
**Condition monitoring and diagnostics of
machines — Requirements for training
and certification of personnel —**

**Part 2:
Vibration condition monitoring and
diagnostics**

*Surveillance et diagnostic d'état des machines — Exigences relatives à
la formation et à la certification du personnel —*

Partie 2: Surveillance des vibrations et diagnostic d'état des machines



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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

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.

ISO 18436-2 was prepared by Technical Committee ISO/TC 108, *Mechanical vibration and shock*, Subcommittee SC 5, *Condition monitoring and diagnostics of machines*.

ISO 18436 consists of the following parts, under the general title *Condition monitoring and diagnostics of machines — Requirements for training and certification of personnel*:

- *Part 1: Requirements for certifying bodies and the certification process*
- *Part 2: Vibration condition monitoring and diagnostics*

The following parts are under preparation:

- *Part 3: Requirements for training bodies*
- *Part 4: Lubrication management and analysis*
- *Part 5: Thermography*
- *Part 6: Diagnostics and prognostics*
- *Part 7: Condition monitoring specialists*

Introduction

Vibration analysis using measurements to monitor condition and diagnose faults in machinery has become a key activity in predictive maintenance programmes for most industries. Other non-intrusive technologies including infrared thermography, acoustic emission, lubricant analysis and motor current analysis, are used as complementary condition analysis tools. Those in the manufacturing industry who have diligently and consistently applied these techniques have experienced a return on investment far exceeding their expectations. However, the effectiveness of these programmes depends on the capabilities of individuals who perform the measurements and analyse the data.

This part of ISO 18436 defines the requirements against which personnel in the non-intrusive machine condition monitoring and diagnostics technologies associated with vibration analysis are to be certified and the methods of testing such personnel. Conformity assessment for certification in vibration analysis will be performed by a body accredited to the requirements of ISO 18436-3.

Condition monitoring and diagnostics of machines — Requirements for training and certification of personnel —

Part 2: Vibration condition monitoring and diagnostics

1 Scope

This part of ISO 18436 specifies the general requirements for vibration analysis personnel who perform machinery condition monitoring and diagnostics of machines. Certification to this standard will provide recognition of the qualifications and competence of individuals to perform machinery vibration measurements and analysis using portable and permanently installed sensors and equipment.

This part of ISO 18436 covers a four-category certification programme that is based on the technical areas discussed herein.

2 Normative references

The following referenced documents are indispensable for the application 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 1925, *Mechanical vibration — Balancing — Vocabulary*

ISO 1940 (all parts), *Mechanical vibration — Balance quality requirements of rigid rotors*

ISO 2017-1, *Mechanical vibration and shock — Resilient mounting systems — Part 1: Application of source and receiver isolation*

ISO 2041, *Vibration and shock — Vocabulary*

ISO 2954, *Vibration of rotating and reciprocating machinery — Requirements for instruments for measuring vibration severity*

ISO 5348, *Mechanical vibration and shock — Mechanical mounting of accelerometers*

ISO 7919 (all parts), *Mechanical vibration of non-reciprocating machines — Measurements on rotating shafts and evaluation criteria*

ISO 8528-9, *Reciprocating internal combustion engine driven alternating current generating sets — Part 9: Measurement and evaluation of mechanical vibrations*

ISO 8569, *Mechanical vibration and shock — Measurement and evaluation of shock and vibration effects on sensitive equipment in buildings*

ISO 10816 (all parts), *Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts*

ISO 11342:1998, *Mechanical vibration — Methods and criteria for the mechanical balancing of flexible rotors*

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 13379, *Condition monitoring and diagnostics of machines — General guidelines on data interpretation and diagnostics techniques*

ISO 14694, *Industrial fans — Specifications for balance quality and vibration levels*

ISO 14695, *Industrial fans — Method of measurement of fan vibration*

ISO 17359, *Condition monitoring and diagnostics of machines — General guidelines*

ISO 18436-1, *Condition monitoring and diagnostics of machines — Requirements for training and certification of personnel — Part 1: Requirements for certifying bodies and the certification process*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2041, ISO 13372, ISO 18436-1 and the following apply.

3.1 analysis
process of using signal processing techniques and machine knowledge to evaluate machine faults and condition

3.2 route
organized series of machine measurement locations listed by machine train, measure or plant geography

3.3 trainee
person who is training to become qualified for certification

3.4 vibration diagnostics
interpretation of vibration data to determine machine faults

3.5 vibration monitoring
process of measurement, trending, and interpretation of vibration data

4 Classification of personnel for vibration condition monitoring and diagnostics of machines

4.1 General

Individuals recognized or certified in accordance with this part of ISO 18436 shall be classified in one of several categories depending upon their qualifications. They shall have demonstrated competence in the concepts of machinery vibration condition monitoring and diagnostics of machines for their classification category as indicated in Annex A and in accordance with the standards listed in Annex B.

4.2 Category I

Individuals meeting the requirements for Category I are recognized as being qualified to perform a range of simple single-channel machinery vibration condition monitoring and diagnostics of machines activities in accordance with ISO 17359 and ISO 13373-1. They shall not be responsible, for example, for the choice of sensor or for any analysis to be conducted, nor for the assessment of test results, except for identifying alert conditions against a pre-established alert setting or settings. They shall be qualified

- a) to operate portable instrumentation on pre-assigned or pre-programmed routes,
- b) to acquire readings from permanently installed instrumentation,
- c) to input results into a database and download routes from a computer,
- d) to conduct testing under steady-state operating conditions following predefined procedures,
- e) to be able to recognize that no signal is present, and
- f) to be able to compare overall or single value vibration measurements against pre-established alert settings.

4.3 Category II

Individuals certified to Category II are qualified personnel who are certified to perform industrial machinery vibration measurements and basic vibration analysis using single-channel measurements, with or without phase trigger signals, according to established and recognized procedures. Personnel certified to Category II require all the knowledge and skills expected of Category I, and shall also be qualified

- a) to select the appropriate machinery vibration measurement technique,
- b) to set up instruments for basic resolution of amplitude, frequency and time,
- c) to perform basic vibration analysis of machinery and components, such as shafts, bearings, gears, fans, pumps and motors, using spectrum analysis,
- d) to maintain a database of results and trends,
- e) to perform basic (single-channel) impact tests to determine natural frequencies,
- f) to classify, interpret and evaluate the test results (including acceptance tests) in accordance with applicable specifications and standards,
- g) to recommend minor corrective actions,
- h) to understand basic single-plane field balancing concepts, and
- i) to be aware of some of the causes and effects of bad measurement data.

4.4 Category III

Individuals certified to Category III are qualified to perform and/or direct and/or establish programmes for vibration condition monitoring and diagnostics of machines in accordance with ISO 17359 and ISO 13373-1. Personnel classified to Category III require all the knowledge and skills expected of personnel classified to Category I and Category II, and shall also be qualified

- a) to select the appropriate machinery vibration analysis technique,

- b) to specify the appropriate vibration instrumentation hardware and software for both portable and permanently installed systems,
- c) to measure and perform diagnosis of single-channel frequency spectra, as well as time domain plots such as waveforms and orbits, under both steady-state and unsteady operating conditions, with or without a phase trigger,
- d) to establish vibration monitoring programmes, including determination of machines for periodic/continuous monitoring, frequency of testing, route plans,
- e) to establish programmes for the specification of vibration levels and acceptance criteria for new machinery,
- f) to measure and analyse basic operating deflection shapes,
- g) to understand and be able to direct the use of alternative condition monitoring technologies (such as acoustic emission, thermography, motor current and oil analysis),
- h) to recommend field corrective actions, such as balancing, alignment and replacement of machine parts,
- i) to be able to use acceleration enveloping (demodulation),
- j) to perform basic single-plane field balancing,
- k) to report to management regarding programme objectives, budgets, cost justification and personnel development,
- l) to prepare reports for appropriate personnel on machine condition, recommend corrective action and report on the effectiveness of repairs, and
- m) to provide instructions and technical direction to vibration trainees.

4.5 Category IV

Individuals certified to Category IV are qualified to perform and/or direct vibration condition monitoring and diagnostics of machines in accordance with ISO 17359 and ISO 13373-1 and all types of machinery vibration measurements and analysis. Personnel certified to Category IV require all the knowledge and skills expected of personnel certified to Category I, Category II and Category III, and shall also be qualified

- a) to apply vibration theory and techniques, including measurement and interpretation of multi-channel spectral results such as frequency response functions, phase and coherence,
- b) to understand and perform signal analysis, including understanding of frequency and time domain processing, including orbits and their limitations,
- c) to determine the natural frequencies, mode shapes and damping of systems, components and assemblies,
- d) to determine the operating deflection shapes of machines and connected structures and recommend means for correction,
- e) to use generally recognized advanced techniques for vibration analysis, parameter identification and fault diagnosis,
- f) to apply the basic principles of rotor-bearing dynamics to vibration diagnosis,
- g) to conduct basic two-plane field balancing,
- h) to recommend advanced two-plane influence coefficient or static/couple balancing,

- i) to recommend corrective actions and/or design modifications, including component change or repair, isolation, damping, change of stiffness and change of mass,
- j) to provide technical guidance to vibration trainees,
- k) to interpret and evaluate published ISO codes of practice, International Standards and specifications,
- l) to recognize vibration caused by gas pulsation in machines such as reciprocating machines and screw compressors, and to measure the necessary parameters and recommend means for correction, and
- m) to recommend corrective actions for resilient mounting and other holding-down and foundation problems.

5 Eligibility for examination

5.1 General

Candidates shall have a combination of education, training and experience to ensure that they understand the principles and procedures applicable to machinery vibration measurement and analysis. Candidates shall affirm adherence to the code of ethics contained in ISO 18436-1.

5.2 Education

Candidates seeking certification do not need to provide evidence of formal education to establish eligibility. However, it is recommended that candidates for Category I and II have at least a secondary school graduation diploma or its equivalent. Category III and IV candidates shall be able to manipulate simple algebraic equations, use a basic scientific calculator (including trigonometric and logarithmic functions), and be familiar with the operation of personal computers. Successful completion of two or more years of mechanical technology or mechanical engineering at an accredited college, university or technical school is highly recommended for candidates seeking certification to Category III and IV.

5.3 Training

5.3.1 Basic training

To be eligible to apply for certification based on this part of ISO 18436, the candidates shall provide evidence of successful completion of training approved by the certification body, which will be based on the requirements of Annex A. The minimum duration of recommended training is shown in Table 1. Approved training should be in the form of lectures, demonstrations and practical exercises. Sources of technical information are listed in the Bibliography. It is recommended that the training include examinations to ensure that the subject matter has been understood. It is recommended that to receive credit for the successful completion of a course, the candidates should satisfy the certification body

- a) that they have successfully completed the training,
- b) that the time devoted to each topic was as specified in Annex A and was consistent with the category of certification being sought, or show a log of self-study time and topics consistent with the effort required in Table 1 and Annex A, and
- c) that they have completed a training course examination provided by a trainer approved by the certification body.

5.3.2 Additional training on machine knowledge

In addition to the training hours shown in Table 1 and detailed in Annex A, it is recommended that candidates attend machinery and component training of at least half the time shown in Table 1.

Table 1 — Recommended minimum duration of cumulative training (hours)

Category I	Category II	Category III	Category IV
32	70	110	174

5.4 Experience

To be eligible to apply for certification based on this part of ISO 18436, the candidate shall provide evidence of experience in the field of machinery condition monitoring and diagnostics. The minimum recommended experience requirements are shown in Table 2. Designation of a person as Category I is not a prerequisite for certification as Category II. However, certification of a person as Category III and Category IV requires previous certification at the lower category. At each higher classification category, the breadth and depth of experience is expected to be greater than at the previous lower category.

Table 2 — Recommended minimum duration of cumulative experience (months)

Category I	Category II	Category III	Category IV
6	18	36	60
NOTE The months shown represent cumulative totals of months of experience for each classification. Work experience in months is based on a nominal 40 h week (175 h per month).			

6 Qualification examinations

6.1 Examination content

For each certification category, it is recommended that the candidates be required to answer a number of questions, specified by the certification body in a specified time duration similar to the example as shown in Table 3. The questions, covering the topics shown in Annex A, will have been selected from a database of questions existing at the time of the examination. Questions shall be of a practical nature, yet test the candidate on concepts and principles required to conduct machinery vibration analysis. The questions may involve the interpretation of charts and plots. Simple mathematical calculations using a basic scientific calculator are required; a summary of common formulae will be provided along, with the examination questions. These questions are to be generated and/or approved by a technical committee of the appropriate certification body.

Table 3 — Example of examination details

Classification	Number of questions	Time h	Pass rate %
Category I	50	2	75
Category II	100	3	75
Category III	100	4	75
Category IV	60	5	75

6.2 Re-examination

A candidate who fails to obtain the pass grade required for certification may be re-examined any number of times, provided that the re-examinations take place not sooner than 30 days after a previous examination. A certification body may use its discretion in allowing an earlier re-examination in the event that further training acceptable to the certification body concerned is undertaken. Candidates excluded for reasons of unethical behaviour shall wait at least 12 months before reapplying.

Annex A

(normative)

Training course requirements for personnel involved in vibration condition monitoring and diagnostics of machines

Table A.1 — Overview

Subject	Hours of training			
	Category			
	I	II	III	IV
1. Principles of vibration	6	4	2	4
2. Data acquisition	8	4	2	2
3. Signal processing	2	4	3	8
4. Condition monitoring	2	4	3	1
5. Fault analysis	2	4	8	6
6. Corrective action	2	4	6	16
7. Equipment knowledge	8	4	4	—
8. Acceptance testing	2	2	2	—
9. Equipment testing and diagnostics	—	2	3	4
10. Reference standards	—	2	2	2
11. Reporting and documentation	—	2	2	4
12. Fault severity determination	—	2	3	3
13. Rotor/bearing dynamics	—	—	—	14
Total hours per category of training	32	38	40	64

Table A.2 — Detailed list of topics and hours of instruction

Subject	Category			
	I	II	III	IV
1. Principles of vibration	6	4	2	4
Basic motion	*	*	*	
Period, frequency	*	*	*	
Amplitude: peak, peak-to-peak, r.m.s.	*	*	*	
Parameters: displacement, velocity, acceleration	*	*	*	
Units, unit conversions	*	*	*	
Time and frequency domains	*	*	*	
Vectors, modulation			*	*
Phase		*	*	*
Natural frequency, resonance, critical speeds	*	*	*	*
Force, response, damping, stiffness			*	*
Instabilities, non-linear systems				*
2. Data acquisition	8	4	2	2
Instrumentation	*	*	*	*
Dynamic range, signal-to-noise ratio			*	*
Transducers	*	*	*	
Sensor mounting, mounted natural frequency	*	*	*	
$F_{\max}$, acquisition time		*	*	
Proximity sensor conventions		*	*	
Triggering		*	*	
Test planning		*	*	*
Test procedures	*	*	*	*
Data formats		*	*	
Computer database upload/download	*			
Recognition of poor data	*	*	*	

Table A.2 (continued)

Subject	Category			
	I	II	III	IV
3. Signal processing	2	4	3	8
R.m.s./peak detection				*
Analog/digital conversion				*
Analog sampling, digital sampling		*	*	*
FFT computation			*	*
FFT application	*	*		
Time windows: uniform, Hanning, flat-top		*	*	
Filters: low pass, high pass, band pass, tracking		*	*	*
Anti-aliasing		*	*	*
Bandwidth, resolution		*	*	*
Noise reduction				*
Averaging: linear, synchronous time, exponential		*	*	*
Dynamic range		*	*	*
Signal-to-noise ratio				*
Spectral maps			*	*
4. Condition monitoring	2	4	3	1
Computer data base set-up, computer database maintenance			*	
Equipment evaluation and prioritization		*		
Monitoring programme design		*	*	*
Alarms set-up: narrowband, envelope			*	
Baseline assessments, trending		*	*	
Route planning		*	*	
Alternative technologies: oil analysis, infrared thermography, motor current analysis and acoustic emission			*	*
Fault condition recognition	*	*		

Table A.2 (continued)

Subject	Category			
	I	II	III	IV
5. Fault analysis	2	4	8	6
Spectrum analysis, harmonics, sidebands		*	*	*
Time waveform analysis			*	*
Phase analysis			*	*
Transient analysis			*	*
Orbit analysis			*	*
Shaft centreline analysis			*	*
Enveloping			*	*
Mass unbalance		*	*	
Misalignment		*	*	
Mechanical looseness		*	*	
Rubs, instabilities			*	*
Bearing defects: rolling element, journal		*	*	
Electric motor defects		*	*	*
Flow induced vibration, aerodynamics and liquids			*	*
Gearbox analysis		*	*	
Resonance and critical speeds		*	*	*
Turbomachinery			*	*
General fault recognition	*			
6. Corrective action	2	4	6	16
Shaft alignment		*	*	
Field balancing		*	*	*
Replacement of machine parts			*	
Flow control			*	*
Isolation and damping			*	*
Resonance control			*	*
Basic maintenance action	*	*	*	

Table A.2 (continued)

Subject	Category			
	I	II	III	IV
7. Equipment knowledge	8	4	4	—
Electric motors, generators and drives	*	*	*	
Pumps, fans	*	*	*	
Steam turbines, gas turbines		*	*	
Compressors	*	*	*	
Reciprocating machinery		*	*	
Rolling mills, paper machines, other process equipment	*	*	*	
Machine tools	*	*	*	
Structures, piping	*	*	*	
Gearboxes	*	*	*	
Rolling element bearings		*	*	
Journal bearings		*	*	
Gearing		*	*	
Couplings, belts		*	*	
8. Acceptance testing	2	2	2	—
Test procedure	*	*		
Specifications and standards		*	*	
Reporting		*	*	
9. Equipment testing and diagnostics	—	2	3	4
Impact testing		*	*	*
Forced response testing		*	*	*
Transient analysis			*	*
Transfer functions				*
Damping evaluation				*
Cross channel phase, coherence				*
Operating deflection shapes			*	*
Modal analysis				*
Torsional vibration				*
10. Reference standards	—	2	2	2
ISO		*	*	*
IEC		*	*	*
Relevant national standards		*	*	*