INTERNATIONAL STANDARD

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Rolling bearings — Measuring methods for vibration —

Part 1: **Fundamentals**

Roulements — Méthodes de mesurage des vibrations —

Partie 1: Principes fondamentaux

Reference number
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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
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Contents

Page

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 15242-1 was prepared by Technical Committee ISO/TC 4, *Rolling bearings*.

ISO 15242 consists of the following parts, under the general title *Rolling bearings — Measuring methods for vibration*:

— *Part 1: Fundamentals*

— *Part 2: Radial ball bearings with cylindrical bore and outside surface*

— *Part 3: Radial double-row spherical and tapered roller bearings with cylindrical bore and outside surface*

Introduction

Vibration in rotating rolling bearings can be of importance as an operating characteristic of such bearings. The vibration can affect the performance of the mechanical system incorporating the bearing and can result in audible noise when the vibration is transmitted to the environment in which the mechanical system operates.

Vibration of rotating rolling bearings is a complex physical phenomenon dependent on the conditions of operation. Measuring the vibration output of an individual bearing under a certain set of conditions does not necessarily characterize the vibration output under a different set of conditions or when the bearing becomes part of a larger assembly. Assessment of the audible sound generated by the mechanical system incorporating the bearing is complicated further by the influence of the interface conditions, the location and orientation of the sensing device, and the acoustical environment in which the system operates. Assessment of airborne noise, which for the purpose of this document can be defined as any disagreeable and undesired sound, is further complicated by the subjective nature of the terms *disagreeable* and *undesired*. Structure-borne vibration can be considered the driving mechanism that ultimately results in the generation of airborne noise. Only selected methods for the measurement of the structure-borne vibration of rotating rolling bearings are addressed in the current edition of ISO 15242.

This part of ISO 15242 serves to define and specify the physical quantities measured and the general test conditions and environment utilized in the measurement of vibration generated by rolling bearings on a test rig. Based on this part of ISO 15242, parties to the acceptance inspection of rolling bearings may, by agreement, establish acceptance criteria with which to control bearing vibration.

Vibration of rotating rolling bearings can be assessed by any of a number of means using various types of transducers and test conditions. No simple set of values characterizing the vibration of a bearing is adequate for the evaluation of the vibratory performance in all possible applications. Ultimately, a knowledge of the type of bearing, its application and the purpose of the vibration testing (e.g., as a manufacturing process diagnostic or an assessment of product quality) is required to select the most suitable method for testing. The field of application for standards on bearing vibration is, therefore, not universal. However, certain methods have established a wide enough level of application to be considered as standard methods for the purposes of this part of ISO 15242.

This part of ISO 15242 serves to define the general principles involved in vibration measurement. It is intended that further parts will specify in more detail the methods for assessing vibration of different types of bearings with cylindrical bore and outside surface.

Rolling bearings — Measuring methods for vibration —

Part 1:
Fundamentals

1 Scope

This part of ISO 15242 specifies measuring methods for vibration of rotating rolling bearings under established test conditions, together with calibration of the related measuring systems.

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 286-2, *ISO system of limits and fits — Part 2: Tables of standard tolerance grades and limit deviations for holes and shafts*

ISO 554, *Standard atmospheres for conditioning and/or testing — Specifications*

ISO 558, *Conditioning and testing — Standard atmospheres — Definitions*

ISO 1132-1, *Rolling bearings — Tolerances — Part 1: Terms and definitions*

ISO 2041, *Vibration and shock — Vocabulary*

ISO 3205, *Preferred test temperatures*

ISO 3448, *Industrial liquid lubricants — ISO viscosity classification*

ISO 5593, *Rolling bearings — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1132-1, ISO 2041, ISO 5593 and the following apply.

3.1
error motion
undesired radial or axial (translational) motion or tilt (angular) motion of an axis of rotation, excluding motions due to changes of temperature or externally applied load

3.2
stiffness
ratio of change of force (or torque) to the corresponding change in translational (or rotational) displacement of an elastic element

3.3
vibration
variation with time of the magnitude of a quantity which is descriptive of the motion or position of a mechanical system, when the magnitude is alternately greater and smaller than some average value or reference

3.4
transducer
device designed to receive energy from one system and supply energy, of either the same or of a different kind, to another system in such a manner that the desired characteristics of the input energy appear at the output

3.5
electromechanical pickup
transducer which is actuated by energy from a mechanical system (strain, force, motion, etc.), and supplies energy to an electrical system, or vice versa

NOTE The principal types of transducers used in vibration and shock measurement are

a) piezoelectric accelerometer;

b) piezoresistive accelerometer;

c) strain-gauge type accelerometer;

d) variable-resistance transducer;

e) electrostatic (capacitor/condenser) transducer;

f) bonded-wire (foil) strain-gauge;

g) variable-reluctance transducer;

h) magnetostriction transducer;

i) moving-conductor transducer;

j) moving-coil transducer;

k) induction transducer.

3.6
displacement
vector quantity that specifies the change of position of a body, or particle, with respect to a reference frame

3.7
velocity
vector quantity that specifies the time-derivative of displacement

3.8
acceleration
vector quantity that specifies the time-derivative of velocity

3.9
filter
wave filter
device for separating oscillations on the basis of their frequency. It introduces relatively small attenuation to wave oscillations in one or more frequency bands and relatively large attenuation to oscillations of other frequencies

3.10
band-pass filter
filter which has a single transmission band extending from a lower cut-off frequency greater than zero to a finite upper cut-off frequency

3.11
pass-band
⟨band-pass filter⟩ frequency band between the upper and lower cut-off frequencies

3.12
nominal upper and lower cut-off frequencies
cut-off frequency
⟨band-pass filter⟩ frequencies above and below the frequency of maximum response of a filter at which the response to a sinusoidal signal is 3 dB below the maximum response

3.13
root mean square (r.m.s.) velocity
$v_{\text{r.m.s.}}(t)$
square root, over a time interval T, of the average of squared values of the velocity' over the time interval

NOTE Root mean square value can also be used for displacement and acceleration.

3.14
exponential mean effective (e.m.e.) velocity
$v_{\text{e.m.e.}}(t)$
parameter for obtaining a time-average velocity, which is similar to root mean square velocity, but considers exponential decay

NOTE 1 Exponential mean effective value can also be used for displacement and acceleration.

NOTE 2 Exponential mean effective value is also known as exponential average value or time relaxation value.

3.15
period
smallest increment of the independent variable of a periodic quantity for which the function repeats itself

4 Fundamental concepts

4.1 Bearing vibration measurement

The diagram in Figure 1 shows the fundamental elements of bearing vibration measurement and the factors that influence the measurement. The numbers in Figure 1 correspond to clauses of this part of ISO 15242.

4.2 Characteristics of an axis of rotation

A rotating rolling bearing is designed to provide an axis of rotation for rotational motion of one machine element relative to another while supporting radial and/or axial loads. An axis of rotation may exhibit motion in six basic degrees of freedom. These are shown in Figure 2, and are listed below:

— rotational motion, see Figure 2 b);

— translational motion in a radial direction, i.e. in one or both orthogonal planes passing through the axis of rotation, see Figures 2 c) and 2 d);

— translational motion in an axial direction, i.e. in a direction parallel to the axis of rotation, see Figure 2 e);

— tilt motion in an angular direction, i.e. in one or both orthogonal planes passing through the axis of rotation, see Figures 2 f) and 2 g).

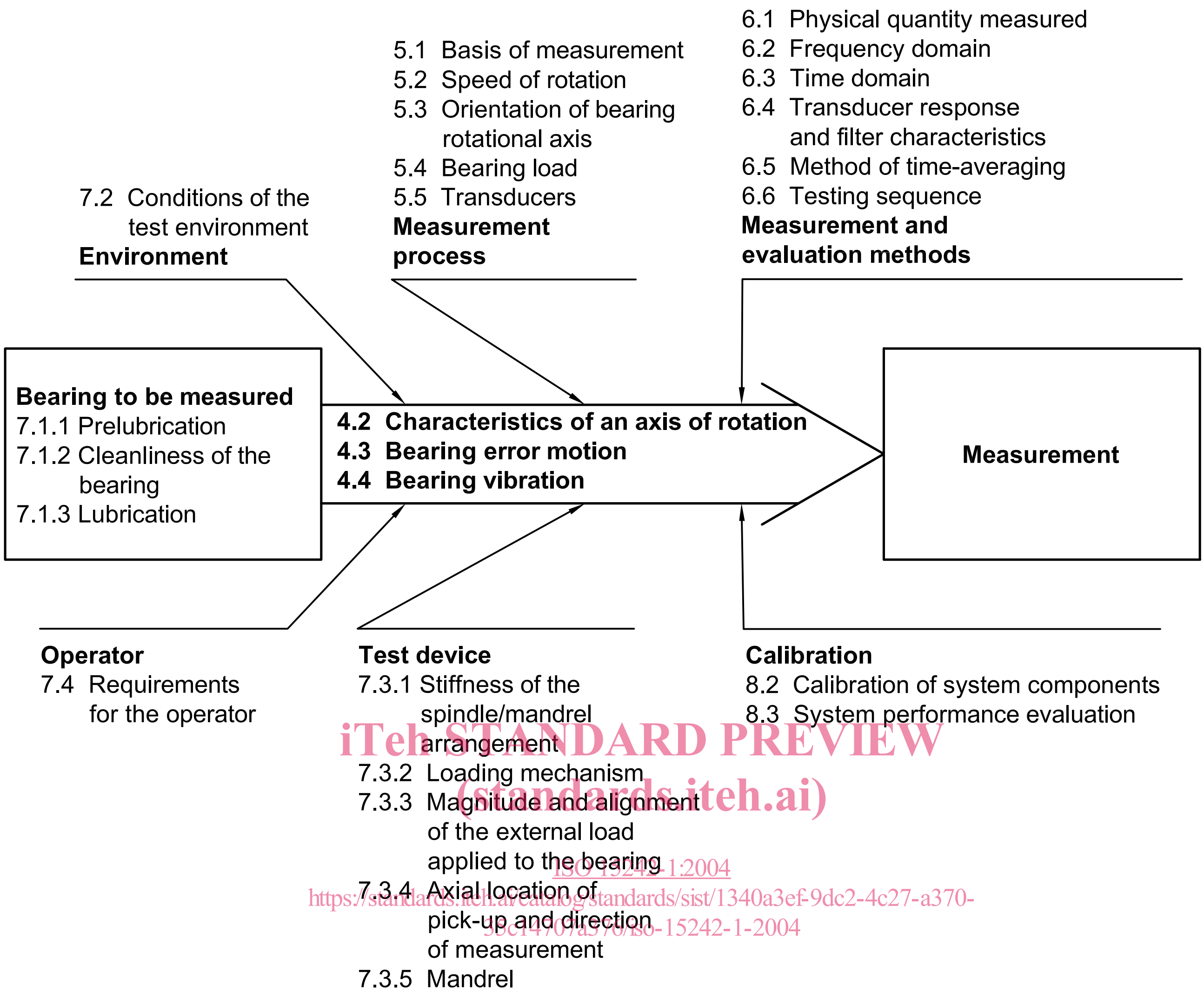
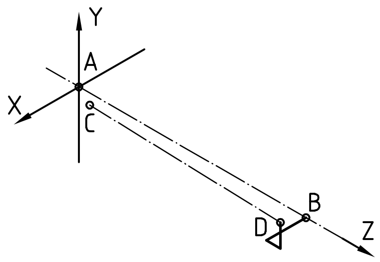


Figure 1 — Fundamental elements of bearing vibration measurement

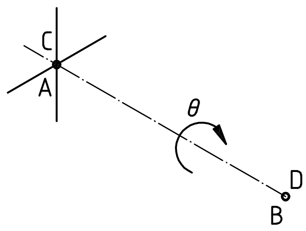
A rotating rolling bearing will, ideally, have no resistance to externally applied forces in the rotational direction, i.e. zero frictional torque. Depending on the type of external loading the bearing is designed to support, the bearing will exhibit stiffness in any or all of the five remaining degrees of freedom. For example, a bearing with self-aligning capabilities may support radial and axial loading, but will, ideally, exhibit no stiffness in the two tilt directions. Other bearings may be designed to allow free axial motion, while exhibiting radial and tilt stiffness.

4.3 Bearing error motion

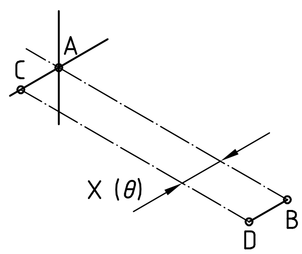
Displacement of the axis of rotation of a rotating bearing in any of the five non-rotational degrees of freedom for which the bearing is designed to support load is known as bearing error motion. This includes any displacements associated with rotation of the bearing, but excludes displacements due to thermal drift or changes in externally applied load. Error motion is reported in terms of displacement and characterizes the deviation from perfection of an axis of rotation. In a rotating rolling bearing, error motion is a consequence of geometric imperfections of the various internal bearing surfaces that undergo relative motion as the bearing rotates. These geometric imperfections may be an intrinsic characteristic of the bearing components (such as form errors in a manufactured surface), or may be the consequence of distortions of the bearing components introduced during mounting or installation.



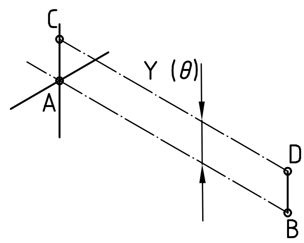
a) General case showing axis designations



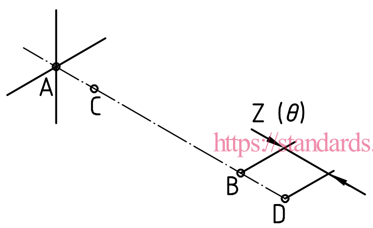
b) Rotational motion coaxial with the Z reference axis



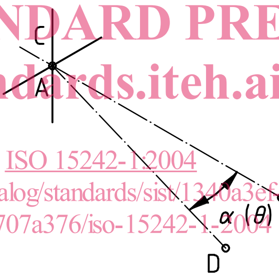
c) Radial translational motion in the X direction



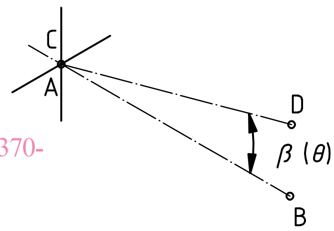
d) Radial translational motion in the Y direction



e) Axial translational motion in the Z direction



f) Tilt motion in the X direction with the origin at A



g) Tilt motion in the Y direction with the origin at A

AB = Z reference axis

CD = Axis of rotation

Figure 2 — Schematic diagrams of the six degrees of freedom of an axis of rotation

4.4 Bearing vibration

The same factors that result in bearing error motion will also result in dynamic vibration of the bearing elements. Vibration is a consequence of the displacements induced by error motion, but with the additional consideration of acceleration-dependent inertial effects and bearing/mounting stiffness characteristics, which will generate internal forces in the bearing. Internal forces will also be generated by time-variable deformations of the bearing parts, several types of non-intended motions of the rolling elements and cages and periodic displacements of the cage with respect to the rolling elements or rings. Vibration is generated by error motion under specific circumstances, such as rotational speed and applied load. Bearing vibration can affect the performance of a mechanical system and contributes, in airborne noise generation, by the system that incorporates the bearing.