INTERNATIONAL STANDARD

ISO 18436-6

Second edition
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Condition monitoring and diagnostics of machines — Requirements for qualification and assessment of personnel —

Part 6: Acoustic emission

Surveillance et diagnostic d'état des machines — Exigences relatives à la qualification et à l'évaluation du personnel —

Partie 6: Émission acoustique

Reference number
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Foreword

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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. www.iso.org/directives

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 108, *Mechanical vibration, shock and condition monitoring*, Subcommittee SC 5, *Condition monitoring and diagnostics of machines*.

This second edition cancels and replaces the first edition which has been revised.

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

— *Part 1: Requirements for assessment bodies and the assessment process*

— *Part 2: Vibration condition monitoring and diagnostics*

— *Part 3: Requirements for training bodies and the training process*

— *Part 4: Field lubricant analysis*

— *Part 5: Lubricant laboratory technician/analyst*

— *Part 6: Acoustic emission*

— *Part 7: Thermography*

— *Part 8: Ultrasound*

The following part is planned:

— *Part 9: Condition monitoring specialists*

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Introduction

The use of acoustic emission technology in condition monitoring is one of the key activities in predictive maintenance programmes for most industries. Other non-intrusive technologies including infrared thermography, vibration analysis, lubricant analysis, wear debris analysis and motor current analysis are used as complementary condition analysis tools. Those in the manufacturing industry who have diligently and consistently applied these technologies 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.

A programme, administered by an assessment body, has been developed to train and assess the competence of personnel whose duties require the appropriate theoretical and practical knowledge of machinery condition monitoring and diagnostics.

This part of ISO 18436 defines the requirements against which personnel in the non-intrusive machinery condition monitoring and diagnostics technologies associated with acoustic emission for machinery condition monitoring are to be qualified and the methods of assessing such personnel.

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Condition monitoring and diagnostics of machines — Requirements for qualification and assessment of personnel —

Part 6: Acoustic emission

1 Scope

This part of ISO 18436 specifies the requirements for qualification and assessment of personnel who perform machinery condition monitoring and diagnostics using acoustic emission.

A certificate or declaration of conformity to this part of ISO 18436 will provide recognition of the qualifications and competence of individuals to perform acoustic emission measurements and analysis for machinery condition monitoring using acoustic emission equipment. This procedure may not apply to specialized equipment or other specific situations.

This part of ISO 18436 specifies a three-category classification programme that is based on the technical areas delineated herein.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

ISO 13374 (all parts), *Condition monitoring and diagnostics of machines — Data processing, communication and presentation*

ISO 13379-1, *Condition monitoring and diagnostics of machines — Data interpretation and diagnostics techniques — Part 1: General guidelines*

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

ISO 18436-1:2012, *Condition monitoring and diagnostics of machines — Requirements for qualification and assessment of personnel — Part 1: Requirements for assessment bodies and the assessment process*

ISO 18436-3, *Condition monitoring and diagnostics of machines — Requirements for qualification and assessment of personnel — Part 3: Requirements for training bodies and the training process*

ISO 22096:2007, *Condition monitoring and diagnostics of machines — Acoustic emission*

ISO/IEC 17000, *Conformity assessment — Vocabulary and general principles*

ASTM E2374-10, *Standard Guide for Acoustic Emission System Performance Verification*

ASTM E1106-12, *Standard Test Method for Primary Calibration of Acoustic Emission Sensors*

ASTM E650-M12, *Standard Guide for Mounting Piezoelectric Acoustic Emission Sensors*

EN 13477-1:2001, *Non-destructive testing — Acoustic emission — Equipment characterization — Part 1: Equipment description*

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EN 13477-2:2001, *Non-destructive testing — Acoustic emission — Equipment characterization — Part 2: Verification of operating characteristic*

EN 13554:2002, *Non-destructive testing — Acoustic emission — General principles*

EN 1330-9:2000, *Non-destructive testing — Terminology — Part 9: Terms used in acoustic emission testing*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13372, ISO/IEC 17000 and the following apply.

3.1
trainee
person who is being trained to become qualified

4 Classification of personnel (acoustic emission)

4.1 General

Individuals assessed as conforming to the requirements of this part of ISO 18436 shall be classified in one of three categories, depending upon their qualifications. They shall have demonstrated the necessary skills in acoustic emission condition monitoring for their category as indicated in Annex A.

Personnel classified as Category II need to have all the knowledge and skills expected of personnel classified as Category I, while personnel classified as Category III need to have all the knowledge and skills expected of personnel classified as Category II.

4.2 Category I

Individuals classified as Category I are qualified to perform acoustic emission measurements according to established and recognized procedures. Personnel classified as Category I shall be able to:

a) apply a specified acoustic emission measurement procedure;

b) set up and verify operation of equipment for basic acoustic emission data collection;

c) verify the integrity of collected data and prevent or control poor data;

d) perform basic acoustic emission analysis;

e) record and categorize the results in terms of written criteria;

f) maintain a database of results or trends; and

g) evaluate and report test results in accordance with instructions.

Persons classified as Category I shall not be regarded as competent to choose the test method or technique to be used nor to assess the test results.

4.3 Category II

Individuals classified as Category II are qualified to perform and/or direct acoustic emission analysis according to established and recognized procedures, and will be aware of the limitations of the acoustic emission method. Personnel classified as Category II shall be able to:

a) select the appropriate acoustic emission technique;

b) define the limitations of the application;

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c) specify the appropriate hardware and software for both portable and permanently installed systems;

d) set up and verify equipment settings;

e) measure and perform diagnosis of acoustic emission signals;

f) measure, interpret and analyse acoustic emission data;

g) verify the calibration of acoustic emission measurement systems;

h) prepare reports on condition, recommend appropriate corrective actions and comment on effectiveness of repairs;

i) provide technical direction to acoustic emission personnel at or below Category II;

j) carry out, supervise and instruct all Category I duties; and

k) be aware of the use of alternative condition monitoring (CM) technologies, at least to Category I level.

4.4 Category III

Individuals classified as Category III are qualified to perform and/or direct all types of acoustic emission measurements and analysis. Personnel classified as Category III shall be able to:

a) apply acoustic emission theory and techniques, including measurement and interpretation of survey results;

b) understand and perform data analysis, including limitations;

c) determine the acoustic emission data acquisition systems and component assemblies;

d) use non-standard techniques for acoustic emission and fault diagnosis;

e) recommend all generally recognized types of corrective actions;

f) interpret and evaluate standards, codes, specifications and procedures;

g) establish acoustic emission programmes, including determination of the requirement for periodic/continuous monitoring, frequency of testing, etc.;

h) establish programmes for acceptance and severity criteria for new and in-service systems and faulty equipment;

i) perform prognostics for fault conditions;

j) recommend the use of alternative or supplementary condition monitoring (CM) technologies; and

k) guide personnel below Category III.

NOTE It is the employer's responsibility to ensure that category III personnel have the necessary competency in the required management skills, for example, creating budgets, preparing cost justifications and managing personnel development.

5 Eligibility

5.1 General

Candidates should have a combination of education, training and experience to ensure that they understand the principles and procedures applicable to acoustic emission measurement and analysis.

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5.2 Education

Candidates seeking classification do not need to provide evidence of formal education to establish eligibility. However, it is recommended that Category I and II candidates have at least a secondary school graduate qualification or its equivalent. Category II and III 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 classification to Category III.

5.3 Training

5.3.1 Introduction

To be eligible to apply for assessment based on this part of ISO 18436, the candidates shall provide evidence of successful completion of training based on the requirements of A.2. The training syllabus in A.2 includes the requirement for practical knowledge and practical skills training within the relevant topics. The documents listed in Annex B provide the body of knowledge for the training syllabus. The minimum duration of cumulative training is shown in Table 1. Training should be in the form of lectures, demonstrations, practical exercises or formal training courses.

Qualification requirements shall be in accordance with this part of ISO 18436. Training time devoted to each topic shall be in accordance with A.2 and Table 1.

Table 1 — Minimum duration of cumulative training (hours)

Category I	Category II	Category III
40	80	120

Training may be modularized into two or more subject areas covering general scientific principles and application-specific knowledge in order to allow mutual recognition between non-destructive testing and condition monitoring assessment bodies.

5.3.2 Additional training on machine knowledge

In addition to the training hours shown in Table 1 and detailed in A.2, candidates should attend formal or on-the-job machinery and component training of at least a similar duration to that shown in Table 1.

Such training shall be in addition to any formal education compliant with 5.2, inclusive of any college or university education. If undertaken, the additional training shall cover the design, implementation, operation and maintenance principles of machines and components, and the failure modes and mechanisms associated with each principle. Such training shall be validated by verifiable records.

5.4 Experience

5.4.1 To be eligible to apply for assessment based on this part of ISO 18436, the candidate shall provide evidence to the assessment body of experience in the field of acoustic emission condition monitoring in accordance with Table 2. Classification to Category II and Category III requires previous classification at the lower category.

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Table 2 — Minimum cumulative experience requirements (months and hours)

Category I	Category II	Category III
6 months 96 h [a]	12 months 192 h [a]	36 months 576 h [a]
[a] Based on 16 h minimum experience per month performing acoustic emission testing.		

5.4.2 Candidates shall keep verifiable documentary evidence of experience. Candidates for Category I and Category II shall have this evidence validated by a person at Category II or higher, or in the absence of such persons, by the candidate's technical supervisor.

5.4.3 Candidates for Category III shall have this evidence validated by a Category III person, or in the absence of such persons, by the candidate's technical supervisor.

5.4.4 The validation process for all categories requires the signature of the validating person on the documentary evidence. The validating person should augment this validation process via oral assessment, accompanied task performance, report submission and review, procedure submission and review, or a combination thereof, in order to increase the confidence in the validation.

6 Examination

6.1 Examination content

6.1.1 For each category, the candidates shall be required to answer a fixed minimum number of multiple choice questions in a specified duration indicated in Table 3. Category III examinations may include fault diagnosis, prognosis and solution recommendation content. Category III examinations may include narrative questions.

6.1.2 The content of the examination paper shall contain questions for each subject in A.2 and in the same weighting as indicated by the percentage of time spent on each subject indicated in A.2.

6.1.3 Questions shall be of a practical nature and test the candidate's knowledge of the concepts, principles and procedures required to conduct acoustic emission condition testing, analysis and evaluations.

6.1.4 Some questions will include the interpretation of data, and simple mathematical calculations using a basic scientific calculator may be required.

6.1.5 Assessment bodies may, at their discretion, make accommodations for candidates with conditions that may require some form of compensation.

Table 3 — Minimum examination content

Category	Number of questions	Time h	Passing grade %
Category I	60	2,0	75
Category II	60	2,0	75
Category III	60	3,0	75

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6.2 Conduct of examinations

All examinations shall be conducted in accordance with ISO 18436-1:2012, 8.1, except that candidates may also have access to pencils and erasers if computer-based marking is used.

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Annex A
(normative)

Training course requirements and minimum training hours for acoustic emission condition monitoring and diagnostics of machines

A.1 Training syllabus

Subject	Hours of training		
	Category I	Category II	Category III
1. Principles of acoustic emission	6	2	1
2. Generic equipment knowledge	2	2	1
3. Data acquisition	7,5	2,5	1
4. Data/signal processing	3	2	2
5. Condition monitoring	3	2	2
6. Applications	8	24	24
7. Fault analysis and severity determination	2	2	6
8. Acoustic emission instrumentation testing and diagnostics	4	1	1
9. Reference standards	2	0,5	0,5
10. Reporting and documentation and corrective action	1	0,5	0,5
11. Personal safety	0,5	0,5	0
12. Training examination	1	1	1
Total hours for each category	**40**	**40**	**40**

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A.2 Detailed list of topics and hours of instruction

Subject	Topics	Hours of training		
		Category I	Category II	Category III
1. Principles of acoustic emission		6	2	1
	a) Introduction to sources	*		
	b) Nature of sources		*	*
	c) Propagation and attenuation	*	*	*
2. Generic equipment knowledge		2	2	1
	a) Calibration of equipment	*	*	*
	b) Sensors and coupling	*	*	*
	c) Amplifiers and signal conditioners		*	*
3. Data acquisition		7,5	2,5	1
	a) Principles of data acquisition	*	*	*
	b) Sensor positioning	*	*	*
	c) Noise	*	*	*
	d) Stimulus	*	*	*
	e) Measurement	*	*	
	f) Other methods	*	*	
4. Data/signal processing		3	2	2
	a) Data storage and structure	*	*	*
	b) Data management and databases	*	*	*
	c) Elements of processing		*	*
	d) Output		*	*
5. Condition monitoring		3	2	2
	a) CM principles	*	*	*
	b) Other technologies (infrared thermography, vibration analysis, wear debris analysis, tribology, airborne ultrasonic testing, etc.)	*	*	*
	c) Procedure writing			*
6. Applications		8	24	24
	a) Machines			
	b) Bearings			
	c) Gearboxes			
	d) Valves	* all	* all	* all
	e) Pipes			
	f) Motors			
	g) Mountings			
	h) Other machines			

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Subject	Topics	Hours of training		
		Category I	Category II	Category III
7. Fault analysis and severity determination		2	2	6
	a) Time domain analysis		*	*
	b) Alarms	*	*	*
	c) Trending		*	*
	d) Case studies		*	*
	e) Diagnostics and prognostics			*
8. Acoustic emission instrumentation testing and diagnostics		4	1	1
	a) Acceptance testing	*	*	*
	b) Benchmarking	*	*	
	c) Demonstration	*	*	
	d) System testing	*	*	*
	e) Fault finding	*	*	*
9. Reference standards		2	0,5	0,5
	a) ISO	*	*	*
	b) EN and ASTM	*	*	*
10. Reporting and documentation and corrective action		1	0,5	0,5
	a) Report structure	*	*	*
	b) Required information	*	*	*
	c) Corrective action	*	*	*
11. Personal safety		0,0	0,5	-
12. Training examination		1	1	1
Total hours		**40**	**40**	**40**

NOTE 1 Category II includes the knowledge of Category I.

NOTE 2 Category III includes the knowledge of Category I and Category II.

NOTE 3 * Indicates the topics to be taught at each category.

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Annex B
(normative)

Standards from which examination questions may be developed

[B.1] ISO 13374 (all parts), *Condition monitoring and diagnostics of machines — Data processing, communication and presentation*

[B.2] ISO 13372, *Condition monitoring and diagnostics of machines — Vocabulary*

[B.3] ISO 17359, *Condition monitoring and diagnostics of machines — General guidelines*

[B.4] ISO 13379-1-, *Condition monitoring and diagnostics of machines — General guidelines on data interpretation and diagnostics techniques*

[B.5] ISO 22096:2007, *Condition monitoring and diagnostics of machines — Acoustic emission*

[B.6] ASTM E2374-10, *Standard Guide for Acoustic Emission System Performance Verification*

[B.7] ASTM E1106-12, *Standard Test Method for Primary Calibration of Acoustic Emission Sensors*

[B.8] ASTM E650M-12, *Standard Guide for Mounting Piezoelectric Acoustic Emission Sensors*

[B.9] EN 13477-1:2001, *Non-destructive testing — Acoustic emission — Equipment characterization — Part 1: Equipment description*

[B.10] EN 13477-2:2001, *Non-destructive testing — Acoustic emission — Equipment characterization — Part 2: Verification of operating characteristic*

[B.11] EN 13554:2002, *Non-destructive testing — Acoustic emission — General principles*

[B.12] EN 1330-9:2000, *Non-destructive testing — Terminology — Part 9: Terms used in acoustic emission testing*

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