Designation: E1256 – 17

Standard Test Methods for Radiation Thermometers (Single Waveband Type)[1]

This standard is issued under the fixed designation E1256; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 The test methods described in these test methods can be utilized to evaluate the following six basic operational parameters of a radiation thermometer (single waveband type):

	Section
Calibration Accuracy	8
Repeatability	9
Field-of-View	10
Response Time	11
Warm-Up Time	12
Long-Term Stability	13

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.3 The term single waveband refers to radiation thermometers that operate in a single band of spectral radiation. This term is used to differentiate single waveband radiation thermometers from those termed as ratio radiation thermometers, two channel radiation thermometers, two color radiation thermometers, multiwavelength radiation thermometers, multichannel radiation thermometers, or multicolor radiation thermometers. The term single waveband does not preclude wideband radiation thermometers such as those operating in the 8–14 µm band.

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*

E2758 Guide for Selection and Use of Wideband, Low Temperature Infrared Thermometers

2.2 *IEC Documents*

IEC/TS 62492-1 ed 1.0 TS Industrial Process Control Devices—Radiation Thermometers—Part 1: Technical Data for Radiation Thermometers

3. Terminology

3.1 *Definitions:*

3.1.1 *blackbody, n*—the perfect or ideal source of thermal radiant power having a spectral distribution described by the Planck equation.

3.1.1.1 *Discussion*—The term blackbody is often used to describe a furnace or other source of radiant power which approximates the ideal.

3.1.2 *center wavelength, n*—a wavelength, usually near the middle of the band of radiant power over which a radiation thermometer responds, that is used to characterize its performance.

3.1.2.1 *Discussion*—The value of the center wavelength is usually specified by the manufacturer of the instrument.

3.1.3 *field-of-view, n*—a usually circular, flat surface of a measured object from which the radiation thermometer receives radiation.[2]

NOTE 1—*Field-of-view* traditionally has been referred to as *target size*.

3.1.4 *measuring distance, n*—distance or distance range between the radiation thermometer and the target (measured object) for which the radiation thermometer is designed.[2]

NOTE 2—*Measuring distance* traditionally has been referred to as *target distance*.

3.1.5 *radiation thermometer, n*—a radiometer calibrated to indicate the temperature of a blackbody.

3.1.6 *radiometer, n*—a device for measuring radiant power that has an output proportional to the intensity of the input power.

3.1.7 *target distance, n*—see *measuring distance*.

3.1.8 *target plane, n*—the plane, perpendicular to the line of sight of a radiation thermometer, that is in focus for that instrument.

3.1.9 *target size, n*—see *field-of-view*.

[1] These test methods are under the jurisdiction of ASTM Committee E20 on Temperature Measurement and are the direct responsibility of Subcommittee E20.02 on Radiation Thermometry.

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[2] IEC 62492-1.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *reference temperature source, n*—a source of thermal radiant power of known temperature or emissivity, or both, used in the testing of radiation thermometers.

3.2.2 *temperature resolution, n*—the minimum simulated or actual change in target temperature that gives a usable change in output or indication, or both.

4. Significance and Use

4.1 The purpose of these test methods is to establish consensus test methods by which both manufacturers and end users may perform tests to establish the validity of the readings of their radiation thermometers. The test results can also serve as standard performance criteria for instrument evaluation or selection, or both.

4.2 The goal is to provide test methods that are reliable and can be performed by a sufficiently skilled end user or manufacturer. It is hoped that it will result in a better understanding of the operation of radiation thermometers and also promote improved communication between the manufacturers and the end users. A user without sufficient knowledge and experience should seek assistance from the equipment makers or other expert sources, such as those found at the National Institute of Standards and Technology in Gaithersburg, Maryland.

4.3 These test methods should be used with the awareness that there are other parameters, particularly spectral range limits and temperature resolution, which impact the use and characterization of radiation thermometers and for which test methods have not yet been developed.

4.3.1 Temperature resolution is the minimum simulated or actual change in target temperature that results in a usable change in output or indication, or both. It is usually expressed as a temperature differential or a percent of full-scale value, or both, and usually applies to value measured. The magnitude of the temperature resolution depends upon a combination of four factors: detector noise equivalent temperature difference (NETD), electronic signal processing, signal-to-noise characteristics (including amplification noise), and analog-to-digital conversion "granularity."

4.3.2 Spectral range limits are the upper and lower limits to the wavelength band of radiant energy to which the instrument responds. These limits are generally expressed in micrometers (µm) and include the effects of all elements in the measuring optical path. At the spectral response limits, the transmission of the measuring optics is 5 % of peak transmission. (See Fig. 1.)

5. Apparatus

5.1 The following apparatus, set up as illustrated in Fig. 2, can be used to perform the standard tests for all six parameters.

5.1.1 *Reference Temperature Source*—A blackbody (or other stable isothermal radiant source of high and known emissivity) with an opening diameter at least as large as that specified in these test methods.

NOTE 3—Typical examples include nearly isothermal furnaces with internal geometries, such as a sphere with an opening small relative to its radius, or a right circular cylinder with one end closed having a radius small relative to its length.[3]

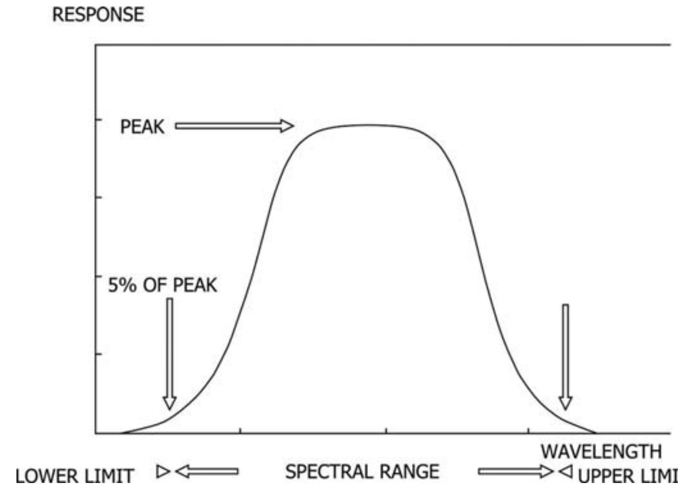

FIG. 1 Spectral Range Limits

5.1.2 *Temperature Indicator*—Either contact or radiometric, which accurately displays the temperature of the reference temperature source.

5.1.3 *Shutter Mechanism*—Of sufficient size so as to completely block the opening of the reference temperature source from the field-of-view of the test instrument. The shutter mechanism shall activate within a time interval that is short when compared with the response time of the test instrument.

5.1.4 *Iris Diaphragm*—Of sufficient size so that when fully open the iris diameter is greater than the opening of the reference temperature source. It shall be located with its opening concentric with and perpendicular to the line of sight of the radiation thermometer.

5.1.4.1 The side of the diaphragm facing the radiation thermometer should be blackened (nearly nonreflective) so as to minimize the effect of radiation reflected from the surrounding environment. In addition the iris should be shaded from sources of intense extraneous radiation. (See Note 11.)

5.1.5 *Aperture Set*—If an iris diaphragm is not available, an aperture disc set of appropriate diameters can be used. Each aperture should be blackened and also mounted and protected from extraneous sources of radiation as discussed in 5.1.4.1.

5.1.6 *Data Acquisition Systems*—Of appropriate speed and storage capacity to measure and record the output signal of the radiation thermometer in Section 10 ("Response Time Test Method").

5.1.7 *Power Supply*—Capable of supplying the proper voltage and frequency, if necessary, to the radiation thermometer.

6. Calibration Accuracy Test Method

6.1 *Summary*—This test method outlines the procedure to be used to evaluate the maximum deviation between the temperature indicated by the radiation thermometer and the known temperature of a reference temperature source, including the uncertainty of the reference temperature source relative to the current International Temperature Scale.

[3] DeWitt, D. P., and Nutter, G. D., eds., "Theory and Practice of Radiation Thermometry," John Wiley and Sons, New York, NY.

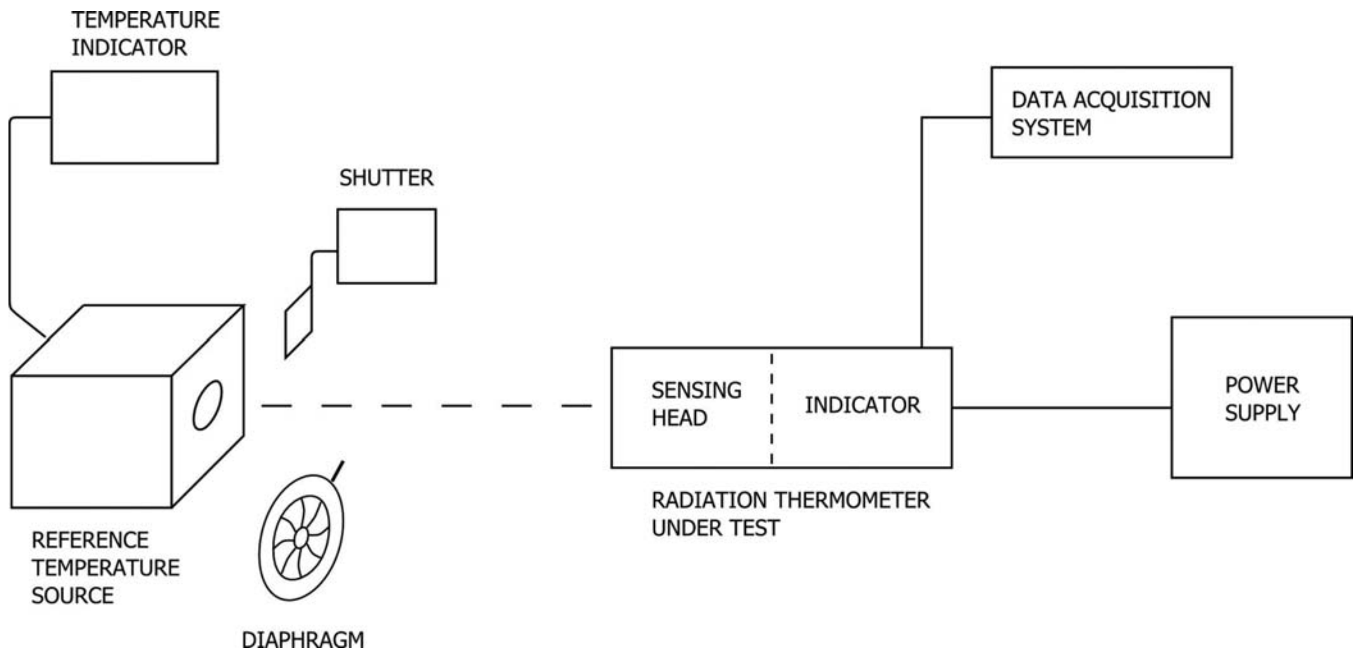

FIG. 2 Test Method Apparatus

6.2 *Test Conditions:*

6.2.1 Rated supply voltage and frequency.

6.2.2 Prescribed warm-up period.

6.2.3 After execution of internal standardization check (if available).

6.2.4 Emissivity compensation set to one (1).

6.2.5 Minimum opening of the reference temperature source shall not obstruct the field-of-view of the radiation thermometer with the test aperture as specified by the manufacturer.

6.2.6 Laboratory ambient temperature range of 20 °C to 25 °C.

6.2.7 The manufacturer shall specify any special conditions such as atmospheric absorption effects, measuring distance, and so forth.

6.2.8 The manufacturer shall specify the output for determining the indicated temperature.

6.3 *Test Method:*

6.3.1 The radiation thermometer is sighted at the reference temperature source whose temperature is sequentially stabilized at three calibration points distributed uniformly over the measurement range of the instrument.

6.3.2 The temperature of the reference temperature source and the temperature indicated by the radiation thermometer are recorded, then the difference between the two values is calculated and recorded. (See Fig. 3.)

6.3.3 The test sequence is repeated twice for the same three calibration points, and an average temperature difference is calculated and recorded for each calibration point.

6.4 *Test Result*—The value for the calibration accuracy of the temperature indication of the radiation thermometer is taken to be the largest of the three average temperature differences determined in 6.3.2 plus or minus the uncertainty of the temperature of the reference temperature source relative to the current International Temperature Scale.

NOTE 4—The calibration accuracy is generally expressed as a temperature difference or a percent of full-scale value, or both.

NOTE 5—The value applies across the entire measurement range.

NOTE 6—If the reference temperature source is measured with other than a calibrated reference or secondary standard radiation thermometer, then the emissivity of the source enters into the calibration of the test radiation thermometer.

7. Procedure

7.1 Detailed directions for evaluation of each parameter listed in 1.1 are included in each parameter test method.

7.2 Each parameter test method is organized by: parameter term, summary, test conditions, test method, test result, and applicable notes.

8. Repeatability Test Method

8.1 *Summary*—This test method outlines the procedure to be used to evaluate the repeatability of the temperature indication of a radiation thermometer for a number of consecutive measurements made under the same conditions over a specified interval of time.

8.2 *Test Conditions:*

8.2.1 Rated supply of voltage and frequency.

8.2.2 Prescribed warm-up period.

8.2.3 After execution of internal standardization check (if available).

8.2.4 Diameter of the reference temperature source opening shall be greater than the radiation thermometer field-of-view, as specified by the manufacturer.

8.2.5 Laboratory ambient temperature range of 20 °C to 25 °C.

8.2.6 Emissivity compensation, if any, set to one (1).

8.2.7 The manufacturer shall specify any special conditions such as response time, atmospheric absorption effects, measuring distance, and so forth.

Calibration Points	Run #1			Run #2			Run #3			Average Value	Difference
	T_{ref}	T_1	ΔT_1 $(T_{ref} - T_1)$	T_{ref}	T_2	ΔT_2 $(T_{ref} - T_2)$	T_{ref}	T_3	ΔT_3 $(T_{ref} - T_3)$	$\frac{\Delta T_1 + \Delta T_2 + \Delta T_3}{3}$	$\Delta T_{max} - \Delta T_{min}$
Approx 10% of Span											
Approx 50% of Span											
Approx 90% of Span											

Note 1 Uncertainty in temperature of reference temperature source . . . . ± ________°C

Note 2 Instrument span (See Note B below) . . . . ________°C

Note 3 Maximum Average Value . . . . ________°C

Note 4 Maximum difference . . . . ________°C

Note A This is only a sample worksheet. More replicates will increase the significance of the results.

Note B For instruments with more than one range (span), each range is calibrated as if it were a separate instrument.

Note C Special care must be taken not to infer too much significance from this test because of the small number of observations.

FIG. 3 Worksheet for Calibration Accuracy Test Method

8.3 *Test Method:*

8.3.1 Once a day for twelve consecutive working days, the radiation thermometer is sighted at the reference temperature source whose temperature is stabilized at the approximate midpoint of the radiation thermometer calibration range.

NOTE 7—The selected reference temperature source temperature shall be reproduced for each of the twelve consecutive tests.

8.3.2 The temperature of the reference temperature source and the temperature(s) indicated by the radiation thermometer during each day's test are recorded.

8.3.3 The radiation thermometer shall be switched off after each series of measurements.

8.4 *Test Result*—The value for the repeatability of the readings of the radiation thermometer is taken to be the standard deviation of the twelve recorded readings.

$$S.D. = \sqrt{\frac{\sum_{i=1}^{N}\left(X_i - \bar{X}\right)^2}{N-1}} = \sqrt{\frac{\sum_{i=1}^{N} X_i^{\,2} - \frac{\left(\sum_{i=1}^{N} X_i\right)^2}{N}}{N-1}}$$

where:

S.D. = standard deviation,
N = number of measurements,
X_i = value of the ith measurement, and
$\bar{X}$ = average of the twelve measurements $= \frac{\sum_{i=1}^{N} X_i}{N}$.

NOTE 8—The repeatability of the temperature indication is generally expressed as a temperature difference or a percent of full-scale value, or both.

NOTE 9—The value for the repeatability can be applied across the entire measuring temperature range, or, the same test can be performed at other selected temperatures across the measuring temperature range in order to assess the repeatability of the radiation thermometer at those temperatures.

9. Field-of-View Test Method

9.1 *Summary*—This test method outlines the procedure to be used to evaluate the diameter of the circle located in the target plane of the reference temperature source, at a known distance along and perpendicular to a radiation thermometer's line of sight, and from which 99 % of the radiant power received by the radiation thermometer is collected. (See Figs. 3 and 4.)

9.2 *Test Conditions:*

9.2.1 Rated supply voltage and frequency.

9.2.2 Prescribed warm-up period.

9.2.3 After execution of internal standardization check (if applicable).

9.2.4 Laboratory ambient temperature range of 20 °C to 25 °C.

9.2.5 Minimum opening of the reference temperature source shall be large enough so as to not obstruct the optical path of the radiation thermometer, as specified by the manufacturer, when it is sighted through an aperture that is twice the diameter of the instrument's field-of-view at the plane of the aperture.

NOTE 10—Some radiation thermometers have a field-of-view so large that a commercially available reference temperature source cannot be used; a separate test method is under preparation for use in such cases.

9.2.6 Manufacturer shall specify any special conditions such as atmospheric absorption effects, measuring distance, how and when to clean the radiation thermometer lens, and so forth.

9.3 *Test Method:*

9.3.1 The temperature of the reference temperature source is stabilized at a value near the top of the calibration range of the radiation thermometer.

9.3.2 The iris is positioned in the front of and concentric with the opening of the reference temperature source (as

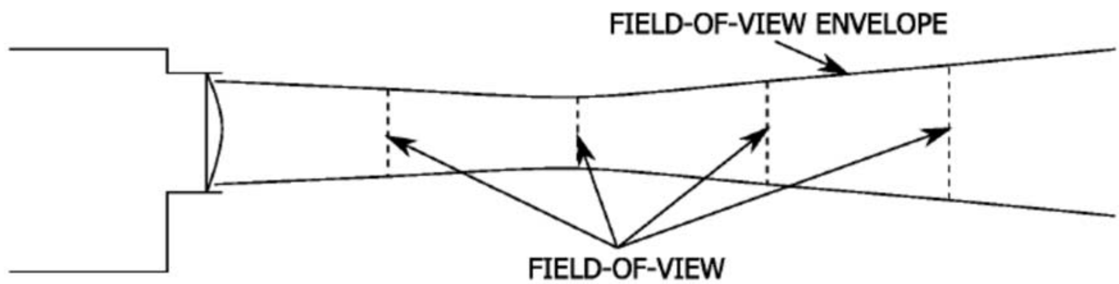

FIG. 4 Field-of-View versus Measuring Distance from Instrument

illustrated in Fig. 2). The iris is then adjusted to a diameter slightly smaller (typically 10 %) than the expected target diameter.

NOTE 11—The iris should be kept cool enough so that its thermal emission does not contribute significantly to the output signal. Uncovering the iris quickly can minimize heating, but this requires care. Evaluation of the error from this source requires computational procedures beyond the scope of this test method.[3] In most cases, however, the error is insignificant if the iris is maintained near room temperature (20 °C) and the reference temperature source temperature is at or above 200 °C.

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

9.3.4 The iris is then opened to the point where the temperature indicated by the radiation thermometer stops increasing, but its diameter is still smaller than the reference temperature source opening.

9.3.5 The temperature indicated by the radiation thermometer (in degrees) is recorded.

9.3.6 The iris diameter is then decreased until the temperature indicated by the radiation thermometer decreases by the amount appearing in Table 1. Table 1 gives the change in indicated temperature defined as the measured temperature minus the source's reference temperature. Reference temperature (T_{REF}) in all equations that are part of Table 1 refer to the traceable temperature of the reference temperature source. This traceability follows an unbroken chain back to the International System of Units (SI). The following example illustrates the use of Table 1:

9.3.6.1 *Example*—Assume that the temperature of the reference temperature source is 500 °C and the radiation thermometer operates at a center wavelength of 6.1 µm. When the iris is closed to the diameter for which the temperature indicated by the radiation thermometer has been reduced by 2.06 °C, the maximum radiant power collected from the source has been reduced by 1 %.

NOTE 12—This same test method can also be applied to a test instrument equipped with an output signal that is proportional to the target radiance. Provided that the test is restricted to the wavelengths and temperatures for which there are entries in Table 1, all that is then required is to reduce the iris opening from its maximum diameter until the output signal is reduced by 1 %.

9.4 *Test Result*—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 has been reduced by 1 % from its maximum value.

NOTE 13—Field-of-view is to be expressed in as a diameter, a percentage, and a measuring distance. For example: 7.0 mm (99 %), measuring distance: 400 mm. (See Fig. 4.)

NOTE 14—This procedure may be repeated for other measuring distances for which the opening of the reference temperature source remains sufficiently large.

10. Response Time Test Method

10.1 *Summary*—This test method outlines the procedure to be used to evaluate the time interval required for the output signal of a radiation thermometer to reach 95 % of full-scale in response to a corresponding step change of input radiant power.

10.2 *Test Conditions:*

10.2.1 Rated supply of voltage and frequency.

10.2.2 Laboratory ambient temperature range of 20 °C to 25 °C.

10.2.3 Reference temperature source stabilized at the maximum temperature the radiation thermometer can indicate.

10.2.4 Radiation thermometer output terminals, as specified by the manufacturer, are connected to the input of the data acquisition system.

10.3 *Test Method:*

10.3.1 The radiation thermometer is sighted at the reference temperature source.

10.3.2 The sight path between the radiation thermometer and the reference temperature source is interrupted by a shutter mechanism and the output of the radiation thermometer is allowed to stabilize.

10.3.3 The data acquisition system is triggered and the shutter is opened such that the signal from the test instrument in response to the full-scale step change in input radiant power can be measured and recorded.

10.3.4 Instruments that contain digital processors may have a variation in the measured value for response time when successive measurements are performed. The test performed in 10.3.1 should be repeated on a single unit a sufficient number of times until the maximum and average values of response time are uniquely determined.

10.3.5 Instruments that contain digital processors may also be programmed to perform other functions besides temperature measurement: for example, the instrument may periodically perform a calibration function. The response time test procedure does not apply during these non-operating intervals.

10.4 *Test Result*—The value for the response time of the test instrument is taken to be the time interval required for the output signal to reach 95 % of full-scale in response to a

TABLE 1 The Change in Indicated Temperature Corresponding to a 1 % Reduction in the Maximum Radiant Power Received by a Radiation Thermometer

Center Wave -length, µm	0.65[A]	0.85[A]	1.0[A]	1.6[A]	2.2[A]	3.0[A]	3.43[A]	4.0[A]	5.1[A]	7.95[A]	11.0[A]	Total Radiation[B]	8–14[C]	
Temp, °C	Temperature Change, °C													
						1 %[D]		5 %[D]						
50	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
100	. . .	. . .	. . .	. . .	-0.21	-0.29	-0.33	-0.39	. . .	. . .	. . .	. . .	-0.61	5 %
150	. . .	. . .	. . .	-0.20	-0.27	-0.37	-0.43	-0.50	-0.63	. . .	. . .	. . .	-0.94	
200	. . .	. . .	. . .	-0.25	-0.34	-0.47	-0.53	-0.62	-0.79	-1.21	. . .	. . .	-1.26	
250	. . .	. . .	. . .	-0.30	-0.42	-0.57	-0.65	-0.76	-0.97	-1.46	. . .	-1.31	-1.58	
300	. . .	. . .	-0.23	-0.37	-0.50	-0.68	-0.78	-0.91	-1.16	-1.74	. . .	-1.44	-1.91	
400	-0.20	-0.27	-0.32	-0.50	-0.69	-0.94	-1.08	-1.25	-1.58	-2.33	-2.97	-1.69	-2.60	1 %
500	-0.27	-0.35	-0.42	-0.66	-0.91	-1.24	-1.42	-1.65	-2.06	-2.98	-3.73	-1.94	-3.34	
600	-0.34	-0.45	-0.53	-0.85	-1.17	-1.58	-1.80	-2.09	-2.60	-3.68	-4.53	-2.19	-4.10	
700	-0.43	-0.56	-0.66	-1.05	-1.45	-1.96	-2.23	-2.57	-3.17	-4.42	-5.35	-2.44	-4.90	
800	-0.52	-0.68	-0.80	-1.28	-1.76	-2.37	-2.69	-3.09	-3.79	-5.19	-6.20	-2.69	-5.72	
900	-0.62	-0.81	-0.96	-1.53	-2.10	-2.82	-3.19	-3.65	-4.44	-5.98	-7.07	-2.94	-6.57	
1000	-0.73	-0.96	-1.13	-1.80	-2.46	-3.30	-3.72	-4.24	-5.12	-6.79	-7.96	-3.19	-7.43	
1200	-0.98	-1.28	-1.51	-2.41	-3.28	-4.35	-4.87	-5.51	-6.56	-8.48	-9.76	-3.70	-9.19	
1400	-1.26	-1.65	-1.95	-3.10	-4.19	-5.50	-6.13	-6.88	-8.08	-10.2	-11.6	-4.20	-11.0	
1600	-1.59	-2.07	-2.45	-3.87	-5.20	-6.75	-7.47	-8.32	-9.68	-12.0	-13.5	-4.70	-12.8	
1800	-1.94	-2.54	-2.99	-4.72	-6.29	-8.08	-8.89	-9.84	-11.3	-13.8	-15.4	-5.20	-14.7	
2000	-2.33	-3.05	-3.60	-5.64	-7.46	-9.47	-10.4	-11.4	-13.0	-15.7	-17.3	-5.70	-16.6	
2500	-3.47	-4.53	-5.33	-8.22	-10.6	-13.2	-14.3	-15.5	-17.4	-20.4	-22.1	-6.96	-21.4	
3000	-4.83	-6.29	-7.38	-11.2	-14.2	-17.2	-18.5	-19.9	-21.9	-25.1	-27.0	-8.21	-26.2	
3500	-6.41	-8.32	-9.70	-14.4	-17.9	-21.4	-22.8	-24.3	-26.6	-30.0	-31.9	-9.47	-31.1	
4000	-8.20	-10.6	-12.3	-17.8	-21.9	-25.7	-27.2	-28.9	-31.3	-34.8	-36.8	-10.7	-36.0	

[A] The entries for wavelengths 0.65 µm through 11.0 µm were calculated using the reciprocal of the temperature derivative of the Planck blackbody spectral radiance distribution function.

$$\Delta T = \left[\frac{\Delta L_{bb}(\lambda\ ,\ T_{REF})}{L_{bb}(\lambda\ ,\ T_{REF})}\right]\left[1\ -\ \exp\left(\frac{-c_2}{\lambda T_{REF}}\right)\right]\left[\frac{\lambda T_{REF}^2}{c_2}\right]$$

where:

ΔT = the change in indicated temperature defined as the difference between the measured temperature (T_{meas}) and the source's reference temperature (T_{REF}) calculated as $T_{REF} - T_{meas}$

$L_{bb}(\lambda,T)$ = the Planck function

c_2 = the second radiation constant (14 387.7736 µm·K)

λ = the wavelength (µm)

T_{REF} = source's reference temperature *(K)*, the quantity $[\Delta L_{bb}(\lambda,T_{REF})/L_{bb}(\lambda,T_{REF})]$ has the value 0.01

[B] The entries for total radiation were calculated using the Stefan-Boltzmann Law, where:

$$\Delta T = T_{REF} - (0.99\ T_{REF}{}^4)^{\frac{1}{4}}$$

$$\Delta T = \left(0.99^{\frac{1}{4}}\ -\ 1\right) T_{REF}$$

where:

ΔT = the change in indicated temperature defined as the difference between the measured temperature (T_{meas}) and the source's reference temperature (T_{REF}) calculated as $T - T_{meas}$

T_{REF} = the temperature of the reference temperature source *(K)*

[C] The entries for the 8–14 µm band were calculated using the Sakuma-Hattori Equation in the Planckian Form (Guide E2758).

$$\Delta T = -0.01\frac{S(T_{REF}) - S(T_{APR})}{\frac{dS(T_{REF})}{dT}}$$

where:

ΔT = the change in indicated temperature defined as the difference between the measured temperature (T_{meas}) and the source's reference temperature, *(T)*, calculated as $T - T_{meas}$

$S(T)$ = the Sakuma-Hattori Equation (shown below)

T_{REF} = source's reference temperature

T_{APR} = aperture temperature (nominal value of 23.0 °C)

$$S(T) = \frac{1}{\exp\left(\frac{C_2}{AT+B}\right) - 1}$$

where:

$S(T)$ = relative irradiance at temperature T

c_2 = the second radiation constant (14 387.7736 µm·K)

A = Sakuma-Hattori parameter (9.364 µm for the 8–14 µm band)

B = Sakuma-Hattori parameter (178.4 µm·K for the 8–14 µm band)

[D] Below the 1 % boundary line, the error in a tabular entry, due to the background contribution from the iris, is estimated to be not greater than 1 % of the value itself. Between the 1 % and 5 % boundary lines, the error ranges from 1 % to 5 % of the tabular entry. Above the 5 % boundary line, the error ranges from 5 % to 10 % of the tabular entry. For the 8–14 µm band, the contribution of the iris is based on a 10 °C iris temperature error (possible iris temperature of 13 °C to 33 °C).

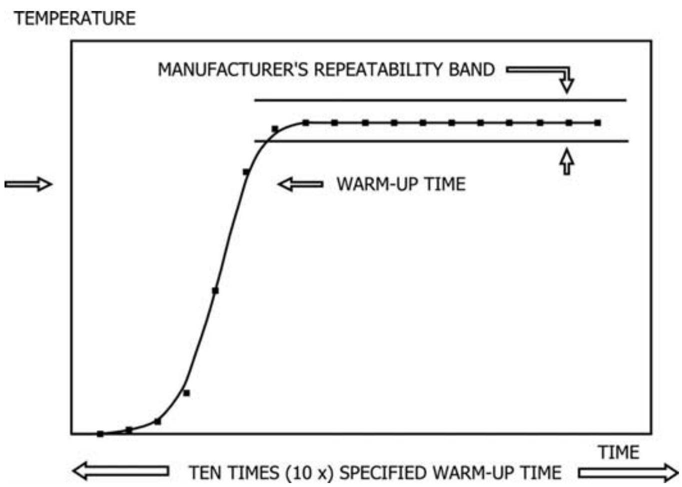

FIG. 5 Example of Warm-Up Time

corresponding step change in input radiant power from the reference temperature source.

NOTE 15—Smaller step changes in radiant power and changes in direction may be tested in the same manner, but they may yield different values for the response time.

11. Warm-Up Time Test Method

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

11.2 *Test Conditions:*

11.2.1 Rated supply voltage and frequency.

11.2.2 Laboratory ambient temperature range of 20 °C to 25 °C.

11.2.3 Reference temperature source stabilized at a temperature within the calibrated range of the radiation thermometer.

11.3 *Test Method:*

11.3.1 The radiation thermometer is turned off and allowed to stand and stabilize at the specified ambient temperature for a period of approximately eight hours.

11.3.2 The radiation thermometer is then sighted at the reference temperature source and switched on. The output signal is periodically recorded as the radiation thermometer warms to its operating temperature. The minimum total test time shall be ten times (10×) the time it takes to stabilize to within the manufacturer's repeatability specification. The total test time shall not be less than 15 min.

11.4 *Test Result*—The value for the warm-up time is taken to be the elapsed time required for the output signal to equal the output signal recorded near the end of the test minus one-half the manufacturer's repeatability band. The value applies across the entire calibration range.

12. Long-Term Stability Test Method

12.1 *Summary*—This test method outlines the procedure to be used to evaluate the change in output indication of a radiation thermometer occurring over a long period of time, but not caused by external influences on the device.

12.2 *Test Conditions:*

12.2.1 Rated supply of voltage and frequency to be set within manufacturer's range and held to a 1 % tolerance.

12.2.2 Prescribed warm-up period.

12.2.3 After execution of internal standardization check (if applicable).

12.2.4 Laboratory ambient temperature range of 20 to 25 °C and held to within 1 °C.

12.2.5 The reference temperature source should be stabilized at a temperature within the calibrated range of the radiation thermometer and regularly monitored to ensure that test results are not distorted by the source.

12.3 *Test Method:*

12.3.1 The radiation thermometer is continuously powered up and sighted at the reference temperature source.

12.3.2 Temperature readings are taken at least once a month. The test duration is the manufacturer's recommended recalibration interval or warranty period, whichever is less.

NOTE 16—Portable radiation thermometers are tested in the same fashion, except that the unit under test need not be powered up or sighted on a reference temperature source continuously.

12.4 *Test Result*—The long-term stability of a radiation thermometer is taken to be the difference between the maximum and minimum temperature readings obtained over the test interval.

NOTE 17—The value for the long-term stability is generally expressed as a temperature difference or a percent of full-scale value per unit of time, or both.

NOTE 18—The value applies at one or more points across the measuring temperature range of the radiation thermometer.

13. Precision and Bias

13.1 No statement can be made about the precision or bias of the test methods described until sufficient experience is obtained by users and manufacturers.

13.2 On a provisional basis, the following guidelines are suggested:

13.2.1 Duplicate tests by the same operator should be considered suspect if any two results for the same parameter differ by more than 0.5 % of the radiation thermometer full-scale reading or 2 °C, whichever is greater.

13.2.2 The end user should consult the manufacturer if calibration results differ from the manufacturer's results by more than 1 % of the radiation thermometer full-scale reading or 3 °C, whichever is greater.

14. Keywords

14.1 blackbody; calibration; field-of-view; long-term stability; radiation thermometer; radiometer; repeatability; response time; temperature; warm-up time; waveband