Employer's Unit of Competence – **Infrared thermography (passive) testing of materials, products and plant**

Apprenticeships

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THE BRITISH INSTITUTE OF NON-DESTRUCTIVE TESTING

Overview

This unit identifies the competencies required to carry out infrared thermography (IRT) survey activities on engineering products, plant, materials or structures in accordance with approved procedures. The use of a passive (condition monitoring) application is covered in this unit.

The apprentice will be required to check that the IRT survey equipment complies with the specification requirements, is safe to use, fit for purpose and has been correctly calibrated. They will prepare the products for survey, identifying the test area for future reference, checking the environmental conditions and the material surface emissivity, which might interfere with the IRT survey. They will set up and adjust the equipment, carry out the specified survey using the correct procedures/techniques, according to the IRT testing instructions and requirements, and observe and record the test indications.

The apprentice will be expected to draw conclusions about the type of thermal gradients and anomalies present, their location and apparent and/or true temperatures. They will complete the survey by preparing/completing an IRT test report containing the required test information and data along with their interpretation of the survey thermographs. If appropriate and safe to do so, they may be expected to mark up the products, objects or structures to identify areas of thermal interest and incorporate a digital image for reference purposes. The completed inspection report will be passed to the appropriate people, in accordance with procedures.

The apprentice's responsibilities will require them to comply with organisational policy and procedures for the IRT survey activities undertaken. Any problems with the activities or equipment in use that they cannot personally resolve, or are outside their permitted authority, are to be reported to the relevant people. They will be expected to work with minimal supervision, taking personal responsibility for their actions and for the quality and accuracy of the work they carry out.

The apprentice's underpinning knowledge will demonstrate a good understanding of their work and will provide an informed approach to the IRT assessment of engineering products, plant, materials or structures using IRT techniques. They will have a working knowledge of the principles of heat and temperature, infrared radiation and radiation energy exchange and will understand the functions and characteristics of short-wave/long-wave IRT cameras, their performance requirements and the use of the different types of optical lenses available.

The apprentice will have a detailed knowledge of good survey practice, including equipment calibration requirements, the effect of emissivity and environmental conditions that may affect temperature measurement techniques and the appropriate corrective or compensating measures required to negate their effects. They will also have detailed knowledge of equipment performance checks and routine care of the equipment.

The apprentice's knowledge will include an appreciation of hazards and safe working practices and they will understand the risks posed by temperature gradients/anomalies outside of the design parameters and the consequences of component failure. The importance of compiling accurate and legible reports will also be a key issue in completing this standard.

The apprentice will understand the safety precautions required when carrying out the IRT survey activities and when using the associated tools and equipment. They will be required to demonstrate safe working practices throughout and will understand the responsibility they owe to themselves and others in the workplace.

Performance Criteria

The apprentice must be able to:

P1 Work safely at all times, complying with health & safety and other relevant regulations, directives and guidelines

P2 Follow the correct procedure/technique for the product or equipment being inspected/surveyed

P3 Use the correct equipment to carry out the inspection

P4 Identify and confirm the environmental checks/emissivity values to be made and acceptance criteria to be used

P5 Carry out all required IRT surveys as specified

P6 Identify any temperature gradients/profiles/anomalies or variations from the specification

P7 Undertake analysis and interpretation of thermographs

P8 Record the results of the IRT surveys in the appropriate format

P9 Deal promptly and effectively with problems within their control and report those that cannot be solved.

Knowledge and Understanding

The apprentice must know and understand:

K1 The specific safety precautions to be taken when carrying out IRT activities on engineering products, plant, materials or structures

K2 The hazards associated with carrying out the IRT activities (such as electrical contact, moving mechanical parts and extremes of temperature) and how the risks associated with these hazards can be minimised

K3 The type(s) of personal protective equipment (PPE) to be used and how to obtain it

K4 How to obtain the necessary job instructions/techniques, IRT testing specifications and how to interpret this information

K5 The reasons why it is sometimes necessary to test products using IRT testing methods

K6 Why products may need to be inspected by a range of different non-destructive testing methods (such as magnetic particle inspection, penetrant flaw detection, ultrasonics and radiography) and/or condition monitoring methods (such as acoustic emission, tribology, visual and vibration)

K7 Heat and temperature – temperature, heat, absolute and relative temperature scales, heat transfer via conduction, convection and radiation

K8 Infrared radiation – electromagnetic spectrum, infrared wavelength region (including SW, MW and LW ranges and their impact on IRT surveys) and Planck, Wien and Boltzmann Laws

K9 Radiation energy exchange – emittance, reflectance and transmittance, emissivity, determining and evaluating emissivity, how emissivity is affected by surface finish, the angle of measurement and blackbodies. Reflectance from spectral and diffused surfaces, transmittance/absorption of various materials. Radiation leaving the target and radiation exchange at the target surface/radiation impinging on a target surface

K10 Infrared thermographic equipment – history of infrared systems, infrared radiation thermometers, thermal scanners, thermal imagers, spot radiometers, waveband selection, lens design, instantaneous field of view, digital *versus* optical zoom, IRT detector performance, camera operation and features, sensitivity, noise equivalent temperature difference, minimum resolvable difference and slit response function

K11 Infrared camera object parameters – range, span and level settings, the use of colour palettes, establishing emissivity values and settings, spot, circle, box and line functions, temperature profiles and isotherms. Lens selection, object distance, image composition and focus. Camera calibration

K12 Infrared inspection practices – avoiding errors by recognising and compensating for solar reflection as well as reflections from nearby objects or spurious sources, recognising and compensating for the convection effects of wind and rain. Recognising and compensating for environmental conditions due to atmospheric transmission *versus* distance, CO_2 in atmosphere, the effect of moisture and solid particles in the atmosphere. Recognising and compensating for temperature changes due to thermal capacitance or mass transport, phase change, energy conversion or direct transfer differences

K13 Infrared image analysis and interpretation – qualitative or quantitative evaluation, defective evaluation through target symmetry or target comparison. Differential temperature (ΔT) measurement. Trending analysis. Establishing thermal severity criteria

K14 Electrical applications – electrical faults, effects of circuit loading, load measurement, electrical panels, electrical component inspection, misconceptions associated with IRT electrical inspection, cable tightening, electrical motors and LV/MV/HV systems

K15 Mechanical applications – baseline surveys, drive trains, bearings, seals, pumps, compressors, the limitations of machine diagnostics, steam heating and traps, steam systems

K16 Civil/building applications – building envelope, thermal insulation, air leakage, water ingress, structural finishes and details

K17 Industrial process monitoring applications – furnace and boilers, ducting, process plant systems, refractory lined vessels, pipelines

K18 The system of quality assurance and control within the company, its importance in underwriting all NDT activities and who is responsible for it

K19 Why it is critical that records of IRT surveys/inspections on the products are accurate, comprehensive and maintained legibly

K20 The person(s) that the inspection records need to be passed to

K21 Care and control of the equipment (to include checking the condition of insulation, all electrical cables and connections, equipment operating controls and displays)

K22 The extent of their own responsibility and to whom they should report if they have problems that they cannot resolve.

Skills

The apprentice must be able to:

1. Carry out **all** of the following during the IRT survey activities:

   - Obtain the required IRT camera and ensure that it is in a safe and usable condition
   - Use appropriate personal protective equipment
   - Comply with job instructions, NDT testing inspection procedures, relevant COSHH sheets and risk assessment documentation
   - Leave the work area in a safe condition on completion of the activities.

2. Obtain the correct type of equipment, as required by the IRT procedures/techniques, to include **all** of the following:

   - SW or LW IRT camera
   - Digital camera
   - Appropriate optical lenses
   - Environmental meters, high emissivity tapes, foil, etc.

3. Prior to undertaking an IRT survey, carry out and record the following environmental checks (where appropriate) that could influence the actual temperatures recorded:

   - Ambient air temperature
   - Reflective apparent temperature
   - Relative humidity
   - Wind speed
   - Establish the surface emissivity of the object under test.

4. Prior to undertaking an IRT survey, enter the following object parameters appropriate to the survey type into the IRT camera to include:

   - Range, span and level settings
   - Colour palatte
   - Emissivity value
   - Spot, circle, line and box functions and isotherms
   - Reflected apparent temperature (T_{amb} or T_{refl})

- Camera-to-target distance
- Atmospheric temperature
- Relative humidity.

5. Preparation prior to commencing survey to include carrying out the following as appropriate:

- Identifying the survey areas
- Checking that the survey areas are correctly prepared for testing
- Checking for key reference (datum) markings
- Recognise and compensate for reflections from solar gain
- Recognise and compensate for convection effects of wind and rain
- Recognise and compensate for environmental conditions due to atmospheric transmission *versus* distance and CO_2 in atmosphere
- Recognise and compensate for the effect of moisture and solid particles in the atmosphere
- Recognise and compensate for temperature changes due to thermal capacitance or mass transport, phase change, energy conversion or direct transfer differences.

6. Undertake the IRT survey using the following:

- The specified type of survey
- The appropriate procedure and technique for the survey conditions
- The correct assessment recording criteria.

7. Carry out an IRT survey on **one** of the following:

- Electrical apparatus
- Mechanical equipment
- Civil applications
- Buildings
- Industrial process plant
- Other specific products.

8. Record a thermographic image (ensuring that the IRT image is optically focused, the target object is contained within the IRT image and the temperature range spans the temperature of the target object) for inclusion into the final report when:

- An object under survey requires comparing to a previous survey or condition monitoring in a future survey
- A thermal anomaly is detected in an object that falls outside of a pre-defined temperature criteria or would be of interest to the object owner
- When a specific object has been identified as requiring an actual target surface temperature
- Any other reason as defined by the object owner.

9. Undertake evaluation of IRT thermographs by use of radiometric analysis software using the following analysis tools:

- Palette selection
- Isotherms
- Spot, area, line, box and circle temperature tools
- Trending functions.

10. Complete an IRT report, to include recording **all** of the following:

- Unique report number
- Object identification
- Survey conditions
- Type of IRT survey, *ie* qualitative or quantitative
- Date of survey
- Name of thermographer, qualification and signature
- Reference drawings
- IRT equipment and camera parameters used
- Each IRT image reported will include: accompanying digital image, location of any appropriate thermal gradients/ anomalies, analysis tools used and interpretation/assessment of the image
- Written summary of survey results including a conclusion.

11. Complete the inspection activities, to include carrying out the following:

- Marking up defective products, plant, materials or structures with all relevant information
- Handing over the inspection details to the appropriate people.