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Mechanical vibration — Rotor balancing —

Part 2:
Vocabulary

Vibrations mécaniques — Équilibrage des rotors —

Partie 2: Vocabulaire

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

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Foreword

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The committee responsible for this document is 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 21940–2 cancels and replaces ISO 1925:2001, which has been technically revised. All terms and definitions formerly contained in different balancing standards have been reviewed and compiled in this document.

A list of all parts in the ISO 21940 series can be found on the ISO website.

Mechanical vibration — Rotor balancing —

Part 2:
Vocabulary

1 Scope

This document defines terms on balancing. It complements ISO 2041, which is a general vocabulary on mechanical vibration and shock.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

— ISO Online browsing platform: available at http://www.iso.org/obp

NOTE An illustrated terminology for balancing machines is provided in Annex A.

3.1 Mechanics

3.1.1
principal axis of inertia
one of three mutually perpendicular axes intersecting each other at a given point about which the products of inertia of a solid body are zero

Note 1 to entry: In *balancing* (3.4.1), the term principal axis of inertia is used to designate the central principal axis of inertia (of the three such axes) most nearly coincident with the *shaft axis* (3.2.7) of the rotor.

[SOURCE: ISO 2041:2009, 1.34, modified — converted to singular and the notes to entry have been changed.]

3.1.2
speed
angular velocity of a rotor

Note 1 to entry: Speed is measured in revolutions per unit time or in angle (in radians) per unit time.Note 2 to entry: The quantities most frequently used for specifying speed are

n rotational speed measured in revolutions per minute;

f rotational frequency measured in revolutions per second;

Ω angular velocity measured in radians per second.

3.1.3
resonance speed
DEPRECATED: critical speed
DEPRECATED: resonant speed
characteristic speed at which resonances of a system are excited

Note 1 to entry: In the context of *balancing* (3.4.1), a resonance speed is related only to the once-per-revolution component of vibration.

[SOURCE: ISO 2041:2009, 2.85, modified — the notes to entry have been changed.]

3.1.4
rigid-body-mode resonance speed
resonance speed (3.1.3) of a rotor at which flexure of the rotor can be neglected

3.1.5
flexural resonance speed
resonance speed (3.1.3) of a rotor at which flexure of the rotor cannot be neglected

3.1.6
service speed
angular velocity at which a rotor operates in its final installation or environment

3.1.7
balancing speed
angular velocity at which rotor *balancing* (3.4.1) is performed

3.1.8
axis of rotation
instantaneous line about which a body rotates

3.1.9
rigid body mode
mode shape of a rotor corresponding to a *rigid-body-mode resonance speed* (3.1.4) for a given support system

3.1.10
flexural mode
mode shape of a rotor corresponding to a *flexural resonance speed* (3.1.5) for a given support system

3.1.11
shape function of the *n*th flexural mode
$\phi_n(z)$
mathematical expression for the deflection shape of the rotor in the corresponding *flexural mode* (3.1.10) normalized so that the maximum deflection is unity

Note 1 to entry: Frequently, it is assumed that the modes are mutually orthogonal and the system is axially symmetric. This is not applicable in all cases.

3.1.12
modal amplification factor
M_n
ratio of the magnitude of the modal vibration displacement vector to the magnitude of the modal eccentricity for the *n*th *flexural mode* (3.1.10)

Note 1 to entry: Modal amplification factor is a non-dimensional quantity. It is expressed for the *n*th mode as

$$M_n = \frac{(\Omega/\omega_n)^2}{\sqrt{\left[1-(\Omega/\omega_n)^2\right]^2 + 4\zeta_n^2(\Omega/\omega_n)^2}}$$

where

Ω is the angular velocity expressed in radians per second;

ω_n is the undamped natural angular frequency expressed in radians per second;

ζ_n is the *modal damping ratio* (3.1.13).

Note 2 to entry: The modal amplification factor at the *flexural resonance speed* (3.1.5) is called “modal sensitivity”.

3.1.13
modal damping ratio
ζ_n
measure of the damping effect on the *n*th *flexural mode* (3.1.10)

3.2 Rotor systems

3.2.1
rigid behaviour
rotor where the flexure caused by its *unbalance* (3.3.1) distribution can be neglected with respect to the agreed *unbalance tolerance* (3.4.12) at any speed up to the maximum *service speed* (3.1.6)

Note 1 to entry: A rotor that behaves as rigid under one set of conditions [e.g. *service speed* (3.1.6), *initial unbalance* (3.3.10) and *unbalance tolerances* (3.4.12)] may not behave as rigid under another set of conditions.

3.2.2
flexible behaviour
rotor where the flexure caused by its *unbalance* (3.3.1) distribution cannot be neglected with respect to the agreed *unbalance tolerance* (3.4.12) at any speed up to the maximum *service speed* (3.1.6)

Note 1 to entry: Flexible behaviour includes *shaft-elastic behaviour* (3.2.3), settling behaviour (i.e. unbalance indication irreversibly changes after the first run-up) and component-elastic behaviour (i.e. unbalance indication reversibly changes with speed due to displacement of rotor components other than the shaft).

3.2.3
shaft-elastic behaviour
rotor where the elastic flexure due to *modal unbalances* (3.3.16) cannot be neglected with respect to the agreed *unbalance tolerances* (3.4.12)

Note 1 to entry: Shaft-elastic behaviour of a rotor is a subset of *flexible behaviour* (3.2.2).

3.2.4
journal
part of a rotor that is supported radially or guided by a bearing in which it rotates

3.2.5
journal axis
mean straight line joining the centroids of cross-sectional contours of a *journal* (3.2.4)

3.2.6
journal centre
intersection of the *journal axis* (3.2.5) and the radial plane of the *journal* (3.2.4) where the resultant transverse bearing force acts

3.2.7
shaft axis
line joining the *journal centres* (3.2.6) which follows the deflected shape of the rotor due to gravity or any other constant force

3.2.8
inboard rotor
rotor that has its centre of mass located between the *journals* (3.2.4)

3.2.9
outboard rotor
rotor that has its centre of mass located other than between the *journals* (3.2.4)

3.2.10
mass eccentricity
radial distance between a centre of mass and the *shaft axis* (3.2.7)

Note 1 to entry: See also *specific unbalance* (3.3.15).

3.2.11
slow-speed runout
real or apparent deflection measured on the rotor surface at a slow *speed* (3.1.2) where no vibration is caused by *unbalance* (3.3.1)

Note 1 to entry: Depending upon the transducer used, a slow-speed runout can contain mechanical, magnetic or electrical components.

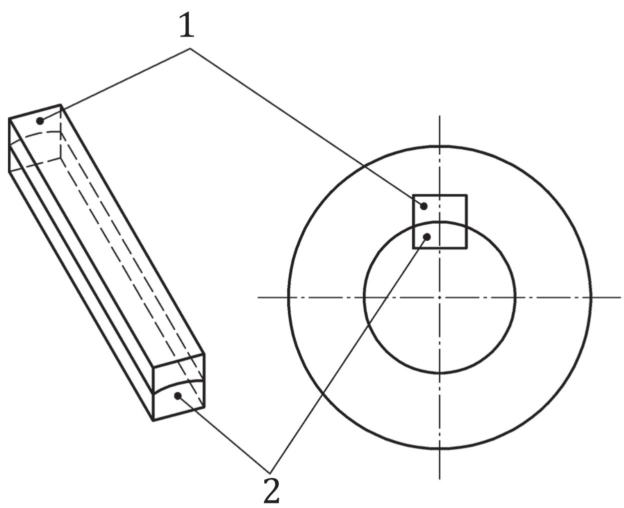
3.2.12
fitment
component of a rotor which has to be mounted on a shaft, a *balancing mandrel* (3.5.14) or a balancing adapter so that its *unbalance* (3.3.1) can be determined

EXAMPLE Couplings, pulleys, pump impellers, blower fans and grinding wheels.

3.2.13
spigot
type of interface used in the coupling of rotor components to maintain concentricity

3.2.14
half-key
key used in *balancing* (3.4.1), having the *unbalance* (3.3.1) value of that portion of the final (full) key which occupies either the shaft keyway or the *fitment* (3.2.12) keyway in the final assembly

Note 1 to entry: See Figure 1.



Key
1 half-key for fitment
2 half-key for shaft

Figure 1 — Contoured half-key set

3.3 Unbalance

3.3.1
unbalance
condition that exists in a rotor when vibration force or motion is imparted to it and its bearings from centrifugal forces of *mass eccentricities* (3.2.10)

3.3.2
unbalance mass
mass whose centre is at a radial distance from the *shaft axis* (3.2.7)

3.3.3
unbalance vector
vector whose magnitude is the *amount of unbalance* (3.3.4) and whose direction is the *angle of unbalance* (3.3.5)

3.3.4
amount of unbalance
product of the *unbalance mass* (3.3.2) and the radial distance of its centre of mass from the *shaft axis* (3.2.7)

3.3.5
angle of unbalance
polar angle at which an *unbalance mass* (3.3.2) is located with reference to the given rotating coordinate system, fixed in a plane perpendicular to the *shaft axis* (3.2.7) and rotating with the rotor

3.3.6
static unbalance
component of the *unbalance* (3.3.1) that corresponds to a parallel misalignment of the central *principal axis of inertia* (3.1.1) of the rotor with respect to the *shaft axis* (3.2.7)

Note 1 to entry: The amount of the static unbalance is equal to the product of the total mass of the rotor and the radial distance of its centre of mass from the shaft axis.

3.3.7
moment unbalance
component of the *unbalance* (3.3.1) that corresponds to an inclined central *principal axis of inertia* (3.1.1) intersecting the *shaft axis* (3.2.7) at the centre of mass

Note 1 to entry: The dimension of a moment unbalance is mass times length squared.

Note 2 to entry: This condition can be produced by two *unbalance vectors* (3.3.3) with equal amounts and opposing directions, acting in two different planes perpendicular to the shaft axis, which thereby constitute a *couple unbalance* (3.3.8).

3.3.8
couple unbalance
two *unbalance vectors* (3.3.3) with equal amounts and opposing directions, acting in two different planes perpendicular to the *shaft axis* (3.2.7)

Note 1 to entry: A couple unbalance is an alternative representation of a *moment unbalance* (3.3.7) with the amount of each of the two unbalance vectors calculated by dividing the amount of moment unbalance by the distance between the two planes of the couple unbalance.

3.3.9
dynamic unbalance
state of *unbalance* (3.3.1) that corresponds to the central *principal axis of inertia* (3.1.1) having any inclined and offset position relative to the *shaft axis* (3.2.7)

Note 1 to entry: This condition can be produced by adding a *couple unbalance* (3.3.8) and a *static unbalance* (3.3.6) to an unbalance-free rotor.

Note 2 to entry: This condition can be produced equivalently by two *unbalance vectors* (3.3.3) acting in two different planes perpendicular to the shaft axis.

3.3.10
initial unbalance
unbalance (3.3.1) of any kind that exists in a rotor before *balancing* (3.4.1)

3.3.11
residual unbalance
unbalance (3.3.1) of any kind that remains in a rotor after *balancing* (3.4.1)

3.3.12
resultant unbalance
U_r
vector sum of all *unbalance vectors* (3.3.3) distributed along the rotor

3.3.13
resultant moment unbalance
P_r
vector sum of the moments of all the *unbalance vectors* (3.3.3) distributed along the rotor with respect to an arbitrarily selected plane perpendicular to the *shaft axis* (3.2.7)

3.3.14
resultant couple unbalance
C_r
pair of two *unbalance vectors* (3.3.3) of equal magnitude acting in opposite directions in two arbitrarily selected planes perpendicular to the *shaft axis* (3.2.7) thereby constituting a *moment unbalance* (3.3.7) equivalent to the *resultant moment unbalance* (3.3.13)

3.3.15
specific unbalance
e
amount of unbalance (3.3.4) divided by the mass of the rotor

Note 1 to entry: The specific unbalance calculated with the amount of *static unbalance* (3.3.6) is numerically equivalent to the *mass eccentricity* (3.2.10).

3.3.16
***n*th modal unbalance**
U_n
unbalance (3.3.1) distribution which only affects the *n*th *flexural mode* (3.1.10) of a rotor and support system

3.3.17
equivalent *n*th modal unbalance
U_{ne}
minimum single *unbalance* (3.3.1) equivalent to the *n*th *modal unbalance* (3.3.16) in its effect on the *n*th *flexural mode* (3.1.10)

Note 1 to entry: The calculated quantity “equivalent *n*th modal unbalance” corresponds to an unbalance imagined to be fixed in that plane perpendicular to the *shaft axis* (3.2.7) and positioned within the main part of the rotor where the deflection of the corresponding *n*th flexural mode has its maximum absolute value.

Note 2 to entry: An unbalance equal in amount and position to the equivalent *n*th modal unbalance affects some modes other than the *n*th flexural mode when attached to the rotor.

3.3.18
balance quality grade
rotor unbalance classification which is the product of the *specific unbalance* (3.3.15) and the maximum *service speed* (3.1.6)

3.4 Balancing

3.4.1
balancing
procedure by which the mass distribution of a rotor is examined and, if necessary, adjusted to ensure that the *residual unbalances* (3.3.11) are within specified limits

3.4.2
single-plane balancing
procedure by which the mass distribution of a rotor is examined and, if necessary, corrected, usually in a single *correction plane* (3.4.7), to ensure that the residual *resultant unbalance* (3.3.12) is within specified limits

3.4.3
two-plane balancing
procedure by which the mass distribution of a rotor is examined and, if necessary, corrected, usually in two *correction planes* (3.4.7), to ensure that the residual *dynamic unbalance* (3.3.9) is within specified limits

3.4.4
multiplane balancing
balancing (3.4.1) procedure that requires *correction* (3.4.6) in more than two *correction planes* (3.4.7)

3.4.5
modal balancing
procedure for the *balancing* (3.4.1) of rotors with *shaft-elastic behaviour* (3.2.3) in which *corrections* (3.4.6) are made to ensure that the residual *modal unbalances* (3.3.16) (as well as the amplitude of vibration generated by it) in the separate *flexural modes* (3.1.10) are within specified limits

3.4.6
correction
part of the *balancing* (3.4.1) procedure by which the mass distribution of a rotor is adjusted to reduce *unbalance* (3.3.1)

Note 1 to entry: Corrections are usually made by adding material to the rotor, removing material from the rotor or by shifting material to a different position on the rotor.

3.4.7
correction plane
plane perpendicular to the *shaft axis* (3.2.7) of a rotor in which *correction* (3.4.6) for *unbalance* (3.3.1) is made

3.4.8
measuring plane
plane perpendicular to the *shaft axis* (3.2.7) in which the *unbalance vector* (3.3.3) is determined

3.4.9
reference plane
plane perpendicular to the *shaft axis* (3.2.7) to which an *amount of unbalance* (3.3.4) is referred

3.4.10
tolerance plane
reference plane (3.4.9) for which an *unbalance tolerance* (3.4.12) is specified

3.4.11
test plane
plane perpendicular to the *shaft axis* (3.2.7) of a rotor in which a *test mass* (3.4.18) may be attached

Note 1 to entry: In most cases, the test plane is also a *correction plane* (3.4.7).

