



Designation: E 563 – 97

Standard Practice for Preparation and Use of an Ice-Point Bath as a Reference Temperature¹

This standard is issued under the fixed designation E 563; 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 a method of preparing, maintaining, and using a temperature reference bath of a mixture of shaved ice and water, saturated with air at a pressure of 101 325 Pa (1 atm).

1.2 An industrial practice for relating values referenced to the ice point and to the water triple point on the ITS-90 is included.

1.3 Methods to promote uniformity of bath temperature by mechanical stirring or agitation are not described in detail.

1.4 Methods of approximating the ice point, as by thermostatically-controlled refrigeration, are not covered by this practice.

1.5 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 1193 Standard Specification for Reagent Water²

E 344 Terminology Relating to Thermometry and Hydrometry³

E 1594 Guide for Expression of Temperature³

3. Terminology

3.1 *Definitions*—Definitions given in Terminology E 344, unless otherwise defined herein, apply to terms as used in this practice.

3.2 Temperature relationships given in Guide E 1594, unless otherwise defined herein, apply to temperature values as used in this practice.

3.3 *Definitions of Terms Specific to This Standard:*

¹ This practice is under the jurisdiction of ASTM Committee E-20 on Temperature Measurement and is the direct responsibility of Subcommittee E20.07 on Fundamentals in Thermometry.

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² *Annual Book of ASTM Standards*, Vol 11.01.

³ *Annual Book of ASTM Standards*, Vol 14.03.

3.3.1 *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.

4. Summary of Practice

4.1 The ice-point bath described by this practice consists of an intimate mixture, without voids, of pure shaved ice or ice particles and distilled air-saturated water in a thermally insulating vessel open to the atmosphere.

4.2 The ice bath realization of the ice point physically approximates, with small uncertainty, a natural fixed-point temperature.

4.2.1 An ice-point bath prepared using distilled-water ice and air-saturated, chilled distilled water, typically has a temperature of $0.000 \pm 0.002^\circ\text{C}$. Consequently, when the bath is used as a fixed-point temperature reference, the bath temperature is assumed to be 0°C, with an uncertainty that depends on the care with which the bath was established and maintained.

4.2.2 The ice-point bath is open to the atmosphere; the effect of barometric pressure on the ice point is -75 nK/Pa (-7.6 mK/atm). The solubility of air in the water is directly proportional to the atmospheric pressure.

4.3 The ice-bath temperature can also be measured with an accurately calibrated thermometer or compared to a water triple point cell and the bath temperature is reported as the measured temperature with an uncertainty that is attributed to the measurement, not to the ice point.

5. Significance and Use

5.1 This practice is adequate for use with other ASTM standards that specify the ice point as a reference. It is also intended to be adequate for most other ice-point reference purposes.

5.2 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.

5.3 *Use in Resistance Thermometry:*

5.3.1 The ice point was a defining fixed point on practical temperature scales prior to 1960.

5.3.2 The ITS-90 defines $W(T_{90}) = R(T_{90})/R(273.16 \text{ K})$, the measured resistance ratio of a Standard Platinum Resistance Thermometer (SPRT), in reference to the water triple point, not the ice point (1).⁴ In many instances, where the water triple point is not available, or when the accuracy obtainable with the water triple point is not required, reference to a properly established and maintained ice-point reference is used. For industrial-quality resistance thermometers, the resistance value is determined for 0°C, and an uncertainty is assigned that is appropriate for the quality of the ice-point realization.

5.4 Use in Thermoelectric Thermometry:

5.4.1 In thermoelectric thermometry, the ice point is ordinarily used as the reference temperature (2).

5.4.2 Adequate thermoelectric reference requires that thermocouple junctions be well-coupled thermally to the bath, electrically isolated from each other and from the bath, and adequately immersed to avoid perturbing the reference-junction temperatures by radiation and longitudinal conduction of heat along the thermoelements (3 and 4).

6. Hazards

6.1 Excess water accumulating in any region, particularly around the reference location, can elevate the temperature in that vicinity above the ice point. Errors, usually somewhat less than 4°C, can occur from this cause in poorly maintained baths and with poorly positioned test objects (3 and 4).

6.2 For a stirred bath, the temperature of the bath will depend on the heat gained by the bath, the amount of water and ice, and the vigor of stirring. The uniformity of temperature of the bath can be enhanced by slowly stirring or agitating the slush of ice and water either manually or by a powered stirring means so that all of the ice and water in the bath come into intimate contact.

6.3 Ice making machines operate below 0°C. Therefore, when excessively large ice particles are used to prepare the ice-point bath, the initial temperature of the bath can briefly be slightly below the ice point. Also, some of the water may freeze and bridge some of the particles. Use of the bath must be delayed long enough to establish thermal equilibrium, and the particles shall be sufficiently small so that the bath approaches the required state of ice and air-saturated water in intimate contact.

6.4 Cleanliness is essential as small amounts of dissolved salts, and other contaminants can cause the equilibrium temperature to be below that of the ice-point temperature.

7. Procedure

7.1 In the practical use of the ice-point bath, two objectives shall be accomplished: (1) the bath shall be established and maintained so that its temperature is a good approximation to that of the ice point, and (2) the object for which the reference temperature is to be obtained shall be in thermal equilibrium with the water-ice equilibrium temperature (water-ice interface temperature).

7.2 Establishing the Ice-Point:

7.2.1 All equipment that comes in contact with the water and ice of an ice-point bath shall be clean. Thoroughly rinse the equipment with tap water, then rinse with the type of water used for the ice-point bath medium. Use clean plastic gloves to handle the ice and equipment.

7.2.2 Use water of purity equivalent to or purer than type IV reagent water, Specification D 1193, for the ice-point bath medium. Chill a quantity of the water to near 0°C in a flask and shake vigorously to aerate the water. Freeze another portion of the water to produce ice for the bath.

7.2.3 Prepare finely divided ice by shaving or crushing. Shaved ice resembling snow is preferred, but crushed ice is acceptable if the particles are small (not exceeding 2 to 3 mm diameter).

7.2.4 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 at least 70 mm and a depth of at least 300 mm may be adequate.

7.2.5 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.

7.2.6 Cover the ice-point bath to protect it. Use an opaque and thermally insulating cover or stopper that is suitable for the application. Allow the bath and vessel to equilibrate for at least 30 minutes before using.

7.3 Using the Ice-Point Bath:

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

7.3.2 Cool the test object to equilibrium in water with temperature less than 3°C before immersing it in the bath. This reduces the time to reach equilibrium at the ice point. Cooling helps to preserve the bath at the ice point for prolonged use. Cooling also helps to ensure that the water-ice interface will be in contact with the thermometer because negligible melting will have occurred to increase the water film thickness.

7.3.3 Insert the test object with the sensor portion of the object, such as the bulb of a liquid-in-glass thermometer or the sensing element of an SPRT, to a depth of at least ten object diameters below the bath surface. For thermoelectric thermoelements of high thermal conductivity, as much as 200 mm immersion may be necessary. 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.

⁴ The boldface numbers in parentheses refer to the list of references at the end of this standard.