# INTERNATIONAL STANDARD

# ISO 2954

Second edition
2012-04-01

# Mechanical vibration of rotating and reciprocating machinery — Requirements for instruments for measuring vibration severity

*Vibrations mécaniques des machines tournantes ou alternatives — Exigences relatives aux appareils de mesure de l'intensité vibratoire*

Reference number
ISO 2954:2012(E)

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## Contents

# Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

ISO 2954 was prepared by Technical Committee ISO/TC 108, *Mechanical vibration, shock and condition monitoring*, Subcommittee SC 3, *Use and calibration of vibration and shock measuring instruments*.

This second edition cancels and replaces the first edition (ISO 2954:1975), which has been technically revised.

The main changes are:

— Filters defined as standardized third-order Butterworth filters.

— The standard now covers other frequency ranges than 10 Hz to 1 000 Hz.

# Mechanical vibration of rotating and reciprocating machinery — Requirements for instruments for measuring vibration severity

## 1 Scope

This International Standard specifies requirements which it is necessary for a measuring instrument for vibration severity of machines to meet if inaccuracies of measurement made on the casing of machines, particularly when making repeated measurements for trend monitoring of a certain machine, are not to exceed a specific value.

The instruments covered by this International Standard give direct indication or recording of root-mean-square (r.m.s.) vibration velocity that is defined as a measurement unit.

NOTE 1 A method of checking true r.m.s. indication is described in Annex A. This method is mainly retained for instruments not based on modern analogue to digital conversion and numerical calculation of r.m.s., but can also be applied to instruments which are so based.

NOTE 2 Subject to adaptation of the measurement frequency range, these instruments can be used for other applications where similar accuracy of measurement is required, measurement of vibration velocity of structures, tunnels, bridges, etc. Optionally phase measurements may be included.

## 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2041, *Mechanical vibration, shock and condition monitoring — Vocabulary*

ISO 10816-1:1995, *Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 1: General guidelines*

ISO 10816-6:1995, *Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 6: Reciprocating machines with power ratings above 100 kW*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2041 apply.

## 4 Measurement quantities

The measurement quantities given in Table 1 are used to describe mechanical vibration of non-rotating parts.

Integration and differentiation among the measurement quantities is allowed both for broad band and discrete frequency component signals (see ISO 10816-1:1995, Annex A).

The maximum measured vibration magnitude is called vibration severity. It can be given a severity grade (see e.g. ISO 10816-6:1995, Table 1).

NOTE Formerly, vibration severity was normally only meant to be the maximum broad-band r.m.s. vibration velocity from 10 Hz to 1 000 Hz. This International Standard specifies the requirements for such a limited instrument, but also permits use of other frequency ranges.

The instrument should preferably be capable of measuring the measurement quantities given in Table 1, but shall at least measure r.m.s. vibration velocity over the frequency range defined in 5.3.

If values at discrete frequencies are filtered from broad-band measurements, the band-pass filter shall have a suitable bandwidth. Phase relative to a shaft trigger reference or similar source may also be measured to give the vibration vector with its magnitude as amplitude or as r.m.s. value.

The actual measurement quantity shall be displayed and/or output as an analogue voltage signal or as digital data. The instrument manufacturer shall give details of the interface(s), which should comply with common standards.

**Table 1 — Measurement quantities for non-rotating parts**

| Measurement quantity | Unit[a] | Broad-band value[b] | At discrete frequencies[c] | |
|---|---|---|---|---|
| Displacement[d] | µm | r.m.s. | — | peak to peak amplitude |
| Vibration velocity[e] | mm/s | r.m.s. | peak amplitude | — |
| Acceleration[f] | $m/s^2$ | r.m.s.[g] | peak amplitude | — |

[a] Other units like inches, in/s and $g_n$ are commonly used in some parts of the world and can be accepted, but the SI system should preferably be used.

[b] Over a defined frequency range (see 5.3).

[c] Directly measured or filtered from broad-band measurements with a band-pass filter. Phase may also be measured to give the vibration vector if a second channel and a reference signal are available.

[d] Especially for low-speed range.

[e] As a general measurement quantity.

[f] Especially for high-speed range and for rolling element bearings. See ISO 10816-1:1995, Figure 6 or ISO 10816-6:1995, Annex C.

[g] For measurements on rolling element bearings, maximum magnitude is also common.

## 5 General requirements

**5.1** A vibration measuring instrument usually consists of: a vibration transducer; an indicating unit; and a power supply system.

**5.2** The requirements specified in this clause apply to the general characteristics of the complete assembly of the transducer and the indicating unit. Clauses 6 and 7 contain the detailed requirements for each of these main units.

**5.3** The measurement frequency range of the vibration severity measuring instrument shall be from 10 Hz to 1 000 Hz but can include other ranges. (In some parts of ISO 10816[2] a lower cut-off frequency of 2 Hz or even less is used. The requirements to the frequency response can be found from the formulas in 5.4).

**5.4** The sensitivity within the measurement frequency range shall not deviate from the reference sensitivity at the reference frequency by more than the quantities given in Table 2 and shown graphically in Figures 1 and 2 for a reference frequency of 79,4 Hz.

NOTE The reference frequency may also be 1 000 rad/s, i.e. approximately 160 Hz.

The band-limiting element is a combination of high- and low-pass third-order Butterworth filter characteristics. These components are defined as follows:

a) high pass

$$H_h(s) = 1 \Big/ \left[ 1 + \frac{\omega_1}{Q_1 s} + \left( \frac{\omega_1}{Q_2 s} \right)^2 + \left( \frac{\omega_1}{s} \right)^3 \right] \tag{1}$$

b) low pass

$$H_l(s) = 1 \Big/ \left[1 + \frac{s}{Q_3\omega_2} + \left(\frac{s}{Q_4\omega_2}\right)^2 + \left(\frac{s}{\omega_2}\right)^3\right] \qquad (2)$$

The product $H_h(s)\ H_l(s)$ represents the band-limiting transfer function.

**Table 2 — Sensitivity relative to the reference sensitivity and limiting values of the permissible deviation within the frequency interval from 1 Hz to 10 000 Hz for an instrument with a nominal frequency range from 10 Hz to 1 000 Hz**

| Frequency Hz | Nominal sensitivity dB | Upper tolerance bands dB | Lower tolerance bands dB | Tolerance dB | Nominal values | Upper tolerance bands | Lower tolerance bands |
|---|---|---|---|---|---|---|---|
| 1 | −60,0 | −40,0 | −80,0 | ±20 | 0,001 | 0,010 0 | 0,000 1 |
| 1,26 | −54,0 | −38,0 | −70,0 | ±16 | 0,002 0 | 0,012 6 | 0,000 3 |
| 1,58 | −48,0 | −36,0 | −60,0 | ±12 | 0,004 0 | 0,015 8 | 0,001 0 |
| 2,00 | −42,0 | −34,0 | −50,0 | ±8 | 0,007 9 | 0,020 0 | 0,003 2 |
| 2,51 | −36,0 | −32,0 | −40,0 | ±4 | 0,015 8 | 0,025 1 | 0,010 0 |
| 3,16 | −30,0 | −26,0 | −34,0 | ±4 | 0,031 6 | 0,050 1 | 0,019 9 |
| 3,98 | −24,0 | −20,0 | −28,0 | ±4 | 0,063 | 0,100 | 0,040 |
| 5,01 | −18,1 | −16,1 | −20,1 | ±2 | 0,125 | 0,157 | 0,099 |
| 6,31 | −12,3 | −10,3 | −14,3 | ±2 | 0,244 | 0,307 | 0,194 |
| 7,94 | −7,0 | −5,0 | −9,0 | ±2 | 0,448 | 0,564 | 0,356 |
| 10 | −3,01 | −1,01 | -5,01 | ±2 | 0,707 | 0,890 | 0,562 |
| 12,6 | -0,97 | -0,14 | -1,89 | +0,83<br>−0,92 | 0,894 | 0,984 | 0,804 |
| 15,8 | −0,27 | 0,56 | −1,19 | +0,83<br>−0,92 | 0,970 | 1,067 | 0,872 |
| 20,0 | −0,07 | 0,76 | −0,99 | +0,83<br>−0,92 | 0,992 | 1,092 | 0,892 |
| 25,1 | −0,02 | 0,81 | −0,94 | +0,83<br>−0,92 | 0,998 | 1,098 | 0,898 |
| 31,6 | 0,00 | 0,83 | −0,92 | +0,83<br>−0,92 | 1,000 | 1,100 | 0,900 |
| 39,8 | 0,00 | 0,83 | −0,92 | +0,83<br>−0,92 | 1,000 | 1,100 | 0,900 |
| 50,1 | 0,00 | 0,83 | −0,92 | +0,83<br>−0,92 | 1,000 | 1,100 | 0,900 |
| 63,1 | 0,00 | 0,83 | −0,92 | +0,83<br>−0,92 | 1,000 | 1,100 | 0,900 |
| 79,4 | 0,00 | 0,00 | 0,00 | +0,83<br>−0,92 | 1,000 | 1,000 | 1,000 |
| 100 | 0,00 | 0,83 | −0,92 | +0,83<br>−0,92 | 1,000 | 1,100 | 0,900 |

NOTE 1 The frequencies used are the theoretical base-10 one-third octave frequencies as defined in IEC 61260.[8] The nominal frequencies found in ISO 266[1] can also be used because the differences are very small.

NOTE 2 The limits in the pass-band are maintained from ISO 2954:1975 to be 10 % limits, here expressed in decibels. The tolerances at the corner frequencies have been made to follow the theoretical curve for the filter rather than trying to maintain the precise tolerances in ISO 2954:1975.

**Table 2** *(continued)*

| Frequency Hz | Nominal sensitivity dB | Upper tolerance bands dB | Lower tolerance bands dB | Tolerance dB | Nominal values | Upper tolerance bands | Lower tolerance bands |
|---|---|---|---|---|---|---|---|
| 126 | 0,00 | 0,83 | −0,92 | +0,83<br>−0,92 | 1,000 | 1,100 | 0,900 |
| 158 | 0,00 | 0,83 | −0,92 | +0,83<br>−0,92 | 1,000 | 1,100 | 0,900 |
| 200 | 0,00 | 0,83 | −0,92 | +0,83<br>−0,92 | 1,000 | 1,100 | 0,900 |
| 251 | 0,00 | 0,83 | −0,92 | +0,83<br>−0,92 | 1,000 | 1,100 | 0,900 |
| 316 | 0,00 | 0,83 | −0,92 | +0,83<br>−0,92 | 1,000 | 1,100 | 0,900 |
| 398 | −0,02 | 0,81 | −0,94 | +0,83<br>−0,92 | 0,998 | 1,098 | 0,898 |
| 501 | −0,07 | 0,76 | −0,99 | +0,83<br>−0,92 | 0,992 | 1,092 | 0,892 |
| 631 | −0,27 | 0,56 | −1,19 | +0,83<br>−0,92 | 0,970 | 1,067 | 0,872 |
| 794 | −0,97 | −0,14 | −1,89 | +0,83<br>−0,92 | 0,894 | 0,984 | 0,804 |
| 1 000 | −3,01 | −1,01 | −5,01 | ±2 | 0,707 | 0,890 | 0,562 |
| 1 259 | −7,0 | −5,0 | −9,0 | ±2 | 0,448 | 0,564 | 0,356 |
| 1 585 | −12,3 | −10,3 | −14,3 | ±2 | 0,244 | 0,307 | 0,194 |
| 1 995 | −18,1 | −16,1 | −20,1 | ±2 | 0,125 | 0,157 | 0,099 |
| 2 512 | −24,0 | −20,0 | −28,0 | ±4 | 0,063 | 0,100 | 0,040 |
| 3 162 | −30,0 | −26,0 | −34,0 | ±4 | 0,031 6 | 0,050 1 | 0,019 9 |
| 3 981 | −36,0 | −32,0 | −40,0 | ±4 | 0,015 8 | 0,025 1 | 0,010 0 |
| 5 012 | −42,0 | −34,0 | −50,0 | ± 8 | 0,007 9 | 0,020 0 | 0,003 2 |
| 6 310 | −48,0 | −36,0 | −60,0 | ± 12 | 0,004 0 | 0,015 8 | 0,001 0 |
| 7 943 | −54,0 | −38,0 | −70,0 | ± 16 | 0,002 0 | 0,012 6 | 0,000 3 |
| 10 000 | −60,0 | −40,0 | −80,0 | ± 20 | 0,001 | 0,010 0 | 0,000 1 |

NOTE 1 The frequencies used are the theoretical base-10 one-third octave frequencies as defined in IEC 61260.[8] The nominal frequencies found in ISO 266[1] can also be used because the differences are very small.

NOTE 2 The limits in the pass-band are maintained from ISO 2954:1975 to be 10 % limits, here expressed in decibels. The tolerances at the corner frequencies have been made to follow the theoretical curve for the filter rather than trying to maintain the precise tolerances in ISO 2954:1975.

The most common interpretation of these equations is in the frequency domain, where they describe the modulus (magnitude) and phase of the band limitation as functions of the imaginary angular frequency:

$$s = \mathrm{j}2\pi f = \mathrm{j}\omega \qquad (3)$$

where

$\omega$ is the angular frequency, in radians per second;

$f$ is the frequency, in hertz.

NOTE 1 Sometimes the symbol $p$ is used instead of $s$.

NOTE 2 It is possible to interpret $s$ as the variable of the Laplace transform.

The magnitudes of the filter responses are then given by:

— high pass

$$\left|H_{\mathrm{h}}(\mathrm{j}\omega)\right| = \frac{1}{\sqrt{1+(\omega_1/\omega)^6}} \tag{4}$$

— low pass

$$\left|H_{\mathrm{l}}(\mathrm{j}\omega)\right| = \frac{1}{\sqrt{1+(\omega/\omega_2)^6}} \tag{5}$$

— band pass

$$\left|H(\mathrm{j}\omega)\right| = \frac{1}{\sqrt{1+(\omega_1/\omega)^6}}\frac{1}{\sqrt{1+(\omega/\omega_2)^6}} \tag{6}$$

See the penultimate paragraph and 5.3, where $f_1$ may be any suitable lower cut-off frequency and $f_2$ may be any suitable upper cut-off frequency.

The parameters for the measurement frequency range 10 Hz to 1 000 Hz are:

$f_1$ = 10 Hz $Q_1 = Q_3$ = 1/2

$f_2$ = 1 000 Hz $Q_2 = Q_4 = 1/\sqrt{2}$

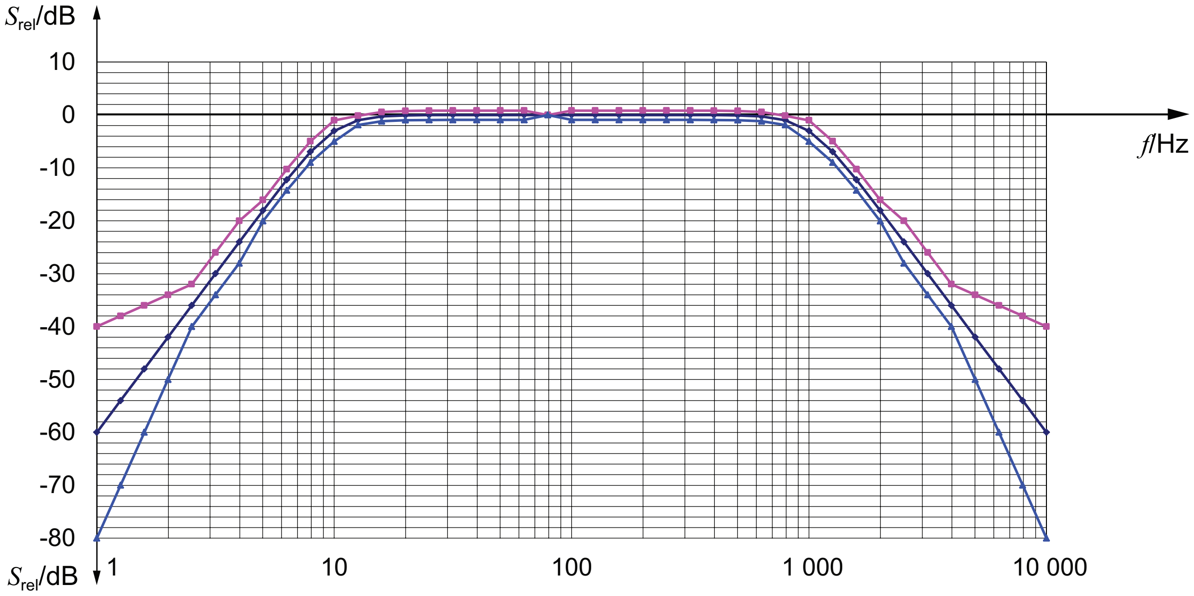
To minimize measurement errors caused by the interference due to vibrations with frequencies outside the measurement frequency range, the sensitivity shall decrease rapidly in a clearly defined manner at the limits of the measurement frequency range. Both the required nominal values of the sensitivity and the permissible minimum and maximum values are given in Table 2.

To preclude doubts about the course of the sensitivity between the cut-off frequencies shown in Table 2, Figures 1 and 2 illustrate the course of the nominal value of the relative sensitivity and the limit of the permissible deviation within the whole frequency range from 1 Hz to 10 000 Hz.

If the total is found, e.g. by using narrow band filtering, all contributions within the frequency range 1 Hz to 10 000 Hz shall be summed.

In some cases, it may be necessary to limit or expand further the measurement frequency range at its upper or lower boundaries to avoid interfering vibrations that are irrelevant to the assessment of the vibration characteristics of a machine or to include important frequencies. For this purpose, the instrument may be equipped with additional or modified high-pass or low-pass filters. It is recommended that the cut-off frequencies, $f_1$ and $f_2$, of these filters be selected in accordance with IEC 61260[8] one-third octave specifications in the range 1 Hz to 10 000 Hz and the edge steepness kept as the filters specified in this International Standard.

Vibration severity can be measured in accordance with the various parts of ISO 10816[2] by changing filter parameters. To avoid errors, it is necessary to state the 3 dB cut-off frequencies for the measurement frequency range as well as the measured value, e.g. $v_{\mathrm{rms}}$ (2 Hz to 1 000 Hz) = 7,5 mm/s.

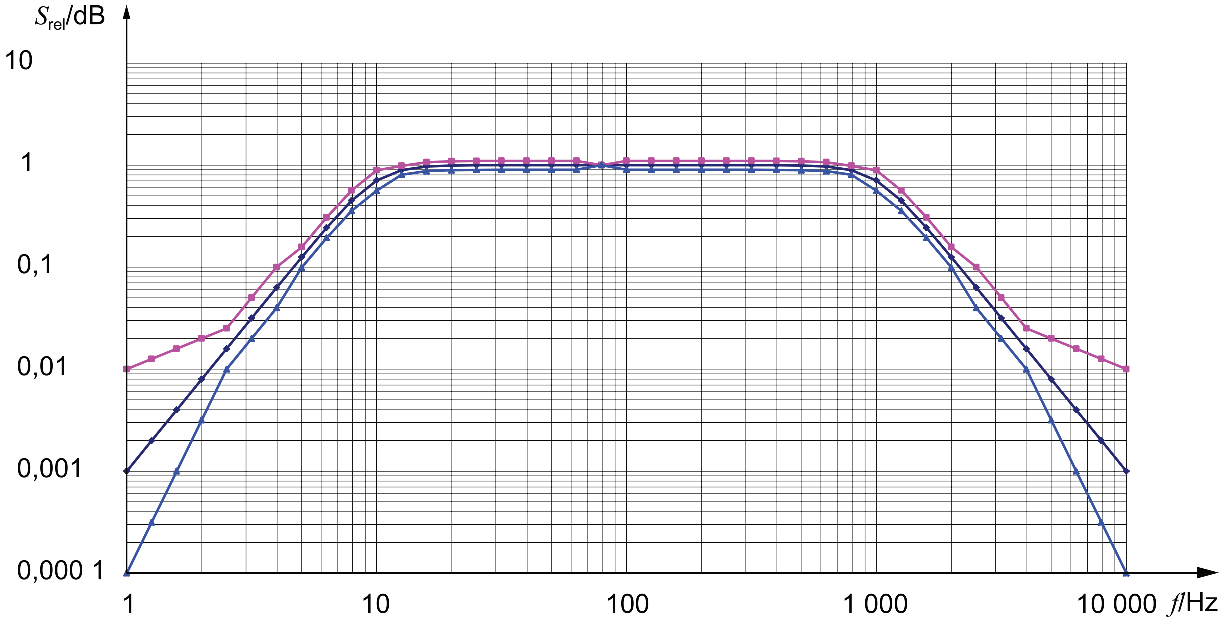


**Key**

$S_{rel}$ relative sensitivity

*f* frequency

Figure 1 — Nominal values in decibels of relative sensitivity and limits of permissible deviations



**Key**

$S_{rel}$ relative sensitivity

*f* frequency

Figure 2 — Nominal absolute values of relative sensitivity and limits of permissible deviations

**5.5** The selection (if available) of the measurement range shall be such that the indication of the lowest level of the vibration severity to be measured shall be equal to at least 10 % of the full-scale value. The minimum and maximum levels of the vibration severity range shall be stated, e.g. “Measuring instrument for vibration severity with measurement range 0,28 mm/s to 28 mm/s”.

**5.6** The uncertainty of the vibration severity measuring instrument is composed of the permissible deviations for the frequency response in accordance with 5.4 and the uncertainty of the absolute value of the sensitivity at the reference frequency (i.e. calibration uncertainty). The measurement uncertainty may be up to a maximum of ±10 % of the indicated value, including the calibration uncertainty, at 10 % to 100 % of full-scale value.

These limits of uncertainty apply over the whole operating temperature range authorized for the vibration transducer and indicating unit (see 6.4), for all types of attachments of the vibration transducer (see Clause 6), for all lengths of connecting cable between the vibration transducer and the indicating unit provided by the manufacturer and a ±10 % fluctuation in the supply voltage. The limits shall include the uncertainty in the calibration.

Only one of the above influence parameters shall be checked at a time.

**5.7** For calibration, the transducer shall be excited by a sinusoidal vibration with a vibration direction which deviates by not more than ±5° from that of the sensitive axis of the transducer. The total harmonic distortion of the exciting vibration velocity shall not exceed 5 %. The velocity of the exciting vibration shall be known with an expanded uncertainty ($2\sigma$ value) better than 3 % within the whole measurement frequency range.

It is recommended that the reference value of the sensitivity be adjusted at the reference frequency and suitable levels of vibration depending on the available ranges and at a room temperature of 23 °C ± 3 °C. It is also recommended that other reference values be checked.

## 6 Requirements for the vibration transducer and connecting cable

**6.1** The transducer shall be of the seismic type, i.e. it shall measure the vibrations of interest by comparison with a static reference system determined by the mode of operation of the transducer. Its output shall not depend on its orientation with respect to gravity. However, if transducers are used whose output signal can be dependent on their orientation with respect to gravity, any influence of gravity on the transducer output signal shall be accounted for. This applies especially to electrodynamic velocity transducers.

**6.2** If a vibration transducer designed for attachment to the object of measurement is used, this shall be affixed by a rigid mechanical connection, e.g. cementing, clamping or screwing on or by means of a magnet foot. For accelerometers, the resulting mounted resonance of the transducer shall be well above the upper frequency of interest. For velocity pick-ups, no structural resonances should occur below the upper frequency of interest. If in doubt, the mounting technique should be tested on a calibration system.

**CAUTION — When applying a hand-held probe tip, the actual vibration may not be transmitted to the transducer.**

NOTE Additional information about mounting can be found in ISO 5348.[2]

**6.3** For all types of attachment, the transverse sensitivity ratio shall be less than 0,1 over the whole measurement frequency range.

The maximum level of vibration velocity for linear response of transducers shall be at least three times the vibration velocity at full-scale deflection in the sensitive direction.

**6.4** The effective mass of the vibration transducer shall be given in the manual. Normal good practice of keeping the mass below 1/10 of the vibrating mass of the measurement object in the near vicinity of the mounting location should be followed. To suit a wide range of applications, the effective mass of the transducer should be kept to the minimum possible.

An indication of whether the mass of the transducer is too great for a particular measurement can be obtained by the following method.

Double the co-vibrating mass of the transducer by an additional mass; if the new indication shows a deviation from the original reading of more than 12 %, the mass of the vibration transducer is too great as compared to the object of measurement and the result should be rejected.

**6.5** The transducer shall withstand, without changing its characteristics, vibration in all directions of at least three times its specified maximum vibration input.

**6.6** The equivalent input quantity of the self-interference by hum and noise and the equivalent input quantity of the extraneous interference for interference fields and excitations with a magnitude as stated below shall not affect the measurement by more than 5 % of the indicated value at 30 % to 100 % of full scale. When the indicated value depends on the orientation of the instrument in the field, the most unfavourable value shall be used.

The manufacturer shall state the results of tests made under the following disturbing conditions (the minimum requirements shall include expanded uncertainty):

- the transducer shall be subjected to a homogeneous magnetic field of more than 100 A/m at 50 Hz and 60 Hz and the field intensity shall be measured before inserting the transducer;
- if the transducer has an electric conducting connection to the object of measurement and the indicator is line operated and has earth terminals, an earth current of more than 100 mA r.m.s. at 50 Hz and 60 Hz shall be fed into the earth connection of the transducer and discharge at the earth terminal of the indicator set;
- the transducer shall be subjected to a homogeneous airborne noise field with an r.m.s. sound pressure level re 20 µPa of more than 100 dB in each octave, produced by a random noise generator or a variable tone generator over the range 32 Hz to 4 kHz.

It is furthermore recommended that ISO 8042[3] be followed for a full description of the vibration transducer.

It is also recommended to check whether the transducer and indicator follow the local EMC and safety requirements often equivalent, to IEC 61000-6-2,[6] and IEC 61010-1.[7]

**6.7** The operating temperature range of the vibration transducer and connecting cable within which the error of measurement does not exceed the limiting values specified in 5.6 shall be stated.

**6.8** The permissible temperature range to which the transducer and connecting cable can be subjected without damage shall be stated.

**6.9** The maximum non-operational vibration and shock limits in any axis of the transducer to which it can be subjected without damage shall be stated.

**6.10** The maximum humidity to which the transducer and connecting cable (as well as supplementary cables which are included) can be exposed and continue to operate within specification shall be stated.

If the transducer is to be used in any other severe environment, e.g. a corrosive atmosphere, the ability of the transducer to withstand this environment shall be indicated. If the transducer is to be used in an explosive atmosphere, its intrinsic safety class shall be stated (if not, it shall not be used under such conditions).

**6.11** The base strain sensitivity of the transducer shall be given.

**6.12** If available, information on the predicted mean time between failures, life expectancy and the recommended time between recalibrations of the transducer should be given.

**6.13** If there is a connecting cable between the vibration transducer and the indicating unit, its length shall be at least 1 m. The manufacturer shall state which additional extension cables can be used without exceeding the tolerances in 5.6. Consideration should be given to the requirements for the input/output impedances of the transducer cable and the measuring instrument.

## 7 Requirements for the indicating unit

**7.1** The indicating unit may be a pointer-type instrument, a graph recorder, a bar chart or a digital display.

**7.2** The $2\sigma$ expanded uncertainty in calibration of the instrument shall not exceed ±2 % of the full-scale value.

**7.3** The indicator on the indicating unit should be easily readable down to 1/10 of the full-scale value. To identify the quantity measured and the unit, for example, “$v_{\mathrm{rms}}$ in mm/s” shall be marked on the unit or shown on the display.

**7.4** For pointer-type instruments only — when a sinusoidal signal with a frequency anywhere within the measurement frequency range and an amplitude permitting a steady-state nominal value of 70 % of the full-scale value is applied to the input of the indicator set as an equivalent voltage and starting at a zero-crossing, the initial overshoot shall not be more than 10 % of the final reading. There shall be no undershoot at the time when the difference of the peak values of the pointer oscillations, as compared to the final position of the pointer, is a maximum of 1,5 % of the full-scale value.

**7.5** For the purpose of checking the amplification, there may be a device that permits a setting of the total amplification of the indicating unit at a specific frequency (e.g. 50 Hz) with a $2\sigma$ expanded uncertainty of less than ±2 %.

**7.6** The operating temperature range and non-operating temperature range of the indicating unit shall be stated.

**7.7** The maximum humidity to which the indicating unit can be exposed and continue to operate within specification shall be stated.

**7.8** If the indicating unit is to be used in any other severe environment such as a corrosive atmosphere, the ability of the indicator set to withstand this environment shall be stated.

**7.9** If the indicating unit is to be used in an explosive atmosphere, its intrinsic safety class shall be stated (if not, it shall not be used under such conditions).

## 8 Power requirements

The input power requirements for the transducer and indicating unit set shall be specified.

## 9 Instruction manual

For all vibration severity measuring instruments, an instruction manual citing this International Standard, i.e. ISO 2954:2012, shall be provided as hard- or softcopy.

The instruction manual shall indicate which measurement quantity/quantities the instrument is capable of measuring and the corresponding frequency range. As soon as the features implemented comply with all the measurement requirements of an International Standard, the manufacturer is allowed to designate its instrument as suitable for vibration severity measurement according to this International Standard that is to be quoted by number and date of publication.

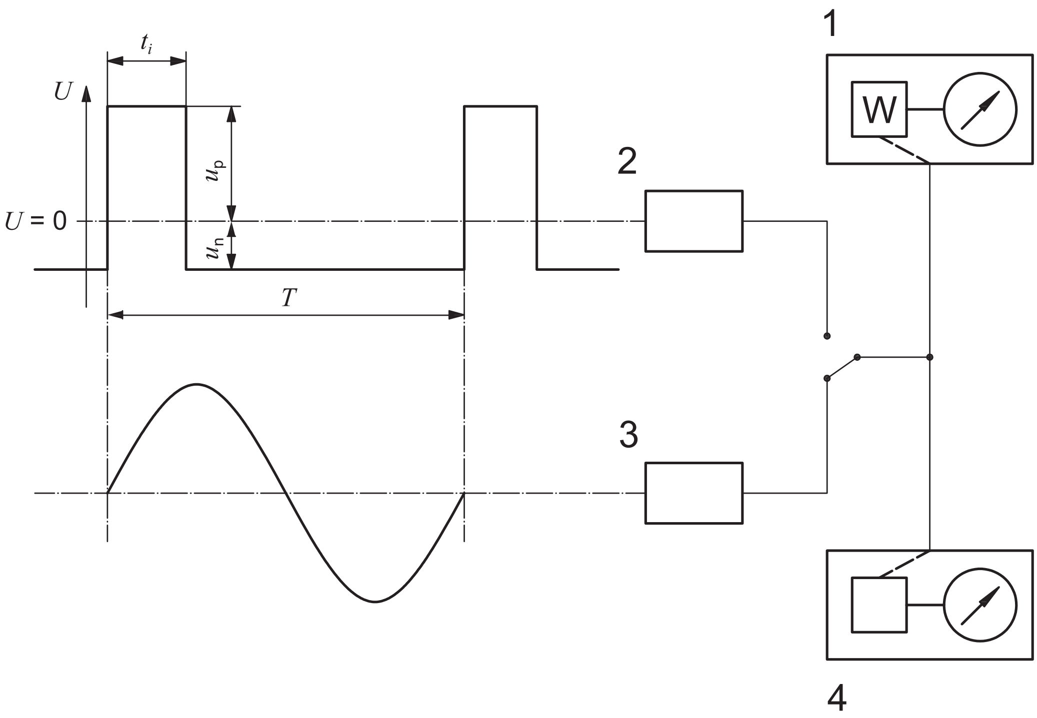
NOTE ISO 10816 (all parts)[2] gives requirements for measuring vibration severity on non-rotating parts of machines.

The instruction manual shall indicate the reference frequency for calibration and test purposes.

# Annex A
(informative)

# Method for testing r.m.s.-voltage indicators

## A.1 Test circuit



**Key**

| | | | |
|---|---|---|---|
| 1 | true r.m.s. meter | $T$ | period of the repeated signal |
| 2 | square-wave generator | $t_i$ | duration of positive part of the square wave |
| 3 | sine-wave generator | $U$ | test voltage output (as a function of time) |
| 4 | instrument under test | $u_n$ | negative voltage of square wave signal |
| W | network corresponding to the frequency response of the instrument under test | $u_p$ | positive voltage of square wave signal |

NOTE See the text for details of the variables.

Figure A.1 — Circuit for the testing of r.m.s.-voltage indicators

### A.1.1 General

The following procedure is given as a method suitable for the testing of r.m.s.-voltage indicators.

The values given below are based on the following definitions of crest factor $C_F$.

$$C_F = \frac{\hat{U}}{\bar{U}} \tag{A.1}$$

where

$\hat{U}$ is the larger amplitude of the generalized rectangular asymmetrical wave in Figure A.1 (i.e. $\hat{U} = |u_\mathrm{p}|$ or $|u_\mathrm{n}|$, whichever is larger);

$\bar{U}$ is the r.m.s. value of the wave.

## A.1.2 Crest factor values

### A.1.2.1 General

By definition,

$$\bar{U} = \sqrt{\frac{1}{T}\int_0^T u^2 dt} \tag{A.2}$$

For the general case shown in Figure A.1, it can be shown that

$$\bar{U} = \sqrt{u_\mathrm{n}^2 + (u_\mathrm{p}^2 - u_\mathrm{n}^2)\frac{t_i}{T}} \tag{A.3}$$

and that the crest factor is given by

$$C_F = \frac{\hat{U}}{\sqrt{u_\mathrm{n}^2 + (u_\mathrm{p}^2 - u_\mathrm{n}^2)\left(t_i/T\right)}} \tag{A.4}$$

Special cases are given in A.1.2.2 to A.1.2.5.

### A.1.2.2 Symmetrical square wave

$u_\mathrm{p} = u_\mathrm{n}$

$t_i = \frac{T}{2}$

$$C_F = 1 \tag{A.5}$$

### A.1.2.3 Asymmetrical square wave, case 1

$u_\mathrm{p} > u_\mathrm{n}$

$t_i = \frac{T}{2}$

$$C_F = \sqrt{\frac{2}{1+\left(u_\mathrm{n}/u_\mathrm{p}\right)^2}} \tag{A.6}$$

### A.1.2.4 Asymmetrical square wave, case 2

$u_\mathrm{p} < u_\mathrm{n}$

$$t_i = \frac{T}{2}$$

$$C_F = \sqrt{\frac{2}{1+\left(u_{\mathrm{p}}/u_{\mathrm{n}}\right)^2}} \qquad \text{(A.7)}$$

#### A.1.2.5 Rectangular-pulse wave

$$u_{\mathrm{p}} = 0$$

$$t_i < T$$

$$C_F = \sqrt{\frac{T}{t_i}} \qquad \text{(A.8)}$$

## A.2 Procedure

**A.2.1** Adjust the square-wave generator for $t_i$ to be 4 ms. Adjust the period for $T$ of both generators to be 8 ms.

**A.2.2** Adjust the sine-wave generator amplitude for a reading on the instrument under test to be approximately 90 % of the full scale value. Note the reading on the true r.m.s. meter.

**A.2.3** Switch the circuit to the square-wave generator and adjust the amplitude to give the same indication as in A.2.2 on the instrument under test. Note the reading on the true r.m.s. meter.

**A.2.4** Repeat the procedure of A.2.3 while varying the period of $T$ from 8 ms to 40 ms.

**A.2.5** The difference between the true r.m.s. readings for A.2.2 and A.2.3 shall not exceed 5 % of the full-scale value related to the instrument under test for all the values of $T$ given in A.2.4.

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