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TECHNICAL SPECIFICATION

colour inside

Industrial process control devices – Radiation thermometers – Part 2: Determination of the technical data for radiation thermometers

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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**INDUSTRIAL PROCESS CONTROL DEVICES –
RADIATION THERMOMETERS –**

**Part 2: Determination of the technical data
for radiation thermometers**

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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC 62492-2, which is a technical specification, has been prepared by subcommittee 65B: Measurement and control devices, of IEC technical committee 65: Industrial-process measurement, control and automation.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
65B/844/DTS	65B/859/RVC

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62492 series, published under the general title *Industrial process control devices – Radiation thermometers*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- transformed into an International Standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

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INDUSTRIAL PROCESS CONTROL DEVICES – RADIATION THERMOMETERS –

Part 2: Determination of the technical data for radiation thermometers

1 Scope

This part of IEC 62492, which is a Technical Specification, applies to radiation thermometry and addresses all technical data specified in IEC/TS 62492-1. It defines standard test methods which can be used by the end user of radiation thermometers to determine or confirm the fundamental metrological data of radiation thermometers with one wavelength range and one measurement field.

The purpose of this specification is to facilitate comparability and testability. Therefore, unambiguous test methods are stipulated for determining technical data, under standardised measuring conditions that can be performed by a sufficiently skilled end user to serve as standard performance criteria for instrument evaluation or selection.

It is not compulsory for manufacturers and sellers of radiation thermometers to include all technical data given in this document in the data sheets for a specific type of radiation thermometer. Only the relevant data should be stated and should comply with this specification and IEC/TS 62492-1.

NOTE Infrared ear thermometers are excluded from this Technical Specification.

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.

IEC/TS 62492-1:2008, *Industrial process control devices – Radiation thermometers – Part 1: Technical data for radiation thermometers*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document the following terms and definitions apply.

NOTE The terms and definitions listed below comply with IEC/TS 62492-1.

3.1.1
measuring temperature range
temperature range for which the radiation thermometer is designed

3.1.2
measurement uncertainty
parameter, associated with the result of a measurement, that characterises the dispersion of the values that could reasonably be attributed to the measurand

3.1.3
noise equivalent temperature difference
parameter which indicates the contribution of the measurement uncertainty in °C, which is due to instrument noise

3.1.4
measuring distance
distance or distance range between the radiation thermometer and the target (measured object) for which the radiation thermometer is designed

3.1.5
field-of-view
a usually circular, flat surface of a measured object from which the radiation thermometer receives radiation

3.1.6
distance ratio
the ratio of the measuring distance to the diameter of the field-of-view, when the target is in focus

3.1.7
size-of-source effect
the difference in the radiance or temperature reading of the radiation thermometer when changing the size of the radiating area of the observed source

3.1.8
emissivity setting
ratio between the radiation emitted from this surface and the radiation from a blackbody at the same temperature

Note 1 to entry: In most measuring situations a radiation thermometer is used on a surface with an emissivity significantly lower than 1. For this purpose most thermometers have the possibility of adjusting the emissivity setting. The temperature reading is then automatically corrected.

3.1.9
spectral range
parameter which gives the lower and upper limits of the wavelength range over which the radiation thermometer collects radiation from a source

3.1.10
influence of the internal instrument temperature
influence of the ambient temperature
temperature parameter
parameter which gives the additional uncertainty of the measured temperature value depending on the deviation of the temperature of the radiation thermometer from the value for which the technical data is valid after warm-up time and under stable ambient conditions

3.1.11
influence of air humidity
humidity parameter
parameter which gives the additional uncertainty of the measured temperature value depending on the relative air humidity at a defined ambient temperature

3.1.12
long-term stability
the reproducibility of measurements repeated over a long time period

Note 1 to entry: The time period is typically three months or one year.

3.1.13
short-term stability
the reproducibility of measurements repeated over a short time period

Note 1 to entry: The time period is several hours.

3.1.14
repeatability
twice the standard deviation of measurements repeated under the same conditions within a very short time span

Note 1 to entry: The time span is several minutes.

3.1.15
interchangeability
the maximum deviation between the readings of two instruments of the same type operating under identical conditions divided by two

3.1.16
response time
time interval between the instant of an abrupt change in the value of the input parameter and the instant from which the measured value of the radiation thermometer remains within specified limits of its final value

Note 1 to entry: The input parameter is an object temperature or an object radiation, and the output value is an output parameter.

3.1.17
exposure time
time interval between an abrupt rise and an abrupt fall in the value of the input parameter, such that the output value of the radiation thermometer reaches a given measurement value

Note 1 to entry: The input parameter is an object temperature or an object radiation.

3.1.18
warm-up time
time period needed for the radiation thermometer, after switching on, before it operates according to its specifications

3.1.19
operating temperature
the permissible temperature range within which the radiation thermometer may be operated

Note 1 to entry: For this temperature the specifications are valid.

3.1.20

operating air humidity range
the permissible humidity range within which the radiation thermometer may be operated

Note 1 to entry: For this humidity range the specifications are valid.

3.1.21
storage and transport temperature
the permissible ambient temperature range within which the radiation thermometer may be stored and transported without suffering permanent change

3.1.22

storage and transport air humidity range
the permissible humidity range within which the radiation thermometer may be stored and transported without suffering permanent change

3.1.23
safety
freedom from unacceptable risk

3.1.24
risk
combination of the probability of the occurrence of harm and the severity of that harm

3.1.25
harm
physical injury or damage to the health of people, or damage to property or the environment

3.1.26
tolerable risk
risk which is accepted in a given context based on the current values of society

3.2 Abbreviations

FWHM Full width at half maximum

NETD Noise equivalent temperature difference

SSE Size-of-source effect

4 Measurement conditions

The following test conditions apply for all measurements, if not stated otherwise:

a) laboratory ambient temperature range from 18 °C to 28 °C;

b) any special ambient conditions (e.g. humidity range, maximum ambient temperature change per time) and measurement conditions (e.g. measuring distance, radiating area diameter, response time) given by the manufacturer for the specific radiation thermometer to be adhered to;

c) the radiation thermometer to be connected to a power supply in accordance to the manufacturer’s instructions;

d) the warm-up time specified by the manufacturer to be adhered to;

e) internal standardization check (initial self-test) to be carried out, if available;

f) emissivity setting set to 1 (one), if available;

g) the reference temperature source shall have a radiating area diameter as large as possible and in any case greater than the radiation thermometer field-of-view (target area) diameter;

h) all tests have to be performed with the reference temperature source set to a temperature that is significantly different from ambient temperature and the internal temperature of the radiation thermometer.

NOTE The reference temperature source is a radiation source of known radiation temperature in the spectral range of the radiation thermometer. Usually it is a blackbody source realised by a cavity radiator of known temperature. It will be called “reference source” throughout this document.

5 Determination of technical data

5.1 Measuring temperature range

5.1.1 General

The purpose of this test is to determine the measuring temperature range. For this temperature range, the measurement uncertainty remains within the specified limits.

Measurement temperature range (5.1), as well as Measurement uncertainty (5.2) and Noise equivalent temperature difference (5.3), are the most important parameters that specify a radiation thermometer. These three parameters are correlated with each other and in general noise equivalent temperature difference is larger at the lower limit of the measuring temperature range where uncertainty is larger. This relation is demonstrated in Table A.1 and the equation of Annex A.

NOTE Sometimes it is useful to determine additionally a wider *indicating temperature range* over which the thermometer will display a temperature but its specifications are not guaranteed.

5.1.2 Test method

5.1.2.1 The determination of the *measuring temperature range* is performed in accordance with 5.2.2 at the top and the bottom temperature of the specified measuring temperature range.

Determination of the indicating *temperature range*:

5.1.2.2 Sight the radiation thermometer at the centre of the radiating area of the reference source.

5.1.2.3 The temperature of the reference source is sequentially adjusted and stabilised at temperatures around the minimum temperature and the maximum temperature of the indicating temperature range given by the manufacturer, to determine the minimum and maximum temperatures for which the radiation thermometer is still indicating.

5.1.2.4 These two temperatures give the indicating temperature range.

5.2 Measurement uncertainty

5.2.1 General

A detailed description of the different methods to determine the measurement uncertainty and its confidence level is beyond the scope of this technical specification. In this technical specification terms, concept and definition of uncertainty is based on ISO/IEC Guide 98-3 and ISO/IEC Guide 99.

The described method is a basic test of the measurement uncertainty across the measuring temperature range.

5.2.2 Test method

5.2.2.1 Sight the radiation thermometer at the centre of the radiating area of the reference source.

5.2.2.2 The temperature of the reference source is sequentially stabilised at, at least, three temperatures distributed at the top, the bottom and an intermediate temperature of the measuring temperature range (see Note 1 of 5.2.2.5).

5.2.2.3 The temperature of the reference source and the temperature indicated by the radiation thermometer are recorded. The difference between these two values is calculated and recorded.

5.2.2.4 The test sequence is performed three times for the same three calibration points. An average temperature difference is calculated and recorded for each calibration temperature point.

5.2.2.5 The value of the measurement uncertainty of the radiation thermometer at each calibration temperature is taken to be the average difference determined in 5.2.2.4 plus the temperature uncertainty of the reference source in respect to the current International Temperature Scale.

NOTE 1 The number of temperature points depends on the requirements of the specific thermometer and its application.

NOTE 2 For radiation thermometers with more than one measuring temperature range each range is calibrated as if it were a separate instrument.

Due to the small number of observations care shall be taken not to infer too much significance from this basic test (i.e. no confidence level can be given).

In order to use this method to test for compliance of measuring temperature range and measurement uncertainty with the data provided by the manufacturer, the temperature uncertainty of the reference source shall be significantly smaller than the uncertainty of the radiation thermometer.

5.3 Noise equivalent temperature difference (NETD)

5.3.1 General

The purpose of this method is to determine the NETD. The measured temperature and the response time of the radiation thermometer are to be stated with the NETD. For some instruments the NETD depends on the instrument or ambient temperature. For these instruments the instrument or ambient temperature also has to be stated. For low cost instruments the NETD may be limited by their resolution.

The NETD is generally largest at the lowest temperature of the measuring temperature range. When using electronic measuring equipment, its bandwidth shall be noted or set accordingly. In particular, the bandwidth of the radiation thermometer shall not be limited by the bandwidth of the external measuring equipment. In contrast to the other metrological data, the confidence level in this case is 68,3 % (standard uncertainty, $k = 1$).

5.3.2 Test method

5.3.2.1 Sight the radiation thermometer at the centre of the radiating area of the reference source.

5.3.2.2 The temperature of the reference source is stabilised at a temperature within the measuring temperature range of the radiation thermometer. The greatest expected noise amplitudes may not exceed the limits of the measuring temperature range.

5.3.2.3 The total measurement time is at least 100 times the set response time of the radiation thermometer with at least 100 measured values taken.

5.3.2.4 The NETD of the radiation thermometer is calculated as the standard deviation of the measured values, and stated together with the reference source temperature and the set response time.

Noise caused by the temperature stability of the reference source and additional measurement equipment shall be significantly lower than the noise of the radiation thermometer.

According to 5.3.1 the NETD is expected to vary across the measuring temperature range. Therefore, for completeness, the NETD should be determined at a minimum of two temperatures, one of which is the lowest measuring temperature.

5.4 Measuring distance

For this distance or distance range the specifications are valid, if not stated otherwise. No specific test method is needed.

NOTE The calibration of a radiation thermometer, with respect to a reference source of the same area, gives different results at different distances due to the SSE of the instrument.

5.5 Field-of-view (target size)

5.5.1 General

Its magnitude is determined by the optical components in the radiation thermometer. As the field-of-view is not sharply defined, it is necessary to state the diameter of the field-of-view at which the radiation signal has dropped to a certain fraction of its total integrated value (hemispherical value or the value for an infinitely extended source). The fraction value should be at least 90 %; typical values are 90 %, 95 % and 99 %.

For some radiation thermometers, especially for high temperature instruments, it is impracticable to relate the field-of-view to a hemispherical value. In this case it is allowed to relate the given field-of-view to a larger source (e.g. twice as large in area as the field-of-view).

As the field-of-view value depends on the measuring distance, it is necessary to state the measuring distance in addition to the fraction.

The transfer function between the *measured radiation* (input parameter) and *temperature* (output parameter) is non-linear. As an example the change in indicated temperature corresponding to a 1 % change in the radiation exchange with a radiation thermometer is given in Annex A. The field-of-view is therefore either defined for the *fraction of measured radiation* or, for instruments which only read directly in temperature, it is necessary to specify a *change in the measured temperature* in °C at a given temperature for the field-of-view in comparison to the total integrated value (hemispherical value or the value for an infinitely extended source). As a minimum, these values should be given for the top, middle and bottom of the temperature range.

The complete field-of-view information would be a graph (see Figure 1), which shows the signal or temperature versus source size (size-of-source effect).

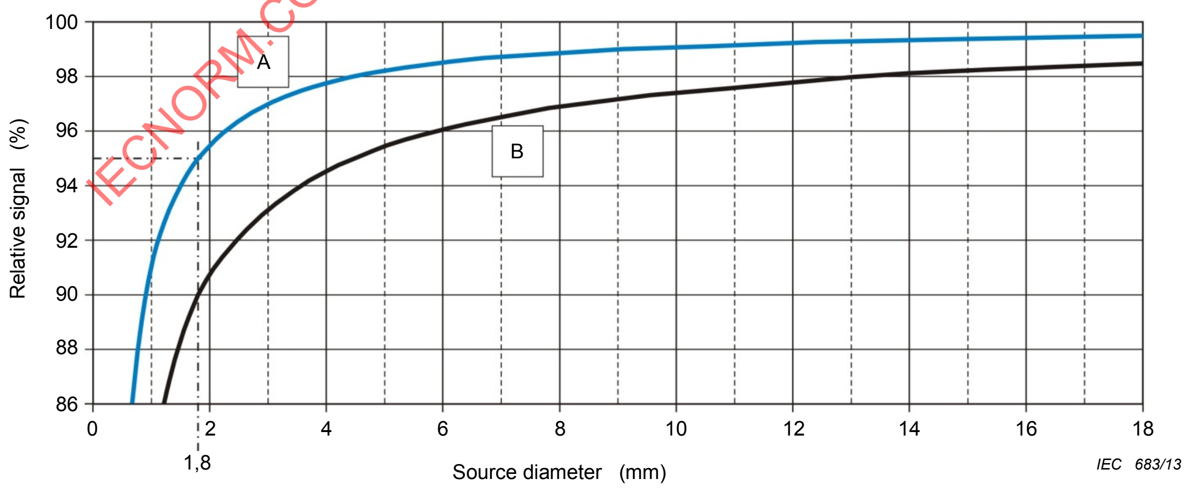


Figure 1 – Relative signal to a signal at a defined aperture size (source size) of 100 mm in diameter for two infrared radiation thermometers A and B versus the source diameter

Explanation of Figure 1: The field-of-view diameter (target diameter) is stated as 1,8 mm for each of the two radiation thermometers A and B. For radiation thermometer A, this corresponds to 95 % of the maximum measuring signal, while for radiation thermometer B it corresponds to 90 % of the maximum measuring signal. The figure indicates the change in the measuring signal with the change in source diameter. In order to achieve 98 % of the maximum measuring signal, a source diameter of 4,5 mm is required for radiation thermometer A while a source diameter of 13 mm is required for radiation thermometer B. The maximum measuring signal in this example is determined at a source (aperture) diameter of 100 mm and is taken to be 100 % of the hemispherical value.

The following test method determines the diameter of the field-of-view at which the signal has dropped to a 99 % fraction of the hemispherical value or is related to a 99 % fraction of the signal at a defined aperture size of the source. The method can be adapted accordingly to determine the field of view of radiation thermometers which relates to 95 % or 90 % of the hemispherical value or the signal at a defined aperture size of the source.

5.5.2 Test method

5.5.2.1 Sight the radiation thermometer at the centre of the radiating area of the reference source at the specified measuring distance. Position an iris diaphragm in front of and concentric with the opening of the reference source. The minimum opening of the reference source shall be large enough so as not to obstruct the optical path (i.e. the nominal field-of-view as specified by the manufacturer) of the radiation thermometer when the thermometer is sighted through the plane of the iris and the iris is set at a diameter of at least twice the field-of-view of the instrument.

5.5.2.2 The temperature of the reference source is stabilised at a temperature near the top of the measuring temperature range of the radiation thermometer.

5.5.2.3 The iris is adjusted to a diameter slightly smaller (typically 10 % less) than the expected field-of-view.

5.5.2.4 The position of the radiation thermometer is adjusted vertically and horizontally and focused if applicable to produce maximum output while also maintaining the line of sight perpendicular to the iris.

5.5.2.5 The iris is opened to the point where the temperature indicated by the radiation thermometer stops increasing, but its diameter is still smaller than the reference source opening. In this case, the field-of-view is defined in terms of the 99 % fraction of the hemispherical value. If the temperature indicated by the radiation thermometer does not stabilize after exceeding the largest possible iris diameter, the field-of-view is defined in terms of the maximum iris diameter for which the temperature source does not obstruct the optical path of the radiation thermometer.

5.5.2.6 The iris diameter is decreased until the radiation measured by the radiation thermometer decreases by 1 % of the original signal or the temperature indicated by the radiation thermometer decreases by the amount appearing in Annex A.

5.5.2.7 The value for the field-of-view at the measuring distance chosen is taken to be the diameter of the iris opening for which the radiant power received by the radiation thermometer or the temperature indicated by the radiation thermometer has been reduced according to 5.5.2.6.

The reference source shall have a stable and homogenous radiance temperature within its radiating area (i.e. *the temperature and emissivity of the source shall not change when changing the size of the radiating area* or such changes have to be corrected).

The iris shall be kept cool enough so that its thermal emission does not contribute significantly to the output signal. In most cases the error is insignificant if the iris is maintained near room temperature and the temperature of the reference source is at or above 200 °C.

5.6 Distance ratio

As the distance ratio is defined as the ratio of the measuring distance to the diameter of the field-of-view no specific test method is needed.

5.7 Size-of-source effect (SSE)

5.7.1 General

To describe the SSE the difference in the radiance or temperature reading of the radiation thermometer when changing the size of the radiating area of the observed source shall be stated. The complete information would be a graph, which shows the signal or temperature reading versus source diameter (see Figure 1).

To simplify the SSE statement and make it more comparable, the following measurement conditions shall be used as far as possible: the SSE is to be stated at a given measuring distance, measured temperature and ambient temperature, when observing a target with the area of the nominal field-of-view and twice the area of the nominal field-of-view or more than twice the area of the nominal field-of-view. In the latter case, the area should be specified.

The SSE is either defined as the relative change in the observed radiance or, for instruments which only read in temperature, as the absolute change in the measured temperature at a given temperature, when changing the observed target area. Since the latter definition depends on the source temperature it is necessary to state the SSE at the top, middle and bottom temperatures of the measuring temperature range.

The following test method determines the SSE when increasing the area of the target from the nominal field-of-view to twice the field-of-view. With the size-of-source effect it is necessary to state the measuring distance, the measured temperature and the surrounding temperature of the source.

5.7.2 Test method

5.7.2.1 Sight the radiation thermometer at the centre of the radiating area of the reference source at the specified measuring distance. Position an iris diaphragm in front of and concentric with the opening of the reference source. The minimum opening of the reference source shall be large enough so as not to obstruct the optical path of the radiation thermometer, i.e. the nominal field-of-view as specified by the manufacturer, when the thermometer is sighted through the plane of the iris and the iris is set at a diameter of at least twice the field-of-view of the instrument.

5.7.2.2 The temperature of the reference source is stabilised at a temperature near the top of the measuring temperature range of the radiation thermometer.

5.7.2.3 The iris is adjusted to a diameter slightly smaller (typically 10 % less) than the expected field-of-view.

5.7.2.4 The position of the radiation thermometer is adjusted vertically and horizontally and focused if applicable to produce maximum output while also maintaining the line of sight perpendicular to the iris.

5.7.2.5 The iris is opened to the diameter specified as the nominal field-of-view by the manufacturer and the radiation signal or the temperature indicated by the radiation thermometer is recorded.

5.7.2.6 The iris area is increased to an area twice the nominal field-of-view of the radiation thermometer. The radiation signal or the temperature indicated by the radiation thermometer is recorded.

5.7.2.7 The relative change in radiance reading or the absolute change in temperature reading when changing the size of the iris is recorded as the SSE of the radiation thermometer.

5.7.2.8 For radiation thermometers which indicate temperature the test method is repeated for a temperature of the reference source stabilized near the middle and bottom of the temperature range.

The reference source shall have a stable and homogenous radiance temperature within its radiating area (i.e. *the temperature and emissivity of the source shall not change when changing the size of the radiating area* or such changes have to be corrected).

The iris shall be kept cool enough so that its thermal emission does not contribute significantly to the output signal. In most cases the error is insignificant if the iris is maintained near room temperature and the temperature of the reference source is at or above 200 °C.

5.8 Emissivity setting

The range and the resolution of the emissivity setting shall be given by the manufacturer. For information on the internal emissivity correction procedure the manufacturer has to be contacted. A test method for the emissivity setting is beyond the scope of this technical specification.

5.9 Spectral range

A test method for the determination of the spectral range is beyond the scope of this technical specification.

The spectral range is given in µm or nm. The lower and upper wavelength limits at which the spectral responsivity has reached 50 % of the peak responsivity are given as the spectral range. Alternatively, a mean wavelength and full wavelength width at which the responsivity has reached 50 % of the peak sensitivity (full width at half maximum (FWHM)) are given.

For some radiation thermometers, especially for narrow band or spectral radiation thermometers, it is more useful to give lower and upper wavelength limits at which the spectral responsivity has reached significantly less than 50 % of the peak responsivity (e.g. 10 %). In this case the criteria for the wavelength limits have to be stated.

5.10 Influence of the internal instrument or ambient temperature (temperature parameter)

5.10.1 General

The technical data of a radiation thermometer, e.g. the measurement uncertainty, shall be valid over the complete operating instrument or ambient temperature range and air humidity range, if not stated otherwise. If the measurement uncertainty is not valid in the complete operating instrument or ambient temperature range, the manufacturer shall state a temperature parameter which gives the additional measurement uncertainty when the instrument or ambient temperature deviates from a given reference temperature after warm-up time and under stable ambient conditions. It is given as the absolute or relative increase in the uncertainty of the measured value when the instrument or ambient temperature deviates from the reference temperature.

5.10.2 Test method

5.10.2.1 The radiation thermometer is operated in an adjustable temperature enclosure (e.g. climate chamber) at the instrument reference temperature given by the manufacturer. For instruments with no internal temperature indication the ambient temperature (i.e. the temperature of the climate chamber) shall be used as the instrument reference temperature.

5.10.2.2 Sight the radiation thermometer at the centre of the radiating area of the reference source.

No window should be used between the radiation thermometer and the reference source. If a window is used, the influence of the window on the temperature indicated by the radiation thermometer shall be corrected for.

5.10.2.3 The temperature of the reference source is stabilised near the bottom of the measuring temperature range of the radiation thermometer. If another source temperature is used, this should be stated.

5.10.2.4 The temperature of the reference source and the temperature indicated by the radiation thermometer are recorded. The difference between these two values is calculated and recorded.

5.10.2.5 The radiation thermometer is stabilised at the minimum internal temperature specified by the manufacturer.

5.10.2.6 The temperature of the reference source and the temperature indicated by the radiation thermometer are recorded. The difference between these two values is calculated and recorded.

5.10.2.7 The radiation thermometer is stabilised at the maximum internal temperature specified by the manufacturer.

5.10.2.8 The temperature of the reference source and the temperature indicated by the radiation thermometer are recorded. The difference between these two values is calculated and recorded.

5.10.2.9 The value of the measurement uncertainty of the radiation thermometer at each internal temperature is taken to be the difference determined in 5.10.2.4, 5.10.2.6 and 5.10.2.8 plus the temperature uncertainty of the reference source in respect to the current International Temperature Scale. From these uncertainties the temperature parameter of the radiation thermometer, as the absolute or relative increase in uncertainty as the ambient temperature deviates from the reference temperature, is derived.

Due to the small number of observations special care shall be taken not to infer too much significance from this test (i.e. no confidence level can be given).

Moisture condensation on the radiation thermometer (i.e. on the optics) shall be avoided throughout the test.

In order to use this method to test for compliance of the temperature parameter with the data provided by the manufacturer the temperature uncertainty of the reference source shall be significantly smaller than the uncertainty of the radiation thermometer.

The minimum time necessary for the thermal stabilisation of the radiation thermometer has to elapse after each change of temperature of the climate chamber. This stabilisation time might be longer than the climate chamber stabilisation time.

5.11 Influence of air humidity (humidity parameter)

The technical data of a radiation thermometer, e.g. the measurement uncertainty, shall be valid over the specified measuring distance and operating temperature range and air humidity range, if not stated otherwise. If within the specified measurement distance range the measurement uncertainty is not valid in the complete operating air humidity range, the manufacturer shall state a humidity parameter which gives the additional measurement uncertainty when the air humidity deviates from a given reference humidity.

A deviation of the air humidity from the reference air humidity leads to an additional uncertainty in temperature measurement. The humidity parameter gives the additional uncertainty of the measured temperature value depending on the relative air humidity at a defined ambient temperature. It is given as the absolute or relative increase in uncertainty in the measured value per percentage change in the air humidity relative to the reference humidity.

For the determination of the humidity parameter well defined atmospheric conditions regarding the chemistry and temperature of the atmosphere have to be realised. A test method for the humidity parameter is beyond the scope of this technical specification.

5.12 Long-term stability

5.12.1 General

The long-term stability should be stated in °C over a time span of 90 days or over one year.

The long-term stability depends on the stability of the mechanical, electrical and optical components of the radiation thermometer, the measured temperature and the confidence level.

5.12.2 Test method

5.12.2.1 Sight the radiation thermometer at the centre of the radiating area of the reference source.

5.12.2.2 The temperature of the reference source is stabilised at a temperature within the measuring temperature range of the radiation thermometer.

5.12.2.3 The total measurement time is at least 10 times the set response time of the radiation thermometer with at least 10 measured values of the temperature indicated by the radiation thermometer taken. The arithmetic mean of the measurement values is calculated.

5.12.2.4 The test sequence from 5.12.2.1 to 5.12.2.3 is performed at least once a month at the same temperature of the reference source over a time span of three months or one year. The radiation thermometer shall be turned off between the test sequences.

It is allowed for a manufacturer to perform an accelerated test in accordance with an established procedure based on the manufacturer’s technical knowledge and experience.

5.12.2.5 The long-term stability is taken to be the difference between the maximum and minimum mean values of temperature reading obtained over the test interval.

The long-term stability of the reference source shall be significantly better than the long-term stability of the radiation thermometer.

The test shall be performed with the reference source set to a temperature such that the radiation thermometer does not indicate its internal temperature or ambient temperature.

The radiation thermometer shall be kept under ambient conditions in accordance with the manufacturer's specifications during the complete test interval.

Due to the small number of observations special care shall be taken not to infer too much significance from this basic test (i.e. no confidence level can be given).

5.13 Short-term stability

5.13.1 General

The short-term stability should be stated in a rate °C/h or as a maximum temperature deviation within a short time span (several hours) after warm-up time.

The short-term stability depends on the measured temperature, the confidence level, the response time and the internal instrument or ambient temperature. These parameters are to be stated.

5.13.2 Test method

5.13.2.1 Sight the radiation thermometer at the centre of the radiating area of the reference source.

5.13.2.2 The temperature of the reference source is stabilised at a temperature within the measuring temperature range of the radiation thermometer.

5.13.2.3 The total measurement time is at least 3 h with at least 10 measurement sequences evenly distributed over the measurement time. For each measurement sequence the measurement time is at least 10 times the set response time of the radiation thermometer with at least 10 measured values of the temperature indicated by the radiation thermometer taken. The radiation thermometer shall not be turned off during the total measurement time. The lens system of the radiation thermometer may be covered in time periods between taking measurement sequences to avoid heating of the radiation thermometer.

5.13.2.4 The arithmetic mean of the measured values of the thermometer output for each measurement sequence is calculated.

5.13.2.5 The short-term stability is taken to be the difference between the maximum and minimum mean values of temperature reading obtained over the measurement time. It may also be stated as the difference between the maximum and minimum mean values of temperature reading divided by the measurement time. The short-term stability should be calculated from half the difference between the maximum and minimum mean values if it is given as a plus or minus (+/-) statement.

The short-term stability of the reference source shall be significantly better than the short-term stability of the radiation thermometer.

The test shall be performed with the reference source set to a temperature such that the radiation thermometer does not indicate its internal temperature or ambient temperature.

The radiation thermometer shall be kept under ambient conditions in accordance with the manufacturer's specifications during the complete test interval.

5.14 Repeatability

5.14.1 General

The repeatability is closely related to the NETD of a radiation thermometer and is determined over a time span of several minutes. The confidence level of the repeatability is twice as large as the confidence level of the NETD.

The measured temperature and the response time of the radiation thermometer are to be stated with the repeatability. For some instruments the repeatability depends on the instrument or ambient temperature. For these instruments the instrument or ambient temperature also has to be stated. For low cost instruments the repeatability may be limited by their resolution.

When using electronic measuring equipment, its bandwidth shall be noted or set accordingly. In particular, the bandwidth of the radiation thermometer shall not be limited by the bandwidth of the external measuring equipment.

5.14.2 Test method

5.14.2.1 Sight the radiation thermometer at the centre of the radiating area of the reference source.

5.14.2.2 The temperature of the reference source is stabilised at a temperature within the measuring temperature range of the radiation thermometer. The greatest expected noise amplitudes may not exceed the limits of the measuring temperature range.

5.14.2.3 The total measurement time shall be at least 3 min, and of a duration of at least 100 times the set response time of the radiation thermometer, with at least 100 measured values of the temperature indicated by the radiation thermometer taken (see 5.14.2.4).

5.14.2.4 The standard deviation is calculated from the measured values. The repeatability is twice the value of the standard deviation of the measured values of the temperature indicated by the radiation thermometer.

If the thermometer is affected by the heat of the reference source a shorter total measurement time shall be chosen.

Noise caused by the temperature stability of the reference source and additional measurement equipment shall be significantly lower than the noise of the radiation thermometer.

5.15 Interchangeability

5.15.1 General

No two instruments will differ by more than twice this figure.

The interchangeability value will not necessarily be the same as the uncertainty value. It is a critical parameter for the production control, when an instrument has to be replaced by another of the same type.

5.15.2 Test method

5.15.2.1 For the determination of the interchangeability at least three instruments of the same type are needed.

5.15.2.2 Sight the first radiation thermometer at the centre of the radiating area of the reference source.

5.15.2.3 The temperature of the reference source is stabilised at a temperature within the measuring temperature range of the radiation thermometer.

5.15.2.4 The total measurement time is at least 100 times the set response time of the radiation thermometer with at least 100 measured values of the temperature indicated by the radiation thermometer taken.

5.15.2.5 The arithmetic mean of the measured temperature values indicated by the radiation thermometer is calculated.

5.15.2.6 The test sequence from 5.15.2.2 to 5.15.2.5 is repeated for at least two more radiation thermometers of the same type, while the temperature of the reference source stays at the same temperature as in the first test.

5.15.2.7 The interchangeability is the difference between the maximum and the minimum calculated arithmetic mean values from the radiation thermometers divided by 2.

Identical and stable ambient conditions shall be realized during the test of all radiation thermometers.

The stability of the temperature of the reference source throughout the test has to be significantly better than the interchangeability of the radiation thermometers.

Due to the small number of radiation thermometers special care shall be taken not to infer too much significance from this test (i.e. no confidence level can be given).

5.16 Response time

5.16.1 General

The lower/upper temperature value for specifying the response time has to be a temperature value within, respectively, the lower/upper quartile of the measuring temperature range (see Figure 2).

For a radiation thermometer the rise and fall times (response times for rising and falling temperature steps) might be different. If this is the case, it shall be stated.

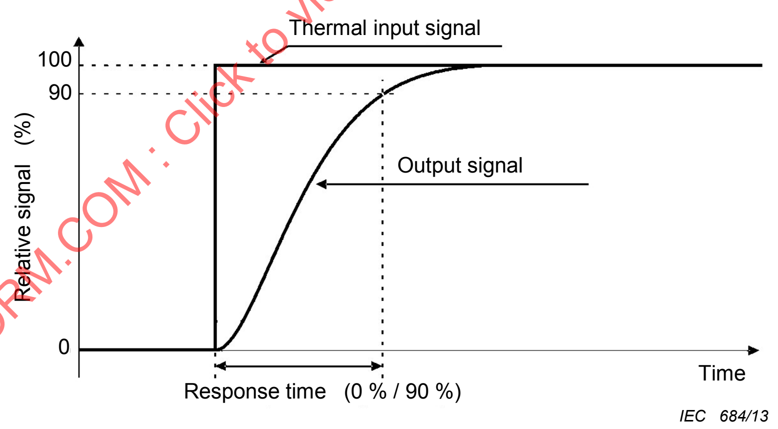


Figure 2 – Demonstration of the response time to a rising temperature step

The response time depends on the type of signal processing within the radiation thermometer. The magnitude of the temperature step (lower value and upper value) as well as the percentage or temperature limits are to be given when stating the response time.

The following test method outlines the procedure to determine the time required for the output signal of a radiation thermometer to reach 90 % of the full scale response to a corresponding step change of input radiant power starting at ambient temperature radiation to a temperature radiation close to the top of the measuring temperature range of the radiation thermometer. The response time may be specified as a different percentage level of the full scale response, e.g. 99 % (see IEC/TS 62492-1:2008, 4.1.1.16.3). In this case the test method has to be adjusted accordingly.

5.16.2 Test method

5.16.2.1 Sight the radiation thermometer at the centre of the radiating area of the reference source.

5.16.2.2 The reference source is stabilised at a temperature close to the top of the measuring temperature range of the radiation thermometer.

5.16.2.3 The sight path between the radiation thermometer and the reference source is interrupted by a shutter mechanism and the output of the radiation thermometer is allowed to stabilize at the radiation temperature of the shutter (ambient temperature).

5.16.2.4 The data acquisition system is triggered and the shutter is opened such that the signal over time from the radiation thermometer in response to the full-scale step change in input radiant power can be measured and recorded (e.g. using a storage oscilloscope).

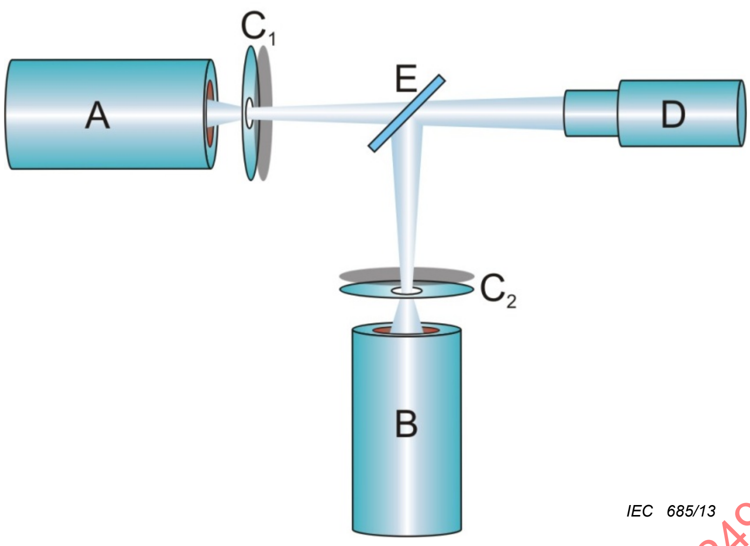
5.16.2.5 As a digitally processed radiation thermometer may have a variation in the measured value of response time the measurement has to be repeated a sufficient number of times (at least five times) until the maximum value of response time is uniquely determined. Care has to be taken that the response time test method is only performed when the radiation thermometer is in the temperature measurement mode of operation, as radiation thermometers may periodically perform e.g. a calibration routine.

5.16.2.6 The response time (0 %/90 %) is the longest measured time period for the thermometer to reach 90 % of the final (maximum) measured value (see Figure 2).

The time period needed for the shutter mechanism to open shall be much shorter than the response time (not more than 10 % of the response time) and the shutter shall have a stable radiation temperature near ambient temperature (i.e. no heating up by the reference source).

Instead of a reference source with a shutter mechanism a radiation source with rapidly adjustable radiation intensity and appropriate wavelength may be used. This can be for example a light emitting diode (LED) which is operated with a pulse generator. The radiation source is switched to continuous output and the signal output of the radiation thermometer is monitored with a rapid signal recording device e. g. a storage oscilloscope. If applying a LED, its operating current shall be adjusted until the required temperature indication at the radiation thermometer is achieved at the beginning of the test method. The pulse width is then reduced until the temperature display indicates a specific proportion of the minimum/maximum signal, e.g. 0 %/90 % of the original display. The set pulse width is now the response time.

For the determination of response times starting at temperatures different from ambient temperature an analogous method based on a more sophisticated setup with two reference sources (see Figure 3) shall be applied.



Key

A	Reference source 1
C_1, C_2	Shutter mechanisms
B	Reference source 2
D	Radiation thermometer
E	Beam splitter

Figure 3 – Possible arrangement for determining the response time with two reference sources

5.17 Exposure time

5.17.1 General

The exposure time is a relevant specification for radiation thermometers which have a significant delay time as part of their response time and observe objects passing through their field of view within a time span shorter than the response time (see Figure 4). In this case the exposure time is a relevant specification which shall be given by the manufacturer of the radiation thermometer.

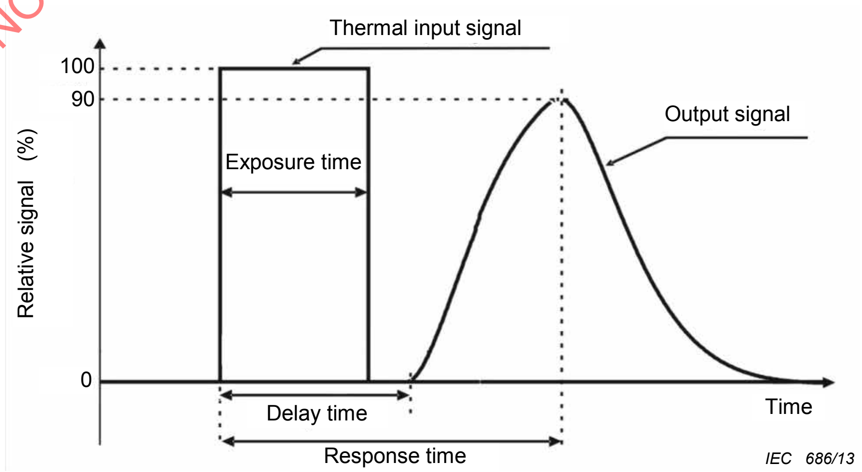


Figure 4 – Demonstration of the exposure time

The exposure time depends on the signal processing conditions within the radiation thermometer, the magnitude of the temperature step (starting value and plateau value) as well as the reached percentage of the temperature step of the output signal.

The following test method outlines the procedure to determine the time interval, a step change in the input radiation power, starting and ending at ambient temperature and, in between, reaching a temperature close to the top of the measuring temperature range of the thermometer, has to be present, such that the output signal of a radiation thermometer reaches 90 % of the full scale response to continuous radiation. The exposure time may be specified as a different percentage level of the full scale response to continuous radiation, e.g. 99 % (see IEC/TS 62492-1:2008, 4.1.1.17.3). In this case the test method has to be adjusted accordingly.

5.17.2 Test method

5.17.2.1 Sight the radiation thermometer at the centre of the radiating area of the reference source.

5.17.2.2 The reference source is stabilised at a temperature close to the top of the measuring temperature range of the radiation thermometer.

5.17.2.3 The sight path between the radiation thermometer and the reference source is interrupted by a shutter mechanism which can be opened and closed very quickly and whose open time can be adjusted with sufficient precision. The output of the radiation thermometer is allowed to stabilize at the radiation temperature of the closed shutter (ambient temperature).

5.17.2.4 The shutter is opened and the final (maximum) output signal of the radiation thermometer for continuous radiation is measured (i.e. 100 % value).

5.17.2.5 The data acquisition system is triggered and the shutter is opened and closed such that the signal over time from the radiation thermometer in response to the step change interval in input radiant power can be measured and recorded (e.g. a storage oscilloscope). Starting with a long pulse time of illumination (significantly longer than the expected exposure time) the pulse width (i.e. the time period of open shutter) is reduced step by step until the maximum signal is only 90 % of the output signal measured for continuous radiation in 5.17.2.4.

As a digitally processed radiation thermometer may have a variation in the measured value of exposure time the measurement has to be repeated a sufficient number of times (at least five times) until the maximum value of exposure time is uniquely determined. Care has to be taken that the exposure time test method is only performed when the radiation thermometer is in the temperature measurement mode of operation, as radiation thermometers may periodically perform e.g. a calibration routine.

5.17.2.6 The exposure time (0 % / 90 %) is the longest measured time period the shutter has to stay open to reach 90 % of the maximum measured value (i.e. the value of continuous radiation) (see Figure 4).

The time period needed by the shutter mechanism to open and close shall be much shorter than the exposure time (not more than 10 % of the exposure time) and the shutter shall have a stable radiation temperature near ambient temperature (i.e. no heating up by the reference source).

Instead of a reference source with a shutter mechanism a radiation source with rapidly adjustable radiation intensity and appropriate wavelength may be used. This can be for example a light emitting diode (LED) which is operated with a pulse generator. The radiation source is switched to continuous output and the signal output of the radiation thermometer is monitored with a rapid signal recording device e.g. a storage oscilloscope. If applying a LED, the operating current shall be adjusted until the required temperature indication at the radiation thermometer is achieved at the beginning of the test method. The pulse width is then reduced until the temperature display is only a specific proportion of the minimum/maximum signal, e.g. 0 %/90 % of the original display. The set pulse width is now the exposure time.

For the determination of exposure times starting at temperatures different from ambient temperature an analogous method based on a more sophisticated setup with two reference sources (see Figure 3) should be applied.

5.18 Warm-up time

5.18.1 General

This test method outlines the procedure to be used to evaluate the time interval, after switching the power of a radiation thermometer on, that is required for the output signal or temperature reading of the radiation thermometer to stabilize within the manufacturer's repeatability specification (5.14) (see Figure 5).

5.18.2 Test method

5.18.2.1 The radiation thermometer is turned off and allowed to stand and stabilize under ambient conditions within the operating temperature range and air humidity range as specified by the manufacturer. The time period shall be sufficiently long for the instrument to reach equilibrium with the environment.

5.18.2.2 The reference source is stabilised at a temperature within the measuring temperature range of the radiation thermometer.

5.18.2.3 The radiation thermometer is sighted on the reference source and switched on. The output signal is periodically recorded as the radiation thermometer warms to its operating temperature. The time span between two measurements has to be significantly shorter than the expected warm-up time. The minimum total test time shall be ten times the warm-up time specified by the manufacturer (see Figure 5).

5.18.2.4 The value for the warm-up time is taken to be the elapsed time required for the output signal to equal its value recorded near the end of the test minus one-half of the manufacturer's repeatability band.

The repeatability of the reference source shall be significantly better than the repeatability of the radiation thermometer.

For some radiation thermometers, the warm-up time may depend on the temperature of the reference source. For such radiation thermometers the test method should be carried out at, at least, a reference source temperature close the top and a temperature close to the bottom of the measuring temperature range of the radiation thermometer.

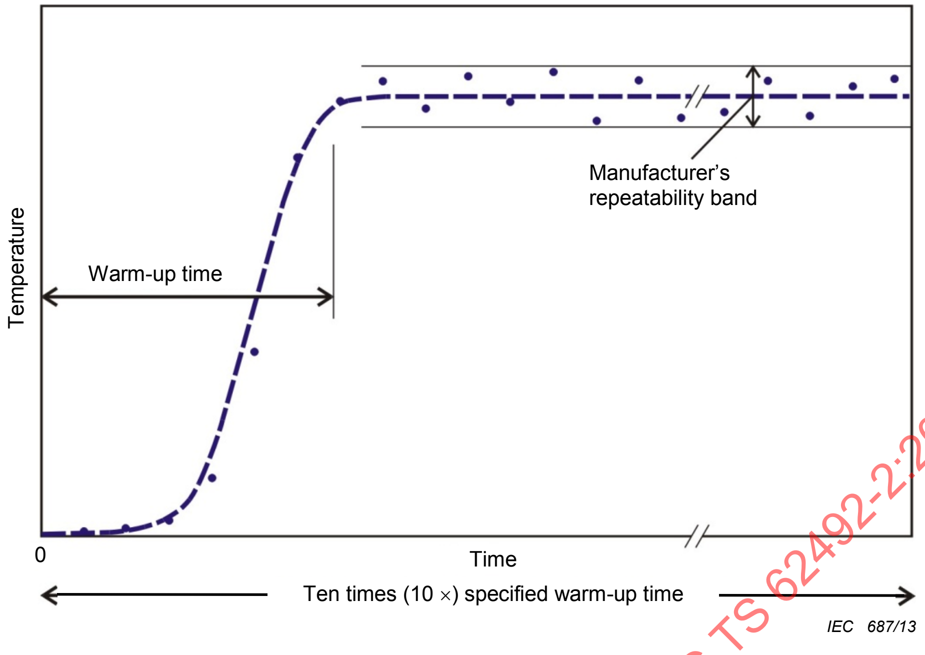


Figure 5 – Example of warm-up time

5.19 Operating temperature and air humidity range

5.19.1 General

For instruments with no internal temperature indication the ambient temperature shall be stated instead of the instrument temperature.

For the determination of the air humidity range well defined atmospheric conditions regarding the humidity and temperature of the atmosphere have to be realised. A test method for the air humidity range is beyond the scope of this technical specification.

Within the operating temperature range given by the manufacturer the radiation thermometer shall stay with all specifications fully functional over the full measuring temperature range. A critical test for the operating temperature range is the following test of the measurement uncertainty over the full measuring and operating temperature range.

5.19.2 Test method

5.19.2.1 The radiation thermometer is operated in an adjustable temperature enclosure (e.g. climate chamber) which allows stable operation of the radiation thermometer within the complete operating temperature range given by the manufacturer. For instruments with no internal temperature indication the ambient temperature (i.e. the temperature of the climate chamber) shall be used as the instrument temperature.

5.19.2.2 Sight the radiation thermometer at the centre of the radiating area of the reference source.

No window should be used between the radiation thermometer and the reference source. If a window is used, the influence of the window on the temperature indicated by the radiation thermometer has to be corrected for.

5.19.2.3 The temperature of the reference source is stabilised near the bottom of the measuring temperature range of the radiation thermometer.