BSR/ASHRAE Standard 143-2015R

Public Review Draft

Method of Test for Indirect Evaporative Air Coolers

First Public Review (June 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).

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(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

This revision of the 2015 version of this standard includes changes throughout the standard, including changes to meet ASHRAE's mandatory language requirements.

1. PURPOSE

This standard provides laboratory test procedures and calculations for establishing the cooling capacities and power requirements for indirect evaporative air-cooling equipment.

2. SCOPE

2.1 This standard applies to testing indirect evaporative air coolers operating at steady-state conditions that:
(a) sensibly cool a primary airstream through heat exchanger(s) by the evaporation of water into a secondary airstream, and

(b) are packaged systems or are components of packaged systems.

2.2 This standard does not apply to:
(a) devices that use mechanical refrigeration or thermal storage to cool the primary airstream, the secondary airstream, or the water provided for evaporation during the test, or
(b) devices that dry the primary or secondary airstream during the test.

3. TERMINOLOGY AND SYMBOLS

3.1 Definitions

determination: a complete set of measurements for a particular point of operation of an IEC. The measurements shall be used to determine all IEC performance variables as defined in this standard.

fan: a device for moving air that utilizes a power-driven rotating impeller.

fan motor power: the electric input power required to drive the fan and any elements in the drive train that are a part of the fan.

fan speed: the rotative speed of the impeller. If a fan has more than one impeller, fan speeds are the rotative speeds of each impeller.

free delivery: the point of operation where the external static pressure is zero.

indirect evaporative cooling (IEC): wet secondary airstream cooling the dry primary airstream.

IEC air boundaries: indirect evaporative cooling unit inlet and outlet boundaries are defined as the interface between the cooling unit and the remainder of the system and are at a plane perpendicular to the airstream where it enters or leaves the indirect evaporative cooling unit. It is acceptable to include filter media assemblies, inlet boxes, inlet vanes, inlet cones, silencers, screens, rain hoods, dampers, discharge cones, and eaves as part of the cooling unit between the inlet and outlet boundaries.

IEC input power boundary: the interface of the wiring entering electrically powered equipment. Drive or coupling losses are included as part of the electric input power.

IEC total electric input power: the sum of the electric input power in watts supplied to the electrical components of the indirect evaporative air cooler. This includes fan motors, pump motors, and other devices needed to produce the cooling effect. The power to control devices such as thermostats, transformers providing low voltage to control mechanisms, and freeze protection devices need not be included in total electric input power.

indirect evaporative cooler with integrated heat exchanger: an indirect evaporative cooling device with integrated primary (dry) and secondary (wet) air passages in a single sensible and evaporative heat exchanger. (See Figure 3-1.)

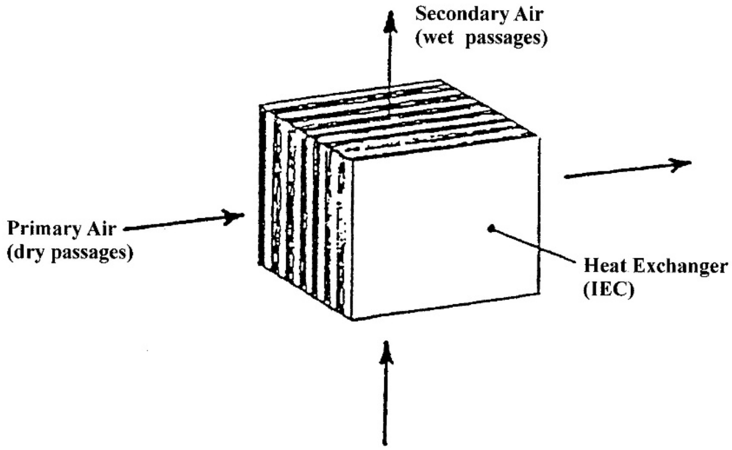


FIGURE 3-1 Integrated air-to-air heat exchanger

indirect evaporative cooler with a nonintegrated heat exchanger: an indirect evaporative cooling device with a separate primary (dry) sensible heat exchanger and a separate secondary (wet) evaporative heat exchanger. The recirculating fluid between these two heat exchangers is used to transfer heat from the primary to the secondary airstream. (See Figure 3-2.)

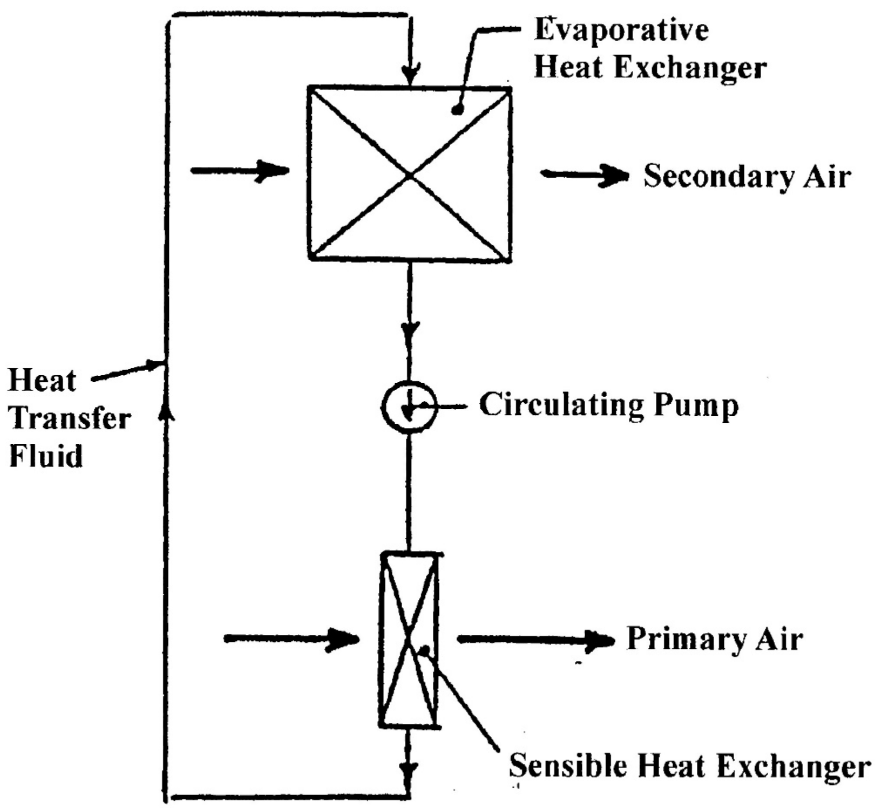


FIGURE 3-2 Nonintegrated sensible and evaporative heat exchanger.

point of operation: the relative position on the cooling unit characteristic curve corresponding to a particular flow rate. A point of operation is controlled during a test by adjusting a throttling device, by changing flow nozzles, by changing the fan characteristic, or by any combination of these.

primary airflow: the airflow that is sensibly cooled by an IEC.

pump: a general term used to describe the secondary irrigation system that may be a sump pump, a rotary device, or another similar device.

secondary air: moist air that is used to cool the primary air. Secondary air is not supplied to the conditioned space.

test: a series of determinations for points of operation.

3.2 SYMBOLS

Symbol	Description	SI Units	IP Units
ε	IEC indirect effectiveness	dimensionless	dimensionless
p_b	Ambient air pressure	Pa	in. of Hg
p_{so}^{p}	Primary air inlet static pressure	Pa	in. of water
p_{s1}^{p}	Primary air inlet static pressure difference	Pa	in. of water
p_{so}^{s}	Primary air inlet static pressure	Pa	in. of water
p_{s1}^{s}	Secondary air inlet static pressure difference	Pa	in. of water
ΔP	Primary air pressure differential across the IEC	Pa	in. of water
ΔP_{std}^{p}	Primary air standard pressure differential across the IEC	Pa	in. of water
t_{do}^{p}	Primary air inlet dry-bulb temperature	ºC	ºF
t_{wo}^{p}	Primary air inlet wet-bulb temperature	ºC	ºF
t_{d2}^{p}	Primary air outlet dry-bulb temperature	ºC	ºF
t_{w2}^{p}	Primary air outlet wet-bulb temperature	ºC	ºF
t_{do}^{s}	Secondar air inlet dry-bulb temperature	ºC	ºF
t_{wo}^{s}	Secondary air inlet wet-bulb temperature	ºC	ºF
t_{d2}^{s}	Secondary air outlet dry-bulb temperature	ºC	ºF
t_{w2}^{s}	Secondary air outlet wet-bulb temperature	ºC	ºF
Q^{p}	Primary volumetric airflow rate	m/s	cfm
Q_{std}^{p}	Primary standard volumetric airflow rate	m/s	scfm
Q^{s}	Secondary volumetric airflow rate	m/s	cfm
Q_{std}^{s}	Secondary standard volumetric airflow rate	m^3/s	scfm
Q_w	Volumetric water flow rate	m^3/s	ft^3/s
q^{p}	Primary cooling capacity	kW	MBtu/h
q_{std}^{p}	Primary standard cooling capacity	kW	MBtu/h
W	Total electric input power	kW	kW

4. CLASSIFICATIONS

For purposes of this standard, an indirect evaporative cooler is defined according to its construction using the categories shown in this section.

4.1 Component Indirect Evaporative Coolers (IEC Modules). This category includes any integrated air-to-air heat exchanger used as an indirect evaporative cooler without air moving devices for the primary and secondary airstreams. More specifically, a component indirect evaporative cooling device consists of an indirect evaporative cooling heat exchanger, a means of delivering and distributing water to the wet passages of the heat exchanger, a basin for collecting water, a recirculating water pump, and the piping that connects the basin and the water distribution system. See Figure 4-1.

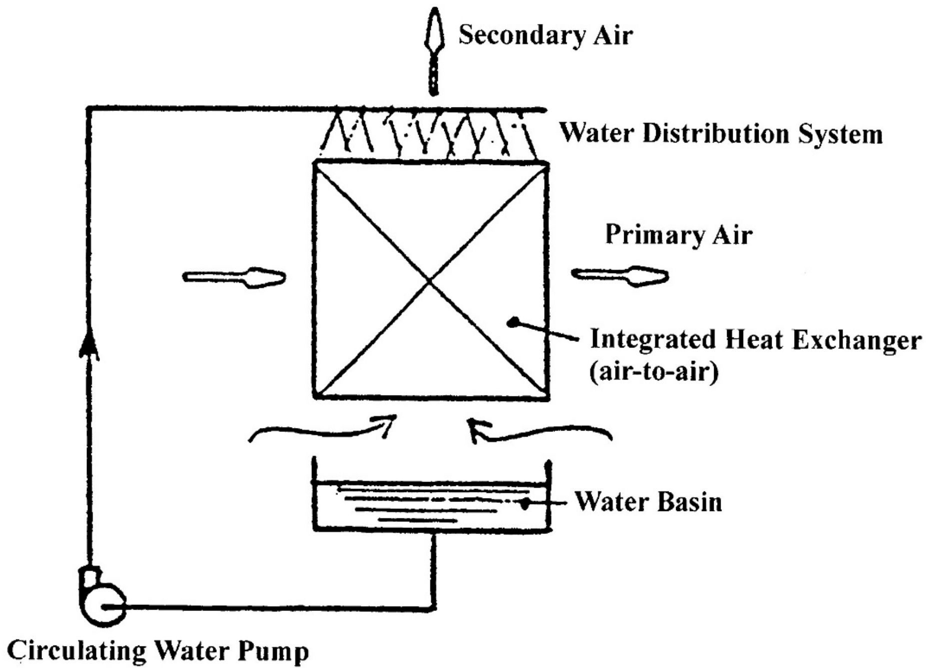


FIGURE 4-1 Component indirect evaporative cooler (IEC module)

4.2 Semi-packaged Secondary Indirect Evaporative Coolers (Semi-packaged Secondary IEC Modules). This category includes any integrated heat exchanger or nonintegrated heat exchanger used as an indirect evaporative cooler with no primary air-moving device. A secondary air-moving device is provided. This category includes cooling towers/finned coils and any evaporative air-to-air precooler equipped with a secondary air-moving device. See Figures 4-2 and 4-3.

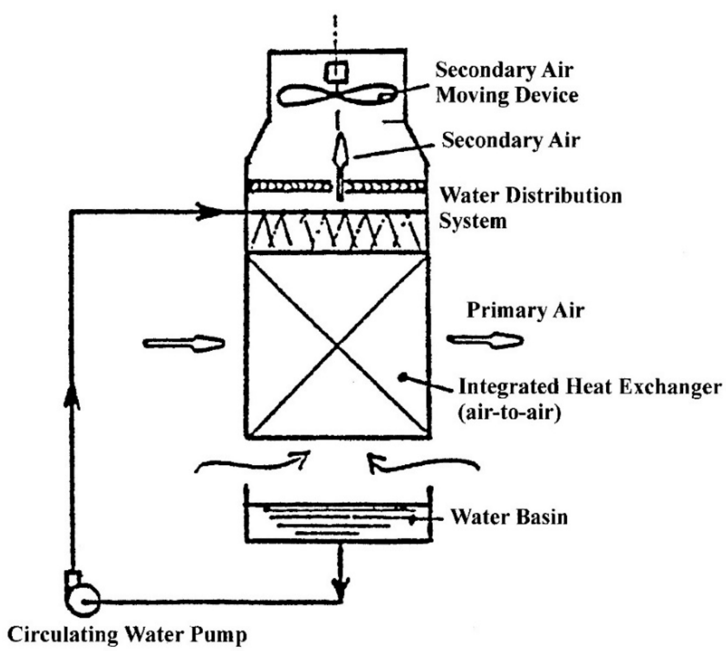


FIGURE 4-2 Semi-packaged secondary indirect evaporative cooler (semi-packaged secondary IEC) with integrated air-to air heat exchanger.

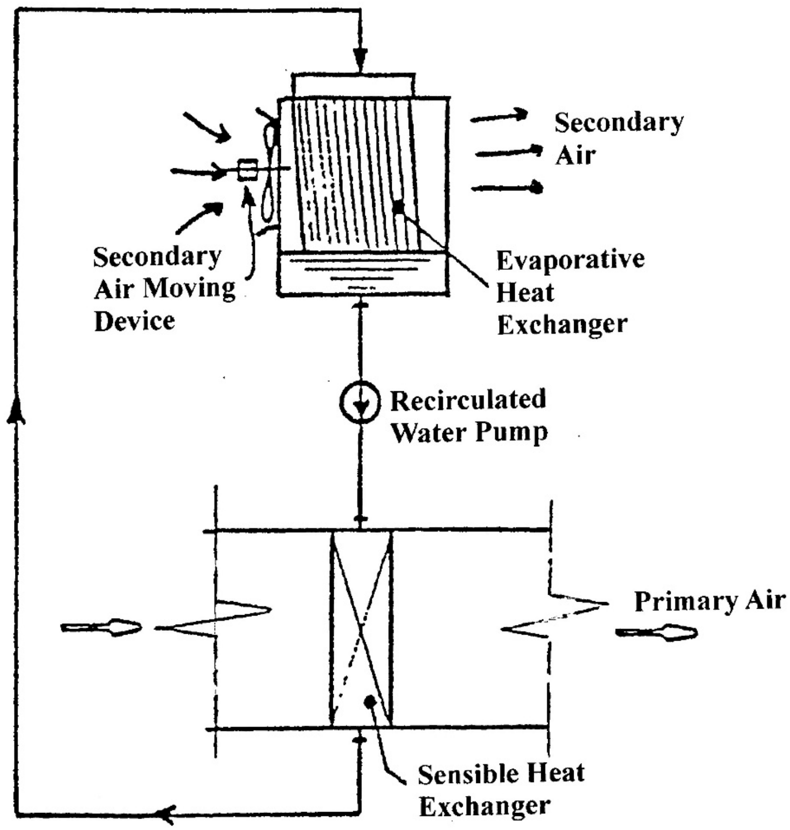


FIGURE 4-3 Semi-packaged secondary indirect evaporative cooler (semi-packaged secondary IEC) with nonintegrated sensible and evaporative heat exchangers

4.3 Semi-packaged Primary Indirect Evaporative Coolers (Semi-packaged Primary IEC Modules). This category includes any integrated heat exchanger used as an indirect evaporative cooler with no secondary air-moving device. A primary air-moving device is provided. See Figure 4-4.

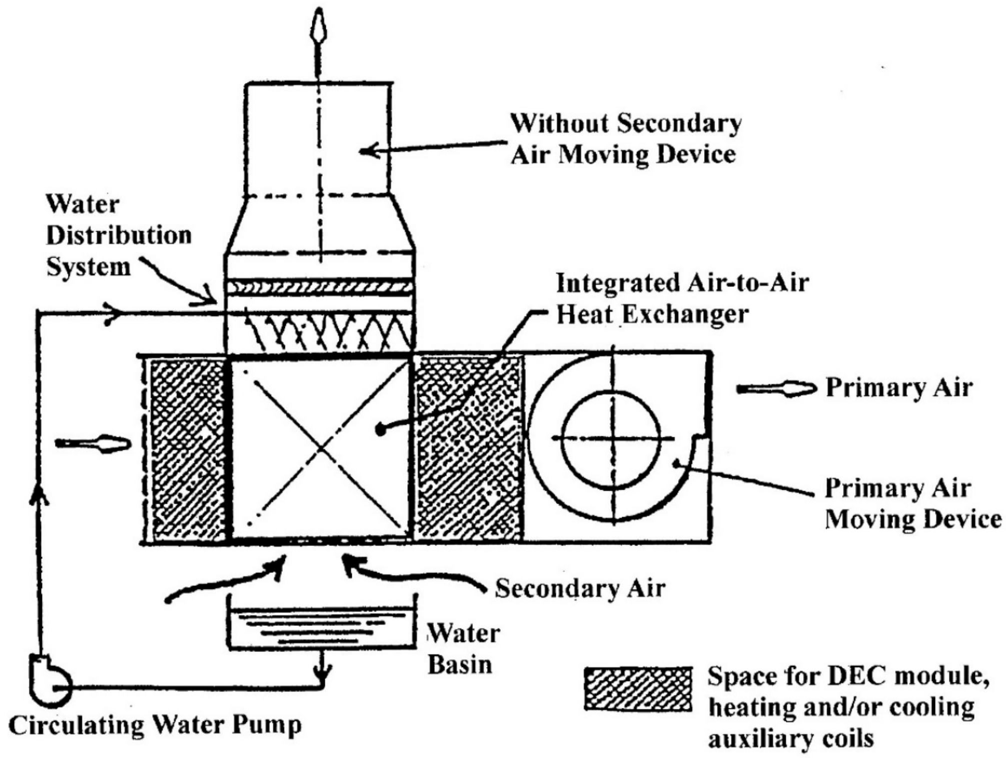


FIGURE 4-4 Semi-packaged primary indirect evaporative cooler (semi-packaged primary IEC)

4.4 Packaged Indirect Evaporative Coolers (Packaged IEC). This category includes integrated or nonintegrated heat exchangers provided with primary and secondary air-moving devices and with all other necessary equipment evaporatively cooled primary airstream. The primary airstream is evaporatively cooled by sensible heat exchange with an evaporatively cooled secondary airstream. See Figure 4-5.

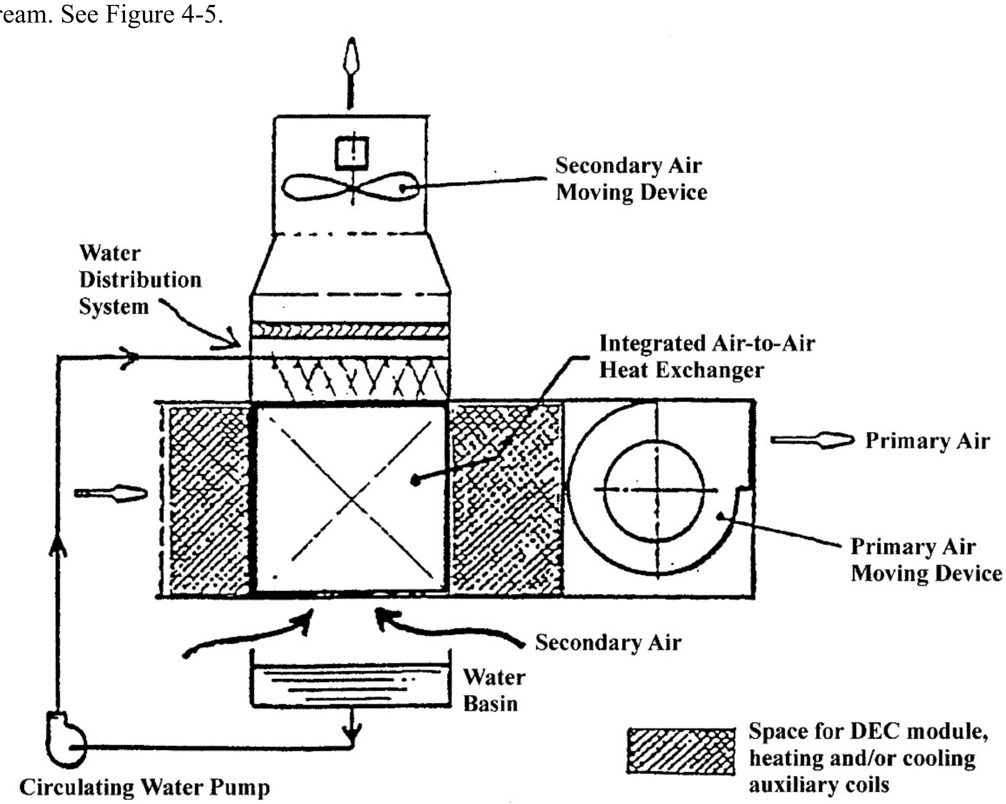


FIGURE 4-5 Packaged indirect evaporative cooler (packaged IEC).

5. REQUIREMENTS

This standard is designed to test airflow and temperatures into and out of indirect evaporative air coolers (IECs) to determine cooling produced and to measure power consumed or pressure drop to produce this cooling.

5.1 Airflow. All units subject to this standard shall have airflow rates simultaneously measured for both primary and secondary airstreams except where the device is classified as a nonintegrated IEC as defined in Section 3 and illustrated in Figure 3-2.

5.2 Temperature Difference. The temperature difference between entering primary dry-bulb temperature and entering secondary wet-bulb temperature shall be greater than 11°C (20°F).

5.3 Determinations. The number of determinations required to establish the performance of an IEC over the range from shutoff to free delivery shall be established depending on the shapes of the various characteristic curves. Plans shall be made to vary the opening of the throttling device to evenly space the test points. For smooth characteristics, at least eight determinations shall be required to define curves that are not smooth. If performance at only one point of operation is required, at least three determinations shall be made to define a short curve that includes that point.

5.4 Test Data Processing. Data point measurements collected during the duration of the testing period shall be processed to calculate sample mean and sample standard deviation.

Equation 5-1 is the number of successive samples:

$$n \geq 30 \tag{5-1}$$

Equation 5-2 is the sample mean:

$$\bar{x} = \frac{1}{n}\sum_{j=1}^{n}(x_j) \tag{5-2}$$

Equation 5-3 3 is the sample standard deviation:

$$\sigma_x = \sqrt{\frac{1}{n-1}\sum_{j=1}^{n}(x_j - \bar{x})^2} \tag{5-3}$$

Equation 5-4 is the sample stability ratio:

$$S_x = \frac{\sigma_x}{\bar{x}} \tag{5-4}$$

Equation 5-5 is the sample stability criteria:

$$S_x \leq 1.0\% \tag{5-5}$$

Recorded test data shall be valid only when all of the stability criteria in Table 5-1 or in Table 5-2 are simultaneously satisfied where the cooling capacity is stated in Equation 5-6 or Equation 5-7.

$$q_{std}^{p} = 1.21 Q_{std}^{p}\left(t_{do}^{p} - t_{d2}^{p}\right) \quad \text{SI} \tag{5-6}$$

$$q_{std}^{p} = 1.08 Q_{std}^{p}\left(t_{do}^{p} - t_{d2}^{p}\right) \quad \text{IP} \tag{5-7}$$

TABLE 5-1: Stability Criteria for Data Recording for Packaged IECs

Measurement or Calculation Result	Values Calculated from Data Samples		Stability Criteria
	Mean	Std. Dev.	
Cooling capacity	$\overline{q^p}$	σ_{q^p}	$S_{q_{std}^p} \leq 0.05$
Total Electric Input Power	$\bar{W}$	σ_W	$S_W \leq 0.05$

TABLE 5-2: Stability Criteria for Data Recording for Component IECs

Measurement or Calculation Result	Values Calculated from Data Samples		Stability Criteria
	Mean	Std. Dev.	
Corrected Static Pressure Ratio	$\overline{\Delta P_{std}^{p}}$	$\sigma_{\Delta P_{std}^{p}}$	$S_{\Delta P_{std}^{p}} \leq 0.05$
IEC Effectiveness:	$\bar{\varepsilon}$	σ_{ε}	$S_{\varepsilon} \leq 0.05$

5.5 Thermodynamic Properties of Air. Dry and moist air properties shall be obtained from or agree with ASHRAE RP-1485[1].

(Informative Note: Software based upon ASHRAE RP-1485 is available. Refer to Informative Appendix A, Section A1 of this standard.)

5.6 Airflow Leakage Requirement: Measured airflow leakage into or out of the test apparatus shall not be greater than 0.25% of the airflow at the leak test pressure that is equal to the maximum operating pressure.

6 INSTRUMENTS AND MEASUREMENT METHODS

6.1 Instrument Calibrations. Measurements from the instruments shall be traceable to primary or secondary standards calibrated by the National Institute of Standards and Technology (NIST) or to the Bureau International des Poids et Mesures (BIPM) if a National Metrology Institute (NMI) other than NIST is used. In either case, the indicated corrections shall be applied to meet the uncertainty stated in subsequent sections. Instruments shall be recalibrated on regular intervals that do not exceed the intervals prescribed by the instrument manufacturer, and calibration records shall be maintained. Instruments shall be installed in accordance with the instrument manufacturer's requirements. If not, the manufacturer's accuracy shall not apply.

6.2 Instrument Accuracy Requirements and Measurement Methods. Measuring instruments shall be selected to meet or exceed the instrument accuracy listed in Table 6-1 for each type of measurement. Instruments and measurement methods shall comply with the ANSI/ASHRAE measurement standards listed in Table 6-1.

TABLE 6-1: Test instrument requirements and measurement methods

Measurement Parameter	Accuracy	Maximum Resolution	ASHRAE Standard
Air dry-bulb temperature	±0.05ºC (±0.1ºF)	±0.05ºC (±0.1ºF)	41.1[2]
Air wet-bulb temperature	±0.05ºC (±0.1ºF)	0.05°C (0.1°F)	41.6[3]
Other temperatures	±0.3ºC (±0.5ºF)	0.1°C (0.2°F)	41.1[2]
Barometric pressure	±34 Pa (±0.01 in. of Mercury)	2 Pa (0.005 in. of Mercury)	41.3[4]
Other pressures	±1.0 percent of reading	±0.5 percent of reading	41.3[4]
Watt meters	±1.0 percent of reading	±0.5 percent of reading	41.11[5]
Fan Speed	±1.0 percent of reading	±0.5 percent of reading	N/A
Time	±0.5% of the elapsed time measured	±0.1% of the elapsed time measured	N/A

6.3 Airflow Measurement. Apply ANSI/ASHRAE Standard 41.2[6] to measure volumetric airflow and standard volumetric airflow using a single- or multiple-nozzle test chamber.

6.4 Static Pressure Measurement in Ducts or Chambers. Static pressure in ducts or chambers shall be measured in accordance with the static pressure tap geometry and the piezometer ring specifications in Section 8 of Standard 41.2[2]

6.5 Air Inlet Temperature Sampling Apparatus. Use an air sampling apparatus and a wet-bulb psychrometer that is constructed as illustrated in Figure 6-1 to obtain the air inlet dry-bulb and wet-bulb temperature. The sample tree shall sample at least nine equal areas.

6.5.1 If the wet-bulb psychrometer is designed in accordance with Section 7.1 of ANSI/ASHRAE Standard 41.6[3], the wet-bulb temperatures shall be read only when the air velocity is 3.5±0.18 m/s (690±50 ft/min) over the wet-bulb sensor, and only when evaporative equilibrium of the sensor has been attained.

6.5.2 If the wet-bulb psychrometer is not designed in accordance with Section 7.1 of ANSI/ASHRAE Standard 41.6[3], the wet-bulb temperatures shall be read only when the air velocity is 3.56 to 10 m/s (700 to 2000 ft/min) over the wet-bulb sensor, and only when evaporative equilibrium of the sensor has been attained.

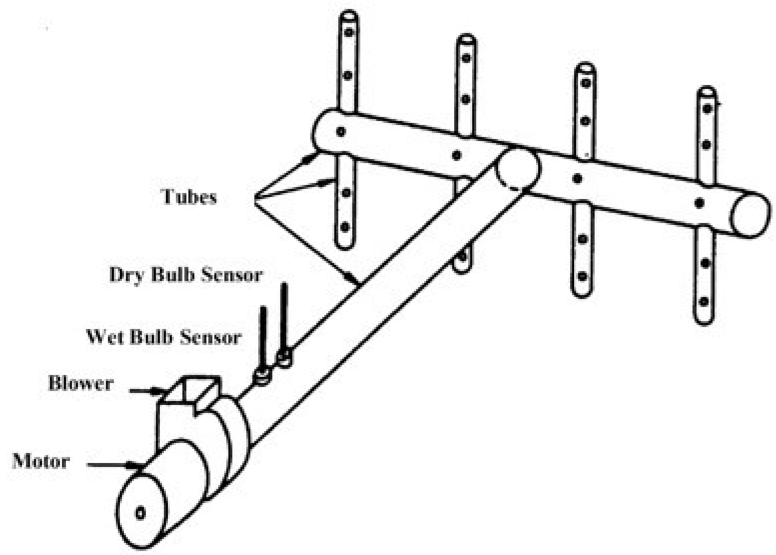
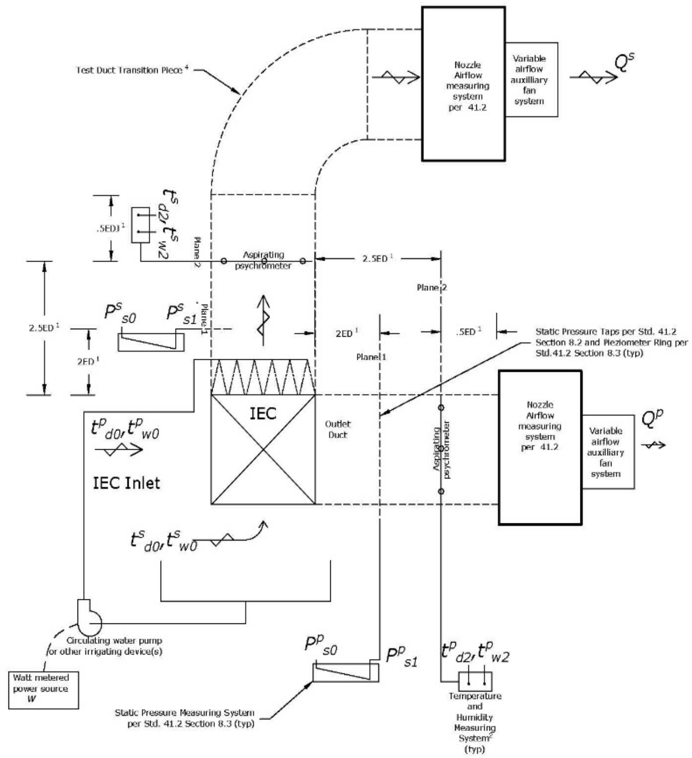


FIGURE 6-1 Example of an airflow sampling tree assembly that includes a wet-bulb psychrometer

7 TEST SETUP

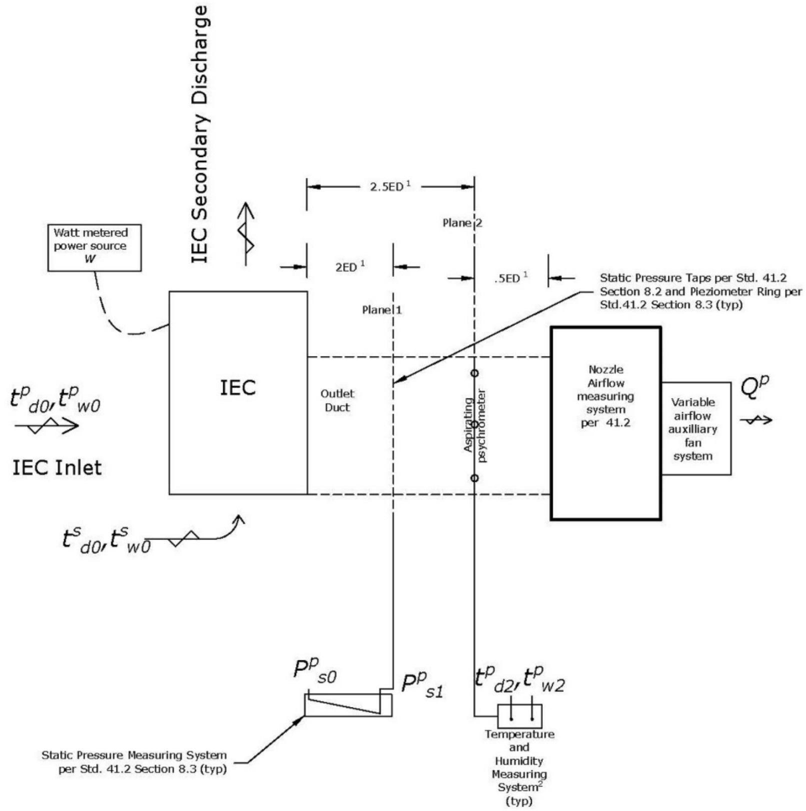
7.1 Indirect Evaporative Coolers (IEC Module) Test Setup. Figure 7-1 is a schematic of the test setup for an indirect evaporative cooler (IEC) module.



1. ED shall be equal to the geometrically equivalent diameter of the IEC outlet port defined in ANSI/ASHRAE Standard 41.2[6] Section 9.3.3.1.
2. Aspirating airflow discharge shall flow back into the airstream upstream of the nozzle plane in the airflow measuring system. If not completely contained within the outlet duct, the entrance and exit duct penetrations shall be airtight.
3. Test air duct transition pieces are permitted per ANSI/ASHRAE Standard 41.2[6] Section 8.5.

FIGURE 7-1 Indirect Evaporative Coolers (IEC Module) Test Setup and Equipment Schematic

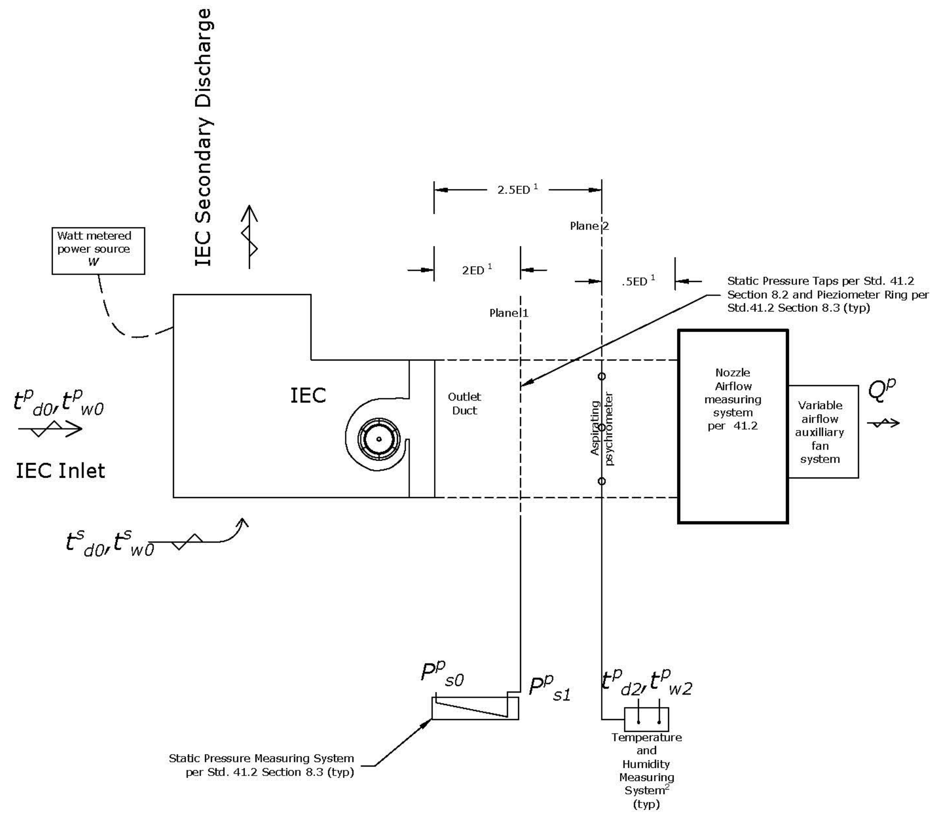
7.2 Semi-packaged Secondary Indirect Evaporative Coolers (Semi-packaged Secondary IEC Modules) Test Setup and Equipment. Figure 7-2 is a schematic of the test setup for a semi-packaged secondary indirect evaporative cooler (IEC) module.



1. ED shall be equal to the geometrically equivalent diameter of the IEC outlet port defined in ANSI/ASHRAE Standard 41.2 Section 9.3.3.1.
2. Aspirating airflow discharge shall flow back into the airstream, upstream of the nozzle plane in the airflow measuring system. If not completely contained within the outlet duct, the entrance and exit duct penetrations shall be airtight.
3. Test air duct transition pieces are permitted per ANSI/ASHRAE Standard 41.2 Section 8.5.

FIGURE 7-2 Semi-packaged Secondary Indirect Evaporative Coolers (Semi-packaged Secondary IEC Modules) Test Setup and Equipment

7.3 Semi-packaged Primary Indirect Evaporative Coolers (Semi-packaged Primary IEC Modules) Test Setup and Equipment. Figure 7-3 is a schematic of the test setup for a semi-packaged primary indirect evaporative cooler (IEC) module.



1. ED shall be equal to the geometrically equivalent diameter of the IEC outlet port defined in ANSI/ASHRAE Standard 41.2[6] Section 9.3.3.1.
2. Aspirating airflow discharge shall flow back into the airstream upstream of the nozzle plane in the airflow measuring system. If not completely contained within the outlet duct, the entrance and exit duct penetrations shall be airtight.
3. Test air duct transition pieces are permitted per ANSI/ASHRAE Standard 41.2[6] Section 8.5.

FIGURE 7-3 Semi-packaged Indirect Evaporative Coolers (Packaged IEC) Test Setup and Equipment

8. TEST DATA TO BE RECORDED

8.1 Test IEC. The description of the test indirect evaporative air cooler shall be recorded. The nameplate data shall be copied. Dimensions shall be checked against a drawing and a copy of the drawing attached to the data.

8.2 Test Setup. The description of the test setup, including specific dimensions, shall be recorded. The instruments and apparatus used in the test shall be listed. Names, model numbers, serial numbers, scale ranges, and proof of calibration shall be recorded.

8.3 Test Data. Where applicable, test data for each determination shall be recorded at each point of operation that satisfies the stability criteria. Readings shall be made simultaneously.

a. Ambient barometric pressure p_b, Pa (in. of Hg)
b. Primary air inlet dry-bulb temperature t_{do}^{p}, ºC (ºF)
c. Primary inlet wet-bulb temperature t_{wo}^{p}, ºC (ºF)
d. Primary air outlet dry-bulb temperature t_{d2}^{p}, ºC (ºF)
e. Primary air outlet wet-bulb temperature t_{w2}^{p}, ºC (ºF)
f. Secondary air inlet dry-bulb temperature t_{do}^{s}, ºC (ºF)

g. Secondary air inlet wet-bulb temperature t^s_{wo} , ºC (ºF)
h. Secondary air outlet dry-bulb temperature t^s_{d4}, ºC (ºF)
i. Secondary air outlet wet-bulb temperature t^s_{w4}, ºC (ºF)
j. Average fan speed for each fan *N*, rad/s (rpm)
k. The electric input power W, W (W)
l. Primary air inlet static pressure p^p_{so}, Pa (in. of water)
m. Secondary air inlet static pressure p^s_{so}, Pa (in. of water)
n. All information required by ANSI/ASHRAE Standard 41.2[6] to calculate the primary volumetric airflow rate Q^p, m^3/s (cfm), the secondary volumetric airflow rate Q^s, m^3/s (cfm), the primary standard volumetric airflow rate Q^p_{std}, m^3/s (scfm), and the secondary standard volumetric airflow rate Q^s_{std}, m^3/s (scfm)
o. If a component IEC is not supplied with a circulating pump, record water volumetric flow rate to the IEC Q_w, m^3/s (ft^3/s)
p. The names of test personnel shall be listed

9. CALCULATIONS

9.1 IEC Standard Airflow Rate. Apply ANSI/ASHRAE Standard 41.2[6] to calculate the primary and secondary standard volumetric airflow rates: Q^p_{std}, m^3/s (scfm) and Q^s_{std}, m^3/s (scfm)

9.2 IEC Indirect Effectiveness.
Apply Equation 9-2 to determine the IEC indirect effectiveness at each test point of operation that satisfies the stability criteria.

$$\varepsilon = \left(\frac{(t^p_{do} - t^p_{d2})}{(t^p_{do} - t^s_{wo})}\right) \times 100\%, \text{ dimensionless} \qquad \text{SI/IP} \qquad (9\text{-}1)$$

9.3 IEC Standard Sensible Cooling Capacity

$$Q^p_{std} = 1.21 Q^p_{std}\left(t^p_{do} - t^p_{d2}\right) \qquad \text{SI} \qquad (9\text{-}2)$$

$$Q^p_{std} = 1.08 Q^p_{std}\left(t^p_{do} - t^p_{d2}\right) \qquad \text{IP} \qquad (9\text{-}3)$$

9.4 IEC Coefficient of Performance (COP) and Energy Efficiency Ratio (EER)

$$COP = \frac{q^p}{W} \text{ , dimensionless} \qquad \text{SI} \qquad (9\text{-}4)$$

$$EER = \frac{q^p}{W} \text{ , Btu/(W-h)} \qquad \text{IP} \qquad (9\text{-}5)$$

10 TEST REPORT

The report of a laboratory indirect evaporative air cooler (IEC) test shall include test data and descriptions of the IEC, including the inlet and outlet boundaries, appurtenances, test setup, and test instruments. The laboratory shall be identified by name and location.

10.1 Performance data shall be provided in a spreadsheet. If the IEC is not supplied with a pump or rotary device, a description of the method of supplying the water and the flow rate of water delivered to the IEC shall be included.

10.2 Performance Curves. The following IEC test results shall be presented as performance curves:

- IEC standard volumetric airflow rate Q^p_{std}, SI or IP
- IEC standard static pressure differential, ΔP^p_{std}, SI or IP
- IEC indirect effectiveness, $\boldsymbol{\varepsilon}$, dimensionless
- IEC standard sensible cooling capacity, q^p_{std}, SI or IP
- IEC overall performance, COP dimensionless. (EER, Btu/(W-h))

10.2.1 Test Points. The results for each determination shall be shown on the performance curve as a series of circled points, one performance curve for each variable plotted as the ordinate.

10.2.2 Curve-Fitting. Curves for each performance variable shall use the test points for reference. The equations for each of those curves shall have an R^2 value greater than 0.95.

.

10.2.3 Coordinates for IEC Performance Curves. Performance curves shall be drawn with IEC standard airflow rate as abscissa. If all results were recorded at or converted to a nominal speed, that speed shall be listed; otherwise, an additional curve with fan speed as ordinate shall be drawn.

11. REFERENCES

1. Herrmann, S., Kretzschmara, H. J., and D.P. Gatley. 2011. *Thermodynamic Properties of Real Moist Air, Dry Air, Steam, Water, and Ice*. ASHRAE Research Project RP-1485, ASHRAE, Atlanta, GA.
2. ASHRAE. 2024. ANSI/ASHRAE Standard 41.1, Standard Methods for Temperature Measurement. Peachtree Corners, GA: ASHRAE.
3. ASHRAE. 2022. ANSI/ASHRAE Standard 41.6, Standard Methods for Humidity Measurement. Peachtree Corners, GA: ASHRAE.
4. ASHRAE. 2022. ANSI/ASHRAE Standard 41.3, Standard Methods for Pressure Measurement. Peachtree Corners, GA: ASHRAE.
5. ASHRAE. 2023. ANSI/ASHRAE Standard 41.11, Standard Methods for Power Measurement. Peachtree Corners, GA: ASHRAE.
6. ASHRAE. 2022. ANSI/ASHRAE Standard 41.2, Standard Methods for Air Velocity and Airflow Measurement. Peachtree Corners, GA: ASHRAE.

(This appendix 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 APPENDIX A BIBLIOGRAPHY

A1 ASHRAE LibHuAirProp software, Peachtree Corners, GA: ASHRAE.