BSR/ASHRAE Standard 29-2015R

Public Review Draft

Method of Testing Automatic Ice Makers

First Public Review (April 2024)
(Complete Draft for Full Review)

This draft has been recommended for public review by the responsible project committee. To submit a comment on this proposed standard, go to the ASHRAE website at www.ashrae.org/standards-research--technology/public-review-drafts and access the online comment database. The draft is subject to modification until it is approved for publication by the Board of Directors and ANSI. Until this time, the current edition of the standard (as modified by any published addenda on the ASHRAE website) remains in effect. The current edition of any standard may be purchased from the ASHRAE Online Store at www.ashrae.org/bookstore or by calling 404-636-8400 or 1-800-727-4723 (for orders in the U.S. or Canada).

The appearance of any technical data or editorial material in this public review document does not constitute endorsement, warranty, or guaranty by ASHRAE of any product, service, process, procedure, or design, and ASHARE expressly disclaims such.

ASHRAE, 180 Technology Parkway, Peachtree Corners, GA 30092

CONTENTS

SECTION **PAGE**

(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

FOREWORD

ASHRAE Standard 29 was first published in 1988 and was reaffirmed in 1999 and 2005 and revised in 2009 and 2015.

The 2015 revision incorporated a clarification in Section 5 to instrumentation, test equipment, and data acquisition. Detail was added to Section 6 for water and air-temperature requirements during test. More specific instruction was provided in Section 7 for ice capacity determination sampling. Finally, revisions were added to Normative Annex A for determination of calorimeter constant and heat of fusion for ice product for continuous-type ice makers.

This is a reaffirmation of Standard 29-2015. This standard was prepared under the auspices of ASHRAE. It may be used, in whole or in part, by an association or government agency with due credit to ASHRAE. Adherence is strictly on a voluntary basis and merely in the interests of obtaining uniform guidelines throughout the industry. This reaffirmation updates references in Informative Annex B.

1. PURPOSE

This standard prescribes a method of testing automatic ice makers by

a. specifying procedures to be used when testing automatic ice makers,
b. establishing the types of equipment to which the provisions of the standard apply,
c. defining terms describing the equipment covered and terms related to testing,
d. specifying the type of instrumentation and test apparatus required in testing,
e. specifying a uniform method for calculation of results, and
f. specifying data and results to be recorded.

2. SCOPE

This standard does not include automatic ice makers installed in household refrigerators, combination refrigerator-freezers, and household freezers.

3. DEFINITIONS

automatic ice maker: a factory-made assembly consisting of a condensing unit and ice-making section operating as an integrated unit, with means for making and harvesting ice. It may also include means for storing or dispensing ice, or both. The automatic ice maker may be composed of one or more sections for shipping purposes.

batch-type ice maker: an ice maker having alternate freezing and harvesting periods.

continuous-type ice maker: an ice maker that continually freezes and harvests ice at the same time.

dump water: water drainage from an ice maker to control the clarity of ice or to prevent scaling. Also referred to as purge water.

harvest rate: the gross weight of ice harvested per unit of time, expressed in lb/24 h, as calculated in Section 9.2.1.

pure ice: ice made by using water with less than 5 ppm of solids concentration.

4. CLASSIFICATION

4.1 Method of Rejecting Heat

4.1.1 Water-cooled condenser.

4.1.2 Air-cooled condenser.

4.2 Type of Ice Harvested

4.2.1 Ice in irregular shapes of chips, flakes, ribbons, or wafers.

4.2.2 Uniformly shaped ice of not over 56 g (2 oz).

5. INSTRUMENTS AND APPARATUS

5.1 Test Room

5.1.1 Ambient Temperature. With the ice maker at rest, the vertical ambient temperature gradient in any meter (foot) of vertical distance from 51 mm (2 in.) above the floor or supporting platform to a height of 2.1 m (7 ft), or to a height of 0.3 m (1 ft) above the top of the cabinet within the clearances specified in Section 6.5, whichever is greater, shall not exceed 0.91°C/m (0.5°F/ft).

5.1.2 Air Circulation. With the ice maker at rest, ambient air movement created by any source external to the unit shall not impinge upon the air inlet openings with a velocity greater than 0.25 m/s (50 fpm).

5.1.3 Test Room Operation. No changes to the test room shall be made during operation of the ice maker under test that would impact the vertical ambient temperature gradient, or the ambient air movement specified in Sections 5.1.1 and 5.1.2.

5.2 Temperature-Measuring Instruments

5.2.1 Types. Temperature shall be measured with instruments of a type having the specified accuracies at the temperatures of use.

5.2.2 Accuracy and readability each shall be within ±0.56°C (1.0°F).

5.2.3 Where accuracy greater than ±0.56°C (1.0°F) is specified, the instrument shall be calibrated by comparison with a certified standard in the range of use or shall itself be certified as to accuracy, and the resolution shall be at least equal to the accuracy requirement unless otherwise specified.

5.3 Electrical Instruments

5.3.1 Accuracy and readability shall each be within ±2.0% of the quantity measured.

5.3.2 Input power shall be measured with an integrating watt-hour meter graduated to 0.01 kWh.

5.4 Water-Measuring Instruments

5.4.1 Flow shall be measured by one or more of the following methods and have accuracy and readability each of ±2.0% of the quantity measured:

a. Liquid quantity, measuring either weight or volume
b. Integrating-type liquid flow meter

5.4.2 Harvest water shall be captured by a nonperforated pan located below the perforated pan used to capture the batch of ice, as described in Section 5.5.2, and measured as liquid quantity.

5.5 Ice-Weighing Instruments

5.5.1 Unless otherwise specified, ice made by the ice maker shall be weighed on an instrument having accuracy and readability each of ±1.0% of the quantity measured.

5.5.2 The intercepted ice sample shall be obtained and weighed in one of the following containers of predetermined weight:

a. For a batch-type ice maker, use a container with perforations through which the ice of the unit under test cannot fall and for which the water retention weight is no more than 1.0% of that of the smallest batch of ice for which the container is used. The water hold-up weight is the maximum weight of water and shall be measured as follows:
   1. Immerse the container in water with the same orientation as when collecting ice.
   2. Gently lift the container out of the water and allow it to drain for 30 seconds without shaking it.
   3. Weigh the container and the held-up water.
   4. Subtract the container's dry weight.
b. For a continuous-type ice maker, use a solid surface metal or plastic pan or bucket.
c. *Collection container for batch type automatic ice makers with harvest rates less than or equal to 50 lb/24 h.* Use an ice collection container, except that the water retention weight of the container is no more than 4.0 percent of that of the smallest batch of ice for which the container is used.

5.6 Water Pressure Instruments. Instruments used to measure water pressure at the ice maker inlet shall have accuracy and readability each of 2.0% of the value measured.

5.7 **Humidity instruments.** Instruments used to measure ambient relative humidity shall be measured with an instrument accuracy of ±6.0 percent.

5.8 Sampling Rate. The maximum interval between data samples for humidity, pressure, temperature, flow rate, and voltage shall be no more than 5 seconds.

6. TEST METHODS

6.1 The voltage shall be measured at the ice-maker service connection, with the ice maker in operation, and shall meet the following:
a. Individual measurements must be within ± 4.0% of rated voltage
b. Average over the test period must be within ±2.0% of rated voltage

6.2 The temperature of the supply water within the conduit shall be measured within 203 mm (8 in.) of the ice maker by inserting the temperature-measuring instrument directly within the water stream or within a well inserted into the conduit. Water temperature shall be measured during the water-fill interval and shall be maintained within ±0.56°C (1°F) of the specified temperature.

6.3 The pressure of the supply water within the conduit shall be measured within 203 mm (8 in.) of the ice maker and shall remain within the specified range during the period starting 5 seconds after water starts flowing into the ice-maker inlet(s) and ending when water stops flowing into the ice maker intlet(s).

6.4 For an air-cooled ice maker, ambient temperature shall be measured with unweighted sensors at a location geometrically centered to the inlet area at a distance of 0.3 m (1 ft) from the air inlet. Where more than one inlet is provided, ambient temperature shall be measured geometrically centered to each inlet area at a distance of 0.3 m (1 ft) in front of each inlet plane, and the average temperature shall be recorded.

Ambient relative humidity shall be measured at the same location(s) used to confirm ambient dry bulb temperature, or as close as the test setup permits.

For automatic ice makers in which warm air discharge from the condenser exhaust affects the ambient conditions as measured 1 foot in front of the air inlet, or automatic ice makers in which the air inlet is located in the rear of the automatic ice maker and the manufacturer's specified minimum rear clearance is less than or equal to 1 foot, the ambient temperature and relative humidity may instead be measured 1 foot from the cabinet, centered with respect to the sides of the cabinet, for any side of the automatic ice maker cabinet with no warm air discharge or air inlet.

Ambient temperature and relative humidity sensors may be shielded if the ambient test conditions cannot be maintained within the specified tolerances because of warm discharge air from the condenser exhaust affecting the ambient measurements. If shields are used, the shields must not inhibit recirculation of the warm discharge air into the condenser or automatic ice maker inlet.

For water-cooled ice makers, ambient temperatures shall be measured at two places 0.3 m (1 ft.) from the cabinet, centered with respect to opposite sides of the cabinet.

During the first 5 minutes of each freeze cycle, the average ambient temperatures shall not vary more than ±1.1°C (2°F) from the specified temperatures and not more than 0.56°C (1°F) thereafter.

6.5 Automatic ice makers shall be tested with a minimum ambient relative humidity of 30% throughout testing.

6.6 Automatic ice makers shall be tested according to the manufacturer's specified minimum rear clearances requirements, or 3 feet from the rear of the automatic ice makers, whichever is less. All other sides of the automatic ice makers and all sides of the remote condensers, if applicable, shall be tested with a minimum clearance of 3 feet or the minimum clearance specified by the manufacturer, whichever is greater.

6.7 Bins shall be used when testing and shall be filled one-half full with ice. Ice makers that convey ice through a conduit to a remote bin shall be tested with the minimum length of conduit that can be used. For an automatic ice maker with an automatic dispenser which is not able to continuously produce and dispense ice because of certain mechanisms within the automatic ice maker that prohibit the continuous production and dispensing of ice throughout testing, those mechanisms must be overridden to the minimum extent which allows for the continuous production and dispensing of ice. The automatic ice maker shall have an empty internal storage bin at the beginning of the test period. Collect capacity samples through continuous use of the dispenser rather than in the internal storage bin. The intercepted ice samples shall be obtained from a container in an external ice bin that is filled one-half full of ice and is connected to the outlet of the ice dispenser through the minimal length of conduit that can be used.

6.8 For ice makers that have water-cooled condensers, the quantity of water shall be determined separately for the condenser and ice-making section.

6.9 The ice maker shall be set up prior to testing and shall be adjusted in accordance with the manufacturer's recommendations.

6.10 Heat exchangers and other accessories shall be used only if they are part of standard equipment furnished with the model tested.

6.11 The ice maker shall be completely assembled with all panels, doors, and lids in their normally closed positions.

6.12 Conduct testing without baffles unless the baffle either is a part of the automatic ice maker or shipped with the automatic ice maker to be installed according to the manufacturer's installation instructions.

6.13 Test automatic ice makers equipped with automatic dump water control using a fixed dump water setting that is described in the manufacturer's written instructions shipped with the unit as being appropriate for water of normal, typical, or average hardness. Dump water settings described in the instructions as suitable for use only with water that has higher or lower than normal hardness (such as distilled water or reverse osmosis water) must not be used for testing."

7. TEST PROCEDURES

7.1 Stabilization and Capacity Requirements

7.1.1 Batch-type ice maker

7.1.1.1 Cycles

Cycles shall begin following completion of a harvest event and end at the same point in the cycle. One cycle includes a complete freezing and harvesting period.

7.1.1.2 Harvest

A perforated container as described in Section 5.5.2(a) or 5.5.2(c), as applicable, precooled to ice temperature, shall be used to capture the ice from each consecutive harvest. A duration of 30 ± 2.5 s shall elapse between the completion of the harvest event and measurement of the weight of the container and ice captured during that harvest event to allow water to drain from the ice sample.

7.1.1.3 24-hour production rate

Calculate the 24-hour ice production rate for each cycle using Section 9.2.1.

7.1.1.4 Cycles used to calculate results

Use the values measured from 3 or more consecutive cycles that meet the applicable stability criterion in Section 7.1.1.5 to calculate the results in Section 9. For example, if using the samples from 3 cycles, the difference in 24-hour calculated production rate between the first and second cycle must meet the applicable stability criterion, the difference in 24-hour calculated production rate between the second and third cycle must meet the applicable stability criterion, and the difference in 24-hour calculated production rate between the first and third cycle must meet the applicable stability criterion.

7.1.1.5 Stability criteria

7.1.1.5.1 Units with harvest rate greater than 50 lb per 24 hours

For units with a harvest rate greater than 50 lb per 24 hours, the absolute value of the difference between each pair of the three or more consecutive 24-hour calculated production rates must be no more than the greater of 1 kg (2.2 lb) or 2% of the average of each pair of 24-hour calculated production rates. Calculate the percentage difference in 24-hour production rates between cycles using Section 7.1.3.

7.1.1.5.2 Units with harvest rate less than or equal to 50 lb per 24 hours

For units with a harvest rate less than or equal to 50 lb per 24 hours, the absolute value of the difference between each pair of the three or more consecutive 24-hour calculated production rates must be no more than 4% of the average of each pair of 24-hour calculated production rates. Calculate the percentage difference in 24-hour production rates between cycles using Section 7.1.3.

7.1.2 Continuous-type ice maker

7.1.2.1 Samples

For continuous-type ice makers, samples of ice shall be captured for consecutive durations of 15.0 min ± 2.5 s each with no more than 5 minutes between the end of a sample collection period and the start of the next sample collection period. A nonperforated container, as described in Section 5.5.2(b), precooled to ice temperature, shall be used. Determine the weight of each sample.

7.1.2.2 Samples used to calculate results

Use the values measured from 3 or more consecutive samples that meet the applicable stability criterion in Section 7.1.2.3 to calculate the results in Section 9. For example, if using 3 samples, the difference in sample weight between the first and second sample must meet the applicable stability criterion, the difference in sample weight between the second and third sample must meet the applicable stability criterion, and the difference in sample weight between the first and third cycle must meet the applicable stability criterion.

7.1.2.3 Stability criteria

7.1.2.3.1 Units with harvest rate greater than 50 lb per 24 hours

For units with a harvest rate greater than 50 lb per 24 hours, the absolute value of the difference in weight between each pair of the three or more consecutive samples must be no more than the greater of 25 g (0.055 lb) or 2% of the average of each pair of sample weights. Calculate the percentage difference in sample weight between samples using Section 7.1.3.

7.1.2.3.2 Units with harvest rate less than or equal to 50 lb per 24 hours

For units with a harvest rate less than or equal to 50 lb per 24 hours, the absolute value of the difference in weight between each pair of the three or more consecutive samples must be no more than 4% of the average of each pair of sample weights. Calculate the percentage difference in sample weight between samples using Section 7.1.3.

7.1.3 Calculation of percentage difference

To calculate the percentage difference in the 24-hour calculated production rates between two cycles or weight between two samples, use the following equation, where A and B are the 24-hour calculated production rates in lb per 24 hours for batch type ice makers or the sample weights in lb per 15 minutes for continuous type ice makers.

$$Percentage\ Difference = \frac{|A-B|}{\frac{A+B}{2}} \times 100 \text{ percent}$$

7.2 Net Cooling Effect of Harvested Ice Test

The procedure for determining the net cooling effect of harvested ice, as described in Normative Annex A, Section A3, shall be performed on each continuous-type ice maker at the same conditions as the capacity test. The ice sample collection period used for determining the net cooling effect of harvested ice shall follow consecutively after the three or more consecutive samples used to determine the capacity have been collected and shall be collected as specified in Section 7.1.2.1. The ice sample shall be collected over a time period of 15 min or until 2.7 kg ± 135 g (6 lb ± 4.8 oz) has been captured, and the entire contents of the container shall be put into the calorimeter. Ice from batch-type ice makers does not require the procedure for determining the net cooling effect of harvested ice.

7.3 Water Consumption Test

7.3.1 Apparatus and instruments, as prescribed in Section 5.4, shall be used to determine water consumption.

7.3.2 Water consumption shall be measured for the same periods prescribed in Sections 7.1.1.4 and 7.1.2.2.

7.3.3 Water consumption for the produced ice shall be measured by one of two methods:

a. Water consumption = collected ice weight + dump water quantity + harvest water quantity
b. Water consumption = inlet water quantity

7.3.4 The water consumption in liters (gallons) per 24 hours shall be listed separately for the condenser and icemaking section for water-cooled ice makers and shall be calculated from consumption measured during the test periods prescribed in Sections 7.1.1.4 and 7.1.2.2.

7.4 Energy Consumption Test

7.4.1 Instruments, as prescribed in Section 5.3.2, shall be used to determine energy consumption in kWh.

7.4.2 Energy consumption shall be determined for the same periods prescribed in Sections 7.1.1.4 and 7.1.2.2.

7.4.3 Total energy consumed in the making and storing of ice, excluding dispensing or other energy-consuming elements, shall be measured.

7.5 Product Density Test

7.5.1 For density testing of product from all types of ice makers, a perforated container of known internal volume, as described in Section 5.5.2(a), precooled to ice temperature, shall be used.

7.5.1.1 The size of the container shall be such that it is filled to overflowing in not more than two hours of operation of the maker but shall not exceed 28.3 dm^3 (28.3 L [1 ft^3]).

7.5.1.2 The shape of the container shall be cylindrical, with a diameter of one-half the height.

7.5.2 The container for ice makers producing uniformly shaped ice shall be filled manually with freshly made ice. The excess shall be struck off with a straight edge and the sample weighed.

7.5.3 The container for makers producing irregular shapes as described in Section 4.2.1 shall be placed inside the bin (see Section 6.5) and be allowed to overfill from normal icemaker discharge. The excess shall then be struck off with a straight edge and the remaining ice weighed.

8. DATA TO BE REPORTED

8.1 General

a. Brand name of maker
b. Type of maker (batch or continuous)
c. Type of condenser (air or water)
d. Model number and serial number
e. Ambient temperature °C (°F)
f. Ambient temperature gradient (ice maker at rest)
g. Maximum air-circulation velocity at inlets (at rest)
h. Supply water temperature °C (°F)
i. Water pressure
j. Voltage, frequency, and phase (nameplate and test)

8.2 Capacity Test

a. Weight in kg (lb) of each intercepted sample (See Sections 7.1.1.4 and 7.1.2.2.)
b. Time in minutes for each cycle or sample

8.3 Water Consumption

a. Condenser water used, if any, in liters (gallons) for making each intercepted sample
b. Water in liters (gallons), including dump and harvest water, used for making each intercepted sample
c. Time in minutes to produce each intercepted sample

8.4 Energy Consumption

a. Energy input in kWh used for making each intercepted sample
b. Time in minutes to produce each intercepted sample

8.5 Product Density

a. Weight of ice measured in kg (lb)
b. Volume of container in m3 (ft3)

9. CALCULATION OF RESULTS

9.1 Data reporting: All intermediate calculations prior to the reported value, as applicable, must be performed with unrounded values. The harvest rate (Section 9.2.1), energy use (Section 9.4), condenser water use (Section 9.3.1), and potable water use (Section 9.3.2) must be calculated by averaging the values for the three or more calculated samples for each respective reported metric.

9.2 Weight Calculation

9.2.1 The gross 24-hour weight of product produced shall be calculated as follows:

For each intercepted sample, calculate the quantity:

kg/24 h = (8.2a/8.2b) × 1440 (SI units)
lb/24 h = (8.2a/8.2b) × 1440 (I-P units)

where the designations "8.2a" and "8.2b" refer to the variables described in Sections 8.2(a) and 8.2(b), respectively.

Average the quantity for the three samples to determine the ice produced.

9.2.2 For continuous-type ice makers, the weight of 0°C (32°F) ice harvested per 24 h (corrected to 335 kJ/kg [144 Btu/lb]) shall be the gross weight, described in Section 9.2.1, times the specific heat of fusion in kJ/kg (Btu/lb) determined in accordance with Section 7.2.4, divided by 335 (144).

9.3 Water Consumption Calculation

9.3.1 The condenser water used shall be determined as follows:

L/kg ice = 8.3a/8.2a (SI units)
gal/100 lb ice = 8.3a/8.2a × 100 (I-P units)

where the designations "8.3a" and "8.3b" refer to the variables described in Sections 8.3(a) and 8.3(b), respectively.

9.3.2 The water used in making ice shall be determined as follows. For each intercepted sample,

L/kg ice = 8.3b/8.2a (SI units)
gal/100 lb ice = 8.3b/8.2a × 100 (I-P units)

where the designations "8.2a" and "8.3b" refer to the variables described in Sections 8.2(a) and 8.3(b), respectively.

9.4 Energy Consumption Calculation. The energy consumption shall be calculated as follows. For each intercepted sample,

kWh/kg ice = 8.4a/8.2a (SI units)
kWh/100 lb ice = 8.4a/8.2a × 100 (I-P units)

where the designations "8.2a" and "8.4a" refer to the variables described in Sections 8.2(a) and 8.4(a), respectively.

9.5 Density Calculation. The density shall be determined as follows:

kg/m3 = 8.5a/8.5b (SI units)
lb/ft3 = 8.5a/8.5b (I-P units)

where the designations "8.5a" and "8.5b" refer to the variables described in Sections 8.5(a) and 8.5(b), respectively.

(This is a normative annex and is part of the standard.)

NORMATIVE ANNEX A
METHOD OF CALORIMETRY

A1. INSTRUMENTATION REQUIRED

a. Weighing scale, accurate to ±14 g (0.5 oz), with a range of at least 0 to 22.7 kg (50 lb)
b. Temperature-measuring instrument for water, accurate to 0.28°C (0.5°F), with a range of at least –1.1°C (30°F) to 48.8°C (120°F) and a resolution of at least one tenth of a degree
c. Temperature measuring instrument for room (ambient) temperature, accurate to 0.56°C (1.0°F), with a range of at least –1.1°C (30°F) to 37.8°C (100°F) and a resolution of at least one degree
d. Timer readable to the nearest second

A2. PROCEDURE FOR CALORIMETER CONSTANT DETERMINATION

Note: The purpose of determining the calorimeter constant of the apparatus used to determine specific heat of fusion for the ice product is to correct for the effects of heat transfer with ambient and heating effect of stirring the contents of the calorimeter.

a. Room temperature shall be within a range of 20.6°C (69°F) to 21.7°C (71°F) during the entire procedure.
b. Weigh the empty calorimeter and record its weight.
c. Add a quantity of water that is 5 times the mass of the ice to be added in Step e below, ±56.7 g (±2 oz), and that has a temperature of 32.2°C ± 0.56°C (90°F ± 1°F). Record the water temperature, and record the combined weight of the calorimeter and water.
d. Stir at 1 ± 0.5 revolutions per second for 15 minutes, and record the water temperature and room temperature just prior to the addition of the ice.
e. Within 1 minute, add a mass of ice that is within a range of 50% to 200% of the rated ice production for a period of 15 minutes of the ice maker to be tested, or 2.7 kg ± 135 g (6 lb ± 4.8 oz), whichever is less, in the form of a single block of pure ice that has been allowed to reach an equilibrium temperature measured by a thermocouple embedded in the interior (at the approximate geometric center) of the block of 0°C (32°F), and is free of trapped water. Any water that remains on the block of ice shall be wiped off the surface of the block before being placed into the calorimeter. Record the time when all ice has been added to the nearest second.
f. Stir at the same rate as in Step 3, recording the water temperature, room temperature, and the time (to the nearest second) when the ice disappears. Continue stirring at a constant rate after the ice has disappeared for a period of 15 minutes, and record the water and room temperature at the end of the 15-minute period. Weigh the calorimeter with the water and the melted ice.
g. Determine the calorimeter constant following the steps and calculations in Table A-1.
h. The calorimeter constant shall be determined at a minimum each time the temperature measuring and weighing instruments are calibrated or when there is any change to the container or stirring apparatus. The calorimeter constant must be in the range of 1.0 to 1.02 for use in determining calorimetry of harvested ice. Apparatus improvements are needed if the constant falls outside of this range.

A3. PROCEDURE FOR DETERMINING NET COOLING EFFECT OF HARVESTED ICE

a. Room temperature shall be within a range of 20.6°C (69°F) to 21.7°C (71°F) during the entire procedure.
b. Weigh the empty calorimeter and record its weight.

c. Add a quantity of water that is 5 times the weight of ice to be added in Step e below, ± 56.7 g (±2 oz), and that has a temperature of 32.2°C ± 0.56°C (90°F ± 1°F). Record the water temperature and record the combined weight of the calorimeter and water.
d. Stir at 1 ± 0.5 revolutions per second for 15 minutes, and record the water temperature and room temperature just prior to the addition of the ice.
e. Add harvested ice. Stir at 1 ± 0.5 revolutions per second, recording the minimum water temperature.
f. Weigh the calorimeter with the water and the melted ice.
g. Calculate the results as tabulated (see Table A-2).

Table A-1 Calorimeter Constant

Data to be Recorded	Units SI (I-P)	Recorded Value Trial 1	Recorded Value Trial 2
1. Weight of calorimeter	kg (lb)		
2. Water temperature after addition to calorimeter	°C (°F)		
3. Combined weight of calorimeter and water	kg (lb)		
4. Weight of the water = (3) – (1)	kg (lb)		
5. Room temperature at time ice is added	°C (°F)		
6. Water temperature at time ice is added	°C (°F)		
7. Time that ice is added	min		
8. Time when ice is completely melted	min		
9. Room temperature when ice is completely melted	°C (°F)		
10. Water temperature at time when ice is completely melted	°C (°F)		
11. Combined weight of calorimeter, water, and added ice	kg (lb)		
12. Weight of the ice = (11) – (3)	kg (lb)		
13. Room temperature after second 15 minute stirring	°C (°F)		
14. Water temperature after second 15 minute stirring	°C (°F)		
15. Temperature drop of water = (6) – (10)	°C (°F)		
16. Refrigeration used to cool the water = (15) × (4) × 4.19 kJ/°C; ([15] × [4])	kJ (Btu)		
17. Average temperature difference between room and water during second 15 minute stirring = [(9) + (13) – (10) – (14)]/2	°C (°F)		
18. Temperature rise during second 15 minute stirring = (14) – (10)	°C (°F)		
19. Heat gain conductance factor = (18) × 4.19 kJ/°C – kg × [(12) + (4)]/[(17) × 15 min]; ([18] × [(12) + (4)]/[(17) × 15 min])	kJ/min/°C (Btu/min/°F)		
20. Average temperature difference between room and water during ice melt period = [(9) + (5) – (6) – (10)]/2	°C (°F)		
21. Ice melt duration = (8) – (7)	min		
22. Ice melt period heat gain = (19) × (20) × (21)	kJ (Btu)		
23. Total cooling effect = (16) + (22)	kJ (Btu)		
24. Sensible cooling from ice meltwater = (12) × (10) × 4.19 kJ/kg – °C; ([12] × [(10) – 32°F])	kJ (Btu)		
25. Heat of fusion = (23) – (24)	kJ (Btu)		
26. Specific heat of fusion = (25)/(12)	kJ/kg (Btu/lb)		
27. Average specific heat of fusion for trial 1 and trial 2	kJ/kg (Btu/lb)		
28. Calorimeter constant = 335 kJ/kg/(27); (144 Btu/lb/[27])			

Note: Numbers in parentheses in the calculation equations in the above steps refer to the numbers determined in each step.

Table A-2 Net Cooling Effect for Ice Sample

Data to be Recorded		Units SI (I-P)	Recorded Value Trial 1	Recorded Value Trial 2
1.	Weight of calorimeter	kg (lb)		
2.	Water temperature after addition to calorimeter	°C (°F)		
3.	Combined weight of calorimeter and water	kg (lb)		
4.	Weight of the water = (3) – (1)	kg (lb)		
5.	Room temperature at time ice is added	°C (°F)		
6.	Water temperature at time ice is added	°C (°F)		
7.	Time that ice is added	min		
8.	Time when ice is completely melted	min		
9.	Room temperature when ice is completely melted	°C (°F)		
10.	Water temperature at time when ice is completely melted	°C (°F)		
11.	Combined weight of calorimeter, water, and added ice	kg (lb)		
12.	Weight of the ice = (11) – (3)	kg (lb)		
13.	Temperature drop of water = (6) – (10)	°C (°F)		
14.	Refrigeration used to cool the water = (13) × (4) × 4.19 kJ/°C; ([13] × [4])	kJ (Btu)		
15.	Heat gain conductance factor from calorimeter constant determination (item [19] in Table A-1)	kJ/min/°C (Btu/min/°F)		
16.	Average temperature difference between room and water during ice melt period = [(9) + (5) – (6) - (10)]/2	°C (°F)		
17.	Ice melt duration = (8) – (7)	min		
18.	Ice melt period heat gain = (15) × (16) × (17)	kJ (Btu)		
19.	Total cooling effect = (14) + (18)	kJ (Btu)		
20.	Sensible cooling from ice meltwater = (12) × (10) × 4.19 kJ/kg·°C; ([12] × [(10) – 32°F])	kJ (Btu)		
21.	Heat of fusion = (19) – (20)	kJ (Btu)		
22.	Specific heat of fusion = (21)/(12)	kJ/kg (Btu/lb)		
23.	Average specific heat of fusion for trial 1 and trial 2	kJ/kg (Btu/lb)		
24.	Net cooling effect/mass = (23) × calorimeter constant	kJ/kg (Btu/lb)		

Note: Numbers in parentheses in the calculation equations in the above steps refer to the numbers determined in each step.

(This annex is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

INFORMATIVE ANNEX B
BIBLIOGRAPHY

AHRI. 2023. AHRI 810-2023, *Performance Rating of Automatic Commercial Ice-Makers*. Arlington, VA: Air-Conditioning, Heating and Refrigeration Institute.

ASHRAE. 2022. *ASHRAE Handbook—Refrigeration*, Chapter 46, “Food Service and General Commercial Refrigeration Equipment.” Atlanta: ASHRAE.