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Mechanical vibration — Balancing machines — Description and evaluation

Vibrations mécaniques — Machines à équilibrer — Description et évaluation

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Contents

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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.

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.

International Standard ISO 2953 was prepared by Technical Committee ISO/TC 108, *Mechanical vibration and shock,* Subcommittee SC 1, *Balancing, including balancing machines.*

This third edition cancels and replaces the second edition (ISO 2953:1985). It contains revised and more detailed recommendations for testing the capability of balancing machines, including outboard proving rotors and overhung test planes. It replaces the previous edition of this document.

Annex A is an integral part of this International Standard. Annexes B to F are for information only.

Mechanical vibration — Balancing machines — Description and evaluation

1 Scope

This International Standard gives requirements for the evaluation of the performance and characteristics of machines for balancing rotating components. It stresses the importance attached to the form in which the balancing machine characteristics should be specified by the manufacturers and also outlines criteria and tests for evaluating balancing machines. Adoption of the format suggested in 4.1 and 4.2 makes it easier for the user to compare products of the different manufacturers. Guidance as to the manner in which users should state their requirements is given in annex B.

Details of proving rotors, test masses and performance tests to be employed to ensure compliance with specified unbalance indicating capability are given. Tests for other machine capacities and performance parameters are not contained in this International Standard.

Annex E describes recommended modifications of old ISO proving rotors.

This International Standard does not specify balancing criteria; these are specified in ISO 1940-1.

This International Standard is applicable to balancing machines that support and rotate workpieces which are rigid at balancing speed, and that indicate the amounts and angular locations of required unbalance corrections in one or more planes. It covers both the machines that measure out-of-balance effects on soft bearings and those that measure this on hard bearings.

Technical requirements for such balancing machines are included, however, special features, such as those associated with automatic correction, are excluded.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 1925:1990, *Mechanical vibration — Balancing — Vocabulary.*

3 Definitions

For the purposes of this International Standard, the definitions given in ISO 1925 and those given in annex A apply.

4 Capacity and performance data of the machine

The manufacturer shall specify the data listed in 4.1 for horizontal or 4.2 for vertical machines respectively, as applicable, and in a similar format.

4.1 Data of horizontal machines

4.1.1 Rotor mass and unbalance limitations

4.1.1.1 The maximum mass of rotor which can be balanced shall be stated over the range of balancing speeds.

The maximum moment of inertia [(mass × (radius of gyration)^2] of a rotor with respect to the shaft axis which the machine can accelerate in a stated acceleration time shall be given for the range of balancing speeds (n_1, n_2, ...) together with the corresponding cycle rate (see table 1).

Table 1 — Data of horizontal machines

Manufacturer: ..... **Model.....**						
Balancing speeds or speed ranges (see also 4.1.3.1)		n_1	n_2	n_3	n_4	n_5
Rotor mass kg (see note 1)	maximum					
	minimum					
Occasional overload force per support (see note 1) N						
Maximum negative force per support (see note 1) N						
Maximum rotor moment of inertia with respect to the shaft axis (see note 2) kg·m^2						
Cycle rate (see note 2)						
Maximum unbalance g·mm/kg or g·mm (see note 3)	measurable					
	permissible					
a) For inboard rotors Minimum achievable residual specific unbalance, e_{mar}, g·mm/kg (see note 4 and clause 6)	maximum mass					
	0,2 × max. mass					
	minimum mass					
Corresponding deflection of analog amount-of-unbalance indicator, mm Number of digital units (see note 4)	maximum mass					
	0,2 × max. mass					
	minimum mass					
b) For outboard rotors Minimum achievable residual specific unbalance, e_{mar}, g·mm/kg (see note 4 and clause 6)	maximum mass					
	0,2 × max. mass					
	minimum mass					
Corresponding deflection of analog amount-of-unbalance indicator, mm Number of digital units (see note 4)	maximum mass					
	0,2 × max. mass					
	minimum mass					

4.1.1.2 Production efficiency (see clause 7) shall be stated, as follows.

4.1.1.2.1 Time per measuring run:

a) Time for mechanical adjustment: ..... s

b) Time for setting indicating system: ..... s

c) Time for preparation of rotor: ..... s

d) Average acceleration time: ..... s

e) Reading time (including time to stabilize): ..... s

f) Average deceleration time: ..... s

g) Relating readings to rotor: ..... s

h) Other necessary time: ..... s

i) Total time per measuring run [a) to h) above]: ..... s

4.1.1.2.2 Unbalance reduction ratio for inboard rotors: ..... %

4.1.1.2.3 Unbalance reduction ratio for outboard rotors: ..... %

4.1.2 Rotor dimensions

4.1.2.1 Adequate envelope drawings of the pedestals and of other obstructions, such as belt-drive mechanism, shroud mounting pads, thrust arms and tie bars, shall be supplied to enable the user to determine the maximum rotor envelope that can be accommodated and the tooling and/or adaptors required.

A combination of large journal diameter and high balancing speed may result in an excessive journal peripheral speed. The maximum journal peripheral speed shall be stated.

When belt drive is supplied, balancing speeds shall be stated for both the maximum and minimum diameters over which the belt can drive, or other convenient diameter.

The manufacturer shall state if the axial position of the drive can be adjusted.

4.1.2.2 Rotor envelope limitations (see figure 1) shall be stated.

4.1.2.3 Rotor diameter:

a) Maximum diameter over bed: ..... mm

b) Maximum diameter over which belt can drive: ..... mm

c) Minimum diameter over which belt can drive: ..... mm

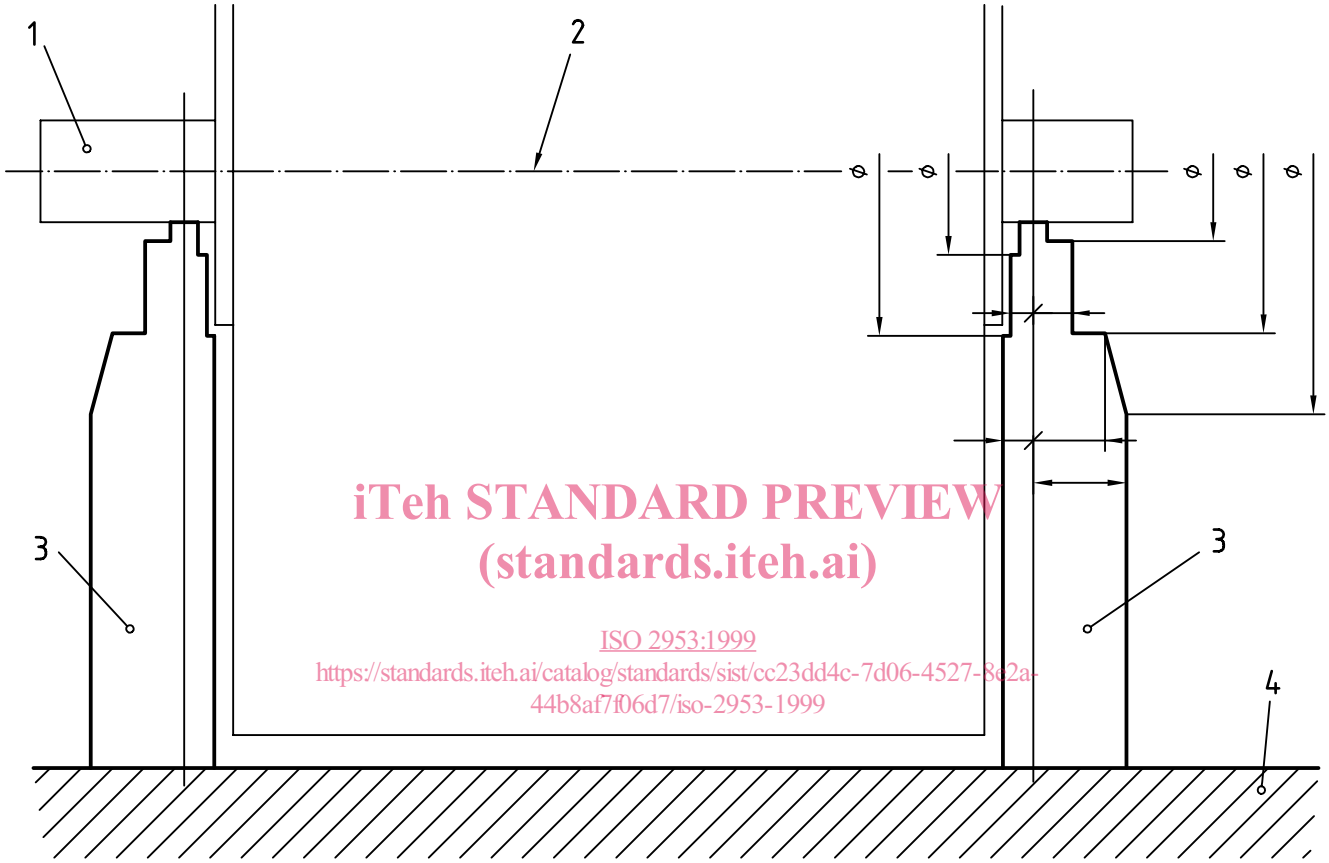
4.1.2.4 Distance between journal centrelines:

a) Maximum: ..... mm

b) Minimum: ..... mm

c) Maximum distance from coupling flange to centreline of farthest bearing: ..... mm

d) Minimum distance from coupling flange to centreline of nearest bearing: ..... mm



Key

1 Shaft
2 Rotor
3 Support
4 Bed

NOTE 1 If the left-hand support is not a mirror image of the right-hand support, separate dimensions shall be shown.

NOTE 2 The profile of the belt-drive equipment shall be shown, if applicable.

Figure 1 — Example of machine support drawing illustrating rotor envelope limitations

4.1.2.5 Journal diameter:

a) Maximum: ..... mm

b) Minimum: ..... mm

Maximum permissible peripheral journal speed ..... m/s

4.1.2.6 Correction plane limitations (consistent with the statements in 5.4) shall be stated.

4.1.2.7 Correction plane interference ratios (consistent with the statements in 5.4 and based on the proving rotor) shall be stated.

4.1.3 Drive

4.1.3.1

	Balancing speed	Rated torque on workpiece
	r/min	N·m
n_1	.....	.....
n_2	.....	.....
n_3	.....	.....
n_4	.....	.....
n_5	.....	.....
n_6	.....	.....
n_7	.....	.....
n_8	.....	.....
	or	or
	steplessly variable	steplessly variable
	from	.....
	to	.....

4.1.3.2 Torque (see note 5):

a) Zero-speed torque: ..... % rated torque on workpiece

b) Run-up torque adjustable from ..... to ..... % rated torque on workpiece

c) Peak torque ..... % rated torque on workpiece

4.1.3.3 Type of drive to workpiece (see note 6): .....

4.1.3.4 Prime mover (type of motor): .....

a) Rated power: ..... kW

b) Motor speed: ..... r/min

c) Power supply, voltage / frequency / phase: .....

4.1.3.5 Brake

a) Type of brake: .....

b) Braking torque adjustable from ..... to ..... % of rated torque

c) Can brake be used as a holding device? Yes / No

4.1.3.6 Motor and controls in accordance with the following standard(s): .....

4.1.3.7 Speed regulation provided:

Accurate or constant within ..... % of ..... r/min, or ..... r/min

4.1.4 Couple unbalance interference ratio ($g \cdot mm/g \cdot mm^2$) ..... % (see note 7)

4.1.5 Air pressure requirements: ..... Pa; ..... m^3/s

NOTE 1 The occasional overload force need only be stated for the lowest balancing speed. It is the maximum force per support that can be accommodated by the machine without immediate damage.

The negative force is the static upward force resulting from a workpiece having its centre of mass outside the bearing support.

NOTE 2 Cycle rate for a given balancing speed is the number of starts and stops which the machine can perform per hour without damage to the machine when balancing a rotor of the maximum moment of inertia.

NOTE 3 In general, for rigid rotors with two correction planes, one-half of the stated value pertains to each plane; for disc-shaped rotors, the full stated value holds for one plane.

NOTE 4 Limits for soft-bearing machines are generally stated in gram millimetres per kilogram (specific unbalance), since this value represents a measure of rotor displacement and, therefore, motion of the balancing machine bearings. For hard-bearing machines, the limits are generally stated in gram millimetres, since these machines are usually factory-calibrated to indicated unbalance in such units (see clause 6). For two-plane machines, this is the result obtained when the minimum achievable residual unbalance is distributed between the two planes.

NOTE 5 In most cases, maximum torque is required for accelerating a workpiece. However, in the case of a workpiece with high windage and/or friction loss, maximum torque may be required at balancing speed. When there is axial thrust, it is necessary that provisions be made to take this into account.

NOTE 6 Examples of the type of drive to the workpiece are:

— end drive by universal joint driver,

— end drive by band,

— belt drive,

— magnetic field,

— driven bearing rollers,

— air jet, etc.

NOTE 7 This value is only applicable for single-plane balancing machines. It describes the influence of couple unbalance in the rotor on the indication of static unbalance.

4.2 Data of vertical machines

4.2.1 Rotor mass and unbalance limitations

4.2.1.1 The maximum mass of rotor which can be balanced shall be stated over the range of balancing speeds.

The maximum moment of inertia [mass × (radius of gyration)^2] of a rotor with respect to the shaft axis which the machine can accelerate in a stated acceleration time shall be given for the range of balancing speeds (n_1, n_2, ...) together with the corresponding cycle rate (see table 2).

Table 2 — Data of vertical machines

Manufacturer: ..... **Model .....**						
Balancing speeds or speed ranges (see also 4.2.3.1)		n_1	n_2	n_3	n_4	n_5
Rotor mass kg (see note 1)	maximum					
	minimum					
Occasional overload force up to (see note 1) N						
Maximum rotor moment of inertia with respect to the shaft axis (see note 2) $kg \cdot m^2$						
Cycle rate (see note 2)						
Maximum unbalance (see note 3) g·mm/kg or g·mm	measurable					
	permissible					
Minimum achievable residual specific unbalance, e_{mar}, (see note 4 and clause 6) g·mm/kg	maximum mass					
	0,2 × max. mass					
	minimum mass					
Corresponding deflection of analog amount-of-unbalance indicator mm Number of digital units (see note 4)	maximum mass					
	0,2 × max. mass					
	minimum mass					

4.2.1.2 Production efficiency (see clause 7) shall be stated, as follows.

4.2.1.2.1 Time per measuring run:

a) Time for mechanical adjustment: ..... s

b) Time for setting indicating system: ..... s

c) Time for preparation of rotor: ..... s

d) Average acceleration time: ..... s

e) Reading time (including time to stabilize): ..... s

f) Average deceleration time: ..... s

g) Relating readings to rotor: ..... s

h) Other necessary time: ..... s

i) Total time per measuring run [a) to h) above]: ..... s

4.2.1.3 Unbalance reduction ratio: ..... %

4.2.2 Rotor dimensions

4.2.2.1 If the machine is equipped with two or more speeds, this information shall be stated for each speed. If the machine is equipped with steplessly variable balancing speeds, then the information shall be given in the form of a table, formula or graph.

Adequate drawings of the support surface of the spindle or mounting plate, and of obstructions, such as drill heads, electrical control cabinets, etc. above the mounting plate, shall be supplied to enable the user to determine the maximum rotor envelope that can be accommodated and the tooling and/or adaptors required.

4.2.2.2 Maximum diameter: ..... mm

4.2.2.3 Rotor height:

a) Maximum overall height: ..... mm

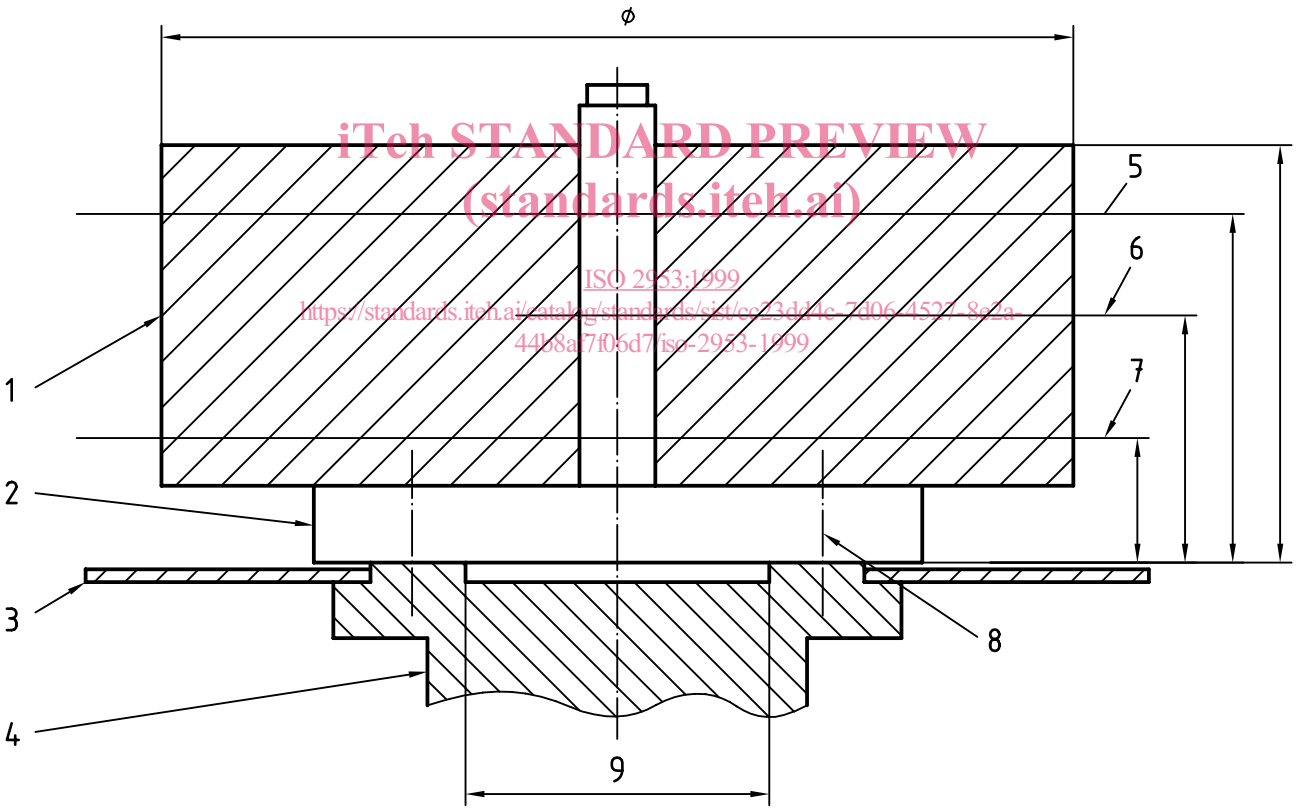
b) Maximum height of centre of gravity: ..... mm

at 100 % of maximum mass: ..... mm

at 50 % of maximum mass: ..... mm

at 25 % of maximum mass: ..... mm

4.2.2.4 Rotor envelope limitations, including machine spindle or mounting plate interface (see figure 2) shall be stated.



Key

1 Rotor
2 Adapter
3 Protractor
4 Spindle
5 Upper correction plane
6 Centre of mass plane
7 Lower correction plane
8 Mounting holes for adapter
9 Pilot ∅

Figure 2 — Example of vertical machine mounting interface illustrating rotor envelope limitations

4.2.2.5 Correction plane limitations (consistent with the statements in 5.4) shall be stated.

4.2.3 Drive

4.2.3.1

	Balancing speed	Rated torque on workpiece
	r/min	N·m
n_1	.....	.....
n_2	.....	.....
n_3	.....	.....
n_4	.....	.....
n_5	.....	.....
n_6	.....	.....
n_7	.....	.....
n_8	.....	.....

4.2.3.2 Torque (see note 5):

a) Zero-speed torque: ..... % of rated torque on workpiece

b) Run-up torque adjustable from ..... to ..... % of rated torque on workpiece

c) Peak torque: ..... % of rated torque on workpiece

4.2.3.3 Prime mover (type of motor):

a) Rated power: ..... kW

b) Motor speed: ..... r/min

c) Power supply, voltage / frequency / phase: ..... / ..... / .....

4.2.3.4 Brake

a) Type of brake:

b) Braking torque adjustable from ..... to ..... % of rated torque

c) Can brake be used as a holding device ? Yes / No

4.2.3.5 Motor and controls in accordance with the following standard(s): .....

4.2.3.6 Speed regulation provided:

Accurate or constant within ..... % of ..... r/min, or ..... r/min

4.2.4 Couple unbalance interference ratio, g·mm / g·mm^2 (see note 6)

4.2.5 Air pressure requirements: ..... Pa; ..... m^3/s

NOTE 1 The occasional overload force need only be stated for the lowest balancing speed. It is the maximum force that can be accommodated by the machine without immediate damage.

NOTE 2 Cycle rate for a given balancing speed is the number of starts and stops which the machine can perform per hour without damage to the machine when balancing a rotor of the maximum moment of inertia.

NOTE 3 In general, for rigid rotors with two correction planes, one-half of the state value pertains to each plane; for disc-shaped rotors, the full stated value holds for one plane.

NOTE 4 Limits for soft-bearing machines are generally stated in gram millimetres per kilogram (specific unbalance), since this value represents a measure of rotor displacement and, therefore, motion of the balancing machine bearings. For hard-bearing machines, the limits are generally stated in gram millimetres, since these machines are usually factory-calibrated to indicate unbalance in such unit. (See also clause 6.) For two-plane-machines, this is the result obtained when the minimum achievable residual unbalance is distributed between the two planes.

NOTE 5 In most cases, maximum torque is required for accelerating a workpiece. However, in the case of workpieces with high windage and/or friction loss, maximum torque may be required at balancing speed.

NOTE 6 This value is only applicable for single-plane balancing machines. It describes the influence of couple unbalance in the rotor on the indication of static unbalance.

5 Machine features

5.1 Principle of operation

An adequate description of the principle of operation of the balancing machine shall be given; for example, motion measuring, force measuring, resonance, compensation.

5.2 Arrangement of the machine

5.2.1 The manufacturer shall describe the general configuration of this machine and the principal features of design, for example:

— horizontal or vertical axis of rotation;

— soft- or hard-bearing suspension system;

— resonance-type machine with mechanical compensator.

5.2.2 The manufacturer shall provide details of the following, as applicable.

5.2.2.1 Components designed to support the rotor, for example:

— vee blocks;

— open rollers;

— plain half-bearings;

— closed-ball, roller or plain bearings;

— devices to accommodate rotors in their service bearings;

— devices to accommodate complete units.

NOTE Details of bearing lubrication requirements shall be given, where applicable.

5.2.2.2 The mechanical adjustment and functioning of the means provided to take up axial thrust from the rotor (horizontal machines only).

5.2.2.3 Type(s) of transducers used to sense unbalance effects.

5.2.2.4 The drive and its control.

5.3 Indicating system

5.3.1 General

A balancing machine shall have means to determine the amount of unbalance and its angular location; such means shall be described, for example:

— wattmetric indicating system;

— voltmetric indicating system with phase-sensitive rectifier (including systems with frequency conversion);

— voltmetric system with stroboscope and filter;

— voltmetric indicating system with marking of angular position on the rotor itself;

— compensator with mechanical or electrical indication.

5.3.2 Amount indicators

The manufacturer shall describe the means of amount indication provided, for example:

— wattmetric or voltmetric component meters;

— wattmetric or voltmetric amount meters;

— wattmetric or voltmetric vector meters;

— mechanical or optical indicators;

— analog or digital readout.

5.3.3 Angle indicators

The manufacturer shall describe the means of angle indication provided, for example:

— wattmetric or voltmetric component meters;

— wattmetric or voltmetric vector meters;

— direct angle indication in degrees on a scale meter;

— oscilloscope, stroboscopic indicators;

— mechanical or optical indicators;

— analog or digital readout.

5.3.4 Operation of the indicating system

The manufacturer shall describe the procedure by which readings are obtained, taking into account at least the following points.

a) How many measuring runs are required to obtain:

   — the two readings for single-plane balancing?

   — the four readings for two-plane balancing?

b) Is an indicator provided for each reading or is it necessary to switch over for each reading?

c) Are readings retained after the end of the measuring run?

d) Is an individual plus-and-minus switch provided for each plane which permits the indication of a heavy or light spot?