
**Mechanical vibration — Vibration of
rotating machinery equipped with active
magnetic bearings —**

**Part 2:
Evaluation of vibration**

iTeh STANDARD PREVIEW
(standards.iteh.ai)
*Vibrations mécaniques — Vibrations de machines rotatives équipées de
paliers magnétiques actifs —
Partie 2: Évaluation des vibrations*

ISO 14839-2:2004

[https://standards.iteh.ai/catalog/standards/sist/560b52d2-9cad-4c3d-8122-
c73189f69638/iso-14839-2-2004](https://standards.iteh.ai/catalog/standards/sist/560b52d2-9cad-4c3d-8122-c73189f69638/iso-14839-2-2004)



PDF disclaimer

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat accepts no liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies. In the unlikely event that a problem relating to it is found, please inform the Central Secretariat at the address given below.

iTeh STANDARD PREVIEW (standards.iteh.ai)

ISO 14839-2:2004

<https://standards.iteh.ai/catalog/standards/sist/560b52d2-9cad-4c3d-8122-c73189f69638/iso-14839-2-2004>

© ISO 2004

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

1	Scope	1
2	Normative references	1
3	Measurement and evaluation procedures	1
4	Evaluation criteria	6
	Annex A (informative) Case study on an LP centrifugal compressor equipped with active magnetic bearings (AMBs)	8
	Annex B (informative) Case study on current evaluation	14
	Annex C (informative) Voltage saturation	17
	Bibliography	20

iTeh STANDARD PREVIEW (standards.iteh.ai)

ISO 14839-2:2004

<https://standards.iteh.ai/catalog/standards/sist/560b52d2-9cad-4c3d-8122-c73189f69638/iso-14839-2-2004>

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.

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 14839-2 was prepared by Technical Committee ISO/TC 108, *Mechanical vibration and shock*, Subcommittee SC 2, *Measurement and evaluation of mechanical vibration and shock as applied to machines, vehicles and structures*.

ISO 14839 consists of the following parts, under the general title *Mechanical vibration — Vibration of rotating machinery equipped with active magnetic bearings*:

- *Part 1: Vocabulary*
- *Part 2: Evaluation of vibration*

The following part is under preparation:

- *Part 3: Evaluation of stability margin.*

Introduction

This part of ISO 14839 concerns steady-state values of rotor vibrations and the AMB coil currents and voltage measured during nominal steady-state operation, but not the transient condition while passing critical speeds. The regulations of these transient vibrations passing at the critical speeds are established in ISO 10814 in which the modal sensitivity, the so-called amplification factor (Q-factor), is then evaluated. This topic is beyond the scope of this part of ISO 14839.

Because of the stiff support of oil-film bearings with small clearances [e.g. bearing radial clearance (C) divided by the journal radius (R), $C/R \approx 0,001$], shaft vibration should be regulated within low levels to avoid oil-film rupture of the lubricant and metal contact inside the bearing. In contrast, the relatively soft support of AMBs and correspondingly large clearances (e.g. $C/R \approx 0,005$), a larger vibration level is often observed in AMB rotors, but is quite normal and acceptable. The lower stiffness introduces no major problems in the transmission force to the machine foundation. Compared to the oil-film bearing rotor standards (see the ISO 7919-1 series), this part of ISO 14839 provides greater values of zone limits for vibration assessment and acceptance.

iTeh STANDARD PREVIEW (standards.iteh.ai)

ISO 14839-2:2004

<https://standards.iteh.ai/catalog/standards/sist/560b52d2-9cad-4c3d-8122-c73189f69638/iso-14839-2-2004>

iTeh STANDARD PREVIEW **(standards.iteh.ai)**

ISO 14839-2:2004

<https://standards.iteh.ai/catalog/standards/sist/560b52d2-9cad-4c3d-8122-c73189f69638/iso-14839-2-2004>

Mechanical vibration — Vibration of rotating machinery equipped with active magnetic bearings —

Part 2: Evaluation of vibration

1 Scope

This part of ISO 14839 sets out general guidelines for measuring and evaluating rotating machinery equipped with active magnetic bearings (AMBs) with respect to the following two indices:

- shaft vibratory displacement measured at or close to the AMBs, and
- working current and voltage measured in magnetic coils or power supply amplifiers.

Both indices are measured under nominal operating conditions in house and/or on site. These guidelines are presented in terms of both steady-state running values of these indices and any magnitude changes which may occur in these steady-state operations.

This part of ISO 14839 is applicable to industrial rotating machines generating or consuming nominal power greater than 15 kW, and is not limited by size or operational rated speed (i.e. comprising turbo-compressors, turbo-pumps, steam turbines, turbo-generators, turbo-fans, electric drives and other rotors supported by AMBs). This part of ISO 14839 establishes the vibration, current and voltage evaluation of the rotating machinery equipped with AMBs, specified by a comparatively large power capacity as described above, excluding small-scale rotors such as turbo-molecular pumps, spindles and flywheels.

This part of ISO 14839 covers both AMB-equipped rigid rotors and AMB-equipped flexible rotors.

2 Normative references

The following referenced documents are indispensable for the application 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.

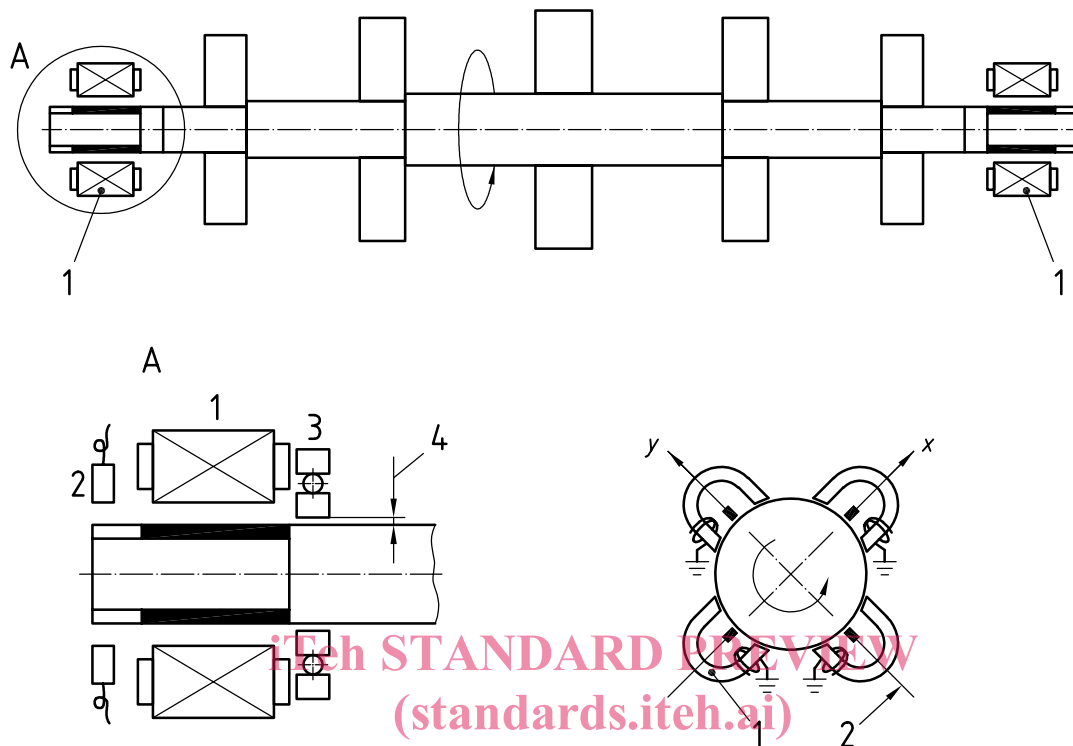
ISO 7919-1, *Mechanical vibration of non-reciprocating machines — Measurements on rotating shafts and evaluation criteria — Part 1: General guidelines*

3 Measurement and evaluation procedures

3.1 Description of rotor-AMB system

A typical rotor system supported by AMBs is illustrated in Figure 1. An AMB is located at each end of the shaft and includes an adjacent displacement transducer and an emergency (auxiliary) ball bearing. The axial AMB is omitted in this figure. The control network for driving the AMB device is shown in Figure 2. As shown in these figures, each displacement transducer detects the shaft journal position at the bearing locations and its signal is fed back to the controller. Deviation from the bearing centre is delivered to the controller. This controller might, for example, implement a proportional, integral and differential actions (PID) control algorithm. The controller drives the power amplifiers to supply the coil current. If the shaft moves downward, the upper electromagnetic coil is activated to lift the rotor upward by the magnetic force. Since, in this manner, the magnetic force acts

upon the shaft so as to maintain the shaft at the neutral position inside the bearing, the AMB accomplishes both levitation and vibration control without mechanical contact.



Key

- 1 AMB
- 2 displacement transducer
- 3 touch-down bearing
- 4 clearance

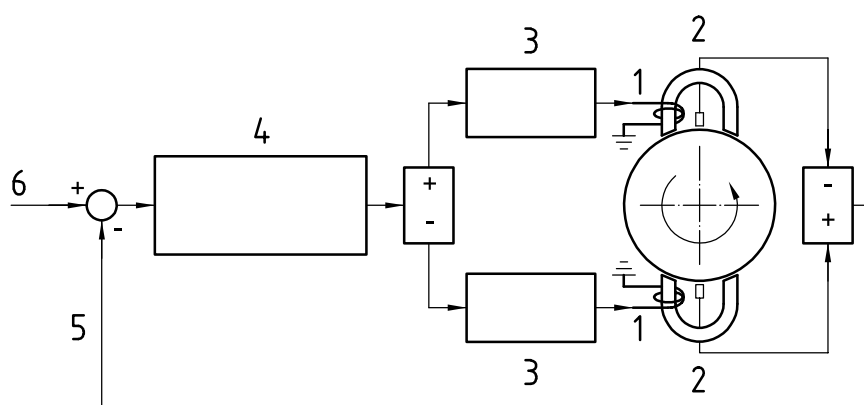
ISO 14839-2:2004
<https://standards.iteh.ai/catalog/standards/sist/560b52d2-9cad-4c3d-8122-c73189f69638/iso-14839-2-2004>

Figure 1 — Rotor system equipped with active magnetic bearings

3.2 Displacement

Throughout this part of ISO 14839, the term “vibratory displacement” refers to the total displacement of the shaft from the bearing's centre, including any static displacement. The vibration measurement of the stationary parts of the machine (e.g. bearing housing) is excluded from this part of ISO 14839.

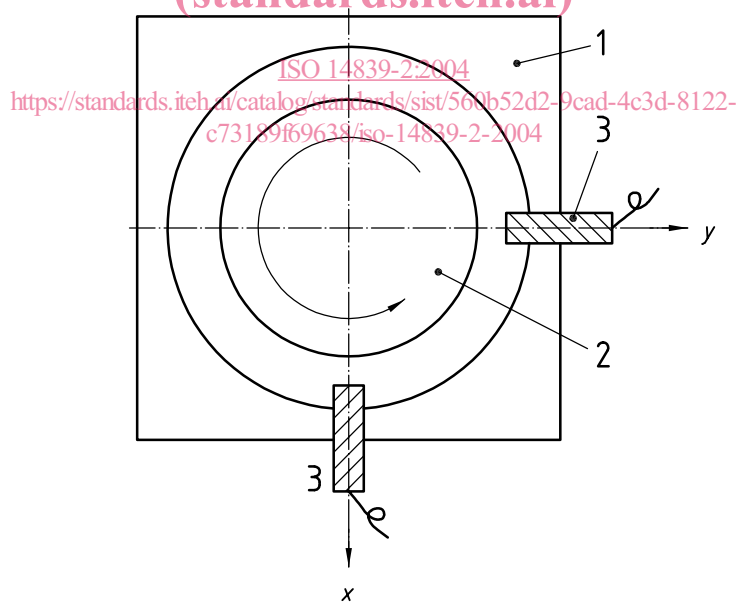
AMB equipment in rotating machines has its own displacement transducers for detecting shaft movement, $x(t)$ and $y(t)$, as shown in Figure 3. No additional displacement transducers are required. The detected values of shaft vibratory position by these displacement transducers is the subject of this part of ISO 14839.

**Key**

- 1 AMB
- 2 displacement transducer
- 3 power amplifier
- 4 controller
- 5 journal position signal
- 6 reference signal

Figure 2 — Layout of AMB control network

iTeh STANDARD PREVIEW
(standards.iteh.ai)

**Key**

- 1 casing
- 2 shaft
- 3 displacement transducers

Figure 3 — Displacement transducers of AMBs

As shown in Figure 3, the displacement transducers are oriented in the x and y directions at each radial bearing. The signals from these displacement transducers indicate the rotor journal position including the d.c. component (eccentricity) and a.c. component (vibration orbit) as shown in Figure 4. Eccentricities from the clearance centre of the AMB (designated O–O_i) in the x and y directions are designated $\varepsilon_x, \varepsilon_y$, while the vibration orbit amplitudes in the x and y directions are designated a_x, a_y . The maximum displacement of the rotor from the clearance centre of the radial AMB, designated $D_{\max}$, can be calculated from Equation (1) exactly

$$D_{\max} = \max \left[\sqrt{x^2(t) + y^2(t)} \right] \quad (1)$$

or approximated by Equation (2), based on the orbit observation:

$$D_{\max} \approx \sqrt{x_{\max}^2 + y_{\max}^2} \quad (2)$$

where

$$x_{\max} = \varepsilon_x + a_x$$

$$y_{\max} = \varepsilon_y + a_y$$

This formula to estimate the maximum displacement in a certain direction will generally overestimate the exact value with a maximum error of approximately 40 %.

The evaluation of $D_{\max}$ from Equation (1) and (2) using the signals measured by two displacement transducers is relatively complex. A digital oscilloscope or other special instrument is required. As a simpler procedure, the maximum value of the displacement values measured in two orthogonal directions is recommended as shown in Figure 4, based on the waveform observation:

$$D_{\max} \geq \max[x_{\max}, y_{\max}] \quad (3)$$

This equation will, in general, underestimate the displacement.

Any of these three displacement quantities may be agreed upon as the method of characterizing the maximum displacement $D_{\max}$. In order to avoid contact problems between the rotor and stators, the following formula should be satisfied with a certain margin against the minimum radial clearance $C_{\min\text{-radial}}$:

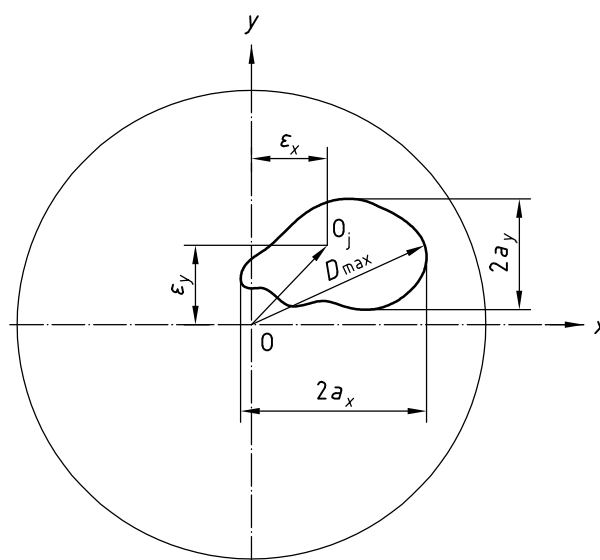
$$D_{\max} < C_{\min\text{-radial}} \quad (4)$$

This $D_{\max}$ is the index used to evaluate the clearance margin in this part of ISO 14839.

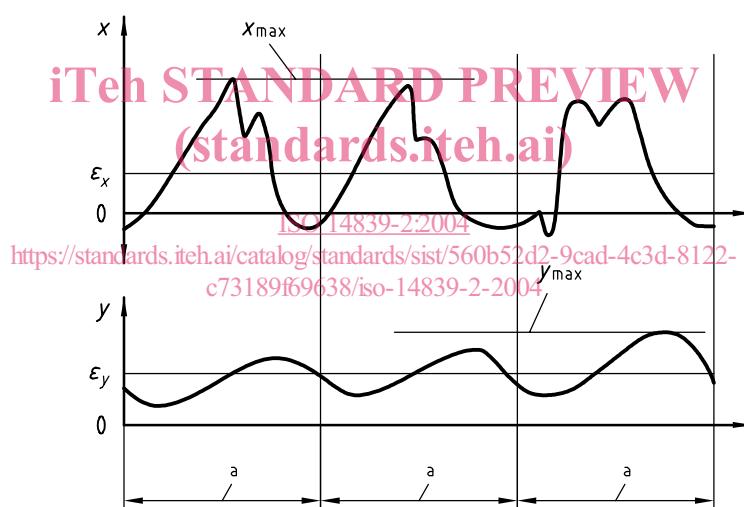
For assessment in this part of ISO 14839, the axial movement, z , of the rotor is measured to compare with the minimum axial clearance $C_{\min\text{-axial}}$ in the same manner as shown in Figure 4. In this case:

$$D_{\max} = z_{\max} < C_{\min\text{-axial}} \quad (5)$$

These measurements considering the radial and axial directions should be made under agreed conditions over the operational speed and load ranges of the machine. These measurements should typically be made after achieving agreed thermal and operating conditions. It should be noted that these $D_{\max}$ indexes are measured only for the specified steady-state conditions including nominal slow changes in load. In addition, measurements may also be taken when different conditions exist or during transient changes, for example, during slow roll, warming-up speed, critical speeds or shut down. However, the result of these measurements may not be suitable for this evaluation.



a) Orbit



b) Vibration time history

a is the vibration orbit amplitude

t is the time

ϵ is the eccentricity from the clearance centre

^a Time for one revolution.

Figure 4 — Unfiltered shaft orbit and vibration time history