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CM/GEN APPENDIX D Issue 9

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SPECIFIC REQUIREMENTS FOR QUALIFICATION AND CERTIFICATION OF CONDITION MONITORING AND DIAGNOSTIC PERSONNEL FOR VIBRATION ANALYSIS

CONTENTS

Introduction

The use of the Vibration Analysis method in condition monitoring and diagnosis of faults in machinery and structures has become a key activity in predictive maintenance programmes for many industries. The effectiveness of this technology depends on the capabilities of individuals who perform the measurements and analyse the data. This document is appended to CM/GEN (General requirements for qualification and certification of condition monitoring and diagnostic personnel). Other Appendices cover:

Appendix A	Acoustic Emission
Appendix B	Infra-red Thermography
Appendix C	Lubrication Analysis

These other non-intrusive technologies 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.

This series of documents is designed to provide comprehensive information for users of the PCN Scheme. The complete list of published PCN condition monitoring documents is detailed in publication reference PSL/8A-CM, which is posted on the Institute's web site at www.bindt.org, where all documents are available for download free of charge.

It is intended, through publication of these documents, to provide industry, PCN candidates and certificate holders with all relevant information. However, if further information or advice is required on any certification matter, contact the Certification Services Division of BINDT on telephone number +44 (0) 1604 438300, or email cm.admin@bindt.org

Organisations requiring at all times to be in possession of the most up to date PCN documents may register with the "PCN Update Scheme" which, for a small annual fee, guarantees that they automatically receive all new and revised PCN documents.

1. Scope

1.1. This appendix to PCN CM/GEN sets out the specific requirements for qualification and certification of personnel engaged in Vibration Analysis Condition Monitoring. In the event of a conflict between the requirements of PCN CM/GEN and this Appendix, the PCN CM/GEN requirements shall prevail.

1.2. This specification is in accordance with ISO 18436-2: Condition monitoring and diagnostics of machines-Requirements for qualification and assessment of personnel- Vibration Condition monitoring and diagnostics

1.3. Certification to this specification will provide evidence and recognition of the qualification and competence of individuals to perform machinery vibration measurements and analysis (hereafter referred to as Vibration Analysis in this specification) using portable and permanently installed sensors and equipment.

1.4. This part of CMGEN covers a four-Category certification programme that is based on the technical areas delineated herein.

1.5. The scope of this programme encompasses the normative references specified in ISO 18436-2 clause 2 and those found in Annex B of this document, and incorporates the terms and definitions found in ISO 18436-2 clause 3 and CMGEN, unless otherwise stated in this document.

1.6. BINDT, as a certification body accredited by UKAS in accordance with EN ISO/IEC 17024, manages this condition monitoring programme against these specifications which are derived from the relevant ISO 18436 parts, but wherever any minor regional or national modification to this adoption exists then it shall be identified as a ‘delta’ and signified by text enclosed in a box, in accordance with ISO/IEC Guide 21-1. At no point does any minor modification diminish the specifications in ISO 18436-2. Where appropriate, the structure and format of this specification shall reflect that of all BINDT PCN specification documents for document harmonization.

2. Classification of Personnel

2.1. General

2.1.1. Individuals certificated in accordance with this specification are classified in one of four Categories depending upon their qualifications and assessment, and have demonstrated the necessary competence and skills in the concepts of machinery vibration condition monitoring and diagnostics for their classification Category as indicated in the examination syllabus at Annex A, in the concepts of machine condition monitoring using VA.

2.1.2. The classification of individuals at all categories shall be subject to the scope and any limitations of the award issued by BINDT. Authority to work shall be limited or specified by the employer or client. Individuals shall provide recommendations based on the limits of their training and experience. This declaration shall not allow a practitioner to make recommendations or give advice that may affect plant design, safety or operation without discussion with, and approval from, the appropriate plant specialist, manager or operator. The limits of the practitioner are specified in this clause whereas the limits of liability shall be agreed between the practitioner and their employer or client.

2.1.3. The classification category of the practitioner and any requirements for additional knowledge to work with specific equipment shall be subject to agreement between the customer and service supplier. This qualification shall provide the practitioner with sufficient knowledge to be able to make measurements and interpret data as appropriate for their category. In addition, the applicability of the qualification to a particular specialized machine type or types should be verified by the client through reference to the previous experience and training of the practitioner. It is recognized that different industrial applications require knowledge of varying aspects of VA. Using supporting documented evidence, the supplier of the VA service shall be able to demonstrate to the employer or client, that staff carrying out work has the appropriate machine knowledge and experience.

2.1.4. Where an individual has specialized knowledge in a particular concept of VA or in specific types of machinery, they may be capable, when approved by the client or employer, of working beyond their qualification classification category. Their certificate or declaration of conformity shall remain as it was at the time it was issued.

2.1.5. In 2.2 to 2.5, an outline is given of the typical competencies and skills required in each category. Detailed recommended topics and sub-topics are shown in Tables A.1 and A.2

2.1.6. Personnel classified at a higher Category shall require the competence, knowledge and skills expected of personnel at all lower Categories

2.2. Vibration Analysis Category 1

PCN certificated Vibration Analysis Category 1 personnel are qualified to perform a range of pre-defined, simple single channel machinery vibration condition monitoring and diagnostics of machines activities in accordance with established procedures. All activities shall be performed under direction. Personnel certified to Category 1 shall at least:

2.2.1. know of the basic principles of vibration and recognize the different units of measurement;

2.2.2. be able to collect reliable data ensuring appropriate standards of repeatability;

2.2.3. be able to identify errors in collected data;

2.2.4. be able to retrieve pre-defined measurement settings for use with VA equipment and transfer data from an analysis system to a computer-based system;

2.2.5. be able to compare overall or single-value vibration measurements against pre-established alert settings;

2.2.6. be able to identify deviations from the norm for single-value vibration values and trends;

2.2.7. report on visual observations of equipment condition.

They shall not be responsible for:

2.2.8. the choice of sensor, test method or technique or for any analysis or diagnosis to be conducted;

2.2.9. the assessment of test results, other than identifying conditions against pre-established criteria, such as acceptance, alert, alarm, shutdown, etc.

2.3. Vibration Analysis Category 2

PCN certificated Vibration Analysis Category 2 personnel are qualified to perform industrial machinery vibration measurements and basic vibration analysis using single-channel measurements, with or without phase trigger signals, according to established and recognised procedures. They require all the knowledge, experience and skills expected of Category 1, and in addition they shall at least:

2.3.1. be able to define the measurement activities to be undertaken by a category 1 individual in the course of routine data collection;

2.3.2. be aware of and capable of using the basic principles of signal analysis and, as such, can define acquisition and analysis settings to collect data appropriate to the machine(s) monitored;

2.3.3. be able to perform basic (single channel) impact tests to determine natural frequencies;

2.3.4. be able to interpret and evaluate test results and acceptance tests in accordance with specifications and standards;

2.3.5. be able to diagnose common fault indications and recommend basic corrective actions commensurate with their area of machinery experience including carrying out single-plane balancing of rigid rotors with or without phase;

2.3.6. be able to provide technical guidance to and instruct category 1 personnel.

2.4. Vibration Analysis Category 3

PCN certificated Vibration Analysis Category 3 personnel require all the knowledge, experience and skills expected of personnel classified to categories 1 and 2, and in addition shall at least:

2.4.1. be able to design, direct and establish routine condition monitoring programmes and non-routine investigations for the purpose of fault diagnosis;

2.4.2. be able specify the appropriate vibration instrumentation hardware, software and processing for portable monitoring systems and permanently installed surveillance systems, and equipment protection systems;

2.4.3. have an in-depth knowledge of the principles and techniques of machinery VA and be able to make initial diagnoses of suspected faults beyond the range of commonly encountered issues. This should include, but not be limited to, the use of frequency spectra, time waveforms and orbits, transfer functions, basic operating deflection shapes, and acceleration enveloping under both steady-state and transient operating conditions, with or without a phase trigger;

2.4.4. be able to manage such condition-monitoring programmes, evaluate the alarm sets, write working procedures and specify vibration acceptance testing procedures;

2.4.5. be able to initiate and validate machinery corrective actions, including in situ two-plane rigid rotor balancing;

2.4.6. be able to recommend restrictions to machine operation;

2.4.7. be able to understand and direct, when necessary, alternative condition monitoring technologies to verify or investigate issues raised through routine data collection;

2.4.8. be able to provide technical guidance to and instruct category 1 and 2 personnel, and, subject to agreement with the employer or client, deem them competent to carry out certain duties which would normally be outside the scope of those competencies.

2.4.9. be able to carry out, manage and supervise PCN CM qualification examinations on behalf of the BINDT, if so appointed.

It is the responsibility of the employer or client to ensure that category 3 personnel have the necessary competency in the required management skills, e.g. creating budgets, preparing cost justifications, and managing personnel development.

2.5 Vibration Analysis Category 4

PCN certificated Vibration Analysis Category 4 personnel require all the knowledge and skills expected of personnel certified to categories 1, 2 and 3, in addition, they shall be able to direct and audit condition monitoring strategies.

Employers should recognize that a category 4 individual is likely to have a broad technical knowledge and experience of a range of machine situations and techniques, and an in-depth knowledge of a selection of them.

In addition, personnel classified to category 4 shall at least:

2.5.1 be able to apply vibration theory and techniques, including measurement and interpretation of multi-channel spectral results such as frequency response functions, phase and coherence;

2.5.2 be able to understand and perform signal analysis, including understanding of frequency and time domain processing, including orbits and their limitations;

2.5.3 be able to determine the natural frequencies, mode shapes and damping of systems, components and assemblies;

2.5.4 be able to determine the operating deflection shapes of machines and connected structures and recommend means for correction;

2.5.5 be able to use generally recognised advanced techniques for vibration analysis, parameter identification and fault diagnosis;

2.5.6 be able to apply basic principles of rotor-bearing dynamics to vibration diagnosis;

2.5.7 be able to recommend advanced two-plane influence coefficient or static and couple balancing theory;

2.5.8 be able to recommend corrective actions or design modifications, including component change or repair, isolation, damping, change of stiffness and change of mass;

2.5.9 be able to interpret and evaluate codes of practice and specification published in International Standards and other documents;

2.5.10 be able to recognise vibration caused by gas pulsation in machines such as reciprocating machines and screw compressors, and be able to measure the necessary parameters and recommend means for correction;

2.5.11 recommend corrective actions for resilient mounting and other holding-down and foundation problems;

2.5.12. carry out, manage and supervise PCN CM qualification examinations on behalf of the BINDT, if so appointed

3. Eligibility for Examination and Certification

3.1. General

3.1.1. In order to conform to the requirements of this document, and to ISO 18436-2, candidates shall have a combination of education, training and experience sufficient

to ensure that they understand the principles and procedures applicable to machinery vibration measurement and analysis consistent with Clause 2 and Annex A.

3.1.2.	Candidates shall affirm adherence to the code of ethics contained in ISO18436-1 and BINDT document CP27- Code of Ethics.

3.2. Education

3.2.1. Candidates seeking classification do not need to provide evidence of formal education to establish eligibility. All candidates shall be able to use a basic scientific calculator and be familiar with the operation of personal computers. Category 3 and 4 candidates shall require familiarity with current VA technology. 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 categories 3 and 4.

3.3. Training

3.3.1. To be eligible to apply for assessment to the requirements of this specification, candidates shall provide documentary evidence of successful completion of a BINDT accredited or recognised course of formal training based on the requirements of Annex A. The minimum duration of recommended training is shown in Table 1.

BINDT allows a maximum of 50% self-study or on-line training for topics consistent with Annex A and as specified by the approved trainer (CMGEN refers).

3.3.2 Training should take the form of formal lectures, demonstrations and trainer specified practical exercises or controlled self-study.

To achieve certification from BINDT the candidate must also provide evidence of required experience as specified below.

Training should be assessed by the trainer for evidence of adequate knowledge acquisition. Training time shall meet the minimum requirements given in Table 1 shall include the topics identified in Annex A.

Table 1 – Minimum training durations (hours)

Category 1	Category 2	Category 3	Category 4
30	Category 1 + 38	Category 2 + 38	Category 3 + 64

3.3.2 Training may be separated into subject areas, but shall comply with the requirements of Annex A. Additional sources of technical information may be found in Annex B. It is recommended that the training includes examinations or written assessment to ensure that the subject matter has been understood and to provide the required documentary evidence.

3.3.3 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, or equivalent on-the-job training of at least half the duration as specified in in Table 1. Such training may be inclusive of any college or university education, or provided as additional courses or on-the-job training by an employer to specific requirements. If undertaken, the additional training should cover the design, manufacturing, installation, operation, and maintenance principles of machines and components, the failure modes and mechanisms associated with each principle, and the typical vibratory behaviours associated with each mechanism. Such training shall be validated by verifiable records.

3.4. Experience

3.4.1 To be eligible for assessment to the requirements to this specification, candidates shall provide evidence of experience in the field of machinery vibration condition monitoring and diagnostics. For category 4 candidates, validation may be acquired from another category 4 practitioner or their company manager.

3.4.2 Candidates must maintain a log of hours and nature of work on BINDT PCN document CP16-CM for all Categories.

The minimum experience requirements are shown in Table 2.

Table 2 – Minimum Experience Requirements (months)

Category 1	Category 2	Category 3	Category 4
6	18	36	60

NOTE The figures shown represent cumulative total months of experience to be held for each classification

Designation of a person as category 1 is not a prerequisite for certification as category 2. However, certification of a person as category 3 and category 4 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.

4 Certification Available

4.1 Category 1 (General – Vibration analysis condition monitoring)

4.2 Category 2 (General – Vibration analysis condition monitoring)

4.3 Category 3 (General –Vibration analysis condition monitoring)

4.4 Category 4 (General –Vibration analysis condition monitoring)

5 Qualification Examination

5.1 Application for qualification examinations

5.1.1 Application for qualification examinations is made on PCN form PSL/57-CM and supported with PSL30 and PSL33 where required.

5.2 Examination content (Theory and practical knowledge)

5.2.1 For each certification Category, the candidates shall be required to answer the number of questions indicated in Table 3. Category 3 examination papers are made up from both multiple choice and narrative questions. On each Category 3 paper there will be ten narrative questions offered, and only five need to be answered. Each narrative question will be worth ten marks, equivalent of ten multiple choice questions.

Table 3 – Qualification examination content

Categories	Number of Questions	Time (Hours)*	Passing Grade %
Category 1	60	2.0	70
Category 2	100	3.0	70
Category 3	100	4.0	70
Category 4	60	5.0	70

** Examination times may be extended by 25% to assist candidates with a disability or in the event that their first language is not English, in accordance with BINDT document CMGEN clause 9.3.*

5.2.2 Questions shall be of a practical nature, yet shall test the candidate regarding the concepts and principles required to conduct machinery vibration analysis for condition monitoring of machines. Some questions may involve the interpretation of charts and plots. Simple mathematical calculations using a basic scientific calculator may be required.

5.2.3 Category 3 and 4 examinations may include both short answer (narrative) and multiple choice questions.

5.2.4 The examination content shall be consistent with the training syllabus contained in Annex A.

5.2.5 Detail of BINDT examination, re-examination and renewal procedure is given in BINDT documents CMGEN and PSL/65-CM-Marine.

5.3 Examination conduct

5.3.1 In order to maintain confidentiality and integrity, all examinations shall be conducted in accordance with the requirements of ISO 18436-1 and the procedures specified in BINDT documents CMGEN and PSL/65-CM-Marine.

Annex A – Training Syllabus

Table A.1 – Overview

Subject		Category			
		1	**2**	**3**	**4**
1.	Principles of vibration	6	3	1	4
2.	Data acquisition	6	4	2	2
3.	Signal processing	2	4	4	8
4.	Condition monitoring	2	4	3	1
5.	Fault analysis	4	5	6	6
6.	Corrective action	2	4	6	16
7.	Equipment knowledge	6	4	4	0
8.	Acceptance testing	2	2	2	0
9.	Equipment testing and diagnostics	0	2	4	4
10.	Reference standards	0	2	2	2
11.	Reporting and documentation	0	2	2	4
12.	Fault severity determination	0	2	2	3
13.	Rotor/bearing dynamics	0	0	0	14
Total hours per category of training		30	38	38	64
NOTE The hours per subject are approximations to allow training bodies and assessment bodies to assess the relative importance of subjects, and it is recognized that subject contents may overlap.					

Table A.2 – Detailed list of topics

	Subject	Category				Recommended sub-topics			
Ref:	Syllabus topic	**1**	**2**	**3**	**4**	**Category 1**	**Category 2**	**Category 3**	**Category 4**
1	**Principles of vibration**	6	3	1	4				
1.01	Basic motion	•	•	•		Recognise vibration, and understand the origin of the sine wave.	Understand superposition of sinusoidal vibrations; single degree of freedom.	Understand damped free vibration; self-excited, steady state and transient vibration; multiple degrees of freedom	
1.02	Period, frequency	•	•	•		Recognise the following features of a vibration signal: time axis, period, frequency. Use of hertz or cycles per minute	Understand relationship of period to frequency, beat frequency	Understand requirements for selecting appropriate time period and frequency. Be aware of octave band analysis	
1.03	Amplitude: peak, peak-to-peak, r.m.s.	•	•	•		Recognise the following features of a vibration signal: amplitude, peak, peak-to-peak, r.m.s	Understand the relationship between peak, peak-to-peak, r.m.s	Understand reasons for using peak, peak-to-peak or r.m.s.	
1.04	Parameters: displacement, velocity, acceleration	•	•	•		Recognise the following parameters: displacement, velocity and acceleration	Understand the application displacement, velocity or acceleration	Understand the factors behind choosing displacement, velocity or acceleration	
1.05	Units, unit conversions	•	•	•		Recognise that units conversion is possible	Understand conversion of units and integration	Be aware of integration, differentiation, effect on frequency distribution	
1.06	Time and frequency domains	•	•	•		Be aware of time and frequency domain.	Be aware of enveloping, bandpass filters; demodulation; crest factor	Be aware of orbit analysis, Lissajous figures, windowing	
1.07	Vectors, modulation			•	•			Understand vector definition, modulation	Acquisition for modal techniques

	Subject	Category				Recommended sub-topics			
Ref:	Syllabus topic	**1**	**2**	**3**	**4**	**Category 1**	**Category 2**	**Category 3**	**Category 4**
1.08	Phase		•	•	•		Units; phase reference position	Phase detection methods	Cross-channel; coherence
1.09	Natural frequency, resonance, critical speeds	•	•	•	•	Be aware resonance exists, and its effect on vibration	Fundamental natural mode; single degree of freedom. Recognise factors including: frequency, stiffness, mass, damping, isolation	Critical speeds, two degrees of freedom, dynamic vibration absorber. Be aware of modal techniques and operational deflection shapes	*Q* Factor, multiple degrees of freedom systems, have a detailed understanding of modal techniques and operational deflection shapes
1.10	Force, response, damping, stiffness			•	•			Understand mobility, compliance	Apply mobility plot, stiffness, impedance, accelerance
1.11	Instabilities, non-linear systems				•				Non-elastic mounting systems
2	**Data acquisition**	**6**	**4**	**2**	**2**				
2.01	Instrumentation	•	•	•	•	Recognising single channel hand-held route-based and on-line measurement and monitoring systems	Dual channel on and off-line acquisition, monitoring, and analysis systems including phase	Multi-channel on and off-line acquisition, monitoring, and analysis systems including phase	Multi-channel including modal analysis and troubleshooting
2.02	Dynamic range, signal-to-noise ratio			•	•			Be aware of requirements for dynamic range and signal-noise ratio. Auto-ranging, integration and system errors	Techniques for improving resolution and accuracy. Noise reduction and post-processing

	Subject	Category				Recommended sub-topics			
Ref:	Syllabus topic	**1**	**2**	**3**	**4**	**Category 1**	**Category 2**	**Category 3**	**Category 4**
2.03	Transducers	•	•	•		Recognise displacement, velocity and acceleration transducers. Be aware of powered and non-powered types	Be familiar with proximity probes, velocity transducers, accelerometers, including those with in-built integration, Be aware of requirements for transducer frequency ranges; runout compensation, need for calibration	Understand transducer selection requirements, including machine expected fault frequency, Understand typical runout compensation methods for proximity probes. Understand and be able to set calibration requirements	
2.04	Sensor mounting, mounted natural frequency	•	•	•		Recognise broad effects of mounting on the frequency response, e.g. stud, magnet or probe	Understand accelerometer mounting methods and effects on frequency response; be familiar with a range of mounting methods. Be aware of transducer sensitive axis, tribo-electric effects	Understand International Standard measurement specifications; axial thrust bearing measurement requirements; mounting response and resonance; adhesive curing times	
2.05	F_{max}, acquisition time		•	•			Understand F_{max}, zoom function; simple resolution calculations; relationship of F_{max} to acquisition time	Understand basic aspects of fast Fourier transform (FFT) processing, samples, sampling rate, aliasing	
2.06	Proximity sensor conventions		•	•			Recognise aspects such as: gap voltage, orthogonal radial fitment, and runout	Field calibration checks; proximity probes; axial thrust bearing measurement, runout compensation	

	Subject	Category				Recommended sub-topics			
Ref:	Syllabus topic	**1**	**2**	**3**	**4**	**Category 1**	**Category 2**	**Category 3**	**Category 4**
2.07	Triggering		•	•			Be aware of use of phase detection: e.g. eddy-current probes, photocells, tracking filters	Understand synchronous time averaging and triggering. Be aware of use with dynamic balancing	
2.08	Test planning		•	•	•		Be able to plan and schedule vibration monitoring (VM)	Managing condition monitoring (CM) programmes	Creating specialised test procedures
2.09	Test procedures	•	•	•	•	Follow pre-set data acquisition procedures for on-line or route-based systems. Recognise measurement points for common machine types. Recognise some poor data and alarm conditions. Be aware calibration is a requirement	Be able to set up VM data collection system, e.g. select machines and measurement points, create appropriate acquisition and alarm settings, carry out and supervise measurement and basic reporting, and carry out calibration procedures	Manage VM programs, set up calibration procedures. Advanced CM reporting. Troubleshooting	Creating test and calibration procedures, Standards development
2.10	Data formats		•	•			Be aware of the common units and basic range of data presentation formats, e.g. trending, spectra, waterfall, time trace, phase	Understand range of data presentation formats e.g. trending, spectra, waterfall, time trace, phase, Bode, Nyquist, Campbell plot etc.	
2.11	Computer database upload/download	•				Be aware of basic functions of host and data collector			
2.12	Recognition of poor data	•	•	•		Recognise simple fault conditions, e.g. ski-ramp, no signal, cable fault	Mounting error; cable faults, tribo-electric, bias voltage and settling time	Processing related errors, incorrect F_{max}, sampling time, integration etc	
3	**Signal processing**	**2**	**4**	**4**	**8**				

	Subject	Category				Recommended sub-topics			
Ref:	Syllabus topic	1	2	3	4	Category 1	Category 2	Category 3	Category 4
3.01	r.m.s./peak detection				•				Understand r.m.s and peak detection features and benefits
3.02	Analogue/digital conversion				•				Understand requirements of analogue to digital conversion. Be aware of key stages in acquisition
3.03	Analogue sampling, digital sampling		•	•	•		Be aware of basic function of analogue to digital conversion, block diagram. Basic understanding of clipping, truncation and leakage	Understand FFT process; minimum multiples of frequency interest; synchronous sampling/key phasor; sampling rates	Understand requirements of analogue sampling and digital sampling. Be aware of key stages in acquisition
3.04	FFT computation			•	•			Be aware of FFT process block diagram. E.g. transducer, signal conditioning, anti-alias, analog-digital, windowing	Understand FFT process block diagram. E.g. transducer, filtering, signal conditioning, anti-alias, analogue-digital, windowing, cepstrum
3.05	FFT application	•	•			Be aware of the term FFT and recognise the following basic FFT terminology, e.g. number of lines, F_{max} and time to sample	Matching FFT requirements to range of common fault profiles. Understand the requirements for number of lines (bins), F_{max} sampling time, sampling rate. Basic understanding of other factors such as: anti-aliasing, windowing and averaging		

	Subject	Category				Recommended sub-topics			
Ref:	Syllabus topic	1	2	3	4	Category 1	Category 2	Category 3	Category 4
3.06	Time windows (uniform, Hanning, flat-top)		•	•			Be aware of Hanning window profile and its effect on sampling, e.g. reducing leakage, effect on amplitude and frequency	Be aware of other window functions: uniform, hamming, flat-top, and their effect on sampling, e.g. reducing leakage, effect on amplitude and frequency	
3.07	Filters (low pass, high pass, band pass, tracking)		•	•	•		Be aware of basic types of vibration filters; low pass; high pass; band pass	Recognise the following filter types; low pass; high pass; band pass. Be aware of pass-band and stop-band and tracking filters	Be aware of other filter types: E.g. Bessel, Butterworth, Chebyshev, Gaussian, elliptic. Be aware of basic filter design parameters, e.g. filter poles and response
3.08	Anti-aliasing		•	•	•		Be aware of requirement for Anti-aliasing filter	Understand requirements for aliasing and anti-aliasing filters and common methods	Be aware of instrumentation anti-aliasing design requirements
3.09	Bandwidth, resolution		•	•	•		Bandwidth of bandpass filter; FFT resolution; signal duration; lines of resolution; analyser sample time; FFT collection time	Frequency resolution; distortion; calculations; frequency resolution	Noise and random vibration; response function
3.10	Noise reduction		•	•	•		Be aware of basic filtering and averaging methods used to reduce noise	Understanding requirements for noise reduction. Analogue and digital filtering	Understand and apply noise reduction techniques such as increased frequency resolution, time synchronous averaging, selection of low inherent

Ref:	Subject Syllabus topic	Category 1	2	3	4	Recommended sub-topics Category 1	Category 2	Category 3	Category 4
									noise sensors and instruments, etc.
3.11	Averaging: Linear, synchronous time, exponential		•	•	•		Be aware of FFT frequency averaging	Linear frequency and synchronous time domain averaging; overlapping averaging	Exponential frequency domain averaging
3.12	Dynamic range		•	•	•		Be aware of the term dynamic range	Understand need for dynamic range.	Digital dynamic range calculations
3.13	Signal-to-noise ratio				•				Be aware of methods for testing and establishing signal-to-noise ratio
3.14	Spectral maps			•	•			Waterfall plots, recognising speed related and resonance frequencies	Cascade plots, Campbell diagrams, spectrogram
4	**Condition monitoring**	**2**	**4**	**3**	**1**				
4.01	Computer data base set-up, computer database maintenance			•				Procedures for setting measurement parameters locations and frequency. Database maintenance	
4.02	Equipment evaluation and prioritisation		•				Be able to review sites and establish equipment VM requirements		

	Subject	Category				Recommended sub-topics			
Ref:	Syllabus topic	**1**	**2**	**3**	**4**	**Category 1**	**Category 2**	**Category 3**	**Category 4**
4.03	Monitoring programme design		•	•	•		Be able to set up a VM programme using ISO 17359 and ISO 13373	Be familiar with applicable CM and VM Standards including ISO 17359 and ISO 13373, and to be able to carry out failure mode and effect analysis (FMEA) to establish program requirements.	Be familiar with all applicable CM and VM Standards, be able to set up and carry out FMEA to establish programme requirements
4.04	Alarms set-up: Narrowband, envelope			•				Be able to specify vibration severity using appropriate ISO Standards and to set and apply frequency band and envelope alarms	
4.05	Baseline assessments, trending		•	•			Measuring baselines E.g. to ISO 10816, ISO 20816, ISO 14694, ISO 8528-9 or other requirements	Be able to set baseline requirements using all appropriate International Standards	
4.06	Route planning		•	•			Be able to set up VM routes	Be able to optimise VM and CM routes	
4.07	Alternative technologies, e.g. infrared thermographic testing (TT); acoustic emission testing (AT); ultrasonic testing (UT), lubricant management (LM) – tribology and wear debris analysis; motor current analysis (MCA)			•	•			Be aware of TT; AT; UT, LM – tribology and wear debris analysis); MCA	Be aware of performance monitoring; causes of bearing wear

Ref:	Subject Syllabus topic	Category 1	2	3	4	Recommended sub-topics Category 1	Category 2	Category 3	Category 4
4.08	Fault condition recognition	•	•			Recognising basic pre-set fault conditions, e.g. unbalance, looseness, misalignment, bearing noise and damage	Recognising more advanced range of fault conditions, e.g. unbalance, looseness, misalignment, bearing noise and damage, gear mesh faults, rotor bar and stator faults, drive belt faults, resonances etc		
5	**Fault analysis**	**4**	**5**	**6**	**6**				
5.01	Spectrum analysis harmonics and sidebands		•	•	•		Understand FFT harmonics, sidebands, and noise. Be aware of enveloping	Be familiar with FFT harmonics, sidebands, modulation and noise, octave bands	Understand cepstrum analysis, octave band analysis
5.02	Time waveform analysis		•	•	•		Understand the use of time waveform for basic analysis.	Be aware of requirements for time waveform sampling duration for different applications	Be able to conduct time waveform analysis on varied applications
5.03	Phase analysis		•	•	•		Understand the use of phase for basic analysis.	Understand basic time waveform analysis. Be able to use phase to confirm misalignment, static/couple unbalance, Bode and Nyquist Plots	Apply time waveform analysis to varied machine problems. Phase analysis of structural components, modal analysis and operational deflection shapes (ODS). System and structural response
5.04	Transient analysis			•	•			Coast down and run down time and phase plots, e.g. Bode plots	Understand swept frequency methods, time and phase run down analysis

	Subject	Category				Recommended sub-topics			
Ref:	Syllabus topic	1	2	3	4	Category 1	Category 2	Category 3	Category 4
5.05	Orbit analysis			•	•		Be aware of basic orbit analysis	Be aware of how the orbit shape indicates potential fault conditions. Explain the difference between filtered and un-filtered orbits. Explain why “glitch removal” is necessary.	Be familiar with orbit analysis, shaft resonance, Nyquist plots, oil whirl, etc
5.06	Shaft centre-line analysis		•	•	•		Be aware of the shaft centre-line plot.	Understand the data presented in a shaft centre-line plot.	Be able to interpret the data presented in the shaft centreline plot.
5.07	Enveloping		•	•	•		Understand the application of enveloping.	Understand the details of enveloping (and associated proprietary techniques) so that routine measurements can be set up correctly.	Understand de-modulation (enveloping) process and requirements
5.08	Mass unbalance		•	•			Understand static, couple and dynamic unbalance; residual unbalance, initial unbalance	Be aware of sensitivity and susceptibility to unbalance; balance errors, sources of unbalance	
5.09	Misalignment		•	•			Be aware of alignment tolerances, recognise misalignment in FFT and time trace	Understand sources of misalignment and methods of detection using FFT and time trace. Understand requirements and tolerances for alignment	

	Subject	Category				Recommended sub-topics			
Ref:	Syllabus topic	**1**	**2**	**3**	**4**	**Category 1**	**Category 2**	**Category 3**	**Category 4**
5.10	Mechanical looseness		•	•			Recognise looseness in FFT and time trace	Understanding sources of misalignment and looseness and methods of detection using FFT and time trace	
5.11	Rubs, instabilities			•	•			Understanding sources and effect of rubs and methods of detection using spectra and time waveform	Recognising sources of process instabilities
5.12	Bearing defects (rolling element, journal)		•	•			Rolling element bearing defects, noise, impacts, damage, ball pass frequency of the outer race (BPFO), ball pass frequency of the inner race (BPFI), ball spin frequency (BSF), and fundamental train frequency (FTF). Time traces and enveloping data. Recognise the term: oil whirl. Recognise patterns of bearing defects in FFT and time traces	Journal bearing rub and sub-synchronous vibrations. Understand dynamics of oil whirl, and methods of avoiding or reducing effect of oil whirl	
5.13	Electric motor defects		•	•	•		AC induction motor poles and line frequency; stator and rotor bar frequency analysis	Variable speed drives, pulse width modulation. AC induction and synchronous motor drives	Thermal effects, DC motor drives

Ref:	Subject Syllabus topic	Category 1	2	3	4	Recommended sub-topics Category 1	Category 2	Category 3	Category 4
5.14	Flow induced vibration, aerodynamics and liquids			•	•			Recognise and understand cavitation, recognise rotating stall	Understanding rotating stall, pulsation
5.15	Gearbox analysis		•	•			Recognising gear mesh frequency and sidebands in FFT and modulation in time trace. Application of demodulation (enveloping)	Time domain averaging; sidebands and gear mesh frequency. Understanding of enveloping	
5.16	Resonance and critical speeds		•	•	•		Resonance; critical speed in rigid rotors; single degree of freedom	Resonance; critical speed in flexible rotors; two degrees of freedom	Resonance; critical speed in flexible rotors; multi degrees of freedom
5.17	Turbomachinery			•	•			Understanding oil whirl, rubs, misalignment, process influence	All faults associated with turbomachinery including oil whirl, oil whip, hogging, sagging, unbalance, misalignment, and intermittent rubs
5.18	General fault recognition	•				Recognise fault frequencies for pre-set FFT and simple time waveforms for unbalance, looseness, misalignment, bearing noise and damage. Also recognise the terms: resonance and phase			
6	**Corrective action**	**2**	**4**	**6**	**16**				

	Subject	Category				Recommended sub-topics			
Ref:	Syllabus topic	**1**	**2**	**3**	**4**	**Category 1**	**Category 2**	**Category 3**	**Category 4**
6.01	Shaft alignment		•	•			Be aware of shaft alignment, tolerances	Understand shaft alignment tolerances e.g. relationship of turbine rotor speed to tolerances	
6.02	Field balancing		•	•	•		Understand single plane balancing of rigid rotors with and without phase. Be able to use balance quality and permissible residual unbalance. Be aware of test mass estimation	Understand two plane balancing of rigid rotors with phase. Be aware of static, couple and dynamic unbalance. offset balancing. balance errors.	Be aware of requirements for flexible rotor balancing, phase and modal techniques. Be aware of range of ISO balancing standards
6.03	Replacement of machine parts			•				Be aware of requirements for replacement parts and factors such as balance and alignment tolerances	
6.04	Flow control			•	•			Understanding relationship of flow and pressure to avoid fluid cavitation	Be aware of influence of pipework or ductwork in fluid and aerodynamic flow
6.05	Isolation and damping			•	•			Be aware of requirements for specifying isolators	Understand requirements and calculations for specifying isolators
6.06	Resonance control			•	•			Be aware of methods of reducing/eliminating resonance: e.g. mass change, stiffness change, frequency change	Understand principles of dynamic vibration absorbers, application of damping and isolation

	Subject	Category				Recommended sub-topics			
Ref:	Syllabus topic	**1**	**2**	**3**	**4**	**Category 1**	**Category 2**	**Category 3**	**Category 4**
6.07	Basic maintenance action	•	•	•		Be aware of simple maintenance actions to rectify or reduce faults, e.g. lubrication, alignment	Be aware of range of responses to fault conditions, e.g. part replacement, lubrication, single plane balancing, alignment, and resonance control	Be aware of range of methods to correct faults, e.g. replacement of parts, balancing, alignment, resonance control. e.g. recommending structural modifications etc.	
7	**Equipment knowledge**	**6**	**4**	**4**	**–**				
7.01	Electric motors, generators and drives	•	•	•		Recognise AC induction motor, and basic faults, e.g. bearing noise and damage, balance, looseness and misalignment	Application of key International Standards e.g. ISO10816-1 and Part 3 to AC induction motors and generators. Be aware of torque pulse, rotor and stator frequencies, variable speed drive harmonics, and slip frequency calculations	Be familiar with common types of AC and DC motor construction; wind turbine generator construction and components. Be familiar with applicable International Standards	
7.02	Pumps, fans	•	•	•		Recognise basic pump and fan combinations, and basic faults, e.g. bearing noise and damage, balance, looseness and misalignment	Application of key International Standards e.g. ISO 10816-7 for pumps and ISO 14694 for fans. Leaks, cavitation, sub-synchronous frequencies; eccentric impellers; Pump flow conditions	Pump seals. Basic fan construction, installation, and operation; Recognise rotating stall, wind turbine rotor construction and components. Be familiar with applicable standards and specifications, e.g. ISO, Verein Deutscher Ingenieure [Association of German Engineers] (VDI) and American Petroleum Institute (API)	

	Subject	Category				Recommended sub-topics			
Ref:	Syllabus topic	**1**	**2**	**3**	**4**	**Category 1**	**Category 2**	**Category 3**	**Category 4**
7.03	Steam turbines, gas turbines		•	•			Application of key International Standards e.g. ISO 10816 and ISO 20816 on vibration, basic fault set: balance, looseness, misalignment, oil whirl, rubs	Proximity probe set-up and calibration, Alarm level triggers (steam/gas turbines), stiffness and thermal dissymmetry. Affect of condenser vacuum, hogging, sagging, oil whirl, oil whip, rubs. Be familiar with applicable standards and specifications, e.g. ISO and API and other specifications.	
7.04	Compressors	•	•	•		Recognise examples of centrifugal and screw compressors	Application of key International Standards e.g. ISO 10816 and ISO 20816 on vibration. Rotating compressor components, fault frequencies e.g. pumping frequency and rotor harmonics	Rotating and reciprocating compressor design and fault frequencies. Influence of process conditions. Be familiar with applicable standards, e.g. ISO and API	
7.05	Reciprocating machinery		•	•			Application of key International Standards e.g. ISO 18016-6 and ISO 8528-9.	Reciprocating piston motion, primary and secondary balancing component standards, e.g. ISO and VDI	
7.06	Rolling mills, paper machines, other process equipment	•	•	•		Recognise examples of these machines	Be aware of components, faults, access	Pulp refining machinery measurements	

	Subject	Category				Recommended sub-topics			
Ref:	Syllabus topic	**1**	**2**	**3**	**4**	**Category 1**	**Category 2**	**Category 3**	**Category 4**
7.07	Machine tools	•	•	•		Recognise examples of these machines	Application of key International Standards e.g. ISO 10816-3 vibration standards, use of velocity and displacement	Acoustic emissions; torque controlled machining	
7.08	Structures, piping	•	•	•		Recognise the term: resonance	Resonances, natural frequencies	Vibration and fatigue of piping	
7.09	Gearboxes	•	•	•		Recognise basic examples of simple gearboxes	Pinion gear mesh and shaft speed calculations; effect of gear misalignment and backlash. Application of displacement, velocity and acceleration and enveloping	Complex gearbox configurations and structures, planetary gears, multiple reduction gearboxes. Use of acceleration time and frequency and cepstrum and demodulation (enveloping)	
7.10	Rolling element bearings		•	•			Bearing defect frequencies, noise and impacts, crest factor	De-modulation, enveloping, kurtosis	
7.11	Journal bearings		•	•			Proximity probe, runout; seismic velocity transducer, accelerometer integration, velomitor; transducer frequency ranges	Be familiar with oil whirl, oil whip, effect of lubrication flow and pressure. Runout compensation methods	
7.12	Gearing		•	•			Pinion gear mesh and shaft speed calculations	Be familiar with a range of gear profiles and design. e.g. pinion, helical, double helical, bevel, epicyclic (planetary), etc.	

	Subject	Category				Recommended sub-topics			
Ref:	Syllabus topic	**1**	**2**	**3**	**4**	**Category 1**	**Category 2**	**Category 3**	**Category 4**
7.13	Couplings, belts		•	•			Belt rotational frequency calculations, belt misalignment	Drive belt resonances, effect of drive belt tension, toothed belt	
8	**Acceptance testing**	**2**	**2**	**2**	–				
8.01	Test procedure	•	•			Be able to apply basic pre-set methods, and be aware of access and safety requirements	Apply test procedures		
8.02	Specifications and standards		•	•			Be aware of applicable International Standards and apply evaluation zones;	Understand range of required International standards and set and interpret evaluation zones; be able to create test procedures	
8.03	Reporting		•	•			Prepare acceptance test reports	Manage acceptance test procedures.	
9	**Equipment testing and diagnostics**	–	**2**	**4**	**4**				
9.01	Impact testing		•	•	•		Be able to carry out impact (hammer) test without phase	Be able to carry out modal hammer impact testing with phase response	Understand impact testing methods with and without phase. Be able to establish modal response
9.02	Forced response testing		•	•	•		Be aware of forced response testing	Be able to carry out excitation (shaker) testing, establishing mobility, compliance and accelerance, establishing transmissibility	Understand excitation (shaker) testing, coherence, transmissibility, transfer functions, mobility, compliance and accelerance

Ref:	Subject Syllabus topic	Category 1	2	3	4	Recommended sub-topics Category 1	Category 2	Category 3	Category 4
9.03	Transient analysis			•	•			Be able to carry out coast down and run down time and phase plots	Be able to set up and carry out coast down and run down time and phase plots
9.04	Transfer functions			•	•			Be aware of transfer functions, including coherence	Transfer function, input output (compressor loop), apply Nyquist plots.
9.05	Damping evaluation				•				Damping evaluation, isolation response testing
9.06	Cross channel phase, coherence			•	•			Be aware of cross-channel phase, coherence	Cross channel phase, coherence
9.07	Operating deflection shapes			•	•			Be aware of use of operating deflection shapes (ODS)	Understand modal analysis, structural response, operating deflection shapes (ODS)
9.08	Modal analysis			•	•			Be aware of modal analysis	Understand range of methods of modal analysis, establishing structural response
9.09	Torsional vibration				•				Be aware of ISO 22266-1
10	**Reference standards**	–	**2**	**2**	**2**				
10.01	ISO		•	•	•		Understand International Standards shown in Table B.1 for category 1 and category 2	Be aware of International Standards shown in Table B.1 for category 3	Be aware of International Standards shown in Table B.1 for category 4
10.02	IEC		•	•	•		Be aware of IEC Standards referenced in ISO 17359	Be aware of IEC Standards referenced in ISO 17359	Be aware of IEC Standards referenced in ISO 17359

Ref:	Subject Syllabus topic	Category 1	2	3	4	Recommended sub-topics Category 1	Category 2	Category 3	Category 4
10.03	Relevant national standards		•	•	•		As required. e.g. API, VDI etc.	As required. e.g. API, VDI etc.	As required. e.g. API, VDI etc.
11	**Reporting and documentation**	–	**2**	**2**	**2**				
11.01	Condition monitoring reports		•	•			Be able to create vibration condition monitoring reports. Feedback to history	Manage and supervise vibration condition monitoring reports and requirements	
11.02	Vibration diagnostic reports		•	•	•		Review routine VM tours, rounds or readings, evaluate trends, spectra, time trace and produce advisory report. Feedback actions to history	Manage vibration diagnostic and prognostic reporting. Be able to carry out root cause analysis (RCA) failure investigations and prepare formal reports	Be able to carry out advanced vibration troubleshooting and prepare formal reports and formats. Be able to act as expert witness in all areas of VA
12	**Fault severity determination**	–	**2**	**2**	**3**				
12.01	Spectrum analysis		•	•	•		Rotor and stator bar defects; gear mesh and sideband frequencies	Bode plots; rotor and stator bar defects; gear mesh and sideband frequencies	Rotating aerodynamic stall; sum and difference frequencies
12.02	Time waveform analysis, orbit analysis		•	•	•		Be familiar with time waveform analysis. Understand crest factor.	Be familiar with time waveform analysis. Understand crest factor. Be able to recognise basic orbit fault patterns E.g. Unbalance, looseness, misalignment, oil whirl and rubs	Apply more advanced orbit analysis e.g. Unbalance, looseness, misalignment, oil whirl and whip, resonance detection, critical speeds and phase response, rubs including Newkirk rub, thermal effects

	Subject	Category				Recommended sub-topics			
Ref:	Syllabus topic	**1**	**2**	**3**	**4**	**Category 1**	**Category 2**	**Category 3**	**Category 4**
12.03	Levels: Overall, narrowband, component		•	•			Be able to apply overall, narrowband or component alert levels	Understand requirements for overall, narrowband or component alert levels. Be able to source, set and apply alerts, alarms and trips	
12.04	Severity charts; graphs, formulae		•	•	•		Apply levels from ISO 10816, ISO 20816, ISO 8528-9, ISO 14694 etc.	Be familiar with relevant International Standard severity charts. Be able to carry out simple statistical review of alarms.	Apply all relevant International Standard severity charts and machine VM standards. Be able to review system and alarms, carry out advanced statistical review methods
13	**Rotor/bearing dynamics**	–	–	–	**14**				
13.01	Rotor characteristics				•				Understand design and characteristics of steam and gas turbine rotors. Be aware of structural response, failure modes and effects, fault frequencies, performance, effect of lubricants etc.

	Subject	Category				Recommended sub-topics			
Ref:	Syllabus topic	**1**	**2**	**3**	**4**	**Category 1**	**Category 2**	**Category 3**	**Category 4**
13.02	Bearing characteristics				•				Understand design and characteristics of rolling element bearings, journal bearings and magnetic bearing. Be aware of failure modes and effects, geometry and fault frequencies, statistical life, performance, lubricants etc.
13.03	Rotor balancing				•				Understand methods and requirements for rigid and flexible rotor balancing, with and without phase, modal techniques. Be familiar with the range of International standards on balancing.

NOTE 1 The symbol • indicates the subject is to be covered within the time allotted, or may be included within training on other topics.
NOTE 2 Category 2 includes the knowledge of Category 1; Category 3 includes the knowledge of Categories 1 and 2; Category 4 includes the knowledge of lower categories.
NOTE 3 If the symbol * appears in more than one category for a subject item, it should be understood that at Category X deeper knowledge of the subject is required than at Category X – 1.

Annex B – Reading and International Standards References

Table B.1 – Recommended reading includes:

Author, Title, Publisher, Pages, ISBN / Publ. No.	Category			
	1	2	3	4
MILLS S.R.W. *Vibration monitoring and analysis handbook.* Northampton: British Institute of Non-Destructive Testing, 2010, 326 p. ISBN 0903132397	•	•	•	•
RMS Ltd, *Vibration Analysis Pocket Guide,* Northampton: British Institute of Non-Destructive Testing, ISBN 0-903132-36-2	•	•	•	•
Professor A. Hope & Mr D. Whittle, An Introduction to Condition Monitoring and Diagnostic Technologies, BINDT, 978 0 903132 76 3	•	•		
WALKER N., *Infrared Thermography- Theory & Practice,* Northampton: British Institute of Non-Destructive Testing, ISBN 0903132338			•	•
HOLROYD T., *Acoustic emission and Ultrasonics,* Chipping Norton: Coxmoor, ISBN 1901892077			•	•
ROYLANCE B. J. & HUNT T. M., *The wear debris analysis handbook,* Chipping Norton: Coxmoor, 1999, ISBN 1901892026			•	•
EVANS and HUNT, *Oil Analysis,* Chipping Norton: Coxmoor, 2008, 180p, ISBN 1901892050			•	•
Donald E Bently & Charles T. Hatch, Bob Grissom (Editor), Fundamentals of Rotating Machinery Diagnostics, 2002, Bently Pressurized Bearing Company, Minden, USA, ISBN 0-9714081-0-6			•	•

Applicable International Standards (material from which BINDT specified examination questions can be developed). Applicable International Standards for each Category are specified in Table B.2. The current published version of each standard applies.

Table B.2 – Applicable International Standards

International Standard Reference	Category			
	1	2	3	4
ISO 21940-2, Mechanical Vibration – Rotor balancing – Part 2 – *Vocabulary**		•	•	•
ISO 21940-11, Mechanical Vibration – Rotor Balancing – Part 11: Procedures and tolerances for rotors with rigid behaviour		•	•	•
ISO 2041, *Mechanical vibration and shock condition monitoring – Vocabulary.**		•	•	•
ISO 20816-1, *Mechanical vibration – Measurement and evaluation of machine vibration – Part 1: General guidelines*	•	•	•	•
ISO 20816-2, *Mechanical vibration. Measurement and evaluation of machine vibration – Part 2: Land-based gas turbines, steam turbines and generators in excess of 40 MW, with fluid-film bearings and rated speeds of 1 500 r/min, 1 800 r/min, 3 000 r/min and 3 600 r/min*	•	•	•	•
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 13381-1, *Condition monitoring and diagnostics of machines – Prognostics – Part 1: General guidelines*		•	•	•
ISO 14694, *Industrial fans – Specification for balance quality and vibration levels*	•	•	•	•
ISO 17359, *Condition monitoring and diagnostics of machines – General guidelines*	•	•	•	•

*These are vocabulary standards and are available free of charge at www.iso.org/obp

The list of standards specified in Table B.3 and associated standards listed within ISO 18436-2 are noted for information only and not an auditable requirement.

Table B.3 – Applicable International Standards

BINDT specified additional standards ***A comprehensive list of standards is available within the latest version of international standard ISO 18436-2***	Category			
	1	2	3	4
ISO 281, *Rolling bearings – Dynamic load ratings and rating life*				•
ISO 15, *Rolling bearings – Radial bearings – Boundary dimensions, general plan*			•	•
ISO 18436-2, *Condition monitoring and diagnostics of machines – Requirements for qualification and assessment of personnel – Part 2: Vibration condition monitoring and diagnostics*	•	•	•	•
ISO 22266-1, *Mechanical vibration – Torsional vibration of rotating machinery – Part 1: Land-based steam and gas turbine generator sets in excess of 50 MW*				•

Summary of changes

Issue number	Issue date	Summary of changes
8	1st July 2018	• Reference to comprehensive list of standards • Reference made to non-auditable standards • Addition of standards 20816 parts 1 and 2
9	8th April 2020	• Update to comprehensive list of standards • Update to ISO reference in Annex A Table A.2