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Non-destructive testing - Thermographic testing - Part 1: General principles

Zerstörungsfreie Prüfung - Thermografische Prüfung - Teil 1: Allgemeine Grundlagen

Essais non destructifs - Analyse thermographique - Partie 1: Principes généraux

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Non-destructive testing - Thermographic testing - Part 1: General principles

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COMITÉ EUROPÉEN DE NORMALISATION
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European foreword

This document (EN 16714-1:2016) has been prepared by Technical Committee CEN/TC 138 “Non-destructive testing”, the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2017, and conflicting national standards shall be withdrawn at the latest by February 2017.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

Non-destructive testing — Thermographic testing consists of the following parts:

— *Part 1: General principles*

— *Part 2: Equipment*

— *Part 3: Terms and definitions*

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This European Standard specifies the general principles for thermography of non-destructive testing. Thermographic testing is used for the detection and localization of discontinuities (e.g. cracks, delamination and inclusions) in different materials (e.g. composites, metals and coatings).

Usually a thermal stimulation is required. The choice of thermal stimulation depends on the application (e.g. type of material, geometry of test object, type of defects to be determined).

Acceptance criteria are not defined in this standard.

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.

EN 1330-1, *Non destructive testing - Terminology - Part 1: List of general terms*

EN 1330-2, *Non destructive testing - Terminology - Part 2: Terms common to the non-destructive testing methods*

EN 16714-2, *Non-destructive testing — Thermographic testing — Part 2: Equipment*

EN 16714-3, *Non-destructive testing — Thermographic testing — Part 3: Terms and definitions*

EN ISO 9712, *Non-destructive testing - Qualification and certification of NDT personnel (ISO 9712:2012)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1330-1, EN 1330-2 and EN 16714-3 apply.

4 Apparatus

According to EN 16714-2.

5 Preparation for testing

5.1 Test instruction

A test instruction shall be prepared that specifies the minimum test requirements relating to each of the items listed in 5.4.

5.2 Description of method

If required, for example by a product standard or contract, a description of the method shall be prepared.

5.3 Availability of test instruction and description of method

Copies of the test instruction and, if applicable, of the description of the method shall be made available to the responsible personnel.

5.4 Preparation criteria

The following points shall be taken into account or stipulated in preparing for the test:

a) position, accessibility and geometry of the objects under test;

b) purpose of testing;

c) scope of test;

d) area to be tested;

e) kind of expected inhomogeneities (e.g. geometry, orientation, depth, surface breaking or not);

f) test requirements, especially those relating to:

- spatial resolution;
- temporal resolution;
- thermal resolution;
- measurement precision;

g) apparatus, including:

- selection of appropriate energy source and its characteristic parameters;
- selection of IR camera and its characteristic parameters;
- spatial set up of energy source, IR camera and test object;
- verification of test equipment (regarding proper working);

h) test procedure including:

- optimization of the spatial set up (e.g. field of view, focusing, avoiding reflection);
- criteria of notation (e.g. size, location, number of indications);
- measurement parameters;

i) ambient conditions at the time of testing;

j) operational state of the objects under test at the time of testing;

k) surface properties, such as emission, transmission and reflection, of the objects under test;

l) personnel qualifications and duties (see Clause 7);

m) scope of test report (see Clause 9).

5.5 Reference test specimens

For controlling the set-up of the whole measurement system as well as the selected measurement parameters, at least one of three different kinds of reference test specimens shall be used:

— **Type 1**: Reference test specimen for calibration check and/or testing the measurement system;

— **Type 2**: Reference test specimen with artificial defects for quantification of detection sensitivity for a distinct type of material;

— **Type 3**: Reference test specimen with natural defects for quantification of detection sensitivity for a distinct type of material (original test object).

Reference test specimens of **type 1** are used preliminary for testing single components as well as the whole measurement set-up (e.g. black body, large metal plate). Prior to and/or during testing, the proper function and, if required, calibration of the infrared camera has to be checked. For controlling the temperature calibration, a calibrated black body should be used at two different temperatures being relevant for the test. Deviations should not exceed the accuracy of the actual calibration. Further function controls have to be performed according to EN 16714-2. If the energy is introduced by homogeneous radiation, the spatial homogeneity of the radiation source should be tested using e.g. a large blackened metal plate.

Reference test specimens of **type 2** include artificial defects like flat bottom holes, notches or step wedges with different geometry made of the same material as the object under test. Additionally, any anisotropic thermal material properties have to be considered, e.g. as for CFRP. For enabling unique defect identification as well as for evaluating the detection limits of the measurement system for these defects, several type 2 reference test specimens may be necessary to cover all of the expected defects.

Reference test specimens of **type 3** are real test specimens with natural defects as they are generated during the production process or during the life of the part. Kind of material, geometry and surface condition are similar to those of the test objects. The defects should be characterized by any non-destructive method, e.g. computed tomography, ultrasonic testing.

5.6 Apparatus check

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 using one of the reference test specimens (see 5.5).

Individual performance of each component can be checked by reference test specimen of type 1 and the global performance of the system using the test specimen of type 2 or 3.

5.7 Surface and emissivity

The performance of temperature measurements on the object under test is influenced by the emissivity and irradiation coming from the surrounding environment, which has to be taken to account.

In the case of objects with low emissivity, i.e. with high reflectance or transmittance, a coating having high emissivity may be applied, if necessary. Type, thickness and further parameters of the coating have to be adapted to the application. This should be determined using a reference test specimen of type 2 or 3.

6 Thermography procedures

6.1 General

Thermographic testing can be performed actively or passively and evaluated qualitatively, comparatively or quantitatively (see Table 1).

Table 1 — Overview of thermographic procedures

Procedure	Excitation	
	Active	Passive
Qualitative	Examination of thermal patterns (radiation distribution)	
Comparative	Differential quantities (e.g. $\Delta\varphi$, ΔT)	Differential quantities (e.g. ΔT)
Quantitative	Absolute quantities (e.g. φ, T)	Absolute quantities (e.g. T)

To be successful, thermographic testing requires:

— choice of a camera with appropriate sensitivity and setting of the suitable measurement range;

— choice of a suitable image section for visually comparing the display with the undisturbed state;

— avoidance of reflections by choosing a suitable viewing angle;

— monitoring or minimizing interference due to external radiation sources, draughts and humidity;

— choice of a lens capable of maintaining the required spatial resolution;

— careful focusing of the image;

— choice of suitable display settings for the temperature scale, contrast, brightness, colour range, etc.

6.2 Passive thermography

Passive thermography uses only the heat flow due to the intrinsic heat of the object under test. Such heat includes both internally generated heat (e.g. in furnaces). Time dependent heat flows are usually not required, i.e. the information is included in one thermogram.

Passive thermography is used for example in building (e.g. to locate moisture, thermal bridges, leaks), for inspecting electrical and mechanical systems, in process and installation diagnostics.

6.3 Active thermography

In active thermography, a non-stationary heat flow is generated in the object under test by natural or additional energy sources only for the purpose of thermographic testing. Exposure to such energy sources can take place on a single occasion, periodically or continuously. Several energy sources (e.g. sun radiation, light, ultrasound, hot and cold air, induction) can be used. They can be selected according to the application and requirements. The performance of the excitation shall be validated on a reference test specimen type 2 or 3. Examples for the excitation sources are given in EN 16714-2.

Active thermography is used to detect defects or discontinuities (e.g. voids, disbonding, delamination, cracks, thickness variation) for example in industrial production and maintenance (e.g. metallic or composite materials such as engine and machine components, joining technology).