Annex A2 Detailed list of topics

Ref:	**Subject** Syllabus topic	**Category**		**Category sub-topics**	
		I	**II**	**I (Hours)**	II (Hours)
0	**Introduction**			**0.5**	
1	**Principles of IRT**			**6**	**6**
1.1	Heat transfer	*		Temperature	
				Heat	
				Heat Transfer	
				• 1^{st} & 2^{nd} Law of Thermodynamics	
				• 0^{th} & 3^{rd} Law of Thermodynamics	
				Conduction	
				Convection	
				Radiation	
				Summary	
1.2	Electromagnetic spectrum	*		Representation of the electromagnetic spectrum	
				Relationship between Frequency/Wavelength/Speed of light	
1.3	Emittance, Reflectance and Transmittance	*		Emissivity - Blackbody, Graybody, Nongraybody (Dielectrics)	
				Reflectance from Spectral and Diffused Surfaces	
				Transmittance/Absorptance of various materials	
				Radiation leaving a target	
				Fundamentals of Radiative Heat Flow	
				• Radiation exchange at the target surface	
				• Radiation impinging on a target surface	
1.4	Atmospheric transmission	*		Transmission vs. wavelength	
				Carbon Dioxide (CO_2) in atmosphere	
				Moisture (H_2O) in atmosphere	
1.5	IR wavebands and lens materials	*		Wavebands - transmittance vs. wavelength	
				Lens materials	
				Lens - types	
				Windows - materials	
1.6	Conduction Fundamentals overview	*		Heat transfer within or between objects	
1.7	Fourier's Law		*		Theory
					Thermal conductivity of composite structures (buildings

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Ref:	**Subject** Syllabus topic	**Category**		**Category sub-topics**	
		I	**II**	**I (Hours)**	II (Hours)
					or refractory) • Building walls • Composite refractory linings
1.8	Conductivity/resistance	*		Thermal conductivity of materials	
				Thermal conductivity of composite structures	
1.9	Convection fundamentals, Newton's Law of Cooling	*		Heat transfer through gasses or liquids	
1.10	**R**adiation fundamentals	*		Radiation properties - Lambertian	
				Radiation properties of dielectrics and other materials	
1.11	Planck's Law		*		Theory
1.12	Wien's Law		*		Theory
1.13	Stefan Boltzmann Law	*		Electromagnetic wave propagation through vacuum or media	
1.14	Active Thermography		*		Principle
					Reflective configuration
					Transmission configuration
					Data analysis in time domain
					Data analysis in frequency domain
					Excitation techniques
1.15	Material evaluation	*	*		
2	**Equipment & data acquisition**			**5**	**3**
2.1	How your imager works	*		Infrared radiation thermometers	
				Line scanners	
				Thermal scanners	
				Thermal imagers (FPA)	
				Waveband selection	
2.2	Selection criteria		*		Camera functions and performance
					Camera features
					Instantaneous field of view (IFOV**)** • Lens angle resolution method • Detector pixel method

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Ref:	**Subject** Syllabus topic	**Category**		**Category sub-topics**	
		I	**II**	**I (Hours)**	II (Hours)
2.3	Range span and Level settings	*		Temperature range	
				Span	
				Level	
2.4	Operation of equipment	*		Overview of available models	
2.5	Controls	*		Emissivity settings	
				Range/span/level settings	
				Temperature measurement	
				Temperature profile	
				Isotherm	
				Palette selection	
				Zoom • Electronic • Optical	
2.6	Lenses	*		Why are different lenses required	
				Electronic zoom vs. optical zoom	
2.7	Getting a good image	*		Importance of correct Temperature range/Span/Level settings	
				Distance (field of view)	
				Minimum target size estimation from lens angle or detector pixels	
2.8	Clarity (focus)	*		Why is correct focus essential when setting up the camera	
2.9	Dynamic range	*	*	Definition of dynamic range	Definition
					Sensitivity, NETD (Noise Equivalent Temperature Difference)
					MRTD (Minimum Resolvable temperature Difference)
					SRF (Slit Response Function)
2.10	Recognising and dealing with reflections	*		Example of solar reflection	
				Example of reflections from nearby objects	
				Method for estimating a reflective temperature	
2.11	Recognising and dealing with convection		*		Thermal Boundary Layer
					Wind effect on surface temperatures
					Thermal conductivity
					Electrical example
					Mechanical example

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Ref:	**Subject** Syllabus topic	**Category**		**Category sub-topics**	
		I	**II**	**I (Hours)**	II (Hours)
					Civil example
2.12	Calibration	*		Quick calibration check using melting ice (about 0°C)	
				Quick calibration check using boiling water (about 100°C) • Include boiling temperature of water vs. pressure for various altitudes	
				Quick calibration check using human tier duct (about 36°C)	
				A check against a calibrated temperature probe	
				A full check on a calibration rig	
2.13	Environmental and operational conditions	*		Atmospheric transmission vs. distance	
				Effect of Carbon Dioxide in the atmosphere	
				Effect of moisture in the atmosphere	
				Effect of solid particles in the atmosphere	
2.14	Data storage	*		Importance of storing data in the original form	
3	**Image processing**			**6**	**2**
3.1	Temperature measurement	*		Cameras can store information in Centigrade and Fahrenheit format	
3.2	Measurement functions	*		Spot temperature	
				Circle function - Maximum/Average/Minimum temperatures	
				Box function - Maximum/Average/Minimum temperatures	
				Temperature profile	
				Isotherm	
3.3	Accuracy (functions affecting accuracy)	*		Atmospheric temperature	
				Reflected temperature	
				Procedure for estimating reflected temperature	
				Target distance – Minimum target size	
				Relative humidity of the atmosphere and Carbon	

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Ref:	**Subject** Syllabus topic	**Category**		**Category sub-topics**	
		I	**II**	**I (Hours)**	II (Hours)
				Dioxide content	
3.4	Emissivity measurement	*	*	Using a calibrated temperature probe	Review Category 1
				Using high emissivity adhesive tape (at low temperatures)	Review Category 1
				Using high emissivity paint (at high temperatures)	Review Category 1
3.5	Avoiding errors (error source recognition, prevention or control)	*		Reflected apparent temperature measurement - Direct method	
				Reflected apparent temperature measurement - Reflector method	
				Importance of initial instrument settings - focus and temperature range	
3.6	Small size	*		Importance of target size	
				Establishing spot size from lens field of view	
				Establishing spot size from detector pixels	
3.7	Distance	*	*	Effect on temperature measurement accuracy	Spectral atmospheric transmission and wavelength
3.8	Atmospheric attenuation	*		Relationship between atmospheric attenuation an wavelength	
3.9	Support data collection and equipment		*		Photographic equipment
					Example applicable to Electrical application • Power measurement instruments
					Example applicable to Mechanical application • Reflected temperature reflector
					Example applicable to Civil application • Energy loss measuring instruments • Wind velocity measuring instruments • Moisture meters
3.10	Environmental data	*	*	Variations in atmospheric temperature	Effect of solar radiation or reflections from the ‘cold’ sky
				Solar radiation/cloud cover	Effect of reflections from nearby hot objects
				Wind speed and direction	Wind speeds during the survey

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Ref:	**Subject** Syllabus topic	**Category**		**Category sub-topics**	
		I	**II**	**I (Hours)**	II (Hours)
				Moisture (effect of rain)	Surface moisture
					Ambient temperature
3.11	Software		*		Choice of software for imager and application
					Complexity of software chosen
3.12	Image interpretation	*	*	Is the image in focus	Review Category 1
				Is the temperature Range/Span/Level correctly set	Target size
				Is the target below minimum spot size	Instrument settings
				Are all instrument settings correct	Genuine or false anomalies
				Are there any reflections from nearby objects or the sky present	Electrical, Mechanical and Civil example
3.13	Establishing thermal severity criteria (absolute, delta, statistical)		*		General severity criteria topics
					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
4	**Condition monitoring**			**3**	**1**
4.1	Fundamental principles of BINDT PCN scheme	*		Electrical	
				Mechanical	
		*		Civil	
4.2	Control values	*		Electrical • Imagers measure surface temperature but not necessarily its source	
				Mechanical • Relationship between friction and heat	
				Civil • Buildings • Large refractory lined	

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Ref:	**Subject** Syllabus topic	**Category**		**Category sub-topics**	
		I	**II**	**I (Hours)**	II (Hours)
				reactors and furnaces • Energy conservation/corrosion under insulation	
4.3	Alternate techniques		*		Acoustic emissions (AE) - Overview
					Lubrication management and analysis (LA) - Overview
					Vibration analysis (VA) - Overview
					Power supply analysis (PA) - Overview
4.4	Correlation of CM techniques	*		Overview	
4.5	Procedure writing				
5	**General applications**			**4.5**	**0**
5.1	Electrical	*		Basic theory	
				Examples of thermograms of various applications • Exposed connections • Fuses • Motors and terminal boxes • Closed panels • Thyristor drives • Transformers	
5.2	Mechanical	*		Bearings	
				Bearing seals	
				Gearboxes	
				Drive belts	
				Alignment of drives	
				Insulated pipes	
				Insulated and un insulated tanks	
				Energy conservation/Corrosion under insulation	
				Build-up of deposits in tanks or pipes	
				Valves	
				Paper machine applications • Steam heated cylinders • Paper web and reel	
				Process industry – various examples	

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Ref:	**Subject** Syllabus topic	**Category**		**Category sub-topics**	
		I	**II**	**I (Hours)**	II (Hours)
	Civil	*		Buildings insulation and construction	
				Delamination in concrete, plaster, etc.	
				Air leakage	
				Water damage in roofs	
				Underground heating	
5.4	Other Applications	*		Aerospace	
				Agriculture	
				Astronomy	
				Automobile industry	
				Medical and veterinary applications	
				Military applications	
				Research and development	
				Surveillance	
				Aerial and ground surveys	

Plus Either section 6, 7 or 8 depending on the specialism at Category (Level) 2

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Electrical

6	**Electrical applications**		*	0	24
6.1	Electrical engineering (components & construction)				Extra -Low Voltage (E-LV)
					Low Voltage (LV)
					High Voltage (HV)
6.2	IR theory to electrical applications and thermal signatures				Electrical theory • Relationship between current, voltage and resistance • Relationship between power, current and resistance • Harmonics (particularly 3rd order/zero sequence) • Effect of eddy currents on thermal patterns • Danger of circulation currents
					Thermal theory
6.3	Applications		*		Examples of common applications
6.3a	Electrical distribution				E- LV, LV and HV examples
6.3b	Electrical panels				E-LV
					LV
					HV
6.3c	Electrical components				Conductor types
					Termination types
					Fuse types
					Contactor types
					Main isolator types
					Overload types
					Other components
6.3d	Electrical motors				Cage and motor windings
					Terminal box
					Bearings
					DC motors
6.4	Fault analysis				Low voltage examples - open and closed panels
					Motors
					Busbars
					High voltage systems
					Transformers
					Power lines
					Measuring temperatures through safety grills and

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					windows
6.5	Safety issues				Review of national and local safety regulations
					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

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Mechanical

7	Mechanical applications		*	0	24
7.1	Mechanical engineering (components and construction)				Bearing designs – ball, taper roller, etc.
					Motor types – externally cooled, enclosed, AC, DC, etc.
					Pump types – centrifugal, piston, screw, etc.
					Fan types - centrifugal, screw, etc.
					Compressor types – piston, screw, fan, etc.
					Valve types and basic design • Shut off valves • Safety valves
					Gearboxes - gear, worm, etc.
					Drive types – directly coupled, belt drives, etc.
					Steam trap types – basic design and principle of operation
					Heat exchangers – finned tube, external flow, internal flow, etc.
7.2	IR theory to mechanical applications and thermal signatures				Standards relevant in the countries applicable to the thermographer
					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
7.3	Applications				Rotating equipment - defective bearings
					Fluid flow - blocked pipes or heat exchangers, deposit in pipes – leaking valves
					Power transmission - overheating gearboxes, belt slip, defective couplings
					Furnaces - Refractory lined, external insulation defects
					Tanks - deposit level in tanks,

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					insulation, heating, etc.
					Process Industry – food, paper, etc.
					Mechanical Thermography Applications – conveyors, etc.
					Active Thermography, e.g., wind turbine blades
7.4	Fault analysis				Rotating equipment
					Conveyor belts
					Paper machines
					Fluid flow
					Heat exchangers
					Furnaces
					Effect of wind on tall structures
					Tanks
					Active Thermography, e.g., a wind turbine blade
7.5	Safety - General				Risk Assessment and Method Statement example

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Civil (Building)

8	**Civil applications**			0	24
8.1	Civil Engineering (components & construction)		*		Overview of construction principles
8.1a	Construction types				Historic buildings
					Domestic buildings built before approximately 1940
					Domestic buildings built after 1940
					Commercial buildings
					Industrial buildings
					Sick-building syndrome
					Wooden frame construction
8.1b	Material types		*		Steel fabrications
					Concrete structures - plain or reinforced
					Various types of brick – building or fire bricks
					Stone types
					Glass
					Plastics
8.2	IR theory to civil applications and thermal signatures		*		Surveys of buildings • Internal (quantitative and qualitative) • External (quantitative and qualitative) • External (using active or passive heat source, e.g., solar energy)
					Heat transfer through structures
					Energy loss calculations
					Convection heat loss from plain surfaces
					Mass transport of heat
					Cold bridging
8.2a	Properties of materials		*		Opaque materials
					Translucent materials
8.2b	Environmental conditions		*		Radiant heat transfer caused by the sun or clear night sky
					Wind effect (convection)
					Effect of rain (moisture)
					Phase change (evaporation)
8.3	Building envelopes - Current designs		*		Domestic buildings
					Commercial buildings
					Industrial buildings
8.3a	Insulation		*		Types of insulation

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					Thermal resistance of materials
8.3b	Moisture				Theoretical and practical methods for dew point estimates
					Dampness
					Condensation
8.3c	Air leakage/air tightness		*		External measurement thermal patterns - building increased pressure
					Internal measurement thermal patterns – building reduced pressure
					Leak detection using smoke
					Equipment for controlling building pressure
					Test procedure
8.4	Other structures		*		Study of structure types
8.4a	Structural details and defects		*		Delamination in concrete structures
					Corrosion of Concrete
					Other Defects
					Industrial refractory lined furnaces
8.4b	Structural finishes		*		Brick or concrete
					Rendering
					Paint
					Glass
					Plastics
					Metals
8.5	Fault analysis		*		Roofs and Ceiling
					Walls
					Glass windows
					Air tightness
					Delamination (Spalling)
					Underground pipes
					Asphalt roads
					Refractory lined industrial furnaces & stacks
					Pollution control
					Active Thermography example
8.6	Safety issues		*		Risk Assessment and Method Statement example
					Building site regulations

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Plus sections 9-16 for all specialisms

9	**Condition monitoring programme design and acceptance testing**	*	*	**0.5**	**0.5**
9.1	Overview	*	*	Overview of CM/GEN, ISO 17359, 18434-1, 13379-1, 13381-1	As recommended in CM/GEN, ISO 17359, 18434-1, 13379-1 13381-1
9.2	Technique selection (include VA, EA, LA)		*		Thermal imagers selection appropriate to application
					Pyrometers (Infrared Radiation Thermometers)
					Heat flux instruments
9.3	Measurement intervals		*		Generic
					Based on practical experience
					Based on manufacturer recommendations
9.4	Procedure development		*		Procedure implementation and where appropriate development of procedures for thermographic surveys
9.5	Reference temperatures		*		As recommended by manufacturers
					Based on practical experience
9.6	Baseline temperatures		*		Based on generic data
					Based on commissioning trials
10	**Condition monitoring programme implementation**			**1**	**1**
10.1	Overview	*	*	Overview of ISO 17359 ,13381-1, 18434-1 • Safe working distances (Electrical)	Review of Category 1
10.2	General safety		*		SO 18434-1 & specific site regulations
10.3	Roles and responsibilities		*		Thermographer • Implement procedures approved by a qualified person
					Customer • Specify what is to be inspected • Provide a guide qualified for the purpose
10.4	Training and accreditation		*	BINDT CM/GEN Appendix B - C1	BINDT CM/GEN Appendix B - C2
11	**Condition monitoring**			**0.5**	**1**

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	programme management				
11.1	Safety management		*	Overview of sections 11.2 - 11.7	Risk assessment & Method statement requirements
11.2	Equipment management		*		Maintenance of documentation
					Calibration records
11.3	Procedure management		*		Thermal camera criteria
					Implementing failure mode, effects and criticality analysis
11.4	Skills and competence management		*		Maintaining records of thermographer skills
					Maintaining records of thermographer certificates and validation
11.5	Database management		*		Images, Reports & Trends
11.6	Managing corrective action implementation		*		As part of 11.5, Records of all anomalies found
					Record of recommendations
					Records of action taken and of any repeat tests
12	**Corrective actions with emphasis according to specialism**			**0**	**3**
12.1	Electrical		*		Review of national and local safety regulations
					Risk Assessment and Method Statement example
					Safe approach boundary implementation
					Working near live equipment at very close range
					Removal of covers on live electrical equipment
					Working at height
12.2	Mechanical		*		Mechanical examples
					Methods of alleviating anomalies due to problems identified in Section 7
12.3	Civil		*		Methods of alleviating anomalies due to problems identified in Section 8
13	**Codes and standards**			**1**	**1**
13.1	Overview	*	*	PCN CM/GEN Appendix B, ISO 18434-1 & 18436-1	Review Category 1
13.2	Electrical		*		Review Standards relevant in the Country of Certification
13.3	Mechanical		*		Review Standards relevant in the Country of Certification
13.4	Civil		*		Review Standards relevant in

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					the Country of Certification
13.5	Diagnostics		*		Diagnostics - ISO 13379-1
13.6	Prognostics		*		Prognostics - ISO 13381-1
13.7	Safety		*		Safety - ISO 18434-1
14	**Reporting and documentation (ISO standards)**			**1**	**0.5**
14.1	Presentation	*	*	Required information in a report	
	Electrical				Example of a typical electrical report
	Mechanical				Example of a typical mechanical report
	Civil				Examples of typical civil reports
				Sample of an electrical report	
				Sample of a mechanical report	
				Sample of a civil report	
14.2	Clients' needs	*	*	Objective of the survey	Review Category 1
				Details of procedure	
				Detailed description of each anomaly	
				Exact location of each anomaly	
				Assessment of severity of each anomaly	
14.3	Thermographers and end users responsibilities (all sections)	*	*	Supervising thermographer and Customer to agree on the objective of the survey	Thermographer and Customer to agree on the objective of the survey
				Supervising thermographer and Customer to agree on the equipment to be surveyed	Thermographer and Customer to agree on the equipment to be surveyed
				Thermographer to be guided by a qualified nominated assistant	Thermographer to be guided by a qualified nominated assistant
15	**Diagnostics and prognostics**			**1**	**2**
15.1	Diagnostics principles and processes	*	*	ISO 13379-1	ISO 13379-1
15.2	Prognostic principles and processes	*	*	ISO 13381-1	ISO 13381-1
16	**Training examination**			**1**	**1**
	Total hours			**33**	**46** **(Only 1 module from 6, 7, or 8)**