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Mechanical vibration — Measurement and evaluation of machine vibration —

Part 9: Gear units

Vibrations mécaniques — Mesurage et évaluation des vibrations de machines —

Partie 9: Engrenages

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www. iso. org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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.

This document was prepared by Technical Committee ISO/TC 108, *Mechanical vibration, shock and condition monitoring*, Subcommittee SC 2, *Measurement and evaluation of mechanical vibration and shock as applied to machines, vehicles and structures*.

This first edition of ISO 20816-9 is a technical revision of ISO 8579-2:1993, which was withrdrawn in 2016.

The main changes compared to ISO 8579-2:1993 are as follows:

— It has been re-formatted to match other parts of the ISO 20816 series and includes zones A to D.

— It has two new tables for values of vibration and displacement at zone boundaries.

— A table with values for vibration acceleration rating at zone boundaries has also been included.

— The classifications table has been revised, referring to these new rating tables.

— The displacement and velocity rating graphs have been moved into an informative annex.

A list of all parts in the ISO 20816 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.

Introduction

ISO 20816-1 is the part of the ISO 20816 series that gives the general requirements for evaluating the vibration of various machine types when the vibration measurements are made on both non-rotating parts and rotating shafts.

ISO 20816-9 (this document) provides specific provisions for assessing the vibration of individually housed, enclosed, speed increasing or speed reducing gear units. It can be used for acceptance testing, and, by agreement between manufacturer and customer and/or operator, for guidance for routine operational measurements.

Guidance is provided for assessing the vibration of gear units when operating under steady-state conditions and considering the magnitude of the observed vibration. However, no criteria are provided for transient operating conditions.

The evaluation procedures presented in this document are based on broad-band measurements. However, because of advances in technology, the use of narrow-band measurements or spectral analysis has become increasingly widespread, particularly for the purposes of vibration evaluation, condition monitoring and diagnostics. The specification of criteria for such measurements is beyond the scope of this document. They are provided in greater detail in the relevant parts of the ISO 13373 series which establish requirements for the vibration condition monitoring of machines.

Mechanical vibration — Measurement and evaluation of machine vibration —

Part 9: Gear units

1 Scope

This document specifies requirements for determining and classifying mechanical vibration of individually housed, enclosed, speed increasing or speed reducing gear units. It specifies methods for measuring housing and shaft vibrations, and the types of instrumentation, measurement methods and testing procedures for determining vibration magnitudes. Vibration grades for acceptance are included.

Torsional vibration measurements are outside the scope of this document.

It applies to a gear unit operating within its design speed, load, temperature and lubrication range for acceptance testing at the manufacturer's facility. By agreement between manufacturer and customer and/or operator, it can be used for guidelines for on-site acceptance testing and for routine operational measurements.

This document applies to gear units of nominal power rating from 10 kW to 100 MW and nominal rotational speeds between 30 r/min and 12 000 r/min (0,5 Hz to 200 Hz).

This document does not apply to special or auxiliary drive trains, such as integrated gear-driven compressors, pumps, turbines, etc., or gear type clutches used on combined-cycle turbo generators and power take-off gears.

The evaluation criteria provided in this document can be applied to the vibration of the main input and output bearings of the gearbox and to the vibration of internal shaft bearings. They can have limited application to the evaluation of the condition of those gears. Specialist techniques for evaluating the condition of gears are outside the scope of this document.

This document establishes provisions under normal steady-state operating conditions for evaluating the severity of the following *in-situ* broad-band vibration:

a) structural vibration at all main bearing housings or pedestals measured radially (i.e. transverse) to the shaft axis;

b) structural vibration at thrust bearing housings measured in the axial direction;

c) vibration of rotating shafts radially (i.e. transverse) to the shaft axis at, or close to, the main bearings;

d) structural vibration on the gear casing.

NOTE Vibration occurring during non-steady-state conditions (when transient changes are taking place), including run up or run down, initial loading and load changes are outside the scope of this document.

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

ISO 2954, *Mechanical vibration of rotating and reciprocating machinery — Requirements for instruments for measuring vibration severity*

ISO 10817-1, *Rotating shaft vibration measuring systems — Part 1: Relative and absolute sensing of radial vibration*

3 Terms and definitions

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

— IEC Electropedia: available at http://www.electropedia.org/

3.1
gear unit
mechanical input/output device with a series of at least two meshing gears

4 General

4.1 System considered

For manufacturer's factory testing, the gear unit shall be measured and tested in such a manner as to minimize, as far as possible, effects of the system (see Annex B). For in-field service testing, the driver and driven machine components, mounting and other factors can influence the vibration of the gear unit. Other International Standards and vibration evaluation can be required for measuring the driver or driven machine when operating in-field service.

4.2 Effects of the system

Vibration magnitudes of the gear unit in field service can be adversely affected by factors beyond the control of the gear unit manufacturer, as listed in Annex B. It is preferable to estimate the vibration of the whole system and to check the system effects at the initial design stage of a transmission system. The responsibility for checking should be clearly defined during this stage and all interested parties made aware of the decision.

4.3 Housing or shaft measurements

The vibrations of a gear unit can be measured in two ways, i.e. on the housing (casing) or relative to the shafts. Housing vibration measurements are preferred for gear units operating with rolling element bearings when the clearance in such bearings is small and little relative movement normally occurs between the shaft and housing.

Both shaft and housing vibration measurements are usually made on gear units operating with plain journal bearings (fluid-film bearings). Shaft vibration measurements can provide detailed information which is sometimes not evident from housing measurements, but only over a limited frequency range (typically up to 500 Hz).

Care shall be taken when choosing the measurement instrument to be used for a given gear unit and operating conditions, as each instrument has its own characteristics (see Annex C). Where possible, it is useful to combine both shaft and housing vibration measurements to obtain the absolute motion of a gear or a shaft.

When operating conditions during acceptance testing deviate considerably from field service, the differences shall be taken into account in the assessment of vibration data.

5 Instrumentation

5.1 Type

5.1.1 General instrumentation requirements

Vibration shall be measured using instrumentation capable of measuring broad-band acceleration, velocity and/or displacement, as appropriate, over frequency ranges specified below.

Care should be taken to ensure that the measuring system is not influenced by environmental factors such as:

— temperature variations;

— magnetic fields;

— surface finish;

— power source variations;

— transducer cable length;

— transducer orientation.

Particular attention should be given to ensure that the vibration transducers are correctly mounted and that such mountings do not degrade the accuracy of the measurements.

The type and use of vibration instrumentation systems shall conform to ISO 2954 for housing vibration measurement and shall conform to ISO 10817-1 for shaft vibration measurement. The instrumentation should preferably include a facility for time and spectral frequency analysis.

5.1.2 Shaft measurement instrumentation

The recommended type of transducer for measuring relative shaft vibration is a non-contacting transducer or proximity probe.

The instrument shall allow a reading of peak or peak-to-peak values of vibration displacement to be taken.

NOTE Shaft-riding transducers are no longer in common use, but if fitted, can be acceptable if the rotational frequency of the shaft is less than 3 000 r/min, the signal frequency is less than 200 Hz, and surface rubbing velocity is less than 30 m/s.

5.1.3 Housing measurement instrumentation

The recommended type of transducer for measuring housing vibration is a seismic transducer measuring velocity or acceleration. In order to measure acceleration, velocity and displacement, it is preferable to use an accelerometer. The instrumentation used to acquire the signal should be capable of displaying the root-mean-square (RMS) values of vibration velocity in millimetres per second and the true peak values of vibration acceleration in metres per second per second. The mounting method can affect the frequency response of the transducer; it should therefore preferably be mounted with a screw or stud or using a suitable bonding material. Magnet-mounted accelerometers can be acceptable if the highest fundamental frequency of tooth meshing is less than 2 000 Hz. Hand-held housing measurements are not acceptable for acceptance testing.

NOTE Information on mounting transducers is contained in ISO 5348 and ISO 13373-1.

5.2 Measurement frequency range

The instrumentation shall be capable of measuring from half the lowest shaft rotational speed to at least 3,5 times the highest tooth mesh frequency.

The shaft displacement frequency measurement range shall be from 2 Hz to at least 500 Hz. The housing velocity frequency measurement range shall be from 10 Hz to at least 2 000 Hz. The acceleration frequency measurement range shall be from 10 Hz to 5 000 Hz. If a component rotational speed or tooth meshing frequency occurs outside these ranges, revised frequency ranges shall be agreed between the gear unit manufacturer and customer and/or operator.

5.3 Permissible errors

The measuring instrumentation system, including both the transducer and instrumentation, shall be capable of indicating the vibration magnitude within a permissible error of ±10 % of the reading over the entire operating frequency range.

NOTE Guidance on transducer selection is given in ISO 13373-1.

5.4 Calibration

For acceptance testing, the vibration instrumentation shall be checked against a reference signal and any specified adjustments made immediately before and rechecked immediately after each series of gear unit acceptance vibration measurements have been taken.

For in-situ measurements, calibration of the complete measuring equipment system should be carried out regularly as specified by the instrumentation supplier. Calibrations are typically valid for one to five years.

NOTE 1 Guidance on transducer calibration by comparison is given in ISO 16063-21.

NOTE 2 Guidance on transducer in-situ calibration is given in ISO 16063-44.

6 Vibration measurements

6.1 Shaft measurements

Vibration displacement of the shafts should be measured relative to the housing. Non-contacting transducers (proximity probes) are normally used to measure radial vibration displacement, fitted in orthogonal pairs through the journal bearing housing. Shaft vibration can also be measured axially, especially when fluid-film thrust bearings are fitted. The number and location of transducers shall be agreed between the gear unit customer and manufacturer. Guidance on mounting proximity probes is given in ISO 10817-1.

Prior to running the gear unit up to its rated speed(s), slow-roll measurements of shaft displacement may be carried out. If so, the measurement system needs to be capable of measuring down to low frequencies (e.g. <5 Hz). Such measurements cannot normally be regarded as giving a valid indication of shaft runout under normal operating conditions, since they can be affected by, for example, temporary bows, erratic movements of the shaft within the bearing clearance, and axial movements. Subtraction of slow-roll measurements from rated-speed vibration measurements should not be carried out without careful consideration of these factors, since the results can provide a misleading interpretation of the machine vibration.

The combined mechanical and electrical runout should not exceed 25 % of the allowable vibration displacement at the shaft rotational frequency, or 6 µm, whichever is greater.

6.2 Housing measurements

Housing vibration shall be measured on a rigid housing section such as a bearing block. Measurements should not be made on housing sections which do not support bearings or are not rigid, since they will not provide a true indication of gear unit vibration. Measurements shall be taken in up to three orthogonal directions, two of which lie in a plane perpendicular to the rotating axis of the gears. If the load zone of the bearing is known, it is preferable to measure radially in this direction; otherwise horizontal, vertical and axial are the preferred measurement directions. Axial measurements can give additional information on faults such as gear misalignment and unbalance.

It is recommended that measurements be taken at each accessible bearing location on a gear unit. If a bearing block is inaccessible, then the nearest mounting point may be used giving due consideration to the transmission path from the bearing to this location. The number and location of transducers shall be agreed between the manufacturer and customer and/or operator.

6.3 Units of measurement

The preferred units of measurement are given in Table 1.

Table 1 — Units of measurement

Quantity	Unit
Displacement (peak-to-peak)	µm
Velocity (RMS)	mm/s
Acceleration (peak)	m/s^2
Frequency	Hz

7 Test conditions

7.1 General

The measurement of vibration on a gear unit can be conducted during:

a) manufacturer's shop test;

b) on-site acceptance testing;

c) in-service monitoring.

Special provisions can be required for vibration measurements in each case. The type of measurement and acceptance values for each case should be agreed between the manufacturer and customer at an early stage of negotiation.

7.2 Arrangement of the test system

7.2.1 Manufacturer's shop test

The mechanism for driving the gearbox during a shop test shall be the gear unit manufacturer's responsibility unless otherwise negotiated with the customer and/or operator.

The test transmission, driver, gear unit and any load applied shall be connected by the in-service couplings or by couplings with similar effective overhung masses. The gear unit can be tested with no-load or with a light load to stabilize operation or in accordance with the conditions set out in 7.3.

7.2.2 On-site acceptance tests

On-site acceptance tests shall be carried out with the gear unit in the as-fitted, in-service configuration, which shall be agreed between the gear unit manufacturer and customer and/or operator.

7.2.3 In-service monitoring

In-service monitoring shall be carried out with the gear unit in its in-service operating configuration, to be agreed between the gear unit manufacturer and customer and/or operator.

7.3 Test conditions

The following test conditions shall apply, unless otherwise agreed between the gear unit manufacturer and customer and/or operator:

a) the gear unit shall be tested at its intended in-service operating speed or, if designed for variable-speed service, at the minimum, maximum and median values of its specified in-service speed range;

b) the gear unit shall be tested in its intended direction of rotation or, if reversible, in both directions;

c) the gear unit shall be tested within its design load range;

d) the gear unit shall be tested using the operating lubricating system and the appropriate type and viscosity of lubricant;

e) the gear unit shall be tested when the machinery is operating within its design temperature range.

8 Evaluation criteria

8.1 General

Guidelines are presented for vibration criteria measured at steady-state operating conditions at the specified rated speed and load ranges, including normal slow changes in power output. The vibration criteria described represent target values which give provisions for ensuring that gross deficiencies or unrealistic requirements are avoided. They serve as a basis for defining acceptance test specifications.

The values presented are the result of experience with machinery of this type and, if due regard is paid to them, acceptable long-term operation can be expected.

The evaluation criteria relate to the vibration produced by the gear unit and not to vibration transmitted from outside the unit. If it is suspected that there is a significant influence on the measured vibration due to transmitted vibration from external sources (either steady-state or intermittent), measurements should be taken with the gear unit shut down in order to confirm this. If the magnitude of the transmitted vibration is unacceptable, steps should be taken to remedy the situation.

8.2 Evaluation zones

The maximum vibration magnitude observed at each measurement location and orientation is assessed against four evaluation zones.

The following evaluation zones are defined to permit a qualitative assessment of the vibration of a given machine under steady-state running conditions at its rated speed, and to provide guidance on possible actions.

Zone A: The vibration of newly commissioned machines normally falls within this zone.

NOTE 1 The effort required to achieve vibration within zone A can be disproportionate and unnecessary.

Zone B: Machines with vibration within this zone are normally considered acceptable for unrestricted long-term operation.

Zone C: Machines with vibration within this zone are normally considered unsatisfactory for long-term, continuous operation. Generally, the machine may be operated for a limited period in this condition until a suitable opportunity arises for remedial action.

Zone D: Vibration values within this zone are normally considered to be of sufficient severity to cause damage to the machine.

NOTE 2 Guidance on setting alarms or trips is given in ISO 20816-1.

8.3 Acceptance criteria

Acceptance criteria should always be subject to agreement between the manufacturer and customer and/or operator. Prior negotiation is encouraged.

The evaluation zones described in 8.2 provide a basis for defining acceptance criteria for new or refurbished machines, but the numerical values assigned to the zone boundaries are not themselves intended to serve as acceptance specifications. Historically, for new machines, acceptance criteria have been specified in zone A or zone B but would normally not exceed 1,25 times the zone A/B boundary.

Different acceptance criteria can be agreed upon based on specific design characteristics and/or fleet experience with similar units.

Acceptance tests shall be carried out under clearly defined duration and operating parameters (e.g. load, temperature, lubrication). After major component replacement, maintenance or service activities, acceptance criteria shall take into account the scope of these activities and the vibration behaviour prior to servicing.

8.4 Vibration evaluation zone boundaries

Guidance values for vibration limits are shown in Tables 2, 3 and 4.

Table 2 — Values for shaft vibration displacement at zone boundaries

Displacement rating (DR)	Shaft relative vibration peak-to-peak displacement at zone boundaries µm		
	Zone boundary		
	A/B	B/C	C/D
31,5	20,0	31,5	50,0
50,0	31,5	50,0	80,0
80,0	50,0	80,0	125
125,0	80,0	125,0	200,0
200,0	125,0	200,0	315,0
NOTE Displacement rating (DR) is described in Annex A (See Figure A.1).			

Table 3 — Values for housing vibration velocity at zone boundaries

Velocity rating (VR)	Housing vibration RMS velocity at zone boundaries mm/s		
	Zone boundary		
	A/B	B/C	C/D
3,15	2,0	3,15	5,0
5,0	3,15	5,0	8,0
NOTE Velocity rating (VR) is described in Annex A (See Figure A.2).			

Table 3 *(continued)*

Velocity rating (VR)	Housing vibration RMS velocity at zone boundaries mm/s		
	Zone boundary		
	A/B	B/C	C/D
8,0	5,0	8,0	12,5
12,5	8,0	12,5	20,0
20,0	12,5	20,0	31,5
NOTE Velocity rating (VR) is described in Annex A (See Figure A.2).			

Table 4 — Values for housing vibration acceleration at zone boundaries

Acceleration rating (AR)	Housing vibration true peak acceleration at zone boundaries m/s^2		
	Zone boundary		
	A/B	B/C	C/D
5,0	3,15	5,0	8,0
8,0	5,0	8,0	12,5
12,5	8,0	12,5	20,0
20,0	12,5	20,0	31,5
31,5	20,0	31,5	50,0
50,0	31,5	50,0	80,0
80,0	50,0	80,0	125,0
125,0	80,0	125,0	200,0
200,0	125,0	200,0	315,0
NOTE Acceleration rating (AR) is derived from VR curves in Annex A (See Figure A.2).			

The zone boundaries apply to vibration measurements taken under steady-state conditions at rated speed. The numerical values assigned to the zone boundaries were established from representative data provided by manufacturers and users, originally published in ISO 8579-2:1993[1)].

In most cases, the values given are consistent with ensuring that the dynamic loads transmitted to the bearing support structure and foundation are acceptable and that running clearances are maintained. However, in certain cases, there can be specific features or available experience associated with a particular machine type which can require other values (higher or lower) to be used for the zone boundaries. For example, shaft relative displacement should typically not be allowed to exceed 70 % of the available bearing clearance.

NOTE Tables 2 and 3 are based on curves showing the vibration rating system for shaft displacement and housing velocity measurements shown in Figures A.1 and A.2. ISO 8579-2:1993 did not provide acceleration guidelines. However, Table 4 is now additionally provided which was also derived from Figure A.2 (rating curves for housing vibration velocity). RMS velocity ratings have been converted to peak acceleration at a conversion point of 280 Hz.

Higher vibration levels can be permitted depending on the application and power or at other measurement positions and during transient conditions. Annex A gives an example of a subjective interpretation of the guide values taking into account variations of gear unit type and power rating.

1) Withdrawn; see Foreword.

8.5 Classifications

Classifications and vibration ratings for a range of typical gear units under manufacturer's test are shown in Table 5.

Table 5 — Classification of typical types of gear units

Class	Subclass	Examples of gear units	Vibration ratings			
			Power	DR	VR	AR
I	a)	Special-purpose, enclosed, precision single or double helical one or two stage speed increasers and reducers of parallel shaft design.	Any	31,5	3,15	50,0
	b)	Industrial, marine, etc.[a]	Low[a]	31,5	3,15	[b]
			High[a]	50,0	5,0	[b]
II	a)	General-purpose, enclosed, single or multi-stage gear units incorporating parallel shaft, helical and right-angle spiral bevel gears.	Any	50,0	5,0	80,0
	b)	High-speed (over 3 600 r/min).	Low[a]	50,0	5,0	[b]
		Industrial, marine etc.[a]	High[a]	80,0	8,0	[b]
III	a)	General-purpose, enclosed, single or two-stage reduction gear units incorporating epicyclic (planetary) gears.	Any	80,0	8,0	125,0
	b)	Industrial, marine, etc.[a]	Low[a]	80,0	8,0	[b]
			High[a]	125,0	12,5	[b]
IV	a)	General-purpose enclosed, single or multi-stage straight cut reduction gear units, e.g. calenders, extruders, etc.	Any	125,0	20,0	125,0
	b)	Mill, etc.	Low[a]	125,0	12,5	[b]
		Industrial, marine, etc.[a]	High[a]	200,0	20,0	[b]

[a] See Figure A.3.

[b] No information available at this time.

DR = displacement rating, VR = velocity rating, AR = acceleration rating. (See Annex A).

Classifications may be agreed between the manufacturer and customer and/or operator, using experience or results of operation.

NOTE As and when circumstances permit, recommendations for vibration ratings for other types of gear unit can be included.

9 Test report

9.1 General

The test report shall include a reference to this document, i.e. ISO 20816-9, together with the information specified in 9.2 to 9.7 and any unusual features observed.

9.2 Manufacturer

Type and description of the gear unit being measured.

9.3 Operating data

Test operating data, conditions for setting-up and running the gear unit, including mounting, coupling and bearing characteristics.

Special attention shall be drawn to any deviation from the conditions specified in 7.3.

9.4 Description of the arrangement

Descriptions shall be provided (including a dimensional sketch of the arrangement of the gear unit), of position, axis and data from individual measurement points in accordance with the requirements of 6.1 and 6.2.

9.5 Measuring equipment

All measuring equipment used shall be listed by make and type.

9.6 Test measurements and results

Test measurements and results shall include one or more of the following parameters for each measurement position:

a) overall vibration values;

b) major vibration frequency components and their amplitude;

c) frequency spectra;

d) time waveform.

A fluctuating reading shall be recorded as a subjective average.

9.7 Acceptance test approval

The acceptance test report shall include the following information:

a) Location of acceptance test;

b) Date(s) of acceptance test;

c) Name(s), position(s) and qualification(s) of person(s) carrying out the acceptance test;

d) Signature(s) of responsible person(s).

Annex A
(informative)

Rating curves for vibration displacement and velocity measurements

A.1 General

Curves describing the rating system for shaft displacement and housing velocity measurements are shown in Figures A.1 and A.2 to form a common basis for comparison. The acceptable rating for a given application can be chosen from the figures and agreed upon between the manufacturer and customer and/or operator at an early stage of negotiation. Acceptability can be established from either a single criterion for the entire gear unit or separate criteria for each shaft or measurement position.

An example of subjective vibration rating curves for several classes of typical gear unit applications is shown in A.3.

A.2 Vibration amplitude curves

A.2.1 General

Vibration characteristics are plotted against frequency in Figures A.1 and A.2. Filtered measurements were used to create these figures. Several components of vibration at different frequencies can acceptably exist at the same time, each one at the allowable limit for that frequency as determined from the curves. Equipment capable of frequency analysis is required for this purpose. Care shall be taken to ensure that this equipment can resolve the vibration into individual component frequencies so that a legitimate comparison can be made with the figures.

A.2.2 Instrument settings

Changing the settings of instruments such as Fast Fourier Transform (FFT) analysers can give apparently different results. This depends upon factors such as: sampling frequency, number of samples, maximum frequency (f_{max}) and the amount of random vibration present. To make meaningful comparisons between readings, similar instrument settings should be used in each case.

A.2.3 Overall value

If frequency spectra are not obtainable or not known, one or both of the following methods may be used to provide an indication of acceptability:

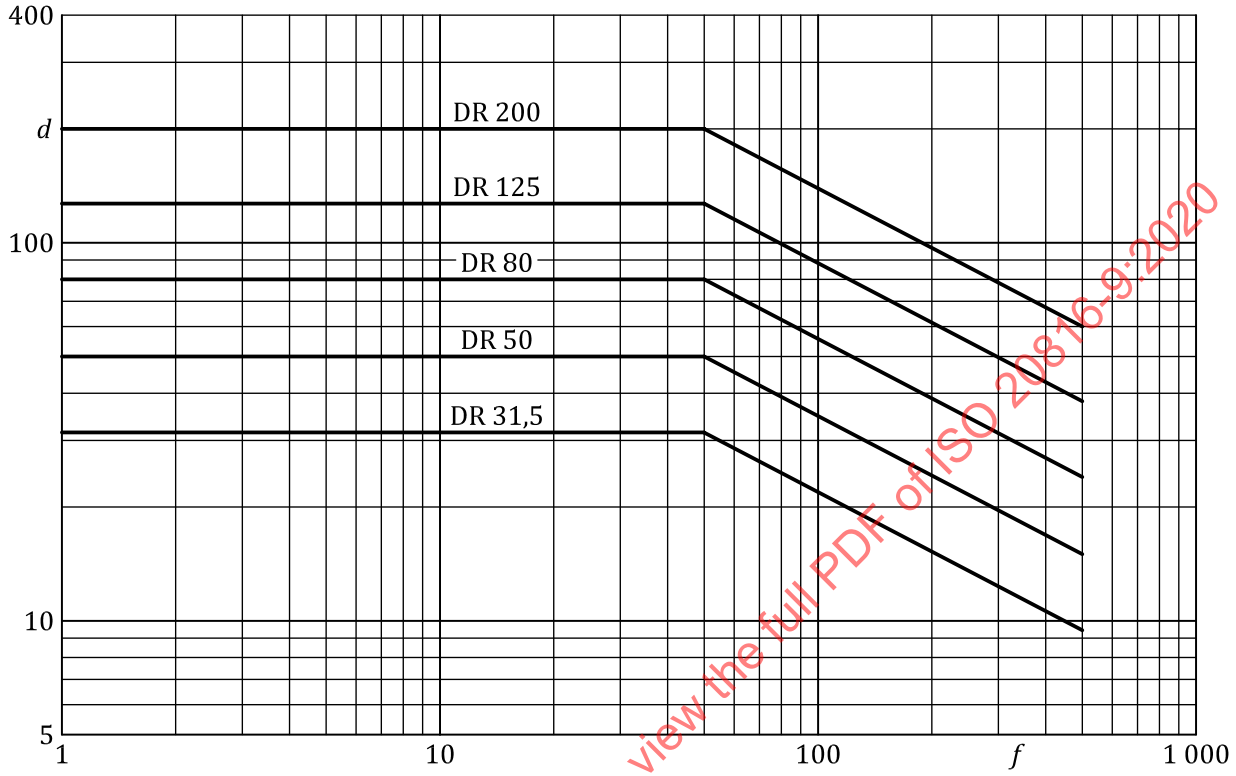
a) the test result is acceptable if the nominal value of the housing overall velocity does not exceed the maximum of the velocity rating grade (see Figure A.2);

b) a nominal shaft displacement value is taken from Figure A.1 using the shaft rotational speed as the discrete frequency of the grade.

NOTE The use of a value from Figure A.1 or A.2 for an overall acceptance, in place of filtered measurements, reduces the allowable vibration (i.e. increases the vibration rating of the gear unit) unless it is known that the vibration is predominantly due to one or two major frequency components.

A.2.4 Rating of measured shaft displacements

Peak-to-peak values of shaft displacement may be rated using Figure A.1. The rating of a gear shaft shall be based on the lowest line enclosing all the measured filtered shaft displacements. A particular gear unit shall be given the highest rating measured on all the shafts monitored.



Key

f frequency, Hz

d peak-to-peak vibration displacement, µm

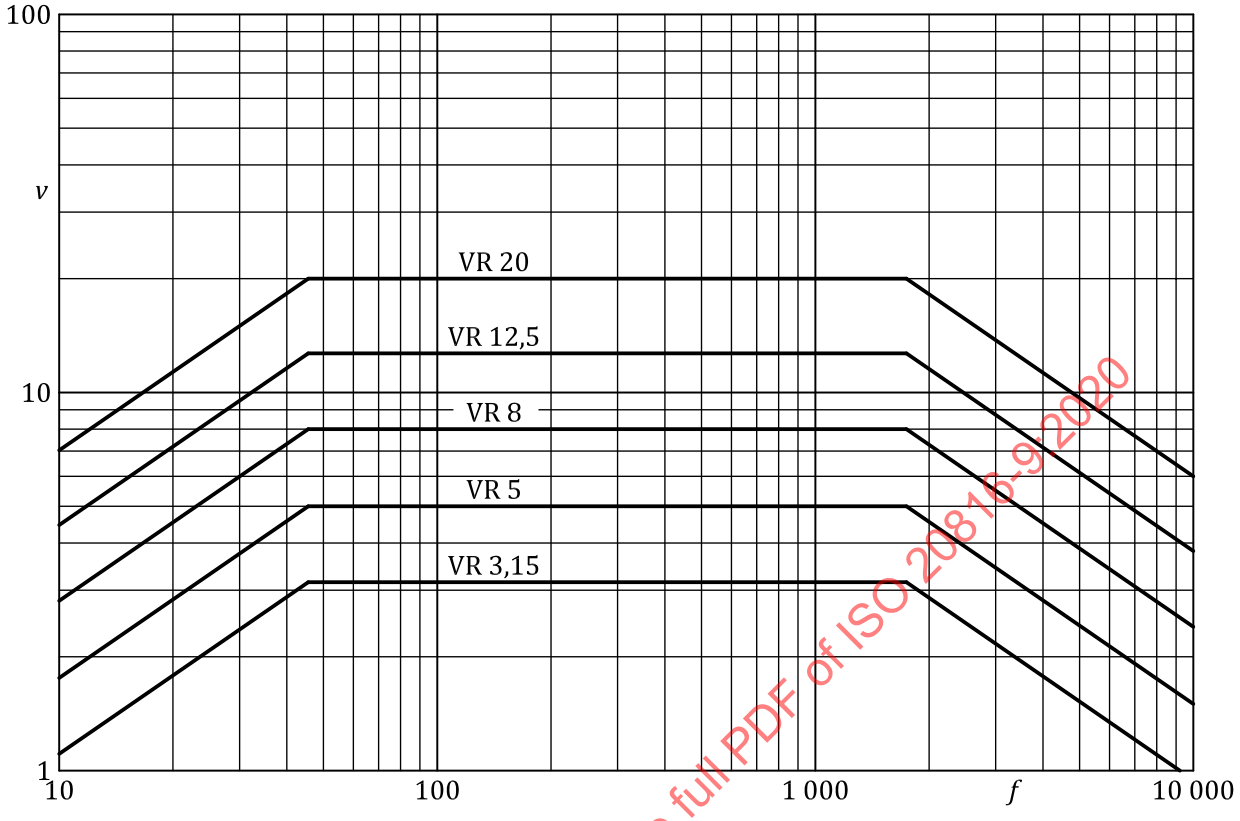
DR displacement rating number

NOTE The displacement rating number, DR, is equivalent to the displacement of the rating curve up to 50 Hz. Above 50 Hz, the curves decrease by 10 dB per decade.

Figure A.1 — Rating curves for shaft vibration (displacement rating)

A.2.5 Rating of measured housing vibration

RMS values of housing vibration velocity may be rated by comparison with Figure A.2. The rating of a given measuring position shall be based on the lowest line fully enclosing its complete vibration spectrum. A particular gear unit shall be given the highest rating measured from all the positions monitored.



Key

f frequency, Hz

v RMS vibration velocity, mm/s

VR velocity rating number

NOTE The velocity rating number, VR, is equivalent to the velocity of the rating curve between 45 Hz and 1 590 Hz. The curves decrease below 45 Hz and above 1 590 Hz at 14 dB per decade.

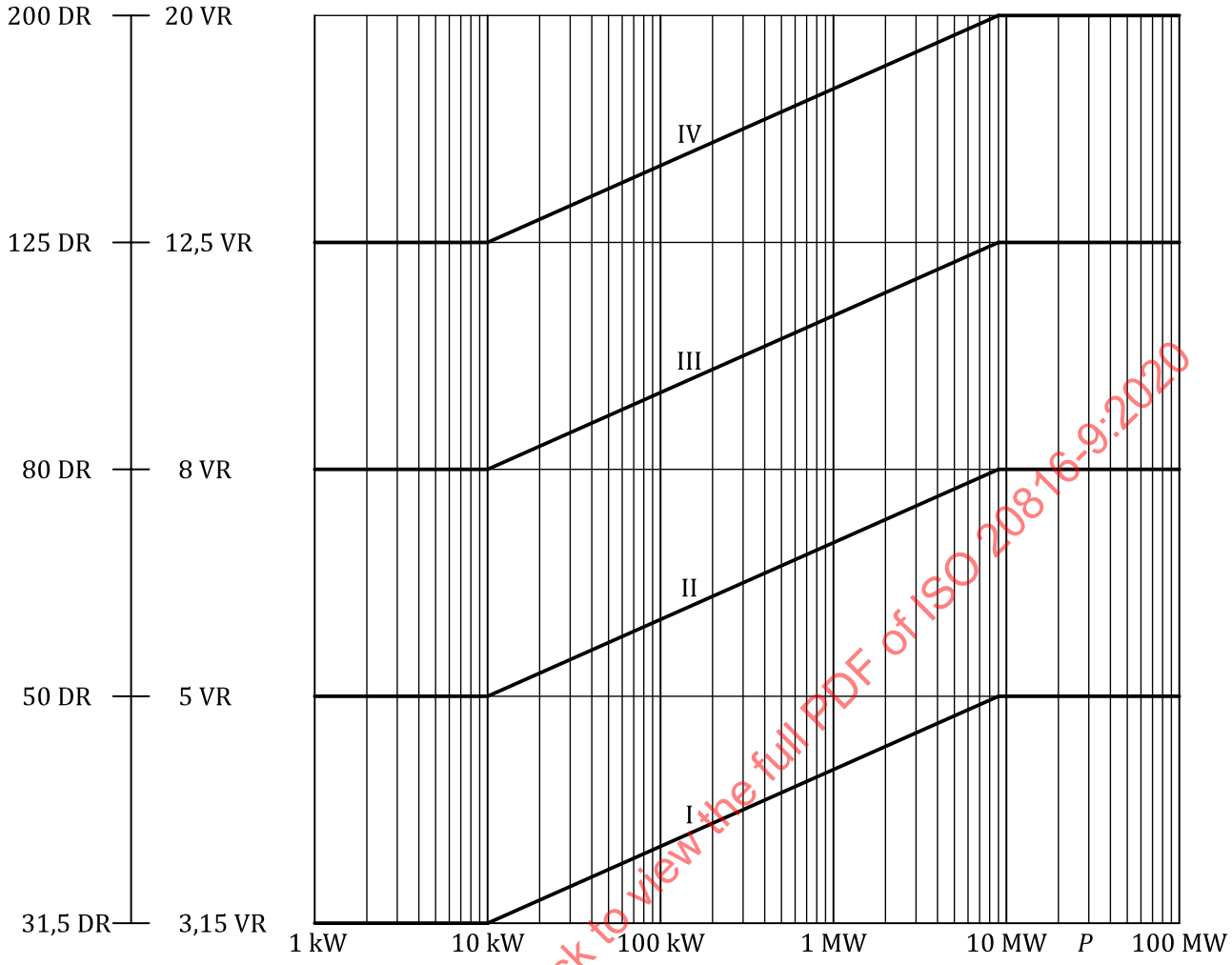
Figure A.2 — Rating curves for housing vibration (velocity rating)

A.3 Subjective vibration rating assessments

A.3.1 General

The vibration of a properly manufactured gear unit varies according to its design, size and application. What can be acceptable for a large, low-speed mill drive might not be suitable for a precision high-speed drive or a marine drive. What can be acceptable for a precision high-speed drive might be unjustifiably expensive for a low-speed mill drive. Care should therefore be taken when applying a given grade as an acceptance criterion.

Figure A.3 shows how subjective vibration ratings for a range of gear unit powers can require limits to be varied according to the classification and power of the gear unit system.



Key

P power

DR displacement rating number

VR velocity rating number

NOTE For key to Class I to Class IV, see Table 5.

Figure A.3 — Subjective vibration ratings versus gear unit power

A.3.2 Example

An example of a subjective assessment of the acceptable vibration rating for a typical gear unit application during acceptance testing at the manufacturer's facility is given here. It should only be used as general guidance for typical gear units.

For example, an industrial or merchant marine gear drive designed to transmit 3 700 kW, at a maximum shaft speed of 1 500 r/min, would have a vibration rating chosen as follows:

On Figure A.3, the intersection of 3 700 kW (3,7 MW) and the curve for Class III is just below the DR 125/VR 12,5 rating line.

An economical gear drive could have the acceptance vibration rating set at DR 125 and/or VR 12,5.

Nevertheless, to be conservative, acceptance levels should be chosen at DR 80, or VR 8, or both.