalogue number	Country of origin	Name of manufacturer	Speed of rotation (r/min)	Recorded velocity RMS. (cm/s)	Modulation mode
DIN 45545	Germany	D.G.G.	33⅓	Not specified	Lateral
JIS 41	Japan	Teichiku Co.	33⅓ and 45	5,6	Lateral
LB 13	German Democratic Republic	VEB Deutsche Schallplatten	33⅓ and 45 16⅔ and 78	3,54	Lateral
GB 3320.3-82	China	China Record Company	33⅓	3,4	Lateral
These records are no longer available to purchase.					

## Annex C (normative)

### Measurement of signal/rumble ratio

#### C.1 Measuring instrument

The characteristics of the measuring instrument employed shall be in accordance with the sound level meter described in IEC 61672-1, employing the long time constant S (slow).

#### C.2 Test record

The dimensions shall comply with those for type 3033 records. The recording shall be as described in Table C.1.

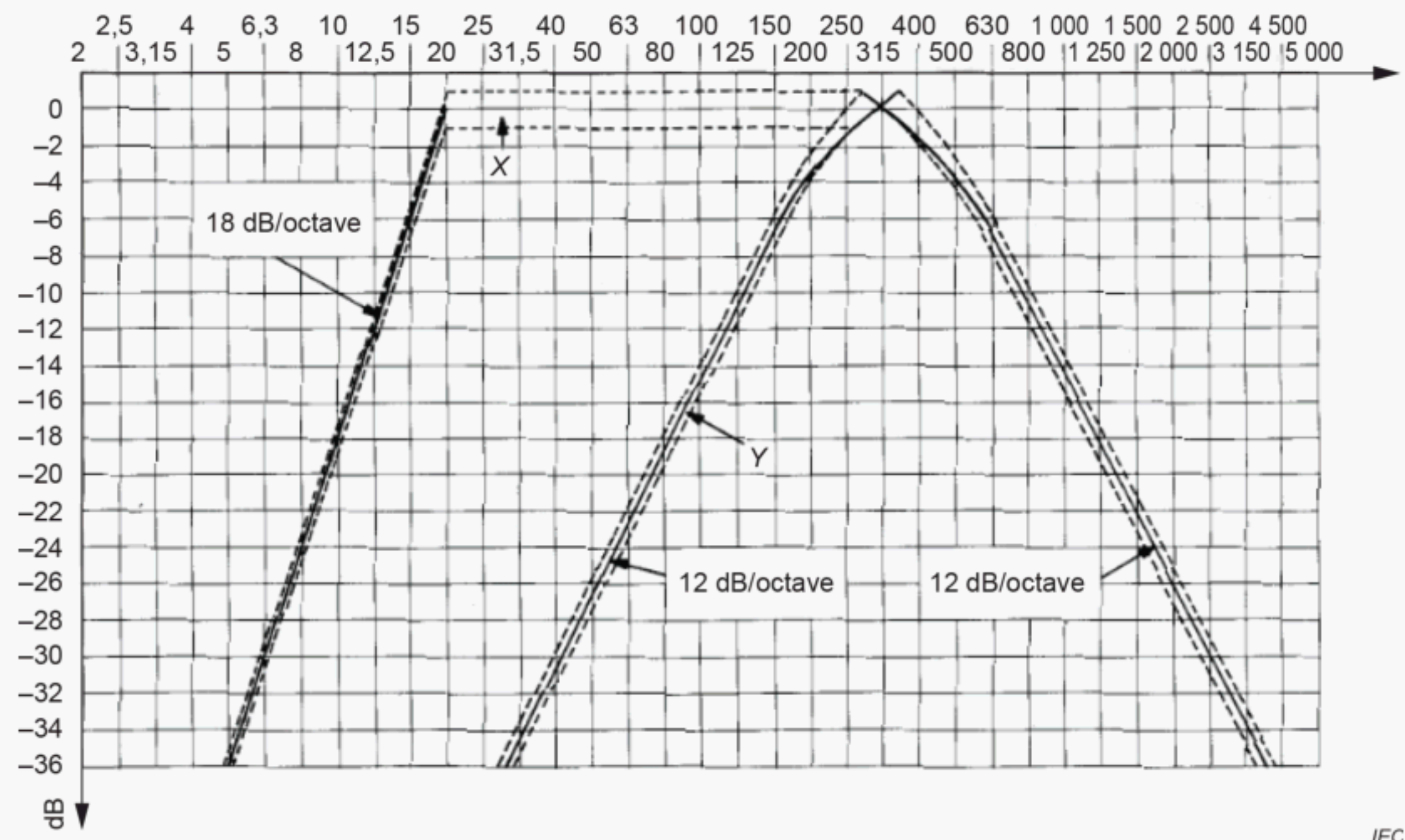
**Table C.1 – Test records for measuring signal/rumble ratio**

Modulation mode	Frequency Hz	Recorded velocity		Duration s
		RMS cm/s	Peak cm/s	
Left	315	3,9	5,51	15
Right	315	3,9	5,51	15
Lateral	315	3,9	5,51	15
Vertical	315	3,9	5,51	15
Unmodulated	None	None	None	15

NOTE The reference frequency of 315 Hz was chosen in order to coincide with the maximum of the weighting filter curve (signal/rumble ratio – weighted) and to lie on the straight-line portion of the low-pass filter curve (signal/rumble ratio – unweighted). Assuming a reference RMS recorded velocity of 7,07 cm/s at 1 000 Hz (10 cm/s peak) on stereo (left or right), the recording characteristic gives an equivalent RMS recorded velocity of 3,90 cm/s (5,51 cm/s peak) at 315 Hz. In a similar manner, reference frequencies other than 315 Hz can be chosen.

#### C.3 Attenuation curve

The attenuation curve shall be as shown in Figure C.1.



IEC

**Figure C.1 – Attenuation curve for rumble meter**



## Annex D (informative)

### Examples of test records for the measurement of channel sensitivity, channel unbalance, separation, signal response, and separation response

It is assumed that test records (see Table D.1) are recorded in accordance with the standard recording characteristic. If this is not the case, it is essential to apply the necessary correction.

**Table D.1 – Examples of test records that may be used**

Catalogue number	Country of origin	Name of manufacturer	Description of signal	Modulation modes	Speed of rotation rev/min	National standard number
QR2009	Denmark	Brüel & Kjær	20 Hz to 20 kHz sweep frequencies	L, R, H, V	45	None
LB207	German Democratic Republic	VEB Deutsche Schallplatten	1 kHz reference level	L, R, H	33 $\frac{1}{3}$	None
LB210	German Democratic Republic	VEB Deutsche Schallplatten	20 Hz to 20 kHz sweep frequencies 20 Hz to 20 kHz spot frequencies	L, R	33 $\frac{1}{3}$	None
LB211	German Democratic Republic	VEB Deutsche Schallplatten	20 Hz to 20 kHz sweep frequencies 16 kHz to 20 Hz spot frequencies	L, R	33 $\frac{1}{3}$	None
DIN 45543	Germany	DGG	20 Hz to 20 kHz sweep frequencies 20 Hz to 20 kHz spot frequencies	L, R, H	33 $\frac{1}{3}$	DIN 45543
JIS 11	Japan	Nippon Columbia	1 kHz reference level	L, R, H, V	33 $\frac{1}{3}$	JIS S8602
JIS 21	Japan	Victor Company of Japan	20 Hz to 20 kHz spot frequencies	L, R	33 $\frac{1}{3}$	JIS S8602
JIS 22	Japan	Victor Company of Japan	20 Hz to 20 kHz sweep frequencies	L, R	33 $\frac{1}{3}$	JIS S8602
TCS 101	United Kingdom	EMI	20 kHz to 30 Hz spot frequencies	L, R	33 $\frac{1}{3}$	BS 1928
TCS 104	United Kingdom	EMI	20 kHz to 30 Hz spot and sweep frequencies	H	33 $\frac{1}{3}$	BS 1928



## Annex E (informative)

### Tracking ability

#### E.1 Test records for tracking ability

The methods of using these records are given in 10.2.12. The dimensions and recording characteristics are as specified in this document.

#### E.2 Examples of test records no longer available new but which may still be used

These records are listed in Table E.1, Table E.2 and Table E.3.

NOTE The previous edition gave much more detail for these records than for those in Annexes A and C. Since the records are no longer available, that level of detail, which complicates the tabulation, seems unjustified.

**Table E.1 – Low-frequency tracking ability – Method A in 10.2.12**

Catalogue number	Country of origin	Name of manufacturer	Description of signal and modulation	Speed of rotation r/min	National standard number
DIN 45549	Germany	DGG	315 Hz/H	33 $\frac{1}{3}$	DIN 45549
JIS 33	Japan	Victor Company of Japan	315 Hz/H	33 $\frac{1}{3}$	JIS S8602
LB 238	German Democratic Republic	VEB Deutsche Schallplatten	315 Hz/H	33 $\frac{1}{3}$	None

**Table E.2 – Low to middle frequency sweep tracking ability**

Catalogue number	Country of origin	Name of manufacturer	Description of signal and modulation	Speed of rotation r/min	National standard number
JIS 32	Japan	Toshiba-EMI	1 kHz to 20 Hz sweeps/H	33 $\frac{1}{3}$	JIS S8602
Side A has a groove width of 50 µm and is intended for high-compliance pickups.					
Side B has a groove width of 100 µm and is intended for low-compliance pickups.					

**Table E.3 – High-frequency tracking ability**

Catalogue number	Country of origin	Name of manufacturer	Description of signal and modulation	Speed of rotation rev/min	National standard number
DIN 45549	Germany	DGG	10 kHz to 250 Hz LRLRLRLRLR	33 $\frac{1}{3}$	DIN 45549
JIS 31	Japan	Nippon Columbia	10 kHz to 250 Hz LRLRLRLRLR	33 $\frac{1}{3}$	JIS S8602
LB 237	German Democratic Republic	VEB Deutsche Schallplatten	10 kHz bursts 8 cycles on, 32 cycles off LRLRLRLRLR	33 $\frac{1}{3}$	None