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Standard Practice for Determination of Minimum Immersion Depth and Assessment of Temperature Sensor Measurement Drift[1]

This standard is issued under the fixed designation D7962; 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 describes two procedures for use with temperature measurement devices. Methodology is described for determining minimum immersion depth for thermal sensors, in particular RTDs or similar temperature sensors. Included is a procedure for consistently preparing a reference bath for the purpose of monitoring measurement drift of thermal sensors such as liquid-in-glass or digital contact thermometers.

1.2 This practice focuses on temperature measurement drift in a laboratory. If the user requires greater measurement accuracy, then they should follow the instructions in Practice E563.

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

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~~ safety, health, and ~~health~~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:*[2]

E563 Practice for Preparation and Use of an Ice-Point Bath as a Reference Temperature

3. Terminology

3.1 *Definitions:*

3.1.1 *digital contact thermometer (DCT), n*—an electronic device consisting of a digital display and associated temperature-sensing probe.

3.1.1.1 *Discussion—*

[1] This practice is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.91 on Coordinating Subcommittee on Thermometry.

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[2] 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.

***A Summary of Changes section appears at the end of this standard**

This device consists of a temperature sensor connected to a measuring instrument; this instrument measures the temperature-dependent quantity of the sensor, computes the temperature from the measured quantity, and provides a digital output. This digital output goes to a digital display and/or recording device that may be internal or external to the device. These devices are sometimes referred to as a "digital thermometer."

3.1.1.2 *Discussion—*
The devices are often referred to as a "digital thermometers," however the term includes devices that sense temperature by means other than being in physical contact with the media.

3.1.1.3 *Discussion—*
Portable electronic thermometers (PET) is an acronym sometimes used to refer to a subset of the devices covered by this definition.

3.1.2 *ice-point bath, n*—physical system containing ice and water assembled to realize the ice point as a reference temperature, or to establish a constant temperature near 0 °C.

3.1.3 *minimum immersion depth, n*—depth that a thermometer should be immersed, in a uniform temperature environment, such that further immersion does not produce a change in indicated temperature greater than the specified tolerance.

4. Summary of Practice

4.1 This practice provides a procedure for determining measurement drift of a temperature sensor and a procedure for determining the minimum immersion depth of temperature sensor using an ice bath.

4.2 This practice describes a procedure for consistently preparing an ice bath that is an intimate mixture of crushed ice or ice particles and water in a thermally insulating vessel open to the atmosphere.

4.2.1 Caution—when the ice bath is notCaution—the ice and water used to prepare an ice bath should be made from distilled water, its temperature will differ from the natural fixed-point temperature by a consistent amount, typically less than 0.02 °C. or deionized water. A bath so prepared can provide a temperature uncertainty of about ±0.005 °C. If the user needs a more accurate ice point, then they should use Practice E563 to prepare the ice bath.

4.2 This practice includes a procedure for determining the minimum immersion depth of the temperature sensor using an ice bath.

4.2.1 This procedure determines minimum immersion depth with a 25 °C differential between sensed temperature and ambient temperature. If the probe is subjected to a greater differential temperature, a larger immersion depth may be required to correctly measure the temperature.

5. Significance and Use

5.1 This practice provides a means for the users of ASTM Committee D02 standards to monitor the drift in sensed temperature of liquid-in-glass thermometer (LiG), and digital contact thermometers (DCT). Digital contact thermometers are sometimes referred to as portable electronic thermometers (PET) or simply digital thermometers.

5.2 This practice is not suitable for determining the accuracy or calibration of a temperature-measuring device as the error in the ice bath temperature can be greater than 0.02 °C. For greater accuracy, the user should use Practice E563 to prepare the ice bath.

5.3 The ice point is a common practical industrial reference point of thermometry. The ice point is relatively simple to realize and provides a readily available natural fixed-point reference temperature.

5.4 This practice only checks the measurement drift at a single temperature. It will not detect a change in measurement response with change in temperature. Temperature-measuring devices should be recalibrated at set intervals. See device supplier for recommendations.

5.5 This practice provides a technique to determine minimum immersion depth of the sensing probe of the thermometer using an ice bath. The minimum immersion depth determined by this practice may change when the differential temperature differs significantly from the conditions described. A greater differential will likely increase the minimum immersion depth.

6. Reagents and Equipment

6.1 *Water*—Good distilled or deionized water from a consistent source.

6.2 *Ice*—Crushed ice prepared from the water in 6.1.

6.3 *Insulated Container*—An insulated container large enough to hold the thermometer and provide several centimeters of water-ice slush around the measuring portion of the thermometer.

7. Procedure – Drift in Temperature Measurement

7.1 *Preparation of the Ice-Point Bath:*

7.1.1 Determine the water source to be used each time this practice is followed in your laboratory to determine measurement drift and note the water source with the measurement. Altering the water source between uses of the practice when monitoring a temperature sensor may result in observing a false drift.

7.1.2 Ensure that all equipment is clean and free of any oily residue. Rinse the equipment with the type of water used for the ice-point bath media. Use clean, powder-free laboratory gloves to handle the ice and equipment.

7.1.3 Prepare ice by using the water from the source determined in 7.1.1. Chill a quantity of the water to near 0 °C in a flask then shake vigorously to aerate the water before freezing in small cubes or thin sheets.

7.1.3.1 Prepare finely divided ice by shaving or crushing. Shaved ice resembling snow is preferred, but crushed ice is acceptable if the particles are small (approximately 2 mm to 6 mm in diameter) and there is a large distribution in size.

7.1.4 Prepare the bath in a clean, thermally insulated vessel, preferably a wide-mouthed Dewar vacuum flask fitted with an insulating closure such as a stopper. The vessel should be large enough that its size does not affect the water-ice equilibrium temperature and of such diameter and depth that in thermal equilibrium the test objects will not significantly modify the temperature of the bath over the region to which the ice point is to be applied. For usual applications, a diameter of 70 mm and a depth of 300 mm may be adequate.

7.1.5 Alternately, add shaved ice and chilled water to the vessel, using enough water to saturate the ice but not enough to float it. As the vessel fills, compress the ice-water mixture to force out excess water. The objective is to surround each particle of ice with water, filling all voids, but to keep the ice particles as close together as possible. Continue adding ice and water and compressing until the vessel is filled to the required level. Decant or siphon off excess water.

7.1.6 Cover the ice-point bath, leaving just enough open space to access the thermometer probe and agitate the mix. Allow the bath and vessel to equilibrate for at least 30 min before using.

7.2 *Determination of Measurement Drift:*

7.2.1 Form a well in the ice-point bath that has the diameter and intended immersion depth of the test object.

7.2.2 It is preferable to cool the test object to less than 3 °C before immersing it in the bath. This reduces the time to reach equilibrium at the ice point. Pre-cooling the sensor helps to preserve the bath at the ice point for a prolonged time and helps ensure that the water-ice interface will be in contact with the thermometer because negligible melting will occur to increase the water film thickness.

7.2.3 Insert the test object to the appropriate depth. This could be (*1*) the scribed immersion line, (*2*) the depth of the minimum immersion depth determined by this practice, or (*3*) the same depth as it is used. For total immersion liquid-in-glass thermometers, immerse to the 0 °C (32 °F) mark. For partial immersion liquid-in-glass thermometers, immerse to the immersion line or stated immersion depth. Keep the sensor portion of the object several centimeters above the bottom of the flask to avoid the zone at the bottom where denser melt water tends to accumulate.

7.2.4 Cover the top of the vessel around the test object but leave sufficient access to periodically agitate the ice-water slush.