BSR/ASHRAE Standard 146-2011R

Public Review Draft

Method of Test for Rating Pool Heaters

Second Public Review (October 2019)

This second draft shows the changes to the first public review draft that have been recommended for public review by the responsible project committee. Only those changes are subject to this public review. To submit a comment on these changes to the proposed revised 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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FOREWORD

This is a revision of Standard 146-2011. This standard was prepared under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (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 standards throughout the industry.

The changes made for the 2019 revision are as follows:

The standard has been reformatted as a method of test. The specific test conditions to determine a rating are set by the users of the standard.
The scope has been expanded to include heat pump pool heaters that use earth, water, or brine as the heat source and hydrid pool heaters equipped with both a fossil-fueled burner and a heat pump. The test method has been revised accordingly to address the products included by the expanded scope.
Definitions and references have been updated.
The specification for use of the optional recirculating loop has been modified to make clear that it applies only when required by the manufacturer.
Test methods have been added to measure the standby and off mode energy consumption.
Two obsolete informative appendices have been deleted and a new Informative Appendix B is added describing the test conditions used by the U.S. Department of Energy to rate pool heaters.

1. PURPOSE

The purpose of this standard is to provide methods of testing for rating pool heaters.

2. SCOPE

2.1 This standard provides methods of testing for heating capacity and energy efficiency.

2.2 This standard applies to forced circulation heaters operated by gas, oil, and/or electricity, including heat pumps using ambient air, earth, water, or a brine solution, as a heat source and hybrid heaters.

3. DEFINITIONS

active mode: the condition during the pool heating season in which the pool heater is connected to the power source, and the main burner, electric resistance element, or heat pump is activated to heat pool water**.**

apparatus: as used in this standard, test room facilities and instrumentation.

coefficient of performance (COP): as applied to a heat pump pool heater, the ratio of heat output in kilowatts (Btu/h) to the total power input in kilowatts (Btu/h).

coil, outdoor: the heat exchanger that absorbs heat from the outdoor air.

electric resistance pool heater: an appliance designed for heating nonpotable water and employing electric resistance heating elements.

equipment: as used in this standard, the equipment to be tested.

fossil fuel-fired pool heater*:* an appliance designed for heating nonpotable water and employing natural gas, propane, or oil burners.

heat output: the rate at which heat is passed to the water in kilowatts (Btu/h) under specified conditions of operation.

heat pump pool heater: a device using a vapor compression or sorption refrigeration system to transfer heat from a low temperature source to a higher temperature sink for the purpose of heating nonpotable water.

- ***air source heat pump pool heater (ASHP):*** a heat pump that utilizes outdoor air as the heat source.
- ***direct geoexchange heat pump pool heater (DGHP):*** a heat pump that utilizes the earth as the heat source.
- ***water source heat pump pool heater (WSHP):*** a heat pump that utilizes water or a brine solution as the heat source.

heating capacity: the rate at which heat is passed to the water in kilowatts (Btu/h) when the pool heater is operating at rated input and standard rating conditions.

hybrid pool heater: an appliance designed for heating nonpotable water and employing both a heat pump and a fossil fueled burner as heating sources.

off mode*:* the condition during the pool non-heating season in which the pool heater is connected to the power source, and neither the main burner, nor the electric resistance elements, nor the heat pump is activated, and the seasonal off switch, if present, is in the ‘‘off’’ position.

pool heater: equipment designed for heating nonpotable water contained at atmospheric pressure in swimming pools, spas, hot tubs, and similar applications.

rated input: the energy-using capacity of a pool heater as specified by the manufacturer and as specified in Section 8 of this standard.

seasonal off switch*:* a switch that results in different energy consumption in off mode as compared to standby mode.

standard conditions: the conditions of temperature and pressure at which the higher heating value of gas is reported, namely, 15.556°C (60°F) and 101.325 kPa (29.921 in. of mercury).

standard rating conditions: the temperature, pressure, and water-flow-rate conditions (specified in Section 8) at which the pool heater input and efficiency are reported.

standby mode*:* the condition during the pool heating season in which the pool heater is connected to the power source, and neither the main burner, nor the electric resistance elements, nor the heat pump is activated and the seasonal off switch, if present, is in the ‘‘on’’ position.

thermal efficiency: the ratio of heat output in kilowatts (Btu/h) to total power input in kilowatts (Btu/h) when a gas-fired, oil-fired, or electrical pool heater is operated at specific conditions.

total power input: the total rate of energy input to the equipment in kilowatts (Btu/h).

4. CLASSIFICATIONS

Pool heaters are classified by energy source and include

a. gas-fired pool heaters;
b. oil-fired pool heaters;
c. air-to-water heat pump pool heaters employing a water-cooled condenser, and outdoor air coil in a single-package assembly;
d. water-to-water heat pump pool heaters employing a water-cooled condenser, and water-to-refrigerant heat exchanger in a single-package assembly;
e. direct geoexchange heat pump pool heaters employing a water-cooled condenser and earth loop heat exchanger in a single-package assembly;
f. electric resistance pool heaters;
g. hybrid pool heaters.

5. REQUIREMENTS

The pool heaters for which compliance with this standard is claimed shall be tested and calculations made to verify capacity and efficiency using the following procedures as appropriate:

a. a steady-state heating capacity test for a pool heater at standard rating conditions;
b. a steady-state efficiency test for a gas, oil, and electric resistance pool heater or coefficient of performance (COP) for a heat pump pool heater;
c. a standby energy consumption test for all pool heaters.

6. INSTRUMENTS

6.1 General. Instruments are required for the following measurements with the minimum precision noted. Instruments shall be calibrated at a minimum of once a year. A record shall be kept containing, as a minimum, the date of calibration, the method of calibration, and the reference standard used.

6.2 Temperature. Temperature-measuring devices and any associated instrumentation systems shall be in accordance with ANSI/ASHRAE Standard 41.1, *Standard Method for Temperature Measurement*.[1] Temperature measuring devices for measuring ambient air and water temperature shall have an accuracy of ±0.1° C (±0.2° F) or less with the exception of heat pump pool heaters, for which the water temperature accuracy shall be ±0.03°C (±0.05°F). Refrigerant temperature measuring devices shall have an accuracy of ±0.1°C (±0.2°F).

6.3 Pressure. Pressure-measuring instruments shall have errors no greater than the following:

a. Gas: ±25 Pa (±0.1 in. of water).
b. Oil: ±3.4 kPa (±0.5 psi).
c. Atmospheric: ±33.8 Pa (±0.01 in. Hg).
d. Water: ± 6.9 kPa (±1.0 psi).
e. Refrigerant: ±0.5% of measured value.

6.4 Draft. Draft gauges shall have an accuracy of ±1.2 Pa (±0.005 in. of water). Minimum divisions on the draft gauge shall be 1.2 Pa (0.005 in. of water).

6.5 Mass. Measuring instruments shall have an accuracy sufficient to ensure an error no greater than 0.5% of the total mass measured.

6.6 Time. Timing instruments shall have an error no greater than ±0.5 s/h.

6.7 Electrical Instruments

6.7.1 Electrical Measurements. Electrical measurements shall be made with indicating or integrating instruments.

6.7.2 Instruments. Instruments used for measuring the electrical input to heaters or other apparatus furnishing heat loads shall be accurate to ±0.5% of the quantity measured at full load input. Instruments used for measuring the electrical input to fan motors, compressor motors, or other equipment accessories shall be accurate to ±1% of the measured value for heat pump pool heaters and for other tested equipment shall be accurate to ±2.0% of the measured value. Instruments for measuring the standby and off mode electric power consumption shall meet the accuracy requirements of IEC 62301.

6.7.3 Voltages. Voltages shall be measured with instruments that are accurate to ±1% of the quantity measured and shall be measured at the equipment terminals.

6.8 Higher Heating Value. Devices used to measure the higher heating value of either natural gas, propane, or fuel oil shall have an error no greater than ±1.0%.

6.9 Water Flow. Water flow rate and quantity shall be measured by either a flowmeter or a tank and scale. Conversion to mass of water, where required, shall be based upon the specific volume listed in the *ASHRAE Handbook— Fundamentals*, Chapter 6, Table 3,[2] for the temperature of the water metered. Water flowmeters shall have an error no greater than 0.5% of measured value.

6.10 Combustion Products. Instruments used to measure the concentration of carbon dioxide shall have an error no greater than ±2.5% of the reading.

6.11 Smoke. Smoke-measuring instruments shall comply with requirements for smoke meters as outlined in ASTM D2156, *Test Method for Smoke Density in the Flue Gases from Burning Distillate Fuels*.[3]

6.12 Relative Humidity. Relative humidity shall be measured with an accuracy of ±1.5% RH, and such measurements shall be made in accordance with the Standard Methods for Humidity Measurement, ASHRAE 41.6-2014.

7. APPARATUS

7.1 Test Platform. The equipment to be tested shall be installed in the test room in accordance with the manufacturer's installation instructions using recommended installation procedures and accessories. In all cases, the manufacturer's recommendations with respect to distances from adjacent walls shall be followed. For a pool heater not approved for installation on combustible flooring, suitable noncombustible material shall be placed under it.

7.2 Water Piping. Water piping shall be installed consistent with the plumbing illustrated in Figure 1a or Figure 1b, as appropriate. Any piping components or insulation supplied with the pool heater shall be included. Install a pressure gauge and temperature sensors as illustrated in Figures 1a and 1b and specified in Section 7.3.

The test piping shall have the smallest diameter recommended in the manufacturer's installation instructions. If a minimum diameter is not specified, the nominal diameter of the test piping shall be the same as that of the corresponding piping connection on the pool heater or the components, whichever is smaller.

Piping connections to the pool heater shall be insulated as specified in the manufacturer's installation instructions. If not specified, pool heater connections, test piping, and test fittings as illustrated in Figures 1a and 1b shall be insulated with material having a thermal resistance R value not less than 0.7 $m^2 \cdot K/W$ (4 $h \cdot ft^2 \cdot {}^\circ F/Btu$). Piping insulation shall be consistent with Figure 1a or 1b, as appropriate. Insulation joints shall be taped or sealed.

When required by the manufacturer, an optional recirculating loop of minimum length and a pump shall be provided as shown in Figure 1b. If the optional recirculation loop is used in the test, it shall be insulated with insulation having an R-value of at least 0.7 $m^2 \cdot K/W$ (4 $h \cdot ft^2 \cdot °F/Btu$). The recirculation pump electricity consumption shall be measured.

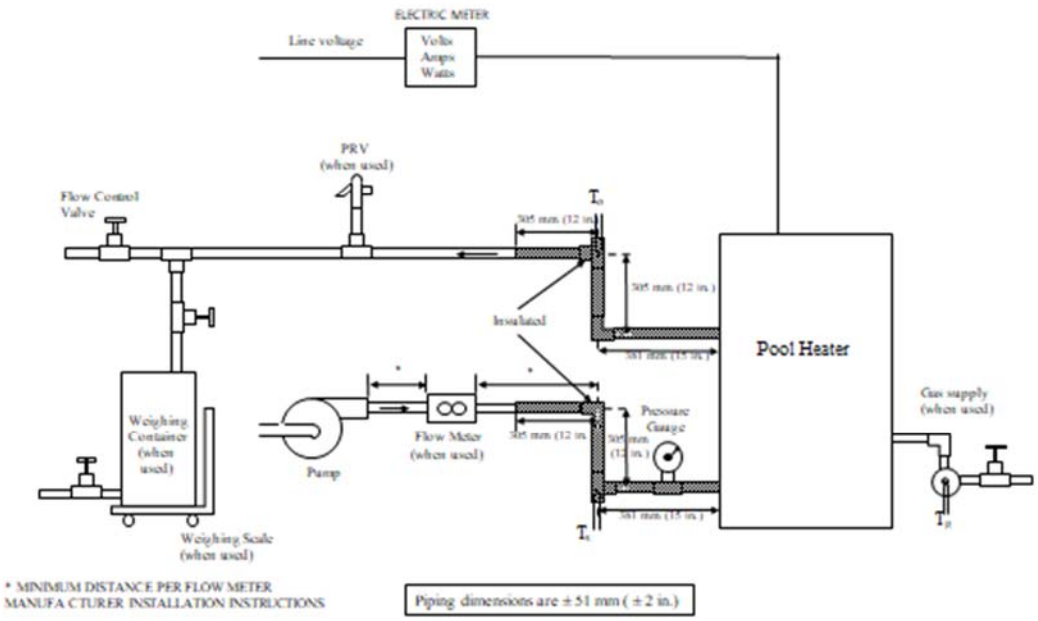

Figure 1a Plumbing layout and location of water temperature measurements for pool heaters not requiring a recirculation loop.

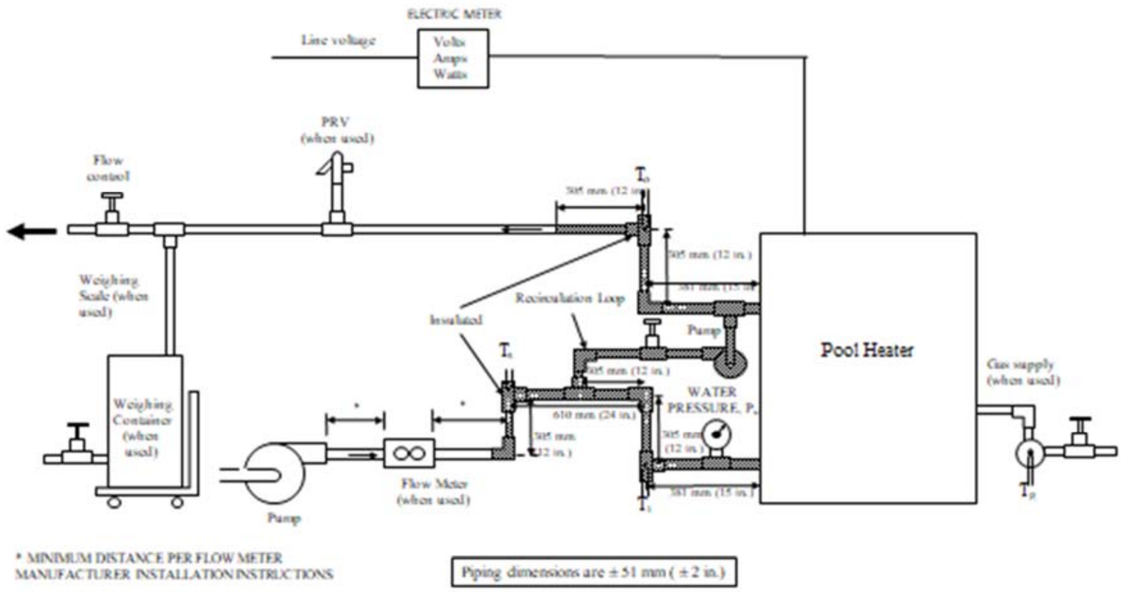

Figure 1b Plumbing layout and location of water temperature measurements for pool heaters requiring a recirculation loop.

7.3 Temperature-Measuring Device Locations

7.3.1 Water Pipe. Install temperature-measuring sensors as illustrated in Figures 1a or 1b, as appropriate. The junction of the temperature-measuring sensor shall not extend more than 0.15 m (6 in.) into the pipe from the appropriate outlet of the tee.

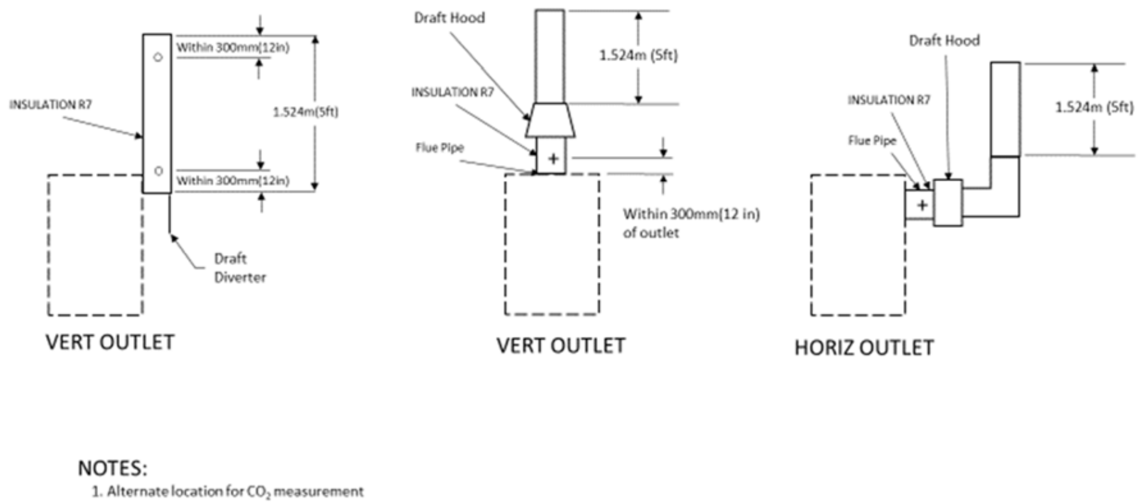

Figure 2: Flue configuration (gas pool heaters).

7.3.2 Test Room

7.3.2.1 For Fossil Fuel, Water Source Heat Pump, Direct Geoexchange Heat Pump, Hybrid, and Electric Resistance Pool Heaters. Install a temperature-measuring device in the test room with its junction shielded against radiation from the pool heater and position it at the vertical midpoint of the heater at a perpendicular distance of 0.60 m ± 0.025 m (24 in. ± 1 in.) from the surface of the pool heater jacket. For heat pump pool heaters, the temperature sensing device shall be shielded against direct fan discharge from the unit.

7.3.2.2 For Air Source Heat Pump Pool Heaters. An outdoor test room or space similar to Figure 3 is required for testing heat pump pool heaters. This test room shall be of sufficient volume and shall circulate air in a manner such that it does not change the normal air circulating pattern of the equipment under test. It shall be of dimensions such that the distance from any room surface to any equipment surface from which air is discharged is not less than 1.8 m (6 ft), and the distance from any other room surface to any other equipment surface is not less than 0.9 m (3 ft), with the exception of the floor. To facilitate more uniform air temperature surrounding the unit, it may be raised off the floor. The room-conditioning apparatus shall handle air at a rate that is greater than the airflow rate of the equipment under test. The room-conditioning apparatus shall take the air from the direction of the air discharge and return it as illustrated in Figure 3.

7.3.2.2.1 Outdoor Air Inlet Temperatures And Humidity. Outdoor air inlet temperatures shall be measured at locations such that the following conditions are fulfilled:

a. The measured temperatures shall be representative of the temperature surrounding the outdoor section and simulate the conditions encountered in an actual application.

b. At the point of measurement, the temperature of air must not be affected by the air discharged from the outdoor section. This makes it mandatory that the temperatures be measured upstream of any recirculation produced. It is intended that the specified test temperatures surrounding the outdoor section under test shall simulate as nearly as possible a normal installation operating at ambient air conditions identical with the specified test temperatures.
c. Install a temperature and humidity measuring equipment in the test room positioned at the vertical midpoint of the heat pump air inlet and at a perpendicular distance of 0.60 m ± 0.025 m (24 in. ± 1 in.) from the surface of the pool heater cabinet.

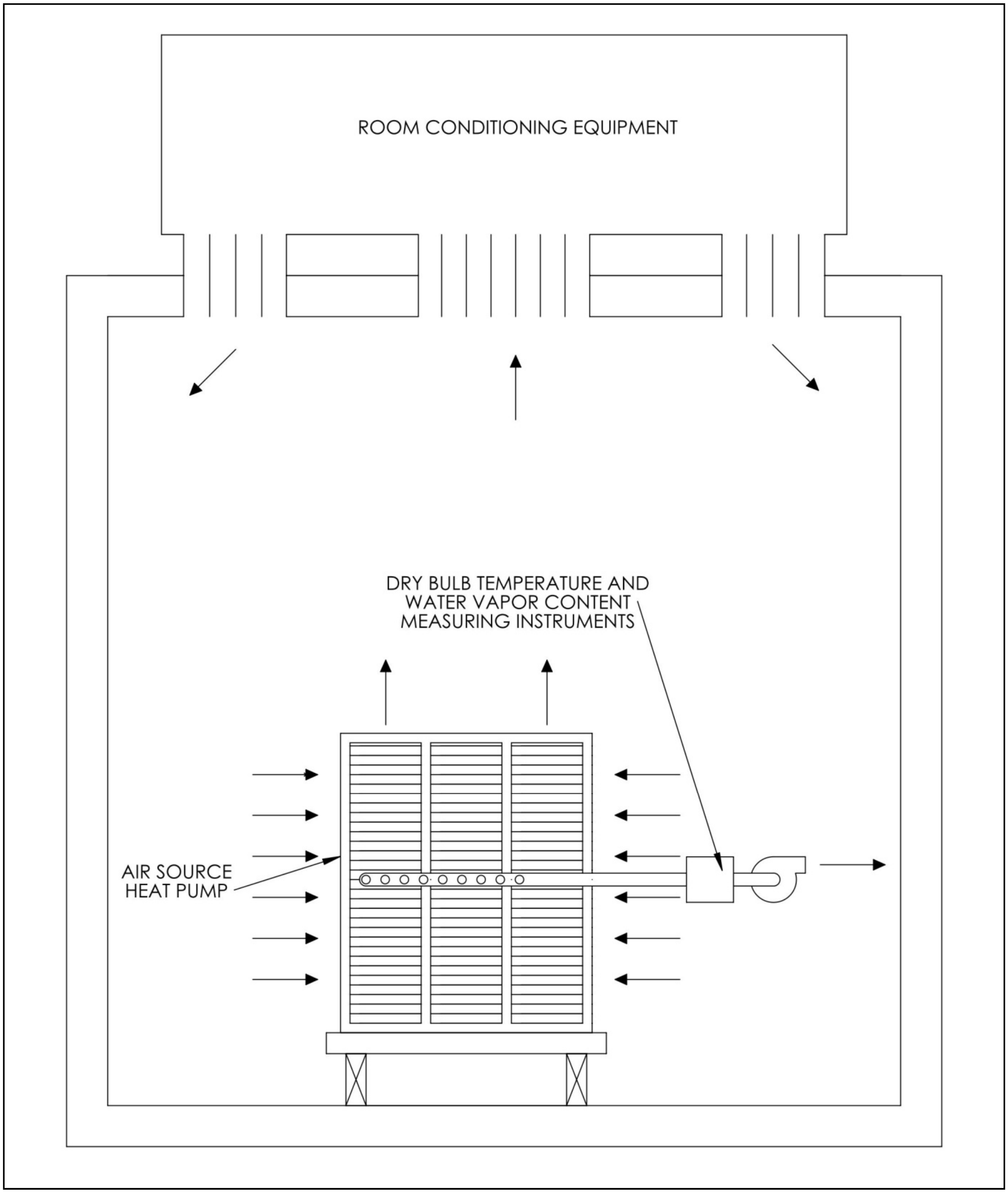

Figure 3 Air Source Heat Pump Temperature Measurement and Air flow Configuration.

7.4 Flue Requirements

7.4.1 Gas-Fired Pool Heaters. For indoor units, a vertical 1.5 m (5 ft) length of flue pipe shall be connected to the flue gas outlet. If the outlet discharges horizontally, a suitable 90° elbow shall be installed first. For outdoor units, no modifications to the integral vent shall be made (and no vent pipe is needed). The flue gas sample shall be taken at the location shown in Figure 2 for indoor units and at the flue outlet for outdoor units.

Pool heaters designed for other than natural draft venting, or for a specific venting system, shall be installed with the venting arrangement specified in the manufacturer's instructions using the minimum lengths of vertical and horizontal vent pipe recommended by the manufacturer.

7.4.2 Oil-Fired Pool Heaters. On indoor units, a vertical 1.5 m (5 ft) length of vent pipe shall be connected to the flue gas outlet to establish the minimum draft at the flue collar as specified in the manufacturer's installation instructions. If the manufacturer's specified minimum draft is not attained, additional stack height or a mechanical draft inducer shall be used to establish the specified minimum draft. If the outlet discharges horizontally, a suitable 90° elbow shall be installed first. For outdoor units, no modification to the integral vent shall be made (and no vent is needed). The flue gas sample shall be taken at the location shown in Figure 4 for indoor units and at the flue outlet for outdoor units. Pool heaters designed for other than natural draft venting, or for a specific venting system, shall be installed with the venting arrangement specified in the manufacturer's instructions using the minimum lengths of vertical and horizontal vent pipe recommended by the manufacturer.

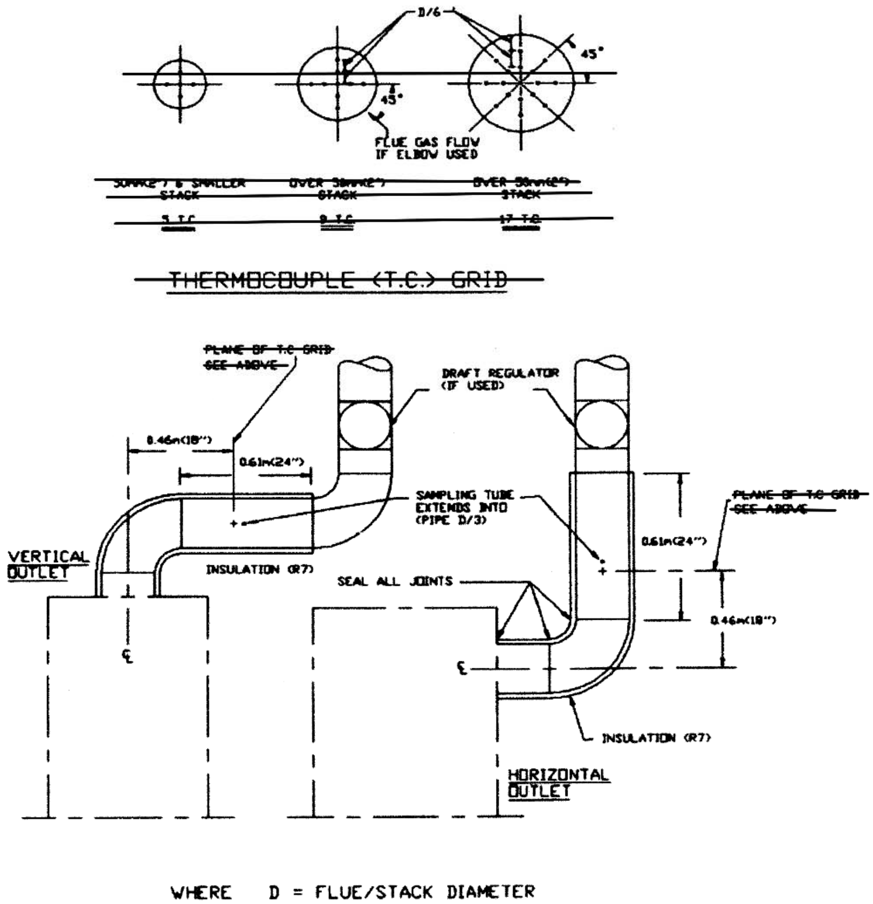

Figure 4 Flue configuration (oil pool heaters).

7.4.3 Insulation Requirements. Insulation with an R-value of no less than 1.2 $m^2 \cdot K/W$ ($7°F \cdot ft^2 \cdot h/Btu$) shall be provided on the flue pipe and elbow (if installed) up to the plane where flue gas temperature is measured. For oil-fired heaters, there shall be no opening between the heater and point where the flue gas sample (for CO_2) is taken.

7.5 Fuel or Energy Consumption Measurement. Install one or more instruments that measure, as appropriate, the quantity and rate of electrical energy, natural gas, LP gas, and fuel oil consumed by the pool heater.

7.6 Water Supply. The water supply shall be capable of delivering water at the conditions specified in Section 8.3.

8. METHODS OF TESTING

8.1 General. The pool heater shall be installed and operated in accordance with the manufacturer's instructions unless specifically required otherwise by the test method. The pool heater shall be equipped with the apparatus described in Section 7, and the instrumentation described in Section 6 shall be set up for obtaining and recording data, as necessary.

Hybrid pool heaters shall be tested with only the heat pump operating as the heating source according to the procedures applicable to the type of heat pump and also tested with only the fossil-fuel burner incorporated in the hybrid pool heater operating as the heating source according to the procedures applicable to the type of burner.

8.2 Energy Supply

8.2.1 Electrical Supply. Throughout the entire operating portion of each test, maintain the electrical supply voltage to within ±2% of appropriate standard voltage. Standard voltage shall be the highest nominal voltage specified on the nameplate of the pool heater .

8.2.2 Gas Supply. Maintain the appropriate gas supply at a pressure within the limits specified by the manufacturer on the nameplate of the pool heater. Record the higher heating value, H, in kJ/m^3 (Btu/ft^3) for the gas to be used in the test, and use this value for all calculations included herein.

8.2.3 Oil Supply. Record the actual higher heating value, H_o, in kJ/kg (Btu/lb) for the fuel oil used in the test, and use this value for all calculations included herein.

8.3 Water Supply. Water temperatures and flow rates shall be as shown in Table 1, and the flow rate shall be maintained throughout the test at ±2%.

8.4 Test Room Setup, Test Conditions, and Start-up

8.4.1 Air Source Heat Pumps (ASHP). With reference to the test arrangement illustrated in Figure 3, maintain the outdoor air inlet temperature and humidity conditions and the water flow rate for the standard test conditions listed in Table 1.

Table 1. Standard Test Conditions

Test Designation	Air Temperatures and Relative Humidity at Heat Pump Inlet			Water Temperature at Heat Pump Inlet, ºC (ºF)
	Dry-Bulb, ºC (ºF)	Wet-Bulb, ºC (ºF)	Relative Humidity, %	
High Air Temperature, High Humidity	T_H	T_{WBH}	RH_H	T_s
High Air Temperature, Mid Humidity	T_H	T_{WBM}	RH_M	T_s
Low Air Temperature, Mid Humidity	T_L	T_{WBL}	RH_M	T_s

The temperature and water flow rate is specified by the rating method.

8.4.2 Direct Geoexchange Heat Pumps (DGHP). The test setup is illustrated in Figure 5. The Test Solution-To-Refrigerant Heat Exchanger simulates the earth loop system for testing purposes and functions as the evaporator in the refrigeration system.

The Test Solution Conditioning and Recirculation Equipment, which circulates 15% methanol solution with a specific heat of 7.84 Btu/gal-ºF (1.09 kWh/m^3-ºC), provides the heat input to the evaporator. The test solution temperature and flow measurements are utilized by the testing laboratory for the purpose of calibrating the heat input to the evaporator, based on the size of the equipment being tested. The measurements are not utilized in calculating performance of the DGHP.

The evaporator saturated vapor refrigerant conditions are listed in Table 2, DGHP Test Conditions. The refrigerant temperature and pressure are measured at the entrance to the equipment being tested as shown in Figure 5. The refrigerant entering the equipment being tested may be a saturated vapor or superheated, based on the equipment design and the manufacturer's instructions.

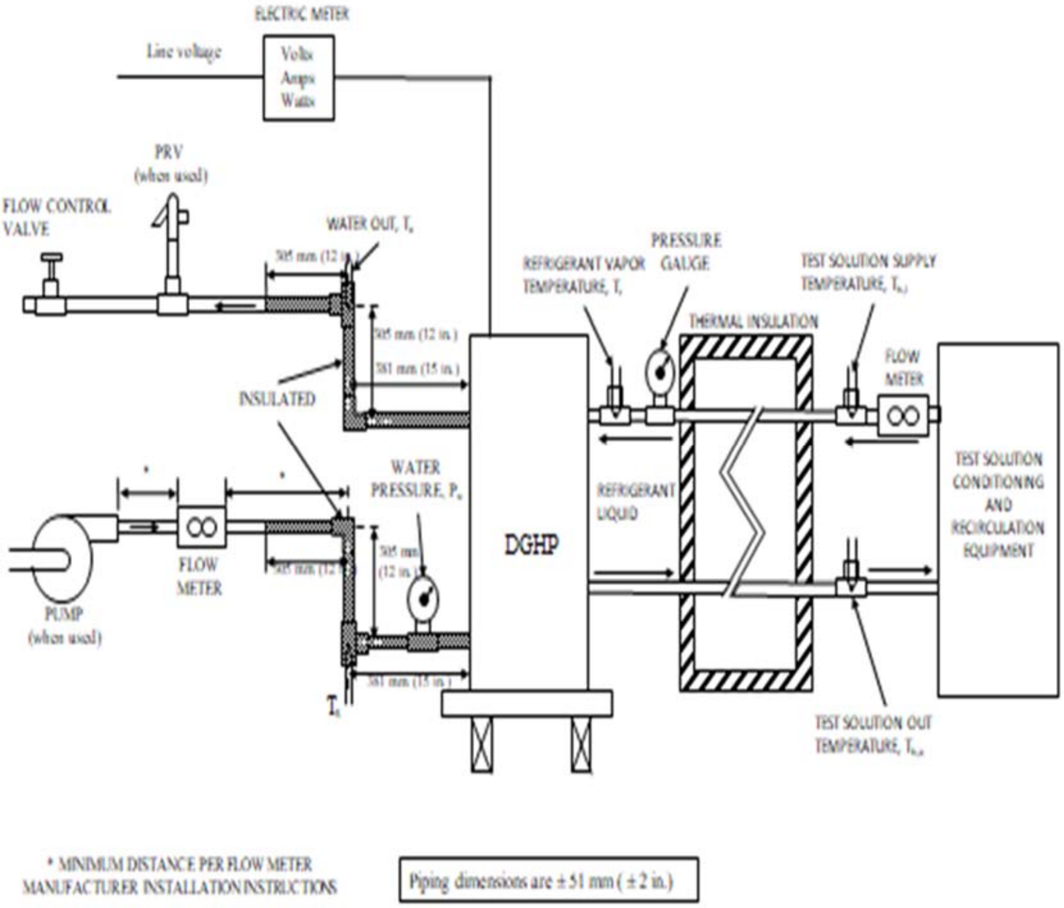

Figure 5 DGHP Test Setup

Table 2. DGHP Test Conditions

Equipment Classification	**Rating Conditions**	**Operating Mode**	**Entering Water Temperature, °C (°F)**	**Surrounding Air Temperature, °C (°F)**	**Saturated Refrigerant Temperature, (Evaporating) °C (°F)**
DGHP	Standard	Heat	T_s	T_a	T_r
Note: 1. Refrigerant pressure and temperature are measured at the inlet to the heat pump being tested. Increasing superheat will increase the refrigerant temperature entering the equipment.					

When starting up the DGHP, the refrigerant charge shall be applied in accordance with the manufacturer's charging instructions and Sections 8.4.2.1 and 8.4.2.2. If the manufacturer does not specify the charging procedure, the refrigerant charge shall be applied and determined by the refrigerant pressure (P_r) and temperature (T_r) conditions at the entrance to the DGHP.

8.4.2.1 When the manufacturer specifies the refrigerant conditions entering the heat pump by requiring either saturated vapor or degrees of superheat above the saturated refrigerant temperature in the evaporator, the heat pump shall be charged with refrigerant to the specified temperature within a tolerance of ± 0.8ºC (± 1.5ºF). If the manufacturer does not specify the refrigerant conditions entering the heat pump, it shall be charged to an entering superheat temperature of 5.6ºC ± 2.8ºC (10ºF ± 5ºF).

8.4.2.2 When the manufacturer specifies a fixed weight of refrigerant for the heat pump, as it is configured for the test, it shall be applied, within ± 1%, by weight.

8.4.3 Water Source Heat Pump (WSHP). The test setup is illustrated in Figure 6. The Test Solution Conditioning and Recirculation Equipment, which circulates 15% methanol solution, provides the heat input to the evaporator, contained within the WSHP equipment being tested. The inlet solution temperatures and flow rates are specified in Table 3, WSHP Test Conditions.

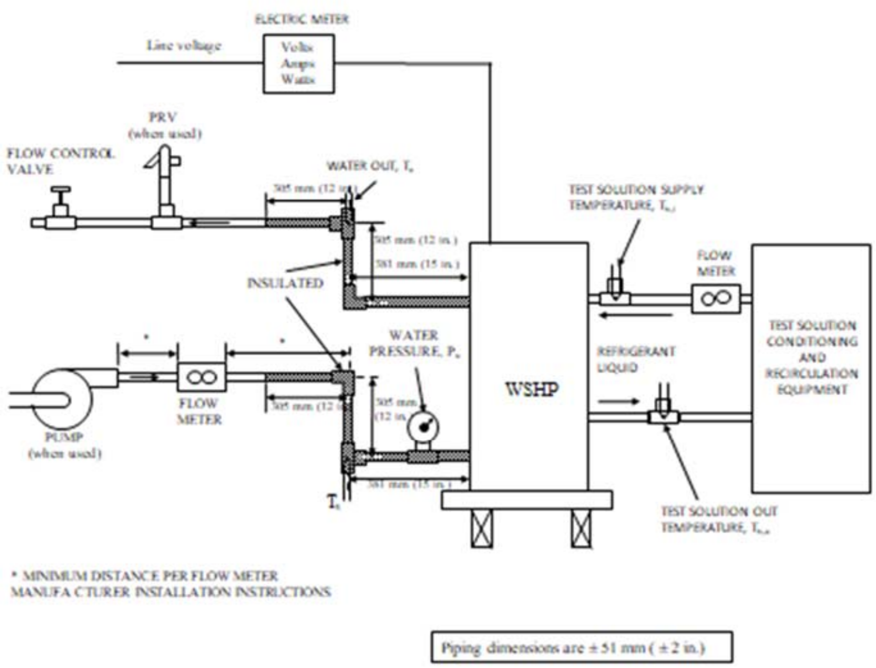

Figure 6 WSHP Test Setup

Table 3. WSHP Test Conditions

Equipment Classification	Rating Conditions	Operating Mode	Entering Water Temperature, ºC (ºF)	Surrounding Air Temperature, ºC (ºF)	Evaporator Supplied Test Solution Temperature, ºC (ºF)	Evaporator Supplied Test Solution Flow Rate* lpm/kW (gpm/ton)
Ground loop	Standard	Heat	T_s	T_a	T_{tsi1}	FR_{ts}
Ground Water	Standard	Heat	T_s	T_a	T_{tsi2}	FR_{ts}
Water Loop	Standard	Heat	T_s	T_a	T_{tsi3}	FR_{ts}
*Note: Unless otherwise specified by the manufacturer, the test Solution flow rate shall be 3.2 lpm per nominal kW (3.0 gpm per nominal ton).						

When starting up the WSHP, the test solution entering the Evaporator shall be at the temperature appropriate to the equipment classification in Table 3.

The Evaporator Supplied Test Solution flow rate (FR_{ts}) shall be specified by the manufacturer in the manufacturer's installation and operation manual, which will also provide the basis for the pump input power to the tested equipment. If the manufacturer does not specify the Test Solution flow rate, a default flow rate of 3.2 liters per minute per nominal kW (3.0 gallons per minute per nominal ton) will be the flow rate.

8.5 Power Input Adjustment

8.5.1 Gas Pool Heater. Adjust the fuel rate to achieve input that is within ±2% of the rating specified by the manufacturer on the nameplate as measured 15 minutes after initiation of pool heater operation. If the pool heater is equipped with a gas equipment pressure regulator, the regulator outlet pressure shall be within ±50 Pa (±0.2 in. w.c.) of the manufacturer's specified manifold pressure. Do not change the equipment pressure regulator setting after the input has been established.

8.5.2 Oil Pool Heater. Adjust the burner to obtain input that is within ±2% of the input rate specified by the manufacturer on the nameplate with the CO_2 reading in accordance with the instructions in the manufacturer's installation and operation manual as measured 15 minutes after initiation of pool heater operation. The smoke density in the flue pipe shall not exceed number 1.[3] The fuel pump pressure shall be within ±10% of the manufacturer's pump pressure specified on the nameplate, except as necessary to meet the input rate.

8.6 Ratings for Models Not Tested. Where there is similarity in design between different models of pool heaters that will not significantly affect the performance, ratings for untested models may be established based upon test results obtained for a similar model. The following conditions must be met:

a. All fossil fuel or electric resistance pool heaters have
   1. identical heat exchanger construction,
   2. identical insulation specifications,
   3. thermostatic or flow-sensing controls of the same style and mode of operation.
b. Gas-fired pool heaters:
   If the input rating for LP gas is within ±10% of the input rating for natural gas, only the natural gas model need be tested.
c. Electric pool heaters with resistance heating elements:
   If an electric pool heater has more than one input rating, the manufacturer shall designate which is the standard input, and the pool heater need be tested only at the designated standard input.
d. Heat pump pool heaters:
   A model need not be tested if there is a similarly designed tested unit whose commonality is that the relative sizes of the compressor, water condenser, and evaporator, outdoor air coil, earth loop heat exchanger, or water-to-refrigerant heat exchanger), capacity are the same.
e. Gas-fired sorption heat pump pool heaters:
   If the input rating for LP gas is within ±10% of the input rating for natural gas, only the natural gas model need be tested.

9. TEST PROCEDURES

9.1 Test Preparation

All test observations shall be within the tolerances specified in Table 4 as appropriate to the test methods and type of equipment.

TABLE 4 Test Tolerances

Pool Heater Type	Readings	Test Operating Tolerance (Total Observed Range)	Test Condition Tolerance (Variation of Average from Specified Test Conditions)
Air Source Heat Pump	Ambient air temperature (entering dry bulb)	1.1°C (2.0°F)	0.3°C (0.5°F)
	Ambient air temperature (entering wet bulb)	0.6°C (1.0°F)	0.2°C (0.4°F)
	Entering water temp	0.6°C (1.0°F)	0.3°C (0.5°F)
All other types	Ambient air temperature	11.1°C (20.0°F)	5.6°C (10.0°F)
	Water temperature	2.2°C (4.0°F)	1.2°C (2.2°F)

9.1.1 Heat Pump Pool Heater

The test room reconditioning apparatus and the equipment under test shall be operated until equilibrium conditions are attained, but for not less than one hour before capacity test data are recorded. For water source and direct geoexchange heat pump pool heaters, the water solution conditioning and recirculation equipment and equipment being tested shall be set up and operated in accordance with the procedure described in Section 8.4. Supply temperature, flow rate, ambient dry bulb temperature, and, for air source heat pump pool heaters, ambient wet-bulb temperature shall then be recorded at one-minute intervals and shall be within the tolerances prescribed in Table

4. The outlet temperature shall be recorded at one-minute intervals until 30 consecutive sets of readings which do not vary by more than ±0.5°C or ±1°F. That is considered the equilibrium condition.

9.1.2 Gas, Electric Resistance, and Oil Pool Heaters. Establish the water flow rate (FR) and outlet temperature (T_o) to be used for the test. This will be done by operating the heater until it reaches equilibrium condition. The outlet temperature shall be recorded at one-minute intervals until 30 consecutive sets of readings which do not vary by more than ±0.5°C or ±1°F. That is considered the equilibrium condition. Any device provided to maintain the water flow rate shall be removed or adjusted to prevent bypassing of water around the heat exchanger.

9.2. Thermal Efficiency Test

After the equilibrium condition required in Section 9.1 is reached, begin the thermal efficiency test.

If a scale and weighing container are used for the test, start the test by diverting the water from the waste line to a weighing container. Water shall be allowed to flow into the weighing container for 30 minutes. At the end of this period, the outlet water shall be diverted back into the waste line. If a flowmeter is used for this test, allow the water to flow for 30 minutes from the start of the test.

During this 30-minute test, measurements of the quantities listed in Table 5 shall be made at the frequency specified in that table.

At the end of the 30-minute test, record the mass (W) of water heated in kg (lb) or volume (G) of water heated in L (gal), the electrical energy consumption (Z or Z_{aux}) in kWh, the gas temperature (T_g) and gas consumption (V) in m^3 (ft^3), and the fuel oil consumption (W_f) in kg (lb), as appropriate, for all parts of the test. Thermal efficiency and COP calculations are covered in Section 11.

TABLE 5 Frequency of data collection during Thermal Efficiency/COP test.

Measurement (when applicable)	Frequency
Gas or fuel oil consumption (V, W_f)	At start, at end
Gas temperature (T_g)	At start, at end
Gas meter pressure (P_g)	At start, at end
Barometric pressure (P_B)	At start, at end
Electrical energy consumption (Z, Z_{aux})	At start, at end
Electric power	Minutely
Weight of weighing container (W)	At start, at end
Volume of water from flowmeter	At start, at end
Flow rate	At start, at end
Inlet water temperature (only when recirculation loop is used) (T_i)	Minutely
Supply water temperature (T_s)	Minutely
Outlet water temperature (T_o)	Minutely
Ambient air temperature (T_a)	Minutely

Ambient relative humidity (RH) or wet-bulb temperature (T_{WB})	Minutely
Inlet temperature of test solution during WSHP and DGHP test (T_{tsi})	Minutely
Outlet temperature of test solution during WSHP and DGHP test (T_{tso})	Minutely
Evaporator supplied test solution flow rate during WSHP and DGHP test	Minutely
Refrigerant temperature (T_r) during DGHP test	Minutely
Refrigerant pressure (P_r) during DGHP test	Minutely

9.3 Standby Mode Energy Consumption Test. Following the 30-minute thermal efficiency test procedure, reduce the thermostat setting to a low enough temperature to put the pool heater into standby mode. Reapply the energy sources and continue to measure the gas, oil, and/or electrical consumption for 60 minutes. Record the electrical energy consumption Z_s in kWh, the gas temperature T_g, the gas consumption in m^3 (ft^3), and the fuel oil consumption W_{fs} in kg (lb) as appropriate at the end of the 60-minute standby test. Standby energy consumption calculations are covered in Section 11.

Measure the electric power consumption during the standby mode ($P_{W,OFF}$) in accordance with the standby power procedures in IEC 62301 except that the room ambient temperature specifications and the electrical supply voltage provision of this test method shall apply in lieu of the corresponding provisions of IEC 62301 at Section 4.2, Test Room, and the voltage specification of Section 4.3, Power Supply. Frequency shall be 60Hz. Clarifying further, IEC 62301 Section 4.4, Power Measurement Instruments, and Section 5, Measurements, apply in lieu of the energy flow rate provisions of this test method. Measure the wattage so that all possible standby mode wattage for the entire appliance is recorded, not just the standby mode wattage of a single auxiliary. Round the recorded standby power ($P_{W,SB}$) to the second decimal place, except for loads greater than or equal to 10W, which must be recorded to at least three significant figures.

9.3.1 Off Mode Power Measurement. If the unit is equipped with an off switch or there is an expected difference between off mode power and standby mode power, measure off mode power ($P_{W,OFF}$) in accordance with the standby power procedures in IEC 62301 (incorporated by reference, see §430.3), except that the room ambient temperature specifications and the electrical supply voltage provision of this test method shall apply in lieu of the corresponding provisions of IEC 62301 at Section 4.2, Test Room, and the voltage specification of Section 4.3, Power Supply. Frequency shall be 60Hz. Clarifying further, IEC 62301 Section 4.4, Power Measurement Instruments, and Section 5, Measurements, apply for this measurement in lieu of the energy flow rate provisions of this test method. Measure the wattage so that all possible off mode wattage for the entire appliance is recorded, not just the off mode wattage of a single auxiliary. If there is no expected difference in off mode power and standby mode power, let $P_{W,OFF} = P_{W,SB}$, in which case no separate measurement of off mode power is necessary. Round the recorded off mode power ($P_{W,OFF}$) to the second decimal place, except for loads greater than or equal to 10W, in which case round the recorded value to at least three significant figures.

10. DATA TO BE RECORDED

Date
Observer(s)
Equipment Nameplate Data
CO_2 = CO_2 concentration by volume in dry flue gas, %
FR_{ts} = flow rate of the test solution during the WSHP primary test, lpm/kW (gpm/ton)
G = total volume of water measured during thermal efficiency test (or COP test), L (gal)
H = higher heating value of gas used, expressed as kJ/m^3 (Btu/ft^3) of dry gas at standard conditions
H_o = higher heating value of the fuel oil used, kJ/kg (Btu/lb)
C_{pt}= specific heat of 15% methanol test solution for WSHP test, kJ/(kg · ºC) (Btu/(lb · ºF))
RH_H = relative humidity, high test condition
RH_M = relative humidity, medium test condition
t = elapsed time of thermal efficiency test (or COP test) in primary test, h
t_s = elapsed time of standby test in primary test, h
T_i = inlet water temperature during the thermal efficiency (or COP) test, °C (°F) (Recirculation loop only)
T_s = supply water temperature during the thermal efficiency (or COP) test, °C (°F)
T_o = outlet water temperature during the thermal efficiency (or COP) test, °C (°F)
T_{mi} = average inlet water temperature during the thermal efficiency (or COP) test, °C (°F) (Recirculation loop only)
T_{ms} = average supply water temperature during the thermal efficiency (or COP) test, °C (°F)
T_{mo} = average outlet water temperature during the thermal efficiency (or COP) test, °C (°F)
T_g = gas temperature, °C (°F)
T_a = room or ambient (dry-bulb) temperature, °C (°F)
T_H = room or ambient (dry-bulb) temperature °C (°F), high test condition
T_L = room or ambient (dry-bulb) temperature °C (°F), low test condition
T_{WB} = room wet-bulb temperature, °C (°F)
T_{WBH} = room wet-bulb temperature, °C (°F), high test condition
T_{WBM} = room wet-bulb temperature, °C (°F), medium test condition
T_{WBL} = room wet-bulb temperature, °C (°F), low test condition
T_r= average saturated refrigerant temperature at equipment inlet during DGHP primary test, ºC (ºF)
T_{tsi}= average inlet temperature of the test solution during the WSHP primary test, ºC (ºF)
T_{tso}= average outlet temperature of the test solution during the WSHP primary test, ºC (ºF)
P_B = barometric pressure, kPa (in. Hg)
P_g = meter pressure, kPa (in. w.c.)
P_w = water pressure, kPa (psi)
P_r= average refrigerant pressure at equipment inlet during DGHP primary test, kPa (psig)
V = volume of gas metered during thermal efficiency test, m^3 (ft^3)
V_s = volume of gas metered during standby test, m^3 (ft^3)
W = mass of water collected during thermal efficiency (or COP) test, kg (lb)
W_g = mass of condensate water collected during thermal efficiency (or COP) test when flowmeter is not used, kg (lb)
W_f = mass of fuel oil used during the thermal efficiency test period, kg (lb)
W_{fs} = mass of fuel oil used during standby test, kg (lb)

W_t= mass of test solution collected during WSHP primary test, kg (lb)
Z = electrical energy measured, kWh
Z_{aux} = electrical energy used by auxiliary equipment, kWh
Z_s = electrical energy used during standby test, kWh

11. CALCULATION OF RESULTS

11.1 Thermal Efficiency or COP. From the supply and outlet water temperatures recorded during the primary test (Section 9.2), calculate the average of the supply temperatures, T_{ms}, and the average of the outlet temperatures, T_{mo}, rounded to the nearest .01 of a degree. Electricity used by the recirculation pump shall be added to the amount of electricity used by the pool heater. Determine the quantity of water, W, in kilograms (pounds) heated during the test. If W was not measured directly, calculate mass based upon the specific volume listed in the *ASHRAE Handbook—Fundamentals*, Chapter 6, Table 3,[2] for the temperature of the water metered. From the electric and/or fuel consumption reading for the primary test (Section 9.1), calculate the energy consumed, Q_r, in kJ (Btu) as follows:

For electric (including heat pump) pool heaters,

$Q_r = 3600\ Z$ (SI) and $Q_r = 3413\ Z$ (I-P)

where
Z = electrical energy used, expressed in kWh;
3600 = a constant to convert kWh to kJ; and
3413 = a constant to convert kWh to Btu.

For gas-fired pool heaters,

$Q_r = V\ H\ C_s + 3600\ Z_{aux}$ (SI) and $Q_r = V\ H\ C_s + 3413\ Z_{aux}$ (I-P)

where
V = quantity of gas metered, expressed in m^3 (ft^3);
H = higher heating value of gas used, expressed in kJ/m^3 (Btu/ft^3);
C_s = a correction factor applied if the gas as metered is not at standard temperature and pressure (see Informative Appendix A);
Z_{aux} = electrical energy used by auxiliary electric equipment, expressed in kWh;
3600 = a constant to convert kWh to kJ; and
3413 = a constant to convert kWh to Btu.

For oil-fired pool heaters,

$Q_r = H_o W_f + 3600 Z_{aux}$ (SI) and $Q_r = H_o W_f + 3413 Z_{aux}$ (I-P)

where
H_o = heating value of the oil, kJ/kg (Btu/lb);

W_f = mass of fuel oil used, kg (lb);
Z_{aux} = electric energy used by any auxiliary electric equipment, kWh;
3600 = a constant to convert kWh to kJ; and
3413 = a constant to convert kWh to Btu.

For gas-fired, electric resistance, oil-fired pool heaters and heat pump pool heaters, calculate the percent thermal efficiency, E_t, as

$$E_t = 100 \frac{kW(T_{mo} - T_{ms})}{Q_r}$$

For heat pump pool heaters, calculate the coefficient of performance (COP), a dimensionless quantity, as

$COP = E_t / 100$

where
k = 4.184 kJ/(kg·°C) (1.0 Btu/lb·°F) nominal specific heat of water;
W = mass of water collected during the test, kg (lb);
T_{mo} = average outlet water temperature recorded during the primary test (Section 9.1), °C (°F);
T_{ms} = average supply water temperature recorded during the primary test (Section 9.1), °C (°F);
and 100 = conversion factor to express a decimal as a percent.

If volume is measured, convert volume (gal) to mass (lbm).

$W = V \cdot \rho$

Where:
W = mass withdrawn, lbm
V = Total volume water measured at the point where flow volume is measured, gal
ρ = Density of the water based on water temperature measured at the point where the flow volume is measured, lbm/gal

$$\rho = \frac{-7.36376 \cdot 10^{-5} \cdot T_s^2 + 0.002427088 \cdot T_s + 62.48442}{7.48052}$$

11.2 Heating Capacity

For gas-fired, electric resistance and oil-fired pool heaters, calculate the heating capacity by multiplying the rated input by the thermal efficiency rounded to the nearest 0.1%.

For heat pump pool heaters, calculate the heating capacity as COP x Q_r x 1/t
Where
COP = as defined in 11.1
Q_r = as defined in 11.1 for electric (including heat pump) pool heaters, and
t = elapsed time of thermal efficiency test (or COP test) in primary test, h

11.3 Standby Energy Consumption. From the electric and/or fuel consumption measurements during the standby test (Section 9.2), calculate the energy consumption rate during standby, *Ps*, in kW (Btu/h) as follows:

For electric and heat pump pool heaters,

$$P_s = \frac{Z_s}{t_s} \quad \text{(SI)}$$

$$P_s = 3413\frac{Z_s}{t_s} \quad \text{(I-P)}$$

where
Z_s = electrical energy used during standby test, expressed in kWh;
3413 = a constant to convert kWh to Btu; and
t_s = time of standby test in primary test (Section 9.1), h.

For gas-fired pool heaters,

$$P_s = \frac{V_s H C_s + 3600 Z_s}{3600 t_s} \quad \text{(SI)}$$

$$P_s = \frac{V_s H C_s + 3413 Z_s}{t_s} \quad \text{(I-P)}$$

where
V_s = volume of gas metered in the standby test, m^3 (ft^3);
H = higher heating value of gas used, kJ/m^3 (Btu/ft^3);
C_s = a correction factor applied if the gas as metered is not at standard temperature and pressure (see Informative Appendix A);
Z_s = electrical energy used during the standby test, expressed in kWh;
3600 = a constant to convert h to s;
3413 = a constant to convert kWh to Btu; and
t_s = time of standby test in primary test (Section 9.1), h.

For oil-fired pool heaters,

$$P_s = \frac{H_o W_{fs} + 3600 Z_s}{3600 t_s} \quad \text{(SI)}$$

$$P_s = \frac{H_o W_{fs} + 3413 Z_s}{t_s} \quad \text{(I-P)}$$

where
H_o = heating value of the oil used, expressed in kJ/kg (Btu/lb);
W_{fs} = mass of fuel oil used, kg (lb);
Z_s = electrical energy used during the standby test, expressed in kWh;
3600 = a constant to convert h to s;
3413 = a constant to convert kWh to Btu; and
t_s = time of standby test in primary test (Section 9.1), h.

12. REFERENCE PROPERTIES

12.1 Thermodynamic Properties of Air. The thermodynamic properties of air-water vapor mixture shall be obtained from the *ASHRAE Handbook—Fundamentals*.[2]

12.2 Thermodynamic Properties of Water. The thermodynamic properties of water and steam shall be obtained from the *ASHRAE Handbook—Fundamentals*.[2]

13. REFERENCES

1. ASHRAE. 2006. ANSI/ASHRAE Standard 41.1- 2013 *Standard Method for Temperature Measurement*. Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers.

2. ASHRAE. 2013 *ASHRAE Handbook—Fundamentals.* Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers.

3. ASTM. 2013 ASTM D2156-2013, *Standard Test Method for Smoke Density in the Flue Gases from Burning Distillate Fuels*. Philadelphia: American Society for Testing and Materials.

4. IEC 62301 2011-01 (Edition 2.0), *Household electrical appliances-Measurement of standby power*.

(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
CORRECTION FACTOR FOR HEATING VALUE OF FUEL GAS

The heating value of gas, *H*, is reported at standard conditions of temperature and pressure. A correction factor, C_s , is applied to this heating value to obtain the heat content of the gas at the temperature and pressure in the meter used for measuring the quantity of fuel used in the test.

Dry gas utilizing dry test meter:

$$C_s = \frac{P_g(273.15 + T_s)}{P_s(273.15 + T_g)} \text{ (SI)}$$

$$C_s = \frac{P_g(459.67 + T_s)}{P_s(459.67 + T_g)} \text{ (I-P)}$$

Saturated gas utilizing a wet test meter:

$$C_s = \frac{(P_g - P_{wv})}{(P_s - P_{wvs})}\frac{(459.67 + T_s)}{(459.67 + T_g)} \text{ (IP)}$$

$$C_s = \frac{(P_g - P_{wv})}{(P_s - P_{wvs})}\frac{(273.15 + T_s)}{(273.15 + T_g)} \text{ (SI)}$$

where
P_g = absolute pressure of gas being metered (barometric pressure plus gas pressure in meter), kPa (in. Hg)
P_s = standard pressure (the absolute pressure on which the heating value is based), kPa (in. Hg)
T_g = temperature of gas in meter, °C (°F)
T_s = standard temperature (the temperature on which the heating value is based), °C (°F)
P_{vw} = water-vapor pressure at T_g, kPa (in. Hg).
P_{wvs} = water-vapor pressure at T_s, kPa (in. Hg).
For water-vapor pressures, see the *2017 ASHRAE Handbook—Fundamentals,* Chapter 1, Table 3, Thermodynamic Properties of Water at Saturation.
If the value of H is based upon a dry condition and the gas is metered with a wet test meter, its value must also be reduced by a factor as calculated by:

$$C_f = \frac{(P_s - P_{\mathrm{wvs}})}{P_s}.$$

Conversely, if the value of H is based upon a saturated condition and the gas is metered dry, its value must be increased by a factor as calculated by:

$$C_f = \frac{P_s}{(P_s - P_{\mathrm{wvs}})}.$$

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INFORMATIVE APPENDIX B
U.S. VALUES FOR TEST VARIABLES

In the United States, federal statutes require that pool heaters be tested and rated in accordance with the U.S. Department of Energy 10 Code of Federal Regulations (CFR) Part 430, Subpart B, Appendix P "Uniform Test Method for Measuring the Energy Consumption of Pool Heaters." That test method provides an integrated thermal efficiency rating that is calculated from ratings that are comparable to those determined by this standard. Below are the U.S. values for test variables prescribed in this standard and the calculation for integrated thermal efficiency.

Table 1. Standard Test Conditions
Air Source Heat Pump

Test Designation	Air Temperatures and Relative Humidity at Heat Pump Inlet			Water Temperature Supply to Heat Pump, ºC (ºF)
	Dry-Bulb, ºC (ºF)	Wet-Bulb, ºC (ºF)	Relative Humidity, %	
High Air Temperature, Mid Humidity	27.0 (80.6)	21.8 (71.2)	63	26.7 (80.0)
Note: Water flow rate is 1.70 liters/min. per kW (0.45 gpm per 1,000 Btu/h) or, manufacturer may specify a flow rate less than 1.70 liters/min. per kW (0.45 gpm per 1,000 Btu/h).				

Values used in the U.S. for other rating conditions for air source heat pumps

Test	Air Temperatures and	Water Temperature

Designation	Relative Humidity at Heat Pump Inlet			Supply to Heat Pump, ºC (ºF)
	Dry-Bulb, ºC (ºF)	Wet-Bulb, ºC (ºF)	Relative Humidity, %	
High Air Temperature, High Humidity	27.0 (80.6)	24.5 (75.8)	80	26.7 (80.0)
Low Air Temperature, Mid Humidity	10.0 (50.0)	7.0 (44.3)	63	26.7 (80.0)
Note: Water flow rate is 1.70 liters/min. per kW (0.45 gpm per 1,000 Btu/h) or, manufacturer may specify a flow rate less than 1.70 liters/min. per kW (0.45 gpm per 1,000 Btu/h).				

Direct Geoexchange Heat Pump

Equipment Classification	Rating Conditions	Operating Mode	Entering Water Temperature, ºC (ºF)	Surrounding Air Temperature, ºC (ºF)	Saturated Refrigerant Temperature, (Evaporating) ºC (ºF)
DGHP	Standard	Heat	26.7 (80.0)	24.0 (75.2)	0.0 (32.0)
Note: 1. Refrigerant pressure and temperature are measured at the inlet to the heat pump being tested. Increasing superheat will increase the refrigerant temperature entering the equipment.					

Water Source Heat Pump

Equipment Classifications	Rating Conditions	Operating Mode	Entering Water Temperature, ºC (ºF)	Surrounding Air Temperature, ºC (ºF)	Evaporator Supplied Test Solution Temperature ºC (ºF)	Evaporator Supplied Test Solution Flow Rate* lpm/kW (gpm/ton)
Ground Loop	Standard	Heat	26.7 (80.0)	24.0 (75.2)	0.0 (32.0)	3.2 (3.0)
Ground Water	Standard	Heat	26.7 (80.0)	24.0 (75.2)	10.0 (50.0)	3.2 (3.0)
Water Loop	Standard	Heat	26.7 (80.0)	24.0 (75.2)	20.0 (68.0)	3.2 (3.0)
*Note: Unless otherwise specified by the manufacturer, the Test Solution flow rate shall be 3.2 lpm per nominal kW (3.0 gpm per nominal ton).						

Gas-Fired, Oil-Fired, and Electric Resistance Pool Heaters
$T_s \geq$ 65°F (18.3°C)
$T_o \leq$ 115°F (46.1°C)

The temperature rise shall be 40°F (22.2°C). When specified by the manufacturer in the installation or operational manual, the water temperature rise may be adjusted to a lower value but not less than 10°F (5.5°C), with the average of the inlet (T_i) and outlet (T_o) water temperature being 90°F ± 5°F (32.0°C ± 3°C).

Calculation of integrated thermal efficiency (TE_I) for gas and oil fired pool heaters

$TE_I = 100 (E_{OUT}/ E_{IN})$
where:

$E_{OUT} = 104[(E_t/100)(Q_{IN} + PE)]$
where:
Q_{IN} = rated fuel energy input as defined according to section.

PE = 2Ec, for fossil fuel-fired heaters tested according to section 4.1.1
Ec = electrical consumption in Btu per 30 min. This includes the electrical consumption (converted to Btus) of the pool heater and, if present, a recirculating pump during the 30-minute thermal efficiency test.
100 = conversion factor, from percent to fraction

$E_{IN} = EF + EAE$

where:

$EF = BOH\ Q_{IN} + (POH-BOH)Q_{PR} + (8760-POH)\ Q_{off,R}$
where:

BOH = average number of burner operating hours = 104 h,
POH = average number of pool operating hours = 4,464 h,
Q_{PR} = average energy consumption rate of continuously operating pilot light, if employed, = (QP/1 h),
Q_P = energy consumption of continuously operating pilot light, if employed, as measured in Section 9.3, in Btu,
8760 = number of hours in one year,
$Q_{off,R}$ = average off mode fossil fuel energy consumption rate = Qoff/(1 h), and
Q_{off} = off mode energy consumption as defined in section 9.3.2.

$EAE = E_{AE,active} + E_{AE,standby,off}$
where
$E_{AE,active}$ = electrical consumption in the active mode = BOH * PE,
$E_{AE,standby,off}$ = auxiliary electrical consumption in the standby mode and off mode = (POH-BOH) $P_{W,SB}$ (Btu/h) + (8760-POH) $P_{W,OFF}$ (Btu/h) ,

$P_{W,SB}$ (Btu/h) = electrical energy consumption rate during standby mode expressed in Btu/h = 3.412 $P_{W,SB}$, Btu/h,
$P_{W,OFF}$ (Btu/h) = electrical energy consumption rate during off mode expressed in Btu/h =

3.412 $P_{W,OFF}$, Btu/h, and

Calculation of integrated thermal efficiency (TE_I) for electric resistance and heat pump pool heaters

$TE_I = 100\ (E_{OUT}/\ E_{IN})$
where:

$E_{OUT} = 104(E_t/100)(PE)$
$E_{IN} = EAE$
where:

$EAE = E_{AE,active} + E_{AE,standby,off}$

$E_{AE,active} = 104 * PE$
$E_{AE,standby,off} = (4360)\ P_{W,SB}(Btu/h) + (4296)\ P_{W,OFF}(Btu/h)$
where:
$E_{AE,active}$ = electrical consumption in the active mode,
$E_{AE,standby,off}$ = auxiliary electrical consumption in the standby mode and off mode,
PE = 2Ec, for electric resistance pool heaters, in Btu/h
= $E_{c,HP} * (60/t_{HP})$, for electric heat pump pool heaters, in Btu/h.
Ec = electrical consumption in Btu per 30 min. This includes the electrical consumption (converted to Btus) of the pool heater and, if present, a recirculating pump during the 30-minute thermal efficiency test.
$E_{c,HP}$ = electrical consumption of the electric heat pump pool heater (converted to equivalent unit of Btu), including the electrical energy to the recirculating pump if used, during the thermal efficiency test, in Btu.
t_{HP} = elapsed time of data recording during the thermal efficiency test on electric heat pump pool heater, as defined in Section 9.2, in minutes

INFORMATIVE APPENDIX C
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ASHRAE. 2006. ANSI/ASHRAE Standard 118.2-2006, *Method of Testing for Rating Residential Water Heaters*. Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers.

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