INTERNATIONAL STANDARD ISO 2953

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Balancing machines — Description and evaluation

Machines à équilibrer — Description, caractéristiques et possibilités

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO Member Bodies). The work of developing International Standards is carried out through ISO Technical Committees. Every Member Body interested in a subject for which a Technical Committee has been set up 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.

Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 2953 was drawn up by Technical Committee ISO/TC 108, *Mechanical vibration and shock*, and circulated to the Member Bodies in May 1973.

It has been approved by the Member Bodies of the following countries :

Australia	Italy	Spain
Austria	Japan	Sweden
Belgium	Netherlands	Thailand
Bulgaria	New Zealand	Turkey
Czechoslovakia	Portugal	United Kingdom
France	Romania	U.S.A.
Germany	South Africa, Rep. of	U.S.S.R.

No Member Body expressed disapproval of the document.

Balancing machines — Description and evaluation

1 SCOPE

This International Standard sets out standards for the evaluation of performance and characteristics of machines for balancing rotating components where correction is required in one or more planes perpendicular to the shaft axis. It stresses the importance attached to the form in which the balancing machine characteristics should be specified by the manufacturer and also outlines methods of evaluating balancing machines. Adoption of the format suggested in 3.1 and 3.2 makes it easier for the user to compare one manufacturer's product with another's. Guidance as to the manner in which users should state their requirements is given in annex A.

It should be noted that the terminology used throughout this document is in accordance with ISO 1925[1)] and this terminology should be employed by manufacturers and users when applying the present International Standard.

2 FIELD OF APPLICATION

This International Standard is applicable to balancing machines that support and rotate rigid workpieces (that is, workpieces that are rigid at balancing speeds) and that indicate the amounts and angular locations of unbalance corrections required.

It covers both those machines that measure out-of-balance effects on soft bearings and those that measure out-of-balance effects on hard bearings. It also relates to resonance-type machines, provided mechanical compensators are incorporated.

Technical requirements for such balancing machines are also dealt with. Details of performance and other tests to be employed to ensure compliance with these requirements are given; however, special features such as those associated with automatic correction are excluded.

Annex A gives an indication of the information a user might supply to a manufacturer and a suggested method of tabulating it. Annex B gives some of the new definitions relevant to the provisions of this document.

This International Standard does not specify balancing criteria; these will be found in ISO 1940[2)].

3 CAPACITY AND PERFORMANCE DATA OF THE MACHINE

The manufacturer shall specify the data listed in 3.1 or 3.2 for horizontal or vertical machines respectively, as applicable and in a similar format.

1) ISO 1925, *Balancing — Vocabulary.*

2) ISO 1940, *Balancing quality of rotating rigid bodies.*

3.1 CAPACITY AND PERFORMANCE DATA OF HORIZONTAL MACHINES (See page 4 for notes)

Manufacturer : . . . . Model : . . . .

3.1.1 Rotor mass and unbalance limitations

		Min.	n_2	n_3	n_4	n_5
3.1.1.1	Balancing speeds or speed ranges					
3.1.1.2[1]	Rotor mass max. : kg (lb)					
	min. : kg (lb)					
	Occasional overload force per support : N (kgf, lbf)					
	Maximum negative force per support : N (kgf, lbf)					
3.1.1.3[2]	Maximum rotor moment of inertia with respect to the shaft axis kg·m^2 (lb·ft^2)					
	Cycle rate					
3.1.1.4[3]	Maximum unbalance g·mm/kg or g·mm (lb·in/lb or oz·in) — Measurable					
	Permissible					
3.1.1.5[4]	Minimum achievable residual specific unbalance (see clause 5) g·mm/kg (lb·in/lb)					
	Corresponding deflection of analogue amount-of-unbalance indicator : mm (in)					

3.1.1.6 Production efficiency (see clause 6)

3.1.1.6.1 Time per balancing run

3.1.1.6.2 Time for mechanical adjustment

3.1.1.6.3 Time for setting indicating system

3.1.1.6.4 Time for preparation of rotor

3.1.1.6.5 Average acceleration time

3.1.1.6.6 Reading time

3.1.1.6.7 Average deceleration time

3.1.1.6.8 Other necessary time

3.1.1.7 Unbalance reduction ratio

3.1.2 Rotor dimensions

3.1.2.1[5] Rotor envelope limitations (see figure 1)

3.1.2.2 Rotor diameter : . . . . mm (in)

Maximum diameter over bed : . . . . mm (in)

Maximum diameter over which belt can drive : . . . . mm (in)

Minimum diameter over which belt can drive : . . . . mm (in)

3.1.2.3 Distance between journal centre lines :

a) Max. : . . . . mm (in)
b) Min. : . . . . mm (in)
c) Maximum distance from coupling flange to centre line of farthest bearing : . . . . mm (in)
d) Minimum distance from coupling flange to centre line of nearest bearing : . . . . mm (in)

3.1.2.4 Journal diameter :

Max. : . . . . mm (in)
Min. : . . . . mm (in)

3.1.2.4.1[6] Maximum permissible peripheral speed . . . . m/s (ft/s)

3.1.2.5 Correction plane limitations (consistent with the statements in 4.4)

3.1.2.6 Correction plane interference ratios (consistent with the statements in 4.4 and based on the proving rotor)

3.1.3 Drive

3.1.3.1[7]

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

3.1.3.2[8] Zero-speed torque : . . . . % of rated torque on workpiece
Run-up torque adjustable from . . . . to . . . . % of rated torque on workpiece
Peak torque : . . . . % of rated torque on workpiece

3.1.3.3[9] Type of drive to workpiece : . . . .

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

3.1.3.4.1 Rated power : . . . . kW (hp)
Motor speed : . . . . rev/min
Power supply, voltage/frequency/phase : . . . . / . . . . / . . . .

3.1.3.5 Brake

3.1.3.5.1 Type of brake :
Braking torque adjustable from . . . . to . . . . % of rated torque
Can brake be used as a holding device ? . . . . Yes/No

3.1.3.6 Motor and controls in accordance with ISO . . .

3.1.3.7 Speed regulation provided :

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

3.1.4[10] **Couple unbalance interference :** . . . . g·mm/g·mm^2 (oz·in/oz·in^2)

NOTES TO 3.1

1) The maximum mass of rotor that can be balanced shall be stated over the range of balancing speeds. 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 gravity outside the bearing supports.

2) The maximum moment of inertia [mass × (radius of gyration)^2] of a rotor with respect to the shaft axis that 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. Cycle rate for a given balancing speed is the number of starts and stops that the machine can perform per hour without damage to the machine when balancing a rotor of the maximum moment of inertia.

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

4) Limits for soft-bearing machines will generally be 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 will generally be stated in gram millimetres since these machines are usually factory calibrated to indicate unbalance in such units. (See clause 5.) For two-plane machines, this is the result obtained when the minimum achievable residual unbalance is distributed between the two planes.

5) 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 furnished to enable the user to determine the maximum rotor envelope that can be accommodated and the tooling and/or adaptors required.

6) 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.

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

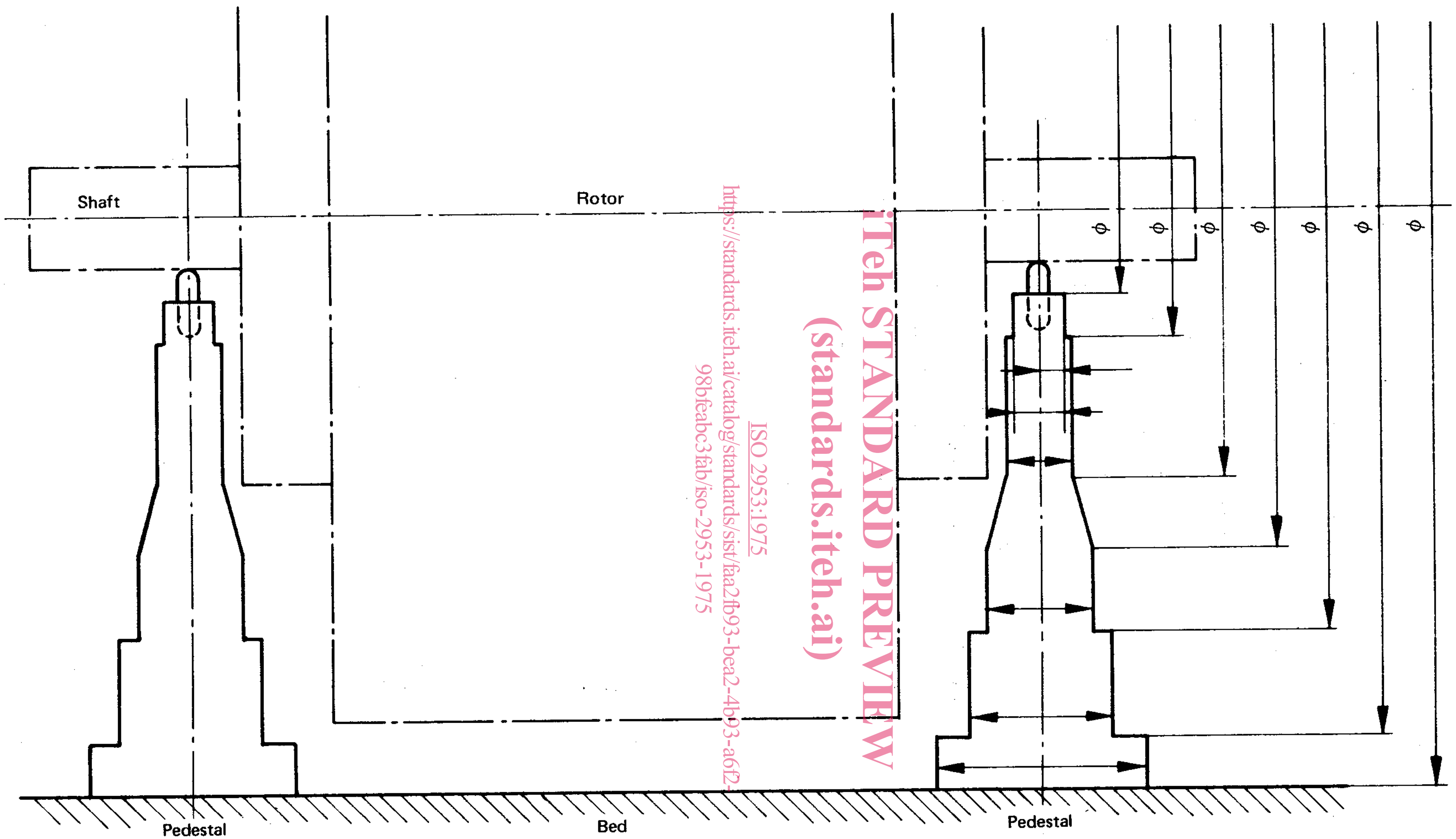
8) In most cases, maximum torque is required for accelerating a workpiece. However, in the case of workpieces with high windage and/or friction loss, maximum torque may be required at balancing speed. When there is axial thrust, it is necessary that provisions be made to take this into account.

9) 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.

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

10) 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.



NOTES

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

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

FIGURE 1 – **Example of machine pedestal drawing illustrating rotor envelope limitations**

3.2 CAPACITY AND PERFORMANCE DATA OF VERTICAL MACHINES (See pages 7 and 8 for notes)

Manufacturer : . . . . Model : . . . .

3.2.1 Rotor mass and unbalance limitations

3.2.1.1	Balancing speeds or speed ranges	Min.	n_2	n_3	n_4	n_5
3.2.1.2[1]	Rotor mass max. : kg (lb)					
	Rotor mass min. : kg (lb)					
	Occasional overload force up to : N (kgf, lbf)					
3.2.1.3[2]	Maximum rotor moment of inertia with respect to the shaft axis kg·m^2 (lb·ft^2)					
	Cycle rate					
3.2.1.4[3]	Maximum unbalance g·mm/kg or g·mm (lb·in/lb or oz·in) — Measurable					
	Permissible					
3.2.1.5[4]	Minimum achievable residual specific unbalance (see clause 5) g·mm/kg (lb·in/lb)					
	Corresponding deflection of analogue amount-of-unbalance indicator : mm (in)					

3.2.1.6 Production efficiency (see clause 6)

3.2.1.6.1 Time per balancing run

3.2.1.6.2 Time for mechanical adjustment

3.2.1.6.3 Time for setting indicating system

3.2.1.6.4 Time for preparation of rotor

3.2.1.6.5 Average acceleration time

3.2.1.6.6 Reading time

3.2.1.6.7 Average deceleration time

3.2.1.6.8 Other necessary time

3.2.1.7 Unbalance reduction ratio

3.2.2 Rotor dimensions

3.2.2.1 Rotor diameter : . . . . mm (in)

3.2.2.2 Rotor height :

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

b)[5] Maximum height of centre of gravity : . . . . mm (in)

at 100 % of max. mass : . . . . mm (in)

at 50 % of max. mass : . . . . mm (in)

at 25 % of max. mass : . . . . mm (in)

3.2.2.3[6] Rotor envelope limitations, including machine spindle or mounting plate interface (see figure 2)

3.2.2.4 Correction plane limitations (consistent with the statements in 4.4)

3.2.3 Drive

3.2.3.1

	Balancing speed rev/min	Rated torque on workpiece N·m (lbf·ft)
n_1	. . . .	. . . .
n_2	. . . .	. . . .
n_3	. . . .	. . . .
n_4	. . . .	. . . .
n_5	. . . .	. . . .
n_6	. . . .	. . . .
n_7	. . . .	. . . .
n_8	. . . .	. . . .

3.2.3.2[7] Zero-speed torque : . . . . % of rated torque on workpiece

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

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

3.2.3.3 Prime mover (type of motor) . . . .

3.2.3.3.1 Rated power : . . . . kW (hp)

Motor speed : . . . . rev/min

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

3.2.3.4 Brake

3.2.3.4.1 Type of brake :

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

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

3.2.3.5 Motor and controls in accordance with ISO . . .

3.2.3.6 Speed regulation provided :

Accurate or constant within . . . . % of . . . . rev/min or . . . . rev/min

3.2.4[8] **Couple unbalance interference :** . . . . g·mm/g·mm^2 (oz·in/oz·in^2)

NOTES TO 3.2

1) The maximum mass of rotor that can be balanced shall be stated over the range of balancing speeds.

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.

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

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

Both the above assume negligible windage (see note 7).

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

4) Limits for soft-bearing machines will generally be 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 will generally be stated in gram millimetres since these machines are usually factory calibrated to indicate unbalance in such units. (*See also clause 5.*) For two-plane machines, this is the result obtained when the minimum achievable residual unbalance is distributed between the two planes.

5) 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 curve.

6) 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 furnished to enable the user to determine the maximum rotor envelope that can be accommodated, and the tooling and/or adaptors required.

7) 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.

8) 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.

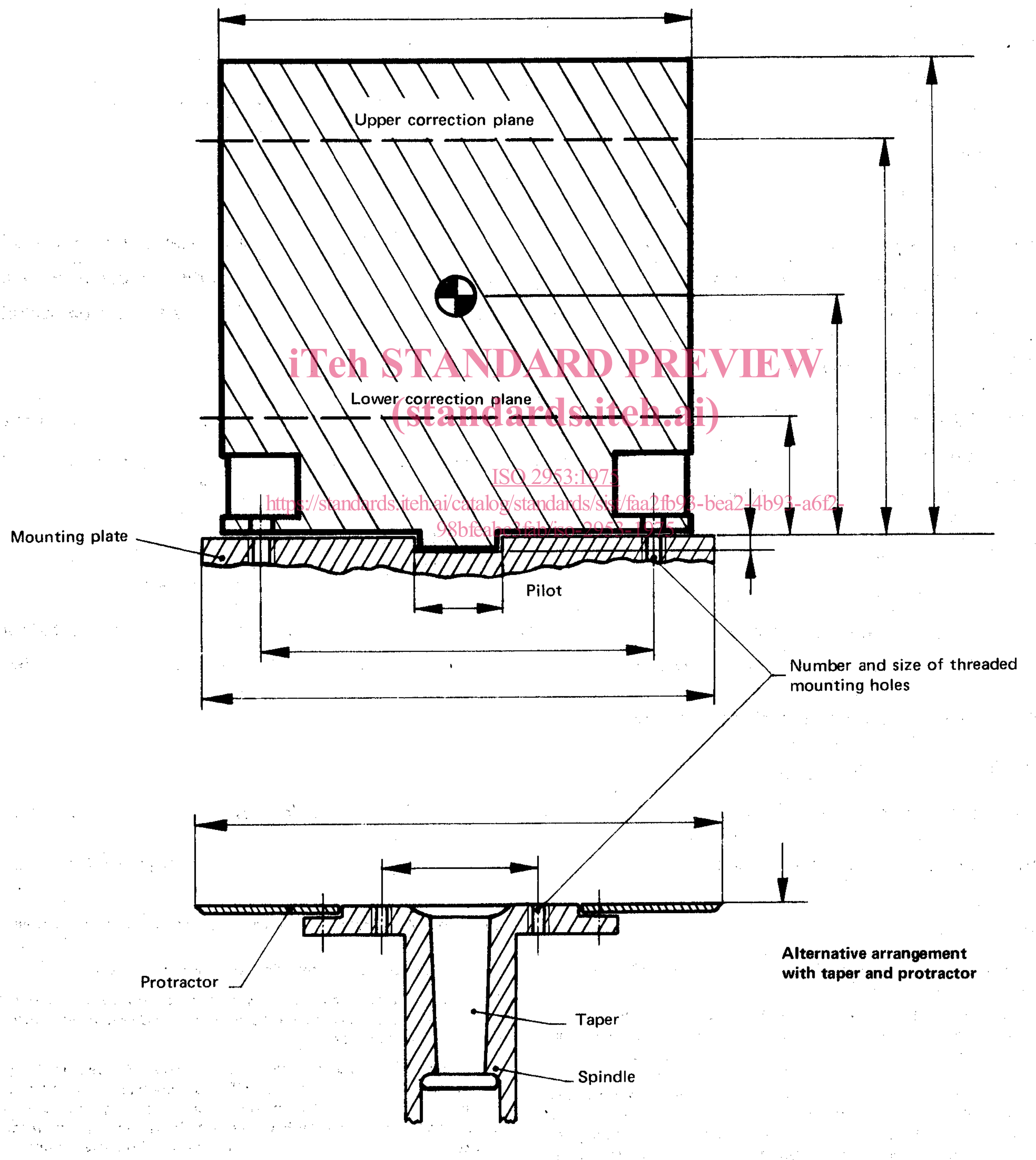


FIGURE 2 – **Example of machine mounting interface illustrating rotor envelope limitations**

4 MACHINES FEATURES

4.1 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, etc.

4.2 Arrangement of the machine

4.2.1 The manufacturer shall describe the general configuration of his 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.

4.2.2 The manufacturer shall provide details of the following, as applicable :

4.2.2.1 Components designed to support the rotor, for example :

- vee blocks;
- open rollers;
- plain half-bearings;
- closed-ball, roller or plain bearings;
- device to use the service bearings;
- device to accommodate complete units.

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

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

4.2.2.3 Elements by which the vibrational effects (force, velocity, acceleration, or displacement) are sensed.

4.2.2.4 The means (mechanical, electrical, electromechanical, optical, etc.) by which the vibration signals are analysed, measured and displayed.

4.2.2.5 The drive and its control.

4.3 Indicating system

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.

4.3.1 *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;
- analogue or digital readout.

NOTE — It shall be specified if values given are peak-to-peak, r.m.s., etc.

4.3.2 *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;
- analogue or digital readout.

NOTE — It shall be specified if values given are peak-to-peak, r.m.s., etc.

4.3.3 *Operation of the indicating system*

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

How many measuring runs are required to obtain :

- the two readings for single-plane balancing ?
- the four readings for two-plane balancing ?

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

Are readings retained after the end of the balancing run ?

What is the maximum retention period ?

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