INTERNATIONAL STANDARD

ISO 21940-21

Second edition
2022-11

Mechanical vibration — Rotor balancing —

Part 21: Description and evaluation of balancing machines

Vibrations mécaniques — Équilibrage des rotors —

Partie 21: Description et évaluation des machines à équilibrer

Reference number
ISO 21940-21:2022(E)

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 of 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 www.iso.org/iso/foreword.html.

ISO 21940-21 was prepared by 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 second edition cancels and replaces the first edition (ISO 21940-21:2012), which has been technically revised.

The main changes are as follows:

— the introduction of new computer based technology into balance machine indication systems;

— the introduction of additional tests for repeatability and speed range (see Annex F and Annex G);

— the introduction of greater clarification for use with automated and special purpose machines.

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

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The purpose of this document is to provide a common framework for the specification, comparison and evaluation of balancing machines.

It describes a proforma on which the baseline balancing machine characteristics can be presented by the manufacturer enabling users to compare products from different manufacturers. Additionally, guidelines are given on the information by which users provide their data and requirements to a balancing machine manufacturer.

This document describes the tests to be performed during the acceptance testing of a balancing machine and later, on a periodic basis, to ensure that the balancing machine is capable of handling the actual balancing tasks. For periodic tests, simplified procedures are specified.

Methods and requirements for preparing proving rotors (which can be of Type A, Type B or Type C, or a user defined proving rotor e.g. based on a user supplied part) are specified, allowing a wide range of applications to be covered.

The accuracy of all balance machines is inherently non-linear over their mass and speed range. In normal practice, a hard bearing balance machine is calibrated over a particular part of its speed and mass range, but outside that its accuracy cannot be assumed. As a consequence, a rotor specific calibration should be performed to establish the machine accuracy at a specific speed and for a rotor of a particular mass. This is normal practice for soft bearing machines or where the manufacturer states that rotor specific calibration should be carried out.

Mechanical vibration — Rotor balancing —

Part 21:
Description and evaluation of balancing machines

1 Scope

This document sets out the requirements for evaluating hard and soft bearing balancing machines that support and rotate:

a) rotors with rigid behaviour at balancing speed (as described in ISO 21940-11);

b) rotors with shaft elastic behaviour and balanced in accordance with low speed balancing procedures (as described in ISO 21940-12).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 21940-2, *Mechanical vibration — Rotor balancing — Part 2: Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 21940-2 apply.

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

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

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

4 Capacity and performance data of the balancing machine

4.1 General

The manufacturer shall specify the data listed in 4.2 for horizontal or 4.3 for vertical balancing machines. Information to be provided by the user to the balancing machine manufacturer is summarized in Annex A.

4.2 Data for horizontal balancing machines

4.2.1 Rotor mass and unbalance limitations

The maximum rotor mass, *m*, which can be balanced, shall be stated over the range of balancing speeds (n_1, n_2, ...).

The maximum moment of inertia of a rotor (given by, $m\,r^2$ where *m* is the rotor mass and *r* the radius of gyration) 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, Note 2).

4.2.2 Production efficiency

The production efficiency (further requirements are described in Clause 7) is the total time taken to carry out the individual steps necessary to perform a balance measuring run.

The individual steps to be measured are:

a) time for mechanical adjustment (s);

b) time for setting indicating system (s);

c) time for preparation of rotor (s);

d) acceleration time for a stated rotor (s);

e) time taken for the balance reading to stabilize and for it to be recorded (s);

f) deceleration time for a stated rotor (s);

g) identifying unbalance readings taken (s);

h) any other times to be taken into account for operations to be carried out but not included in 4.2.2 a) to 4.2.2 g) (s).

Total time per measuring run is given by adding the individual times measured in steps 4.2.2 a) to 4.2.2 h) (s).

Table 1 — Horizontal balancing machine data

<table>
<tr><td colspan="2">Manufacturer:</td><td colspan="6">Model:</td></tr>
<tr><td colspan="3">Balancing speeds or speed ranges</td><td>n_1</td><td>n_2</td><td>n_3</td><td>n_4</td><td>...</td></tr>
<tr><td colspan="2" rowspan="2">Rotor mass (kg) (see Note 1)</td><td>maximum, m_{max}</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>minimum</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Occasional overload force per support (N) (see Note 1)</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Maximum negative force per support (N) (see Note 1)</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Maximum rotor moment of inertia with respect to the shaft axis (kg m^2)</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Cycle rate per hour (see Note 2)</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2" rowspan="2">Maximum unbalance (g mm/kg or g mm) (see Note 3)</td><td>measurable</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>permissible</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">a) For inboard rotors minimum achievable residual specific unbalance, e_{mar}, (g mm/kg) (see Note 4)</td><td rowspan="3">Rotor mass (kg) (see Note 1)</td><td>maximum mass, m_{max}</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>0,2 m_{max}</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>minimum mass</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">b) For outboard rotors minimum achievable residual specific unbalance, e_{mar}, (g mm/kg) (see Note 4)</td><td rowspan="3">Rotor mass (kg) (see Note 1)</td><td>maximum mass, m_{max}</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>0,2 m_{max}</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>minimum mass</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="8">NOTE 1 The occasional overload force is only 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 rotor having its centre of mass outside the bearing support.

NOTE 2 The cycle rate per hour 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 rotors with rigid behaviour with two planes, the stated value is distributed proportionally to each tolerance plane. For disc-shaped rotors with only one tolerance plane, the full stated value holds for one plane.

NOTE 4 This is the machine’s ability to measure the smallest amount of unbalance for a rotor (see 5.5.3).</td></tr>
</table>

4.2.3 Rotor dimensions

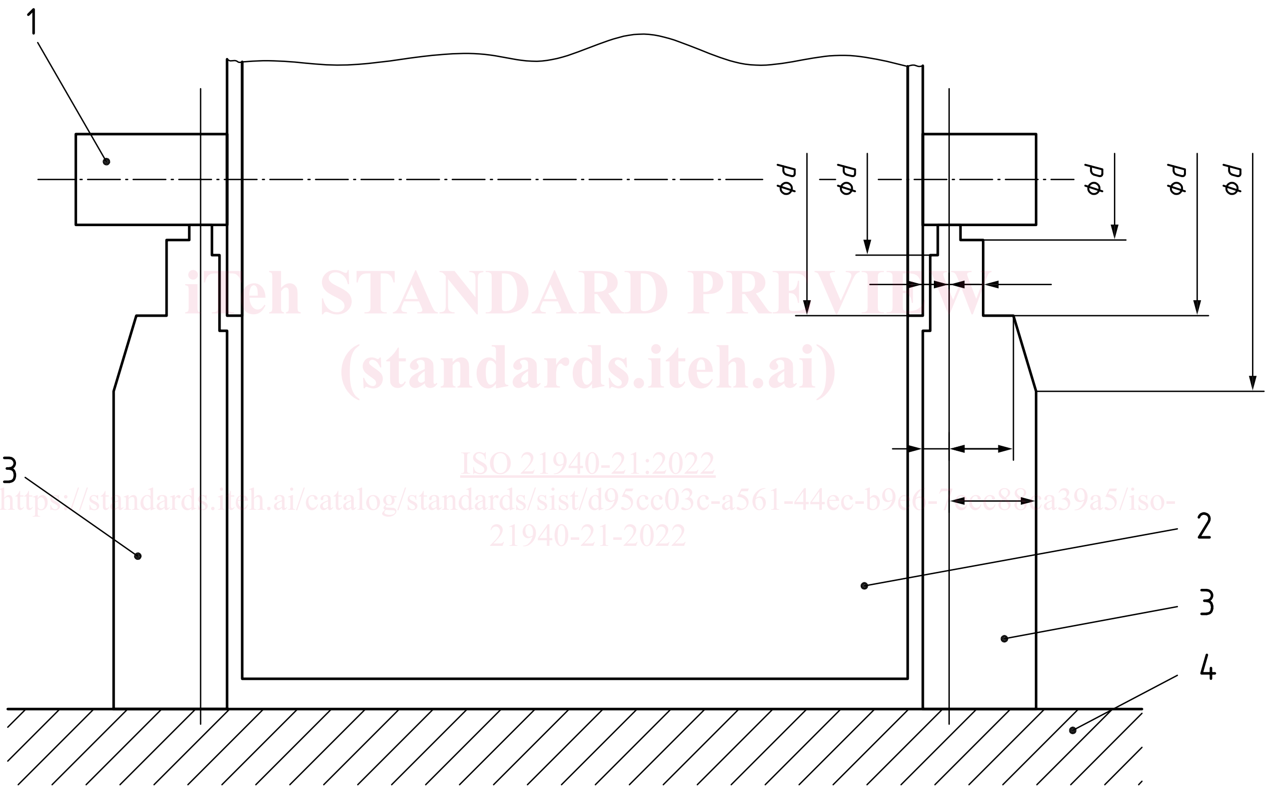
General arrangement drawings of the pedestals and other obstructions (e.g. belt-drive mechanism, shroud mounting pads, thrust arms and tie bars) shall be supplied to enable the user to determine the maximum rotor envelope that can be accommodated and the tooling or adaptors required to support and or drive the rotor.

A combination of large journal diameter and high balancing speed can 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 the rotor.

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

Rotor envelope limitations shall be stated (see Figure 1).



Key

1 shaft
2 rotor
3 supports
4 bed
d diameter

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

If the left-hand support is not a mirror image of the right-hand support, separate dimensions for each shall be shown. All maximum rotor swing diameters shall be dimensioned along with the pedestal widths as indicated in the right hand pedestal.

If applicable, the profile of the belt-drive equipment shall be shown.

In addition, these dimensions shall be recorded:

a) maximum diameter over bed (mm);

b) maximum diameter over which the belt can drive (mm);

c) minimum diameter over which the belt can drive (mm);

d) distance between journal centrelines:

   1) maximum (mm);

   2) minimum (mm);

   3) maximum distance from coupling flange to centreline of farthest bearing (mm);

   4) minimum distance from coupling flange to centreline of nearest bearing (mm).

e) journal diameter:

   1) maximum (mm);

   2) minimum (mm).

f) maximum permissible peripheral journal speed (m s^{-1});

g) correction plane limitations (consistent with the requirements of 5.4);

h) correction plane interference ratios (consistent with the requirements of 5.4 and based on the proving rotor used).

4.2.4 Balancing machine drive data

Balancing machine drive parameters shall be recorded as shown in Table 2.

Table 2 — Balancing machine drive parameters

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

4.2.5 Torque

The balancing machine torque parameters to be recorded are

a) zero-speed torque (% of rated torque on rotor),

b) adjustable run-up torque (from ...... % to ...... % of rated torque on rotor), and

c) peak torque (% of rated torque on rotor).

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

4.2.6 Type of rotor drive

The type of rotor drive shall be recorded (e.g. end drive by band, belt drive, magnetic field, driven bearing rollers, air jet).

In addition, these drive motor parameters shall be recorded:

a) rated power (kW);

b) motor speed (r/min);

c) power supply, voltage (V), frequency (Hz) and phase (single or three phase).

4.2.7 Brake

These brake parameters shall be recorded:

a) type of brake;

b) adjustable braking torque (from ...... % to ...... % of rated torque on rotor);

c) if the brake can be used as a holding device.

4.2.8 Motor and controls

The standards against which the drive motor and its controls have been manufactured and tested shall be recorded.

4.2.9 Speed regulation

It shall be recorded whether or not motor speed regulation has been incorporated and if it has, what its specifications are (range within ...... % of ...... r/min, or constant at ...... r/min).

4.2.10 Couple moment interference ratio, I_{sc}

The couple moment interference ratio (g mm/(g mm^2)) shall be recorded.

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

4.2.11 Air pressure requirements

The air pressure requirements for the balancing machine shall be recorded in Pa and volume flow rate in m^3 s^{-1}.

4.3 Data for vertical balancing machines

4.3.1 Rotor mass and unbalance limitations

The maximum mass of a rotor, m, which can be balanced shall be stated over the range of balancing speeds (n_1, n_2, ...) for the machine.

The maximum moment of inertia of a rotor (given by, $m\, r^2$ where, m, is the rotor mass and, r, is the radius of gyration) 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 3).

Table 3 — Vertical balancing machine data

Manufacturer:	**Model:**					
Balancing speeds or speed ranges		n_1	n_2	n_3	n_4	...
Rotor mass (kg) (see Note 1)	maximum, m_{max}					
	minimum					
Occasional overload force per support (N) (see Note 1)						
Maximum rotor moment of inertia with respect to the shaft axis (kg m^2) (see Note 2)						
Cycle rate per hour (see Note 2)						
Maximum unbalance (g mm/kg or g mm) (see Note 3)	measurable					
	permissible					

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

NOTE 2 Cycle rate per hour 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 rotors with rigid behaviour with two planes, the stated value is distributed proportionally to each tolerance plane. For disc-shaped rotors with only one tolerance plane, the full stated value holds for one plane.

NOTE 4 This is the machine's ability to measure the smallest amount of unbalance for a rotor (see 5.5.3).

4.3.2 Production efficiency

The production efficiency (further requirements are described in Clause 6) is the total time taken to carry out the individual steps necessary to perform a balance measuring run.

The individual steps to be measured are

a) any mechanical adjustment of the balancing machine needed, including to the drive, tooling or adaptor,

b) preparation of any other devices and systems needed,

c) setting the indicating system,

d) preparation of the rotor for the measuring run,

e) balance cycle acceleration time,

f) reading time (e.g. the total time between the end of the acceleration run and the start of the deceleration run),

g) deceleration time,

h) any further operations necessary to relate the readings obtained to the rotor being balanced,

i) loading and unloading times, and

j) time taken for any other relevant operations to be completed (e.g. safety measures).

4.3.3 Rotor dimensions

If the machine has two or more speeds, the rotor dimensions shall be stated for each speed. If the machine has continuously variable balancing speeds, then the information shall be presented in the form of a table, formula or graph.

Drawings of the spindle support surface or mounting plate and of any obstructions (e.g. drill heads and electrical control cabinets) above the mounting plate shall be supplied to enable the user to determine the maximum rotor envelope that can be accommodated and the tooling or adaptors required.

In addition, these rotor dimensions shall be recorded:

a) maximum diameter (mm);

b) height:

  1) maximum overall height (mm);

  2) maximum centre of mass height (mm):

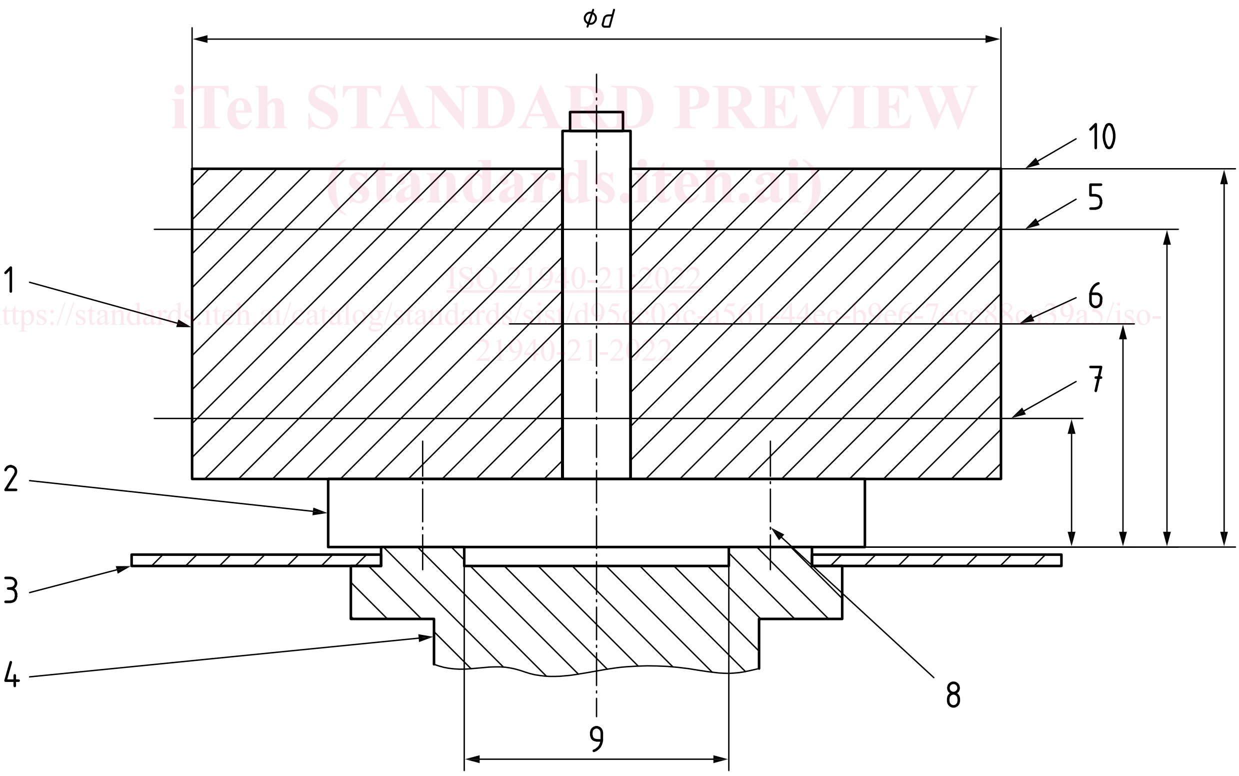
    i) at 100 % of maximum mass (mm);

    ii) at 50 % of maximum mass (mm);

    iii) at 25 % of maximum mass (mm).

c) envelope limitations (including machine spindle or mounting plate interface (see Figure 2));

d) correction plane limitations (consistent with the requirements of 5.4).



Key

1 rotor
2 adaptor
3 protractor
4 spindle
5 upper correction plane
6 centre of mass plane
7 lower correction plane
8 mounting holes for adaptor
9 spigot diameter
10 maximum height above spindle
d diameter

Figure 2 — Example of vertical machine mounting interface and rotor envelope