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Field balancing equipment — Description and evaluation

Appareils pour l'équilibrage in situ — Description et caractéristiques

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (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 set up 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 2371 was drawn up by Technical Committee ISO/TC 108, *Mechanical vibration and shock*, and circulated to the Member Bodies in June 1971.

It has been approved by the Member Bodies of the following countries :

Austria	Ireland	Sweden
Belgium	Japan	Switzerland
Egypt, Arab Rep. of	Netherlands	United Kingdom
France	New Zealand	U.S.A.
Germany	South Africa, Rep. of	U.S.S.R.

No Member Body expressed disapproval of the document.

Field balancing equipment — Description and evaluation

0 INTRODUCTION

IEC Publications 184, *Methods for specifying the characteristics of electro-mechanical transducers for shock and vibration measurements,* and 222, *Methods for specifying the characteristics of auxiliary equipment for shock and vibration measurement,* have been taken into consideration in the preparation of this International Standard where applicable. Components forming part of the equipment and system shall meet the requirements of the relevant IEC Publications where applicable.

1 SCOPE AND FIELD OF APPLICATION

This International Standard gives rules for the description and evaluation of equipment for field balancing. Specifically, it outlines information that the manufacturer of the equipment should provide to permit the evaluation of such equipment for meeting individual field balancing requirements. Additionally, it may assist the user in specifying his requirements to the manufacturer.

This International Standard applies to portable field balancing equipment which provides adequate information for determining both the amount-of-unbalance and its angular location in one or more planes.

It does not apply to general vibration measuring equipment, nor does it specify acceptable balancing criteria.

2 DEFINITION

For the purpose of this International Standard the following definition shall apply.

field balancing : The process of balancing a rotor in its own bearings, other than in a balancing machine. Under such conditions, the information required to perform balancing is derived from measurements of vibratory forces or motions of the supporting structure and/or rotor caused by rotor unbalance.

3 DESCRIPTION OF EQUIPMENT

3.1 A description of the principles of operation shall be given for all major components of the equipment and system, and may include the following items.

3.1.1 Transducer (mechanical, electro-dynamic, piezo-electric, seismic, magnetostrictive, proximity, etc.).

3.1.2 Filter (resonant mechanical, active or passive networks, wattmetric, etc.).

3.1.3 Amplitude indicator (mechanical, electro-mechanical, optical, electronic, etc.).

3.1.4 Angle indicator (mechanical, electrical, stroboscopic, optical, electronic, etc.).

3.1.5 Frequency or speed indicator (resonant mechanical, electro-mechanical, electronic, etc.).

3.1.6 Other special devices (plane separator, calibrator, vibration analyser, etc.).

3.2 A physical description of the system indicating dimensions, mass, power requirements and power consumption shall be given. If an external power source is required, the source voltage, frequency range(s) and number of phases over which the equipment will operate within system performance specifications shall be stated. If the equipment is capable of operation from more than one power source, the method of changing from one to another shall be described.

3.3 If a specially regulated power source voltage is required, the percentage regulation required shall be specified and recommendations given as to the most effective method of obtaining this regulation.

3.4 For battery-operated equipment, the voltage, capacity (ampere-hours), operating life, testing means and charging procedure (if applicable) shall be described.

4 DESCRIPTION OF PROCEDURES

4.1 System operation

Typical balancing procedures shall be described in such a manner as will clearly explain the operation of the equipment. This description shall include the following items.

4.1.1 The setting up of the equipment, including all attachments and adjustments in preparation for performing the balancing operation.

4.1.2 The methods of determining the magnitude and position of the compensation weights from the measured values, such as :

a) plane separation and associated calibration;

b) graphical and trigonometric methods;

c) computer methods.

4.1.3 The methods for checking and/or calibrating the equipment.

5 SYSTEM PERFORMANCE LIMITS

The following specifications, which define the limits of system performance, shall be given.

5.1 Speed range.

5.2 Range of vibration amplitudes (displacement, velocity or acceleration) (peak, rms, average, etc.).

Where the amplitude range is dependent on the speed range, this shall be stated.

5.3 Accuracy and precision (repeatability) of the indicated amplitude over the operating rotational speed and amplitude ranges.

5.4 Accuracy, including phase lag, and precision (repeatability) of the indicated angle from a given reference over the operating rotational speed and amplitude ranges.

5.5 The manufacturer shall state the range of the environmental factors within which the equipment is capable of achieving the guaranteed performance; for example :

a) temperature;

b) extraneous vibration;

c) magnetic fields;

d) sound fields;

e) light intensities;

f) power source variations;

g) cable length;

h) tropical climatic conditions.

NOTE — Performance limitations shall be stated for both the transducer and indicator units.

5.6 The extremes of the factors given in 5.5, where applicable, over which the equipment can be used without suffering permanent damage shall be stated.

6 COMPONENT PERFORMANCE

The mechanical and electrical characteristics of the system's components shall be given, including the following, as applicable :

6.1 Vibration transducer

6.1.1 The frequency range in which the transducer operates within specified sensitivity limits shall be stated. Factors that influence sensitivity shall be stated; for example :

a) mounting surfaces and finishes;

b) transducer mounting means, such as vice clamps, magnetic holders, brackets, etc;

c) length and characteristics of the connecting cables.

6.1.2 The sensitivity of the transducer shall be stated in terms of output per unit of displacement, velocity or acceleration (for example, $\frac{\text{mV}}{\text{mm/s}}$).

NOTE — In the case of proximity transducers, the conditions of mounting and the effect of surrounding material shall be stated.

6.1.3 The amplitude range of the transducer over which the relationship of input to output is within specified limits shall be stated. If the amplitude range is a function of frequency, the range may be shown graphically.

6.1.4 The maximum transverse sensitivity of the transducer and its direction shall be stated and expressed as a percentage of rated sensitivity over a specified frequency range.

6.1.5 The natural frequencies of the transducer shall be stated.

6.1.6 Where appropriate, the percentage of critical damping, and the method of damping (oil, air or magnetic) shall be stated.

6.1.7 The limiting values of shock and vibration, in all three principal axes, to which the transducer can be subjected without impairing performance shall be stated.

6.1.8 The dimensions, mass and effective mass of the transducer shall be stated.

6.1.9 The means for attaching the transducer to the rotor or its supporting structure shall be described in detail, including restrictions on transducer orientation relative to the gravity axis.

6.1.10 The direction of the principal axis of sensitivity relative to the mounting surface shall be stated.

6.1.11 If the transducer is not self-generating, the energizing requirements shall be described.

6.1.12 Precautions which must be observed in the field, including protective equipment needed to obtain satisfactory performance, in the presence of extremes in the following conditions shall be indicated :

a) temperature;

b) moisture;

c) dust;

d) corrosive substances;

e) air-borne sound fields;

f) magnetic fields;

g) explosive hazards;

h) oil;

i) atmospheric pressure;

j) surrounding metallic masses.

6.1.13 The electrical impedance of the transducer shall be stated.

6.1.14 If an insulating coupling is provided to avoid interference from earth currents, any effect on performance shall be stated.

6.2 Amplitude indicator

6.2.1 The type of amplitude indication shall be described (analogue or digital read-out). The full-scale amplitude ranges that may be selected by the operator, the means of selection, and the indicator scale lengths and divisions shall be stated, as applicable.

6.2.2 The manufacturer of the equipment shall state the amplitude of the noise that can be tolerated by the equipment for a specified change in amplitude indication, in relation to the amplitude of the rotational-speed signal. This statement shall be made for at least the rotational speed that gives the least favourable results within the rotational-speed range given in 5.1. The statement shall apply to noise at frequencies that are higher and lower than that of the rotational-speed signal. For an example, see annex B.

6.2.3 The following filter characteristics shall be specified :

a) the ranges over which the nominal upper and lower cut-off frequencies (or centre frequency) can be adjusted by the operator, and the means of adjustment;

b) the filter bandwidth, measured at specified attenuation levels, expressed as a percentage of centre frequency (for constant-percentage bandwidth filters) or in frequency units (for constant bandwidth filters);

c) the filter attenuation one octave or more removed from the cut-off frequency (or centre frequency), expressed in decibels relative to the passband (or peak) response;

d) any discontinuities in the rejection characteristics.

6.2.4 The method of calibrating the indicating system for use with a given transducer shall be described.

6.2.5 For the purpose of calibration, the required electrical input for full-scale indication of the amplitude indicator shall be stated for the most sensitive range.

6.2.6 The input impedance of the amplitude indicator shall be stated.

6.3 Angle reference generator

The mechanical and electrical characteristics as defined in 6.1.1 to 6.1.14 shall be given, as applicable. Information shall be provided pertaining to special conditions which must be considered for accurate and reliable system performance such as :

a) ambient light or degree of contrast, if applicable;

b) special couplings to the rotor;

c) necessary attachments or modifications made to the rotor.

6.4 Angle indicator

6.4.1 The methods for adapting the angle indicator for use with specific angle reference generators shall be described.

6.4.2 The manufacturer of the equipment shall state the amplitude of the noise that can be tolerated by the equipment for a specified change in angle indication, in relation to the amplitude of the rotational-speed signal. This statement shall be made for at least the rotational speed that gives the least favourable results within the rotational-speed range given in 5.1. The statement shall apply to interference frequencies that are higher or lower than that of the rotational-speed signal. For an example, see annex B.

6.4.3 The range of electrical input for operation within the specified accuracy shall be stated.

6.4.4 The input impedance of the angle indicator shall be stated.

6.4.5 Other information, as applicable, shall be given in sufficient detail to convey an understanding of accuracy and ease of use in field balancing, such as :

a) type of angle indication (for example stroboscopic light, meter, oscilloscope or other means);

b) the illumination at a given distance over the extremes of the frequency range;

c) the average bulb life for stroboscopic lights;

d) scale ranges and method of selection;

e) the special operator techniques or interpretations necessary to obtain angle indications if the angle indication is not obtained directly.

NOTE — For systems which combine the amplitude and angle indicators, the operation and characteristics of the integrated system shall be described.

7 SPECIAL FEATURES TO AID BALANCING

7.1 Rotational-speed indicator

The rotational-speed indicating device shall be described (analogue or digital read-out). The full-scale ranges, the means of selection and the indicator scale length and divisions shall be stated. The deviation and repeatability of the indicated rotational speed from the actual speed shall be stated as a constant error or a percentage limit, as applicable, over the rated range for the limiting conditions of input signal amplitude.

7.2 Auxiliary balancing devices

Auxiliary balancing devices included with field balancing equipment to compensate for initial unbalance, to cancel cross-effects, and to convert amplitude and phase indications to amount-of-unbalance and angular location shall be described. Sufficient information shall be given on the individual networks to allow the relative usefulness of such devices to be assessed.

ANNEX A

OPERATOR TRAINING

Training should be sufficiently broad in scope to enable personnel with defined skills and educational background to correct rotor unbalance through proper use of the equipment.

The type of operator training available should be described (formal classroom instruction, practical demonstrations, printed material).

1) Principles of equipment operation and design.

2) Equipment set-up and adjustments, for example :

a) preparations required on the rotor and/or its supporting structures (transducer mounting, phase marks, reference generator attachment, etc.);

b) preparation and adjustments required on the balancing equipment (filter adjustment, range adjustment, plane separator adjustment, etc.);

c) methods of determining the amount-of-unbalance and its angular location from the measured values such as :

– plane separation and associated calibration;

– graphical and trigonometric methods (graphical evaluation, trigonometric calculations, direct read-out through plane separator and calibration networks, etc.).

3) Methods for checking the equipment after balancing to assure accuracy of calibration and plane separation.

4) Equipment maintenance procedures, methods for field and laboratory calibration, parts replacement, troubleshooting procedures and other information for maintaining consistent and reliable operation.

In addition, at the request of the purchaser, the manufacturer should state whether facilities can be provided for the general training of the operator, which should include the following :

1) Balancing theory, methods for determining solutions of unbalance problems (trial and error, vector calculations, graphical) and methods for determining residual unbalance.

2) Common field balancing practices, such as transducer placement, reducing effects of extraneous vibration, selection of trial weights, recognition of vibration problems not related to unbalance, means of applying permanent correction weights, etc.

ANNEX B

OVERLOAD CHARACTERISTICS OF INTERFERENCE

The usefulness of field balancing equipment (like that of any instrumentation package) may be limited by the relative magnitudes of the desired once-per-revolution signal (due to the presence of an unbalance) and the interference present (say, due to the overload characteristics of the electronic equipment package). For some ratio of interference to desired signal it will not be possible to use the equipment effectively. Thus, it is desirable to know this ratio (as a function of speed over the operating range of the equipment) in order to evaluate the range of usefulness of the equipment.

In the figure, the ratio of interference to rotational-speed signal is plotted for three systems (as a function of speed) for a 10 % change in amplitude or a 10 % change in angle. Each system has a filter with different characteristics.

The most desirable system is that which will provide the greatest ratio of the frequencies of the interference present. In the examples of the figure, system A provides the most accurate readings in the presence of interference at frequencies greater than 1,6 times or less than 0,7 times rotational speed, since the maximum permissible interference ratio for system A is greater in those speed ranges than it is for both systems B and C. If the interference is at frequencies between 0,7 times and 1,6 times rotational speed, system B has the most desirable characteristic. At all frequencies, system C has the least desirable filter characteristic; the maximum permissible ratio is relatively small at all frequencies, especially at the odd harmonics of rotational speed.

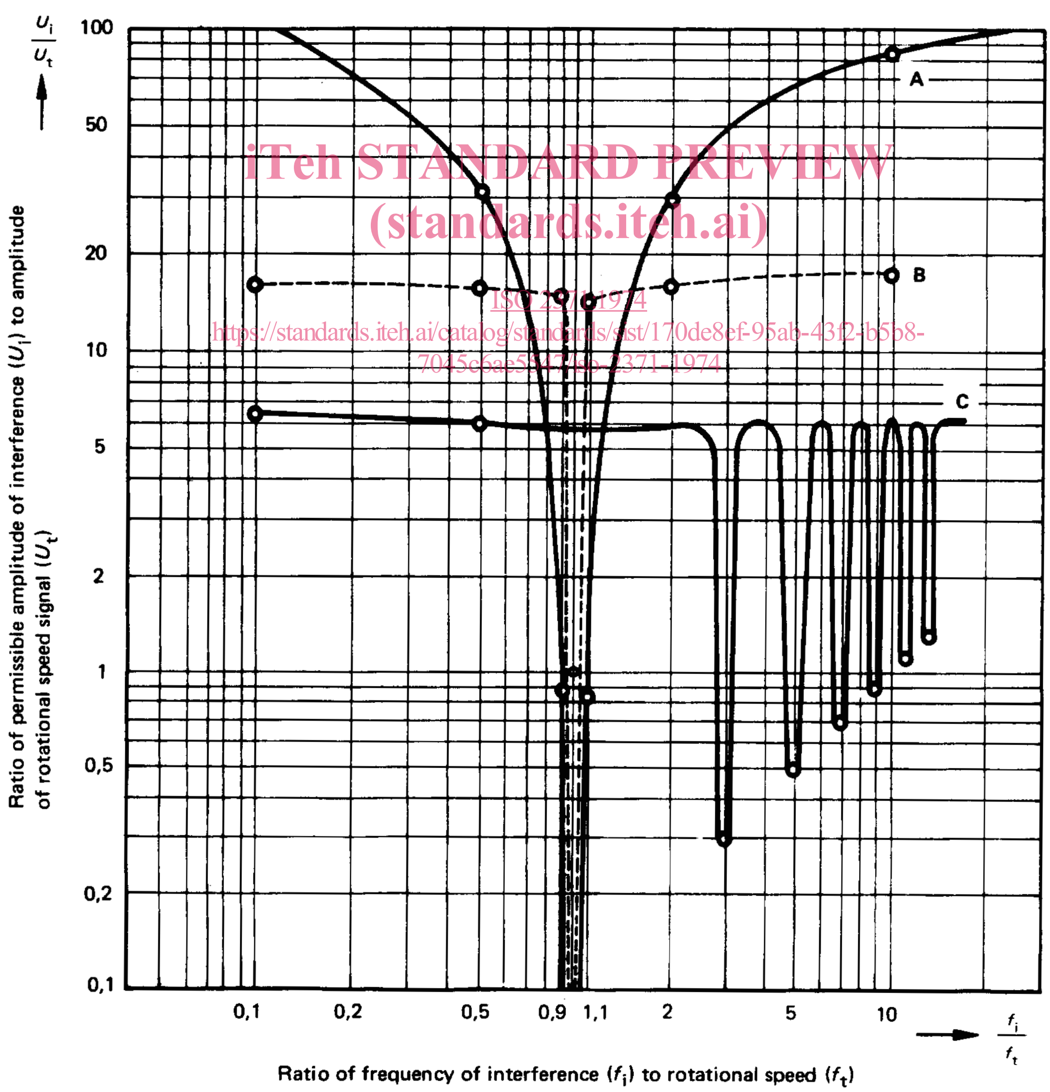

FIGURE — **Maximum permissible interference for 10 % amplitude change (10° change in angle indication)**