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INTERNATIONAL STANDARD

COMMENTED VERSION

Rotating electrical machines -
Part 14: Mechanical vibration of certain machines with shaft heights 56 mm and higher - Measurement, evaluation and limits of vibration severity

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Rotating electrical machines - Part 14: Mechanical vibration of certain machines with shaft heights 56 mm and higher - Measurement, evaluation and limits of vibration severity

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This commented version (CMV) of the official standard IEC 60034-14:2026 edition 5.0 allows the user to identify the changes made to the previous IEC 60034-14:2018 edition 4.0. Furthermore, comments from IEC TC 2 experts are provided to explain the reasons of the most relevant changes, or to clarify any part of the content.

A vertical bar appears in the margin wherever a change has been made. Additions are shown in green text, and deletions in red text with strikethrough. Hover over the comment icons to display pop-up notes containing the comments, which are also available in the margin of the publication.

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IEC 60034-14 has been prepared by IEC technical committee 2: Rotating machinery. It is an International Standard.

This fifth edition cancels and replaces the fourth edition published in 2018. This edition constitutes a technical revision.

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

a) subclause 6.3.3 Vertical machines: added two new subclauses: Type and routine tests;
b) subclause 7.3 Test conditions: added two new subclauses: Direct-on-line and variable speed;
c) Table 1: decreased limits for Grade A in free suspension for 56 ≤ H ≤ 132 mm;
d) Clause 9 Limits of relative shaft vibration: added information how to mitigate effects of run-out on shaft vibration measurements.

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

Draft	Report on voting
2/2323/FDIS	2/2329/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

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This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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A list of all parts in the IEC 60034 series, published under the general title *Rotating electrical machines*, can be found on the IEC website.

NOTE A table of cross-references of all IEC TC 2 publications can be found in the IEC TC 2 dashboard on the IEC website.

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

– reconfirmed,
– withdrawn, or
– revised.

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1 Scope

This part of IEC 60034 specifies the factory acceptance vibration test procedures and vibration limits for certain electrical machines under specified conditions, when uncoupled from any load or prime mover.

It is applicable to DC and three-phase AC machines, with shaft heights 56 mm and higher and a rated output up to 50 MW, at operational speeds from 120 min^{-1} up to and including 15 000 min^{-1}.

This document is not applicable to machines mounted in situ (on site), three-phase commutator motors, single-phase machines, three-phase machines operated on single-phase systems, vertical waterpower generators, turbine generators greater than 20 MW and machines with magnetic bearings or series-wound machines.

NOTE 1 For machines measured in situ, refer to applicable clauses or subclauses of ~~ISO 20816, ISO 10816 and ISO 7919~~ ISO 20816-1 and ISO 20816-3.

NOTE 2 For output power above 50 MW reference is made to the ISO 20816 series.

NOTE 3 Vibration routine tests are not mandatory according to IEC 60034-1. If performed, the method for testing is included in this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all 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.

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IEC 60034-1, *Rotating electrical machines - Part 1: Rating and performance*

~~IEC 60034-7, *Rotating electrical machines – Part 7: Classification of types of constructions and mounting arrangements (IM Code)*~~

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 ~~from rotating shafts~~*

ISO 20816-1, *Mechanical vibration - Measurement and evaluation of machine vibration - Part 1: General guidelines*

ISO 21940-32, *Mechanical vibration - Rotor balancing - Part 32: Shaft and fitment key convention*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60034-1 apply.

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

– IEC Electropedia: available at https://www.electropedia.org/
– ISO Online browsing platform: available at https://www.iso.org/obp

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4 Measurement quantities

4.1 General

Measurement quantities are the vibration displacement and vibration velocity at the machine bearings and the relative shaft vibration displacement within or near the machine bearings.

4.2 Vibration magnitude

The criterion for the vibration magnitude measured at the machine bearings shall be the broadband RMS value of the vibration displacement in micrometers or the vibration velocity in millimeters per second in the frequency range specified in Clause 5. The maximum value, determined at the specified measurement positions and specified measuring variable, according to this document, characterizes the vibration magnitude of the machine.

Induction motors (especially of two-pole type) frequently show vibration beating at twice slip frequency. In these cases, the decisive vibration magnitude shall be determined from the relationship:

$$x_{\mathrm{RMS}} = \sqrt{\frac{x_{\mathrm{max}}^{\ 2} + x_{\mathrm{min}}^{\ 2}}{2}}$$

where

x_{max} is the maximum RMS value of vibration displacement or vibration velocity;

x_{min} is the minimum RMS value of vibration displacement or vibration velocity.

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The chosen sample rate shall be large enough to reliably capture the maximum and minimum values of the vibration.

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NOTE Large AC induction machines running at very low slip values at no load ~~may~~ can require several minutes to more than ten minutes for such measurements to be completed at each vibration measuring position.

4.3 Relative shaft vibration

The criterion adopted for the relative shaft vibration measurement shall be the vibratory peak-to-peak displacement ($S_{\mathrm{p\text{-}p}}$) in the direction of measurement from ISO 20816-1.

5 Measurement equipment

The measurement equipment shall be capable of measuring broadband RMS vibration with flat response over a frequency range of 10 Hz to 1 000 Hz, in accordance with the requirements of ISO 2954. However, for machines with speeds approaching or below 600 min^{-1}, the lower limit of the flat response frequency range shall not be greater than 2 Hz.

Measurement equipment for relative shaft vibration measurements shall comply with the requirements in ISO 10817-1.

Multi-directional vibration sensors shall not be used.

NOTE Multi-directional sensors do not provide proper vibration measurement in all directions when mounted in only one location.

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6 Machine mounting

6.1 General

The vibration of an electrical machine is closely linked with the mounting of the machine. To permit evaluation as far as balance and vibration of rotating electrical machines are concerned, it is necessary to measure the vibration on the machine alone, under properly determined test conditions, to enable reproducible tests to be carried out and to provide comparable measurements.

6.2 Free suspension

This condition is achieved by suspending the machine on a spring or by mounting on an elastic support (springs, rubber, etc.).

The highest natural oscillation frequency (f_{no}) of the suspension system and machine shall be less than 1/3 of the frequency f_1 corresponding to the speed of the machine under test, as defined in 7.3. Based on the mass of the machine being tested, the necessary elasticity of the suspension system as a function of rated speed from 600 min^{-1} to 3 600 min^{-1} can be determined from Figure 1. For speeds lower than 600 min^{-1} measurements in free suspension are not practical. For speeds greater than 3 600 min^{-1}, the static displacement Z should be not less than the value for 3 600 min^{-1}.

The curve in Figure 1 presents the minimum elastic displacement to attain the necessary vertical rigid body natural oscillation, which is usually the highest rigid body natural frequency. Static displacement Z is expressed as:

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$$Z = \frac{a^2 g}{(2\pi n)^2} \qquad ,a = \frac{f_1}{f_{no}}; a \geq 3$$

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where

Z is the displacement in m,

n is the rated speed in units of s^{-1}, and

g is the acceleration of gravity (9,81 m/s^2).

When a is set to 3, then the curve in Figure 1 is generated.

The suspension system should exhibit linear stiffness characteristics within the operating displacement range.

6.3 Rigid mounting

6.3.1 Foundation

6.3.1.1 General

During the ~~shop running~~ factory acceptance test of the assembled machine, vibration measurements shall be made with the machine properly mounted, shimmed if necessary, and securely fastened to a massive foundation or test floor stand. Elastic mounts are not permitted.

NOTE 1 For proper mounting, shimming can be applied: Typically shimmed to within 25 µm to 50 µm (approximately 1 mil to 2 mil) to avoid soft foot.

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The horizontal and vertical natural frequencies of the complete test arrangement shall not coincide within:

a) ±10 % of the rotational frequency of the machine;

b) ±5 % of twice the rotational frequency; or

c) ±5 % of once and twice the fundamental electrical ~~line~~ supply frequency.

NOTE 2 These criteria apply to each rated speed according to 7.3.1.

Either one of the following two mounting conditions may be chosen by the manufacturer.

6.3.1.2 Rigid mounting on massive foundation

One indication of massive foundation is when the vibration velocity measured in the horizontal and vertical directions at the machine feet (or at the base frame near to the bearing pedestals or stator feet) does not exceed 30 % of the maximum velocity~~, which is measured~~ at the adjacent bearing housing in the same measurement direction. The ratio of foot to bearing vibration velocities is valid for the rotational frequency component or twice-line frequency component (if the latter is being evaluated).

NOTE 1 The rigidity of a foundation is a relative quantity. It is compared with the rigidity of the machine bearing system. The ratio of bearing housing vibration to foundation vibration is a characteristic quantity for the evaluation of foundation flexibility.

NOTE 2 ~~If the machine is to be supported in the field by a structure other than a massive foundation, it may be necessary to perform a system dynamic analysis to make the necessary changes to the foundation dynamic stiffness.~~ If the machine will be installed in the field (in situ) on a structure that is not a massive foundation, a system dynamic analysis can be required to assess and adjust the dynamic stiffness of the field supporting structure.

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6.3.1.3 Rigid mounting on test floor stand

This condition is achieved by mounting the machine on an adequately rigid test foundation free of resonances at forcing frequencies, see 6.3.1.1.

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NOTE This mounting is the most used in manufacturers test labs.

6.3.2 Horizontal machines

The machine under test shall be bolted or clamped using all bolt-hole positions to a foundation that meets the requirements of 6.3.1.2 or 6.3.1.3.

There are constructions and mountings in which the above fixing conditions cannot be met. Examples include single-bearing or flange mounted machines. In those cases, there should be an agreement between the supplier and customer.

6.3.3 Vertical machines

~~Vertical machines shall be mounted onto a solid rectangular or circular steel plate with a bore hole in the centre of the shaft extension, a machined surface for the flange of electrical machine being measured and holes provided for fasteners or clamps. The steel plate thickness shall be at least three times greater than the machine flange thickness, five times is recommended. The edge length respective to the diameter shall be at least equal to the height of the top bearing, *L*. Figure 6 is an example for IM V1 (see IEC 60034-7).~~

6.3.3.1 Type test

Vertical electrical machines shall be mounted on a solid steel plate, either rectangular or circular, with the following features:

– a central bore hole aligned with the shaft extension;

– a machined surface to support the machine flange accurately;

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– holes for fasteners or clamps to secure the machine.

The steel plate thickness shall be at least three times the flange thickness of the machine; five times is recommended for improved rigidity. The edge length (or diameter) of the plate shall be at least equal to the height of the machine's top bearing, denoted as L (see Figure 6).

The steel base shall be clamped firmly and tilt safe to a solid floor and meet the requirements of 6.3.1.2 or 6.3.1.3. The flange connection shall use the correct number of fasteners or clamps. When the first natural frequency of the lateral vibration mode of a vertical machine mounted on a solid foundation is close to the machine's rotational speed, the machine shall be tested on a different support or foundation to avoid a resonant test condition, as the machine's field support structure is different from a solid massive foundation.

If the above method of mounting is not ~~reasonable~~ feasible, other arrangements can be according to agreement between supplier and customer.

6.3.3.2 Routine test

If measurement results according to 6.3.3.1 exist for a particular motor design with bearing arrangement also suitable for horizontal operation, other motors with a corresponding design can be tested also in a horizontal position.

The machine shall be mounted on a test support. The test support shall have sufficient stiffness. The motor shall be clamped or fastened to the test support with the specified number of screws via the motor flange or feet if any.

Other arrangements can be agreed between supplier and customer.

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6.4 Active environment determination

The support systems described in 6.2 and 6.3 are considered passive, admitting insignificant external disturbances to the machine. When, for the same measurement position, the vibration magnitude with the machine at standstill exceeds 25 % of the value when the machine is running, then an active environment is said to exist, and this document does not apply (see ISO 20816-1).

7 Conditions of measurement

7.1 Key

For the ~~balancing and~~ vibration measurement of machines provided with a shaft extension keyway, the ~~keyway~~ key shall be considered according to ISO 21940-32, unless specified by customer.

7.2 Measurement positions and directions

7.2.1 Measurement positions for vibration

The location of the preferred measurement positions and directions to which the levels of vibration magnitude apply are shown in Figure 2 for machines with end-shield bearings and in Figure 4 for machines with pedestal bearings. Figure 3 applies to those machines where measurement positions according to Figure 2 are not possible without disassembly of parts. When measurements cannot be performed according to Figure 2 or Figure 3, there should be an agreement between supplier and customer.

Figure 6 applies to machines mounted in the vertical position.

NOTE 1 Measurement according to Figure 3 and Figure 6 ~~might~~ can be on the frame as close to the bearing housing as possible.

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NOTE 2 ~~Axial vibration measurement may~~ It will probably not be possible to measure axial vibration without disassembly on both ends. If a machine has thrust bearings, this ~~may~~ can be according to agreement between supplier and customer, see 8.3.

7.2.2 Measurement positions for relative shaft displacement

Non-contacting transducers shall be installed inside the bearing, measuring directly the relative shaft journal displacement, or (when inside mounting is not possible) adjacent to the bearing shell. The preferred radial positions are as indicated in Figure 5.

7.3 Test conditions

7.3.1 Direct-on-line

Machines shall be tested at no-load with ~~all relevant quantities at their rated value~~ each rated frequency (50 Hz / 60 Hz) and the corresponding rated voltage.

~~Fixed speed AC machines shall be run with a sinusoidal supply voltage according to IEC 60034-1.~~

~~The test shall be performed at each rated fixed speed or over the rated speed range for variable frequency drives. For all tested speeds, the values shall not exceed the corresponding limit in Table 1.~~

~~In order to discern the mechanically induced vibration from other vibration excitation forces, it is recommended that DC machines are tested with a low current ripple supply or pure DC.~~

~~NOTE Tests with variable-frequency power supply normally only confirm mechanically induced vibrations. It is possible that electrically induced vibrations will be different. If possible, the tests with the actual converter to be installed with the motor on site will provide better information about vibration behaviour.~~

NOTE When rated voltage cannot be achieved, the motor can be tested at lower voltage with a winding/connection that achieves rated flux or according to agreement with the customer.

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For multi-speed motors (e.g. pole changing windings) the test shall be performed for each pole number. For all tested speeds, the values shall not exceed the corresponding limit in Table 1.

For machines that are bi-directional, the vibration limits apply for both directions of rotation but should be measured in only one direction.

7.3.2 Variable speed

The type test shall be performed over the specified speed range (or ranges) with a speed ramp (up or down) or coast down slow enough to detect the peak levels. The measured vibration values shall not exceed the corresponding limit in Table 1.

NOTE 1 De-energized coast down test can be done to evaluate mechanical vibration source peaks throughout the speed operation range.

NOTE 2 Tests with variable-frequency power supply will only confirm mechanically induced vibrations. It is possible that electrically induced vibrations might also be present. Testing with the actual converter installed with the motor in situ will provide better information about vibration behaviour.

For routine testing of variable speed machines, it is permitted to test at a single speed based upon information obtained during type test.

~~For machines that are bi-directional, the vibration limits apply for both directions of rotation, but need to be measured in only one direction.~~

To discern the mechanically induced vibration from other vibration excitation forces, it is recommended to use the coast down test. DC machines are to be tested with a low current ripple supply or pure DC.

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