INTERNATIONAL STANDARD

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Performance of buildings — Detection of heat, air and moisture irregularities in buildings by infrared methods —

Part 3: Qualifications of equipment operators, data analysts and report writers

Performance des bâtiments — Détection d'irrégularités de chaleur, air et humidité dans les bâtiments par des méthodes infrarouges —

Partie 3: Qualification des opérateurs de l'équipement, des analystes de données et des rédacteurs de rapports

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 163 *Thermal performance and energy use in the built environment*, Subcommittee SC 1, *Test and measurement methods*.

ISO 6781 consists of the following parts under the general title *Performance of buildings — Detection of heat, air and moisture irregularities in buildings by infrared methods*

— *Part 3: Qualifications of equipment operators, data analysts and report writers*

The following parts are under development:

— *Part 1: General procedures*

— *Part 2: Equipment requirements*

— *Part 4: Conducting thermographic inspections and reporting of results for residential and small buildings*

— *Part 5: Conducting thermographic inspections and reporting of results for commercial buildings*

— *Part 6: Conducting thermographic inspections and reporting of results for institutional and special use buildings*

A.1, A.2 and Annex B form *normative* parts of this part of ISO 6781.

Introduction

Reducing energy use in buildings is paramount to improving our environment. Infrared building thermography provides a tool to quantitatively and qualitatively identify the presence of energy-wasting defects and anomalies within building structures. These defects and anomalies can include, for example, thermal insulation defects, moisture content, and / or unwanted air movement or leakage within the building envelope.

Building thermography is carried out by means of an infrared radiation sensing system, which produces an image based on the apparent radiance temperature of the target surface area. The thermal radiation (infrared radiation density) from the target area is converted by the infrared radiation sensing system to produce a thermal image (thermogram). This image (thermogram) represents the relative intensity of thermal radiation from different parts of the surface. The radiation intensity indicated by the image is directly related to (i) the surface temperature and distribution, (ii) the characteristics of the surface, (iii) the ambient conditions, and (iv) the sensor itself. Also included in the thermographic process is valid interpretation of the thermal images.

As a result, surface temperature distribution can be a key parameter for monitoring the performance of building components, building envelopes and the diagnostics of problems. In use, via analysis of surface temperature distributions, irregularities in the heat and moisture properties of building envelopes and components, and air movement within the building envelope, can be indicated. These irregularities can be due to, for example, thermal insulation defects, moisture content, air leakage within components, or incorrect installation of components which comprise the construction of the building.

To realize its full utility as an initial qualitative screening technique, or in-depth diagnostic technique, thermography is often supported and / or validated by other methods. Such methods include, but are not limited to, infrared photosensitive tracer gas methods, fan pressurization of the building envelope, heat-flow meters, smoke diffusion, anemometry, etc.

The effectiveness of the investigations depends on the competence of individuals who perform the measurements and analyse the data. A person or entity wishing to use or implement infrared thermographic services for buildings can refer to this part of ISO 6781 to understand and specify (i) the competence required of operators of the thermographic equipment, and (ii) the qualifications required of interpreters of data gathered from the thermographic surveys.

This part of ISO 6781 sets out the requirements and levels of competence that equipment operators, data analysts and report writers shall possess in order to undertake thermographic investigations and the analysis and reporting of thermographic results stemming from investigations.

For validity of requirements to this part of ISO 6781, assessment of competence will be undertaken by bodies qualified to train and assess the competence of personnel whose duties require the appropriate theoretical and practical knowledge applicable to thermography of buildings.

Performance of buildings — Detection of heat, air and moisture irregularities in buildings by infrared methods —

Part 3: Qualifications of equipment operators, data analysts and report writers

1 Scope

This part of ISO 6781 specifies the qualifications and competence requirements for personnel who (i) perform thermographic investigations on buildings, (ii) interpret the data emanating from thermographic investigations, and (iii) report the results of thermographic investigations.

This part of ISO 6781 provides the basis for a statement of conformity, in three classes, of the knowledge, skills and abilities of individuals to perform thermographic measurements, analysis and reporting of results for small buildings, residential buildings, and commercial and institutional buildings.

This part of ISO 6781 is not applicable to specialized equipment or other specific situations.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 9288:1989, *Thermal insulation* — Heat transfer by radiation — Physical quantities and definitions

ISO/IEC 17024:2012, *Conformity assessment — General requirements for bodies operating certification of persons*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 9288:1989 and the following apply.

3.1
trainee
person who is being trained to become qualified

3.2
significant interruption
absence or change of activity which prevents the assessed individual from practising the duties corresponding to the defined scope of their classification for (a) a continuous period in excess of 365 days or (b) two or more periods for a total time exceeding two-fifths of the total period of validity of the certificate or declaration of conformity

3.3
test instrument
any means used (whether oral, written or demonstrative) to test that required knowledge, skills and abilities have been effectively assimilated, and can be effectively deployed in practice, by an individual

3.4
qualification body
body independent of the employer, able to prepare and administer qualification examinations

4 Classification of personnel

4.1 General

Individuals assessed as conforming to the training and practical experience requirements of this part of ISO 6781 shall be classified into one of three classes depending upon their qualifications. They shall have demonstrated the necessary knowledge, skills, abilities and experience in thermography of buildings for their Class as detailed in Annexes A and B. Training durations shall be at least the minimum duration summarized in Table 1. Required practical experience will be of duration at least the minimum as summarized in Table 2.

Personnel classified as Class II need to have all the knowledge, skills and abilities expected of personnel classified as Class I, while personnel classified as Class III need to have all the knowledge, skills and abilities expected of personnel classified as Class II.

4.2 Class I

For the requirements of this part of ISO 6781 to be met, training specified in 5.2 shall be delivered by (i) a qualifying body, (ii) training will be delivered by persons fully qualified as Class III for thermography of buildings, and (iii) assessments of competence shall conform to the requirements of ISO/IEC 17024:2012 in assessing the knowledge, skills and abilities of personnel who require the theoretical and practical knowledge applicable to thermography of buildings.

Individuals classified as Class I are qualified to perform infrared thermography of buildings according to established and recognized procedures. Personnel classified as Class I shall have the knowledge, skills and abilities to be able to:

a) apply a specified thermographic measurement technique;

b) have knowledge of, set up and operate the thermal imaging equipment for safe thermographic data collection;

c) prevent, minimize or control poor data and error sources;

d) perform basic fault detection, severity assessment, and diagnosis in accordance with established instructions;

e) perform basic image post processing (measurement tools, emissivity adjustments, span and scale adjustments, etc);

f) maintain a database of results and trends;

g) verify the calibration of thermographic measurement systems;

h) in accordance with established criteria, evaluate and report test results and highlight areas of concern; and

i) be able to recognize and prevent or control factors that result in the acquisition of poor-quality data (sources of data error).

4.3 Class II

Individuals classified as Class II are qualified to perform infrared thermography of buildings according to established and recognized procedures. Preparation of reports involving structural components and

elements of buildings shall be undertaken by registered professionals in accordance with local statutes and regulations. Personnel classified as Class II shall have the knowledge, skills and abilities to be able to:

a) select the appropriate infrared thermography technique and understand its limitations;

b) apply thermography theory and techniques, including measurement and interpretation of survey results;

c) specify the appropriate hardware and software;

d) perform advanced diagnoses of irregularities found during thermographic investigations;

e) in accordance with industry-accepted practices, standards and regulations and statutes, recommend appropriate corrective actions;

f) perform advanced image post processing (image, trending, montage, subtraction, super-imposition, statistical analysis, etc.);

g) use generally recognized advanced techniques for infrared thermography of buildings and diagnosis of irregularities in accordance with established procedures;

h) prepare reports on as-found building condition, faults, irregularities and diagnoses, and recommend corrective actions for repair and remediation;

i) be aware of the use of alternative or supplementary technologies that support or enhance the effectiveness of thermographic investigations of buildings;

j) provide guidance to and supervise Class I personnel.

4.4 Class III

Individuals classified as Class III are qualified to perform infrared thermography of buildings according to established and recognized procedures. Personnel classified as Class III shall have the knowledge, skills and abilities to be able to:

a) develop and establish thermographic programmes, procedures, and instructions including determination of regimens for periodic / continuous monitoring, frequency of testing, the use of advanced techniques;

b) determine severity assessment and acceptance criteria for new, existing and renovated buildings;

c) interpret and evaluate codes, standards, specifications and procedures;

d) designate the particular test methods, procedures, equipment and instructions to be used;

e) perform prognostics for detected heat, air movement and moisture irregularities;

f) recommend appropriate types of corrective actions based on sound building technology practices;

g) provide guidance to and supervise Class I and II personnel; and

h) be able to recommend the use of alternative or supplementary technologies for detection of heat, air and moisture irregularities in buildings by infrared methods.

5 Eligibility

5.1 General

Candidates shall have a combination of education, training and experience to ensure that they understand the principles and procedures applicable to thermographic measurement, analysis and report writing.

Candidates shall have colour perception assessed by the Ishihara 24 plate test. A record of test results shall be retained and presented to the assessment body upon request. In the event that a colour perception deficiency, indicated by misreading four or more of the 24 plates, is detected during the Ishihara test, a further 'task specific' test is to be carried out by the employer to ascertain whether the detected colour perception deficiency affects the individual's ability to satisfactorily perform analysis of thermographic data using colour palettes. Failure to pass this test shall 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 assessment body upon request.

5.2 Qualifications — Education, training and experience

5.2.1 Education requirements — General

Candidates seeking classification do not need to provide evidence of formal education to establish eligibility. Candidates for Class I and II shall have at least a secondary school (i.e. high school) or equivalent graduate qualification. Class II and III shall be able to manipulate simple algebraic equations, use a scientific calculator, and be familiar with the operation of personal computers.

It is recommended for candidates seeking classification to Class III that two or more years of mechanical technology, building technology or mechanical engineering at a college, university, or training at a technical school, be successfully completed.

5.2.2 Qualification requirements — Training

Candidates shall be qualified by confirming the knowledge, skills and abilities outlined in the essential learning specified in 4.2, 4.3 and 4.4. The prerequisites required to attain each level of classification are listed in 5.1 and 5.2. The competence requirements for each of an equipment operator, a data analyst, and a report writer shall be the same.

5.2.2.1 Structure of training materials

Training shall be modularised into two or more subject areas covering general scientific principles of thermography, application-specific knowledge of building thermography, and building technology, in order to allow for mutual recognition between building-thermography training and assessment bodies.

5.2.2.2 Candidate training — Building thermography

To be eligible to apply for a Class based on this part of ISO 6781, candidates shall submit evidence of training in thermography subjects in accordance with the requirements and minimum training time of Annex A. Training shall be in the form of lectures, demonstrations, practical exercises or formal training courses.

5.2.2.3 Candidate training — Building technology

Candidates shall attend and successfully complete building technology training, or equivalent on-the-job training, as assessed by the qualification body (3.4), of at least a similar duration as specified in Annex A.

Building technology training shall be in addition to the general education requirements in 5.2.1.

Class I training shall consist of the design, construction, installation and maintenance of building materials and systems as it relates to the heat, air and moisture flow in buildings.

Class II training shall consist of the building science principles related to the degradation and failure of materials and systems as it relates to the heat, air and moisture flow in buildings.

Class III training shall consist of the building science principles related to the mitigation, remediation and/or replacement of materials and systems as it relates to the heat, air and moisture flow in buildings.

Training shall include the design, manufacturing, installation, operation, and maintenance principles of building construction and components, the failure modes and mechanisms associated with each principle, and the typical thermodynamic behaviours associated with each mechanism. Records of training shall be provided.

5.2.2.4 Total minimum training time

For ab-initio trainees, the total minimum training time to cover all subjects in accordance with Annex A is summarized in Table 1:

Table 1 — Minimum duration of training in each class (hours)

Class I	Class II	Class III
60	60	40

5.2.3 Qualifications — Practical experience

Candidates shall submit verified documented evidence of practical experience in thermographic building investigations and evaluations in accordance with 4.2, 4.3 and 4.4 and of at least the duration shown on Table 2.

Verifiable documentary evidence of hours and nature of candidate's thermography-based building investigations experience shall be provided for Class I. Class I candidates shall have this evidence validated by a Class II or III person and by a second qualified independent person or body. Class II candidates shall have this evidence validated by a Class III person and by a second qualified independent person or body. The validation process for all categories requires the signature of the validating persons on the documentary evidence. The validating persons shall augment this validation process via oral assessment based on the requirements of this part of ISO 6781, accompanied task performance, reports' submission and review, procedures' submission and review, or a combination thereof in order to ensure confidence in the validation.

Attainment of the next Class requires that the previous Class practical work experience has been attained.

Table 2 — Minimum practical, interpretation and programme-management experience requirements (months and hours)

Class I	Class II	Class III
12 months	24 months	48 months
400[a] h	1200[a] h	1920[a] h
a Denotes the actual hours of practical thermography experience that are required.		

5.2.3.1 Candidates with practical experience in other fields of thermography

For candidates with verified practical experience in fields of thermography other than buildings, and complying with this part of ISO 6781, a modular supplementary training course designed to cover the topics particular to thermographic investigations of building performance shall be undertaken.

The supplementary training course shall cover the topics outlined in Annex A for subjects Five (5) through Eleven (11) inclusive. The duration of such training shall comply with the durations stated in Annex A for the relevant subject areas.

Subjects Zero (0) through Four (4) need not be taken.

5.2.3.2 Candidates with practical experience in thermography of buildings

Candidates who have 200 or more hours of verified practical experience, verified by the qualification body, in the thermographic investigation of buildings in each of the previous three years, without

significant interruption, may have their knowledge, skills, and abilities assessed for exemption from Class 1 training examination subjects 0 to 12 specified in Annex A.

6 Test instruments (examinations)

6.1 Administration of test instruments

All test instruments shall be administered in accordance with ISO/IEC 17024:2012. Candidates shall have access to pencils and erasers if computer-based marking is used. The candidate shall be allowed the times specified in Table 3 for undertaking the test instruments for each Class. These cover (i) completion of examination of subjects 1 to 11 of the training syllabus on Infrared thermography — General, in A.1, and (ii) completion of examination of subjects 13 to 17 of the training syllabus, Building technology and building thermography, in A.1.

6.2 Content

The test instruments for Classes I, II and III shall comprise a Part A: General thermography, and a Part B: Building technology, in accordance with Table 3

Table 3 — Minimum examination content

Classes	Number of questions	Time (hours) Multiple choice	Time (hours) Written problem(s)	Time (hours) Practical demonstration	Passing grade
Class I: IRT — General	50	1,5	0	0,5	75
Class I: Building Technology	50	1,5	0	0,5	75
Class II: IRT — General	30	1,0	0,5	0,5	75
Class II: — Building Technology	30	1,0	0,5	0,5	75
Class III: IRT — General	10	0,5	2,0	0,5	75
Class III: Building Technology	10	0,5	2,0	0,5	75

6.2.1 Knowledge

For each Class, the candidates shall be required to demonstrate their knowledge with a set number of multiple choice questions, written problems and practical demonstrations per the specified times allowed by Table 3. Each question shall have four answers with one correct answer and three distractors.

Questions shall be of a practical nature and test the candidate on concepts and principles required, per Annex B, to conduct infrared thermography for the detection of heat, air and moisture in building materials and systems.

6.2.2 Skills

The candidates shall be required to demonstrate their skills by solving a set number of practical applied problems in the specified time as allowed in by Table 3.

The image interpretation problems shall be based on case histories requiring fault identification, solution recommendation, and a solution verification process. Some problems shall involve the interpretation of thermal images. Simple mathematical calculations using a scientific calculator shall be required. A summary of common formulas shall be provided along with the problems.

6.2.3 Abilities

The candidates shall be required to demonstrate their abilities by means of a defined practical assignment in a specified time.

Class I: The test instrument shall cover accurate data acquisition, the recognition, prevention and control of error sources, and basic fault diagnosis. This test instrument shall include both physical data acquisition tasks and image interpretation. The test instrument shall be based on the concept, principles and practical experience outlined in Annexes A and B.

Class II: The test instrument shall cover advanced data acquisition, the recognition, prevention and control of error sources, and basic fault diagnosis. This test instrument shall include both physical data acquisition tasks and image interpretation. The test instrument shall be based on the concept, principles and practical experience outlined in Annexes A and B.

Class III: The test instrument shall cover advanced diagnostics and image interpretation, solution design, and solution verification. This examination shall include both physical data acquisition tasks in addition to image interpretation. The test instrument shall be based on the concept, principles and practical experience outlined in Annexes A and B.

Annex A
(normative)

Training course requirements for thermography personnel

A.1 Training syllabus

Subject	Class I h	Class II h	Class III h
Infrared thermography (IRT) — General	-	-	-
0. Introduction	0,5	-	-
1. Principles of IRT	8	8	2
2. Equipment and data acquisition	2,5	1,5	0
3. Introduction to ancillary equipment	1	0	0
4. Image processing	3,5	2	2
5. General applications	3,0	0	0
6. Diagnostics and prognostics	0,5	2	2
7. Corrective actions	0,5	4	4
8. Reporting and documentation (ISO standards)	1	1	0,5
9. Design of buildings' thermographic, diagnostic and monitoring programmes	0	1	3,5
10. Thermographic programme implementation for buildings	1	1	3
11. Thermographic programme management for buildings	0,5	1,5	4
12. Training examination: Subjects 1 to 11	2	2	3
Infrared thermography — General — Total	**24**	**24**	**24**
Building technology and thermography			
13. Building technology / Building physics	16	6	2
14. Building thermography	8	12	4
15. Ancillary devices	2	4	2
16. Detection of heat, air and moisture in building materials and systems	8	12	5
17. Training examination: Subjects 13 to 16	2	2	3
Building technology and building thermography — Total	**36**	**36**	**16**
Total hours for each class	**60**	**60**	**40**

A.2 Detailed list of topics and hours of instruction

Subject	Topics	Class I h	Class II h	Class III h
0. Introduction		0,5	-	-
1. Principles of IRT		8	8	2
	Fundamental principles of energy and heat	*		
	Temperature scales and conversions	*		
	1st and 2nd Law of Thermodynamics	*		
	0th and 3rd Law of Thermodynamics		*	
	Transient and steady-state heat flow	*	*	*
	Principles of heat capacity	*		
	Phase change and latent heat	*	*	
	Thermal diffusivity and system response time		*	*
	Material properties related to heat, air and moisture flow	*	*	
	Specular and diffuse surfaces	*	*	
	Kirchhoff's Law	*	*	*
	Emissivity of building materials	*	*	*
	Heat and heat transfer	*		
	Conduction fundamentals	*		
	Fourier's Law		*	*
	Conductivity/Resistance	*		
	Convection fundamentals	*		
	Newton's Law of Cooling		*	*
	Radiation fundamentals	*		
	Electromagnetic spectrum	*		
	Atmospheric transmission	*	*	
	IR wavebands and lens materials	*		*
	Radiation reference sources		*	*
	Planck's Law		*	
	Wien's Law		*	
	Stefan Boltzmann Law	*		
	Emittance, reflectance and transmittance	*		
	Emissivity	*	*	*
	Factors affecting emissivity	*	*	*
2. Equipment and data acquisition		2,5	1,5	0
	How your infrared camera works	*		
	Infrared camera selection criteria		*	
	Spectral band	*	*	
	Temperature measurement range	*		
	Thermal sensitivity (NETD)		*	
	Lens selection	*	*	
	Optical resolution	*	*	
	Operation of equipment	*	*	

Subject	Topics	Class I h	Class II h	Class III h
	Accessories	*	*	
	Camera controls		*	
	ISO 6781-1, *General procedures*	*	*	
	Safe data acquisition	*	*	
	Getting a good image	*		
	Image composition	*	*	*
	Image clarity (optical focus)	*		
	Thermal tuning (range, level and span)	*		
	Palette selection	*		
	Emissivity determination	*	*	
	Error source recognition, prevention or control	*	*	
	Waveband selection criteria		*	*
	Recognizing and dealing with radiation (reflections, reflected apparent temperature)	*	*	*
	Recognizing and dealing with convection	*	*	*
	Recognizing and dealing with conduction	*	*	*
	Effects of incorrect emissivity	*	*	
	Camera calibration	*	*	
	Environmental and operational conditions	*	*	
	Data and image storage	*		
	Optical resolution: detection	*	*	
	Optical resolution: recognition		*	
	High bit versus low bit data storage	*		
3. Introduction to ancillary equipment		1	0	0
	Thermometers	*		
	Moisture meters	*		
	Hygrometers	*		
	Air flow meters, anemometers	*		
	Heat flow meters	*		
	Manometers	*		
	Smoke generators and pencils	*		
	Boroscopes	*		
	Photographic and videographic equipment	*		
	Blower doors	*		
	Building fan systems	*		
	Data loggers	*		
4. Image processing		3,5	2	2
	Temperature measurement	*	*	
	ISO 6781-1, *General procedures*	*	*	*
	Non-contact thermometry	*		
	Comparative quantitative thermography	*	*	
	Comparative qualitative thermography	*	*	
	Environmental influences	*	*	

Subject	Topics	Class I h	Class II h	Class III h
	Camera measurement tools	*	*	
	Measurement tools	*	*	
	Palette selection	*		
	Level and span adjustment	*		
	Distance (atmospheric) correction	*	*	
	Emissivity correction		*	
	Statistical analysis		*	
	Image subtraction		*	*
	Image montage	*	*	*
	Temperature trending	*	*	*
	General image interpretation guidelines		*	*
	General guidelines for establishing thermal severity assessment criteria (engineering codes and standards)		*	*
	Image storage and archiving	*	*	*
5. General applications		3	0	0
	Discussion on active and passive thermography in buildings and building equipment including acceptance criteria	*		
	Safety issues	*		
6. Diagnostics and prognostics		0,5	2	2
	Basic principles of diagnostics	*	*	*
	Basic principles of prognostics		*	*
7. Corrective actions		0,5	4	4
	Corrective and/or preventive actions that can be taken to solve or mitigate the heat, air of moisture irregularities in buildings		*	*
8. Reporting and documentation (ISO standards)		1	1	0,5
	Thermographers' and end-users' responsibilities	*	*	*
	Report writing	*	*	*
	Local, regional and international standards	*	*	*
9. Programme design for buildings thermographic investigations		0	1	3,5
	General principles	*	*	*
	Technique selection		*	*
	Measurement		*	*
	Reference temperatures	*	*	*
	Expected temperatures	*	*	*
	Remediative measures		*	*
10. Programme implementation for buildings thermographic investigations		1	1	3
	General principles	*		
	Safe systems of work	*	*	
	Roles and responsibilities		*	*
	Training and accreditation		*	*

Subject	Topics	Class I h	Class II h	Class III h
11. Programme management for buildings thermographic investigations		0,5	1,5	4
	Safety management	*	*	*
	Equipment management	*	*	*
	Procedure management		*	*
	Skills and competencies management		*	*
	Database management	*	*	*
	Managing corrective action implementation		*	*
12. Training examination	Subjects 1 to 11	2,0	2,0	3,0
13. Building technology / Building physics		16	6	2
	Building envelope definition	*		
	Construction types	*		
	Material types	*		
	Properties of materials	*		
	Vapour flow, heat flow, air flow fundamentals	*		
	Components and construction	*		
	Structural finishes	*		
	Structural details and defects	*		
	Building regulations	*		
14. Building thermography		8	12	4
	Thermal-anomaly survey objectives and methods	*	*	*
	Air leakage survey objectives and methods	*	*	
	Environmental conditions		*	
	Method selection		*	*
	Supplementary inspection methods	*	*	*
	Fault analysis		*	
	Acceptance criteria		*	
	Safe systems of work	*	*	
	Roles and responsibilities	*	*	*
	Training, certification and accreditation		*	
	Codes and standards:		*	
	Reporting		*	
15. Ancillary devices		2	4	2
	Applications, principles and operation of moisture meters	*		
	Contact and immersion thermometers	*		
	Hygrometers	*		
	Air flow meters, anemometers	*		
	Manometers	*		
	Heat flow meters	*	*	

Subject	Topics	Class I h	Class II h	Class III h
	Smoke generators and pencils	*		
	Photographic and videographic equipment	*		
	Boroscopes	*		
	Blower doors	*	*	
	Building fan systems		*	*
	Data loggers		*	*
	Specification of the above instrumentation		*	*
16. Building applications – Detection of heat, air and moisture in building materials, systems and components		8	12	5
	Building technology (construction, system and operation) – General	*	*	*
	Building technology (construction, system and operation) – by building type	*	*	*
	Typical heat and air leakage and moisture transport mechanisms and modes and their associated thermal signatures	*	*	*
	Severity assessment and acceptance criteria (engineering codes and standards)	*	*	*
	Safety issues	*	*	*
	ISO 6781-1, *General procedures*	*	*	
17. Training examination	Subjects 13 to 15	2,0	2,0	3,0
Total hours		**60**	**60**	**40**

NOTE 1 Class II includes the knowledge of Class I; Class III includes the knowledge of Class I and Class II.

NOTE 2 * indicates subject taught at indicated Class level.

Annex B
(normative)

Training course details

This is a guide to the topics that shall be covered. This list is not exhaustive.

Topics	Details
1. Principles of IRT	
Heat transfer	General principles of conduction, convection and radiation
Phase change and latent heat	Condensation, evaporation, freezing and thawing; Phase change heat transfer rate; Latent heat heat-transfer values associated with phase changes; Dew point considerations
Electromagnetic spectrum	Basic characteristics of electro-magnetic (E-M) radiation and the different wavebands
Emittance, reflectance and transmittance	Factors affecting emissivity, reflectance and transmittance
Atmospheric transmission	Primary absorption (CO_2, H_2O, aerosol) factors affecting IR transmission in both IR thermal wavebands
IR wavebands and lens materials	Wavelengths of the mid-wave and long-wave bands
Conduction fundamentals	Where conduction occurs and why; heat flux; thermal conductivity of materials
Fourier's Law	General principles. Mathematical formula and basic discussion of the variables influencing conductive heat flow and surface temperature
Conductivity/Resistivity	The inverse relation between these values and typical building material conductivity and resistivity values
Convection fundamentals	Where convection occurs and why; heat flow; convection loops; rate of heat loss; temperature differentials
Newton's Law of Cooling	Formula and basic discussion of the variables influencing convective heat flow and surface temperature
Radiation fundamentals	Where radiation occurs and why. Reference sources
Planck's Law	General principles; introduction and basic explanation of the Planck Curve re different temperatures; black bodies; emissivity; real temperature difference
Wien's Law	General principles; explanation of shift to shorter wavelength emission with increasing temperature
Stefan Boltzmann Law	Formula and basic discussion of the two variables influencing radiant heat emission
2. Equipment and data acquisition	
How your imager works and selection criteria	Noise Equivalent Temperature Difference (NETD); frame repetition; object size; distances; transmissivity; Instantaneous Field Of View (IFOV); filters; detectors; resolution; palette selection; waveband selection criteria; effects of incorrect emissivity
Range and level settings	Temperature measurement range; thermal tuning (range, level and span)
Operation of equipment	Accessories; emissivity determination
Controls	Level, span, focus, emissivity, background, palette
Lenses	Lens material: The special materials used in thermal IR cameras, selection
Getting a good image	Image composition