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Part 5:
Diagnostic techniques for fans and blowers

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 108, *Mechanical vibration, shock and condition monitoring*, Subcommittee SC 2, *Measurement and evaluation of mechanical vibration and shock as applied to machines, vehicles and structures*.

A list of all parts in the ISO 13373 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document defines the procedures to be considered when carrying out vibration diagnostics of fans and blowers. It is intended to be used by vibration practitioners, engineers and technicians and it provides them with useful diagnostic tools. These tools include the use of diagnostic flow charts, process tables and fault tables. The material contained in this document presents the most basic, logical and intelligent steps that should be taken when diagnosing problems associated with these particular types of machines.

The ISO 7919 (rotating shafts), ISO 10816 (non-rotating parts) and ISO 20816 (both rotating shafts and non-rotating parts) series of International Standards contain acceptable vibration values and zones for various types and sizes of machines, ranging from new and well-running machines to machines that are in danger of failing.

ISO 13373-1 presents the basic procedures for vibration narrow-band signal analysis. It includes the types of transducers used, their ranges and their recommended locations on various types of machines; on-line and periodic vibration monitoring systems; and potential machinery problems.

ISO 13373-2 includes descriptions of the signal conditioning equipment that is required; time and frequency domain techniques; and the waveforms and signatures that represent the most common machinery operating phenomena or machinery faults that are encountered when performing vibration signature analysis.

ISO 13373-3 provides some procedures to determine the causes of vibration problems common to all types of rotating machines. It includes systematic approaches to characterize vibration effects; the diagnostic tools available; which tools are needed for particular applications; and recommendations on how the tools are to be applied to different machine types and components. However, this does not preclude the use of other diagnostic techniques.

ISO 17359 indicates that diagnostics:

— can be started as a succeeding activity after detection of an anomaly during monitoring; or

— can be executed synchronously with monitoring from the beginning.

This document considers only the former, in which diagnostics are performed after an anomaly has been detected. Moreover, it focuses mainly on the use of flow charts and process tables as diagnostic tools, as well as fault tables, since it is felt that these are the tools that are most appropriate for use by practitioners, engineers and technicians in the field.

The flow-chart and diagnostic process table methodology presents a structured procedure for a person in the field to diagnose a fault and find its cause. This step-by-step procedure aims at guiding the practitioner in the vibration diagnostics of the machine anomaly, in order to reach the probable root cause of this anomaly.

The fault tables present a list of the most common faults in machinery, as well as their manifestations in the vibration data. When used with the flow charts, the tables assist with the identification of machinery faults.

When approaching a machinery problem that manifests itself as a high or erratic vibration signal, the diagnosis of the problem should be performed in a well thought out, systematic manner. This document, together with ISO 13373-3, achieves that purpose by providing to the analyst guidance on the selection of the proper measuring tools, the analysis tools and their use, and the step-by-step recommended procedures for the diagnosis of problems associated with various types of fans and blowers.

Condition monitoring and diagnostics of machines — Vibration condition monitoring —

Part 5: Diagnostic techniques for fans and blowers

1 Scope

This document sets out the specific procedures to be considered when carrying out vibration diagnostics of various types of fans and blowers.

This document is intended to be used by condition monitoring practitioners, engineers and technicians and provides a practical, step-by-step, vibration-based approach to fault diagnosis. In addition, it gives a number of examples for a range of machine and component types and their associated fault symptoms.

The approach given in this document is based on established good practice, put together by experienced users, although it is acknowledged that other approaches can exist. Recommended actions for a particular diagnosis depend on individual circumstances, the degree of confidence in the fault diagnosis (e.g. has the same diagnosis been made correctly before for this machine), the experience of the practitioner, the fault type and severity as well as on safety and commercial considerations. It is neither possible nor the aim of this document to define actions for all circumstances.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

ISO 13372, *Condition monitoring and diagnostics of machines — Vocabulary*

ISO 13373-1, *Condition monitoring and diagnostics of machines — Vibration condition monitoring — Part 1: General procedures*

ISO 13373-2, *Condition monitoring and diagnostics of machines — Vibration condition monitoring — Part 2: Processing, analysis and presentation of vibration data*

ISO 13373-3:2015, *Condition monitoring and diagnostics of machines — Vibration condition monitoring — Part 3: Guidelines for vibration diagnosis*

ISO 21940-2, *Mechanical vibration — Rotor balancing — Part 2: Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2041, ISO 13372 and ISO 21940-2 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Measurements

4.1 Vibration measurements

Vibration measurements may be obtained using two main categories of transducers:

— non-contacting, e.g. inductive, capacitive and eddy current probes used on rotating shafts; and

— seismic transducers, e.g. accelerometers or velocity transducers used on non-rotating parts, such as bearing housings.

International Standards are available to help assess the vibration severity for the described types of measurement, in particular the ISO 7919, ISO 10816 and ISO 20816 series.

Descriptions of transducer and measurement systems as well as specification of techniques are given in ISO 13373-1 and ISO 13373-2, which shall be considered for appropriate selection.

4.2 Machine operational parameter measurements

Machine operational parameter measurements are operational parameters, e.g. rotational speed, load, fan orientation (vertical or horizontal), mounting configuration (solid or flexible support arrangement) and temperatures, that can have an influence on the machine vibration characteristics and are therefore important to acquire in order to arrive at an appropriate diagnosis. For a given machine, these parameters can be associated with a range of steady-state and transient operating conditions.

5 Initial analysis

An initial analysis shall be performed in accordance with ISO 13373-3:2015, Annex A. This analysis should identify safety concerns, the presence of high vibration and, if so, its vibration severity, past history, effects of operating parameters, consequences of not taking corrective actions and the need for a fan shutdown. Other factors such as mounting configuration, position relative to other rotating machines, building structure, environment, etc. should be considered during an initial analysis. See also ISO 13373-3:2015, Annexes B to D, for common faults such as from installation and bearing defects.

6 Specific analysis of fans and blowers

This document covers vibration diagnosis information for the most common types of fans and blowers. Symptoms of the most prevalent fan and blower defects that cause excessive vibration magnitudes are given in Annex A, which shall be used. This annex does not cover fan or blower vibration from hydrodynamic bearing or rolling element bearing problems, which are addressed in ISO 13373-3:2015, Annexes C and D, respectively.

The systematic procedure used in the ISO 13373 series includes usage of fault tables and a step-by-step methodology of vibration diagnosis of faults. For this document, the fault table for the diagnosis of fans and blowers to be used is given by Table A.1, while the methodology of vibration diagnosis is presented in Annex B. Examples of the use of the fault table and methodology of vibration diagnosis of fans and blowers are given in Annex C.

Different designs of fans are presented in ISO 14694 and ISO 14695, as well as VDI 3839 Part 4. These include coupling driven fans and belt driven fans. In addition, overhung and centrally-hung fans are described. The user is advised to consult these standards for various fan designs.

Annex A
(normative)

Systematic approach to vibration analysis of fans and blowers

A.1 Fault table

The systematic approach to vibration analysis of fans and blowers is given by the fault table in Table A.1. The fault table includes mainly installation faults. For faults regarding fan or blower bearings, see ISO 13373-3:2015, Annexes C and D. Several faults can give similar indications and further investigation would be necessary to distinguish between them.

Table A.1 — Fault table for fans and blowers

Fault	Vibration characteristics	Other descriptors	Comment
Shaft misalignment/ concentricity errors	1x, or 1x and 2x, sometimes 1x and 2x and 3x.	Directional force 180° phase shift across coupling. Offset misalignment tends to produce phase shift across the coupling in the radial direction, while angular misalignment tends to produce the phase shift in the axial direction.	There are two types of misalignment: parallel and angular, and in most cases there would be a combination of the two.
Looseness	Usually a series of peaks at rotational speed and integer harmonics of rotational speed, generally the amplitude of these peaks decreasing with higher harmonic numbers.	Looseness can be at bearings or skid, or anchor bolts. Check for difference in amplitude and/or phase at the interface to discern position of looseness.	Looseness can be at the bearing housing (sometimes due to the bearing installation), and/or at the pedestal or the skid.
Excessive bearing clearance	1x. With low amplitude harmonics in rolling element bearings.	Directional.	Can be due to wear, in both fluid film and rolling element bearings.
Piping strain	1x	Directional, wave clipping in time waveform.	Piping flanges should match without jacking.
Soft foot	1x, plus 2x line frequency in the electric motor	Soft foot test.	Soft foot is the condition that exists when all feet are not correctly supporting the machine.
Shaft rubbing	Clipping in time waveform, with 1x and multiple harmonics in spectrum. Light rubbing can cause rotating vectors (spiral vibration).		Not commonly observed on fans.
NOTE ODS stands for operational deflection shape.			

Table A.1 *(continued)*

Fault	Vibration characteristics	Other descriptors	Comment
Unbalance	1x	Phase shift across coupling depends on the mode. Cylindrical modes tend to have 0° phase shift across the coupling, while conical modes tend to have 180° phase shift. Usually, 90° phase shift between the horizontal and vertical measurements at the same bearing location.	Unbalance is often due to erosion, or deposits on blades. Overhung fans may require a couple balance, while centre-hung fans can generally be balanced in a single-plane.
Bent shaft	1x similar to unbalance, manifests itself at slow roll speed.	Can cancel with unbalance at particular rotational speeds.	Rarely seen on fans.
Casing distortion	1x, sometimes 2x.	180° phase shift from end to end.	Only important where bearings are integral with the casings.
Resonance	High vibration at a particular frequency.	Resonance testing indicates natural frequency.	Avoid operating close to a resonant frequency e.g. by changing speed, or by changing resonant frequency, e.g. by stiffening machine or adding mass. Sometimes damping can be needed.
Tilting foundation	High 1x vibration levels that cannot be explained by unbalance, misalignment, bent shaft or eccentricity.	Rocking motion in 1x ODS.	ODS study to analyse problem in more depth.
Aerodynamic forces	Blade passing frequency.	Can have high noise.	Usually caused when fan is operating off best efficiency point.
Belt faults	Belt Passing frequency.	Less than 1x.	Typically due to belt wear, misalignment and/or incorrect tension.
Belt resonance	Belt resonance frequency.	Usually less than 1x.	Usually due to lack of belt tension.
Excessive belt tension	1x	Directional.	Similar symptoms to misalignment
Belt pulley eccentricity	Usually directional 1x, sometimes 1x and 2x.	Sometimes visually observed as wobbly motion.	
NOTE ODS stands for operational deflection shape.			