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Industrial process control devices – Radiation thermometers —

Part 1: Technical data for radiation thermometers

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INDUSTRIAL PROCESS CONTROL DEVICES – RADIATION THERMOMETERS –

Part 1: Technical data for radiation thermometers

1 Scope

This Technical Specification applies to radiation thermometry. It defines the technical data, i.e. metrological data to be given in data sheets and operating instructions for radiation thermometers with one wavelength range and one measurement field, to ensure that the data and terminology are used consistently.

Technical data for radiation thermometers are frequently given using terms whose meaning is not clear and therefore open to misinterpretation. Moreover, the data are given for measuring conditions which are not standardised. Often, influence parameters and mutual interdependencies of technical data are not given. As a result, the user cannot easily compare the technical design and performance data of radiation thermometers and tests for compliance with the manufacturer's specifications are difficult to carry out.

The purpose of this Technical Specification is to facilitate comparability and testability. Therefore, unambiguous definitions are stipulated for stating technical data under standardised measuring conditions.

NOTE 1 Infrared ear thermometers are excluded from this Specification.

NOTE 2 It is not compulsory for manufacturers and sellers of radiation thermometers to include all items given in this Specification for a specific type of radiation thermometer. Only the relevant data should be stated and should comply with this Specification.

2 Normative references

The following referenced documents are indispensable for the application 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.

Guide to the Expression of Uncertainty of Measurement (1995) [BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML]

International Vocabulary of Basic and General Terms in Metrology (1993) [BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML]

3 Terms, definitions and abbreviations

3.1 Terms and definitions

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

3.1.1

measuring temperature range

temperature range for which the radiation thermometer is designed

3.1.2**measurement uncertainty (accuracy)**

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**

usually circular, flat surface of a measured object from which the radiation thermometer receives radiation

3.1.6**distance ratio**

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**

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**

the emissivity of a surface is the ratio between the radiation emitted from this surface and the radiation from a blackbody at the same temperature. The emissivity describes a thermo-physical material characteristic, which in addition to the chemical composition of the material may also be dependent on the surface structure (rough, smooth), the emission direction as well as on the observed wavelength and the temperature of the measured object.

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 operates

3.1.10**influence of the internal instrument or 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

reproducibility of measurements repeated over a long time period

3.1.13

short-term stability

reproducibility of measurements repeated over a short time period (several hours)

3.1.14

repeatability

twice the standard deviation of measurements repeated under the same conditions within a very short time span (several minutes)

3.1.15

interchangeability

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 (object temperature or object radiation) and the instant from which the measured value of the radiation thermometer (output parameter) remains within specified limits of its final value

3.1.17

exposure time

time interval necessary during which an abrupt change in the value of the input parameter (object temperature or object radiation) has to be present, such that the output value of the radiation thermometer reaches a given measurement value

3.1.18

warm-up time

time period needed after switching on the radiation thermometer for the radiation thermometer to operate according to its specifications

3.1.19

operating temperature range and air humidity range

permissible temperature range and humidity range within which the radiation thermometer may be operated. For this temperature range and humidity range the specifications are valid

3.1.20

storage and transport temperature range and air humidity range

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

3.2 Abbreviations

FWHM: Full width at half maximum

NETD: Noise equivalent temperature difference

SSE: Size-of-source effect

4 Technical data

4.1 Types of technical data

Two types of technical data have to be distinguished: metrological data and equipment features. The metrological data relate to the metrologically relevant values measured with a radiation thermometer, whereas the equipment features are mainly important for operation and convenience in the use of the equipment.

4.1.1 Metrological data

The following metrological data are used to describe the characteristics of a radiation thermometer:

- measuring temperature range (3.1.1)
- measurement uncertainty (accuracy) (3.1.2)
- noise equivalent temperature difference (NETD) (3.1.3)
- measuring distance (3.1.4)
- field-of-view (target area, measurement field) (3.1.5)
- distance ratio (distance factor) (3.1.6)
- size-of-source effect (SSE) (3.1.7)
- emissivity setting (3.1.8)
- spectral range (3.1.9)
- temperature parameter (3.1.10)
- humidity parameter (3.1.11)
- long-term stability (3.1.12)
- short-term stability (3.1.13)
- repeatability (3.1.14)
- interchangeability (3.1.15)
- response time (3.1.16)
- exposure time (3.1.17)
- warm-up time (3.1.18)
- operating temperature range and air humidity range (3.1.19)
- storage and transport temperature range and air humidity range (3.1.20)

Relevant parameters for the particular metrological data, e.g. measuring conditions, influence parameters and mutual interdependences shall be given.

Since several metrological data of a radiation thermometer depend on the emissivity setting of the instrument, they shall always be given for an emissivity setting of 1, if not stated otherwise. For radiation thermometers with an internal fixed emissivity setting different from 1, the specifications shall be given for the standard setting of the instrument and the emissivity value shall be stated. The measuring temperature range (3.1.1), the measurement uncertainty (3.1.2) and the noise equivalent temperature difference (3.1.3) of a radiation thermometer strongly depend on the emissivity setting of the radiation thermometer.

4.1.1.1 Measuring temperature range

4.1.1.1.1 General

The measurement uncertainty remains within the specified limits for the following temperature range.

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

4.1.1.1.2 Examples of data

Measuring temperature range:

-50 °C to 1 000 °C

or

400 °C to 2 500 °C for the emissivity range 0,1 to 1,0

4.1.1.2 Measurement uncertainty (accuracy)

4.1.1.2.1 General

The value of the measurement uncertainty shall be given together with the measurement result (see the *Guide to the Expression of Uncertainty of Measurement*).

NOTE Where the measurement result M and the measurement uncertainty U are established, the value of the measurand lies with high probability within the limits $M - U$ and $M + U$. The measurement uncertainty should be stated as U , with a confidence level of approximately 95 % (expanded uncertainty, coverage factor $k = 2$).

The measurement uncertainty should be quoted with respect to the International Temperature Scale (currently ITS-90) – i.e. the uncertainty should include both the dispersion of the instrument readings with respect to the calibration artefacts used and the uncertainty in the traceability of these calibration artefacts to the ITS-90. Alternatively, the two contributions may be stated separately.

The frequently-used term “accuracy” is a qualitative concept and should not be used with numerical details. It generally signifies the closeness of the agreement between the result of a measurement and the value of the measurand (see the *International Vocabulary of Basic and General Terms in Metrology*).

4.1.1.2.2 Required parameters

The measurement uncertainty depends on the confidence level (a confidence level of approximately 95 % should be given), the measured temperature, the ambient temperature, the internal temperature of the radiation thermometer, the air humidity, the source diameter and the field of view (respectively the measurement distance), therefore these parameters are to be stated.

To simplify the uncertainty statement and make it more comparable, standardised measurement conditions shall be used as far as possible: The measurement uncertainty shall be stated for a confidence level of approximately 95 % and shall be valid over the complete specified operating temperature range and air humidity range (3.1.19), if not stated otherwise. Alternatively it shall be stated for: Confidence level approximately 95 %, ambient temperature 23 °C, relative air humidity of 50 % at 23 °C.

NOTE Radiation thermometers often cover a wide measuring temperature range and the radiance signal strongly increases with the target temperature. Uncertainties in temperature measurement arise from drift and noise. The noise contribution is often higher at the bottom of the temperature range and typically insignificant over most of the temperature range. For a complete specification manufacturers should provide the measurement uncertainty sampled across the complete measuring temperature range (3.1.1). This may be done by a table (see Table 1 and Table 2).