INTERNATIONAL STANDARD

ISO 10880

First edition
2017-02

Non-destructive testing — Infrared thermographic testing — General principles

Essais non destructifs — Essais thermographiques infrarouge — Principes généraux

Reference number
ISO 10880:2017(E)

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Foreword

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This document was prepared by Technical Committee ISO/TC 135, *Non-destructive testing*, Subcommittee SC 8, *Thermographic testing*.

Introduction

The industrial applications of infrared thermographic testing in non-destructive testing (NDT) are growing, along with a remarkable improvement in thermographic technologies. The effectiveness of any application of infrared thermographic testing depends upon proper and correct usage of the method. The purpose of this document is to provide general principles for infrared thermographic testing in order to promote the correct and effective application of a variety of industrial NDT, such as in power plants, buildings and structures, electronic instruments and industrial materials.

Non-destructive testing — Infrared thermographic testing — General principles

1 Scope

This document provides general principles for infrared thermographic testing in the field of industrial non-destructive testing (NDT).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel*

ISO 10878, *Non-destructive testing — Infrared thermography — Vocabulary*

3 Terms and definitions

For the purposes of this document the terms and definitions given in ISO 10878 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

4 Infrared thermographic testing personnel

Personnel who are responsible for conducting infrared thermographic testing (TT) shall meet the following criteria.

a) TT personnel shall have an adequate knowledge of the basics of infrared measurement and heat-transfer engineering as required by ISO 9712.

b) The TT personnel's visual acuity and colour vision shall meet the requirements of ISO 9712.

5 Infrared thermographic testing equipment

5.1 Infrared camera

Each infrared camera has different properties and functions, such as the type of infrared detecting device, the spatial resolution (instantaneous field of view, effective pixels), temperature range, temperature resolution, temperature accuracy, frame time, exposure time, detection wavelength range, cooling method, scanning method, and the visible image display and recording function. It is necessary to ensure that an infrared camera with appropriate properties and functions with appropriate temperature calibration to meet the purpose of the testing is used.

If necessary, various devices that can be attached to the infrared camera such as wavelength filters, attenuation filters, replacement lenses, monitors, computers and software for data collection and processing, and infrared-reflecting mirrors may be used.

5.2 Equipment used for active thermography

Select the appropriate heating or cooling system, taking into account the properties and functions of the infrared camera, the test environment, and the status of the test object (dimensions, shape, emissivity, material, temperature before thermal loading, and so on.)

NOTE For the heating system, a heating lamp, a flash lamp, an electric radiation heater, an induction coil, a contact-type heater, a hot-air device, a reflection board, a power-distribution device, or a vibrational apparatus can be used. For the cooling system, a sprinkler, an atomizer, or an air blower can be used.

6 Test environment

6.1 Installation environment for the test equipment

Conduct the test in an environment where the temperature, humidity, and atmosphere are appropriate for the test equipment, including the infrared camera.

6.2 Avoidance of disturbance

In order to avoid reflections from objects other than the test object or background (temperature of the ambient environment), increasing the object's emissivity may be necessary. This can be achieved with paint or any other type of adequate surface preparation and/or treatment as described in 7.1. Moreover, during the installation of the infrared camera, several positions may be tested in order to determine which one minimizes the effect of reflections.

If the temperature of the test object is low, note that the proportion of the reflected apparent temperature to the total infrared radiation energy arriving at the infrared camera can be high.

Take care of absorption, scattering, and reflection of infrared radiation energy by any substances that are present between the infrared camera and the test object (for example, water vapour, carbon dioxide, or window materials).

7 Test method

7.1 Emissivity of test object

For temperature measurements, the emissivity of the test object shall be taken into account. Set the emissivity value within the radiometric software or within the camera as correctly as possible in order to match the apparent temperature with the true temperature [3] [4].

NOTE 1 If the emissivity of the surface of the test object is not uniform, the infrared radiation energy will not be uniform, even if the temperature of the surface of the test object is uniform. If the emissivity is low, the effects of reflections and/or transmission become proportionately larger.

NOTE 2 The emissivity of test object may vary with the material, the temperature, the roughness of the surface, the thickness of any oxidized membrane on the surface, the presence of impurities on the surface, the angle, and wavelength range of the infrared camera.

NOTE 3 If the emissivity of the test object is low or not uniform, a coating of matte black material can be applied thinly and uniformly until the surface of the base material is covered. Alternatively, a thin membrane of a material with a high emissivity can be attached to the surface to ensure that the emissivity is as uniform as possible during the test.

NOTE 4 Other methods can also be used, such as roughening the surface of plastics (for example, with sandpaper) or oxidizing the surface of metals and so on.

In the radiometric software, the ambient temperature shall also be considered.

7.2 Passive thermography and active thermography

Passive thermography is a thermographic technique for inspecting objects or installations by measuring their emitted thermal radiation, without using any additional energy source for thermal stimulation. It is not necessary to induce an additional temperature change within the objects or installations for the purpose of the test.

EXAMPLE Passive thermography can be used, for instance, for inspecting electrical installations and mechanical components, in process. It can also be used, for instance, when natural thermal loading by solar radiation exists, such as for buildings and structures[1] [7] [9], or when the presence of an anomaly or a defect results in the generation or absorption of heat, such as a defect in transmission or distribution equipment.

Detecting anomalies by passive thermography has some physical limitations, which are often overcome by active thermography.

Active thermography is a thermographic examination of materials and objects which requires additional thermal stimulation.

NOTE The thermal stimulation can be optical, sonic (ultrasonic), inductive, microwave, or using any other form of energy.

In active thermography, if a test is meant to detect conductive anomalies, then a uniform thermal loading is preferred. The intensity of the thermal load shall be properly adjusted in relation to

— the performance of the infrared camera,

— the thermal properties of the test object, such as the thermal diffusivity, and

— the position, shape, dimensions, and depth of an anomaly or defect.

Care shall be taken not to damage the object under test, as a result of excessive thermal loading.

7.3 Imaging method

7.3.1 General

Steps shall be taken to ensure that the apparatus to be used for the test is operating correctly, i.e. in accordance with the technical specifications, and its settings are appropriate to the object under test.

7.3.2 Non-uniformity and infrared intensity value correction

Before imaging is performed, it is necessary to enable the non-uniformity correction function of the infrared camera to correct for variations in the sensitivity of individual infrared detection elements. If any equipment, such as a wavelength filter, replacement lens, or infrared-reflecting mirror, is attached to the optical system, it is necessary to apply an appropriate correction to the infrared intensity value.

7.3.3 Field of view and spatial resolution

One of the limitations in the detection of anomalies is the spatial resolution on the object. The distance between the camera and the object shall be adapted so that the spatial resolution is at least equal to the size of the anomalies. Changing the lens, for one offering a better resolution, might be necessary.

7.3.4 Angle

An angle of 45° or less between a line normal to the surface to be tested and the optical axis of the infrared camera is preferred. If this is not possible, an angle of 60° maximum is acceptable.

NOTE If the angle exceeds 60°, or for tests on the rear face of the object, a method involving an infrared-reflecting mirror can be used as described in 7.3.8.

7.3.5 Temperature range and temperature resolution

Set the optimum measurement range of the infrared camera according to the expected signal dynamics to obtain with the test object.

NOTE 1 Sufficient signal-to-noise is needed for a proper analysis.

NOTE 2 The temperature resolution of the infrared camera decreases as the temperature range is increased.

7.3.6 Display of thermal images

The level and span of the image display should be properly adjusted not to miss the indications from the image.

7.3.7 Frame time and exposure time

Appropriate frame rate and integration time shall be selected to detect any anomaly and defect of the test object.

When imaging an unsteady or high-speed phenomenon, the frame time of the infrared camera should be set to be sufficiently short to permit capture of the transient phenomenon. For imaging high-speed phenomena, a short exposure time is therefore desirable; however, note that the sensitivity of the camera is low for short exposure times.

7.3.8 Testing by using the infrared-reflecting mirror

A test object that cannot be imaged directly can be imaged indirectly by means of an infrared-reflecting mirror. Note that right and left directions on the shot image will be reversed and that the reflectivity of the mirror affects the accuracy of the test.

7.3.9 Adjustment of focus

The infrared camera shall be focused on the test object during imaging.

NOTE For test objects with a low intrinsic contrast, the focus can be set accurately by attaching a thin metallic scale or similar object at the surface of the test object, which can be recognized in thermal images.

7.3.10 Confirmation of settings

Before the test, check the settings under the test conditions, as described in 7.3.2 to 7.3.9.

NOTE The settings of the temperature range and the focus cannot be adjusted after recording.

7.4 Signal processing and image processing

To reduce test errors and/or to extract and emphasize anomalies, carry out the appropriate signal-processing and image-processing operations when necessary. Methods such as threshold-value processing, averaging, smoothing, background elimination, difference processing, frequency analysis, lock-in processing, or motion compensation are available for signal and image processing, and these should be used when necessary.

8 Implementation and reporting of tests

8.1 Items described in the NDT procedures

Procedures giving information on the test and the object to test shall be prepared and written. They shall contain details such as (but not limited to)

a) the purpose of the test,

b) applicable scope,

c) applicable standards,

d) testing personnel,

e) the test object and area to be tested,

f) test equipment,

g) test environment,

h) the test method and test conditions,

i) the evaluation method, and

j) the record and report.

8.2 Items described in the NDT instructions

NDT instructions shall be prepared and written. They shall contain items such as (but not limited to)

a) the test date, time, and location,

b) the test area,

c) test equipment (model, type number, and lens of the infrared camera, optical systems used, such as the infrared-reflecting mirrors, etc.),

d) the test method and test condition (passive or active thermography, thermal loading method and conditions, values of settings for the infrared camera, method of surface preparation for pseudo black body, ambient disturbance factors that require attention, etc.), and

e) the method for recording.

8.3 Record of test conditions

The results of infrared thermographic testing are different depending on the test environment, the test equipment, and the test method. Any conditions that could affect the result shall be recorded such as

a) test date, time, and location,

b) test personnel,

c) test object and area to be tested (shape, dimensions, material, and surface texture of the test object; distance between the infrared camera and the test object, a visual image of the test object and so on),

d) test equipment [models and type numbers of infrared camera (detection element, effective number of pixels), optical system such as lens, filter and infrared-reflecting mirror, temperature range, exposure time, frame rate and so on],

e) test environment [temperature, humidity, weather (in the case of outdoor testing), positional relationships between the infrared camera, test object, and any ambient factors that could affect the results],

f) test method and test conditions

— method of surface preparation for pseudo black body to improve emissivity,

— selection of passive or active thermography; in the case of active thermography, the thermal loading method and conditions such as the thermal source, distance, heating method, and heating time,

— signal processing and image processing methods used, and

g) the evaluation method (reasons why relevant data are evaluated as pertaining to abnormal heat-generation points or flaws, based on the indications obtained).

8.4 Report

Report items that are described in the NDT procedures and items described in the NDT instructions as the occasion demands.

Bibliography

[1] ISO 6781:1983, *Thermal insulation — Qualitative detection of thermal irregularities in building envelopes — Infrared method*

[2] ISO 18251-1, *Non-destructive testing — Infrared thermography — System and equipment — Part 1: Description of characteristics*

[3] ISO 18434-1:2008, *Condition monitoring and diagnostics of machines — Thermography — Part 1: General procedures*

[4] ASTM E1933-14, *Standard Practice for Measuring and Compensating for Emissivity Using Infrared Imaging Radiometers*

[5] ASTM E1934-99a (2010), *Standard Guide for Examining Electrical and Mechanical Equipment with Infrared Thermography*

[6] ASTM E 2582-07, *Standard Practice for Infrared Flash Thermography of Composite Panels and Repair Patches Used in Aerospace Applications*

[7] DIN 54190-1:2004, *Non-destructive testing — Thermographic testing — Part 1: General principles*

[8] DIN 54190-3:2006, *Non-destructive testing — Thermographic testing — Part 3: Terms and definitions*

[9] NDIS 3427:2009, *General principles of infrared thermographic testing method*

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