
**Non-destructive testing — Infrared
thermography —**

Part 2:

**Test method for integrated
performance of system and equipment**

*Essais non destructifs — Thermographie infrarouge —
Partie 2: Méthode d'essai relative aux performances intégrées du
système et de l'appareillage*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

A list of all parts in the ISO 18251 series can be found on the ISO website.

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.

Introduction

Industrial applications of infrared thermographic testing are getting wider along with remarkable improvement of thermographic technologies. The effectiveness of any application of infrared thermographic testing depends upon proper and correct usage of the system and equipment. The purpose of this document is to provide a test method for the integrated performance of the system and equipment for infrared thermography in the field of industrial non-destructive testing. The establishment of this document can solve the problem that there is no ISO standard for the performance test method of the infrared equipment and system. The main interested parties who can benefit from this document are manufacturers and users of the infrared testing equipment and system.

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Non-destructive testing — Infrared thermography —

Part 2:

Test method for integrated performance of system and equipment

1 Scope

This document specifies a test method for integrated performance parameters specified in ISO 18251-1 of an infrared (IR) imaging system and related equipment used in non-destructive testing (NDT). It also aims to assist the user in the selection of an appropriate system for a particular testing task.

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

ISO 18251-1, *Non-destructive testing — Infrared thermography — Part 1: Characteristics of system and equipment*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 10878 and ISO 18251-1 apply.

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

4 General requirements

4.1 Environmental requirements

General environmental requirements shall be in accordance with ISO 10880 and the following.

The test for integrated performance shall be carried out in a stable indoor environment within the temperature range from 20 °C to 25 °C and with a relative humidity in the range from 40 % to 80 %. The IR imaging system and related equipment shall not be affected by shocks, vibrations, external electromagnetic fields or external radiation sources affecting the readings of measuring instruments.

4.2 Testing equipment and imaging methods requirements

4.2.1 General

Testing equipment shall include at least a blackbody simulator, target, optical table, positioning stage, computer system, constant temperature and humidity chamber, infrared radiometer. Sometimes a collimator is required. The basic requirements are given in [4.2.2](#) to [4.2.9](#).

The requirements and information of the imaging methods are described in ISO 10880.

4.2.2 Blackbody simulator

- a) Blackbody simulators are often used to provide a uniform temperature background when performing parametric tests.
- b) The blackbody simulator shall be a rectangular or circular planar cavity with a small hole to assure high emissivity.
- c) The temperature range shall cover the temperature measurement range of the IR imaging system.
- d) Temperature stability: $\leq \pm 0,1$ °C when blackbody temperature is less than or equal to 100 °C, $\leq \pm 0,1$ % blackbody temperature when it is greater than 100 °C.
- e) Temperature uniformity: $\leq \pm 0,15$ °C when blackbody temperature is less than or equal to 100 °C, $\leq \pm 0,15$ % blackbody temperature when it is greater than 100 °C.
- f) Emissivity: $\geq 0,95$.

4.2.3 Common target

- a) Common targets are used to test the parameters other than minimum resolvable temperature difference (MRTD) and minimum detectable temperature difference (MDTD).
- b) It shall be a rectangle with clear edges.
- c) Emissivity: $\geq 0,95$.
- d) Length: > 100 mm.
- e) Width: < 20 mm.

4.2.4 MRTD four-shot target

- a) The four-shot target is specifically used to test MRTD.
- b) It is comprised of four periodic rectangular slots with aspect ratio (width: height) 7:1, as shown in [Figure 1](#); $L = 7 \times D$.
- c) The distance between the rectangular slots is equal to the width of the slots, which is in accordance with the accuracy of the MRTD to be measured; $D = W$; $G = (1 \sim 2) \times W$. W is generally in the range of 5 mm to 15 mm.
- d) The target shall be made of metal such as copper or stainless steel with thickness above 0,5 mm, painted with black matt paint.
- e) Emissivity: $\geq 0,95$.

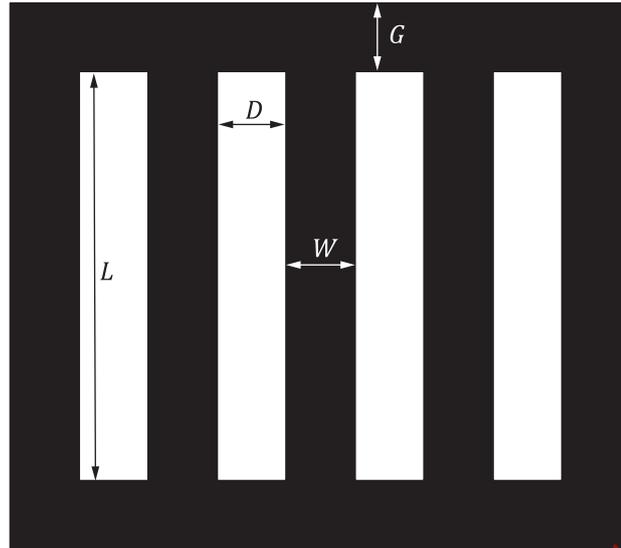


Figure 1 — Four-shot target

4.2.5 MDTD disk target

- a) The disk target is specifically used to test MDTD.
- b) [Figure 2](#) shows the layout of MDTD target. The MDTD target is generally round with the diameter D generally in the range of 100 mm to 300 mm and it can cover the whole field of view (FOV) of the infrared camera. There is a circular target hole which the diameter d is generally in the range of 20 mm to 40 mm. The distance L from the target hole centre to the MDTD target centre is generally in the range of 25 mm to 60 mm;
- c) The target shall be metal (e.g. copper) with thickness above 0,5 mm, painted with black matt paint.
- d) Emissivity: $\geq 0,95$.

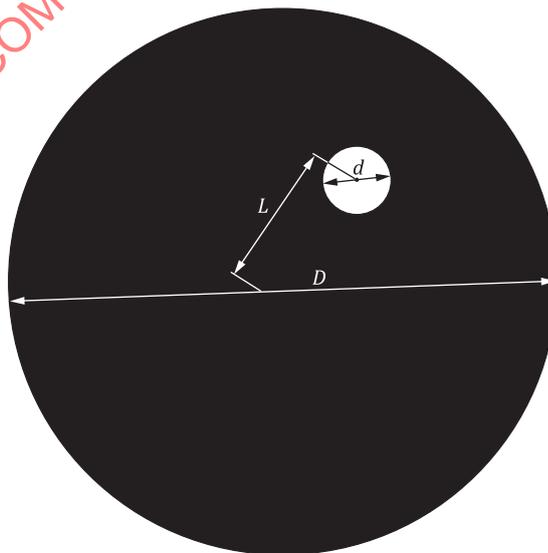


Figure 2 — MDTD target

4.2.6 Optical table

Optical table is used to test infrared system and equipment parameters. Its flatness shall be less than 0,05 mm/m².

4.2.7 Positioning stage

- a) Positioning stage is used to move and rotate the infrared camera.
- b) The positioning stage shall be able to carry the infrared camera in a steady speed and manageable manner.
- c) The infrared camera shall be able to move up and down in z direction, move on horizontal plane in one dimension and rotate on the horizontal plane. Its range and accuracy shall meet the test requirements of the IR imaging system.

4.2.8 Infrared radiometer

- a) The infrared radiometer is used to calibrate target temperature.
- b) Measuring range: -20 °C to 500 °C.
- c) Measurement accuracy: ±1 °C or ±1 % (using the higher).

4.2.9 Collimator

- a) The collimator is used to turn the target's infrared beam into parallel light. Its use is optional.
- b) The focal length shall be at least 3 times the focal length of the infrared camera being measured.
- c) The optical aperture shall be greater than the receiving aperture of the infrared camera being measured.

4.3 Document requirements

4.3.1 Testing specification

A written testing specification shall be formulated, with following items at least:

- a) version number;
- b) scope of application;
- c) basis of standards, regulations or other technical documents;
- d) a reference to this document, i.e. ISO 18251-2:2023;
- e) environment requirements;
- f) requirements of personnel;
- g) testing equipment requirements;
- h) information of tested equipment and pre-test preparation requirements;
- i) test methods and test procedures;
- j) requirements of test records;
- k) test results and reporting requirements;
- l) signature and date.

4.3.2 Test report

The following items shall be included in the testing report at least:

- a) report number;
- b) subcontractor;
- c) testing company;
- d) implementation standards;
- e) location and environment;
- f) test instrument;
- g) information of tested equipment;
- h) test data and results;
- i) inspector and reviewer signature and date.

4.3.3 Test record

The test record shall contain the contents specified in test procedures and the report at least.

5 Testing method

5.1 Noise equivalent temperature difference (NETD)

5.1.1 Put the infrared camera on the operating platform, place the blackbody in a position with a distance greater than 300 mm from the infrared camera, and ensure that the blackbody covers the whole FOV of the infrared camera.

5.1.2 Set the blackbody temperature to the middle temperature point of the infrared camera's measurement range, acquire thermograms over a period of time (typically 1 s). The size of the thermogram is $K \times L$; the frame average is according to [Formula \(1\)](#):

$$P^i = \frac{\sum_{x=1}^K \sum_{y=1}^L P_{x,y}^i}{K \times L} \quad (1)$$

where

P^i is the average of frame i ;

$P_{x,y}^i$ is the grayscale of pixel (x,y) in frame i ;

The root-mean-square of noise grayscale is according to [Formula \(2\)](#):

$$N = \frac{1}{n} \sum_{i=1}^n \sqrt{\frac{\sum_{x=1}^K \sum_{y=1}^L (P_{x,y}^i - P^i)^2}{K \times L}} \quad (2)$$

where n is the number of acquired thermograms over a period of time.

5.1.3 Set the blackbody temperature to the middle temperature point of the infrared camera's measurement range and adjust the temperature difference of the blackbody (usually 2 °C), make the target at least occupy 10 % of FOV, measure signal and noise voltage.

5.1.4 Calculate the NETD, ΔT_{NE} , according to [Formula \(3\)](#):

$$\Delta T_{NE} = \frac{\Delta T}{S/N} \tag{3}$$

where

ΔT is the setting temperature difference (usually 2 °C), if the output of thermography is in the saturated state, the ΔT can be reduced;

S is the grayscale of the signal;

N is the root-mean-square of the noise grayscale.

5.2 Minimum resolvable temperature difference (MRTD)

5.2.1 As show in [Figure 3](#), place the infrared camera on a platform, make its visual axis and the main optical axis of the test equipment coaxial, and install the four-shot target in front of the blackbody. If necessary, a collimator can be placed between the infrared camera and the four-shot target.

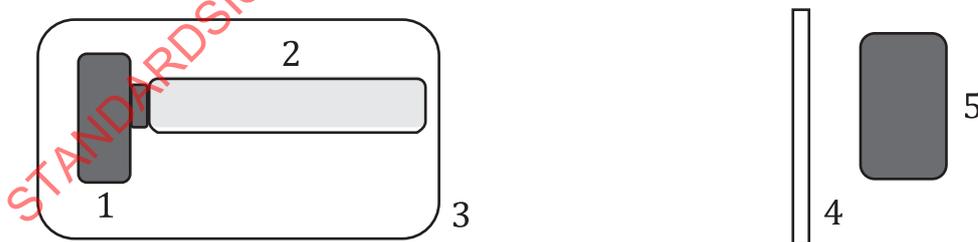
5.2.2 Adjust the monochrome video monitor controls so that the presence of noise is barely perceivable by the observer. Make the display luminance and the laboratory ambient luminance mutually suitable for visual acuity and viewing comfort.

5.2.3 Set the nominal ΔT (the nominal temperature of the bars minus the nominal temperature of the conjugate bars) to equal zero. Gradually increase the nominal ΔT in increments not exceeding 0,1 °C until the observer signals. At least 2 of 3 observers give the signals, the nominal ΔT is recorded as ΔT_1 .

5.2.4 Set the nominal ΔT equal to zero. Gradually reduce the nominal ΔT in increments not exceeding 0,1 °C until the observer signals. At least 2 of 3 observers give the signals, the nominal ΔT is recorded as ΔT_2 .

5.2.5 The MRTD, ΔT_{MR} , in this spatial frequency is given by [Formula \(4\)](#):

$$\Delta T_{MR} = \frac{|\Delta T_1| + |\Delta T_2|}{2} \tag{4}$$



Key

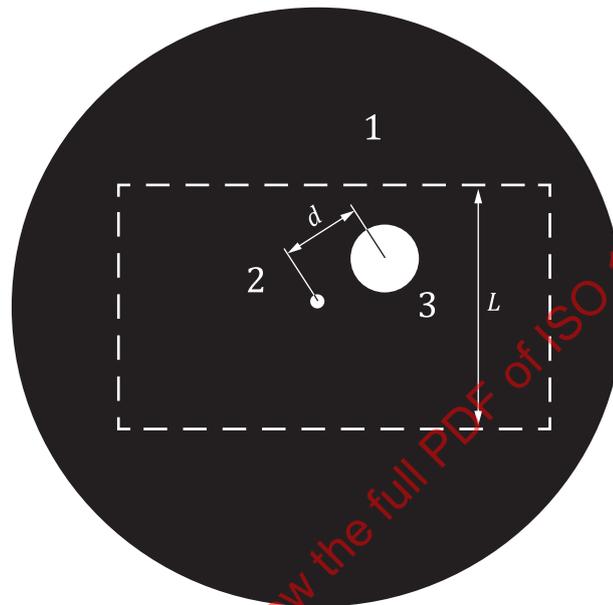
- 1 IR imaging system
- 2 collimator (optional)
- 3 platform
- 4 target plate
- 5 blackbody simulator

Figure 3 — Schematic of MRTD and MDTD test configuration

5.3 Minimum detectable temperature difference (MDTD)

5.3.1 As show in [Figure 3](#), place the infrared camera on a platform; the MDTD target plate is used.

5.3.2 Adjust the FOV of the infrared camera as shown in [Figure 4](#); the disk should cover the whole FOV of the infrared camera; make the circular targets cover 5 % to 10 % of the FOV area; the distance between the target hole centre and the MDTD target centre is approximately equal to 1/3 of the height of the FOV.



Key

- 1 MDTD target plate
- 2 FOV of the infrared camera
- 3 circular target hole in the MDTD target plate
- d distance between the target hole centre and the MDTD target centre
- L height of the FOV

Figure 4 — Sketch map of FOV in MDTD test

5.3.3 Make the display luminance and the laboratory ambient luminance mutually suitable for visual acuity and viewing comfort; make its visual axis and the main optical axis of the test equipment coaxial; the infrared camera should be placed on the operating platform for the adjustment of coaxiality.

5.3.4 Set the nominal ΔT (the nominal temperature of the targets minus the nominal temperature of the background) to equal zero.

5.3.5 Gradually increase the nominal ΔT in increments not exceeding 0,1 °C/min until the observer can identify the target location accurately. Record the size of the circular target hole, the size of the field, the distance of the observer to the MDTD target.

5.3.6 Remove the thermal imaging system from the platform and replace it with an infrared spot radiometer and measure the temperature distribution of the circular target hole and the target background. The circular target hole shall be uniformly measured in three points (T_{tar1} , T_{tar2} , T_{tar3}). The target background shall be measured 3 points in zone 1 and 6 points in zone 2. Zone 1 is the area adjacent to the circular target hole which the distance between the detection point and the centre of the circular target hole is smaller than the circular target hole's diameter. Zone 2 is the area outside of zone

1. 3 points in zone 1 ($T_{\text{back1-1}}$, $T_{\text{back1-2}}$, $T_{\text{back1-3}}$) and 6 points ($T_{\text{back2-1}}$, $T_{\text{back2-2}}$, $T_{\text{back2-3}}$, $T_{\text{back2-4}}$, $T_{\text{back2-5}}$, $T_{\text{back2-6}}$) in zone 2 shall be uniformly distributed in each zone.

5.3.7 The average temperature of the target is T_{tar} , calculated in [Formula \(5\)](#); the weighted average temperature of the background is T_{back} , calculated in [Formula \(6\)](#); the observed temperature difference for this observer is ΔT_1 , calculated in [Formula \(7\)](#).

$$T_{\text{tar}} = \frac{T_{\text{tar-1}} + T_{\text{tar-2}} + T_{\text{tar-3}}}{3} \quad (5)$$

$$T_{\text{back}} = \frac{6 \times (T_{\text{back-1-1}} + T_{\text{back-1-2}} + T_{\text{back-1-3}}) + (T_{\text{back-2-1}} + T_{\text{back-2-2}} + T_{\text{back-2-3}} + T_{\text{back-2-4}} + T_{\text{back-2-5}} + T_{\text{back-2-6}})}{24} \quad (6)$$

$$\Delta T_N = T_{\text{tar}} - T_{\text{back}} \quad (7)$$

5.3.8 Repeat the entire test (steps [5.3.5](#) to [5.3.7](#)) with another two observers; record their observed temperature differences as ΔT_2 , ΔT_3 .

5.3.9 The MDTD, ΔT_{MD} , is the mid-value of ΔT_1 , ΔT_2 and ΔT_3 , calculated in [Formula \(8\)](#).

$$\Delta T_{\text{MD}} = \text{Me}(\Delta T_1, \Delta T_2, \Delta T_3) \quad (8)$$

5.4 Field of view (FOV), instantaneous field of view (IFOV) and spatial resolution

5.4.1 Place the infrared camera on a positioning stage at a fixed distance from a common target, which is not less than the minimum image distance of the infrared camera, ensuring the common target is not in the FOV of the infrared camera.

5.4.2 Turn the infrared camera, with the positioning stage clockwise, until the target comes into view, record the rotating angle of the positioning stage as Φ_1 .

5.4.3 Continue turning the infrared camera, with the positioning stage, until the target leaves the FOV and record the rotational angle of the positioning stage as Φ_2 .

5.4.4 Remove the infrared camera from the positioning stage and rotate it so the FOV is 90° from the original FOV and then replace and secure it back onto the positioning stage and then repeat [5.4.2](#) and [5.4.3](#), recording the rotational angles as Φ_3 , for the incoming angle and Φ_4 for the outgoing angle.

5.4.5 The FOV is $[(\Phi_1 - \Phi_2), (\Phi_3 - \Phi_4)]$.

5.4.6 The IFOV is $[(\Phi_1 - \Phi_2) / n_{\text{hp}}, (\Phi_3 - \Phi_4) / n_{\text{vp}}]$, where n_{hp} is the horizontal number of pixels and n_{vp} is the vertical number of pixels.

5.4.7 The horizontal spatial resolution is $[2\pi \times (\Phi_1 - \Phi_2)] / (360^\circ \times n_{\text{hp}})$.

5.4.8 The vertical spatial resolution is $[2\pi \times (\Phi_3 - \Phi_4)] / (360^\circ \times n_{\text{vp}})$.

5.5 Minimum working distance

5.5.1 Place the infrared camera on a positioning stage at a fixed distance from a common target.