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CM/GEN APPENDIX C- Issue 2 rev C

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

CONTENTS

Introduction

The use of Lubricant Analysis (LA) in condition monitoring and diagnosis of faults in machinery 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 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 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 assessment of personnel engaged in Condition Monitoring using Lubricant Analysis. 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: Condition monitoring and diagnostics of machines: Requirements for qualification and assessment of personnel- Part 4: Field Lubricant Analysis and Part 5: Lubricant laboratory technician/analyst

1.3. Certification to this document may be acquired according to sector of employment. The sectors are ‘Laboratory’ (Lab) and ‘Field’, or may be a combined qualification (Lab + Field) for ‘field laboratory’ operations.

1.4. This specification offers three modules for training and assessment. They are Module A- ‘general theory- common subjects’ and two practical applications based modules- Module B - ‘Laboratory’ and Module C - ‘Field’.

1.5. Certification to this document may be acquired for a single sector or both, but each requires completion and successful examination in module A. If a candidate succeeds in Module A examination but fails a sector module, then no certificate is awarded but Module A credited for 12 months.

2. Classification of Personnel

2.1. General

2.1.1. Individuals certificated in accordance with this specification are classified in one of three Categories and have demonstrated the necessary skills in the concepts of machinery Lubricant Analysis, as defined in the scope for their classification Category and sector, as indicated in the examination syllabus at Annex A1.

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.

2.1.3. The classification of personnel in two sectors and three Categories are presented in the following order:

- Clause 2.2 Category 1 combined –Laboratory and Field Analyst
- Clause 2.3 Category 2 combined –Laboratory and Field Analyst
- Clause 2.4 Category 3 combined –Laboratory and Field Analyst
- Clause 2.5 Category 1 Laboratory Analyst
- Clause 2.6 Category 2 Laboratory Analyst
- Clause 2.7 Category 3 Laboratory Analyst
- Clause 2.8 Category 1 Field Analyst
- Clause 2.9 Category 2 Field Analyst
- Clause 2.10 Category 3 Field Analyst

2.2. Lubrication Management and Analysis Category 1 (Laboratory and Field Analyst)

PCN certificated Lubrication Management and Analysis Category 1 (Laboratory and Field Analyst) personnel are qualified to supervise industrial machinery lubrication, lubricant sampling, and basic lubricant testing and analysis according to established and recognised procedures and shall be able to:

2.2.1. install sampling hardware for sample acquisition;

2.2.2. dispense lubricants, re-lubricate, collect and/or inspect/sample lubricants on a pre-programmed route from machinery systems, equipment and/or storage containers, as appropriate and in accordance with established procedures;

2.2.3. properly maintain lubrication devices and equipment;

2.2.4. prepare samples for transport and/or testing in accordance with established procedures;

2.2.5. manage the safe transport, receipt, storage and handling of lubricant samples and application of lubricants in accordance with established procedures;

2.2.6. install sampling hardware deemed appropriate, safe and non-intrusive*

2.2.7. selection of approved lubricants appropriate to machines commonly found in general industry

2.2.8. operate and maintain portable oil analysis instrumentation on pre-programmed sampling routes for simple on-site tests and download/upload raw test data;

2.2.9. perform common laboratory and/or field tests using established procedures with an understanding of the principles of these tests;

2.2.10. inspect data from individual test methods only

2.2.11. input results into a database/spreadsheet, maintain the database and trend;

2.2.12. set up instruments and/or equipment for basic on-site testing and/or basic laboratory testing, including verification of calibration checks, in accordance with established procedures and report to appropriate personnel when action is needed;

2.2.13. maintain basic lubricant analysis of machinery systems and components such as engines, transmissions, hydraulics, turbines, compressors, gearboxes, etc. using in-field or testing laboratory analysis;

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

2.2.15. prevent and control errors relating to handling and testing;

2.2.16. report test results in accordance with instructions and established criteria, identifying whether data is reasonable ;

2.2.17 undertake basic machine systems and equipment visual inspections;

2.2.18 demonstrate basic quality knowledge and laboratory good practice in accordance with ISO 17025;

Note 1: *A Category 2 or higher certificated person must deem whether sampling hardware is appropriate, safe and non-intrusive and any intrusive sampling hardware installation shall be undertaken by a suitably qualified person authorised by the customer or owner

Note 2: Category 1 certificated personnel shall not be responsible for the choice of test method or technique to be used, nor for the diagnosis of test results.

2.3 Lubrication Management and Analysis Category 2 (Laboratory and Field Analyst)

PCN certificated Lubrication Management and Analysis Category 2 (Laboratory and Field Analyst) personnel are qualified to undertake all competencies of Category 1 (laboratory and Field) and additionally, to schedule and direct machinery lubricant management and lubricant analysis according to established and recognised procedures, and shall be able to:

2.3.1 prepare samples for field and/or laboratory analysis, as defined by the technique or procedure chosen;

2.3.2 recognise potential contamination and data that is a change from the norm;

2.3.3 establish procedures for sample acquisition, preparation and transport;

2.3.4 select/specify the appropriate machinery lubricant analysis technique (method), sample point locations; instrumentation hardware and software for portable on-site lubricant testing and permanently installed laboratory testing and oversee installation of sampling hardware;

2.3.5 perform selected test methods for on-site and/or laboratory testing and wear debris particle testing, interpretation and basic analysis;

2.3.6 set-up routine or customised (bespoke) laboratory testing schedules and test slates and maintain a database of analysis schedules, results and diagnoses;

2.3.7 liaise with off-site laboratories;

2.3.8 employ and/or operate basic field or laboratory techniques to troubleshoot lubricant, hydraulic, machinery, grease and components problems;

2.3.9 classify, interpret and evaluate basic test results, including acceptance tests, in accordance with established procedures;

2.3.10 establish programmes for the specification of lubricant analysis Categories and acceptance criteria for new machinery;

2.3.11 manage a database of results, with trends and diagnostics (including fault analysis);

2.3.12 recommend corrective actions and prepare reports based on test results (eg: suggestion of replacement of machine parts) from diagnosis of related failure mechanisms and modes;

2.3.13 perform basic failure mode and criticality analysis;

2.3.14 perform and/or verify the calibration of portable and fixed on-site and laboratory lubricant analysis instrumentation as per specified procedures;

2.3.15 manage and perform administrative tasks for lubricant analysis software and databases;

2.3.16 operate wear debris analysis equipment and perform evaluation of particulate population;

2.3.17 recommend the use of alternative CM technologies, with an awareness of the principles of other CM technologies specified in CM/GEN, at least to Category 1;Category

2.3.18 Provide technical supervision and training for Laboratory and Field personnel up to and including Category 2;

2.3.19 Demonstrate advanced laboratory quality knowledge in accordance with ISO17025.

2.4 Lubrication Management and Analysis Category 3 (laboratory and Field Analyst)

PCN certificated Lubrication Management and Analysis Category 3 (Laboratory and Field Analyst) personnel are qualified to perform all competencies specified for Category 2

(Laboratory and Field) and additionally, to manage and implement lubricant condition monitoring programmes, and shall be able to:

2.4.1 Apply advanced lubricant analysis theory and techniques, including trending, interpretation, FMECA analysis and fault severity determination;

2.4.2 Design and manage calibration programmes;

2.4.3 establish lubricant analysis monitoring programmes, including determination of machines for periodic/continuous monitoring, frequency and type of testing, route plans, etc and quality assurance testing;

2.4.4 manage lubricant analysis information and associated software programmes, both in the field and laboratory;

2.4.5 determine the optimal inspection frequencies using probability density function, cost and risk criteria;

2.4.6 set up testing schedules and test slates when established standards do not exist, including design and set-up of special tests and interpretation of results;

2.4.7 determine the operating characteristics of machines and economic life cycles and recommend strategies for optimisation;

2.4.8 design and establish new techniques (both Field and Laboratory), interpret criteria standards and specifications;

2.4.9 prepare or approve procedures and work instructions for tests and calibration of all testing equipment;

2.4.10 perform generally recognised advanced testing techniques for lubricant analysis, and wear debris analysis, failure potential identification, lubricant and machine failure mechanism diagnosis and fault diagnosis;

2.4.11 manage an analysis programme;

2.4.12 classify, interpret and evaluate advanced test results and wear debris analysis, including acceptance tests) in accordance with appropriate specifications, standards or procedures;

2.4.13 perform advanced diagnosis of lubricant failure mechanisms and offer possible machine failure mechanisms that relate to those lubricant failure characteristics, if required;

2.4.14 establish acceptance and severity criteria, and lubricant monitoring programmes for acceptance, for new, in-service and faulty equipment, using periodic or continuous monitoring, defining the frequency and type of testing, route plans etc

2.4.15 establish programmes for the specification of targets, alarms and limits for machinery;

2.4.16 perform prognostics for fault conditions;

2.4.17 recommend all generally recognised types of corrective actions including statistical analysis and modification of machine systems and components;

2.4.18 evaluate the performance of 3rd party lubricant analysis services and recommend corrective changes as required;

2.4.19 assist in establishing new acceptance criteria;

2.4.20 interpret and evaluate test methods, Standards, Codes, specifications and procedures;

2.4.21 prepare reports based on advanced lubricant testing and wear debris analysis on lubricant and machine condition;

2.4.22 make major maintenance corrective action recommendations (normally intrusive) and report on the effectiveness of repairs or changes (if relevant);

2.4.23 report to management regarding programme objectives, budgets, cost justification, and personnel development;

2.4.24 review the lubricants in use and recommend changes to lubrication schedule for system performance enhancement;

2.4.25 direct the use of alternative CM technologies, with an understanding of the principles of other CM technologies specified in CM/GEN, at least to Category 1;

2.4.26 assess the influence of physical and chemical properties of lubricants on the stability of rotor bearings, turbine control systems, gear wear and hydrodynamic seal wear;

2.4.27 instruct and train Laboratory and Field personnel at Categories 1, 2 and 3 Category;

2.4.28 guide Laboratory and Field personnel below Category 3;

2.4.29 carry out, manage and supervise PCN CM qualification examinations on behalf of the British Institute of NDT, if so appointed;

2.4.30 understand and apply the principles of predictive and condition-based maintenance programmes;

2.4.31 perform internal laboratory audits in accordance with ISO 17025;

2.4.32 establish the laboratory certification programme and management documentation for the employer, where applicable.

2.5 Lubrication Management and Analysis Category 1 (Laboratory Analyst)

PCN certificated Lubrication Management and Analysis Category I (laboratory Analyst) personnel are qualified to perform simple tasks related to the proper handling and testing, in a laboratory setting, of machinery lubricant samples according to established and recognised procedures. Personnel classified as Category I (Laboratory Analyst) shall be able to:

2.5.1 properly and safely receive and handle lubricant samples;

2.5.2 ensure laboratory testing equipment is within calibration, as per specified procedures;

2.5.3 recognise sources of error;

2.5.4 be capable of preventing and controlling errors related to handling, testing and data;

2.5.5 perform testing using established procedures and standards, with an understanding of the common laboratory tests;

2.5.6 report results as determined by established criteria, identifying whether data obtained through the testing is reasonable;

2.5.7 inspect data from individual test methods only;

2.5.8 Demonstrate basic quality knowledge and laboratory good practice in accordance with ISO17025

2.6 Lubrication Management and Analysis Category 2 (Laboratory Analyst)

PCN certificated Lubrication Management and Analysis Category 2 (Laboratory Analyst) personnel are qualified to perform sample analysis and interpretation. Personnel classified as Category 2 (Laboratory Analyst) shall be able to:

2.6.1 set-up routine testing schedules and test slates (suite, programme);

2.6.2 verify calibration of laboratory instruments as per specified procedures;

2.6.3 recognise all forms of contamination and be able to undertake all associate test methods, recognise data which is a change from the norm;

2.6.4 diagnose lubricant failure mechanisms and modes;

2.6.5 perform wear particle testing and basic analysis;

2.6.6 manage and perform administrative tasks for lubricant analysis software and databases;

2.6.7 customise tests and perform sample analysis and interpretation;

2.6.8 report results;

2.6.9 demonstrate advanced quality knowledge in accordance with ISO 17025;

2.6.10 provide guidance, supervision and training to Category 1 and 2 Laboratory Analyst personnel;

2.6.11 recommend the use of alternative CM technologies, with an awareness of the principles of other CM technologies specified in CM/GEN, at least to Category 1.

2.7 Lubrication Management and Analysis Category 3 (Laboratory Analyst)

PCN Lubrication Management and Analysis Category 3 (Laboratory Analyst) personnel are qualified to perform and/or direct all types of lubricant analysis. Personnel classified as Category 3 (Laboratory Analyst) shall also be able to:

2.7.1 perform advanced testing, analysis and manage an analysis programme;

2.7.2 set-up testing schedules and test slates, including design and set-up of special tests and interpretation of results when established standards do not exist;

2.7.3 establish new techniques, interpret criteria, standards and specifications;

2.7.4 prepare or approve procedures and instructions, including for calibration of laboratory testing equipment;

2.7.5 interpret data and prepare reports for appropriate personnel, based on advanced lubricant testing and wear debris analysis, with an understanding of the main features of software used to report analysis results and their interpretation or diagnosis;

2.7.6 perform advanced diagnosis of lubricant failure mechanisms and offer possible machine failure mechanisms that relate to those lubricant failure characteristics;

2.7.7 perform internal audits in accordance with ISO 17025;

2.7.8 establish the laboratory certification programme and documentation for the employer;

2.7.9 direct the use of alternative CM technologies, with an understanding of the principles of other CM technologies specified in CM/GEN, at least to Category 1;

2.7.10 assist in establishing acceptance criteria when none are otherwise available;

2.7.11 provide guidance, supervision and training to Category 1, 2 and 3 Laboratory Analyst personnel.

2.8 Lubrication Management and Analysis Category 1 (Field Analyst)

PCN certificated Lubrication Management and Analysis Category 1 (Field Analyst) personnel are qualified to perform field lubricant analysis according to established and recognised procedures. Personnel classified as Category 1 (Field Analyst) shall be able to:

2.8.1 dispense lubricants, re-lubricate and/or inspect lubricants on a pre-programmed route, as appropriate in accordance with established procedures;

2.8.2 properly maintain lubrication devices and equipment;

2.8.3 install sampling hardware deemed appropriate, safe and non-intrusive*;

2.8.4 verify that analysis instruments are calibrated and report to the appropriate personnel where action is needed;

2.8.5 operate (and maintain) portable lubricant analysis instrumentation on pre- programmed routes;

2.8.6 download and upload raw test data from portable lubricant analysis instrumentation;

2.8.7 acquire lubricant samples from machine systems, equipment, and/or storage containers in accordance with established procedures; and

2.8.8 prepare samples for transport and/or testing in accordance with established procedures.

*A Category 2 or higher certificated person must deem whether sampling hardware is appropriate, safe and non-intrusive and any intrusive sampling hardware installation shall be undertaken by a suitably qualified person authorised by the customer or owner

2.9 Lubrication Management and Analysis Category 2 (Field Analyst)

PCN certificated Lubrication Management and Analysis Category 2 (Field Analyst) personnel are qualified to perform basic field lubricant testing and analysis according to established and recognised procedures. Personnel classified as Category 2 (Field Analyst) shall be able to:

2.9.1 set up instruments for basic on-site testing;

2.9.2 perform calibration checks on instruments used for on-site testing;

2.9.3 establish procedures for sample acquisition, preparation and transport;

2.9.4 select sample point locations, methods and hardware and oversee installation of sampling hardware;

2.9.5 manage and perform administrative tasks for lubricant analysis software and databases;

2.9.6 apply selected test methods for on-site testing and wear debris analysis;

2.9.7 liaise with parent and/or 3rd party laboratories;

2.9.8 classify, interpret and evaluate test results (including acceptance tests) in accordance with applicable specifications and standards;

2.9.9 employ lubricant analysis techniques to troubleshoot lubricant, machinery and components;

2.9.10 maintain a database of analysis schedules, results and diagnosis;

2.9.11 prepare reports for appropriate personnel on lubricant and machine condition, recommend corrective action (non-intrusive maintenance) and report on effectiveness of repairs/changes ;

2.9.12 recommend the use of alternative CM technologies, with an awareness of the principles of other CM technologies specified in CM/GEN, at least to Category 1;

2.9.13 provide guidance, supervision and training to Category I and 2 Field Analyst personnel.

2.10 Lubrication Management and Analysis Category 3 (Field Analyst)

PCN certificated Lubrication Management and Analysis Category 3 (Field Analyst) personnel are qualified to perform and/or direct all types of field lubricant testing and analysis. Personnel classified as Category 3 (Field Analyst) shall be able to:

2.10.1 interpret and evaluate test methods, standards, codes, specifications and procedures;

2.10.2 select the appropriate machinery lubricant analysis technique;

2.10.3 specify the appropriate instrumentation hardware and software for both portable and permanently installed systems;

2.10.4 design and manage calibration programmes;

2.10.5 establish lubricant monitoring programmes including determination of machines for periodic/continuous monitoring, frequency and type of testing, route plans, etc., and quality assurance testing;

2.10.6 establish programmes for the specification of targets, alarms and limits for machinery;

2.10.7 perform advanced on-site tests and wear debris analysis;

2.10.8 classify, interpret and evaluate advanced test results and wear debris analysis (including acceptance tests) in accordance with applicable specifications and standards;

2.10.9 perform Failure Mode, Effect and Criticality Analysis (FMECA);

2.10.10 perform prognostics for fault conditions;

2.10.11 evaluate the performance of outside lubricant analysis services and recommend necessary corrective changes;

2.10.12 prepare reports for appropriate personnel based on advanced lubricant testing and wear debris analysis on lubricant and machine condition;

2.10.13 make major maintenance corrective action recommendations (normally intrusive maintenance) and report on effectiveness of repairs/changes;

2.10.14 report to management regarding programme objectives, budgets, cost justification, and personnel development;

2.10.15 direct the use of alternative CM technologies, with an understanding of the principles of other CM technologies specified in CM/GEN, at least to Category 1;

2.10.16 based on the accrued data, review the lubricants currently in use and make recommendations, inclusive of required lubrication schedule, with a view to enhancing performance;

2.10.17 assess the influence of physical/chemical properties on stability of rotor in bearings, stability of turbine control systems, wear of gears and hydrodynamic seals;

2.10.18 provide guidance, supervision and training to Category 1, 2 and 3 Field Analyst personnel.

3. Eligibility for Qualification and Certification

3.1 Training

3.1.1 In addition to the training hours shown in Table 1, Category 2 candidates only should have completed formal or on-the-job training on machinery knowledge, covering machinery and components, of a similar duration to that in Table 1. This training should cover design, implementation, manufacture, installation, operation and maintenance principles of machines and lubrication systems and programmes, and include failure mechanisms and modes associated with each principle and the typical tribological aspects associated with each mechanism. Such training, if undertaken, shall be validated by verifiable records.

3.1.2 Training should be modularised to facilitate the three modules of 'general theory-common subjects', field and laboratory sectors, in order to allow for mutual recognition between non-destructive testing (if applicable) and CM assessment bodies.

3.1.3 The training declaration shall attest to the successful completion of a practical evaluation of the exercises at Category 1.

3.1.4 To qualify for both Field and laboratory the candidate must attend Modules A + B + C

3.1.5 Trainers and BINDT should satisfy themselves that applicants qualified from other assessing bodies either to ISO18436 part 4 or part 5, that the subject matter covered for their 'general theory-common subjects' is comparable to that required in this specification at Annex A2. If not, then the trainer should offer a 'catch-up' module for the subjects not covered in their existing qualification and add them as ancillary subjects to their 'declaration of conformity'.

3.1.6 To acquire certification the candidate must be successful at the general theory module A and either Module B or Module C of the practical applications modules. The times specified in Table 1 pertain to a basic qualification as a Laboratory Analysts (A+ B) or Field Analyst (A+C)

Table 1. Minimum Duration of training (hours)- includes General Theory module

Category 1 Field	Category 1 Lab	Category 2 Field	Category 2 Lab	Category 3 Field	Category 3 Lab
28	34	31	34	47	36
In accordance with Annex A1, a candidate attempting Field and Laboratory qualification must attend 42 hrs at Category 1, 55 hrs at Category 2 and 63 hrs at Category 3					

3.2 Experience

3.2.1 To be eligible to apply for certification the candidate shall provide evidence of experience (practical and theoretical) in the disciplines of machinery lubrication management condition monitoring appropriate to the Category sought. The minimum experience requirements are shown in Table 2.

3.2.2 Certification at Category 2 and Category 3 requires previous certification at the lower Categories.

3.2.3 Candidates must maintain a log of hours and nature of work on PCN documents CP16 for Categories 1 and 2 and CP17 for Category 3 and transferred to PSL30 when applying for certification.

Table 2. Minimum Cumulative Experience (sampling, testing, analysis) requirements (months)

Category 1 Field	Category 1 Lab	Category 2 Field	Category 2 Lab	Category 3 Field	Category 3 lab
12 months	12 months	24	24	36	36
	1200 hrs		2400		3600

Note 1: The months of experience are based on 16 hr minimum per month of lubricant analysis based machinery condition monitoring experience that can be accrued concurrently or separately, and based on a 160 hr/month work.
Note 2: The hours of experience denotes the actual testing and analysis experience accrued in a laboratory

Category4. Certification Available

4.1 Category 1 (Field Analyst)
4.2 Category 1 (Laboratory Analyst)
4.3 Category 1 (Field and Laboratory Analyst)
4.4 Category 2 (Field Analyst)
4.5 Category 2 (Laboratory Analyst)
4.6 Category 2 (Field and Laboratory Analyst)
4.7 Category 3 (Field Analyst)
4.8 Category 3 (Laboratory Analyst)
4.9 Category 3 (Field and Laboratory Analyst)

5. Qualification Examinations

5.1 Application for qualification examinations

5.1.1 Application for qualification examination is made on PCN form PSL/57-CM and supported by PSL/30-CM and PSL/33-CM where required.

5.2 Examination content (Theory and practical application parts)

5.2.1 For each certification Category, the candidates shall be required to answer multiple choice questions indicated in Table 3 for each module (general theory and practical applications). The candidate must attempt the general module–A and either module B or C, or both. Failure of any module attempted constitutes failure of examination, but if only one module is passed then it is credited and re-examination will require attempt at the failed module.

5.2.2 On each Category 3 paper there will be ten narrative questions offered, but only five needs to be answered.

5.2.3 At Category 3, each narrative question will be worth 5 marks.

5.2.4 The content of the examination paper shall:

5.2.4.1 contain multiple-choice question(s) for each subject in Annex A2

5.2.4.2 within reason, number in the same weighting as indicated by the percentage of time spent on each subject indicated in Annex A2

5.2.5 Questions will be of a practical nature and will test the candidate's knowledge and practical applications of the principles and procedures required to conduct machinery lubrication management testing and analysis.

5.2.6 Questions will include the interpretation of practical data, charts, plots and images. Simple mathematical calculations using a basic scientific calculator may be required.

TABLE 3 – Qualification examination content

Categories	Number of questions	Time (hours)*	Passing Grade (%)
Category 1 –Module A	40	1	70
Category 1 –Module B (Lab)	30	1	70
Category 1-Module C (Field)	30	1	70
Category 2-Module A	50	1.5	70
Category 2-Module B (Lab)	50	1.5	70
Category 2- Module C (Field)	50	1.5	70
Category 3-Module A	45 (10 narrative- answer 5)	1.5	70
Category 3-Module B (Lab)	45 (10 narrative- answer 5)	1.5	70
Category 3 -Module C (Field)	45 (10 narrative- answer 5)	1.5	70

Annex A1 – Training syllabus (normative)

Module A- General Theory & common subjects (normative)

	Hours of training (hr)		
Subject	**Category 1**	**Category 2**	**Category 3**
1. Lubrication theory and fundamentals	4	1	6
2. Lubricant roles, functions and failure modes	0	2	7
3. Lubrication selection	2	0	0
4. Principles of lubricant application	4	0	0
5. Lubricant storage and management	2	0	0
6. Oil sampling	2	4	0
7. Lubricant contamination measurement and control	2	3	0
8. Wear debris monitoring and analysis	1	4	11
9. Alternate Technologies: Vibration Analysis, Infrared Thermography, Acoustic Emission	0	1	3
10. Training examination	1	1	1
11. Training practical skills evaluation	2		
Total hours for each Category	**20**	**16**	**28**

Module B- Laboratory Analyst (normative)

	Hours of training (hr)		
Subject	**Category 1**	**Category 2**	**Category 3**
1. Sample handling and preparation	2	0	0
2. Lubricant health monitoring	5	5	0
3. Reagent management	2	0	0
4. Instrument calibration	2	0	0
5. Testing for wrong or mixed lubricants	0	1	0
6. Contamination (water, glycol, soot, fuel, air, particle)	0	8	0
7. Data interpretation	0	2	2
8. Quality control	0	1	2
9. Sensorial inspections	0	0	1
10. Environmental effects on results	0	0	1
11. Personnel training	0	0	1
12. Training examination	1	1	1
13. Practical examination/evaluation	2		
Total hours for each Category	**14**	**18**	**8**

Module C- Field Analyst (normative)

	Hours of training (hr)		
Subject	**Category 1**	**Category 2**	**Category 3**
1. Maintenance strategies, philosophies (CBM, RCM) and basic Reliability methodologies	2.5	5	0
2. Lubricant health monitoring, diagnostics and general maintenance recommendations	2.5	5	5
3. Lubricant health monitoring prognostics	0	0	3
4. Lubricant CM analysis programme design, implementation and management	0	0	6
5. Corrective Action (Breakdown, Scheduled)	0	4	4
6. Training examination	1	1	1
7. Practical examination/evaluation	2		
Total hours for each Category	**8**	**15**	**19**

Annex A2 - Detailed list of topics and hours of Instruction

Module A- General Theory and common subjects (normative)

		Hours of Training		
Subject	**Topic**	**Category 1**	**Category 2**	**Category 3**
1. Lubrication Theory and fundamentals		**4**	**1**	**6**
	1. Fundamentals of tribology	*		
	2. Functions of a lubricant	*	*	
	3. Lubrication regimes (Hydrodynamic, Elasto-hydrodyanamic and Boundary)	*	*	*
	4. Base oils			
	a. Functions and properties (physical and chemical)	*	*	*
	b. Characteristics, advantage and disadvantages	*	*	*
	5. Additive functions			
	a. Antioxidants/oxidation inhibitors, rust/corrosion inhibitors, demulsifying agents			*
	b. Viscosity index (VI) improvers	*	*	*
	c. detergents	*	*	*
	d. pour-point depressants, foam inhibitors, anti-wear agents, extreme pressure agents			*
	6. Oil lubricant physical, chemical and performance properties and classifications	*		
	a. Grease lubrication, how grease is made, thickener types	*		
	7. Grease lubricant physical, chemical and performance properties and classifications	*		
	8. Solid lubrication			
	a. Mechanisms, types	*		
	b. Pressure-velocity factor	*		
	c. Specific-wear rate	*		
	9. Gas lubrication	*		
	a. Advantages of gas lubricated bearings	*		
	b. Properties of lubricating gases	*		
	10. Classification systems	*		

2. Lubricant roles, functions and failure modes		**0**	**2**	**7**
	1. Base oil –functions and properties		*	*
	2. Additive types and functions		*	*
	3. Synthetic lubricants – types and use		*	*
	4. Identifying additive discrepancies			*
	5. Lubricant failure modes		*	*
3. Lubrication selection		**2**	**0**	**0**
	1. Advantages/disadvantages of oil, grease, solid, gas	*		
	2. Viscosity, base-oil type, additive system and grease thickener selections	*		
	3. Machine-specific lubricant requirements	*		
	4. Application and environment related adjustments	*		
4. Principles of lubrication application		**4**	**0**	**0**
	1. Manual delivery techniques	*		
	2. Automatic delivery systems (distributed, automated lubricators)	*		
	3. Maintenance of automated lubrication systems	*		
5. Lubricant storage and management		**2**	**0**	**0**
	1. Lubricant receiving procedures	*		
	2. Proper storage and inventory management of lubricants, grease-guns and other lube application devices	*		
	3. Lubricant storage containers	*		
	4. Maintenance of automated grease systems	*		
	5. Health and safety assurance	*		
6. Oil sampling		**2**	**4**	**0**
	1. Objectives for lube sampling	*	*	
	2. Equipment specific sampling (e.g. gearboxes with circulating systems)		*	
	3. Sampling methods	*	*	
	4. Managing interference	*	*	
	5. Sampling process management (frequency, procedures, processing, sampling point selection)	*	*	

7. Lubricant contamination measurement and control		**2**	**3**	**0**
	1. Particle, moisture, glycol, soot, fuel, air contamination: a. Effects on the machine b. Effects on the lubricant c. Methods and units for measure contaminant d. Techniques for controlling contaminant e. Demulsibility measurement f. States of coexistence		*	
	2. Filtration and separation technologies	*		
	3. Filter rating	*		
	4. Filtration system design and filter selection	*		
8. Wear debris monitoring and analysis		**1**	**4**	**11**
	1. Common machine wear mechanisms		*	*
	a. introduction	*		
	b. Abrasive wear (2-body & 3-body)		*	*
	c. Surface fatigue (2-body & 3-body)		*	*
	d. Adhesive, corrosive and cavitation wear		*	*
	e. Fretting, erosive & electrical wear			*
	2. Common machine-specific wear modes			*
	3. Wear particle types, origins and probable causes	*		*
	4. Wear debris analysis techniques		*	*
	5. Atomic emission elemental spectroscopy (AES)			
	a. ICP		*	
	b. Arc-spark emission		*	
	c. Density measurement		*	
	d. Advanced techniques (XRF, microwave digestion, rotrode filter spectroscopy)			*
	e. Evaluating lock-step and sequential trends			*
	f. Particle size limitations of common AES			*
	g. Determination of particle metallurgy			*
	6. Size distribution of particles		*	

9. Alternate Technologies		**0**	**1**	**3**
	1. Awareness of VA, IRT, AE		*	
	2. Understanding of VA, IRT, AE			*
10. Training examination		**1**	**1**	**1**
11. Training practical skills evaluation		**2**		
Total hours for each Category		**20**	**16**	**28**

Module B- Laboratory Analyst (normative)

		Hours of Training		
Subject	**Topic**	**Category 1**	**Category 2**	**Category 3**
1. Sample handling and preparation		**2**	**0**	**0**
	1. Sample cleanliness (dilution, cross contamination)	*		
	2. Contaminant re-suspension (bottle Ullage, sample agitation)	*		
2. Lubricant health monitoring		**5**	**5**	**0**
	1. Viscosity	*	*	
	2. Viscosity index	*	*	
	3. AN	*	*	
	4. BN	*	*	
	5. FTIR	*	*	
	6. AES	*	*	
	7. TGA	*	*	
	8. Flash Point	*	*	
	9. Schiff's Reagent	*	*	
	10. Crackle Test	*	*	
	11. Co-distillation	*	*	
	12. Karl Fischer titration	*	*	
	13. Cyclic Voltammetry	*	*	
	14. Insoluble's	*	*	
	15. Rotating Pressure vessel Oxidation Test		*	
	16. Air release Characteristics		*	
	17. Foam stability characteristics		*	

	18. Gas Chromatography	*	*	
	19. Water demusibility		*	
	20. Data correlation		*	
	21. Exception testing		*	
3. Reagent Management		**2**	**0**	**0**
	1. Equipment and glassware (cleaning and preparation)	*		
	2. Chemicals (preparation, labeling, storage, safety, disposal, MSDS)	*		
4. Instrument Calibration		**2**	**0**	**0**
	1. Reference materials (primary and secondary standards)	*		
	2. Record keeping (routine control charts)	*		
5. Testing for wrong or mixed lubricants		**0**	**1**	**0**
	1. Kinematic viscosity		*	
	2. FTIR		*	
	3. AES		*	
6. Contamination		**0**	**8**	**0**
	1. Water contamination		*	
	2. Glycol contamination		*	
	3. Soot contamination		*	
	4. Fuel contamination		*	
	5. Air contamination		*	
	6. Particle contamination		*	
7. Data Interpretation (limits, targets and trending)		**0**	**2**	**2**
	1. Understanding Statistical limits (wear debris)		*	
	2. Understanding Ageing limits (AN, viscosity)		*	
	3. Understanding Targets (water, ISO, cleanliness)		*	
	4. Establishing goal based limits			*

	5. Establishing limits (Statistical, aging)			*
	6. Graphical trend analysis a. Rate of change analysis b. Data normalisation c. Reference/baseline data comparison d. Effects of make-up oil e. Lock-step trending		* * *	* * *
8. Quality Control		**0**	**1**	**2**
	1. Procedure writing		*	
	2. Record management (generation and storage)			*
	3. Quality control samples (types and control charts)			*
	4. Procedures editing			*
	5. Audits (internal & external)			*
9. Sensorial inspection		**0**	**0**	**1**
	1. Detecting water contamination and particle presence [sight]			*
	2. Detecting Paramagnetic particles (magnetic bar)			*
	3. Irregular odours			*
10. Environmental effects on results		**0**	**0**	**1**
11. Personnel training (internal, ISO17025 compliance)		**0**	**0**	**1**
	1. Scope of training			*
	2. Certification and re-certification requirements			*

	3. Job qualification			*
12. Training examination		**1**	**1**	**1**
13. Training practical skills evaluation		**2**		
Total hours for each Category		**14**	**18**	**8**

Module C - Field Analyst (normative)

		Hours of Training		
Subject	**Topic**	**Category 1**	**Category 2**	**Category 3**
1. Maintenance strategies, philosophies (CBM, RCM) and basic reliability methodologies		**2.5**	**5**	**0**
	1. Why machines fail	*		
	2. Impact of poor maintenance (efficiency, profits)	*		
	3. Avoiding failure (effective lubrication)	*		
	4. Fundamentals/basics of Reliability-centred Maintenance (RCM)		*	
	5. Fundamentals/basics of Condition-based Maintenance		*	
	6. Fundamentals/basics of Predictive maintenance strategies		*	
	7. Fundamentals/basics of Proactive maintenance strategies		*	
	8. Lube routes and scheduling	*		
	9. Lubricant analysis and technologies to assure lubrication effectiveness	*		
	10. Equipment tagging	*		

2. Lubricant health monitoring, diagnostics and general maintenance recommendations		**2.5**	**5**	**5**
	1. Lubricant failure mechanisms a. Oxidative degradation b. Thermal degradation c. Additive depletion d. Additive degradation e. Wrong or mixed lubricants f. Fluid properties test methods	* all	* all	* all
3. Lubricant health monitoring prognostics		**0**	**0**	**3**
	1. Prognostics (ISO 13381-1)			*
4. Lubricant CM analysis programme design, implementation and management		0	0	6
	1. design			*
	2. machine-specific test slate selection			*
	3. Optimising frequency of analysis			*
	4. Setting alarms and limits a. Goal-based limits for contamination b. Statistical limits c. Rate of change limits d. Setting aging limits e. Trend analysis			*
	5. Managing lubricant analysis information			*
	6. Creating and managing lubricant analysis procedures			*
	7. Reviewing reliability of technicians, trades persons and management			*
	8. Cost-benefit analysis and contamination control programmes			*
	9. Quality assurance (on-site, off-site analysis)			*
5. Corrective Action		**0**	**4**	**4**
	1. Breakdown		*	*
	2. Scheduled		*	*

6. Training examination		**1**	**1**	**1**
7. Training practical evaluation		**2**		
Total hours for each Category		**8**	**15**	**19**

Annex B – Reading references (normative)

Table B1. Essential reading (material from which examination questions can be developed)

Category	Title	Author(s)	Publisher	ISBN
1, 2, 3	The Wear Debris Analysis Handbook	B. J. Roylance and T. M. Hunt, 1999.	Coxmoor	1901892026
1, 2, 3	Oil Analysis Basics 2nd edition	D Troyer and J. Fitch..	Noria Publishing. USA	0967596416
1, 2, 3	Machinery Oil Analysis 3rd edition	Larry A Toms, 2008		0-9664604-0-5
1, 2, 3	The Tribology Handbook 1996	M. J. Neale, 2nd edition.	Butterworth-Heinemann	0750611987
1,2,3	Oil Analysis	Evans and Hunt 2008	Coxmoor	1901892050

Standards and specifications

(material from which examination questions can be developed) (normative). The most current standard applies.

1. ASTM D 6224 Standard practice for In-Service Monitoring of Lubricating Oil for Auxiliary Power Plant Equipment, (2002).
2. ASTM D 4378 Standard practice of In-Service Monitoring of Mineral Turbine Oils for Steam and gas Turbines.
3. ISO 13379, Condition monitoring and diagnostics of machines- Data interpretation and diagnostic techniques.- General guidelines
4. ISO 13372, Condition monitoring and diagnostics of machines- vocabulary
5. ISO 13374. Part 1. Condition monitoring and diagnostics of machines- Data processing, communication and presentation, Part 1: General guidelines
6. ISO 17359, Condition monitoring and diagnostics of machines- general guidelines
7. SAE J300, Surface Vehicle standard- engine oil viscosity classification.
8. CMGEN, General requirements for qualification and certification of condition monitoring and diagnostic personnel
9. ISO 13381-1, Condition monitoring and diagnostic of machines; prognostics: Part 1 general Guidelines
10. ISO 18436-1, Condition monitoring and diagnostics of machines; requirements for qualification and assessment of personnel Part 1, Requirements for certifying bodies and the certification process
11. ISO/IEC 17024, Conformity assessment- general requirements for bodies operating certification of persons
12. ISO 4406, Hydraulic Fluid Power. Fluids. Method for coding the Category of contamination by solid particles
13. SAE J310, Automotive lubricating greases: recommended practice

14. ISO 11500, Hydraulic fluid power. Determination of particulate contamination by automatic counting using the light extinction principle.

15. ISO 11171, Hydraulic fluid power. Calibration of automatic particle counters for liquids.

16. ISO 18436-4, Condition monitoring and diagnostics of machines; requirements for qualification and assessment of personnel- Part 4: Industrial lubricant analysis.

17. ISO 18436-5, Condition monitoring and diagnostics of machines; requirements for qualification and assessment of personnel- Part 5: Laboratory lubricant analysis

18. ISO 14830, Condition monitoring and diagnostics of machines- Tribology Based Monitoring- Part 1: General Guidelines.

19. ISO 17025, General requirements for the competence of testing and calibration laboratories

20. BS 5760-5. Reliability of systems, equipment and components: Guide to failure modes, effects and criticality analysis (FMEA and FMECA) ISBN 0580 196607

21. BS 5760-7(IEC 61025: 1990). Reliability of systems, equipment and components. Fault tree analysis. ISBN 0580 203387

Table B2 Recommended reading (material which contains helpful information on a related subject) (informative)

Category	Title	Author(s)	Publisher	ISBN
2, 3	Infrared Thermography- Theory & Practice	N Walker	BINDT	0903132338
2,3	Acoustic emission and ultrasonics	T Holroyd	Coxmoor	1901892077
1, 2, 3	Practical lubrication for industrial facilities	H Bloch, 2000	Marcel Dekker, NY	
1, 2, 3	Quality in the analytical chemistry laboratory	E Prichard, 1995	John Wiley & Sons, UK	
1, 2, 3	Handbook of hydraulic fluid technology	G Totten, 2000	Marcel Dekker, NY	
2, 3	High temperature lubrication	A Landsdown, 1994	Mechanical Engineering Publications, UK	
1, 2, 3	Machinery Malfunction Diagnosis and Correction	Sr R. C. Eisenmann, 1998	Prentice Hall	013240946-1
1, 2, 3	Machinery Analysis and Monitoring	J. S. Mitchell, 1993	PenWell Publishing Co	087814401-3
1, 2, 3	Handbook of condition monitoring- techniques and methodology.	A Davies 1998	Chapman & Hall	0412613204
1, 2	Lubricating Grease Guide	The National Lubricating Grease Institute, 1996	NLGI, USA	
2,3	Reliability centred Maintenance	John Moubray	Elsevier	075063358
2,3	Vibration Monitoring and Analysis Handbook	Simon R Mills	BINDT	9780903132397

Annex C- Sub-topics related to Annex A2 (informative)Category

Citation of ASTM methods is not exclusive, as any equivalent EN, BS, ISO or other national standard may be used, including references listed in Annex B

Table C1.

Classification systems	Viscosity (ISO/SAE), Grease consistency (NLGI), Engine (API/ILSAC), API automotive gear oil classification, ATF classifications, Automotive brake fluid classifications, AGMA gear classifications, AGMA gear coupling classifications, Turbine oil classifications (BSI, DIN, GE, ABB), hydraulic fluids (ISO, Factory Mutual fire resistance grading system, ASTM, various components/system OEM performance specifications, USDA/FSIS and NSF food-grade lubricant classification
Additive types and functions	Surface active additives and their functions, bulk oil additives and their functions
Machine-specific lubricant requirements	Hydraulic systems, plain bearings, rolling element bearings, journal bearings, reciprocating engines, gearing and gearboxes, ropes, chains, steam turbines, gas turbines, internal combustion engines, compressors, transmissions, pumps, filtration
Sampling methods	Pressurised systems (low and high), non-pressurised systems
Managing interference	Bottle cleanliness and management, flushing, machine conditions appropriate for sampling
Common machine-specific wear modes	Gearing, plain bearings, rolling element bearings, hydraulics
Wear particle types, origins and probable causes	Cutting wear particles, spherical particles, chunky particles, laminar particles, red oxide particles, black oxide particles, corrosion particles, non-ferrous particles, friction polymer particles
Wear debris analysis techniques	Ferrogram preparation, filtergram preparation, light effects, magnetism effects, heat treatment, chemical treatment, morphology, surface detail
Lubricant health monitoring	Kinetic viscosity (ASTM D445), Absolute Viscosity (ASTM D2893), Viscosity Index (ASTM D2270), TAN (ASTM D974, D664), TBN (ASTM D974, D2896, D664, D4739), FTIR (ASTM E169, D7418), AES (ASTM D5185, D6595, D6495), Flash Point (ASTM D92, D93, D3828), TGA (ASTM D5967-A4), Schiff's Reagent (ASTM D2982), Crackle Test, Co-distillation (ASTM D95), Karl Fischer titration (ASTM D6304), Cyclic Voltammetry (ASTM 6971), Insolubles (ASTM D893), Rotating Pressure vessel Oxidation Test (ASTM D2272), Air release characteristics (ASTM D 3427), Foam Stability characteristics (ASTM D892), Gas Chromatography (ASTM D3524, D3525), Water demulsibility (ASTM D1401, D2711)
Water contamination	Scope and significance of commonly accepted water-oil analysis test methods (ASTM D1401, D2711), causes of poor water demulsibility, states of co-existence of water in oil; methods for assessing water contamination (Crackle test, FTIR, Co-distillation, Karl Fischer titration); effects of water contamination on the lubricant and the machine
Glycol contamination	Scope and significance of commonly accepted oil-glycol analysis test methods; methods for assessing (AES, FTIR, Schiff's reagent, GC), effects on lubricant and the machine
Soot contamination	Scope and significance of commonly accepted soot-oil analysis test methods; methods for assessing (TGA, FTIR,

	pentane Insolubles (ASTM D893), Blotter test); effects of soot on the lubricant and the machine
Fuel contamination	Scope and significance of commonly accepted fuel-oil analysis test methods; methods of assessing (Kinematic viscosity, FTIR, Flash Point Test, GC); effects of fuel on the lubricant and the machine
Air contamination	Scope and significance of commonly accepted air-oil analysis test methods: methods of assessing (Air release characteristics, Foam stability), states of co-existence of air in oil, effects of air on the lubricant and the machine
Particle contamination	Scope and significance of commonly accepted particle-oil analysis test methods; methods of assessing (ISO solid contamination code (ISO4406), Optical particle counter (ISO11500, ISO 11171), Pore blockage particle counting); effects of particles on lubricant and the machine
Lubricant failure mechanisms	Oxidative degradation (the process, causes and effects, at risk lubricants and applications, strategies for deterring it, strengths, limitations and applicability of tests used to detect and troubleshoot oxidation such as AN, viscosity, FTIR, RPVOT, sensory inspection); thermal degradation (the process, causes and effects, strengths, limitations and applicability of tests used to detect and troubleshoot thermal failure such as AN, viscosity, FTIR, thermal stability test, ultracentrifuge detection of carbon insoluble's, sensory inspection); additive depletion/degradation- mechanisms, additives at risk, risk assessment for common mechanisms (neutralization, shear down, hydrolysis, oxidation, thermal degradation, water washing, particle scrubbing, surface adsorption, rubbing contact, condensation settling, filtration, aggregate adsorption, evaporation, centrifugations); strengths, limitations and applicability of methods for measuring –such as AES, FTIR, AN, BN, VI, RPVOT, Blotter spot test); testing for wrong or mixed lubricants (base-lining physical and chemical properties tests, additive discrepancies); fluid properties test methods and measurement units- viscosity (kinematic, absolute and VI), AN/BN, AES, FTIR, RPVOT

Table C2.

Additional guidance to sub-topics that should ideally be covered (informative)

Categories**Topic**	**Sub-topics**
Condition Monitoring (oil analysis programme design, implementation and management)	
1. Equipment audit and Prioritisation	Baselines, limits and objectives; equipment knowledge;
2. Alarms; Categories & status	Goal-based targets; establishing limits; setting alarms and limits;
3. Baseline Assessments, Trending	Trend interpretation;
4. Route Planning	Test parameters; methodology applications; optimizing frequency of analysis;
5. Alternate Technologies: Vibration Analysis, Infrared Thermography, Acoustic Emission	IRT, VA and AE basic principles; NDT methodologies;
6. Procedure writing	Not applicable at Category 2
Generic Equipment Knowledge	
1. Engines	Fault analysis; components; reciprocating engines;
2. Transmissions	Primary function; components;
3. Turbines & Compressors	Primary function; components;
4. Gear reduction Systems	Gear types; lubrication choice and applications; components; gearing and gearboxes;
5. Hydraulic Systems	System categorisation; components; contamination;
6. Pumps	Hydraulics; pump types and applications; components;
7. Bearings	Operation; components; lubrication choice and properties; rolling element bearings; journal bearings;
8. Filtration	Components; applications and system specifications; wear debris analysis; de-aeration; filtration and separation technologies; filter rating; filtration system design and filter selection;
Inspection Optimisation	
1. Time-base policies	
2. Data collection	Understanding statistical limits (wear debris), ageing limits, targets, goal-based limits
3. Bathtub Hazard Rate Curve	Trend analysis; graphical representation;
4. Potential failure (P-F) Curve	