INTERNATIONAL STANDARD

ISO 11342

Second edition
1998-04-15

Mechanical vibration — Methods and criteria for the mechanical balancing of flexible rotors

Vibrations mécaniques — Méthodes et critères pour l'équilibrage mécanique des rotors flexibles

Reference number
ISO 11342:1998(E)

Contents

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Printed in Switzerland

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.

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 11342 was prepared by technical committee ISO/TC 108, *Mechanical vibration and shock*, Subcommittee SC 1, *Balancing, including balancing machines*.

This second edition cancels and replaces the first edition (ISO 11342:1994), of which it constitutes a technical revision.

Annexes A to I of this International Standard are for information only.

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Introduction

The aim of balancing any rotor is to achieve satisfactory running when installed on site. In this context "satisfactory running" means that not more than an acceptable magnitude of vibration is caused by the unbalance remaining in the rotor. In the case of a flexible rotor, it also means that not more than an acceptable magnitude of deflection occurs in the rotor at any speed up to the maximum service speed.

Most rotors are balanced in manufacture prior to machine assembly because afterwards, for example, there may be only limited access to the rotor. Furthermore, balancing of the rotor is often the stage at which a rotor is approved by the purchaser. Thus, while satisfactory running on site is the aim, the balance quality of the rotor is usually initially assessed in a balancing facility. Satisfactory running on site is in most cases judged in relation to vibration from all causes, while in the balancing facility primarily once-per-revolution effects are considered.

This International Standard classifies rotors in accordance with their balancing requirements and establishes methods of assessment of residual unbalance.

This International Standard also shows how criteria for use in the balancing facility may be derived from either vibration limits specified for the assembled and installed machine or unbalance limits specified for the rotor. If such limits are not available, this International Standard shows how they may be derived from ISO 10816 and ISO 7919 if desired in terms of vibration, or from ISO 1940-1 if desired in terms of permissible residual balance. ISO 1940 is concerned with the unbalance quality of rotating rigid bodies and is not directly applicable to flexible rotors because flexible rotors may undergo significant bending deflection. However, in subclause 8.3 of this International Standard, methods are presented for adapting the criteria of ISO 1940-1 to flexible rotors.

As this International Standard is complementary in many details to ISO 1940, it is recommended that, where applicable, the two should be considered together.

There are situations in which an otherwise acceptably balanced rotor experiences an unacceptable vibration level *in situ*, owing to resonances in the support structure. A resonant or near resonant condition in a lightly damped structure can result in excessive vibratory response to a small unbalance. In such cases it may be more practicable to alter the natural frequency or damping of the structure rather than to balance to very low levels, which may not be maintainable over time. (See also ISO 10814.)

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Mechanical vibration — Methods and criteria for the mechanical balancing of flexible rotors

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1 Scope

This International Standard presents typical flexible rotor configurations in accordance with their characteristics and balancing requirements, describes balancing procedures, specifies methods of assessment of the final state of unbalance, and gives guidance on balance quality criteria.

This International Standard may also be applicable to serve as a basis for more involved investigations, for example when a more exact determination of the required balance quality is necessary. If due regard is paid to the specified methods of manufacture and limits of unbalance, satisfactory running conditions can be expected.

This International Standard is not intended to serve as an acceptance specification for any rotor, but rather to give indications of how to avoid gross deficiencies and/or unnecessarily restrictive requirements.

The subject of structural resonances and modifications thereof is outside the scope of this International Standard.

The methods and criteria given are the result of experience with general industrial machinery. They may not be directly applicable to specialized equipment or to special circumstances. Therefore, there may be cases where deviations from this International Standard may be necessary[1].

2 Normative references

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

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

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

[1] Information on such exceptions will be welcomed and should be communicated to the national standards body in the country of origin for transmission to the secretariat of ISO/TC 108/SC1.

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

ISO 2041:1990, *Vibration and shock — Vocabulary*

ISO 8821:1989, *Mechanical vibration — Balancing — Shaft and fitment key convention*

3 Definitions

For the purposes of this International Standard, the definitions relating to mechanical balancing given in ISO 1925 and the definitions relating to vibration given in ISO 2041 apply.

NOTE — Definitions from ISO 1925 relating to flexible rotors are given for information in annex H.

4 Fundamentals of flexible rotor dynamics and balancing

4.1 General

Flexible rotors normally require multiplane balancing at high speed. Nevertheless, under certain conditions a flexible rotor can also be balanced at low speed. For high-speed balancing two different methods have been formulated for achieving a satisfactory state of balance, namely modal balancing and the influence coefficient approach. The basic theory behind both of these methods and their relative merits are described widely in the literature and therefore no further detailed description will be given here. In most practical balancing applications, the method adopted will normally be a combination of both approaches, often incorporated into a computer package.

4.2 Unbalance distribution

The rotor design and method of construction can significantly influence the magnitude and distribution of unbalance along the rotor axis. Rotors may be machined from a single forging or they may be constructed by fitting several components together. For example, jet engine rotors are constructed by joining many shell, disc and blade components. Generator rotors, however, are usually manufactured from a single forging, but will have additional components fitted. The distribution of unbalance may also be significantly influenced by the presence of large unbalances arising from shrink-fitted discs, couplings, etc.

Since the unbalance distribution along a rotor axis is likely to be random, the distribution along two rotors of identical design will be different. The distribution of unbalance is of greater significance in a flexible rotor than in a rigid rotor because it determines the degree to which any flexural mode is excited. The effect of unbalance at any point along a rotor depends on the mode shapes of the rotor.

The correction of unbalance in transverse planes along a rotor other than those in which the unbalance occurs may induce vibrations at speeds other than that at which the rotor was originally corrected. These vibrations may exceed specified tolerances, particularly at, or near, the flexural critical speeds. Even at the same speed such correction can induce vibrations if the flexural mode shapes on site differ from those dominating during the balancing process.

In addition, some rotors which become heated during operation are susceptible to thermal bows which can lead to changes in the unbalance. If the rotor unbalance changes significantly from run to run it may be impossible to balance the rotor within tolerance.

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