

BS ISO 21940-13:2012



BSI Standards Publication

Mechanical vibration — Rotor balancing

Part 13: Criteria and safeguards for the in-situ balancing of medium and large rotors

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National foreword

This British Standard is the UK implementation of ISO 21940-13:2012. It supersedes BS ISO 20806:2009 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee GME/21/5, Mechanical vibration, shock and condition monitoring - Vibration of machines.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Mechanical vibration — Rotor balancing —

Part 13: Criteria and safeguards for the *in-situ* balancing of medium and large rotors

Vibrations mécaniques — Équilibrage des rotors —

*Partie 13: Critères et sauvegardes relatifs à l'équilibrage in situ des
rotors moyens et grands*



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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

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.

ISO 21940-13 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 first edition of ISO 21940-13 cancels and replaces ISO 20806:2009, of which it constitutes a minor editorial revision.

ISO 21940 consists of the following parts, under the general title *Mechanical vibration — Rotor balancing*:

- *Part 1: Introduction*¹⁾
- *Part 2: Vocabulary*²⁾
- *Part 11: Procedures and tolerances for rotors with rigid behaviour*³⁾
- *Part 12: Procedures and tolerances for rotors with flexible behaviour*⁴⁾
- *Part 13: Criteria and safeguards for the in-situ balancing of medium and large rotors*⁵⁾
- *Part 14: Procedures for assessing balance errors*⁶⁾

1) Revision of ISO 19499:2007, *Mechanical vibration — Balancing — Guidance on the use and application of balancing standards*

2) Revision of ISO 1925:2001, *Mechanical vibration — Balancing — Vocabulary*

3) Revision of ISO 1940-1:2003, *Mechanical vibration — Balance quality requirements for rotors in a constant (rigid) state — Part 1: Specification and verification of balance tolerances* (+ Cor.1:2005)

4) Revision of ISO 11342:1998, *Mechanical vibration — Methods and criteria for the mechanical balancing of flexible rotors* (+ Cor.1:2000)

5) Revision of ISO 20806:2009, *Mechanical vibration — Criteria and safeguards for the in-situ balancing of medium and large rotors*

6) Revision of ISO 1940-2:1997, *Mechanical vibration — Balance quality requirements of rigid rotors — Part 2: Balance errors*

- *Part 21: Description and evaluation of balancing machines*⁷⁾
- *Part 23: Enclosures and other protective measures for balancing machines*⁸⁾
- *Part 31: Susceptibility and sensitivity of machines to unbalance*⁹⁾
- *Part 32: Shaft and fitment key convention*¹⁰⁾

7) Revision of ISO 2953:1999, *Mechanical vibration — Balancing machines — Description and evaluation*

8) Revision of ISO 7475:2002, *Mechanical vibration — Balancing machines — Enclosures and other protective measures for the measuring station*

9) Revision of ISO 10814:1996, *Mechanical vibration — Susceptibility and sensitivity of machines to unbalance*

10) Revision of ISO 8821:1989, *Mechanical vibration — Balancing — Shaft and fitment key convention*

Introduction

Balancing is the process by which the mass distribution of a rotor is checked and, if necessary, adjusted to ensure that the residual unbalance or the vibrations of the journals or bearing supports and/or the forces at the bearings are within specified limits. Many rotors are balanced in specially designed balancing facilities prior to installation into their bearings on site. However, if remedial work is carried out locally or a balancing machine is not available, it is common to balance the rotor *in situ*.

Unlike balancing in a specially designed balancing machine, *in-situ* balancing has the advantage that the rotor is installed in its working environment. Therefore, there is no compromise with regard to the dynamic properties of its bearings and support structure, nor from the influence of other elements in the complete rotor train. However, it has the large disadvantage of restricted access and the need to operate the whole machine. Restricted access can limit the planes at which correction masses can be added, and using the whole machine has commercial penalties of both downtime and running costs. Where gross unbalance exists, it may not be possible to balance a rotor *in situ* due to limited access to correction planes and the size of correction masses available.

Mechanical vibration — Rotor balancing —

Part 13:

Criteria and safeguards for the *in-situ* balancing of medium and large rotors

1 Scope

This part of ISO 21940 specifies procedures to be adopted when balancing medium and large rotors installed in their own bearings on site. It addresses the conditions under which it is appropriate to undertake *in-situ* balancing, the instrumentation required, the safety implications and the requirements for reporting and maintaining records.

This part of ISO 21940 can be used as a basis for a contract to undertake *in-situ* balancing.

It does not provide guidance on the methods used to calculate the correction masses from measured vibration data.

NOTE The procedures covered in this part of ISO 21940 are suitable for medium and large machines. However, many of the principles are equally applicable to machines of a smaller size, where it is necessary to maintain good records of the vibration behaviour and the correction mass configurations.

2 Normative references

The following referenced documents are indispensable for the application 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 1925, *Mechanical vibration — Balancing — Vocabulary*¹¹⁾

ISO 1940-1, *Mechanical vibration — Balance quality requirements for rotors in a constant (rigid) state — Part 1: Specification and verification of balance tolerances*¹²⁾

ISO 2954, *Mechanical vibration of rotating and reciprocating machinery — Requirements for instruments for measuring vibration severity*

ISO 7919 (all parts), *Mechanical vibration — Evaluation of machine vibration by measurements on rotating shafts*

ISO 10816 (all parts), *Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts*

11) To become ISO 21940-2 when revised.

12) To become ISO 21940-11 when revised.

ISO 10817-1, *Rotating shaft vibration measuring systems — Part 1: Relative and absolute sensing of radial vibration*

ISO 11342, *Mechanical vibration — Methods and criteria for the mechanical balancing of flexible rotors*¹³⁾

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1925 apply.

4 *In-situ* balancing

4.1 General

For *in-situ* balancing, correction masses are added to the rotor at a limited number of conveniently engineered and accessible locations along the rotor. By doing this, the magnitude of shaft and/or pedestal vibrations and/or unbalance is reduced to within acceptable values, so that the machine can operate safely throughout its whole operating envelope. As part of a successful balance, transient-speed vibration might be compromised to some degree to obtain acceptable normal running speed vibration on a fixed-speed machinery train.

NOTE In certain cases, machines that are very sensitive to unbalance cannot be successfully balanced over the complete operating envelope. This usually occurs when a machine is operating at a speed close to a lightly damped system mode (see ISO 10814 to become ISO 21940-31 when revised) and has load-dependent unbalance.

Most sites have limited instrumentation and data-processing capabilities, when compared to a balancing machine, and additional instrumentation is required to undertake *in-situ* balancing in these situations. In addition, the potential safety implications of running a rotor with correction masses shall be taken into account.

4.2 Reasons for *in-situ* balancing

4.2.1 Although individual rotors might be correctly balanced, as appropriate, in a high- or low-speed balancing machine, *in-situ* balancing may be required when the rotors are coupled into the complete rotor train. This can be due to a range of differences between the real machine and the isolated environment in the balancing machine, including:

- a) a difference in dynamic characteristics of the rotor supports between the balancing facility and the installed machine;
- b) assembly errors that occur during installation, which cannot be reasonably found and corrected;
- c) rotor systems that cannot be balanced prior to assembly;
- d) a changing unbalance behaviour of the rotor under full functional operating conditions.

4.2.2 Balancing may also be required to compensate for in-service changes to the rotor, including:

- a) wear;
- b) loss of components, such as rotor blade erosion shields;
- c) repair work, where components can be changed or replaced;
- d) movement of components on the rotor train causing unbalance, such as couplings, gas turbine discs and generator end rings.

NOTE Rotor blades are normally added as balanced sets, but this can be impossible if a small number of blades are replaced.

¹³⁾ To become ISO 21940-12 when revised.

4.2.3 *In-situ* balancing may be necessary due to a range of economic and technical reasons, including:

- a) the investment in a balancing machine cannot be justified;
- b) when a suitable balancing machine is not available in the correct location or at the required time;
- c) when it is not economic to dismantle the machine and transport the rotor(s) to a suitable balancing facility.

4.2.4 Machines under normal operation or during speed variations (following remedial work, or after commissioning) can have unacceptable magnitudes of vibration when compared with common practice, contractual requirements, or International Standards such as ISO 7919 and ISO 10816. In many cases, it is possible to bring the machine within acceptable vibration magnitude by *in-situ* balancing.

4.3 Objectives of *in-situ* balancing

The reason for balancing is to reduce the vibration magnitudes to acceptable values for long-term operation. For most machines, the overall vibration magnitude limits shall either be based on common practice or the appropriate part of ISO 7919 (for shaft vibration) and ISO 10816 (for bearing housing and pedestal vibration).

Where the magnitude of unbalance is of concern, reduce the magnitude of unbalance to within permissible limits (see ISO 1940-1 and ISO 11342 for details).

5 Criteria for performing *in-situ* balancing

Prior to *in-situ* balancing, a feasibility study shall be carried out to assess if the available correction planes are suitable to influence the vibration behaviour being observed, since limited access to correction planes and measurement points on the fully built-up machine can make *in-situ* balancing impractical. Where possible, experience from previous *in-situ* balancing should be used. Sometimes modal analysis may be required.

In-situ balancing shall only be attempted in the following circumstances:

- a) the reasons for the high vibrations are understood and cannot be corrected at the source;
- b) after analysis of the vibration behaviour, it is judged that balancing is a safe and practical approach;
- c) under the required normal operating conditions, the vibration vector is steady and repeatable prior to and during *in-situ* balancing;
- d) since the addition of correction masses only affects the once-per-revolution component of vibration, *in-situ* balancing makes sense only if this is a significant component of the overall vibration magnitude.

In special circumstances, where the once-per-revolution vibration component changes during normal operation of the machine (such as thermally induced bends in generator rotors), it is possible to reach acceptable balancing results across the operating envelope by adding correction masses. Here, with the vibration magnitude at full speed, no load might be compromised to obtain an acceptable vibration magnitude at full load. Again, this shall only be attempted if the reasons for the unbalance are understood.

NOTE When systems are operating in a non-linear mode, correction masses can affect other vibration components, including both sub and high shaft speed harmonics.

The once-per-revolution component of vibration might not originate from unbalance but is generated from system forces such as those found in hydraulic pumps and electric motors. Many defects, such as shaft alignment errors and tilting bearings, can also contribute to the once-per-revolution component of vibration. Such effects should not normally be corrected by balancing, since this can mask a real system fault.