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Mechanical vibration — Balance quality requirements of rigid rotors —

Part 2: Balance errors

*Vibrations mécaniques — Exigences en matière de qualité
dans l'équilibrage des rotors rigides —*

Partie 2: Défauts d'équilibrage

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ISO 1940-2:1997(E)**Foreword**

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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 1940-2 was prepared by Technical Committee ISO/TC 108, *Mechanical vibration and shock*, Subcommittee SC 1, *Balancing, including balancing machines*.

ISO 1940 consists of the following parts, under the general title *Mechanical vibration — Balance quality requirements of rigid rotors*:

- *Part 1: Determination of permissible residual unbalance*
- *Part 2: Balance errors*

Annexes A to C of this part of ISO 1940 are for information only.

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Introduction

The balance quality of a rigid rotor is assessed during the balancing operation in accordance with ISO 1940-1 by the measurement of residual unbalance. This measurement may contain errors which originate from a number of sources. It is therefore necessary to consider the errors involved. Where experience has shown that these are significant they should be taken into account when defining the balance quality of the rotor. ISO 1940-1 does not deal with balance errors in detail, and especially not with the assessment of balance errors, therefore this part of ISO 1940 gives examples of typical errors that can occur and provides recommended procedures for determining them. In addition generalized methods for evaluating the residual unbalance in the presence of balance errors are described.

Mechanical vibration — Balance quality requirements of rigid rotors —

Part 2: Balance errors

1 Scope

This part of ISO 1940 covers the following:

- identification of errors in the balancing process of rigid rotors;
- assessment of errors;
- guidelines for taking errors into account;
- the evaluation of residual unbalance in any two correction planes.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 1940. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 1940 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

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

ISO 1925:1990/Amd.1:1995, *Amendment 1 to ISO 1925:1990*.

ISO 1940-1:1986, *Mechanical vibration — Balance quality requirements of rigid rotors — Part 1: Determination of permissible residual unbalance*.

ISO 2953:1985, *Balancing machines — Description and evaluation*.

3 Definitions

For the purposes of this part of ISO 1940, the definitions given in ISO 1925 (and its Amendment 1) apply.

4 Sources of balance errors

Balance errors may be classified into one of the following groups:

- a) systematic errors, in which the amount and angle can be evaluated either by calculation or by measurement;
- b) randomly variable errors, in which the amount and angle vary in an unpredictable manner for a number of measurements carried out under the same conditions;
- c) scalar errors, in which the maximum amount can be evaluated or estimated, but the angle is indeterminate.

Depending on the manufacturing processes used, the same error may be placed in one or more of the above categories.

Examples of the sources of errors which may occur are listed in 4.1, 4.2 and 4.3. Some of these errors are discussed in greater detail in annex A.

4.1 Systematic errors

The following are examples of the sources of systematic errors.

- a) Inherent unbalance in the drive shaft of the balancing machine.
- b) Inherent unbalance in the mandrel.
- c) Radial and axial runout in the drive element on the rotor shaft axis.
- d) Radial and axial runout in the rotor fit for components or in the mandrel (see subclause 5.3).
- e) Lack of concentricity between journals and support surfaces used for balancing.
- f) Radial and axial runout of rolling element bearings which are not the service bearings and which are used to support the rotor in the balancing machine.
- g) Radial and axial runout of rotating races (and their tracks) of rolling element service bearings fitted after balancing.
- h) Unbalance from keys and keyways.
- i) Residual magnetism in rotor or mandrel.
- j) Errors caused by re-assembly.
- k) Errors caused by the balancing equipment and instrumentation.
- l) Differences between service shaft and balancing mandrel diameters.
- m) Defect in universal joints.
- n) Permanent bend in a rotor after balancing.

4.2 Randomly variable errors

The following are examples of the sources of randomly variable errors.

- a) Loose parts.
- b) Entrapped liquids or solids.
- c) Distorsion caused by thermal effects.
- d) Windage effects.
- e) Use of a loose coupling as drive element.
- f) Transient bend in horizontal rotor caused by gravitational effects, when the rotor is stationary.

4.3 Scalar errors

The following are examples of the sources of scalar errors.

- a) Clearance at interfaces which are to be disassembled after the balancing process.
- b) Excessive clearance in universal joints.
- c) Excessive clearance on mandrel or shaft.
- d) Design and manufacturing tolerances.
- e) Runout of the balancing machine support rollers if their diameters and the rotor journal diameter are the same or nearly the same or have an integer ratio.

5 Assessment of errors

5.1 General

In some cases rotors are in balance by design, are uniform in material and are machined to such narrow tolerances that they do not need to be balanced after manufacture. However, in the large majority of rotors initial unbalance exceeds the permitted levels given in ISO 1940-1, so that these rotors have to be balanced. Subclauses 5.2 to 5.6 deal with balance errors that may occur during this process.

5.2 Errors caused by balancing equipment and instrumentation

Balance errors caused by balancing equipment and instrumentation may increase with the amount of the unbalance present. Every attempt should therefore be made to design a symmetrical rotor. Furthermore, by considering unbalance causes during the design stage, some causes can be eliminated altogether, e.g. by combining several parts into one, or reduced by decreased fit tolerances. The cost of tighter tolerances must be weighed against the benefit of decreased unbalance causes. Where such causes cannot be eliminated or reduced to negligible levels, they should be mathematically evaluated.

5.3 Balance errors caused by radial and axial runout of fits for components

When a perfectly balanced rotor component is mounted eccentric to the rotor shaft axis, the resulting static unbalance U_s equals the mass m of the component multiplied by the eccentricity e :

$$U_s = m \cdot e \quad \dots (1)$$