Designation: E1933 – 14 (Reapproved 2022)

Standard Practice for Measuring and Compensating for Emissivity Using Infrared Imaging Radiometers[1]

This standard is issued under the fixed designation E1933; 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 This practice covers procedures for measuring and compensating for emissivity when measuring the surface temperature of a specimen with an infrared imaging radiometer.[2]

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *These procedures may involve use of equipment and materials in the presence of heated or electrically-energized equipment, or both.*

1.4 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *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:*[3]

E1316 Terminology for Nondestructive Examinations

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *reflected temperature*—the temperature of the energy incident upon and reflected from the measurement surface of the specimen.

3.1.2 *surface-modifying material*—any tape, spray, paint, or the like that is used to change the emissivity of the specimen surface.

3.2 See also Terminology E1316.

4. Summary of Practice

4.1 Two procedures are given for measuring the emissivity of a specimen surface, the contact thermometer method and the non-contact thermometer method.

4.2 A procedure is also given for compensating for the error produced by emissivity using the computer built into an infrared imaging radiometer.

5. Significance and Use

5.1 The emissivity of a specimen can cause surface temperature measurement errors. Two procedures are provided for measuring and compensating for this error source.

5.2 These procedures can be used in the field or laboratory, using commonly available materials.

5.3 These procedures can be used with any infrared radiometers that have the required computer capabilities.

5.4 The values of emissivity are defined only in terms of the procedure for the purpose of process control and nondestructive evaluation of materials.

6. Interferences

6.1 *Contact Thermometer Method*—Contact thermometers can act as heat sinks and change the temperature of the specimen.

6.2 *Noncontact Thermometer Method:*

6.2.1 The use of surface-modifying materials can change the heat transfer properties and temperature of the specimen. Any such errors can be minimized by applying surface-modifying materials to the smallest area that satisfies the measurement accuracy requirements of the radiometer and infrared thermographer.

[1] This practice is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.10 on Specialized NDT Methods.

Current edition approved Dec. 1, 2022. Published December 2022. Originally approved in 1997. Last previous edition approved in 2018 as E1933 – 14(2018). DOI: 10.1520/E1933-14R22.

[2] These procedures are adapted from the *Guideline for Measuring and Compensating for Reflected Temperature, Emittance and Transmittance* developed by the Infraspection Institute, 425 Ellis Street, Burlington, NJ 08016.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

6.2.2 Before the surface-modifying material is applied to an area of the specimen adjacent to the area where the emissivity is to be measured (as directed in 8.2.4), errors can be minimized by viewing the imager display to ensure that both areas have the same temperature.

6.2.3 When removing a surface-modifying material, as directed in 8.2.7, errors can be minimized by ensuring that the surface is returned to its original condition.

6.3 Both procedures require the specimen to be at a temperature that is at least 10 °C warmer or cooler than the ambient temperature. Potential errors can be minimized by ensuring the stability of the temperature difference between the specimen and the ambient temperature during the procedure. Also, the emissivity measurement accuracy can be increased by increasing this temperature difference.

6.4 The emissivity of a specimen may be specific to the temperature of the specimen and the spectral waveband of the infrared imaging radiometer used to make the measurement. Therefore, the temperature of the specimen and the spectral waveband of the radiometer should be noted along with the measured emissivity value.

6.5 These procedures are valid only for specimens that are opaque in the waveband of the infrared imaging radiometer.

6.6 As the emissivity of a specimen decreases, its reflectivity increases. Careful consideration and avoidance of potential error sources, including the precise determination of reflected temperature in 8.1.3 and 8.2.3, is required to accurately measure the emissivity values of specimens having lower emissivities. For materials with emissivities less than 0.5, radiometric temperature measurements and emissivity measurements may have a high likelihood of error.

7. Apparatus

7.1 *Calibrated Infrared Imaging Radiometer,* with a built-in computer that allows the infrared thermographer to input reflected temperatures and emissivity values.

7.2 *Tripod,* or device to support the infrared imaging radiometer.

7.3 A natural or induced means of heating or cooling the specimen at least 10 °C above or below the ambient temperature.

7.4 The contact thermometer method requires a calibrated contact thermometer.

7.5 The noncontact thermometer method requires a surface-modifying material with a known emissivity at a temperature close to that of the specimen and in the same spectral waveband of the infrared imaging radiometer.

NOTE 1—For best results, the surface modifying material should have a high emissivity, preferably 0.9 or greater.

8. Procedure

8.1 *Contact Thermometer Method:*

8.1.1 Place the infrared imaging radiometer on the tripod or support device at the desired location and distance from the specimen.

8.1.2 Point the infrared imaging radiometer at the specimen and focus on the portion where the emissivity is to be measured.

8.1.3 Use an appropriate infrared imaging radiometer measurement function (such as spot temperature, crosshairs, or isotherm) to measure and compensate for the reflected temperature error incident upon the specimen.

NOTE 2—Such measurements are generally more accurate when the measurement is averaged over a small region of the image. Use of an average temperature box or a narrow band isotherm will produce more reproducible results than single pixel measurements.

8.1.4 Use the contact thermometer to measure the temperature of the point or area just measured in 8.1.3. Record this temperature.

8.1.5 Without moving the imager, adjust its computer's emissivity control until the imager's computer indicates the same temperature recorded in 8.1.4. The indicated emissivity value is the measured emissivity of the specimen, at this temperature and spectral waveband.

8.1.6 Repeat procedures 8.1.1 through 8.1.5 a minimum of three times and average the emissivity values to yield an average emissivity.

8.2 *Noncontact Thermometer Method:*

8.2.1 Place the infrared imaging radiometer on the tripod or support device at the desired location and distance from the specimen.

8.2.2 Point the infrared imaging radiometer at the specimen and focus on the portion where the emissivity is to be measured.

8.2.3 Use an appropriate infrared imaging radiometer measurement function (such as spot temperature, crosshairs, or isotherm) to measure and compensate for the reflected temperature error incident upon the specimen.

8.2.4 Apply the surface-modifying material to, or immediately adjacent to, the portion of the specimen where the emissivity is to be measured. Make sure the surface-modifying material is dry and in good contact with the specimen.

8.2.5 Enter the known emissivity value of the surface-modifying material in the radiometer's computer under the emissivity input (sometimes referred to as *emittance* or *E*).

8.2.6 Use the radiometer to measure the temperature of the surface-modifying material. Record this temperature.

8.2.7 Focus the infrared imaging radiometer on the portion of the specimen immediately adjacent to the surface-modifying material (where the emissivity is to be measured), or remove the surface-modifying material and focus the imager on the previously-modified specimen (where the emissivity is to be measured).

8.2.8 Without moving the imager, adjust its computer's emissivity control until the imager's computer indicates the same temperature recorded in 8.2.6. The indicated emissivity value is the measured emissivity of the specimen, at this temperature and spectral waveband.

8.2.9 Repeat 8.2.1 through 8.2.8 a minimum of three times and average the emissivity values to yield an average emissivity.