where $\dot{Q}_c^k(T)$ and $\dot{E}_c^k(T)$ are the space cooling capacity and electrical power consumption determined from the 30-minute data collection interval of the same steady-state wet coil cooling mode test and calculated as specified in section 3.3 of this appendix. Add the letter identification for each steady-state test as a subscript (*e.g.*, EER_{A_2}) to differentiate among the resulting EER values. The represented value of EER is determined from the A or A_2 test, whichever is applicable. The represented value of EER determined in accordance with this appendix is called EER2.

[82 FR 1533, Jan. 5, 2017]

APPENDIX N TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF FURNACES AND BOILERS

NOTE: Prior to July 13, 2016, representations with respect to the energy use or efficiency of residential furnaces and boilers, including compliance certifications, must be based on testing conducted in accordance with either this appendix as it now appears or appendix N as it appeared at 10 CFR part 430, subpart B revised as of January 1, 2016.

After July 13, 2016, representations with respect to energy use or efficiency of residential furnaces and boilers, including compliance certifications, must be based on testing conducted in accordance with this appendix.

1.0 *Scope.* The scope of this appendix is as specified in section 2 of ASHRAE 103–1993 (incorporated by reference, see §430.3).

For purposes of this appendix, the Department of Energy incorporates by reference several industry standards, either in whole or in part, as listed in §430.3. In cases where there is a conflict, the language of the test procedure in this appendix takes precedence over the incorporated standards.

2.0 *Definitions.* Definitions include those specified in section 3 of ASHRAE 103–1993 (incorporated by reference, see §430.3) and the following additional and modified definitions.

2.1 *Active mode* means the condition in which the furnace or boiler is connected to the power source, and at least one of the burner, electric resistance elements, or any electrical auxiliaries such as blowers or pumps, are activated.

2.2 *Boiler pump* means a pump installed on a boiler and that is separate from the circulating water pump.

2.3 *Control* means a device used to regulate the operation of a piece of equipment and the supply of fuel, electricity, air, or water.

2.4 *Draft inducer* means a fan incorporated in the furnace or boiler that either draws or forces air into the combustion chamber.

2.5 *Gas valve* means an automatic or semi-automatic device consisting essentially of a valve and operator that controls the gas supply to the burner(s) during normal operation of an appliance. The operator may be actuated by application of gas pressure on a flexible diaphragm, by electrical means, by mechanical means or by other means.

2.6 *Installation and operation (I&O) manual* means instructions for installing, commissioning, and operating the furnace or boiler, which are supplied with the product when shipped by the manufacturer.

2.7 *Isolated combustion system* means a system where a unit is installed within the structure, but isolated from the heated space. A portion of the jacket heat from the unit is lost, and air for ventilation, combustion and draft control comes from outside the heated space.

2.8 *Multi-position furnace* means a furnace that can be installed in more than one airflow configuration (*i.e.*, upflow or horizontal; downflow or horizontal; upflow or downflow; and upflow, or downflow, or horizontal).

2.9 *Off mode* means a mode in which the furnace or boiler is connected to a mains power source and is not providing any active mode or standby mode function, and where the mode may persist for an indefinite time. The existence of an off switch in off position (a disconnected circuit) is included within the classification of off mode.

2.10 *Off switch* means the switch on the furnace or boiler that, when activated, results in a measurable change in energy consumption between the standby and off modes.

2.11 *Oil control valve* means an automatically or manually operated device consisting of an oil valve for controlling the fuel supply to a burner to regulate burner input.

2.12 *Standby mode* means any mode in which the furnace or boiler is connected to a mains power source and offers one or more of the following space heating functions that may persist:

a. To facilitate the activation of other modes (including activation or deactivation of active mode) by remote switch (including thermostat or remote control), internal or external sensors, or timer;

b. Continuous functions, including information or status displays or sensor based functions.

2.13 *Thermal stack damper* means a type of stack damper that relies exclusively upon the changes in temperature in the stack gases to open or close the damper.

3.0 *Classifications.* Classifications are as specified in section 4 of ASHRAE 103–1993 (incorporated by reference, see §430.3).

4.0 *Requirements.* Requirements are as specified in section 5 of ASHRAE 103–1993 (incorporated by reference, see §430.3).

5.0 *Instruments.* Instruments must be as specified in section 6 of ASHRAE 103–1993 (incorporated by reference, see §430.3).

6.0 *Apparatus.* The apparatus used in conjunction with the furnace or boiler during the testing must be as specified in section 7 of ASHRAE 103–1993 (incorporated by reference, see §430.3) except for sections 7.1, 7.2.2.2, 7.2.2.5, 7.2.3.1, and 7.8; and as specified in sections 6.1 through 6.5 of this appendix.

6.1 *General.*

a. Install the furnace or boiler in the test room in accordance with the I&O manual, as defined in section 2.6 of this appendix, except that if provisions within this appendix are specified, then the provisions herein drafted and prescribed by DOE govern. If the I&O manual and any additional provisions of this appendix are not sufficient for testing a furnace or boiler, the manufacturer must request a waiver from the test procedure pursuant to 10 CFR 430.27.

b. If the I&O manual indicates the unit should not be installed with a return duct, then the return (inlet) duct specified in section 7.2.1 of ASHRAE 103–1993 (incorporated by reference, see §430.3) is not required.

c. Test multi-position furnaces in the least efficient configuration. Testing of multi-position furnaces in other configurations is permitted if energy use or efficiency is represented pursuant to the requirements in 10 CFR part 429.

d. The apparatuses described in section 6 of this appendix are used in conjunction with the furnace or boiler during testing. Each piece of apparatus shall conform to material and construction specifications listed in this appendix and in ASHRAE 103–1993 (incorporated by reference, see §430.3), and the reference standards cited in this appendix and in ASHRAE 103–1993.

e. Test rooms containing equipment must have suitable facilities for providing the utilities (including but not limited to environmental controls, sufficient fluid source(s), applicable measurement equipment, and any other technology or tools) necessary for performance of the test and must be able to maintain conditions within the limits specified in section 6 of this appendix.

6.2 *Forced-air central furnaces (direct vent and direct exhaust).*

a. Units not equipped with a draft hood or draft diverter must be provided with the minimum-length vent configuration recommended in the I&O manual or a 5-ft flue pipe if there is no recommendation provided in the I&O manual (see Figure 4 of ASHRAE 103–1993 (incorporated by reference, see §430.3)). For a direct exhaust system, insulate the minimum-length vent configuration or the 5-ft flue pipe with insulation having an R-value not less than 7 and an outer layer of aluminum foil. For a direct vent system, see section 7.5 of ASHRAE 103–1993 for insulation requirements.

b. For units with power burners, cover the flue collection box with insulation having an R-value of not less than 7 and an outer layer of aluminum foil before the cool-down and heat-up tests described in sections 9.5 and 9.6 of ASHRAE 103–1993 (incorporated by reference, see §430.3), respectively. However, do not apply the insulation for the jacket loss test (if conducted) described in section 8.6 of ASHRAE 103–1993 or the steady-state test described in section 9.1 of ASHRAE 103–1993.

c. For power-vented units, insulate the shroud surrounding the blower impeller with insulation having an R-value of not less than 7 and an outer layer of aluminum foil before the cool-down and heat-up tests described in sections 9.5 and 9.6, respectively, of ASHRAE 103–1993 (incorporated by reference, see §430.3). Do not apply the insulation for the jacket loss test (if conducted) described in section 8.6 of ASHRAE 103–1993 or the steady-state test described in section 9.1 of ASHRAE 103–1993. Do not insulate the blower motor or block the airflow openings that facilitate the cooling of the combustion blower motor or bearings.

6.3 *Downflow furnaces.* Install an internal section of vent pipe the same size as the flue collar for connecting the flue collar to the top of the unit, if not supplied by the manufacturer. Do not insulate the internal vent pipe during the jacket loss test (if conducted) described in section 8.6 of ASHRAE 103–1993 (incorporated by reference, see §430.3) or the steady-state test described in section 9.1 of ASHRAE 103–1993. Do not insulate the internal vent pipe before the cool-down and heat-up tests described in sections 9.5 and 9.6, respectively, of ASHRAE 103–1993. If the vent pipe is surrounded by a metal jacket, do not insulate the metal jacket. Install a 5-ft test stack of the same cross-sectional area or perimeter as the vent pipe above the top of the furnace. Tape or seal around the junction connecting the vent pipe and the 5-ft test stack. Insulate the 5-ft test stack with insulation having an R-value not less than 7 and an outer layer of aluminum foil. (See Figure 3–E of ASHRAE 103–1993.)

6.4 *Units with draft hoods or draft diverters.* Install the stack damper in accordance with the I&O manual. Install 5 feet of stack above the damper.

a. For units with an integral draft diverter, cover the 5-ft stack with insulation having an R-value of not less than 7 and an outer layer of aluminum foil.

b. For units with draft hoods, insulate the flue pipe between the outlet of the furnace and the draft hood with insulation having an R-value of not less than 7 and an outer layer of aluminum foil.

c. For units with integral draft diverters that are mounted in an exposed position (not

inside the overall unit cabinet), cover the diverter boxes (excluding any openings through which draft relief air flows) before the beginning of any test (including jacket loss test) with insulation having an R-value of not less than 7 and an outer layer of aluminum foil.

d. For units equipped with integral draft diverters that are enclosed within the overall unit cabinet, insulate the draft diverter box with insulation as described in section 6.4.c before the cool-down and heat-up tests described in sections 9.5 and 9.6, respectively, of ASHRAE 103–1993 (incorporated by reference, see §430.3). Do not apply the insulation for the jacket loss test (if conducted) described in section 8.6 of ASHRAE 103–1993 or the steady-state test described in section 9.1 of ASHRAE 103–1993.

6.5 *Condensate collection.* Attach condensate drain lines to the unit as specified in the I&O manual. Maintain a continuous downward slope of drain lines from the unit. Additional precautions (such as eliminating any line configuration or position that would otherwise restrict or block the flow of condensate or checking to ensure a proper connection with condensate drain spout that allows for unobstructed flow) must be taken to facilitate uninterrupted flow of condensate during the test. Collection containers must be glass or polished stainless steel to facilitate removal of interior deposits. The collection container must have a vent opening to the atmosphere.

7.0 *Testing conditions.* The testing conditions must be as specified in section 8 of ASHRAE 103–1993 (incorporated by reference, see §430.3), except for section 8.2.1.3, 8.3.3.1, 8.4.1.1, 8.4.1.1.2, 8.4.1.2, 8.4.2.1.4, 8.4.2.1.6, 8.6.1.1, 8.7.2, and 8.8.3; and as specified in sections 7.1 to 7.10 of this appendix, respectively.

7.1 *Fuel supply, gas.* In conducting the tests specified herein, gases with characteristics as shown in Table 1 of ASHRAE 103–1993 (incorporated by reference, see §430.3) shall be used. Maintain the gas supply, ahead of all controls for a furnace, at a test pressure between the normal and increased values shown in Table 1 of ASHRAE 103–1993. Maintain the regulator outlet pressure at a level approximating that recommended in the I&O manual, as defined in section 2.6 of this appendix, or, in the absence of such recommendation, to the nominal regulator settings used when the product is shipped by the manufacturer. Use a gas having a specific gravity as shown in Table 1 of ASHRAE 103–1993 and with a higher heating value within ±5% of the higher heating value shown in Table 1 of ASHRAE 103–1993. Determine the actual higher heating value in Btu per standard cubic foot for the gas to be used in the test within an error no greater than 1%.

7.2 *Installation of piping.* Install piping equipment in accordance with the I&O manual. In the absence of such specification, install piping in accordance with section 8.3.1.1 of ASHRAE 103–1993 (incorporated by reference, see §430.3).

7.3 *Gas burner.* Adjust the burners of gas-fired furnaces and boilers to their maximum Btu input ratings at the normal test pressure specified by section 7.1 of this appendix. Correct the burner input rate to reflect gas characteristics at a temperature of 60 °F and atmospheric pressure of 30 in of Hg and adjust down to within ±2 percent of the hourly Btu nameplate input rating specified by the manufacturer as measured during the steady-state performance test in section 8 of this appendix. Set the primary air shutters in accordance with the I&O manual to give a good flame at this condition. If, however, the setting results in the deposit of carbon on the burners during any test specified herein, the tester shall adjust the shutters and burners until no more carbon is deposited and shall perform the tests again with the new settings (see Figure 9 of ASHRAE 103–1993 (incorporated by reference, see §430.3)). After the steady-state performance test has been started, do not make additional adjustments to the burners during the required series of performance tests specified in section 9 of ASHRAE 103–1993. If a vent-limiting means is provided on a gas pressure regulator, keep it in place during all tests.

7.4 *Modulating gas burner adjustment at reduced input rate.* For gas-fired furnaces and boilers equipped with modulating-type controls, adjust the controls to operate the unit at the nameplate minimum input rate. If the modulating control is of a non-automatic type, adjust the control to the setting recommended in the I&O manual. In the absence of such recommendation, the midpoint setting of the non-automatic control shall be used as the setting for determining the reduced fuel input rate. Start the furnace or boiler by turning the safety control valve to the ''ON'' position. For boilers, use a supply water temperature that will allow for continuous operation without shutoff by the control. If necessary to achieve such continuous operation, supply water may be increased above 120 °F; in such cases, gradually increase the supply water temperature to determine what minimum supply water temperature, with a 20 °F temperature rise across the boiler, will be needed to adjust for the minimum input rate at the reduced input rate control setting. Monitor regulated gas pressure out of the modulating control valve (or entering the burner) to determine when no further reduction of gas pressure results. The flow rate of water through the boiler shall be adjusted to achieve a 20 °F temperature rise.

7.5 *Oil burner.* Adjust the burners of oil-fired furnaces or boilers to give a CO_2 reading specified in the I&O manual and an hourly Btu input during the steady-state performance test described in section 8 of this appendix. Ensure the hourly BTU input is within ±2% of the normal hourly Btu input rating as specified in the I&O manual. Smoke in the flue may not exceed a No. 1 smoke during the steady-state performance test as measured by the procedure in ASTM D2156R13 (incorporated by reference, see §430.3). Maintain the average draft over the fire and in the flue during the steady-state performance test at the value specified in the I&O manual. Do not allow draft fluctuations exceeding 0.005 in. water. Do not make additional adjustments to the burner during the required series of performance tests. The instruments and measuring apparatus for this test are described in section 6 of this appendix and shown in Figure 8 of ASHRAE 103–1993 (incorporated by reference, see §430.3).

7.6 Adjust air throughputs to achieve a temperature rise that is the higher of a and b, below, unless c applies. A tolerance of ±2 °F is permitted.

a. 15 °F less than the nameplate maximum temperature rise or

b. 15 °F higher than the minimum temperature rise specified in the I&O manual.

c. A furnace with a non-adjustable air temperature rise range and an automatically controlled airflow that does not permit a temperature rise range of 30 °F or more must be tested at the midpoint of the rise range.

7.7 Establish the temperature rise specified in section 7.6 of this appendix by adjusting the circulating airflow. This adjustment must be accomplished by symmetrically restricting the outlet air duct and varying blower speed selection to obtain the desired temperature rise and minimum external static pressure, as specified in Table 4 of ASHRAE 103–1993 (incorporated by reference, see §430.3). If the required temperature rise cannot be obtained at the minimum specified external static pressure by adjusting blower speed selection and duct outlet restriction, then the following applies.

a. If the resultant temperature rise is less than the required temperature rise, vary the blower speed by gradually adjusting the blower voltage so as to maintain the minimum external static pressure listed in Table 4 of ASHRAE 103–1993 (incorporated by reference, see §430.3). The airflow restrictions shall then remain unchanged. If static pressure must be varied to prevent unstable blower operation, then increase the static pressure until blower operation is stabilized, except that the static pressure must not exceed the maximum external static pressure as specified by the manufacturer in the I&O manual.

b. If the resultant temperature rise is greater than the required temperature rise, then the unit can be tested at a higher temperature rise value, but one not greater than nameplate maximum temperature rise. In order not to exceed the maximum temperature rise, the speed of a direct-driven blower may be increased by increasing the circulating air blower motor voltage.

7.8 *Measurement of jacket surface temperature.* Divide the jacket of the furnace or boiler into 6-inch squares when practical, and otherwise into 36-square-inch regions comprising 4 inch by 9 inch or 3 inch by 12 inch sections, and determine the surface temperature at the center of each square or section with a surface thermocouple. Record the surface temperature of the 36-square-inch areas in groups where the temperature differential of the 36-square-inch areas is less than 10 °F for temperature up to 100 °F above room temperature, and less than 20 °F for temperatures more than 100 °F above room temperature. For forced-air central furnaces, the circulating air blower compartment is considered as part of the duct system, and no surface temperature measurement of the blower compartment needs to be recorded for the purpose of this test. For downflow furnaces, measure all cabinet surface temperatures of the heat exchanger and combustion section, including the bottom around the outlet duct and the burner door, using the 36-square-inch thermocouple grid. The cabinet surface temperatures around the blower section do not need to be measured (See Figure 3–E of ASHRAE 103–1993 (incorporated by reference, see §430.3)).

7.9 *Installation of vent system.* Keep the vent or air intake system supplied by the manufacturer in place during all tests. Test units intended for installation with a variety of vent pipe lengths with the minimum vent length as specified in the I&O manual, or a 5-ft. flue pipe if there are no recommendations in the I&O manual. Do not connect a furnace or boiler employing a direct vent system to a chimney or induced-draft source. Vent combustion products solely by using the venting incorporated in the furnace or boiler and the vent or air intake system supplied by the manufacturer. For units that are not designed to significantly preheat the incoming air, see section 7.5 of this appendix and Figure 4a or 4b of ASHRAE 103–1993 (incorporated by reference, see §430.3). For units that do significantly preheat the incoming air, see Figure 4c or 4d of ASHRAE 103–1993.

7.10 *Additional optional method of testing for determining D_P and D_F for furnaces and boilers.* On units whose design is such that there is no measurable airflow through the combustion chamber and heat exchanger when the burner(s) is (are) off as determined by the optional test procedure in section 7.10.1 of this appendix, D_F and D_P may be set equal to 0.05.

7.10.1 *Optional test method for indicating the absence of flow through the heat exchanger.* Manufacturers may use the following test protocol to determine whether air flows through the combustion chamber and heat exchanger when the burner(s) is (are) off. The minimum default draft factor (as allowed per sections 8.8.3 and 9.10 of ASHRAE 103–1993 (incorporated by reference, see §430.3)) may be used only for units determined pursuant to this protocol to have no airflow through the combustion chamber and heat exchanger.

7.10.1.1 *Test apparatus.* Use a smoke stick that produces smoke that is easily visible and has a density less than or approximately equal to air. Use a smoke stick that produces smoke that is non-toxic to the test personnel and produces gas that is unreactive with the environment in the test chamber.

7.10.1.2 *Test conditions.* Minimize all air currents and drafts in the test chamber, including turning off ventilation if the test chamber is mechanically ventilated. Wait at least two minutes following the termination of the furnace or boiler on-cycle before beginning the optional test method for indicating the absence of flow through the heat exchanger.

7.10.1.3 *Location of the test apparatus.* After all air currents and drafts in the test chamber have been eliminated or minimized, position the smoke stick based on the following equipment configuration: (a) For horizontal combustion air intakes, approximately 4 inches from the vertical plane at the termination of the intake vent and 4 inches below the bottom edge of the combustion air intake; or (b) for vertical combustion air intakes, approximately 4 inches horizontal from vent perimeter at the termination of the intake vent and 4 inches down (parallel to the vertical axis of the vent). In the instance where the boiler combustion air intake is closer than 4 inches to the floor, place the smoke device directly on the floor without impeding the flow of smoke.

7.10.1.4 *Duration of test.* Establish the presence of smoke from the smoke stick and then monitor the direction of the smoke flow for no less than 30 seconds.

7.10.1.5 *Test results.* During visual assessment, determine whether there is any draw of smoke into the combustion air intake vent.

If absolutely no smoke is drawn into the combustion air intake, the furnace or boiler meets the requirements to allow use of the minimum default draft factor pursuant to section 8.8.3 and/or section 9.10 of ASHRAE 103–1993 (incorporated by reference, see §430.3).

If there is any smoke drawn into the intake, proceed with the methods of testing as prescribed in section 8.8 of ASHRAE 103–1993.

8.0 *Test procedure.* Conduct testing and measurements as specified in section 9 of ASHRAE 103–1993 (incorporated by reference, see §430.3) except for sections 9.1.2.2.1, 9.1.2.2.2, 9.5.1.1, 9.5.1.2.1, 9.5.1.2.2, 9.5.2.1, 9.7.4, and 9.10; and as specified in sections 8.1 through 8.11 of this appendix. Section 8.4 of this appendix may be used in lieu of section 9.2 of ASHRAE 103–1993.

8.1 *Fuel input.* For gas units, measure and record the steady-state gas input rate in Btu/hr, including pilot gas, corrected to standard conditions of 60 °F and 30 in. Hg. Use measured values of gas temperature and pressure at the meter and barometric pressure to correct the metered gas flow rate to the above standard conditions. For oil units, measure and record the steady-state fuel input rate.

8.2 *Electrical input.* For furnaces and boilers, during the steady-state test, perform a single measurement of all of the electrical power involved in burner operation (PE), including energizing the ignition system, controls, gas valve or oil control valve, and draft inducer, if applicable. For boilers, the measurement of PE must include the boiler pump if so equipped. If the boiler pump does not operate during the measurement of PE, add the boiler pump nameplate power to the measurement of PE. If the boiler pump nameplate power is not available, use 0.13 kW.

For furnaces, during the steady-state test, perform a single measurement of the electrical power to the circulating air blower (BE). For hot water boilers, use the circulating water pump nameplate power for BE, or if the pump nameplate power is not available, use 0.13 kW.

8.3 *Input to interrupted ignition device.* For burners equipped with an interrupted ignition device, record the nameplate electric power used by the ignition device, PE_{IG}, or record that PE_{IG} = 0.4 kW if no nameplate power input is provided. Record the nameplate ignition device on-time interval, t_{IG}, or, if the nameplate does not provide the ignition device on-time interval, measure the on-time interval with a stopwatch at the beginning of the test, starting when the burner is turned on. Set t_{IG} = 0 and PE_{IG} = 0 if the device on-time interval is less than or equal to 5 seconds after the burner is on.

8.4 *Optional test procedures for condensing furnaces and boilers, measurement of condensate during the establishment of steady-state conditions.* For units with step-modulating or two-stage controls, conduct the test at both the maximum and reduced inputs. In lieu of collecting the condensate immediately after the steady state conditions have been reached as required by section 9.2 of ASHRAE 103–1993 (incorporated by reference, see §430.3), condensate may be collected during the establishment of steady state conditions as defined by section 9.1.2.1 of ASHRAE 103–1993. Perform condensate collection for at least 30 minutes. Measure condensate

mass immediately at the end of the collection period to prevent evaporation loss from the sample. Record fuel input for the 30-minute condensate collection test period. Observe and record fuel higher heating value (HHV), temperature, and pressures necessary for determining fuel energy input (Qc,ss). Measure the fuel quantity and HHV with errors no greater than 1%. The humidity for the room air shall at no time exceed 80%. Determine the mass of condensate for the establishment of steady state conditions (Mc,ss) in pounds by subtracting the tare container weight from the total container and condensate weight measured at the end of the 30-minute condensate collection test period.

8.5 *Cool-down test for gas- and oil-fueled gravity and forced-air central furnaces without stack dampers.* Turn off the main burner after completing steady-state testing, and measure the flue gas temperature by means of the thermocouple grid described in section 7.6 of ASHRAE 103–1993 (incorporated by reference, see §430.3) at 1.5 minutes ($T_{F,OFF}(t_3)$) and 9 minutes ($T_{F,OFF}(t_4)$) after shutting off the burner. When taking these temperature readings, the integral draft diverter must remain blocked and insulated, and the stack restriction must remain in place. On atmospheric systems with an integral draft diverter or draft hood and equipped with either an electromechanical inlet damper or an electromechanical flue damper that closes within 10 seconds after the burner shuts off to restrict the flow through the heat exchanger in the off-cycle, bypass or adjust the control for the electromechanical damper so that the damper remains open during the cool-down test.

For furnaces that employ post-purge, measure the length of the post-purge period with a stopwatch. Record the time from burner ''OFF'' to combustion blower ''OFF'' (electrically de-energized) as t_P. If the measured t_P is less than or equal to 30 seconds, set t_P at 0 and conduct the cool-down test as if there is no post-purge. If t_P is prescribed by the I&O manual or measured to be greater than 180 seconds, stop the combustion blower at 180 seconds and use that value for t_P. Measure the flue gas temperature by means of the thermocouple grid described in section 7.6 of ASHRAE 103–1993 at the end of the post-purge period, $t_P(T_{F,OFF}(t_P))$, and at the time (1.5 + t_P) minutes ($T_{F,OFF}(t_3)$) and (9.0 + t_P) minutes ($T_{F,OFF}(t_4)$) after the main burner shuts off.

8.6 *Cool-down test for gas- and oil-fueled gravity and forced-air central furnaces without stack dampers and with adjustable fan control.* For a furnace with adjustable fan control, measure the time delay between burner shutdown and blower shutdown, t^+. This time delay, t^+, will be 3.0 minutes for non-condensing furnaces or 1.5 minutes for condensing furnaces or until the supply air temperature drops to a value of 40 °F above the inlet air temperature, whichever results in the longest fan on-time. For a furnace without adjustable fan control or with the type of adjustable fan control whose range of adjustment does not allow for the time delay, t^+, specified above, bypass the fan control and manually control the fan to allow for the appropriate delay time as specified in section 9.5.1.2 of ASHRAE 103–1993 (incorporated by reference, see §430.3). For a furnace that employs a single motor to drive both the power burner and the indoor air circulating blower, the power burner and indoor air circulating blower must be stopped at the same time

8.7 *Cool-down test for gas- and oil-fueled boilers without stack dampers.* After steady-state testing has been completed, turn the main burner(s) ''OFF'' and measure the flue gas temperature at 3.75 minutes (temperature designated as $T_{F,OFF}(t_3)$) and 22.5 minutes (temperature designated as $T_{F,OFF}(t_4)$) after the burner shut-off using the thermocouple grid described in section 7.6 of ASHRAE 103–1993 (incorporated by reference, see §430.3).

a. During this off-period, for units that do not have pump delay after shut-off, do not allow any water to circulate through the hot water boilers.

b. For units that have pump delay on shut-off, except those having pump controls sensing water temperature, the unit control must stop the pump. Measure and record the time between burner shut-off and pump shut-off (t^+) to the nearest second.

c. For units having pump delay controls that sense water temperature, operate the pump for 15 minutes and record t^+ as 15 minutes. While the pump is operating, maintain the inlet water temperature and flow rate at the same values as used during the steady-state test, as specified in sections 9.1 and 8.4.2.3 of ASHRAE 103–1993 (incorporated by reference, see §430.3).

d. For boilers that employ post-purge, measure the length of the post-purge period with a stopwatch. Record the time from burner ''OFF'' to combustion blower ''OFF'' (electrically de-energized) as t_P. If t_P is prescribed by the I&O manual or measured to be greater than 180 seconds, stop the combustion blower at 180 seconds and use that value for t_P. Measure the flue gas temperature by means of the thermocouple grid described in section 7.6 of ASHRAE 103–1993 at the end of the post-purge period t_P ($T_{F,OFF}(t_P)$) and at (3.75 + t_P) minutes ($T_{F,OFF}(t_3)$) and (22.5 + t_P) minutes ($T_{F,OFF}(t_4)$) after the main burner shuts off. If the measured t_P is less than or equal to 30 seconds, record t_P as 0 and conduct the cool-down test as if there is no post-purge.

8.8 *Direct measurement of off-cycle losses testing method.* [Reserved.]

8.9 *Calculation options.* The rate of the flue gas mass flow through the furnace and the

factors D_P, D_F, and D_S are calculated by the equations in sections 11.6.1, 11.6.2, 11.6.3, 11.6.4, 11.7.1, and 11.7.2 of ASHRAE 103–1993 (incorporated by reference, see §430.3). On units whose design is such that there is no measurable airflow through the combustion chamber and heat exchanger when the burner(s) is (are) off (as determined by the optional test procedure in section 7.10 of this appendix), D_F and D_P may be set equal to 0.05.

8.10 *Optional test procedures for condensing furnaces and boilers that have no off-period flue losses.* For units that have applied the test method in section 7.10 of this appendix to determine that no measurable airflow exists through the combustion chamber and heat exchanger during the burner off-period and having post-purge periods of less than 5 seconds, the cool-down and heat-up tests specified in sections 9.5 and 9.6 of ASHRAE 103–1993 (incorporated by reference, see §430.3) may be omitted. In lieu of conducting the cool-down and heat-up tests, the tester may use the losses determined during the steady-state test described in section 9.1 of ASHRAE 103–1993 when calculating heating seasonal efficiency, $Effy_{HS}$.

8.11 *Measurement of electrical standby and off mode power.*

8.11.1 *Standby power measurement.* With all electrical auxiliaries of the furnace or boiler not activated, measure the standby power ($P_{W,SB}$) in accordance with the procedures in IEC 62301 (incorporated by reference, see §430.3), except that section 8.5, *Room Ambient Temperature,* of ASHRAE 103–1993 (incorporated by reference, see §430.3) and the voltage provision of section 8.2.1.4, *Electrical Supply,* of ASHRAE 103–1993 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 ASHRAE 103–1993 section 6.10, *Energy Flow Rate*. 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.

8.11.2 *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 section 8.5, *Room Ambient Temperature,* of ASHRAE 103–1993 (incorporated by reference, see §430.3) and the voltage provision of section 8.2.1.4, *Electrical Supply,* of ASHRAE 103–1993 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 ASHRAE 103–1993 section 6.10, *Energy Flow Rate*. 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.

9.0 *Nomenclature.* Nomenclature includes the nomenclature specified in section 10 of ASHRAE 103–1993 (incorporated by reference, see §430.3) and the following additional variables:

Eff_{motor} = Efficiency of power burner motor
PE_{IG} = Electrical power to the interrupted ignition device, kW
$R_{T,a} = R_{T,F}$ if flue gas is measured
$= R_{T,S}$ if stack gas is measured
$R_{T,F}$ = Ratio of combustion air mass flow rate to stoichiometric air mass flow rate
$R_{T,S}$ = Ratio of the sum of combustion air and relief air mass flow rate to stoichiometric air mass flow rate
t_{IG} = Electrical interrupted ignition device on-time, min.
$T_{a,SS,X} = T_{F,SS,X}$ if flue gas temperature is measured, °F
$= T_{S,SS,X}$ if stack gas temperature is measured, °F
y_{IG} = Ratio of electrical interrupted ignition device on-time to average burner on-time
y_P = Ratio of power burner combustion blower on-time to average burner on-time
E_{SO} = Average annual electric standby mode and off mode energy consumption, in kilowatt-hours
$P_{W,OFF}$ = Furnace or boiler off mode power, in watts
$P_{W,SB}$ = Furnace or boiler standby mode power, in watts

10.0 *Calculation of derived results from test measurements.* Perform calculations as specified in section 11 of ASHRAE 103–1993 (incorporated by reference, see §430.3), except for sections 11.5.11.1, 11.5.11.2, and appendices B and C; and as specified in sections 10.1 through 10.11 and Figure 1 of this appendix.

10.1 *Annual fuel utilization efficiency.* The annual fuel utilization efficiency (AFUE) is as defined in sections 11.2.12 (non-condensing systems), 11.3.12 (condensing systems), 11.4.12 (non-condensing modulating systems) and 11.5.12 (condensing modulating systems) of ASHRAE 103–1993 (incorporated by reference, see §430.3), except for the definition for the

term $Effy_{HS}$ in the defining equation for AFUE. $Effy_{HS}$ is defined as:

$Effy_{HS}$ = heating seasonal efficiency as defined in sections 11.2.11 (non-condensing systems), 11.3.11 (condensing systems), 11.4.11 (non-condensing modulating systems) and 11.5.11 (condensing modulating systems) of ASHRAE 103–1993, except that for condensing modulating systems sections 11.5.11.1 and 11.5.11.2 are replaced by sections 10.2 and 10.3 of this appendix. $Effy_{HS}$ is based on the assumptions that all weatherized warm air furnaces or boilers are located outdoors, that non-weatherized warm air furnaces are installed as isolated combustion systems, and that non-weatherized boilers are installed indoors.

10.2 *Part-load efficiency at reduced fuel input rate.* If the option in section 8.10 of this appendix is not employed, calculate the part-load efficiency at the reduced fuel input rate, $Effy_{U,R}$, for condensing furnaces and boilers equipped with either step-modulating or two-stage controls, expressed as a percent and defined as:

$$Effy_{U,H} = 100 - L_{L,A} + L_G - L_C - C_J L_J - \left[\frac{t_{ON}}{t_{ON} + \left(\frac{Q_P}{Q_{IN}}\right) t_{OFF}}\right](L_{S,ON} + L_{S,OFF} + L_{I,ON} + L_{I,OFF})$$

If the option in section 8.10 of this appendix is employed, calculate $Effy_{U,R}$ as follows:

$$Effy_{U,H} = 100 - L_{L,A} + L_G - L_C - C_J L_J - \left[\frac{t_{ON}}{t_{ON} + \left(\frac{Q_P}{Q_{IN}}\right) t_{OFF}}\right](C_S)(L_{S,SS})$$

Where:

$L_{L,A}$ = value as defined in section 11.2.7 of ASHRAE 103–1993 (incorporated by reference, see §430.3)

L_G = value as defined in section 11.3.11.1 of ASHRAE 103–1993, at reduced input rate,

L_C = value as defined in section 11.3.11.2 of ASHRAE 103–1993 at reduced input rate,

L_J = value as defined in section 11.4.8.1.1 of ASHRAE 103–1993 at maximum input rate,

t_{ON} = value as defined in section 11.4.9.11 of ASHRAE 103–1993,

Q_P = pilot fuel input rate determined in accordance with section 9.2 of ASHRAE 103–1993 in Btu/h,

Q_{IN} = value as defined in section 11.4.8.1.1 of ASHRAE 103–1993,

t_{OFF} = value as defined in section 11.4.9.12 of ASHRAE 103–1993 at reduced input rate,

$L_{S,ON}$ = value as defined in section 11.4.10.5 of ASHRAE 103–1993 at reduced input rate,

$L_{S,OFF}$ = value as defined in section 11.4.10.6 of ASHRAE 103–1993 at reduced input rate,

$L_{I,ON}$ = value as defined in section 11.4.10.7 of ASHRAE 103–1993 at reduced input rate,

$L_{I,OFF}$ = value as defined in section 11.4.10.8 of ASHRAE 103–1993 at reduced input rate,

C_J = jacket loss factor and equal to:
- = 0.0 for furnaces or boilers intended to be installed indoors
- = 1.7 for furnaces intended to be installed as isolated combustion systems
- = 2.4 for boilers (other than finned-tube boilers) intended to be installed as isolated combustion systems
- = 3.3 for furnaces intended to be installed outdoors
- = 4.7 for boilers (other than finned-tube boilers) intended to be installed outdoors
- = 1.0 for finned-tube boilers intended to be installed outdoors
- = 0.5 for finned-tube boilers intended to be installed in isolated combustion system applications

$L_{S,SS}$ = value as defined in section 11.4.6 of ASHRAE 103–1993 at reduced input rate,

C_S = value as defined in section 11.3.10.1 of ASHRAE 103–1993 at reduced input rate.

10.3 *Part-Load Efficiency at Maximum Fuel Input Rate.* If the option in section 8.10 of this appendix is not employed, calculate the part-load efficiency at maximum fuel input rate, $Effy_{U,H}$, for condensing furnaces and boilers equipped with two-stage controls, expressed as a percent and defined as:

$$Effy_{U,R} = 100 - L_{L,A} + L_G - L_C - C_J L_J - \left[\frac{t_{ON}}{t_{ON} + \left(\frac{Q_P}{Q_{IN}}\right) t_{OFF}}\right](L_{S,ON} + L_{S,OFF} + L_{I,ON} + L_{I,OFF})$$

If the option in section 8.10 of this appendix is employed, calculate $Effy_{U,H}$ as follows:

$$Effy_{U,R} = 100 - L_{L,A} + L_G - L_C - C_J L_J - \left[\frac{t_{ON}}{t_{ON} + \left(\frac{Q_P}{Q_{IN}}\right) t_{OFF}}\right](C_S)(L_{S,SS})$$

Where:

$L_{L,A}$ = value as defined in section 11.2.7 of ASHRAE 103–1993 (incorporated by reference, see §430.3),

L_G = value as defined in section 11.3.11.1 of ASHRAE 103–1 at maximum input rate,

L_C = value as defined in section 11.3.11.2 of ASHRAE 103–1993 at maximum input rate,

L_J = value as defined in section 11.4.8.1.1 of ASHRAE 103–1993 at maximum input rate,

t_{ON} = value as defined in section 11.4.9.11 of ASHRAE 103–1993,

Q_P = pilot fuel input rate determined in accordance with section 9.2 of ASHRAE 103–1993 in Btu/h,

Q_{IN} = value as defined in section 11.4.8.1.1 of ASHRAE 103–1993,

t_{OFF} = value as defined in section 11.4.9.12 of ASHRAE 103–1993 at maximum input rate,

$L_{S,ON}$ = value as defined in section 11.4.10.5 of ASHRAE 103–1993 at maximum input rate,

$L_{S,OFF}$ = value as defined in section 11.4.10.6 of ASHRAE 103–1993 at maximum input rate,

$L_{I,ON}$ = value as defined in section 11.4.10.7 of ASHRAE 103–1993 at maximum input rate,

$L_{I,OFF}$ = value as defined in section 11.4.10.8 of ASHRAE 103–1993 at maximum input rate,

C_J = value as defined in section 10.2 of this appendix,

$L_{S,SS}$ = value as defined in section 11.4.6 of ASHRAE 103–1993 at maximum input rate,

C_S = value as defined in section 11.4.10.1 of ASHRAE 103–1993 at maximum input rate.

10.4 *National average burner operating hours, average annual fuel energy consumption, and average annual auxiliary electrical energy consumption for gas or oil furnaces and boilers.*

10.4.1 *National average number of burner operating hours.* For furnaces and boilers equipped with single-stage controls, the national average number of burner operating hours is defined as:

BOH_{SS} = 2,080 (0.77) (A) DHR − 2,080 (B)

Where:

2,080 = national average heating load hours

0.77 = adjustment factor to adjust the calculated design heating requirement and heating load hours to the actual heating load experienced by the heating system

A = 100,000/[341,300 (y_P PE + y_{IG} PE_{IG} + y BE) + (Q_{IN} − Q_P) $Effy_{HS}$], for forced draft unit, indoors

= 100,000/[341,300 (y_P PE Eff_{motor} + y_{IG} PE_{IG} + y BE) + (Q_{IN} − Q_P) $Effy_{HS}$], for forced draft unit, isolated combustion system,

= 100,000/[341,300 (y_P PE (1 − Eff_{motor}) + y_{IG} PE_{IG} + y BE) + (Q_{IN} − Q_P) $Effy_{HS}$], for induced draft unit, indoors, and

= 100,000/[341,300 (y_{IG} PE_{IG} + y BE) + (Q_{IN} − Q_P) $Effy_{HS}$], for induced draft unit, isolated combustion system.

DHR = typical design heating requirements as listed in Table 8 (in kBtu/h) of ASHRAE 103–1993 (incorporated by reference, see §430.3), using the proper value of Q_{OUT} defined in 11.2.8.1 of ASHRAE 103–1993.

B = 2 Q_P ($Effy_{HS}$) (A)/100,000

Where:

Eff_{motor} = nameplate power burner motor efficiency provided by the manufacturer,

= 0.50, an assumed default power burner efficiency if not provided by the manufacturer.

100,000 = factor that accounts for percent and kBtu

y_P = ratio of induced or forced draft blower on-time to average burner on-time, as follows:

1 for units without post-purge;

1 + (t_P/3.87) for single stage furnaces with post purge;

1 + (t_P/10) for two-stage and step modulating furnaces with post purge;

1 + (t_P/9.68) for single stage boilers with post purge; or

1 + (t_P/15) for two stage and step modulating boilers with post purge.

PE = all electrical power related to burner operation at full load steady-state operation, including electrical ignition device if energized, controls, gas valve or oil control valve, draft inducer, and boiler pump, as determined in section 8.2 of this appendix.

y_{IG} = ratio of burner interrupted ignition device on-time to average burner on-time, as follows:

0 for burners not equipped with interrupted ignition device;

(t_{IG}/3.87) for single-stage furnaces or boilers;

(t_{IG}/10) for two-stage and step modulating furnaces;

(t_{IG}/9.68) for single stage boilers; or

(t_{IG}/15) for two stage and step modulating boilers.

PE_{IG} = electrical input rate to the interrupted ignition device on burner (if employed), as defined in section 8.3 of this appendix

y = ratio of blower or pump on-time to average burner on-time, as follows:

1 for furnaces without fan delay or boilers without a pump delay;

1 + ($t^+ - t^-$)/3.87 for single-stage furnaces with fan delay;

1 + ($t^+ - t^-$)/10 for two-stage and step modulating furnaces with fan delay;

1 + (t^+/9.68) for single-stage boilers with pump delay;

1 + (t^+/1.5) for two-stage and step modulating boilers with pump delay.

BE = circulating air fan or water pump electrical energy input rate at full-load steady-state operation as defined in section 8.2 of this appendix.

t_P = post-purge time as defined in section 8.5 (furnace) or section 8.7 (boiler) of this appendix

= 0 if t_P is equal to or less than 30 second

t_{IG} = on-time of the burner interrupted ignition device, as defined in section 8.3 of this appendix

Q_{IN} = as defined in section 11.2.8.1 of ASHRAE 103–1993

Q_P = as defined in section 11.2.11 of ASHRAE 103–1993

$Effy_{HS}$ = as defined in section 11.2.11 (non-condensing systems) or section 11.3.11.3 (condensing systems) of ASHRAE 103–1993, percent, and calculated on the basis of:

isolated combustion system installation, for non-weatherized warm air furnaces;

indoor installation, for non-weatherized boilers; or

outdoor installation, for furnaces and boilers that are weatherized.

2 = ratio of the average length of the heating season in hours to the average heating load hours

t^+ = delay time between burner shutoff and the blower or pump shutoff measured as defined in section 9.5.1.2 of ASHRAE 103–1993 (furnace) or section 8.7 of this appendix (boiler).

t^- = as defined in section 9.6.1 of ASHRAE 103–1993

10.4.1.1 For furnaces and boilers equipped with two stage or step modulating controls the average annual energy used during the heating season, E_M, is defined as:

$E_M = (Q_{IN} - Q_P)\ BOH_{SS} + (8{,}760 - 4{,}600)\ Q_P$

Where:

Q_{IN} = as defined in 11.4.8.1.1 of ASHRAE 103–1993 (incorporated by reference, see § 430.3)

Q_P = as defined in 11.4.12 of ASHRAE 103–1993

BOH_{SS} = as defined in section 10.4.1 of this appendix, in which the weighted $Effy_{HS}$ as defined in 11.4.11.3 or 11.5.11.3 of ASHRAE 103–1993 is used for calculating the values of A and B, the term DHR is based on the value of Q_{OUT} defined in 11.4.8.1.1 or 11.5.8.1.1 of ASHRAE 103–1993, and the term ($y_P PE + y_{IG} PE_{IG} + yBE$) in the factor A is increased by the factor R, which is defined as:

R = 2.3 for two stage controls

= 2.3 for step modulating controls when the ratio of minimum-to-maximum output is greater than or equal to 0.5

= 3.0 for step modulating controls when the ratio of minimum-to-maximum output is less than 0.5

A = 100,000/[341,300 (y_P PE + y_{IG} PE_{IG} + y BE) R + (Q_{IN} − Q_P) $Effy_{HS}$], for forced draft unit, indoors

= 100,000/[341,300 (y_P PE Eff_{motor} + y_{IG} PE_{IG} + y BE) R + (Q_{IN} − Q_P) $Effy_{HS}$], for forced draft unit, isolated combustion system,

= 100,000/[341,300 (y_P PE (1 − Eff_{motor}) + y_{IG} PE_{IG} + y BE) R + (Q_{IN} − Q_P) $Effy_{HS}$], for induced draft unit, indoors, and

= 100,000/[341,300 (y_{IG} PE_{IG} + y BE) R + (Q_{IN} − Q_P) $Effy_{HS}$], for induced draft unit, isolated combustion system.

Where:

Eff_{motor} = nameplate power burner motor efficiency provided by the manufacturer,

= 0.50, an assumed default power burner efficiency if not provided by the manufacturer.

$Effy_{HS}$ = as defined in 11.4.11.3 or 11.5.11.3 of ASHRAE 103–1993, and calculated on the basis of:

isolated combustion system installation, for non-weatherized warm air furnaces;

indoor installation, for non-weatherized boilers; or

outdoor installation, for furnaces and boilers that are weatherized.

8,760 = total number of hours per year

4,600 = as defined in 11.4.12 of ASHRAE 103–1993

10.4.1.2 For furnaces and boilers equipped with two-stage or step-modulating controls, the national average number of burner operating hours at the reduced operating mode (BOH_R) is defined as:

$BOH_R = X_R\ E_M/Q_{IN,R}$

Where:

X_R = as defined in 11.4.8.7 of ASHRAE 103–1993 (incorporated by reference, see § 430.3)

E_M = as defined in section 10.4.1.1 of this appendix

$Q_{IN,R}$ = as defined in 11.4.8.1.2 of ASHRAE 103–1993

10.4.1.3 For furnaces and boilers equipped with two-stage controls, the national average number of burner operating hours at the maximum operating mode (BOH_H) is defined as:

$BOH_H = X_H\ E_M/Q_{IN}$

Where:

X_H = as defined in 11.4.8.6 of ASHRAE 103–1993 (incorporated by reference, see §430.3)
E_M = as defined in section 10.4.1.1 of this appendix
Q_{IN} = as defined in section 11.4.8.1.1 of ASHRAE 103–1993

10.4.1.4 For furnaces and boilers equipped with step-modulating controls, the national average number of burner operating hours at the modulating operating mode (BOH_M) is defined as:

$BOH_M = X_H E_M/Q_{IN,M}$

Where:

X_H = as defined in 11.4.8.6 of ASHRAE 103–1993 (incorporated by reference, see §430.3)
E_M = as defined in section 10.4.1.1 of this appendix
$Q_{IN,M} = Q_{OUT,M}/(Effy_{SS,M}/100)$
$Q_{OUT,M}$ = as defined in 11.4.8.10 or 11.5.8.10 of ASHRAE 103–1993, as appropriate
$Effy_{SS,M}$ = as defined in 11.4.8.8 or 11.5.8.8 of ASHRAE 103–1993, as appropriate, in percent
100 = factor that accounts for percent

10.4.2 *Average annual fuel energy consumption for gas or oil fueled furnaces or boilers.* For furnaces or boilers equipped with single-stage controls, the average annual fuel energy consumption (E_F) is expressed in Btu per year and defined as:

$E_F = BOH_{SS} (Q_{IN} - Q_P) + 8{,}760\ Q_P$

Where:

BOH_{SS} = as defined in section 10.4.1 of this appendix
Q_{IN} = as defined in section 11.2.8.1 of ASHRAE 103–1993 (incorporated by reference, see §430.3)
Q_P = as defined in section 11.2.11 of ASHRAE 103–1993
8,760 = as defined in section 10.4.1.1 of this appendix

10.4.2.1 For furnaces or boilers equipped with either two-stage or step modulating controls, E_F is defined as:

$E_F = E_M + 4{,}600\ Q_P$

Where:

E_M = as defined in section 10.4.1.1 of this appendix
4,600 = as defined in section 11.4.12 of ASHRAE 103–1993
Q_P = as defined in section 11.2.11 of ASHRAE 103–1993

10.4.3 *Average annual auxiliary electrical energy consumption for gas or oil-fueled furnaces or boilers.* For furnaces and boilers equipped with single-stage controls, the average annual auxiliary electrical consumption (E_{AE}) is expressed in kilowatt-hours and defined as:

$E_{AE} = BOH_{SS} (y_P\ PE + y_{IG}\ PE_{IG} + yBE) + E_{SO}$

Where:

BOH_{SS} = as defined in section 10.4.1 of this appendix
y_P = as defined in section 10.4.1 of this appendix
PE = as defined in section 10.4.1 of this appendix
y_{IG} = as defined in section 10.4.1 of this appendix
PE_{IG} = as defined in section 10.4.1 of this appendix
y = as defined in section 10.4.1 of this appendix
BE = as defined in section 10.4.1 of this appendix
E_{SO} = as defined in section 10.11 of this appendix

10.4.3.1 For furnaces or boilers equipped with two-stage controls, E_{AE} is defined as:

$E_{AE} = BOH_R (y_P\ PE_R + y_{IG}\ PE_{IG} + yBE_R) + BOH_H (y_P\ PE_H + y_{IG}\ PE_{IG} + y\ BE_H) + E_{SO}$

Where:

BOH_R = as defined in section 10.4.1.2 of this appendix
y_P = as defined in section 10.4.1 of this appendix
PE_R = as defined in section 8.2 of this appendix and measured at the reduced fuel input rate
y_{IG} = as defined in section 10.4.1 of this appendix
PE_{IG} = as defined in section 10.4.1 of this appendix
y = as defined in section 10.4.1 of this appendix
BE_R = as defined in section 8.2 of this appendix and measured at the reduced fuel input rate
BOH_H = as defined in section 10.4.1.3 of this appendix
PE_H = as defined in section 8.2 of this appendix and measured at the maximum fuel input rate
BE_H = as defined in section 8.2 of this appendix and measured at the maximum fuel input rate
E_{SO} = as defined in section 10.11 of this appendix

10.4.3.2 For furnaces or boilers equipped with step-modulating controls, E_{AE} is defined as:

$E_{AE} = BOH_R (y_P\ PE_R + y_{IG}\ PE_{IG} + y\ BE_R) + BOH_M (y_P\ PE_H + y_{IG}\ PE_{IG} + y\ BE_H) + E_{SO}$

Where:

BOH_R = as defined in section 10.4.1.2 of this appendix
y_P = as defined in section 10.4.1 of this appendix
PE_R = as defined in section 8.2 of this appendix and measured at the reduced fuel input rate
y_{IG} = as defined in section 10.4.1 of this appendix
PE_{IG} = as defined in section 10.4.1 of this appendix

y = as defined in section 10.4.1 of this appendix
BE_R = as defined in section 8.2 of this appendix and measured at the reduced fuel input rate
BOH_M = as defined in 10.4.1.4 of this appendix
PE_H = as defined in section 8.2 of this appendix and measured at the maximum fuel input rate
BE_H = as defined in section 8.2 of this appendix and measured at the maximum fuel input rate
E_{SO} = as defined in section 10.11 of this appendix

10.5 *Average annual electric energy consumption for electric furnaces or boilers.* For electric furnaces and boilers, the average annual electrical energy consumption (E_E) is expressed in kilowatt-hours and defined as:

$E_E = 100\ (2{,}080)\ (0.77)\ DHR/(3.412\ AFUE) + E_{SO}$

Where:

100 = to express a percent as a decimal
2,080 = as defined in section 10.4.1 of this appendix
0.77 = as defined in section 10.4.1 of this appendix
DHR = as defined in section 10.4.1 of this appendix
3.412 = conversion factor from watt-hours to Btu
AFUE = as defined in section 11.1 of ASHRAE 103–1993 (incorporated by reference, see §430.3), in percent, and calculated on the basis of:
isolated combustion system installation, for non-weatherized warm air furnaces;
indoor installation, for non-weatherized boilers; or
outdoor installation, for furnaces and boilers that are weatherized.
E_{SO} = as defined in section 10.11 of this appendix.

10.6 *Energy factor.*

10.6.1 *Energy factor for gas or oil furnaces and boilers.* Calculate the energy factor, EF, for gas or oil furnaces and boilers defined as, in percent:

$EF = (E_F - 4{,}600\ (Q_P))(Effy_{HS})/(E_F + 3{,}412\ (E_{AE}))$

Where:

E_F = average annual fuel consumption as defined in section 10.4.2 of this appendix
4,600 = as defined in section 11.4.12 of ASHRAE 103–1993 (incorporated by reference, see §430.3)
Q_P = pilot fuel input rate determined in accordance with section 9.2 of ASHRAE 103–1993 in Btu/h
$Effy_{HS}$ = annual fuel utilization efficiency as defined in sections 11.2.11, 11.3.11, 11.4.11 or 11.5.11 of ASHRAE 103–1993, in percent, and calculated on the basis of:
isolated combustion system installation, for non-weatherized warm air furnaces;
indoor installation, for non-weatherized boilers; or
outdoor installation, for furnaces and boilers that are weatherized.
3,412 = conversion factor from kW to Btu/h
E_{AE} = as defined in section 10.4.3 of this appendix

10.6.2 *Energy factor for electric furnaces and boilers.* The energy factor, EF, for electric furnaces and boilers is defined as:

EF = AFUE

Where:

AFUE = annual fuel utilization efficiency as defined in section 10.4.3 of this appendix, in percent

10.7 *Average annual energy consumption for furnaces and boilers located in a different geographic region of the United States and in buildings with different design heating requirements.*

10.7.1 *Average annual fuel energy consumption for gas or oil-fueled furnaces and boilers located in a different geographic region of the United States and in buildings with different design heating requirements.* For gas or oil-fueled furnaces and boilers, the average annual fuel energy consumption for a specific geographic region and a specific typical design heating requirement (E_{FR}) is expressed in Btu per year and defined as:

$E_{FR} = (E_F - 8{,}760\ Q_P)\ (HLH/2{,}080) + 8{,}760\ Q_P$

Where:

E_F = as defined in section 10.4.2 of this appendix
8,760 = as defined in section 10.4.1.1 of this appendix
Q_P = as defined in section 11.2.11 of ASHRAE 103–1993 (incorporated by reference, see §430.3)
HLH = heating load hours for a specific geographic region determined from the heating load hour map in Figure 1 of this appendix
2,080 = as defined in section 10.4.1 of this appendix

10.7.2 *Average annual auxiliary electrical energy consumption for gas or oil-fueled furnaces and boilers located in a different geographic region of the United States and in buildings with different design heating requirements.* For gas or oil-fueled furnaces and boilers, the average annual auxiliary electrical energy consumption for a specific geographic region and a specific typical design heating requirement (E_{AER}) is expressed in kilowatt-hours and defined as:

$E_{AER} = (E_{AE} - E_{SO})\ (HLH/2080) + E_{SOR}$

Where:

E_{AE} = as defined in section 10.4.3 of this appendix
E_{SO} = as defined in section 10.11 of this appendix
HLH = as defined in section 10.7.1 of this appendix

2,080 = as defined in section 10.4.1 of this appendix

E_{SOR} = as defined in section 10.7.3 of this appendix.

10.7.3 *Average annual electric energy consumption for electric furnaces and boilers located in a different geographic region of the United States and in buildings with different design heating requirements.* For electric furnaces and boilers, the average annual electric energy consumption for a specific geographic region and a specific typical design heating requirement (E_{ER}) is expressed in kilowatt-hours and defined as:

$E_{ER} = 100\ (0.77)\ DHR\ HLH/(3.412\ AFUE) + E_{SOR}$

Where:

100 = as defined in section 10.4.3 of this appendix

0.77 = as defined in section 10.4.1 of this appendix

DHR = as defined in section 10.4.1 of this appendix

HLH = as defined in section 10.7.1 of this appendix

3.412 = as defined in section 10.4.3 of this appendix

AFUE = as defined in section 10.4.3 of this appendix

E_{SOR} = E_{SO} as defined in section 10.11 of this appendix, except that in the equation for E_{SO}, the term BOH is multiplied by the expression (HLH/2080) to get the appropriate regional accounting of standby mode and off mode loss.

10.8 *Annual energy consumption for mobile home furnaces*

10.8.1 *National average number of burner operating hours for mobile home furnaces (BOH_{SS}).* BOH_{SS} is the same as in section 10.4.1 of this appendix, except that the value of $Effy_{HS}$ in the calculation of the burner operating hours, BOH_{SS}, is calculated on the basis of a direct vent unit with system number 9 or 10.

10.8.2 *Average annual fuel energy for mobile home furnaces (E_F).* E_F is same as in section 10.4.2 of this appendix except that the burner operating hours, BOH_{SS}, is calculated as specified in section 10.8.1 of this appendix.

10.8.3 *Average annual auxiliary electrical energy consumption for mobile home furnaces (E_{AE}).* E_{AE} is the same as in section 10.4.3 of this appendix, except that the burner operating hours, BOH_{SS}, is calculated as specified in section 10.8.1 of this appendix.

10.9 *Calculation of sales weighted average annual energy consumption for mobile home furnaces.* To reflect the distribution of mobile homes to geographical regions with average HLH_{MHF} values different from 2,080, adjust the annual fossil fuel and auxiliary electrical energy consumption values for mobile home furnaces using the following adjustment calculations.

10.9.1 For mobile home furnaces, the sales weighted average annual fossil fuel energy consumption is expressed in Btu per year and defined as:

$E_{F,MHF} = (E_F - 8{,}760\ Q_P)\ HLH_{MHF}/2{,}080 + 8{,}760\ Q_P$

Where:

E_F = as defined in section 10.8.2 of this appendix

8,760 = as defined in section 10.4.1.1 of this appendix

Q_P = as defined in section 10.2 of this appendix

HLH_{MHF} = 1880, sales weighted average heating load hours for mobile home furnaces

2,080 = as defined in section 10.4.1 of this appendix

10.9.2 For mobile home furnaces, the sales-weighted-average annual auxiliary electrical energy consumption is expressed in kilowatt-hours and defined as:

$E_{AE,MHF} = E_{AE}\ HLH_{MHF}/2{,}080$

Where:

E_{AE} = as defined in section 10.8.3 of this appendix

HLH_{MHF} = as defined in section 10.9.1 of this appendix

2,080 = as defined in section 10.4.1 of this appendix

10.10 *Direct determination of off-cycle losses for furnaces and boilers equipped with thermal stack dampers.* [Reserved.]

10.11 *Average annual electrical standby mode and off mode energy consumption.* Calculate the annual electrical standby mode and off mode energy consumption (E_{SO}) in kilowatt-hours, defined as:

$E_{SO} = (P_{W,SB}\ (4160 - BOH) + 4600\ P_{W,OFF})\ K$

Where:

$P_{W,SB}$ = furnace or boiler standby mode power, in watts, as measured in section 8.11.1 of this appendix

4,160 = average heating season hours per year

BOH = total burner operating hours as calculated in section 10.4 of this appendix for gas or oil-fueled furnaces or boilers. Where for gas or oil-fueled furnaces and boilers equipped with single-stage controls, BOH = BOH_{SS}; for gas or oil-fueled furnaces and boilers equipped with two-stage controls, BOH = (BOH_R + BOH_H); and for gas or oil-fueled furnaces and boilers equipped with step-modulating controls, BOH = (BOH_R + BOH_M). For electric furnaces and boilers, BOH = $100(2080)(0.77)DHR/(E_{in}\ 3.412(AFUE))$

4,600 = as defined in section 11.4.12 of ASHRAE 103–1993 (incorporated by reference, see § 430.3)

$P_{W,OFF}$ = furnace or boiler off mode power, in watts, as measured in section 8.11.2 of this appendix

K = 0.001 kWh/Wh, conversion factor from watt-hours to kilowatt-hours

Where:

100 = to express a percent as a decimal

2,080 = as defined in section 10.4.1 of this appendix

0.77 = as defined in section 10.4.1 of this appendix

DHR = as defined in section 10.4.1 of this appendix

E_{in} = steady-state electric rated power, in kilowatts, from section 9.3 of ASHRAE 103–1993

3.412 = as defined in section 10.4.3 of this appendix

AFUE = as defined in section 11.1 of ASHRAE 103–1993 in percent

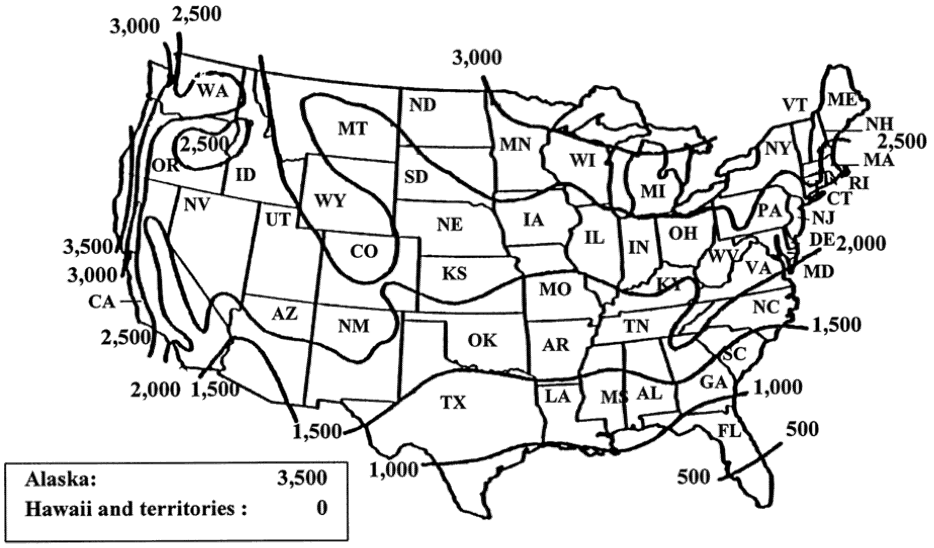

FIGURE 1- HEATING LOAD HOURS (HLH) FOR THE UNITED STATES

[81 FR 2647, Jan. 15, 2016]

APPENDIX O TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF VENTED HOME HEATING EQUIPMENT

NOTE: On and after July 6, 2015, any representations made with respect to the energy use or efficiency of vented home heating equipment must be made in accordance with the results of testing pursuant to this appendix. On and after this date, if a manufacturer makes representations of standby mode and off mode energy consumption, then testing must also include the provisions of this appendix related to standby mode and off mode energy consumption. Until July 6, 2015, manufacturers must test vented home heating equipment in accordance with this appendix or appendix O as it appeared at 10 CFR part 430, subpart B revised as of January 1, 2014. Any representations made with respect to the energy use or efficiency of such vented home heating equipment must be made in accordance with whichever version is selected. DOE notes that, because testing under this appendix O is required as of July 6, 2015, manufacturers may wish to begin using this test procedure immediately.

1.0 Definitions

1.1 ''Active mode'' means the condition during the heating season in which the vented heater is connected to the power source, and either the burner or any electrical auxiliary is activated.

1.2 ''Air shutter'' means an adjustable device for varying the size of the primary air