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CM/GEN APPENDIX B Issue 1 Rev G

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

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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 certification of condition monitoring personnel). Other Appendices cover:

- Appendix A Acoustic Emission
- Appendix C Lubrication Management and 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 259056, 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.

Definitions

Civil: The term 'Civil' when used in this document includes buildings, structures, roads, bridges, etc.

Mechanical: The term 'Mechanical' when used in this document includes mechanical systems and 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 Levels 2 and 3 only, and attempted either during, or after the first examination that consists of the general part and another sector-specific part.

1. Scope

- 1.1. This appendix to PCN CM/GEN sets out the specific requirements for qualification and certification 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. Certification to this specification will provide evidence of the qualification and competence 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 levels and have demonstrated competence in the concepts of thermographic analysis for their classification level as indicated in the examination syllabus at Annex A.
 - 2.1.2. Personnel classified as Level 2 require all the knowledge and skills expected of personnel classified as Level 1, and personnel classified as Level 3 require all the knowledge and skills expected of personnel classified as Level 2.

2.1.3. Those personnel seeking to be classified as Level 2 or Level 3 will elect to specialise in one of three industry sectors, as specified at clause 5.

2.2. Infrared Thermography Level 1 (General)

PCN certificated Infrared Thermography Level 1 personnel are qualified to perform industrial infrared thermography measurements according to established and recognised procedures and may be authorised (within the scope and limitations of the certification held) 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 and severity assessment;
- 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.

Level 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 Level 2.

Individuals certificated as Infrared Thermography Level 2 are qualified to perform and/or direct infrared thermography analysis according to established and recognised procedures. Level 2 personnel may be authorised (within the scope and limitations of the certification held) 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 Level 2;
- 2.3.9. carry out, supervise and instruct all level 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 all four condition monitoring (CM) technologies specified in CM/GEN at least to Level 1.

2.4. Infrared Thermography Level 3

Individuals certificated as Infrared Thermography Level 3 are qualified to perform and/or direct all types of infrared thermography measurements and analysis and will be competent 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 Level 1 and 2 personnel;
- 2.4.9. guide personnel below level 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 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 all four condition monitoring (CM) technologies specified in CM/GEN at least to Level 1.
- 2.4.14. carry out, manage and supervise PCN CM qualification examinations on behalf of the British Institute of NDT, 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.

ISO 18436-8 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 necessary indicative of a persons ability to interpret colour differences on a thermogram.

3.2. Education

It is recommended that level 1 and 2 candidates have at least a secondary school science or technical qualification, or its equivalent. Infrared Thermography personnel must be able to manipulate simple algebraic equations at a level equivalent to that of a basic mathematics qualification, use a basic scientific calculator, and be familiar with the operation of personal computers.

3.3. Training

3.3.1 To be eligible to apply for examination based on this Specification, the candidate shall provide documentary evidence of successful completion of a BINDT approved or recognised course of formal training based on the requirements of Annex A2. Further guidance for content of the level 2 training syllabus is given in Annex C. Sources of technical information are listed in Annex B. The minimum duration of cumulative training shall be as shown in Table 1. The training syllabus indicated includes a requirement for practical knowledge and practical skills training within the relevant topics.

TABLE 1. Minimum Cumulative Duration of Training (hours)		
Level 1	Level 2	Level 3
40	80	120

3.3.2 In addition to the training hours in Table 1, Level 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.

3.4. Experience

3.4.1. 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 level and sector sought. The minimum experience requirements are shown in Table 2.

3.4.2. Certification at Level 2 and Level 3 requires previous certification at the lower levels.

The PCN scheme will allow mature candidates direct entry to Level 2 only, without the need to have previously held certification at level 1, providing they can produce verifiable documentary evidence of training and experience that satisfies the requirement for both level 1 and level 2 qualifications. This delta will apply for the duration of the transition period indicated in the General Requirements for Qualification and Certification of Condition Monitoring personnel (CM/GEN) clause 20.1.

3.4.3. Candidates must maintain a log of hours and nature of work (see ISO18436-8 clause 5.4), especially scanning (practical) times, on PCN document CP16-CM.

TABLE 2. Minimum Cumulative Experience Requirements (months)		
Level 1	Level 2	Level 3
12*	24*	48*
400 hours**	1200 hours**	1920 hours**

*Work experience in months is based on a nominal 40 hour Week (160hours/month). **Indicates the minimum cumulative scanning (inspection/practical) and/or interpretation experience requirements in hours. .

4. Certification Available

4.1 Level 1 (IRT-General)

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

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

Level 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 forms.

5.2 Initial examination

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

5.2.1 Level 2 and Level 3 candidates for Infra-red Thermography are required to be successful in a written examination comprising at least two modules covering:

5.2.1.1 the basic principles and practical knowledge of Infra-red Thermography;

5.2.1.2 at least one module paper on the specific application of Infra-red Thermography in terms of civil, mechanical or electrical engineering, as selected by the candidate. At level 2 the sector paper will cover diagnostics and image interpretation. At level 3 the sector paper will cover diagnostics, prognostics, image interpretation, solution design and solution verification. The 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.

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

5.3 Supplementary examination

5.3.1 Supplementary modular examinations are only available to existing PCN Infra-red Thermography Level 2 or Level 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 Re-examination (retests of failed examinations)

Failed examinations may be re-attempted without limitation, except that a period of not less than 30 days will usually elapse between retest attempts. Only BINDT, at its sole discretion, may issue derogation to this rule.

5.5 Examination content (Theory and practical knowledge)

5.5.1 For each certification level, the candidates shall be required to answer the fixed number of multiple choice questions within specified time duration as indicated in Table 3. At level 3, 10% of the examination paper will consist of narrative questions.

5.5.2 Each narrative question will be worth 10 points.

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

5.5.4 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.

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

5.5.6 The level 1 examination paper will comprise 60 questions covering the general topics listed in Annex A2. The level 2 and 3 examination papers will comprise general (30 questions) and 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			
Levels	Number of Questions	Time (Hours)*	Passing Grade %
Level 1	60	2.0	75
Level 2 (General + 1 st sector module)	60 (30 + 30)	2.0	75
Level 2 (Supplementary module)	30	1.0	75
Level 3 (General + 1 st sector module)	60 (30 + 30)	2.0	75
Level 3 (Supplementary module)	30	1.0	75

*Examination times include a 30 minute reading period to assist candidates with English as a second language or any disability in accordance with CMGEN clause 9.3.

Annex A1 Training Syllabus

Subject	Hours of training		
	Level 1	Level 2 [Only 1 module from subjects 6,7 or 8]	Level 3 [Only 1 module from subjects 6,7 or 8]
0. Introduction	1	-	-
1. Principles of IRT	7	2	2
2. Equipment and data acquisition	7	2	2
3. Image Processing	7	2	2
4. Condition Monitoring	3	-	8
5. General Applications	8	1	1
6. Electrical Applications	-	24	7
7. Mechanical Applications	-	24	7
8. Civil Applications	-	24	7
9. Condition monitoring programme design and Acceptance testing	1	1	6
10. Condition monitoring programme implementation	2	1	3
11. Condition monitoring programme management	-	2	3
12. Corrective Actions	-	1	1
13. Codes and standards	1	1	2
14. Reporting and documentation (ISO Standards)	2	-	-
15. Diagnostics & prognostics	-	2	2
16. Training examination	1	1	1
Total hours for each level	40	40	40 <i>[only one module from 6, 7 or 8]</i>

Annex A2 – Detailed list of Topics and hours of Instruction

SUBJECT	Level 1 Hours	Level 2 Hours	Level 3 Hours
0. Introduction	1	-	-
1. Principles of IRT	7	2	2
1. Heat transfer	*		
2. Electromagnetic spectrum	*		
3. Emittance, reflectance and transmittance	*		
4. Atmospheric transmission	*		
5. IR wavebands and lens materials	*		
6. Conduction Fundamentals	*		
7. Fourier's Law		*	*
8. Conductivity/Resistance	*		
9. Convection Fundamentals, Newton's Law of Cooling	*		
10. Radiation Fundamentals	*		
11. Planck's Law		*	*
12. Wien's Law		*	*
13. Stefan Boltzmann Law	*		
2. Equipment and data acquisition	7	2	2
1. How your imager works	*		
2. Selection criteria		*	*
3. Range and level settings	*		
4. Operation of Equipment	*		
5. Controls	*		
6. Lenses	*		
7. Getting a good image	*		
8. Clarity (focus)	*		
9. Dynamic Range	*	*	*
10. Recognising and dealing with reflections	*		
11. Recognising and dealing with convection		*	*
12. Calibration	*		
13. Environmental and operational conditions	*		
14. Data storage	*		
3. Image Processing	7	2	2
1. Temperature Measurement	*		
2. Measurement functions	*		
3. Accuracy	*		
4. Emissivity measurements	*	*	
5. Avoiding Errors (error source recognition, prevention or control)	*		

SUBJECT	Level 1 Hours	Level 2 Hours	Level 3 Hours
6. Small spot size	*		
7. Distance	*	*	
8. Atmospheric Attenuation	*		
9. Support Data Collection and Equipment		*	*
10. Environmental Data	*	*	*
11. Software		*	*
12. Image Interpretation	*	*	*
13. Establishing thermal severity criteria (absolute, Delta, statistical)		*	*
4. Condition Monitoring	3	-	8
1. Fundamental principles	*		
2. Control values	*		
3. Alternate technologies		*	*
4. Correlation of CM techniques	*		*
5. Procedure writing			*
5. General Applications	8	1	1
1. Electrical	*	*	*
2. Mechanical	*	*	*
3. Civil	*	*	*
6. Electrical Applications	-	24	7
1. Electrical engineering (components & construction)		*	*
2. IR theory to electrical applications and thermal signatures		*	*
3. Applications		*	*
3a. Electrical distribution		*	*
3b. Electrical panels		*	*
3c. Electrical components		*	*
3d. Electric motors		*	*
4. Fault analysis		*	*
5.			
5. Safety issues		*	*
7. Mechanical Applications	-	24	7
1. Mechanical engineering (components & construction)		*	*
2. IR theory to mechanical applications and thermal signatures		*	*
3. Applications		*	*
3a. Rotating equipment		*	*
3b. Fluid flow		*	*
3c. Power transmission		*	*

SUBJECT	Level 1 Hours	Level 2 Hours	Level 3 Hours
3d. Furnaces		*	*
3e. Tanks		*	*
4. Fault analysis		*	*
5.			
5. Safety issues		*	*
8. Civil Applications	-	24	7
1. Civil engineering (components & construction)		*	*
1a. Construction types		*	*
1b. Material types		*	*
2. IR theory to civil applications and thermal signatures		*	*
2a. Properties of materials		*	*
2b. Environmental conditions		*	*
3. Building envelope		*	*
3a. Insulation		*	*
3b. Moisture		*	*
3c. Air leakage		*	*
4. Other structures		*	*
4a. Structural details and defects		*	*
4b. Structural finishes		*	*
5. Fault analysis		*	*
6.			
5. Safety issues		*	*
9. Condition monitoring programme design and Acceptance testing	1	1	6
1. Overview	*	*	*
2. Techniques selection (include VA, AE, LM)		*	*
3. Measurement intervals		*	*
4. Procedure development		*	*
5. Reference temperatures		*	*
6. Baseline temperatures		*	*
10. Condition monitoring programme implementation	2	1	3
1. Overview	*	*	*
2. Safe systems of work and data acquisition		*	*
3. Roles and responsibilities		*	*
4. Training and accreditation		*	*
11. Condition monitoring programme management	-	2	3
1. Safety management		*	*
2. Equipment management		*	*
3. Procedure management		*	*

SUBJECT	Level 1 Hours	Level 2 Hours	Level 3 Hours
4. Skills and competencies management		*	*
5. Database management		*	*
6. Managing corrective action implementation		*	*
12. Corrective Actions	-	1	1
1. Electrical		*	*
2. Mechanical		*	*
3. Civil		*	*
13. Codes and Standards	1	1	2
1. Overview (ISO 18434, 18436)	*	*	*
2. Electrical		*	*
3. Mechanical		*	*
4. Civil		*	*
5. Diagnostics		*	*
6. Prognostics		*	*
7. Safety		*	*
14. Reporting and documentation (ISO Standards)	2	0	0
1. Presentation	*		
2. Clients' needs	*		
3. Thermographers' and end-users responsibilities (all sectors)	*		
15. Diagnostics & prognostics	-	2	2
1. Diagnostics principles and processes		*	*
2. Prognostic principles and processes		*	*
16. Training examination	1	1	1
Total Hours	40	40** [Only 1 module from subjects 6, 7 or 8]	40** [Only 1 module from subjects 6, 7 or 8]

Notes:

- Level 2 includes the knowledge of Level 1; Level 3 includes the knowledge of Level 1 and Level 2.
- The topics specific to each sector [topics 6, 7 and 8] at level 2 and 3 are modularised, so that the candidate can gain training from various ATO's that may specialise in the sectors of application sought for certification.

** At levels 2 and 3 the times allocated are indicative only, indicating the bias towards application topics, and the actual times spent for each topic is flexible, providing an advised minimum of approximately 24 hours is allocated per field of application.

Annex B – Reading references

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

Levels	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
1, 2, 3	Safe Thermal Imaging of Electrical Systems	C. Pearson	UK Thermography Association, 1997	Application Guide AG/97
1, 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
1, 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	<i>Business-focussed Maintenance- A BSRIA Guide</i>	<i>J Harris, P Hastings</i>	<i>BSRIA, 2004 BG/3/2004</i>	<i>0860226042</i>

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

1. ISO 13374. Part 1. 2003. Condition monitoring and diagnostics of machines- Data processing, communication and presentation: Part 1. general Guidelines
2. ISO 13372: 2004, Condition monitoring and diagnostics of machines- vocabulary
3. ISO 17359: 2003, Condition monitoring and diagnostics of machines- general guidelines
4. ISO 13379: 2003, Condition monitoring and diagnostics of machines- Data interpretation and diagnostic techniques.- General guidelines
5. CMGEN: 2004, General requirements for qualification and certification of condition monitoring and diagnostic personnel
6. ISO 13381-1: 2004, Condition monitoring and diagnostic of machines; prognostics: Part 1 general Guidelines

7. ISO 18436-1: 2004, Condition monitoring and diagnostics of machines; requirements for training and certification of personnel. Part 1, Requirements for certifying bodies and the certification process
8. ISO/IEC 17024: 2003, Conformity assessment- general requirements for bodies operating certification of persons
9. ISO/DIS 18434-1. Condition monitoring and diagnostics of machines. Thermography. Part 1: General procedures.
10. *BS 5760-5: 1991. Reliability of systems, equipment and components: Guide to failure modes, effects and criticality analysis (FMEA and FMECA). ISBN 0580 196607*
11. *BS 5760-7: 1991 (IEC 61025: 1990). Reliability of systems, equipment and components. Fault tree analysis. ISBN 0580 203387*

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

Level	Title	Author(s)	Publisher	ISBN/Publ No
1, 2	Product Technology Classroom Training Handbook		BINDT	
2, 3	Practical Applications of Infrared Thermal Sensing and Imaging Equipment	H Kaplen	Society of Photo-Optical Instrumentation Engineers, 1999, 2 nd Edition	0819431389
2,3	<i>NFPA 70E Standard for electrical safety in the workplace</i>	<i>NFPA</i>	<i>NFPA (USA), 2004 Edition</i>	
2,3	<i>NFPA 70B Recommended practice for electrical equipment maintenance</i>	<i>NFPA</i>	<i>NFPA (USA), 2002 Edition</i>	

Topics	Level 2	Sub-topics
Establishing thermal severity criteria (absolute, Delta, statistical)	*	reflection; qualitative evaluation; radiosity; image subtraction; image montage; general image interpretation guidelines; Principles; quantitative evaluation; maximum operating temperature; general guidelines for establishing thermal severity assessment criteria (ISO/DIS 18434, Engineering codes and standards)
5. General Applications		Discussion on general industrial applications not covered by the sector topics defined.
Electrical	*	MCB; MCC; HV lines; LV lines; sub-stations; micro-electronics; active and passive thermography;
Mechanical	*	Principles; motors; pumps; gearboxes; engines; pumps; compressors, fans; rotating equipment; reciprocating equipment; steam traps; active and passive thermography;
Civil	*	Buildings; bridges; viaducts; roads; ground; materials; diffusivity; thermal capacity; concrete; de-laminations; corrosion; materials in general; active and passive thermography;
6. Electrical Applications		
Electrical engineering (components & construction)	*	Principles; load current; heat transfer paths;
IR theory to electrical applications and thermal signatures	*	Principles; 3-phase motor drives; cable insulation; PVC, Cu; conductivity;
Applications		
3a. Electrical distribution	*	MCC, MCB, LV/HV lines; MIBC cables; transformers
3b. Electrical panels	*	Busbars; MCC; MCB; transmissivity; Perspex; windows;
3c. Electrical components	*	Crimping; batteries; principles; construction; circuit breakers;
3d. Electric motors	*	Motors; principles; construction; bearings
Fault analysis	*	Isolators; sub-stations; load current; colour palette, principles, MCC, MCB, BS 7671
Acceptance criteria	*	Principles; allowed temperatures and temperature drops;
Safety issues	*	Principles; risk assessment; health, safety and environment; Electricity at Work regulations; HV current breakers; maximum temperature; inspections; safety protocols
7. Mechanical Applications		
Mechanical engineering (components & construction)	*	Principles; mechanisms; bearings;
IR theory to mechanical applications and thermal signatures	*	Applications; signatures; steam traps; propane/butane tanks; friction; typical machinery failure modes and their associated thermal signatures; ISO/DIS18434, valves
Applications	*	Limitations
3a. Rotating equipment	*	Drive shafts; bearings; worm and wheel fan drives; fans;
3b. Fluid flow	*	Heat exchangers; clean labs; steam traps; pumps; boilers; safety valves; pressure vessels; pipes; condensates
3c. Power transmission	*	Belts; pumps; fan drive;
3d. Furnaces	*	Construction; refractories; components; windows; quartz
3e. Tanks	*	Tanks; pressure vessels; floating roofs;

Topics	Level 2	Sub-topics
Fault analysis	*	Principles; Pipe cladding; cryogenics; baseline; paper machines;
Acceptance criteria	*	Baseline; acceptance principles; severity assessment and acceptance criteria (engineering codes and standards);
Safety issues	*	Risk assessment; principles and protocols; superheated steam systems;
8. Civil Applications		
Civil engineering (components & construction)	*	Principles, components and construction; thermal bridging; sick building syndrome;
1a. Construction types	*	Types; buildings, historical, 1880-1940 structures, post 1940 structures; roads; bridges;
1b. Material types	*	Materials (concrete, glass, steel, timber, plastics); emissivity;
IR theory to civil applications and thermal signatures	*	Principles and applications; signatures
2a. Properties of materials	*	Conduction; phase change; cryogenics;
2b. Environmental conditions	*	Direct transfer; night-day; wind; rain; sun;
Building envelope	*	Principles; construction; rules; mechanisms;
3a. Insulation	*	Active and passive surveys; resolution; night surveys; wind; moisture; types; flux; freezers/cryogenics
3b. Moisture	*	Condensation; affects of moisture; industrial/domestic buildings; roofs;
3c. Air leakage	*	Pressure differentials; temperature differentials; building construction and anomalies; permeability;
Other structures	*	Buried tanks; roads; viaducts; bridges
4a. Structural details and defects	*	Gas turbines; boilers; tanks; refractories; ducts; pipes; walls; windows;
4b. Structural finishes	*	Concrete block; rendering; paints; surfaces; de-bond
Fault analysis	*	Grilles; SW/LW systems; pipes; solar reflection; principles; anomalies; reflections from other bodies
Acceptance criteria	*	Warranty period; solar path; environmental conditions; construction-type-materials;
Safety issues	*	detection of anomalies; roof surveys
9. Condition monitoring programme design and Acceptance testing		
Overview	*	CMGEN; ISO17359, 18434, 13379, 13381; general principles
Techniques selection	*	Thermal imaging; non-contact pyrometers; heat flux indicators;
Measurement intervals	*	Principles;
Procedure development	*	Prioritisation; costs; protocols; defect severity analysis
Reference temperatures	*	Principles; severity of anomalies;
Baseline temperatures	*	Principles
10. Condition monitoring programme implementation		
Overview	*	CMGEN; ISO 17359, 13381, ISO/DIS 18434
Safe systems of work	*	Procedures
Roles and responsibilities	*	CMGEN; ISO 18436
Training and accreditation	*	CMGEN, ISO 18436
11. Condition monitoring programme management		

Topics	Level 2	Sub-topics
Safety management	*	Protocols; risk assessment
Equipment management	*	Principles
Procedure management	*	Principles, ISO 17359
Skills and competencies management	*	CMGEN, ISO18436
Database management	*	ISO 13374, 13372, 13379
Managing corrective action implementation	*	Principles; protocols; corrosion/temperature
12. Corrective Actions		
Electrical	*	Recommendations for distribution boards, panels, components, motors; HV, LV lines; substations
Mechanical	*	Recommendations for pumps, bearings, motors, compressors, engines; machinery corrective and preventive actions;
Civil	*	Recommendations for building defects, bridge anomalies, road defects; physical inspection; boroscope; study of designs/plans
13. Codes and Standards		
Overview	*	ISO 13374, 13372, 13379, 18436, 17359; ISO/DIS18434
Electrical	*	BS 7671
Mechanical	*	ISO 281, ISO 18436-2;
Civil	*	Annex B (Guide AG1/2003, Building fabric)
Diagnostics	*	ISO/DIS 13373-1
Prognostics	*	ISO 13381-1
Safety	*	HSWA; EAW; PUWER; CDM;
15. Diagnostics & prognostics		
Diagnostics principles and processes	*	Principles; processes; ISO/CD 13373-1, 13379
Prognostic principles and processes	*	Principles; processes; motors; ISO 13381-1