Certification Services Department
Midsummer House, Riverside Way
Northampton, NN1 5NX
United Kingdom

Tel: +44 (0)1604 438300
Fax: +44 (0)1604 438301
E-mail: cm.admin@bindt.org

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SPECIFIC REQUIREMENTS FOR QUALIFICATION AND PCN CERTIFICATION OF CONDITION MONITORING AND DIAGNOSTIC PERSONNEL FOR ULTRASOUND

CONTENTS

Introduction

The use of the Airborne and Structure-borne Ultrasound method in condition monitoring 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 PCN certification of condition monitoring and diagnostic personnel). Other Appendices cover:

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

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 893811, or email pcn@bindt.org.

Organisations requiring to be in possession, at all times, 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 assessment of personnel engaged in **asset condition monitoring using Ultrasound equipment**. 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 ISO18436-8, *Condition monitoring and diagnostics of machines - Requirements for qualification and assessment of personnel Part 8: Ultrasound.*

1.3. Certification to this specification will provide evidence of the qualification and competence of individuals to perform Ultrasound measurements and analysis using appropriate sensors and equipment.

2. Classification of Personnel

2.1. General

2.1.1. Individuals certified in accordance with this specification are classified in one of three categories and have demonstrated the necessary skills in using Ultrasound for condition monitoring to the category as indicated in the examination syllabus at Annex A.

2.1.2. Personnel classified as Category 2 require all the knowledge and skills expected of personnel classified as Category 1, and personnel classified as Category 3 require all the knowledge and skills expected of personnel classified as Category 2.

2.2. Ultrasound Category 1

PCN certificated Ultrasound Category 1 personnel are qualified to perform Ultrasound measurements according to established and recognised procedures and shall be able to:

2.2.1. apply a specified ultrasound measurement technique; however, persons classified as category 1 shall not be regarded as competent to choose the test method or technique used;

2.2.2. set up and operate the ultrasound equipment for safe ultrasound data collection;

2.2.3. verify the integrity of collected data and prevent or control poor data and error sources;

2.2.4. perform basic fault detection, severity assessment, and diagnosis in accordance with established instructions;

2.2.5. record and categorise the results and trends;

2.2.6. maintain a database of results and trends;

2.2.7. evaluate and report test results in accordance with instructions highlighting areas of concern;

2.2.8. recognise and prevent or control factors that result in the acquisition of poor-quality data.

Category 1 certificated personnel shall not be regarded as competent to choose the test method or technique to be used nor to assess the test results.

2.3. Ultrasound Category 2

Individuals certificated as ultrasound Category 2 are qualified to perform and/or direct ultrasound analysis according to established and recognised procedures and are aware of the limitations of the ultrasound method. Category 2 personnel shall be able to:

2.3.1. select the appropriate ultrasound measurement technique and understand its limitations;

2.3.2. specify the appropriate hardware and software;

2.3.3. set up and verify equipment settings;

2.3.4. apply ultrasound theory and techniques where no procedures exist;

2.3.5. measure and perform diagnosis of ultrasound signals inclusive of amplitude, frequency, and time domain analysis;

2.3.6. classify and evaluate the test results (including acceptance tests) in accordance with applicable codes, standards, specifications, and procedures;

2.3.7. prepare reports on equipment condition fault diagnoses, recommend appropriate corrective actions, and comment on effectiveness of repairs;

2.3.8. provide technical direction to ultrasound monitoring personnel at category 1;

2.3.9. be aware of the use of alternative or supplementary condition monitoring (CM) technologies.

2.4. Ultrasound Category 3

Personnel certificated as category 3 are qualified to perform and/or direct all types of ultrasound measurements and analysis and shall be able to:

2.4.1. apply ultrasound theory and techniques, including measurement and interpretation of survey results such as amplitude, frequency, and time domain processing;

2.4.2. understand and perform data analysis, including limitations;

2.4.3. determine the ultrasound data acquisition systems and component assemblies required;

2.4.4. use non-standard techniques for ultrasound monitoring and fault diagnosis;

2.4.5. interpret and evaluate standards, codes, specifications, and procedure;

2.4.6. develop and establish ultrasound programmes, procedures, and instructions including determination of the requirement for periodic/continuous monitoring, frequency of testing, etc.;

2.4.7. determine severity assessment acceptance criteria for new, in-service, and faulty equipment;

2.4.8. measure and perform more advanced diagnosis and prognosis of ultrasound signal analysis with amplitude, frequency, and time domain;

2.4.9. recommend the use of alternative or supplementary condition monitoring (CM) technologies;

2.4.10. provide guidance to supervise and instruct category 1 and 2 personnel.

Note: it is the employer's responsibility to ensure that category 3 personnel have the necessary competency in the required management skills, for example creating budgets, preparing cost justifications, and management personnel development.

3. Eligibility for Examination and Certification

3.1 General

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

It is advised that all candidates utilising instrumentation with headphones should be given hearing examinations to ensure natural or corrected hearing acuity exists in at least one ear. A record of the results should be retained and presented to the assessment body upon request. The individual should be capable of hearing a standard pure tone audiometry with results of an average of 25 dB hearing level or lower. This examination should be administered upon initial certification and upon recertification. The examinations shall be administered by a licensed professional and a record of the test made available to the assessment body upon request.

Note: BINDT holds the right to request proof a hearing examination has been carried out to the above specifications.

3.2 Education

Candidates seeking certification do not need to provide evidence of formal education to establish eligibility. However, it is recommended that Category 1 and 2 candidates have at least a secondary school graduation diploma or its equivalent. Category 3 candidates shall be able to manipulate simple algebraic equations, use a basic scientific calculator (including 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 3.

3.3 Training

3.3.1 To be eligible to apply for examination based on this Specification, the candidate shall provide documentary evidence of successful completion of a BINDT approved or recognised course of formal training, which will be based on the requirements of Annex A2. Sources of technical information are listed in Annex B. The minimum duration of training required shown in Table 1.

BINDT allows a maximum of 50% self-study or on-line training for topics consistent with Annex A2 and as specified by the approved trainer (CMGEN refers).

3.3.2 Approved training should be in the form of lectures, demonstrations and practical exercises. The approved training shall include examinations to ensure

that the subject matter has been understood and that they have successfully completed the training.

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

TABLE 1. Minimum Duration of Training (hours)		
Category 1	Category 2	Category 3
32	64	96
The hours shown represent cumulative totals of training hours for each Category.		

3.4 Experience

3.4.1 To be eligible to apply for certification the candidate shall provide evidence of experience in the field of Ultrasound condition monitoring appropriate to the category sought. The minimum experience requirements are shown in Table 2.

3.4.2. Certification at Categories 2 and 3 requires previous certification at the lower categories

3.4.3. For the purposes of renewal, the candidates must maintain a log of hours and nature of work on PCN document CP16-CM for all categories.

TABLE 2. Minimum Cumulative Experience Requirements (months)		
Category 1	Category 2	Category 3
6	12	36

4. Certification Available

4.1 Category 1 (Airborne and Structure-borne Ultrasound Condition Monitoring)

4.2 Category 2 (Airborne and Structure-borne Ultrasound Condition Monitoring)

4.3 Category 3 (Airborne and Structure-borne Ultrasound Condition Monitoring)

5. Qualification Examination

5.1 Application for qualification examinations

5.1.1 Application for initial qualification examination is made on PCN form PSL/57-CM and supported with PSL/33-CM and PSL30-CM where required.

5.2 Examination content (Theory and practical knowledge)

5.2.1 For each certification Category, candidates will be required to answer the number of multiple choice questions indicated in Table 3.

5.2.2 A number of questions on the Category 3 examination paper may consist of narrative questions. Category 3 examinations may include fault diagnosis, prognosis and solution recommendation content.

Table 3 – qualification examination content

Categories	Number of Questions	Time (Hours)*	Passing Grade %
Category 1	60	2.0	70
Category 2	60	2.0	70
Category 3	60	2.0	70

** 30 minutes additional time may be allowed to assist candidates with English as a second language or any disability.*

5.2.4 The content of the examination paper shall contain multiple-choice questions for each subject in Annex A2, and in the same weighting as indicated by the percentage of time spent on each subject indicated in Annex A2, together with the indicated narrative questions in the case of Category 3.

5.2.5 Questions will be of a practical nature and will test the candidate's knowledge of the principles and procedures required to conduct Airborne and Structure-borne Ultrasound condition testing and analysis.

5.2.6 Questions may include the interpretation of practical data and simple mathematical calculations using a basic scientific calculator may be required.

Annex A1 Training Syllabus Heading

	Hours of training		
Subject	Category 1	Category 2	Category 3
1 Principles of ultrasound	3.00	2.00	1.00
2 Generic equipment knowledge	1.50	1.00	1.00
3 Data acquisition in ultrasound	2.50	1.00	1.00
4 Data storage and management	1.00	2.00	2.00
5 Condition monitoring principles	1.50	1.00	1.00
6 Applications to machine systems	17.00	17.00	16.50
7 Severity determination	2.00	4.00	4.00
8 Programme implementation	0.50	0.50	1.00
9 Reporting and corrective action	0.50	1.00	2.00
10 Personal safety	0.50	0.50	0.50
11 Training examination	2.00	2.00	2.00
Total hours for each category	32	32	32

Annex A2 – Detailed list of topics and hours of Instruction

Ref	Subject	Durations in hours			Recommended Sub-Topics		
		Cat I	Cat II	Cat III	Category I sub-topics	Category II sub-topics	Category III sub-topics
1	**Principles of ultrasound**	**3.00**	**2.00**	**1.00**			
1.01	Basics of sound	•	—	—	Be aware of the basics of sound. Infrasound/Audible/Ultrasound. Relationship between Velocity, Frequency and Wavelength V=λf. Wavelength and barriers to transmission		
1.02	Sound wave motion	•	—	—	Be aware of sound wave motion longitudinal vs. transverse motion. Non-continuous motion		
1.03	Acoustic impedance	•	•	•	Be aware of acoustic impedance and its influence on Reflection and Transmission at a boundary between two different materials	Recognise acoustic impedance and its influence on propagation and attenuation Be aware of attenuation caused by material interfaces. Understand how material changes will affect measurements	Understand acoustic impedance and its influence on propagation and attenuation Be able to identify where material changes will cause measurement problems and develop improvements. Be able to identify and calculate attenuations caused by material interfaces and changes.
1.04	Inverse distance law	•	—	—	Be aware of the inverse distance law Conclude that an airborne measurement MUST have a distance associated with it	Understand how reflections may limit the losses from distance	
1.05	What produces ultrasound	•	•	•	Be aware of how friction, turbulence, and impacting produce ultrasound	Be familiar with how friction, turbulence, and impacting produce ultrasound and	Understand how friction, turbulence, and impacting produce ultrasound and

						where they apply Understand that multiple defects can occur together	where they apply develop broader application range based upon the fundamentals
1.06	Properties of the decibel	•	•	—	Be aware of the properties of the decibel Cannot multiply or divide decibels. Decibels are comparative numbers and need a reference. +6dB is a doubling in voltage amplitude	Understand the properties of the decibel Be able to express a decibel as a ratio and vice versa. Understand Crest Factor calculation with dBs	
2	**Generic equipment knowledge**	**1.50**	**1.00**	**1.00**			
2.01	Instrument operation and function	•	•	•	Be aware of instrument operation and function. Sensors, signal conditioning, processing and perhaps storage	Be familiar with instrument operation and function Be able to show CAT1 and lower users how to operate	Understand instrument operation and function Understand and instruct on how settings can change measurements
2.02	Airborne sensors	•	•	•	Be aware of the different types of airborne sensors for use in different circumstances. Be able to inspect sensors for signs of damage.	Be familiar with airborne sensors Be able to select sensors and methods for appropriate application.	Understand airborne sensors Inspect sensors for defects and instruct users on best usage practice
2.03	Structure-borne sensors	•	•	•	Be aware of the different types of contact sensors for use in different circumstances. Be able to inspect sensors and cables for signs of damage.	Be familiar with structure-borne sensors. Be able to select sensors and contact methods for appropriate application.	Understand structure-borne sensors Inspect sensors for defects and instruct users on best usage practice
2.04	Heterodyne principle and application	•	•	•	Be aware of the use of heterodyning. Making the inaudible, audible. Varying the mixer frequency can change instrument sensitivity	Be familiar with the heterodyne principle and application Understand that by changing the mixer frequency it is possible to allow sub-20kHz audio into the measurement	Understand the heterodyne principle and application If your instruments have variable frequency, ensure that users always know which frequency to use

2.05	Sensitivity validation	•	•	—	Be aware of sensitivity validation. Be able to follow a sensor validation procedure	Be familiar with sensitivity validation Be able to develop and document this procedure and to arrange OEM calibrations	
3	**Data acquisition in ultrasound**	**2.50**	**1.00**	**1.00**			
3.01	Principles of data acquisition	•	•	—	Be aware of principles of data acquisition. Be aware of different types of measurement: RMS, Peak, Crest Factor, Time Signal, Spectrum	Be familiar with the principles of data acquisition Are we measuring the right parameter? Understand the influence of operating variables such as machine speed on measurements. Understand different types of measurement: RMS, Peak, Crest Factor, Time Signal, Spectrum.	
3.02	Sensor positioning	•	•	—	Be aware of sensor positioning: Airborne sensors are directional, contact sensors need to be perpendicular to the surface	Understand sensor positioning. Be able to recommend various installation and measurement methods	
3.03	Competing ultrasound and shielding techniques	•	•	•	Be aware of competing ultrasound and shielding techniques. Always listen to your data - is what you hear, what you expect to hear?	Be familiar with competing ultrasound and shielding techniques. Be capable of developing corrective procedures	Understand competing ultrasound and shielding techniques Identify likely sources and design barriers to ease problems
3.04	Measurement of ultrasound	•	•	•	Be aware of measurement of ultrasound - a measurement of RMS amplitude may not be enough	Be familiar with the measurement of ultrasound Be able to explain RMS, Peak, Crest Factor.	Understand measurement of ultrasound Understand how on-line systems can be helpful. When and how to use them

3.05	Capturing time domain and spectrum signals for analysis	•	•	•	Be aware of capturing time domain and spectrum signals for analysis. Understand that the time signal should be what you are listening to, and the spectrum is derived from that.	Be familiar with capturing time domain and spectrum signals for analysis Understand the significance of sample time to measurements	Understand capturing time domain and spectrum signals for analysis Understand the benefits of oversampling to data capture
4	**Data storage and management**	**1.00**	**2.00**	**2.00**			
4.01	Developing and using a database	•	•	•	Be aware of databases. Understand the need for consistency	Be able to develop and use a database. Create a small database, move tree elements inside that database	Understand developing and using a database Primary responsibility for database creation - understand the need to interrogate the database for Reliability data
4.02	Managing stored data	•	•	•	Be aware of managing stored data. Understand the need for data to be representative of the operating conditions	Be familiar with managing stored data. Know how to back up and to restore data	Understand managing stored data Consider ways of pruning database tress for more efficient operation. Be able to remove old machines and unwanted data from the main databases
4.03	Detect and correct anomalies	—	•	•	Be aware of bad data. bad data is a distractor - identify clipping	Be able to detect and correct data anomalies know how to remove bad data from a database and organise replacement measurements	Understand detecting and correcting data anomalies continue to train inspectors to improve measurement quality
5	**Condition monitoring principles**	**1.50**	**1.00**	**1.00**			
5.01	What is condition monitoring and why is it useful	•	—	—	Be aware of CM and why is it useful		

5.02	Other CM Technologies	•	•	•	Be aware other CM technologies exist	Be familiar with range of other CM Technologies: E.g., Vibration Analysis (VA), Infrared Thermography (IRT); Acoustic Emission (AE); Lubricant Management (LM) - tribology and wear debris	Be familiar with and be able to apply other CM Technologies: E.g., Vibration Analysis (VA), Infrared Thermography (IRT); Acoustic Emission (AE); Lubricant Management (LM) - tribology and wear debris
5.03	CM with ultrasound	•	—	—	Be aware of why and when ultrasound would be useful as a CM technique. Come back to Friction, Impacting and Turbulence		
5.04	Acceptance testing	•	•	•	Be aware of acceptance testing. New and newly repaired assets are very likely to fail	Be familiar with acceptance testing	Be able to develop acceptance testing procedures
5.05	Benchmarking	—	•	•	Be aware of benchmarking. Performance comparison can be very useful	Be familiar with benchmarking. Understand the need for consistent measurements for comparison	Be able to develop benchmarking processes
6	**Applications to machine systems**	**17.00**	**17.00**	**16.50**			
6.01	General leak detection	•	•	•	Be aware of general leak detection: identifying faults including: turbulence and flow What is a leak? Energy losses and Reliability applications. The importance of controlling distance, angle and sensor used. What does a leak sound like?	Be familiar with general leak detection: identification of faults including; turbulence and flow, directionality, measurement precautions, pressurized gases and compressed air, vacuum Running an air leak detection programme	Be familiar with leak detection: identification of faults including; turbulence and flow, directionality, pressurized gases and compressed air, vacuum, tightness testing using the ultrasonic tone method

6.02	Valve Inspection	•	•	•	Be aware of valve inspection: the need for valve asset management. Defect detection including: blockage, passing and cavitation What are the practical detection limits? Small overview of valve designs. What the different defects sound like	Be familiar with valve inspection: defect detection including; blockage, passing, cavitation etc. Running a valve inspection programme	Be able to develop valve inspection procedures: defect detection including; blockage, passing, cavitating etc.
6.03	Steam trap inspection	•	•	•	Be aware of steam trap inspection: The importance of steam traps (e.g., condensate & gas removal, risk of water hammer) The need to manage them. Small overview of trap designs. identification of faults using ultrasound. What the different defects sound like.	Be familiar with steam trap inspection: identification of faults using ultrasound, using ultrasound in combination with temperature, reporting techniques Running a steam trap inspection programme.	Be able to apply steam trap inspection: identification of faults using ultrasound, using ultrasound in combination with temperature, developing reporting techniques.
6.04	Electrical inspection	•	•	•	Be aware of electrical inspection: Understand that not all defects generate heat. Be aware of faults including; Corona, tracking, arcing, partial discharge etc. Overview of defect generation and severity. Be aware what the different defects sound like.	Be familiar with electrical inspection. Be able to identify faults including; Corona, tracking, arcing, partial discharge etc.. Working with LV, MV & HV Running MV and HV inspection programmes.	Be able to apply electrical inspection: Identification of faults including; Corona, tracking, arcing, partial discharge etc.. Develop procedures for working with LV, MV & HV.

6.05	Hydraulic systems inspection	•	•	•	Be aware of hydraulic systems inspection: How hydraulics works and how they generate Ultrasound. detection of faults in; cylinders, valves, pipework, and pumps etc.	Be familiar with hydraulic systems inspection: Detection of faults in; Cylinders, valves, pipework, and pumps etc. Running inspections on hydraulic cylinders	Understand hydraulic systems inspection: detection of faults in; cylinders, valves, pipework, and pumps etc.
6.06	On-condition bearing lubrication using ultrasonics	•	•	•	Be aware of on-condition bearing lubrication using ultrasonics, under and over-lubricated bearings The relationship between friction, ultrasound, and lubrication condition. What under- and over-lubrication sound like - how to tell the difference.	Be familiar with on-condition bearing lubrication using ultrasonics, lubrication process considerations, under and over-lubricated bearings, trending values Understand the needs when developing an on-condition lubrication programme	Understand on-condition bearing lubrication using ultrasonics, lubrication process considerations, under and over-lubricated bearings, trending values
6.07	Bearing Inspection	•	•	•	Be aware of bearing inspection: bearing defect detection including poor lubrication, mechanical faults, slow speed bearings etc. Bearing failure progression, random impacts, repeating impacts. How these change the measurement. What these defects sound like	Be familiar with bearing Inspection: Bearing defect detection including poor lubrication, mechanical faults, slow speed bearings etc. Understand the progression of failure. Be able to identify and find bearing defect frequencies in a time signal and spectrum	Understand bearing inspection: bearing defect detection including poor lubrication, mechanical faults, slow speed bearings etc.
6.08	Gearbox Inspection	•	•	•	Be aware of gearbox inspection: detection of faults in gearing and gearboxes including poor lubrication, damaged gears, damaged teeth etc. Where to place the sensors. What the defects sound like	Be familiar with gearbox Inspection: Detection of faults in gearing and gearboxes including poor lubrication, friction, rubbing, damaged gears, damaged teeth etc. Calculate a 1x and GMF and find them in a time signal and spectrum	Understand gearbox inspection: detection of faults in gearing and gearboxes including poor lubrication, friction, rubbing, damaged gears, damaged teeth etc.

6.09	Pump Inspection	•	•	•	Be aware of pump inspection: detection of faults including cavitation, turbulence, leakage, mechanical faults etc. Basic source location - valve or pump? What the defects sound like	Be familiar with pump Inspection: Detection of faults including cavitation, turbulence, leakage, mechanical faults etc. Where to place the sensors.	Understand pump inspection: detection of faults including cavitation, turbulence, leakage, mechanical faults etc.
6.10	Electric Motor Inspection	•	•	•	Be aware of electric motor inspection: detection of faults including. bearings and effect of variable speed drives etc. Practical problems caused by VFDs Application to couplings. What the defects sound like	Be familiar with electric motor inspection: detection of faults including. bearings, stator, winding, arcing and effect of variable speed drives etc. Where to place the sensors.	Understand electric motor inspection: detection of faults including. bearings, stator, winding, arcing and effect of variable speed drives etc.
7	**Severity determination**	**2.00**	**4.00**	**4.00**			
7.01	Setting up decibel alarms	—	•	•		Be familiar with setting up decibel alarms Understand that dB alarms are additive not multipliers	Be able to develop and set up decibel alarms
7.02	Trending decibels	•	•	•	Be aware of trending decibels and alarm levels.	Be familiar with trending decibels	Understand trending decibels
7.03	Statistical alarm creation	—	•	•		Be aware of statistical alarm creation Understand about distributions and standard deviations - what this means in terms of alarm significance	Be familiar with statistical alarm creation Be able to export dB data, test the population and calculate statistical characteristics of the data in order to create alarm values
7.04	Time signal analysis	•	•	•	Be aware of time signal analysis. Look at examples such as friction vs. bearing defect. Aware of amplitude and of clipping	Be familiar with time signal analysis Know how to use cursors to find periodic signals	Understand time signal analysis

7.05	Spectrum analysis	•	•	•	Be aware of spectrum analysis.	Be familiar with spectrum analysis (e.g., BPFI, BPFO, GMF etc.) Know how to use cursors to find harmonic signals	Understand spectrum analysis (e.g., BPFI, BPFO, GMF etc.)
7.06	Case studies	•	•	•	Be aware of case studies. Show how we combine all of these learnt items into identifying problems	Be able to record case studies. Be familiar with what information should be contained within a report.	Be able to develop and record case studies
7.07	Diagnosis and prognosis	—	•	•		Be familiar with diagnosis and prognosis.	Be able to develop diagnosis and prognosis
8	**Program implementation**	**0.50**	**0.50**	**1.00**			
8.01	Routine CM inspection considerations	•	•	•	Be aware of routine CM inspection considerations	Be familiar with routine CM inspection considerations Identify areas where sensors may need to be installed or guards modified	Be able to develop and implement routine CM inspection considerations Devise routes based upon personnel and operating needs and conditions
8.02	Routine CM program management	•	•	•	Be aware of routine CM program management	Be familiar with routine CM program management	Be able to develop and implement routine CM program management. Track missed measurements and devise strategies to identify why and then catch up
8.03	CM Report structuring	—	•	•		Be familiar with CM report structuring The key elements of a good report	Be able to develop and implement CM report structuring
8.04	Corrective action for alarm incidences	—	•	•		Be familiar with corrective action for CM alarm incidences	Be able to develop and implement corrective action for CM alarm incidences
9	**Reporting and corrective action**	**0.50**	**1.00**	**2.00**			

9.01	Key information needed	•	•	•	Be aware of key report information needed	Be familiar with key CM reporting information needed	Be able to develop and implement key CM reporting information needed
9.02	Recommending corrective action	—	•	•		Be familiar with recommending CM corrective action	Be able to develop and implement recommended corrective action
9.03	Tracking corrective action outcome	•	•	•	Be aware of tracking corrective action outcome	Be familiar with tracking corrective action outcome	Be able to develop and implement tracking processes for corrective action outcome
10	**Personal safety**	**0.50**	**0.50**	**0.50**			
		•	•	•	Be able to apply basic pre-set ultrasonic CM inspections and monitoring methods and be aware of access and safety requirements. Particularly stress the need to be able to still hear alarms when wearing ear defenders	Be able to apply all ultrasonic CM and inspection methods, and be familiar with access and safety requirements Be aware of applications of Ultrasound which should be part of improved safety procedures	Be able to apply all ultrasonic and other CM methods, and be familiar with and able to develop safe access and safety requirements
11	**Training examination**	**2.00**	**2.00**	**2.00**			
		•	•	•	Category I training examination	Category II training examination	Category III training examination
	Total hours per category	**32.00**	**32.00**	**32.00**			
	• Topics to be taught at each category NOTE 1 Category II includes the knowledge of category I NOTE 2 Category III includes the knowledge of category I and category II						

Annex B – References

Essential material

Title	Author	Publisher	ISBN
Have a listen to Ultrasound: The high frequency world of Reliability	Murphy T.J.	N/A	979-8412080727

Recommended material

Title	Author	Publisher	ISBN
Have a listen to Ultrasound: The high frequency world of reliability	Murphy T.J.	N/A	9798412080727
Airborne/structure-borne ultrasound technology sourcebook.	Nuclear Maintenance Applications Center.	Palo Alto, CA: Electric Power Research Institute, 2007.	
Acoustic leak testing. In: *Non-destructive testing handbook*	Moore P.O.	Columbus, OH: American Society for Nondestructive Testing,	978-1-57117-421-5
An Introduction to Condition Monitoring and Diagnostic Technologies	Editors: Prof A. Hope D. Whittle	BINDT	978 0 903132 76 3

Standards and Specifications

1. ISO 29821:2018 Condition monitoring and diagnostics of machines -- Ultrasound -- General guidelines, procedures and validation
2. ISO 17359 : 2018 Condition monitoring and diagnostics of machines – General guidelines