INTERNATIONAL STANDARD

ISO 21940-2

First edition
2017-05

Mechanical vibration — Rotor balancing —

Part 2: Vocabulary

Vibrations mécaniques — Équilibrage des rotors —

Partie 2: Vocabulaire

Reference number
ISO 21940-2:2017(E)

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

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.

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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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.

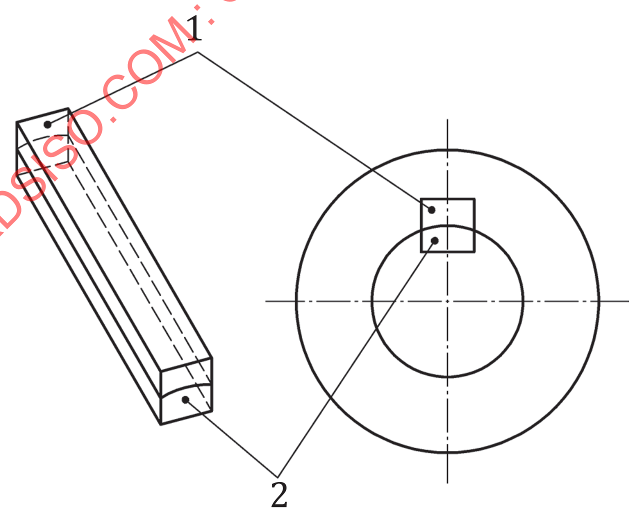
3.2.12
fitment
component of a rotor which has to be mounted on a shaft, a *balancing mandrel* (3.5.14) or a balancing adapter so that its *unbalance* (3.3.1) can be determined

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).

3.4.12
unbalance tolerance
amount of unbalance (3.3.4) that is specified as the maximum up to which the state of *unbalance* (3.3.1) is considered to be acceptable

3.4.13
permissible residual unbalance
U_{per}
numerical value of the *unbalance tolerance* (3.4.12)

Note 1 to entry: The permissible residual unbalance is an overall value for a rotor derived from the *balance quality grade* (3.3.18).

3.4.14
***in-situ* balancing**
DEPRECATED: field balancing
process of *balancing* (3.4.1) a rotor in its operational situation (with operational drive, bearings and supporting structure) instead of in a *balancing machine* (3.5.1)

3.4.15
correction mass
known *unbalance mass* (3.3.2) attached to a rotor in a given *correction plane* (3.4.7) at a known radial distance from the *shaft axis* (3.2.7) for the purpose of *correction* (3.4.6)

Note 1 to entry: The same correction can be effected by removing mass from the opposite side of the rotor or by moving masses to different positions.

3.4.16
calibration mass
known *unbalance mass* (3.3.2) used for calibration

3.4.17
trial mass
unbalance mass (3.3.2) selected arbitrarily (or by prior experience with similar rotors) and attached to a rotor to determine the rotor response

3.4.18
test mass
precisely defined mass to be attached to a rotor at a precisely defined position to provide a precisely defined change of the state of *unbalance* (3.3.1), frequently used in combination with other test masses to establish a test mass set for the evaluation of a *balancing machine* (3.5.1)

3.4.19
bias unbalance
unbalance (3.3.1) added to a *balancing mandrel* (3.5.14) or a drive adapter to create a desired unbalance bias

3.4.20
indexing
incrementally rotating a rotor or component of a rotor assembly for the purpose of bringing it to a desired angular position

3.4.21
index balancing
procedure whereby the rotor is *indexed* (3.4.20) relative to the balance tooling to enable the evaluation and, if necessary, the *correction* (3.4.6) of the rotor's *unbalance* (3.3.1) without the influence of the tooling

Note 1 to entry: More generally on multipart rotors, where parts can be rotated with respect to each other, it is possible to use index balancing to evaluate and, if necessary, correct the unbalance contributions from each part separately.

3.4.22
balancing in stages during assembly
DEPRECATED: progressive balancing
DEPRECATED: sequential balancing
procedure by which one or more components of a group of rotor components are added to a balanced shaft, the *unbalance* (3.3.1) of the assembly being then corrected for these component(s) and this process being repeated until the assembly is completed

3.4.23
trim balancing
correction (3.4.6) of small *residual unbalances* (3.3.11), often carried out *in situ*

3.4.24
low-speed balancing
procedure for *balancing* (3.4.1) at a *balancing speed* (3.1.7) where the rotor exhibits *rigid behaviour* (3.2.1)

3.4.25
high-speed balancing
procedure for *balancing* (3.4.1) at one or more *balancing speeds* (3.1.7) where the rotor exhibits *flexible behaviour* (3.2.2)

3.4.26
susceptibility to unbalance
indication of the likelihood of a rotor having a change of *unbalance* (3.3.1) over a certain period of operation

3.4.27
local sensitivity
ratio of the magnitude of the change of the measured vibration vector in a specified *measuring plane* (3.4.8) to the magnitude of the corresponding change of the *unbalance* (3.3.1) in a specified plane in the rotor at a specified *speed* (3.1.2)

3.4.28
influence coefficient
ratio of the vector of the change of vibration in a specified *measuring plane* (3.4.8) to the vector of the change of the *unbalance* (3.3.1) in a specified plane in the rotor at a specified *speed* (3.1.2), when each of the vectors is expressed by a complex number

Note 1 to entry: The *local sensitivity* (3.4.27) is equal to the magnitude of the influence coefficient.

3.5 Balancing machines

3.5.1
balancing machine
machine or facility that enables the *unbalance* (3.3.1) in a rotor to be measured and corrected

Note 1 to entry: Single-plane balancing machines can only be used for *single-plane balancing* (3.4.2).

Note 2 to entry: Two-plane balancing machines can be used to carry out *single-plane balancing* (3.4.2) and *two-plane balancing* (3.4.3).

3.5.2
hard-bearing balancing machine
balancing machine (3.5.1) having a *balancing speed* (3.1.7) range below the natural frequency of the combined rotor and support system

3.5.3
soft-bearing balancing machine
balancing machine (3.5.1) having a *balancing speed* (3.1.7) range above the natural frequency of the combined rotor and support system

3.5.4
compensator
facility built into a *balancing machine* (3.5.1) to adjust the *unbalance* (3.3.1) reading

EXAMPLE Adjustment of the unbalance reading can be necessary to compensate for the effect of the *initial unbalance* (3.3.10).

3.5.5
correction plane interference ratio
I_{AB}, I_{BA}
ratio of the change in *unbalance* (3.3.1) indication for one *correction plane* (3.4.7) and the change in unbalance indication for the other correction plane of a *proving rotor* (3.5.15) inducing the change in indication

Note 1 to entry: The interference ratio of correction plane A is calculated by

$$I_{AB} = \frac{U_{AB}}{U_{BB}}$$

where

U_{AB} is the change in unbalance indication for correction plane A induced by a change in unbalance in correction plane B;

U_{BB} is the associated change in unbalance indication for correction plane B.

Note 2 to entry: For the correction plane interference ratio for correction plane B, I_{BA}, exchange A and B in Note 1.

3.5.6
couple unbalance interference ratio
I_{SC}
ratio of the change in *static unbalance* (3.3.6) indication and the change in *couple unbalance* (3.3.8) inducing the change in indication

Note 1 to entry: The couple unbalance interference ratio is calculated by

$$I_{SC} = \frac{U_S}{U_C}$$

where

U_S is the change in static unbalance indication induced by a change in couple unbalance;

U_C is the change in couple unbalance.

3.5.7
plane separation
capability of a *balancing machine* (3.5.1) to minimize the *correction plane interference ratio* (3.5.5)

3.5.8
unbalance reduction ratio
R_{UR}
ratio of the reduction in the *unbalance* (3.3.1) by a single unbalance *correction* (3.4.6) to the *initial unbalance* (3.3.10) as shown by

$$R_{UR} = \frac{U_1 - U_2}{U_1} = 1 - \frac{U_2}{U_1}$$

where

U_1 is the amount of initial unbalance;

U_2 is the *amount of unbalance* (3.3.4) remaining after one correction

3.5.9
minimum achievable residual unbalance
U_{mar}
smallest amount of *residual unbalance* (3.3.11) that a *balancing machine* (3.5.1) is capable of achieving under given conditions

3.5.10
minimum achievable residual specific unbalance
e_{mar}
smallest amount of residual *specific unbalance* (3.3.15) that a *balancing machine* (3.5.1) is capable of achieving under given conditions

3.5.11
claimed minimum achievable residual unbalance
$U_{mar,cl}$
amount of *minimum achievable residual unbalance* (3.5.9) stated by the manufacturer of a *balancing machine* (3.5.1)

3.5.12
measuring run
procedure of rotating the rotor to be balanced at *balancing speed* (3.1.7) to obtain information on *unbalance* (3.3.1) and *correction* (3.4.6)

3.5.13
balancing run
procedure consisting of one *measuring run* (3.5.12) followed by the associated *correction* (3.4.6) process

3.5.14
balancing mandrel
machined shaft on which a *fitment* (3.2.12) is mounted for *balancing* (3.4.1)

3.5.15
proving rotor
rotor with *rigid behaviour* (3.2.1) of suitable mass, designed for testing *balancing machines* (3.5.1), and balanced sufficiently to permit the introduction of *unbalances* (3.3.1) by means of *test masses* (3.4.18) with appropriate accuracy and reproducibility of the magnitude and angular position

Annex A
(informative)

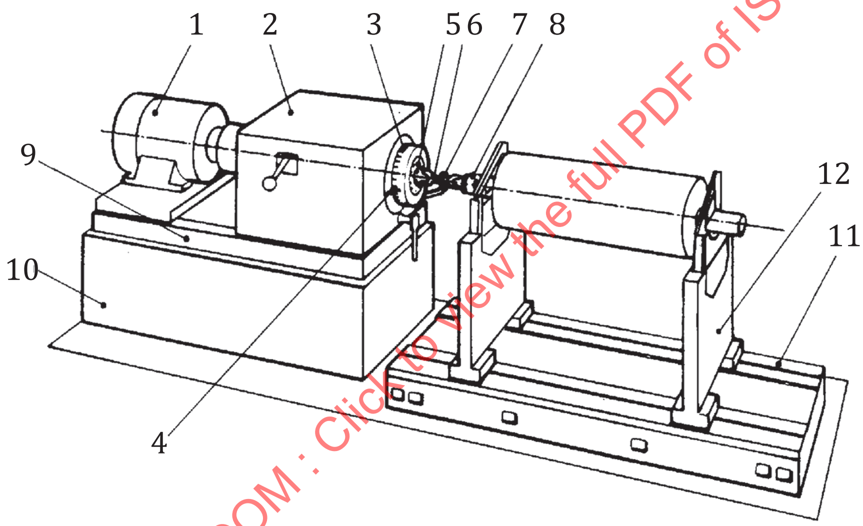
Illustrated terminology for balancing machines

A.1 General

This annex provides illustrated terminology for balancing machines. It applies to all forms of communication, e.g. technical correspondence, specification and catalogues.

A.2 Figures illustrating terms

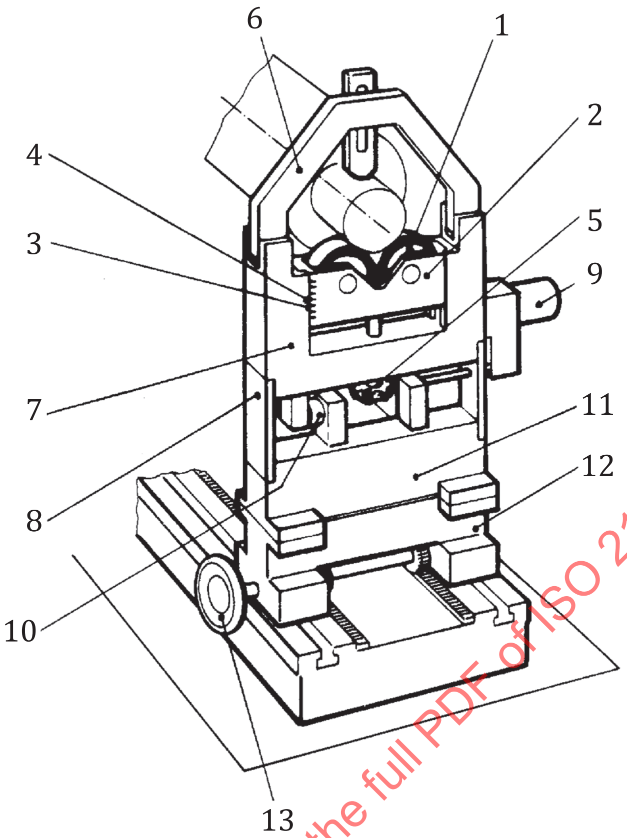
Some terms defined in this document are illustrated in Figure A.1 to Figure A.20.



Key

1 drive motor
2 headstock
3 protractor or angle scale
4 index mark
5 face plate
6 universal joint drive shaft
7 drive shaft safety guard
8 drive adapter
9 sub-base
10 plinth
11 bed
12 support

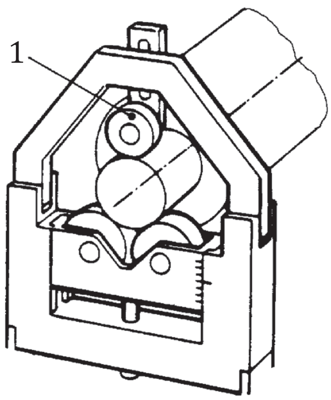
Figure A.1 — Balancing machine with end-drive



Key

1	open roller
2	roller carriage
3	journal diameter scale
4	index mark
5	height adjustment
6	safety bracket (hold-down)
7	bearing bridge
8	suspension springs
9	transducer
10	transducer (alternative position)
11	support
12	riser
13	moving gear (axial adjustment)

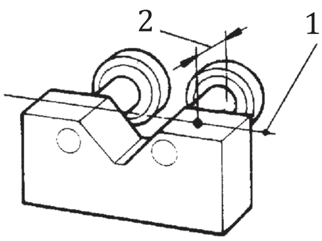
Figure A.2 — Support assembly



Key

1 negative load roller

Figure A.3 — Hold-down with negative load bearing

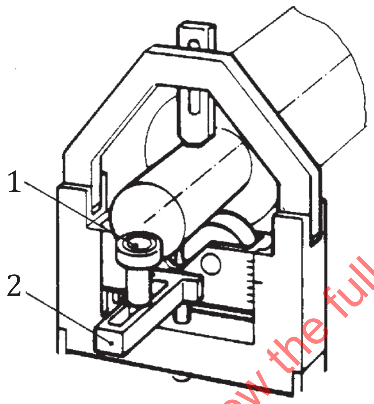


Key

1 centreline of support

2 offset

Figure A.4 — Offset roller carriage

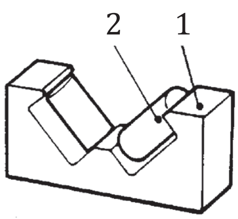


Key

1 roller

2 bracket

Figure A.5 — Axial thrust stop



Key

1 V-roller carriage

2 inclined rollers

Figure A.6 — V-roller carriage

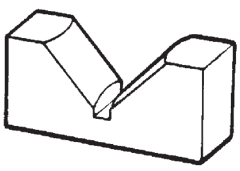
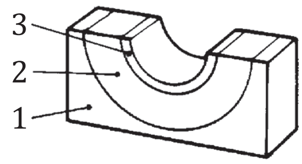


Figure A.7 — V-block



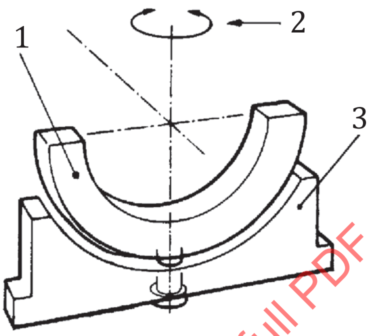
Key

1 sleeve-bearing carriage

2 liner

3 half-sleeve bearing (hydrodynamic or hydrostatic)

Figure A.8 — Half-sleeve-bearing carriage



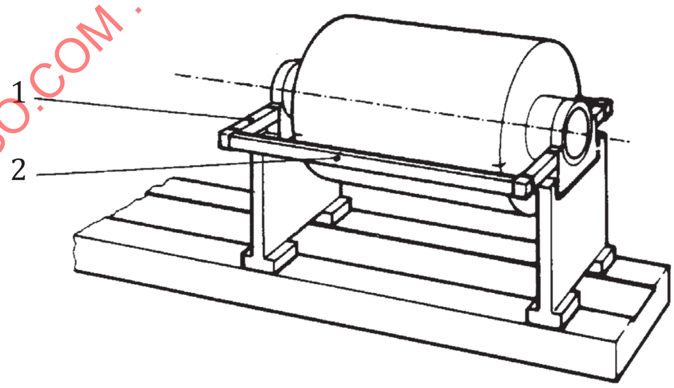
Key

1 saddle

2 degree of freedom

3 vertical axis saddle-bearing carriage

Figure A.9 — Saddle-bearing assembly

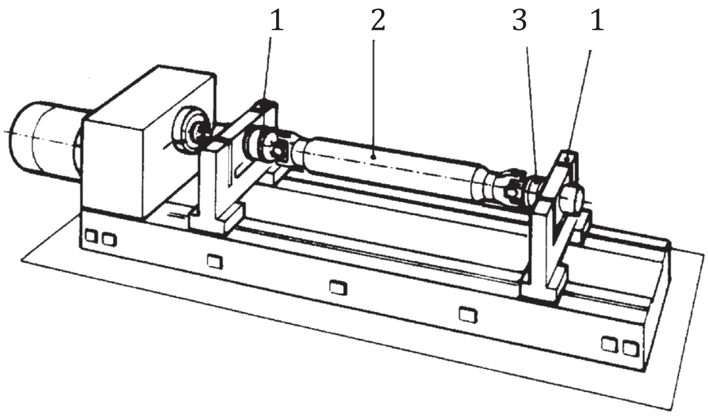


Key

1 tiebar arm

2 tiebar

Figure A.10 — Tiebar frame



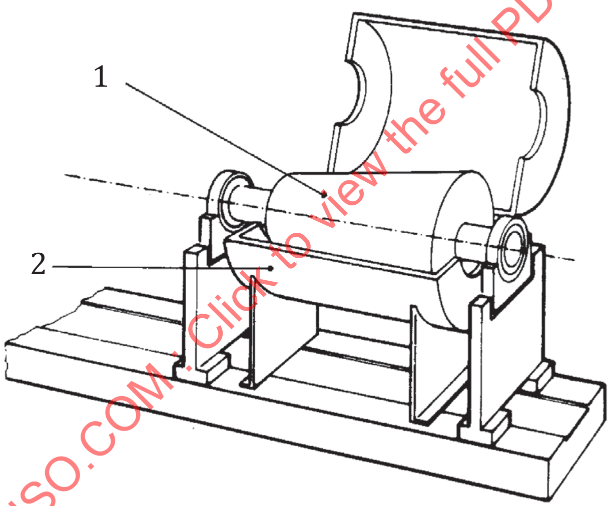
Key

1 support

2 rotor

3 spindle

Figure A.11 — Support with spindle heads

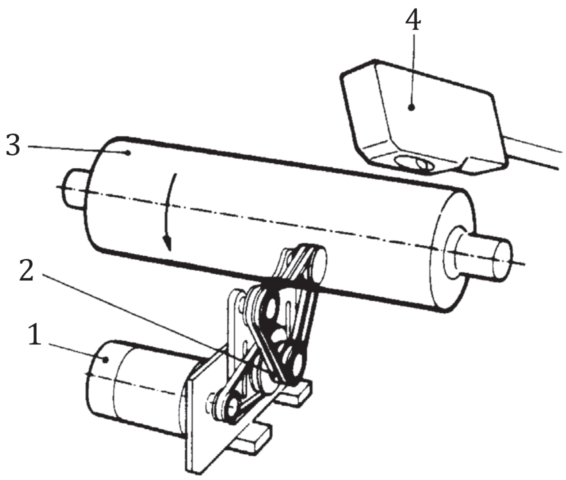


Key

1 rotor

2 rotor enclosure

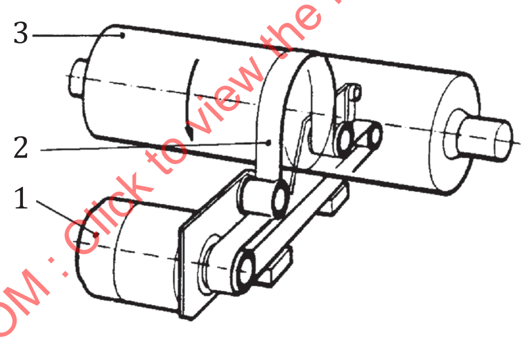
Figure A.12 — Rotor enclosure



Key

1 drive motor
2 driving belt
3 rotor
4 scanning head (typical for machines with other than end-drive)

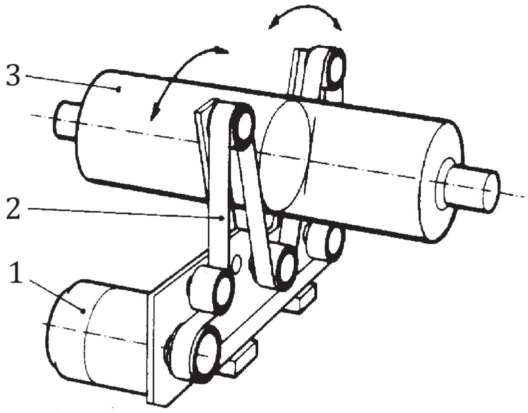
Figure A.13 — Tangential belt-drive



Key

1 drive motor
2 driving belt
3 rotor

Figure A.14 — Underslung belt-drive



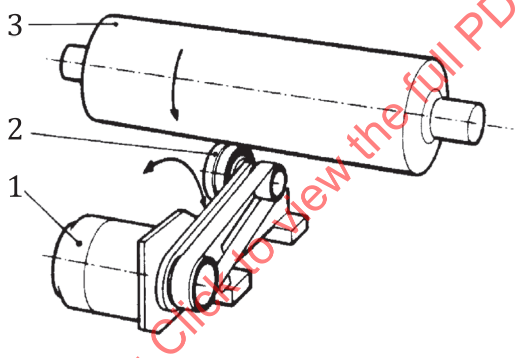
Key

1 drive motor

2 driving belt

3 rotor

Figure A.15 — Scissor-type belt-drive



Key

1 drive motor

2 friction roll

3 rotor

Figure A.16 — Friction roller-drive