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Mechanical vibration — 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 20806:2009. It supersedes BS ISO 20806:2004 which is withdrawn.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 — Criteria and safeguards for the in-situ balancing of medium and large rotors

Vibrations mécaniques — Critères et sauvegardes relatifs à l'équilibrage in situ des rotors moyens et grands

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Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
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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 20806 was prepared by Technical Committee ISO/TC 108, *Mechanical vibration, shock and condition monitoring*.

This second edition cancels and replaces the first edition (ISO 20806:2004), of which it constitutes a minor revision.

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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/bearing supports and/or 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 becoming increasingly 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 balance planes and the size of correction masses available.

A general guide to the International Standards associated with mechanical balancing of rotors is given in ISO 19499[4]. Rotors with a constant (rigid) behaviour are covered by ISO 1940-1 and rotors with a shaft elastic (flexible) behaviour are covered by ISO 11342[3].

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Mechanical vibration — Criteria and safeguards for the in-situ balancing of medium and large rotors

1 Scope

This International Standard 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 International Standard 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 International Standard 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 amendments) applies.

ISO 1925, *Mechanical vibration — Balancing — Vocabulary*

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

ISO 2041, *Mechanical vibration, shock and condition monitoring — Vocabulary*

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*

IS0 10817-1, *Rotating shaft vibration measuring systems — Part 1: Relative and absolute sensing of radial vibration*

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3 Terms and definitions

For the purpose of this document, the terms and definitions given in ISO 1925 and ISO 2041 apply.

3.1
***in-situ* balancing**
process of balancing a rotor in its own bearings and support structure, rather than in a balancing machine

NOTE Adapted from the definition of "field balancing" in ISO 1925:2001, 4.14. As it is easier to understand, the term "*in-situ* balancing" is to replace "field balancing" in the next revision of ISO 1925.

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 may 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[2]) and has load-dependent unbalance.

Most sites have limited instrumentation and data-processing capabilities, when compared to a balancing facility, 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 may be correctly balanced, as appropriate, in a high- or low-speed balancing machine, *in-situ* balancing might be required when the rotors are coupled into the complete rotor train. This could 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 might 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 could 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 may not be possible if a small number of blades are replaced.

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4.2.3 *In-situ* balancing might 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 and/or during speed variations (following remedial work, or after commissioning) might have unacceptable magnitudes of vibration when compared with common practice, contractual requirements, or International Standards such as ISO 10816 (all parts) and ISO 7919 (all parts). In many cases, it may be 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 10816 and ISO 7919 for pedestals and shafts, respectively.

Where the magnitude of unbalance is of concern, reduce the magnitude of unbalance to within permissible limits (see ISO 1940-1 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) the addition of correction masses only affects the once-per-revolution component of vibration and, therefore, *in-situ* balancing shall only be carried out 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 be 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 balancing is effective at only a single speed and could mask a real system fault.

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