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Non-destructive testing — Infrared thermographic testing — General principles for thermoelastic stress measuring method

PROOF/ÉPREUVE

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Contents

Page

Foreword

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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).

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

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

Thermoelastic stress measuring method, which utilizes the thermoelastic properties of materials, is a "full-field", "noncontact" technique for surface stress mapping of materials and structures. Unlike the conventional technique such as strain gauge method, the unique advantage of the method is its ability to image whole-surface stress ($\Delta\,(\sigma_1+\sigma_2)$) distribution in specimens easily (ISO 10878).

Industrial applications of thermoelastic stress measuring method are getting wider along with remarkable improvement of thermographic technologies. The effectiveness of any application of thermoelastic stress measuring depends upon proper and correct usage of the method. The purpose of this document is to provide general principles of the thermoelastic stress measuring method to promote correct and effective application to various industrial non-destructive testing, such as automobiles, aerospace products, electronic instruments, medical devices, industrial materials and so on.

Non-destructive testing — Infrared thermographic testing — General principles for thermoelastic stress measuring method

1 Scope

This document provides general principles for thermoelastic stress measuring method of 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 10878, *Non-destructive testing — Infrared thermography — Vocabulary*

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

ISO/TS 25107, *Non-destructive testing — NDT training syllabuses*

ISO 10880, *Non-destructive testing — Infrared thermographic testing — General principles*

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:

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

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

4 Infrared thermographic testing personnel

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

a) TT personnel shall have an adequate knowledge of the testing including the basics of infrared measurement and heat-transfer engineering as required by ISO 9712 and ISO/TS 25107.

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

5 Test Environment

5.1 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 as required by ISO 10880. Be sure to avoid condensation on the surface of the test object.

In order to avoid occurrence of image blur due to fluctuation of the field of view, make sure that vibration is not applied to the infrared camera as much as possible. However, when the vibration period of the infrared camera is synchronized with the load cycle to the test object, the influence can be reduced by the position correction technique.

5.2 Avoidance of disturbances

For the avoidance of disturbances, requirements and information are given in ISO 10880.

In addition, care should be taken to minimize the surface temperature change of the test object other than based on the thermoelastic effect. For example, in order to avoid temperature change due to air currents, reduce the influence of wind as much as possible.

6 Equipment

6.1 Configuration

Schematic of an example of equipment configuration is shown in Figure 1.

In addition to the infrared camera (key 3 in Figure 1), the measuring equipment is constituted by a computer or the like which performs camera control, reference signal processing, image processing, image display and the like (key 7 in Figure 1).

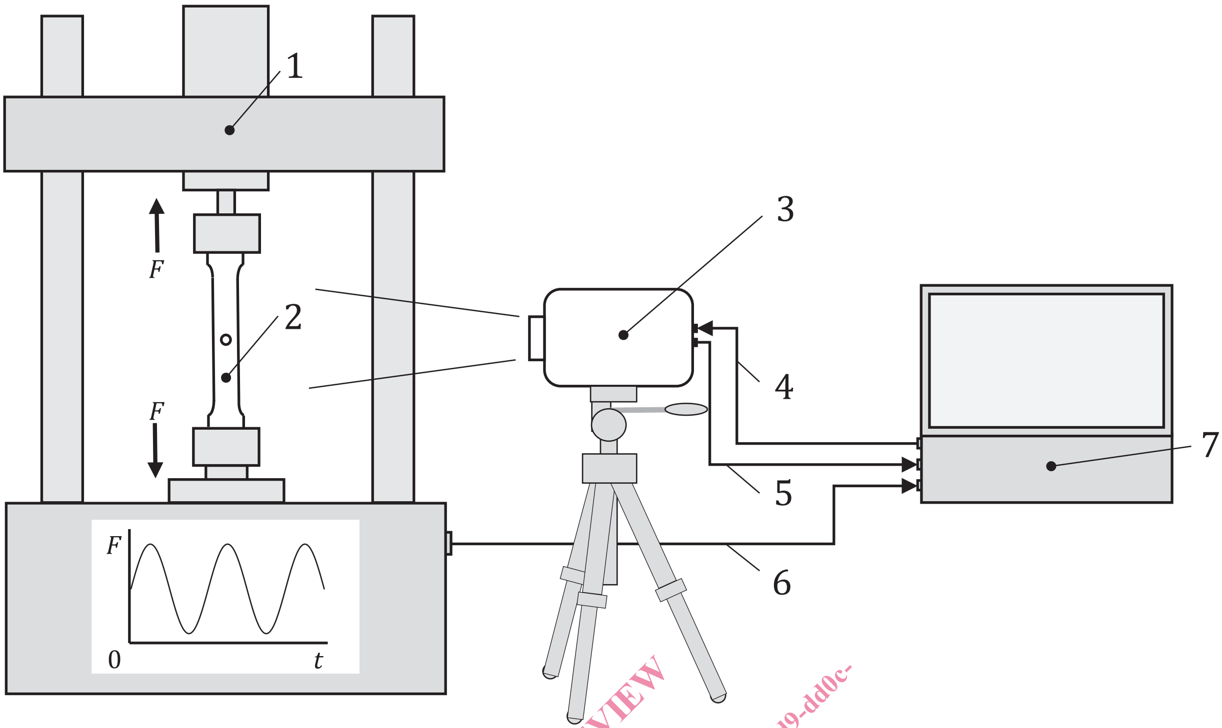
When applying cyclic load to the test object, the material testing machine is required to have the ability to load the required waveform and frequency (key 1 in Figure 1).

6.2 Infrared camera

An infrared camera shall meet the requirements of ISO 10880. In addition, an infrared camera should have an infrared measuring wavelength range about 3 µm to 5 µm or about 8 µm to 14 µm to be capable of measuring extremely small temperature changes. A camera with a frame repetition rate that provides a sufficient number of frames per cycle of load shall be used. In order to obtain the spatial resolution necessary for the test, the lens viewing angle of the infrared camera, the number of effective pixels of the camera and the distance between the camera and the test object shall be considered.

The infrared camera with appropriate temperature resolution should be used in order to obtain the required stress (the sum of surface principal stresses) resolution.

NOTE In the case of steel, a temperature resolution of about 0,001 K is necessary to obtain 1 MPa stress resolution. Generally, the temperature resolution can be enhanced by image processing such as image averaging, using an infrared camera which has about 0,03 K of noise equivalent temperature difference (NETD) value.



Key

1 material testing machine
2 test object
3 infrared camera
4 control signal to infrared camera
5 detector signal from infrared camera
6 reference load or displacement signal from material testing machine
7 computer with signal processing unit and display
F load
t time

Figure 1 — Schematic of an example of equipment configuration

6.3 Detection of temperature change by thermoelastic effect

As signal processing methods for extracting the amount of temperature change with the thermoelastic effect from the time series of temperature data, "temperature difference image technique" or "lock-in technique" or an equivalent method is applied.

A reference signal synchronized with the stress change of the test object is utilized to perform the signal processing techniques. As the reference signal, a load or displacement signal from the material testing machine (key 6 in Figure 1), or a signal obtained from the strain gauge attached to the test object or the like, shall be used.

NOTE The temperature difference image technique is a signal-processing method to obtain a picture of the change of the sum of principal stresses, consisting of measuring temperature distribution images during the maximum temperature period and the minimum temperature period, and making an overall "temperature range image" from the images, as defined in ISO 10878. The lock-in technique allows for the extraction of a signal of a known carrier wave from an extremely noisy environment. This signal can be, but is not restricted to, temperature.