

International Standard



5343

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Criteria for evaluating flexible rotor balance

Critères d'équilibrage pour les rotors flexibles

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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 developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been authorized 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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 5343 was developed by Technical Committee ISO/TC 108, *Mechanical vibration and shock*, and was circulated to the member bodies in June 1982.

It has been approved by the member bodies of the following countries :

Austria	Germany, F.R.	Romania
Belgium	Italy	South Africa, Rep. of
Canada	Japan	United Kingdom
China	Korea, Rep. of	USA
Czechoslovakia	Netherlands	
Egypt, Arab Rep. of	New Zealand	

The member body of the following country expressed disapproval of the document on technical grounds :

France

Criteria for evaluating flexible rotor balance

0 Introduction

The aim of balancing any rotor is satisfactory running when installed on site. In this context "satisfactory running" means that no more than an acceptable level of vibration is transmitted to the machine by the unbalance remaining in the rotor. In the case of a flexible rotor, it also means that no more than an acceptable magnitude of deflection occurs in the rotor at any speed up to maximum service speed.

Most rotors are balanced by their manufacturers prior to machine assembly because afterwards, *inter alia*, there may be only limited access to the rotor. Furthermore, completion and 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 usually judged in relation to vibration from all causes, while in the balancing facility primarily once-per-revolution effects are considered.

This International Standard 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 2372, or ISO 3945/ISO 2373 (if desired in terms of vibration) or from ISO 1940 (if desired in terms of permissible residual unbalance). ISO 1940 is concerned with the balance quality of rotating rigid bodies and is thus not directly applicable to flexible rotors because they may undergo significant bending deflection. However, in clause 6 of this International Standard, methods are presented for adapting the criteria of ISO 1940 to flexible rotors.

This International Standard on criteria is to be read in conjunction with ISO 5406.

The criteria values given in annex A are derived from ISO 2372, and those in 6.2 and 6.3 are based on the results of practical experience. It is recommended that users compare these values with their own experiences. If discrepancies or omissions are discovered, comments on the results of such comparisons will be welcome.¹⁾

The methods and criteria values given are the result of experience with general industrial machinery. They may not be directly applicable to specialized equipment or to special circumstances. Information on such exceptions will also be welcome.¹⁾

1 Scope and field of application

This International Standard specifies two methods for evaluating the quality of balance of a flexible rotor in a balancing facility before machine assembly, with the aim that the rotor will run satisfactorily after machine assembly and installation on site. If the rotor balance tolerances suggested herein are achieved during correction in a balancing facility, the final vibration limits of the assembled machine (see ISO 2372 and ISO 3945) will most probably be achieved. Accordingly, the criteria specified are those to be met when the rotor is tested in the balancing facility, but they are derived from those specified for the complete machine, when installed, or from values known to ensure satisfactory running of the rotor when it is installed.

2 References

ISO 1925, *Balancing — Vocabulary*.

ISO 1940, *Balance quality of rotating rigid bodies*.

ISO 2041, *Vibration and shock — Vocabulary*.

ISO 2372, *Mechanical vibration of machines with operating speeds from 10 rev/s to 200 rev/s — Basis for specifying evaluation standards*.

ISO 2373, *Mechanical vibration of certain rotating electrical machinery with shaft heights between 80 mm and 400 mm — Measurement and evaluation of the vibration severity*.

ISO 3945, *Mechanical vibration of large rotating machines with rotational operating speeds from 10 rev/s to 200 rev/s — Measurement and evaluation of vibration severity in situ*.

ISO 5406, *The mechanical balancing of flexible rotors*.

3 Definitions

The definitions relating to mechanical balancing in ISO 1925 and many of the definitions relating to vibration and shock in ISO 2041 are applicable to the subject matter of this International Standard. For the convenience of users of this International Standard, the following terms and definitions are repeated from ISO 1925.

1) Comments should be directed to the national standards body in the country of origin for transmission to the secretariat of ISO.

3.1 rigid rotor : A rotor is considered rigid when it can be corrected in any two (arbitrarily selected) planes and, after that correction, its unbalance does not significantly exceed the balancing tolerances (relative to the shaft axis) at any speed up to maximum service speed and when running under conditions which approximate closely to those of the final supporting system. (Such rotors are referred to as class 1 rotors as defined in ISO 5406.)

3.2 flexible rotor : A rotor not satisfying definition 3.1 because of bending deflection. (Such rotors are referred to as being in classes 2 to 5 inclusive as defined in ISO 5406.)

3.3 (rotor) flexural critical speed : A speed of a rotor at which there is maximum bending of the rotor and where flexure of the rotor is more significant than deflection of the bearings.

3.4 (rotor) flexural principal mode : For undamped rotor/bearing systems, that mode shape which the rotor takes up at one of the (rotor) flexural critical speeds.

3.5 modal balancing : A procedure for balancing flexible rotors in which balance corrections are made to reduce the amplitude of vibration in the separate significant principal flexural modes to within specified limits.

3.6 n^{th} modal unbalance : That unbalance which affects only the n^{th} principal mode of the deflection configuration of a rotor/bearing system.

NOTE — This n^{th} modal unbalance is not a single unbalance but an unbalance distribution $\vec{u}_n(z)$ in the n^{th} principal mode. It can be mathematically represented with respect to its effect on the n^{th} principal mode by a single unbalance vector $\vec{U}_n$ obtained from the formula :

$$\vec{U}_n = \int_0^l \vec{u}_n(z) \phi_n(z) dz$$

where $\phi_n(z)$ is the mode function.

3.7 equivalent n^{th} modal unbalance : The minimum single unbalance $\vec{U}_{ne}$, equivalent to the n^{th} modal unbalance in its effect upon the n^{th} principal mode of the deflection configuration.

NOTES

1 There exists the relation $\vec{U}_n = \vec{U}_{ne} \phi_n(z_0)$, where $\phi_n(z_0)$ is the mode function value for $z = z_0$ the axial co-ordinate of the transverse plane where $\vec{U}_{ne}$ is applied.

2 A set of balance masses distributed in an appropriate number of correction planes and so proportioned that the mode under consideration will be affected, may be called the equivalent n^{th} modal unbalance set.

3 An equivalent n^{th} modal unbalance will affect some modes other than the n^{th} mode.

3.8 modal unbalance tolerance : With respect to a mode, that amount of modal unbalance that is specified as the maximum below which the state of unbalance in that mode is considered acceptable.

3.9 low speed balancing (relating to flexible rotors) : A procedure of balancing at a speed where the rotor to be balanced can be considered rigid.

3.10 high speed balancing (relating to flexible rotors) : A procedure of balancing at speed where the rotor to be balanced cannot be considered rigid.

4 Choice of method

It is a usual practice when assessing the balance quality of a flexible rotor in the factory to consider the once-per-revolution vibration of the bearing pedestals or journals in a balancing facility or test-bed that reasonably imitates the site conditions for which the rotor is intended (see however 5.4). This is the method described in clause 5.

Another practice is to assess the balance quality by considering the unbalance remaining in specified correction planes. This is the method described in clause 6. For class 2 rotors¹⁾, the assessment may be made at low speed, without any necessity to use a high speed balancing facility.

When employing either practice described above, it is also sometimes possible, based on experience, to adjust acceptance levels to permit the use of facilities or installations that do not closely imitate site conditions and/or to allow for the final effect of coupling to another rotor on site.

The choice between the use of the method described in clause 5 and the use of that described in clause 6 shall be at the discretion of the manufacturer of the rotor.

5 Recommendations for establishing criteria as vibrations permissible at specified measuring points in the balancing facility

5.1 General

This clause explains how permissible levels of once-per-revolution vibration can be derived from the vibration severity specified in the product specification. If no product specification describing the acceptable running conditions on site exists, reference should be made to ISO 2372, ISO 2373, ISO 3945 or other appropriate document.

Numerical values derived according to this clause are not intended to serve as acceptance specifications but as guidelines. When used in this manner, gross deficiencies or unrealistic requirements may be avoided.

If due regard is paid to the recommended values, satisfactory running conditions can be expected. However, there may be cases when deviations from these recommendations become necessary.

These recommendations may also serve as the basis for more detailed investigations, for example when, in special cases, a more exact determination of the required balance quality is necessary.

1) See table in ISO 5406 for details of rotor classification.