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

CONTENTS

Introduction

The use of Infrared Thermography (IRT) using measurements of surface temperature to monitor condition and diagnose faults in civil, mechanical and electrical systems has become a key activity in predictive maintenance programmes for most industries. The effectiveness of these programmes depends on the capabilities of individuals who perform the measurements and analyse the data. This document is appended to CM/GEN (General requirements for the qualification and PCN certification of condition monitoring personnel). Other Appendices cover:

Appendix A	Acoustic Emission
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 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.

Definitions

Civil: The term ‘Civil’ when used in this document includes buildings, structures, roads and bridges.

Mechanical: The term ‘Mechanical’ when used in this document includes mechanical systems and associated processes.

Electrical: The term ‘Electrical’ when used in this document includes low and high voltage electrical systems, but does not include electronic systems.

Supplementary examination: The term supplementary examination when used in this document refers to an additional sector-specific examination available at Categories 2 and 3 only, and attempted either during, or after the first examination that consists of the general part and at least one other sector-specific part.

1. Scope

1.1. This appendix to PCN CM/GEN sets out the specific requirements for qualification and assessment of personnel engaged in Infrared Thermography 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 part 7: Condition monitoring and diagnostics of machines- Requirements for qualification and assessment of personnel- Thermography.

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

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 thermographic analysis and thermal condition monitoring for their classification 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.

2.1.3. Those personnel seeking to be classified as Category 2 or Category 3 can elect to qualify in any or all of three industry sectors, as specified at clause 5.

2.2. Infrared Thermography Category 1 (General)

PCN certificated Infrared Thermography Category 1 personnel are qualified to perform industrial infrared thermography measurements according to established and recognised procedures and shall be able to:

2.2.1. apply a specified thermographic measurement technique;

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

2.2.3. perform basic infrared thermography of plant and machinery, buildings and electrical systems;

2.2.4. verify the calibration of the measurement systems and the integrity of collected data

2.2.5. prevent, minimise or control poor data (sources of data error);

2.2.6. maintain a data base of results and trends;

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

2.2.8. perform basic image post processing (measurement tools, emissivity adjustment, span and scale adjustment etc.);

2.2.9. verify the calibration of thermographic measurement systems;

2.2.10. evaluate and report test results in accordance with established instructions and highlight areas of concern.

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

2.3. Infrared Thermography Category 2.

Individuals certificated as Infrared Thermography Category 2 are qualified to perform and/or direct infrared thermography analysis according to established and recognised procedures. Category 2 personnel shall be able to:

2.3.1. select the appropriate infrared thermography technique and understand its limitations;

2.3.2. specify the appropriate hardware and software for both portable and permanently installed systems;

2.3.3. measure and analyse thermographic data;

2.3.4. perform advanced image post processing (trending, montage, image subtraction, statistical analysis etc.) and diagnosis;

2.3.5. apply thermography theory and techniques, including measurement and interpretation of survey results;

2.3.6. recommend appropriate corrective actions;

2.3.7. prepare reports on condition, recommend corrective action and report on effectiveness of repairs;

2.3.8. provide technical direction for personnel at or below Category 2;

2.3.9. supervise and instruct all Category 1 duties;

2.3.10. establish infrared thermography programmes including determination of the requirement for periodic /continuous monitoring, frequency of testing, etc.;

2.3.11. establish acceptance and severity criteria;

2.3.12. establish programmes for acceptance for new and in-service systems;

2.3.13. recommend the use of alternative CM technologies with an awareness of the principles of other CM technologies specified in CM/GEN.

2.4. Infrared Thermography Category 3

Individuals certificated as Infrared Thermography Category 3 are qualified to perform and/or direct all types of infrared thermography measurements and analysis and shall be able to:

2.4.1. determine the thermographic signature of systems, components and assemblies (sector specific, where applicable);

2.4.2. establish infrared thermography programmes including determination of the requirement for periodic /continuous monitoring, frequency of testing, etc.;

2.4.3. establish acceptance and severity criteria;

2.4.4. establish programmes for acceptance for new and in-service systems;

2.4.5. understand and perform data analysis;

2.4.6. use advanced techniques of infrared thermography and fault diagnosis;

2.4.7. recommend appropriate types of thermodynamic (radiation, convection, conduction based) corrective actions;

2.4.8. supervise trainees and Category 1 and 2 personnel;

2.4.9. guide personnel below Category 3;

2.4.10. interpret and evaluate Standards, Codes, specifications and procedures;

2.4.11. perform prognostics for fault conditions;

2.4.12. prepare reports on machine civil and electrical systems condition, recommended appropriate corrective actions and effectiveness of repairs;

2.4.13. direct the use of alternative CM technologies with an understanding of the principles of other CM technologies specified in CM/GEN.

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

3. Eligibility for Examination and Certification

3.1. General

Candidates shall have a combination of education, training and experience to ensure that they understand the principles and procedures applicable to thermographic measurement and analysis. Colour vision requirement in this scheme is specified in the following delta.

ISO 18436-7 recommends that candidates have colour perception tested to the criteria of the Ishihara test, where it may be required of employers to determine whether failure to meet the requirements of this test will affect the candidate's ability to perform analysis on IRT data using colour palettes. Failure to pass the Ishihara test may require the candidate to use a monochrome palette. This task-specific test, and any requirement to use a monochrome palette, is to be documented and the record of the test made available to the certifying body upon request. The PCN scheme will not enforce this recommendation as (1) recording of the candidates failure of the Ishihara test and limiting their work to monochrome palettes could potentially limit his/her employment and yet he/she may be capable of interpreting colour images if the degree of colour blindness is not severe, (2) the pass/fail criteria of the Ishihara test is not necessarily indicative of a person's ability to interpret colour differences on a thermogram.

3.2. Training

3.2.1 At Category 1 the written examination shall contain practical application questions that cover quality data acquisition, the recognition, prevention and control of error sources and basic fault diagnosis. At Category 2 it will cover diagnostics and image interpretation for condition monitoring of machines, electrical or civil systems and image interpretation. At Category 3 it will include all topics for Categories 1 and 2 and include solution design and verification.

3.2.2 The image interpretation questions should be based on case histories requiring fault identification, solution recommendation and a solution verification process.

TABLE 1. Minimum Cumulative Duration of Training (hours)		
Category 1	Category 2	Category 3
33	65	97

3.2.3 Training may be modularised into two or more subject areas covering general scientific principles and application-specific knowledge in order to allow for mutual recognition between non-destructive testing (e.g.: ISO9712, SNT-TC-1A) and other condition monitoring assessment bodies (2nd or 3rd party).

3.2.4 In addition to the training hours in Table 1 and formal education specified in CM/GEN, Category 2 candidates only, should have completed formal or on-the-job training on mechanical, electrical or civil engineering, with either a training examination certificate or verifiable records (PSL30-CM), including the relevant systems and components, of at least a similar duration to that in Table 1, which covers the sector specific certification sought. This training should cover design, manufacture, installation, operation and maintenance principles relevant to the sector (civil, mechanical or electrical systems), and include failure mechanisms associated with each principle and the typical thermodynamic signatures associated with each mechanism.

3.3. Experience

3.3.1. To be eligible to apply for certification the candidate shall provide evidence of experience in the field of machinery, electrical or civil infrared thermography condition monitoring, appropriate to the Category and sector sought. The minimum experience requirements are shown in Table 2.

3.3.2. Certification at category 3 requires previous certification at the lower categories.

3.3.3. Candidates must maintain verifiable documentary evidence and log of hours and nature of work (see ISO18436-7 clause 5.4), especially scanning (practical) times, on PCN document CP16-CM for all categories.

TABLE 2. Minimum Cumulative Experience Requirements (months)		
Category 1	Category 2	Category 3
12*	24*	48*

*The experience hours are based on 16 hours minimum per month of thermography-based machinery condition monitoring experience in accordance with Clauses 2 & 3.

4. Certification Available

4.1 Category 1 (IRT-General)

4.2 Category 2 (IRT- Civil, IRT-Mechanical, IRT-Electrical)

4.3 Category 3 (IRT- Civil, IRT-Mechanical, IRT-Electrical)

Category 2 and 3 candidates may attempt any or all modules in one sitting.

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 with PSL/30-CM and PSL/33-CM where required.

5.2 Initial examination

5.2.1 Category 1 candidates are required to be successful in a multiple choice examination paper covering the basic principles and practical knowledge of the CM technology in terms of civil, mechanical and electrical engineering and basic thermography theory. The examination will also test for quality data acquisition and error source recognition, prevention and control.

5.2.2 Category 2 and 3 candidates for Infrared Thermography are required to be successful in a multiple choice examination comprising at least two modules covering:

5.2.2.1 the basic principles and practical knowledge of Infrared Thermography;

5.2.2.2 at least one practical applications module paper on the specific application of Infrared Thermography in the civil, mechanical or electrical engineering sector, as selected by the candidate. At Category 2 the practical applications sector paper will cover diagnostics and image interpretation. At Category 3 the sector paper will cover diagnostics, prognostics, image interpretation, solution design and solution verification. The practical sector specific module pertains to subjects 6, 7 or 8 in Annex A2, but must also include material derived from subjects 9, 10, 11, 12 and 13 for the respective sector.

5.2.2.3 the basic principles of alternative condition monitoring technologies as defined in Table A2.

5.2.2.4 Category 3 examination papers have a narrative component (see below).

5.3 Supplementary practical applications examination

5.3.1 Supplementary modular practical examinations are only available to existing PCN Infrared Thermography Category 2 or 3 certificate holders. This examination comprises separate supplementary modules covering civil, mechanical or electrical engineering, as selected by the candidate.

5.3.2 Supplementary examination modules will be graded separately, so that a candidate electing to attempt two modules at the same examination sitting may be awarded certification for a module in which success was achieved, even if the other module was failed.

5.3.3 Supplementary examination candidates must have satisfactorily completed a course of training covering the syllabus to be examined, and provide documentary evidence of the training.

5.4 Examination content (Theory and practical knowledge)

5.4.1 For each certification category, the candidates shall be required to answer the fixed number of multiple choice questions in the two-part written paper, within specified time duration as indicated in Table 3. Part A covers general theory and Part B is the sector specific practical application module paper. At Category 3, 10% of each part of the examination paper will consist of narrative questions. In a 30 question paper module four narrative questions will be offered but only three need to be answered.

5.4.2 Each narrative question will be worth 5 points.

5.4.3 The examination will cover the training syllabus at Annex A2.

5.4.4 Questions will test the candidate's knowledge of the principles and procedures required to conduct infrared thermography condition testing and analysis in the sector (machinery, electrical or civil) that the examination pertains.

5.4.5 Questions are of a practical nature and include the interpretation of practical data and thermal images and simple mathematical calculations using a basic scientific calculator may be required.

5.4.6 The Category 1 examination paper will comprise 60 questions covering the general topics listed in Annex A2. The Category 2 and 3 examination papers will comprise general (30 questions) and practical application specific (30 questions) parts. Modules will be graded separately. Examinations for additional sector specific modules will comprise 30 questions per module, as noted in Table 3.

Table 3 – qualification examination content

Categories	Number of Questions	Time (Hours)*	Passing Grade %
Category 1	60	2.0	75
Category 2 (General + 1st sector module)	60 (30 + 30)	2.0	75
Category 2 (Supplementary module)	30	1.0	75
Category 3 (General + 1st sector module)	60 (30 + 30)	3.0	75
Category 3 (Supplementary module)	30	1.0	75

*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.

Annex A1 Training Syllabus

	Hours of training		
Subject	Category 1	Category 2 [Only 1 module from subjects 6]	Category 3 [Only 1 module from subjects 6]
0. Introduction	0.5	-	-
1. Principles of IRT	6	7	6
2. Equipment and data acquisition	5	3	1
3. Image Processing	6	2	1
4. General Applications	4.5	0	0
5. Diagnostics and prognostics	1	2	2
6. Condition monitoring applications	4	10.5	7
a) Electrical applications			
b) Mechanical applications			
c) Civil applications			
7. Corrective actions	-	3	6
8. Reporting and documentation (ISO standards)	1	0.5	0.5
9. Condition monitoring programme design	0.5	0.5	3.5
10. Condition monitoring programme implementation	1	1	1
11. Condition monitoring programme management	0.5	0.5	2
12. Training examination	1	2	2
13. Practical skills evaluation*	2		
Total hours for each Category	33	32	32

Ref:	Subject Syllabus topic	Category			Category sub-topics		
		1	2	3	Category 1	Category 2	Category 3
0	**Introduction**				**0.5**	0	0
1	**Principles of IRT**				**6**	**7**	**6**
1.01	Heat and heat transfer basics	●			Distinguish between various temperature scales, e.g., Centigrade (°C), Kelvin (K). Define 'Energy' and 'Heat'. Understand the basic principles of the following: transient & steady state heat flow; principles of heat capacity; phase change & Latent Heat; thermal diffusivity & system response time.		
1.02	Laws of thermodynamics	●			Distinguish between the definitions of the following Thermodynamic Laws: 1st & 2nd Law 0th & 3rd Law		
1.03	Conduction fundamentals	●	●	●	Understand the principles of conduction fundamentals.	Understanding of the following: Fourier's Law; heat transfer between objects in contact.	Comprehensive understanding of the principle of heat transfer through complex structures.
1.04	Conductivity / resistance	●			Understand the basic principles of: thermal conductivity of materials; thermal conductivity of composite structures (buildings or composite refractory linings).		
1.05	Convection fundamentals	●	●	●	Understand the basic principles of heat convection.	Understand: Heat convection; Newton's Law of cooling; heat transfer through gasses and liquids; boundary layer; thermal conductivity of gases & liquids.	Critically analyse: heat convection; Newton's Law of cooling; heat transfer through gasses and liquids; boundary layer; thermal conductivity of gases and liquids.
1.06	Radiation fundamentals	●			Understand the basic principles of the following: propagation through vacuum; Stefan Boltzmann Law; Planck's Law; Wien's Law (Planckian Curves); radiation properties – Lambertian; radiation properties of dielectrics and other materials.		
1.07	Electromagnetic spectrum	●		●	Understand the basic principles of the following: electromagnetic spectrum; relationship between Frequency/Wavelength/Speed of light.		Analysis of the 'Electromagnetic Spectrum' and highlight any areas which may be relevant to other NDT techniques (UV, X ray, etc.).
1.08	Spectral band used by IR cameras	●			Understand the basic principles of the spectral band and why the following bands are used for IR cameras: (IR band is considered to be 0.7 to 1000 µm). SW band 1 to 3 µm.		

Ref:	Subject Syllabus topic	Category			Category sub-topics		
		1	2	3	Category 1	Category 2	Category 3
					MW band 2 to 6 µm. LW band 8 to 14 µm.		
1.09	Atmospheric transmission	●	●		Understand the basic principles of atmospheric transmission and the fundamentals of effects on atmospheric transmission: distance; Carbon Dioxide (CO_2); Moisture (H_2O); solid particles; transmission vs. wavelength characteristics.	Fully understand how transmission vs. distance is influenced by the following: atmospheric moisture (H_2O); atmospheric Carbon Dioxide (CO_2); solids in atmosphere.	
1.10	Distance (atmospheric) correction	●	●		Understand the effect of atmospheric transmission on temperature measurement accuracy and the reason for compensation within the IR camera. The relationship between atmospheric attenuation and wavelength.	Understand the effect of solid particles on the spectral atmospheric transmission of gases (Can the IR camera compensate for any such errors?).	
1.11	IR lens materials and types of lenses	●			Lens types and why different lens materials are used. Why a range of lenses is required for some applications.		
1.12	IR windows	●	●		Understand the currently available range of IR windows.	Fully understand the currently available range of IR windows and analyse their specifications and safety standards.	
1.13	Radiation reference sources		●	●		Extrapolate relevant information from the 'Recommended reading material' listed in Annex B	Extrapolate relevant information from the 'Recommended reading material' listed in Annex B and any other relevant reference document.
1.14	Emissivity	●	●	●	Definition of emissivity and basic difference between the emissivity of a Blackbody, Graybody and Non-graybody (Dielectrics).	Definition of emissivity and fully understand difference between the emissivity of a Blackbody, Graybody and Non-graybody (Dielectrics).	Definition of emissivity and critical analysis of the difference between the emissivity of a Blackbody, Graybody and Non-graybody (Dielectrics).
1.15	Emissivity determination	●	●		Conduct the following emissivity calibration method: using a calibrated temperature probe; using high emissivity adhesive tape (at low temperatures); using high emissivity paint (at high temperatures).	Critical analysis of the following emissivity calibration method: using a calibrated temperature probe; using high emissivity adhesive tape (at low temperatures); using high emissivity paint (at high temperatures).	
1.16	Factors affecting emissivity	●	●	●	Differentiate between reflectance from 'Spectral' and 'Diffused' surfaces. Material types, surface condition, viewing angle, temperature, etc.	Analyse differences between reflectance from 'Spectral' and 'Diffused' surfaces. Material types, surface condition, viewing angle, temperature, etc.	Critically analyse differences between reflectance from 'Spectral' and 'Diffused' surfaces. Material types, surface condition, viewing angle, temperature, etc.
1.17	Emittance , reflectance and transmittance	●			Awareness of: transmittance / absorptance of various materials; fundamentals of radiative heat flow; radiation impinging on a target surface; radiation exchange at the target surface; radiation leaving a target.		

Ref:	Subject Syllabus topic	Category			Category sub-topics		
		1	2	3	Category 1	Category 2	Category 3
1.18	Active Thermography		●	●		'Passive' and 'active' thermography and principle properties of various active thermography excitation techniques.	'Passive' and 'active' thermography and critically analyse the key properties of various active thermography excitation techniques.
2	**Equipment & data acquisition**				**5**	**3**	**1**
2.01	How your infrared camera works	●			Operate Focal Plane Array (FPA) IR imagers. Also, understanding basics of: infrared radiation thermometers; line scanners; various other thermal scanners.		
2.02	Infrared camera selection criteria		●	●		Evaluate various features and functions of FPA thermal imagers, including selection of: temperature range requirements; detector pixels matric size; lens angle requirements (IFOV).	Evaluate requirements of IR cameras and associated equipment which may be applicable to other IR application, such as: Acoustic emissions (AE); Lubrication analysis (LA); Vibration analysis (VA).
2.03	Waveband selection criteria	●	●	●	Basic knowledge of currently available wavebands for various IR applications and correctly selecting the applicable waveband.	Extended knowledge of currently available wavebands for various IR applications and correct selection of applicable waveband.	Critically evaluate the currently available wavebands for IR applications, including selection of a correct waveband range for specific CM & NDT applications.
2.04	IR system specifications	●	●		Basic functions of currently available IR systems and their choice for specific applications.	Critically evaluate all functions of currently available IR systems and their choice for specific applications.	
2.05	Typical IR camera controls and temperature measurement tools	●			Apply and understand their effect on the appearance of a thermogram: Camera controls Temperature Range/span/level settings; emissivity settings; ambient temperatures (atmospheric and reflected); compensation; temperature functions (spot, circle, square); distance; electronic zoom vs lens selection; palette selection. Temperature measurement Spot; circle: Max/Av/Min; square / rectangle: Max/Av/Min; temperature profile; Isotherms (temperature line or band).		
2.06	Operation of equipment	●	●		Control and measurement features of a standard (FPA) IR cameras.	Apply all control and measurement features of the following IR instruments: FPA, 'Scanner type', line scanners and special IR cameras.	
2.07	Temperature measurement range/considerations	●			Importance of settings on the accuracy of temperature measurement: (Temperature range, span and level).		
2.08	Thermal sensitivity (NETD)		●			Understand thermal sensitivity; NETD (Noise Equivalent Temperature Difference);	

Ref:	Subject Syllabus topic	Category			Category sub-topics		
		1	2	3	Category 1	Category 2	Category 3
						MRTD (Minimum Resolvable temperature Difference); SRF (Slit Response Function).	
2.09	Lens selection	●	●		Lens selection importance for certain applications.	Optical and physical properties of currently available lens materials and determining lens selection for application.	
2.10	Optical resolution	●	●		Differentiate between the optical (different lenses) and electronic zoom.	Differentiate between the optical (different lenses) and electronic zoom and the effect each has on the appearance on a thermogram.	
2.11	Getting a good image	●			Producing a good image, considering the following IR instrument settings: temperature Range/Span/Level; ambient temperatures (atmospheric and reflected); emissivity; distance (field of view); Minimum target size (estimation from lens angle or detector pixels). Focus.		
2.12	Image composition	●	●	●	Ensuring correct adjustment of composition to clearly show the anomalies and accurate temperature measurements.	Ensuring correct adjustment of composition to clearly show the anomalies and accurate temperature measurements.	Ensuring correct adjustment of composition to clearly show the anomalies and accurate temperature measurements.
2.13	Image clarity (optical focus)	●			Understand correct optical focus prior to image procuring. (Clarity and temperature measurement accuracy).		
2. 14	Thermal tuning (range, level and span)	●			Understand importance of correct temperature range setting.		
2.15	Temperature measurement	●	●		Understand importance of collation of data for accurate non-contact temperature measurement with FPA IR cameras.	Specify data collation requirements for accurate non-contact temperature measurement with various IR cameras.	
2.16	Comparative quantitative thermography	●	●		Understand measurement of ΔT between 'good' components and anomaly temperatures.	Full knowledge of ΔT between 'good' components and anomaly temperatures.	
2.17	Comparative qualitative thermography	●	●		Understand measurement of ambient and anomaly temperatures.	Comprehensive understanding of measurement of ambient and anomaly temperatures.	
2.18	Environmental influences	●	●		Recognise the effect on the temperature measurement accuracy of the following: variations in atmospheric temperature; solar radiation/cloud cover; wind speed and direction; moisture (effect of surface moisture, fog, rain, solid particles, etc.); effect of reflections from nearby hot or cold objects.	Understand of the effect on the temperature measurement accuracy of the following: variations in atmospheric temperature; solar radiation/cloud cover; wind speed and direction; moisture (effect of surface moisture, fog, rain, solid particles, etc.); effect of reflections from nearby hot or cold objects.	
2.19	Error source recognition, prevention or control	●	●		Recognise the effect on the temperature measurement accuracy from the following error sources: reflected apparent temperature measurement – direct method;	Recognise and fully correct the effect of error sources on the temperature measurement accuracy. (Reflected apparent temperature measurement –	

Ref:	Subject Syllabus topic	Category			Category sub-topics		
		1	2	3	Category 1	Category 2	Category 3
					reflected apparent temperature measurement – reflector method; importance of initial instrument settings - focus and temperature range.	direct method; reflected apparent temperature measurement – reflector method; importance of initial instrument settings - focus and temperature range).	
2.20	Recognising and dealing with radiation (reflections, reflected apparent temperature, angle of incidence)	●	●	●	Recognise the existence of error sources and their influence on the final result. (Solar or clear sky reflection; reflections from nearby hot or cold objects; methods for estimating a reflective temperature, angle of incidence).	Existence of error sources and their influence on the final result. (Solar or clear sky reflection; reflections from nearby hot or cold objects; methods for estimating a reflective temperature, angle of incidence).	Critical analysis of error sources and their influence on the final result: solar or clear sky reflection; reflections from nearby hot or cold objects; methods for estimating a reflective temperature, angle of incidence.
2.21	Recognising and dealing with convection	●	●	●	Recognise sources of convection and their influence on the final result. (Thermal Boundary Layer; wind effect on structure surface temperatures; mass heat/energy transport.	Understand sources and their influence on the final result: Thermal Boundary Layer. Wind effect on surfaces of a structure temperatures. Mass heat/energy transport.	Critically analyse sources and their influence on the final result: Thermal Boundary Layer. Wind effect on surfaces of a structure temperatures. Mass heat/energy transport.
2.22	Recognising and dealing with conduction	●	●	●	Recognise sources and their influence on the final result e.g., Nearby objects contributing to conduction, e.g., hot fan near a bearing housing.	Understand sources and explain their influence on the final result by giving examples e.g., Nearby objects contributing to conduction, e.g., hot fan near a bearing housing.	Critically analyse sources and explain their influence on the final result by giving examples e.g., Nearby objects contributing to conduction, e.g., hot fan near a bearing housing.
2.23	Effects of incorrect emissivity	●	●		Importance of emissivity settings on temperature measurement accuracy: Correct emissivity - accurate temperature. Emissivity higher – lower temperatures. Emissivity lower – higher temperatures.	Importance of emissivity settings on temperature measurement accuracy: Correct emissivity - accurate temperature. Emissivity higher – lower temperatures. Emissivity lower – higher temperatures.	
2.24	Environmental and operation conditions	●	●		Basic principles of atmospheric or environmental conditions and the influence they may have on temperature measurement, e.g., moisture, rain, wind, solar or reflections from nearby objects, etc.	Principles of atmospheric or environmental conditions and the influence they may have on temperature measurement, e.g., moisture, rain, wind, solar or reflections from nearby objects, etc.	
2.25	Camera calibration	●	●		Carry out quick calibration procedures and understand the basic procedure for full calibration test: Quick calibration check using melting ice (about 0°C). • Take a thin sheet of ice and place it on a high emissivity surface. When nearly melted, take spot reading at the interface of ice and water. Quick calibration check using boiling water (about 100°C) • Boil water in a pan, filled nearly to the top (not a kettle). View at slight angle to avoid	Specify procedures for calibration of IR cameras and basic procedure for full calibration test: Quick calibration check using melting ice (about 0°C). • Take a thin sheet of ice and place it on a high emissivity surface. When nearly melted, take spot reading at the interface of ice and water. Quick calibration check using boiling water (about 100°C) • Boil water in a pan, filled nearly to the top (not a kettle). View at slight angle to avoid	

Ref:	Subject Syllabus topic	Category			Category sub-topics		
		1	2	3	Category 1	Category 2	Category 3
					interference from steam and take a spot reading near the edge of the pan. • Take into consideration boiling temperature of water vs. pressure for various altitudes. Quick calibration check using human tear duct at room temperature (about 36°C). Check against a calibrated temperature probe. A full check on a calibration test rig.	interference from steam and take a spot reading near the edge of the pan. • Take into consideration boiling temperature of water vs. pressure for various altitudes. Quick calibration check using human tear duct at room temperature (about 36°C). Check against a calibrated temperature probe. A full check on a calibration test rig.	
2.26	Safe data acquisition	●	●		Importance of some IR camera settings on date relevant to the thermogram, e.g.,: Is the image in focus? Is the temperature Range/Span/Level correctly set? Is the target below minimum spot size? Are all instrument settings correct? Are there any other 'external anomalies' that may corrupt the genuine result?	Specify checks should be applied before recording and analysing a thermogram, e.g.,: Is the image in focus? Is the temperature Range/Span/Level correctly set? Is the target below minimum spot size? Are all instrument settings correct? Are there any reflections from nearby objects or the sky present? Genuine or false anomalies.	
2.27	Data and image storage	●			Storing data in its original format.		
2.28	Accessories	●	●		Basic requirement for accessories: Photographic equipment (if not fitted to infrared camera). Spare batteries. High emissivity PVC tape. Lens brush.	Requirement of accessories: <u>Mechanical</u>: Corrugated reflector for reflected temperature measurement. <u>Electrical:</u> Current clamp ammeter. <u>Civil:</u> Air flow meters. Borescopes. Contact and immersion thermometers. Heat flow meters. Hydrometers. Moisture meters. Blower doors. Building fan systems. Specification for above instruments.	
3	**Image processing**				**6**	**2**	**1**
3.01	ISO 18434-1	●	●	●	<u>B</u>asic requirements of the standard.	Complete understanding of the standard.	Complete understanding and application of the standard.

Ref:	Subject Syllabus topic	Category			Category sub-topics		
		1	2	3	Category 1	Category 2	Category 3
3.02	General guidelines for establishing thermal severity assessment criteria (ISO 18434-1: engineering codes and other standards)		●	●		Basic guidelines listed in the standards, CM/GEN Appendix B and other literature, including: General severity criteria topics (absolute, delta, statistical). Severity criteria applied to individual components or like groups. Factors affecting severity assessment criteria. Temperature difference criteria (ΔT or qualitative). Maximum permissible temperature criteria (quantitative). Profile assessment criteria.	Guidelines listed in the standard, CM/GEN Appendix B and other literature, including: General severity criteria topics (absolute, delta, statistical). Severity criteria applied to individual components or like groups. Factors affecting severity assessment criteria. Temperature difference criteria (ΔT or qualitative). Maximum permissible temperature criteria (quantitative). Profile assessment criteria.
3.03	Level and span adjustment	●			Understand settings for widest temperature, level and span, in the area of the anomaly and reference temperatures.		
3.04	Statistical analysis		●			Evaluate existing software packages and recommend one suitable for the instrument and application being considered.	
3.05	Image subtraction		●	●		Evaluate existing software packages and recommend some suitable for the instrument and application being considered.	Evaluate existing software packages and specify one suitable for the instrument and application being considered.
3.06	Image montage	●	●	●	Basic requirement for image montage.	Image montage procedures to achieve the best image quality.	Specify the procedure for achieving image montage quality.
3.07	Temperature trending	●	●	●	Understand how to use the software and be able to demonstrate the basic principles of temperature trending.	Evaluate existing software packages and recommend one suitable for the instrument and application being considered.	Evaluate existing software packages and specify one suitable for the instrument and application being considered.
3.08	General image interpretation guidelines	●	●	●	Ensure recorded thermogram is a true representation of an anomaly, e.g.,: Is the image in focus? Is the temperature Range/Span/Level correctly set? Is the target below minimum spot size? Are all instrument settings correct? Are there any other 'external anomalies' that may corrupt the genuine result?	Record and evaluate the thermogram as a true representation of an anomaly, e.g., Is the image in focus? Is the temperature Range/Span/Level correctly set? Is the target below minimum spot size? Are all instrument settings correct? Are there any reflections from nearby objects or the sky present? Genuine or false anomalies.	Recorded thermogram is a true representation of an anomaly, e.g.,: Is the image in focus? Is the temperature Range/Span/Level correctly set? Is the target below minimum spot size? Are all instrument settings correct? Are there any reflections from nearby objects or the sky present? Genuine or false anomalies.
4	**Condition monitoring**				**4.5**	**0**	**0**
4.01	Discussion on general industrial applications	●			Basic application of thermography in the following fields: Mechanical & Process. Electrical. Building & Civil examples.		
4.02	Active and passive thermography	●	●	●	Basic difference between the two techniques.	Fully understand the difference between the two techniques.	Extensive knowledge of the difference between the two techniques and various excitation sources.

Ref:	Subject Syllabus topic	Category			Category sub-topics		
		1	2	3	Category 1	Category 2	Category 3
5	**Diagnostics and prognostics**				**1**	**2**	**2**
5.01	Basic principles of diagnostics (ISO 17359 & 13379-1)	●	●	●	Basic understanding of the standards.	Complete understanding of the standards, concentrating on the application of diagnostic techniques.	Complete understanding of the standards and be able to critically evaluate sections relating to diagnostic techniques.
5.02	Basic principles of prognostics (ISO 13381-1)		●	●		Complete understanding of the standard, concentrating on the application of prognostics techniques.	Complete understanding of the standard and critically evaluate sections relating to prognostics techniques.
6	**Condition monitoring applications**				**4**	**10.5**	**7**
6.01	Plant & equipment engineering principles, their failure modes and associated thermal signatures	●	●	●	Knowledge of the basic principles of ISO 13379-1, 17359, and BSEN 60812 relating to failure modes of systems and associated thermal signatures.	Knowledge and understanding of the principles of ISO 13379-1, 17359, and BSEN 60812 relating to failure modes and associated thermal signatures of basic electrical, mechanical (such as rotating and sliding theory) and building construction systems.	Knowledge and understanding of ISO 13379-1, 17359, and BSEN 60812 including failure modes and associated thermal signatures of the complex electrical, mechanical (such as rotating and sliding theory) and building construction systems. Also, including the basic principles of the following CM activities: Acoustic emissions (AE). Lubrication analysis (LA). Vibration analysis (VA).
6.02	Severity assessment and acceptance criteria (engineering codes and standards)	●	●	●			
6.03	Safety issues	●			Basic principles of national or local safety procedure specified by the National standards, 'Client' or C2/C3 Thermographer.		
6.04	Fault analysis	●			Basic principles of fault analysis.		
6.a)	**Electrical applications**						
6.a.01	Electrical engineering (components & construction)		●	●		Basic construction of typical electrical component and systems, areas where heat is likely to be generated and possible anomalies arise: Extra-Low Voltage (E-LV). Low Voltage (LV). High Voltage (HV).	Construction of typical electrical component and systems, highlighting the areas where heat is likely to be generated and possibly anomalies arise: Extra-Low Voltage (E-LV). Low Voltage (LV). High Voltage (HV).
6.a.02	IR theory to electrical applications and thermal signatures		●	●		Basic electrical theory, including: Relationship between current, voltage and resistance. Relationship between power,	Extensive electrical theory, including: Relationship between current, voltage and resistance. Relationship between power,

Ref:	Subject Syllabus topic	Category			Category sub-topics		
		1	2	3	Category 1	Category 2	Category 3
						current and resistance. Harmonics (particularly 3rd order/zero sequence). Effect of eddy currents on thermal patterns. Danger of circulation currents. Thermal theory.	current and resistance. Harmonics (particularly 3rd order/zero sequence). Effect of eddy currents on thermal patterns. Danger of circulation currents. Thermal theory.
6.a.03	Applications		●	●		Basic principles of electrical distribution systems and present thermograms of various electrical anomalies, with full analysis, for examples listed below:	Principles of electrical systems and present thermograms of complex electrical anomalies, with full analysis, for examples listed below:
	a) Electrical distribution					E-LV, LV and HV.	E-LV, LV and HV.
	b) Electrical panels					E-LV, LV and HV.	E-LV, LV and HV.
	c) Electrical components					Conductor types. Termination types. Fuse types. Contactor types. Main isolator types. Overload types. Other components.	Conductor types. Termination types. Fuse types. Contactor types. Main isolator types. Overload types. Other components.
	d) Electrical motors					Cage and motor windings. Terminal box. Bearings. AC/DC motors.	Cage and motor windings. Terminal box. Bearings. AC/DC motors.
6.a.04	Fault analysis and recommended corrective action		●	●		Evaluate anomalies and recommend corrective action in the following: Low voltage examples - open and closed panels. Motors. Busbars. High voltage systems. Transformers. Power lines. Measuring temperatures through safety grills and windows.	Critically evaluate anomalies and recommend corrective action in the following: Low voltage examples - open and closed panels. Motors. Busbars. High voltage systems. Transformers. Power lines. Measuring temperatures through safety grills and windows.
6.a.05	Safety issues		●	●		National and local electrical standards and knowledge of the following: Risk Assessment and Method Statement example. Safe approach boundary. Working near live equipment at very close range. Removal of panels on live electrical equipment. Working at height. Prepare a basic Risk Assessment and Method Statement document.	National and local electrical standards and extensive knowledge of the following: Prepare Risk Assessment and Method Statement example. Specify safe approach boundary. Specify regulations when working near live equipment at very close range. Specify or follow local requirements regarding removal of panels on live electrical equipment. Specify or follow local rules for working at height.

Ref:	Subject Syllabus topic	Category			Category sub-topics		
		1	2	3	Category 1	Category 2	Category 3
6.b)	**Mechanical applications**						
6.b.01	Mechanical engineering (components and construction)		●	●		Basic principles of design and operation of the following: Bearing design – ball, taper, roller and other types. Motor types – externally cooled, enclosed, AC, DC. Pump types – centrifugal, piston, screw. Fan types – centrifugal, piston, screw. Compressor types – piston, screw. Valve types and basic design: Shut off and check valves and Safety valves Gearboxes – gear, worm, bevel. Drive types – direct coupled, belt gear drives. Steam trap types – thermostatic & thermodynamic including basic design and principle of operation. Heat exchangers – finned tube, external flow, internal flow.	Design and operation of the following: Bearing design – ball, taper, roller and other types. Motor types – externally cooled, enclosed, AC, DC. Pump types – centrifugal, piston, screw. Fan types – centrifugal, piston, screw. Compressor types – piston, screw. Valve types and basic design: Shut off and check valves and Safety valves. Gearboxes – gear, worm, bevel. Drive types – direct coupled, belt gear drives. Steam trap types – thermostatic & thermodynamic including basic design and principle of operation. Heat exchangers – finned tube, external flow, internal flow.
6.b.02	IR theory to mechanical applications and thermal signatures		●	●		Basic knowledge of the following: Drives. Steam theory: Boiling temperature vs. pressure. Phase change – ice–water-steam. Steam tables. Wet steam and superheated steam. Energy loss calculations: Example - heat transfer through a furnace wall. Example – heat loss from a furnace wall.	Advanced knowledge of the following: Drives. Steam theory: Boiling temperature vs. pressure. Phase change – ice–water-steam. Steam tables. Wet steam and superheated steam. Energy loss calculations: Example - heat transfer through a furnace wall. Example – heat loss from a furnace wall.
6.b.03	Applications		●	●		Basic principles of mechanical systems and present thermograms of various mechanical anomalies, with full analysis: Process Industry: Food, paper, petrochemical etc. Mechanical applications: Conveyors, etc. Active Thermography, e.g., wind turbine blades.	Principles of mechanical systems and present thermograms of various mechanical anomalies, with full analysis: Process Industry: Food, paper, petrochemical etc. Mechanical applications: Conveyors, etc. Active Thermography, e.g., wind turbine blades.
	a) Rotating equipment					Defective bearings, shafts, couplings, misalignment, etc.	Defective bearings, shafts, couplings, misalignment, etc.
	b) Fluid flow					Blocked pipes or heat exchangers. Deposit in pipes or leaking valves.	Blocked pipes or heat exchangers. Deposit in pipes or leaking valves.
	c) Power transmission					Overheating gearboxes, belt slip. Defective couplings	Overheating gearboxes, belt slip. Defective couplings
	d) Furnaces					Refractory lined or external insulation defects.	Refractory lined or external insulation defects.
	e) Tanks					Deposit level in tanks. Trace heating defects, etc.	Deposit level in tanks. Trace heating defects, etc.

Ref:	Subject Syllabus topic	Category			Category sub-topics		
		1	2	3	Category 1	Category 2	Category 3
6.b.04	Fault analysis and recommended corrective action		●	●		Evaluate basic anomalies and recommend corrective action in the following: Rotating equipment, preload, alignment, etc. Conveyor belts problems. Paper machines, mechanical & process. Fluid flow problems. Heat exchangers blockage. Furnace refractories and tubes. Effect of wind on tall structures. Tank deposits and insulation. Active Thermography, e.g., a wind turbine blade.	Evaluate anomalies and recommend corrective action in the following: Rotating equipment, preload, alignment, etc. Conveyor belts problems. Paper machines, mechanical & process. Fluid flow problems. Heat exchangers blockage. Furnace refractories and tubes. Effect of wind on tall structures. Tank deposits and insulation. Active Thermography, e.g., a wind turbine blade.
6.b.05	Safety issues		●	●		Know about national and local mechanical standards and demonstrate knowledge of the following: Risk Assessment and Method Statement example. In the absence of a C3 thermographer, be able to prepare a basic Risk Assessment and Method Statement document.	Know about national and local mechanical standards and demonstrate knowledge of the following: Risk Assessment and Method Statement example. In the absence of a C3 thermographer, be able to prepare a basic Risk Assessment and Method Statement document.
6.c)	**Civil applications**						
6c.01	Civil Engineering (components & construction)		●	●		Basic knowledge of the following: Overview of building envelope types	Complex knowledge of the following: Overview of building envelope types
	a) Construction types					Building Technology: • Historic buildings. • Domestic buildings before approximately 1940. • Domestic buildings built after 1940. • Commercial buildings. • Industrial buildings. • Sick-building syndrome. • Wooden frame construction.	Building Technology: • Historic buildings. • Domestic buildings before approximately 1940. • Domestic buildings built after 1940. • Commercial buildings. • Industrial buildings. • Sick-building syndrome. • Wooden frame construction.
	b) Material types					Steel fabrications. Concrete structures - plain or reinforced. Various types of brick – building or fire bricks. Stone types. Glass Plastics.	Steel fabrications. Concrete structures - plain or reinforced. Various types of brick – building or fire bricks. Stone types. Glass. Plastics.
6.c.02	IR theory to civil applications and thermal signatures		●	●		Typical thermal signatures in civil applications as well as:	Complex thermal signatures in civil applications as well as:
	a) Properties of materials					Physical & mechanical properties of building materials. Thermal properties of building materials.	Physical & mechanical properties of building materials. Thermal properties of building materials.

Ref:	Subject Syllabus topic	Category			Category sub-topics		
		1	2	3	Category 1	Category 2	Category 3
	b) Environmental conditions					Radiant heat transfer caused by the solar radiation or cloudless night sky. Wind effect (convection). Effect of rain (moisture). Phase change (evaporation).	Radiant heat transfer caused by the solar radiation or cloudless night sky. Wind effect (convection). Effect of rain (moisture). Phase change (evaporation).
6.c.03	Building envelopes		●	●		Basic knowledge of the following: Domestic buildings. Commercial buildings. Industrial buildings.	Extensive knowledge of the following: Domestic buildings. Commercial buildings. Industrial buildings.
	a) Insulation					Types of insulation. Thermal resistance of insulating materials.	Types of insulation. Thermal resistance of insulating materials.
	b) Moisture					Theoretical and practical methods for dew point estimates. Dampness, transport mechanism and thermal signature. Condensation, transport mechanism and thermal signature.	Theoretical and practical methods for dew point estimates. Dampness, transport mechanism and thermal signature. Condensation, transport mechanism and thermal signature.
	c) Air leakage/air tightness					External measurement of thermal patterns - building increased pressure and examples. Internal measurement of thermal patterns – building reduced pressure and examples. Leak detection using smoke IR equipment. Equipment for controlling building pressure. Test procedure.	External measurement of thermal patterns - building increased pressure and examples. Internal measurement of thermal patterns – building reduced pressure and examples. Leak detection using smoke IR equipment. Equipment for controlling building pressure. Test procedure.
6.c.04	Other structures		●	●		Basic knowledge of other structures: Rendered buildings. Concrete tarmac surfaces. Tunnels & bridges, etc.	Knowledge of other structures: Rendered buildings. Concrete tarmac surfaces. Tunnels & bridges, etc.
	a) Structural details and defects					Delamination in concrete structures. Corrosion of Concrete. Other Defects. Industrial refractory lined furnaces.	Delamination in concrete structures. Corrosion of Concrete. Other Defects. Industrial refractory lined furnaces.
	b) Structural finishes					Brick or concrete. Rendering. Paint. Glass. Plastics. Metals.	Brick or concrete. Rendering. Paint. Glass. Plastics. Metals.
6.c.05	Fault analysis and recommended corrective action		●	●		Evaluate basic anomalies and recommend corrective action for the following: Roofs and Ceiling. Walls. Glass windows. Air tightness. Delamination (Spalling). Underground pipes.	Evaluate complex anomalies and recommend corrective action for the following: Roofs and Ceiling. Walls. Glass windows. Air tightness. Delamination (Spalling).

Ref:	Subject Syllabus topic	Category			Category sub-topics		
		1	2	3	Category 1	Category 2	Category 3
						Asphalt roads. Refractory lined industrial furnaces & stacks. Pollution control. Active Thermography example.	Underground pipes. Asphalt roads. Refractory lined industrial furnaces & stacks. Pollution control. Active Thermography example.
6.c.06	Safety issues		●	●		National and local mechanical standards and demonstrate knowledge of the following: Risk Assessment and Method Statement example. Prepare a basic Risk Assessment and Method Statement document.	National and local mechanical standards and demonstrate knowledge of the following: Risk Assessment and Method Statement example. Prepare Risk Assessment and Method Statement documents
7	**Reporting and documentation (ISO international standards)**				**1**	**0.5**	**0.5**
7.01	Report writing	●	●	●	Produce reports, based on instructions from a C2 thermographer, on the survey findings that include requirements from ISO 18434-1.	Produce extensive reports based on the survey findings in compliance to ISO 18434-1. Analyse reports produced by C1 thermographers.	Produce comprehensive reports based on the survey findings in compliance with ISO 18434-1. Analyse reports produced by C1 & C2 thermographers. Specify the required format and content.
7.02	Thermographers' and end-users' responsibilities	●	●	●	Produce reports that satisfy all requirements of ISO 18434-1 and the 'Client'.	Produce reports that satisfy all requirements of ISO 18434-1 and the 'Client'. Analyse reports produced by C1 thermographers.	Produce reports that satisfy all requirements of ISO 18434-1 the 'Client '. Specify report format, analyse reports produced by C1 & C2 thermographers.
8	**Condition monitoring programme design**				**0.5**	**0.5**	**3.5**
8.01	General principles	●	●	●	Basic principles as described in: CM/GEN Appendix B, ISO 17359, 18434, 13379-1 and 13381.	Analyse information from the following documents: CM/GEN Appendix B, ISO 17359, 18434, 13379-1 and 13381.	Critically analyse and design appropriate programme based on requirements: CM/GEN Appendix B, ISO 17359, 18434, 13379-1 and 13381.
8.02	Technique selection		●	●		Consider survey technique appropriate to application, e.g., selection of IR instrument and additional equipment.	Specify survey technique appropriate to application or write new procedures.
8.03	Measurement intervals		●	●		Implement inspection interval requirements in compliance with supplier recommendations and historic anomaly records.	Specify inspection interval requirements based on supplier recommendations and historic anomaly records.
8.04	Reference temperatures	●	●	●	Principles of reference temperatures	Evaluate data presented in existing literature or specifications. Provide instructions to C1 thermographers.	Critically evaluate data in existing literature or specifications or create data specific to application.
8.05	Plant & equipment baseline temperatures	●	●	●	Principles for baseline temperatures.	Evaluate established baseline temperatures data based on:	Establish baseline temperatures data as well as specify new values based on:

Ref:	Subject Syllabus topic	Category			Category sub-topics		
		1	2	3	Category 1	Category 2	Category 3
						• New equipment (or building) at operating loads • Recommendations by manufacturers or (designers) • Experience Issue instructions to C1 thermographers on the values to be used.	• New equipment (or building) at operating loads • Recommendations by manufacturers or (designers) • Experience Issue instructions to thermographers.
8.06	CM management procedure and process development		●	●		Evaluate existing data and recommend corrective procedures based on severity, safety, cost, etc. Instruct C1 thermographers. Maintain up to date records.	Evaluate existing data and recommend corrective procedures based on the anomaly severity, safety, cost, etc. Write instructions for thermographers. Implement procedures.
8.07	Alarm values		●	●		Understand severity of the anomalies and establish alarm values	Evaluate severity of the anomalies and set alarm values.
9	**Condition monitoring programme implementation**				**1**	**1**	**1**
9.01	Overview	●			Basic principles behind the documents: ISO 17359, 13381-1, 18434-1 and their effect on IR surveys.		
9.02	Safe system of work	●	●	●	Follow basic regulations in ISO 18434-1 and specific national and local site regulations related to thermography.	Implement the basic regulations in ISO 18434-1 and specific national and local site regulations related to thermography. Also analyse topics raised in sections 6.a) 5, 6.b) 5 and 6.c) 6.	Ensure compliance with regulations in ISO 18434-1 and specific national and local site regulations related to thermography. Also, analyse topics raised in sections 6.a) 5, 6.b) 5 and 6.c) 6.
9.03	Roles and responsibilities		●	●		Roles of the 'Client' and the thermographer: • Implement procedures approved by a qualified person. Customer • Specify what is to be inspected. • Provide a guide qualified for the purpose. • Provide site induction course.	Roles of the 'Client' and thermographer: • Write procedures Customer • Specify what is to be inspected. • Provide a guide qualified for the purpose. • Provide site induction course.
9.04	Training and accreditation		●	●	PCN requirements to obtain the C1 certificate.	PCN requirements to obtain the C2 certificate.	PCN requirements to obtain the C3 certificate.
10	**Condition monitoring programme management**				**0.5**	**0.5**	**2**
10.01	Safety management	●	●	●	Interpret and apply safety requirements specified by the 'Client' and/or qualified C2 or C3 certified supervisor.	Interpret and apply safety requirements specified by the 'Client' and the qualified supervisor with C3 certificate.	Write and implement safety requirements agreed by the 'Client'

Ref:	Subject Syllabus topic	Category			Category sub-topics		
		1	2	3	Category 1	Category 2	Category 3
10.02	Equipment management	●	●	●	Follow equipment management procedure and make certain that the IR instrument to be used is 'certified' and functioning correctly.	Implement equipment management procedure and ensure the equipment to be used is 'certified' and functioning correctly.	Write and implement equipment management procedure; ensure full compliance.
10.03	Procedure management		●	●		Thermography procedure management and ensure it is fully implemented by all site thermographers.	Thermography (and other CM) procedure management system and ensure it is fully implemented by all staff. Write new procedures.
10.04	Skills and competence management		●	●		Collate the following records: Thermographer skills; Thermographer valid certification.	Collate and manage records: Thermographer skills: Thermographer valid certification; Write new procedures.
10.05	Database management	●	●	●	Follow procedure for thermography database management	Follow procedure for thermography database management and ensure it is followed by C1 thermographers.	Write the procedure for thermography database management ensuring it is followed by all thermographers.
10.06	Managing corrective action implementation		●	●		Collate and in conjunction with the 'Client', recommend corrective action to be taken. Whenever possible, making certain that the database is kept up to date on the action actually taken and ensure that this procedure is followed by all C1 thermographers.	Collate and in conjunction with the 'Client', recommend corrective action to be taken. Whenever possible, making certain that the database is kept up to date on the action actually taken and ensure that this procedure is followed by all thermographers.
11	**Training examination**				**1**	**2**	**2**
12	**Practical skills evaluation**				**2**	**0**	**0**
	Total Hours				**33**	**32**	**32**

Notes:

1. Category 2 includes the knowledge of Category 1; Category 3 includes the knowledge of Category 1 and Category 2.
2. At Categories 2 and 3, the times allocation are indicative only, indicating the bias towards application topics, and the actual time spent for each topic is flexible, provided an advised minimum of approximately 24hours is allocated per field of application.

Annex B – Reading references

Essential Reading (material from which examination questions can be developed)

Categories	Title	Author(s)	Publisher	Reference
1, 2, 3	ASNT Level 3 Study Guide- Infrared and Thermal Testing Method	H Kaplen	American Society of Non Destructive Testing, 2001	ISBN 1571170154
2, 3	Safe Thermal Imaging of Electrical Systems	C. Pearson	UK Thermography Association, 1997	Application Guide AG/97
2, 3	Thermal Imaging of Building Fabric	C. Pearson	BSRIA	ISBN 086022-590-9
1, 2, 3	Common sense approach to thermal imaging	G C Holst	Society of Photo-Optical Instrumentation Engineers, 2000	ISBN 0819437220
1, 2, 3	Infrared Thermography- Applications	A Nowicki	BINDT	090313232X
2, 3	Measurement in Thermography	C. Ohman	FLIR Systems AB	1557498 Rev A
3	Condition-based Maintenance using Non-Destructive Testing: Application Guide AG 1/2003	C Pearson A Seaman	BSRIA	ISBN 860226115
1, 2, 3	Infrared Thermography- Theory & Practice	N Walker	BINDT	0903132338
3	Acoustic emission and ultrasonics	T Holroyd	Coxmoor	1901892077
3	Vibration monitoring handbook	C W Reeve	Coxmoor, 1998	190189200X
3	The wear debris analysis handbook	B J Roylance & T M Hunt	Coxmoor, 1999	1901892026
3	Oil Analysis	Evans and Hunt	Coxmoor	1901892050
3	Defects in Buildings, symptoms, investigation, diagnosis and cure',	M Billington; 2001	Carillion Services	ISBN 0117024368
2,3	Measuring Air Permeability of Building Envelopes –Technical Standard 1.	ATTMA	ATTMA; 2006	NA
2,3	Airtightness testing- The essential guide to Part 2 of the 2006 Building Regulations (UK)- BG4/2006	David Pickavance and Tom Jones	BSRIA, 2006	086022662X
2,3	Airtightness testing for new Dwellings; A practical guide for builders and testers (UK); BG11/2004	Nigel Potter and Chris Knights	BSRIA, 2004	0860226484

Standards, codes and specifications (Material from which examination questions can be developed)

1. ISO 13374. Part 1. Condition monitoring and diagnostics of machines- Data processing, communication and presentation: Part 1. general Guidelines
2. ISO 13372, Condition monitoring and diagnostics of machines- vocabulary
3. ISO 17359, Condition monitoring and diagnostics of machines- general guidelines
4. ISO 13379-1, Condition monitoring and diagnostics of machines. Data interpretation and diagnostics techniques. General guidelines
5. CMGEN, General requirements for qualification and PCN certification of condition monitoring and diagnostic personnel
6. ISO 13381-1, Condition monitoring and diagnostic of machines; prognostics: Part 1 general Guidelines
7. 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
8. ISO 18436-7, Condition monitoring and diagnostics of machines; requirements for qualification and assessment of personnel. Part 7, Thermography
9. ISO 18434-1. Condition monitoring and diagnostics of machines. Thermography. Part 1: General procedures.
10. -BS EN 60812, Analysis techniques for system reliability. Procedure for failure mode and effects analysis (FMEA)
11. BS EN 61025, Fault tree analysis (FTA)
12. ISO 13187. Thermal performance of buildings- Qualitative detection of thermal irregularities in building envelopes- Infrared method

Recommended reading (Informative) (material that contains helpful information on a related subject)

Category	Title	Author(s)	Publisher	ISBN/Publ No
1, 2	Product Technology Classroom Training Handbook		BINDT	NA
2, 3	Practical Applications of Infrared Thermal Sensing and Imaging Equipment	H Kaplen	Society of Photo-Optical Instrumentation Engineers, 1999, 2nd Edition	0819431389
2,3	NFPA 70E Standard for electrical safety in the workplace	NFPA	NFPA (USA), 2004 Edition	NA
3	Business-focussed Maintenance- A BSRIA Guide	J Harris, P Hastings	BSRIA, 2004 BG/3/2004	0860226042
3	NFPA 70B Recommended practice for electrical equipment maintenance	NFPA	NFPA (USA), 2002 Edition	NA