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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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Contents

Page

Foreword

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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).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 4, *Rolling bearings*.

This second edition cancels and replaces the first edition (ISO 15242-1:2004), which has been technically revised.

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 spherical and tapered roller bearings with cylindrical bore and outside surface*

— *Part 4: Radial cylindrical 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, can lead to damages, and can even create health problems.

Vibration of rotating rolling bearings is a complex physical phenomenon dependent on the conditions of operation. Measuring the vibration of an individual bearing under a certain set of conditions does not necessarily characterize the vibration 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 further complicated 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 part of ISO 15242 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 measurement conditions and environment utilized in the measurement of vibration generated by rolling bearings on a measuring device. 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 a number of means using various types of transducers and measurement 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 measuring (e.g. as a manufacturing process diagnostic or an assessment of product quality) is required to select the most suitable method for measuring. 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.

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 measuring conditions, together with calibration of the related measuring systems.

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 286-2, *Geometrical product specifications (GPS) — ISO code system for tolerances on linear sizes — Part 2: Tables of standard tolerance classes and limit deviations for holes and shafts*

ISO 2041:2009, *Mechanical vibration, shock and condition monitoring — Vocabulary*

ISO 5593, *Rolling bearings — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in 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
vibration
mechanical oscillations about an equilibrium point

Note 1 to entry: The oscillations may be periodic or random.

[SOURCE: ISO 2041:2009, 2.1, modified]

3.3
transducer
device designed to convert energy from one form to another in such a manner that the desired characteristics of the input energy appear at the output

Note 1 to entry: The output is usually electrical.

Note 2 to entry: The use of the term “pick-up” is deprecated.

Note 3 to entry: Examples of types of transducers used in vibration measurement are the following:

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;

l) laser vibrometer.

Note 4 to entry: Other types of transducers such as dynamic force transducers may be used, provided their signal can be converted to displacement, velocity or acceleration.

[SOURCE: ISO 2041:2009, 4.1, modified — Note 3 to entry and Note 4 to entry have been added.]

3.4
filter
wave filter
analogue or digital device for separating oscillations on the basis of their frequency, introducing relatively small attenuation to wave oscillations in one or more frequency bands and relatively large attenuation to oscillations of other frequencies

3.5
band-pass filter
filter (3.4) which has a single transmission band extending from a lower cut-off frequency greater than zero to a finite upper cut-off frequency

3.6
nominal upper and lower cut-off frequencies
cut-off frequency
f_{upp} and f_{low}
nominal frequencies that define the *band-pass filter* (3.5)

3.7
root mean square velocity
rms velocity
$v_{rms}(t)$
square root of the average of squared values of the vibration velocity within a time interval, T

Note 1 to entry: Root mean square value can also be used for displacement and acceleration.

Note 2 to entry: In the first edition of this part of ISO 15242, root mean square was abbreviated as r.m.s.

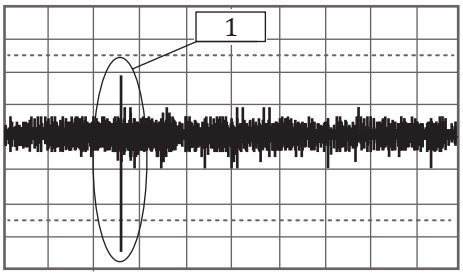
3.8
fundamental period
period
smallest increment of time for which a periodic function repeats itself

Note 1 to entry: If no ambiguity is likely, the fundamental period is called the period.

[SOURCE: ISO 2041:2009, 2.32]

3.9
spike
single significant rapid transient changes in amplitude above the general signal level

Note 1 to entry: Figure 1 shows an example for a spike.



Key
1 spike

Figure 1 — Example showing a spike phenomenon in the time domain

3.10
pulse
significant repetitive rapid transient changes in amplitude above the general signal level

Note 1 to entry: Figure 2 shows an example for a pulse.

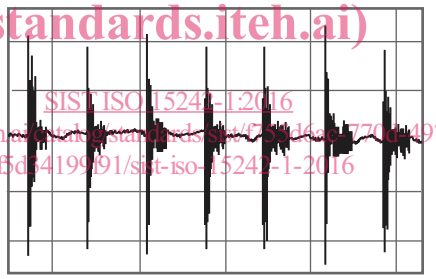


Figure 2 — Example showing a pulse phenomenon in the time domain

4 Fundamental concepts

4.1 Bearing vibration measurement

The diagram in Figure 3 shows the fundamental elements of bearing vibration measurement and the factors that influence the measurement. The numbers in Figure 3 correspond to subclauses of this part of ISO 15242.

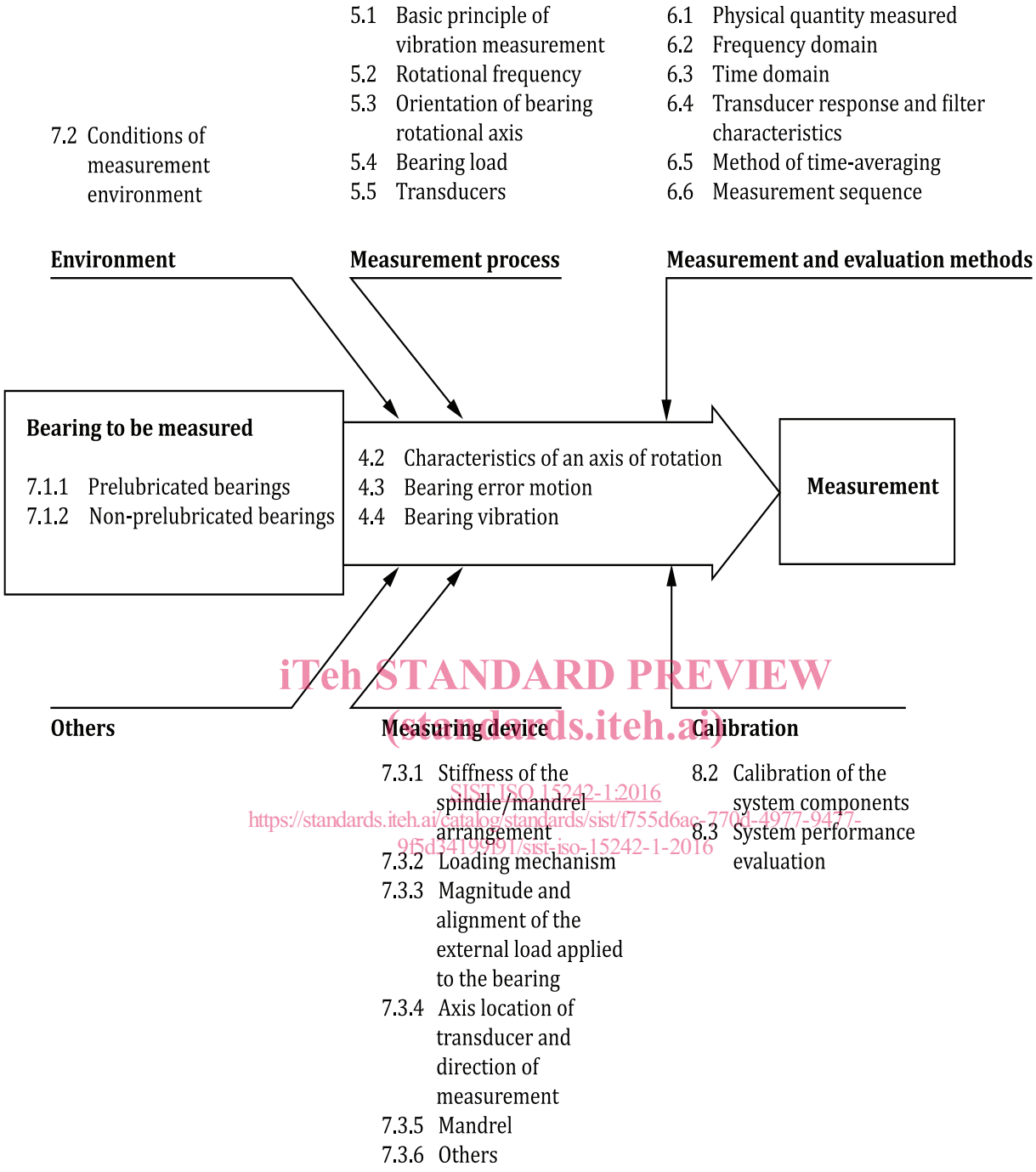


Figure 3 — Fundamental elements of bearing vibration measurement

4.2 Characteristics of an axis of rotation

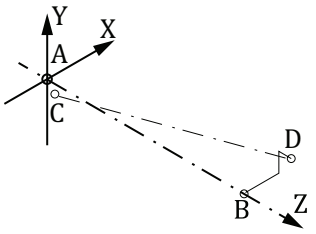
A rotating rolling bearing is designed to provide an axis of rotation for rotational motion of one machine element relative to another while supporting radial and/or axial loads. An axis of rotation may exhibit motion in six basic degrees of freedom. These are shown in Figure 4, and are listed below:

— rotational motion, see Figure 4 b);

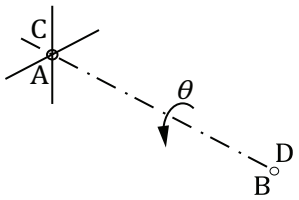
— translational motion in a radial direction, i.e. in one or both orthogonal planes passing through the axis of rotation, see Figures 4 c) and 4 d);

— translational motion in an axial direction, i.e. in a direction parallel to the axis of rotation, see Figure 4 e);

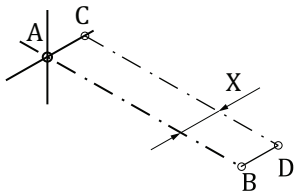
— tilt motion in an angular direction, i.e. in one or both orthogonal planes passing through the axis of rotation, see Figures 4 f) and 4 g).



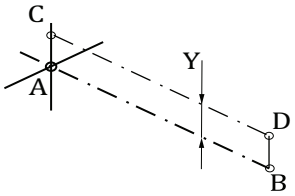
a) General case showing axis designations



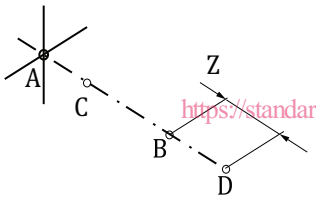
b) Rotational motion coaxial with the Z reference axis



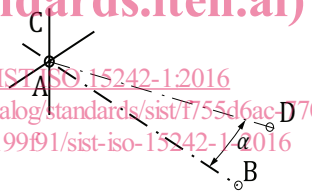
c) Radial translational motion in the X direction



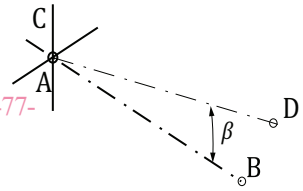
d) Radial translational motion in the Y direction



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

Key

AB Z reference axis

CD axis of rotation

Figure 4 — Schematic diagrams of the six degrees of freedom of an axis of rotation

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,