Pt. 430, Subpl. B, App. O

4,600 = average non-heating season hours per year
K = 0.001 kWh/Wh, conversion factor for watt-hours to kilowatt-hours
BOH = total burner operating hours as calculated in section 10.2 for gas or oil-fueled furnaces or boilers. Where for gas or oil-fueled furnaces and boilers equipped with single-stage controls, BOH = BOHg; for gas or oil-fueled furnaces and boilers equipped with two-stage controls, BOH = (BOHg + BOHn); and for gas or oil-fueled furnaces and boilers equipped with step-modulating controls, BOH = 100(2080(0.77)DHR/(E3.412(AFUE)))

Where:

100 = to express a percent as a decimal
2,080 = as specified in 10.2.1 of this appendix
DHR = as defined in 10.2.1 of this appendix
3.412 = conversion to express energy in terms of K BTUs instead of kilowatt-hours
AFUE = as defined in 11.1 of ANSI/ASHRAE Standard 103—1993 (incorporated by reference, see §430.3) in percent
E3.412 = Steady-state electric rated power, in kilowatts, from section 9.3 of ANSI/ASHRAE Standard 103—1993 (incorporated by reference, see §430.3).


EFFECTIVE DATE NOTE: At 77 FR 76839, Dec. 17, 2012, appendix N was amended as follows, effective Jan. 30, 2013.

1.0 Definitions

1.1 “Air shutter” means an adjustable device for varying the size of the primary air inlet(s) to the combustion chamber power burner.
1.2 “Air tube” means a tube which carries combustion air from the burner fan to the burner nozzle for combustion.
1.3 “Barometric draft regulator or barometric damper” means a mechanical device designed to maintain a constant draft in a vented heater.
1.4 “Draft hood” means an external device which performs the same function as an integral draft diverter, as defined in section 1.17 of this appendix.
1.5 “Electro-mechanical stack damper” means a type of stack damper which is operated by electrical and/or mechanical means.
1.6 “Excess air” means air which passes through the combustion chamber and the vented heater flues in excess of that which is theoretically required for complete combustion.
1.7 “Flue” means a conduit between the flue outlet of a vented heater and the integral draft diverter, draft hood, barometric damper or vent terminal through which the flue gases pass prior to the point of draft relief.
1.8 “Flue damper” means a device installed between the furnace and the integral draft diverter, draft hood, barometric draft regulator, or vent terminal which is not equipped with a draft control device, designed to open the venting system when the appliance is in operation and to close the venting system when the appliance is in a standby condition.

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

Published at 77 FR 74571, Dec. 17, 2012.

1.0 Definitions

1.1 “Air shutter” means an adjustable device for varying the size of the primary air inlet(s) to the combustion chamber power burner.
1.2 “Air tube” means a tube which carries combustion air from the burner fan to the burner nozzle for combustion.
1.3 “Barometric draft regulator or barometric damper” means a mechanical device designed to maintain a constant draft in a vented heater.
1.4 “Draft hood” means an external device which performs the same function as an integral draft diverter, as defined in section 1.17 of this appendix.
1.5 “Electro-mechanical stack damper” means a type of stack damper which is operated by electrical and/or mechanical means.
1.6 “Excess air” means air which passes through the combustion chamber and the vented heater flues in excess of that which is theoretically required for complete combustion.
1.7 “Flue” means a conduit between the flue outlet of a vented heater and the integral draft diverter, draft hood, barometric damper or vent terminal through which the flue gases pass prior to the point of draft relief.
1.8 “Flue damper” means a device installed between the furnace and the integral draft diverter, draft hood, barometric draft regulator, or vent terminal which is not equipped with a draft control device, designed to open the venting system when the appliance is in operation and to close the venting system when the appliance is in a standby condition.
Department of Energy
Pt. 430, Subpt. B, App. O

1.9 “Flue gases” means reaction products resulting from the combustion of a fuel with the oxygen of the air, including the inerts and any excess air.

1.10 “Flue losses” means the sum of sensible and latent heat losses above room temperature of the flue gases leaving a vented heater.

1.11 “Flue outlet” means the opening provided in a vented heater for the exhaust of the flue gases from the combustion chamber.

1.12 “Heat input” ($Q_h$) means the rate of energy supplied in a fuel to a vented heater operating under steady-state conditions, expressed in Btu’s per hour. It includes any input energy to the pilot light and is obtained by multiplying the measured rate of fuel consumption by the measured higher heating value of the fuel.

1.13 “Heating capacity” ($Q_{hm}$) means the rate of useful heat output from a vented heater, operating under steady-state conditions, expressed in Btu’s per hour. For room and wall heaters, it is obtained by multiplying the “heat input” ($Q_h$) by the steady-state efficiency ($\eta_w$) divided by 100. For floor furnaces, it is obtained by multiplying ($A$) the “heat input” ($Q_h$) by ($B$) the steady-state efficiency divided by 100, minus the quantity ($2.8B$) ($L_j$) divided by 100, where $L_j$ is the jacket loss as determined in section 3.2 of this appendix.

1.14 “Higher heating value” (HHV) means the heat produced per unit of fuel when complete combustion takes place at constant temperature and pressure and the products of combustion are cooled to the initial temperature of the fuel and air and when the water vapor formed during combustion is condensed. The higher heating value is usually expressed in Btu’s per pound, Btu’s per cubic foot for gaseous fuels, or Btu’s per gallon for liquid fuel.

1.15 “Induced draft” means a method of drawing air into the combustion chamber by mechanical means.

1.16 “Infiltration parameter” means that portion of unconditioned outside air drawn into the heated space as a consequence of loss of conditioned air through the exhaust system of a vented heater.

1.17 “Integral draft diverter” means a device which is an integral part of a vented heater, designed to: (1) Provide for the exhaustion of the products of combustion in the event of no draft, back draft, or stoppage beyond the draft diverter, (2) prevent a back draft from entering the vented heater, and (3) neutralize the stack action of the chimney or gas vent upon the operation of the vented heater.

1.18 “Manually controlled vented heaters” means either gas or oil fueled vented heaters equipped with thermostats.

1.19 “Modulating control” means either a step-modulating or two-stage control.

1.20 “Power burner” means a vented heater burner which supplies air for combustion at a pressure exceeding atmospheric pressure, or a burner which depends on the draft induced by a fan incorporated in the furnace for proper operation.

1.21 “Reduced heat input rate” means the factory adjusted lowest reduced heat input rate for vented home heating equipment equipped with either two stage thermostats or step-modulating thermostats.

1.22 “Single stage thermostat” means a thermostat that cycles a burner at the maximum heat input rate and off.

1.23 “Stack” means the portion of the exhaust system downstream of the integral draft diverter, draft hood or barometric draft regulator.

1.24 “Stack damper” means a device installed downstream of the integral draft diverter, draft hood, or barometric draft regulator, designed to open the venting system when the appliance is in operation and to close off the venting system when the appliance is in the standby condition.

1.25 “Stack gases” means the flue gases combined with dilution air that enters at the integral draft diverter, draft hood or barometric draft regulator.

1.26 “Steady-state conditions for vented home heating equipment” means equilibrium conditions as indicated by temperature variations of not more than 5 °F (2.8°C) in the flue gas temperature for units equipped with draft hoods, barometric draft regulators or direct vent systems, in three successive readings taken 15 minutes apart or not more than 3 °F (1.7°C) in the stack gas temperature for units equipped with integral draft diverters in three successive readings taken 15 minutes apart.

1.27 “Step-modulating control” means a control that either cycles off and on at the low input if the heating load is light, or gradually, increases the heat input to meet any higher heating load that cannot be met with the low firing rate.

1.28 “Thermal stack damper” means a type of stack damper which is dependent for operation exclusively upon the direct conversion of thermal energy of the stack gases into movement of the damper plate.

1.29 “Two stage control” means a control that either cycles a burner at the reduced heat input rate and off or cycles a burner at the maximum heat input rate and off.

1.30 “Vaporizing-type oil burner” means a device with an oil vaporizing bowl or other receptacle designed to operate by vaporizing liquid fuel oil by the heat of combustion and mixing the vaporized fuel with air.

1.31 “Vent/air intake terminal” means a device which is located on the outside of a building and is connected to a vented heater by a system of conduits. It is composed of an air intake terminal through which the air for combustion is taken from the outside atmosphere and a vent terminal from which flue gases are discharged.
1.32 “Vent limiter” means a device which limits the flow of air from the atmospheric diaphragm chamber of a gas pressure regulator to the atmosphere. A vent limiter may be a limiting orifice or other limiting device.

1.33 “Vent pipe” means the passages and conduits in a direct vent system through which gases pass from the combustion chamber to the outdoor air.

2.0 Testing conditions.

2.1 Installation of test unit.


2.1.2 Vented floor furnaces. Install vented floor furnaces for test as specified in sections 35.1 through 35.5 of UL–729–1976.

2.1.3 Vented room heaters. Install in accordance with manufacturer’s instructions.

2.2 Flue and stack requirements.

2.2.1 Gas fueled vented home heating equipment employing integral draft diverters and draft hoods (excluding direct vent systems). Attach to, and vertically above the outlet of gas fueled vented home heating equipment employing draft diverters or draft hoods with vertically discharging outlets, a five (5) foot long test stack having a cross sectional area the same size as the draft diverter outlet.

Attach to the outlet of vented heaters having a horizontally discharging draft diverter or draft hood outlet a 90 degree elbow, and a five (5) foot long vertical test stack. A horizontal section of pipe may be used on the floor furnace between the diverter and the elbow if necessary to clear any framing used in the installation. Use the minimum length of pipe possible for this section. Use stack, elbow, and horizontal section with same cross sectional area as the diverter outlet.


2.2.3 Direct vent systems. Have the exhaust/air intake system supplied by the manufacturer in place during all tests. Test units intended for installation with a variety of vent pipes with the minimum length recommended by the manufacturer. Do not connect a heater employing a direct vent system to a chimney or induced draft source. Vent the gas solely on the provision for venting incorporated in the heater and the vent/air intake system supplied with it.

2.3 Fuel supply.

2.3.1 Natural gas. For a vented heater utilizing natural gas, maintain the gas supply to the unit under test at a normal inlet test pressure immediately ahead of all controls at 7 to 10 inches water column. Maintain the regulator outlet pressure at normal test pressure approximately at that recommended by the manufacturer. Use natural gas having a specific gravity of approximately 0.65 and a higher heating value within ±5 percent of 1,025 Btu’s per standard cubic foot. Determine the actual higher heating value in Btu’s per standard cubic foot for the natural gas to be used in the test with an error no greater than one percent.

2.3.2 Propane gas. For a vented heater utilizing propane gas, maintain the gas supply to the unit under test at a normal inlet pressure of 11 to 13 inches water column and a specific gravity of approximately 1.58. Maintain the regulator outlet pressure on units so equipped, approximately at that recommended by the manufacturer. Use propane having a specific gravity of approximately 1.58 and a higher heating value within ±5 percent of 2,500 Btu’s per standard cubic foot. Determine the actual higher heating value in Btu’s per standard cubic foot for the propane to be used in the test with an error no greater than one percent.

2.3.3 Other test gases. Use other test gases with characteristics as described in section 2.2, table VII, of ANSI Standard Z21.11.1–1974. Use gases with a measured higher heating value within ±5 percent of the values specified in the above ANSI standard. Determine the actual higher heating value of the gas used in the test with an error no greater than one percent.

2.3.4 Oil supply. For a vented heater utilizing fuel oil, use No. 1, fuel oil (kerosene) for vaporizing-type burners and either No. 1 or No. 2 fuel oil, as specified by the manufacturer, for mechanical atomizing type burners. Use No. 1 fuel oil with a viscosity meeting the specifications as specified in UL–730–1974, section 36.9. Use test fuel conforming to the specifications given in tables 2 and 3 of ANSI Standard Z21.1–1972 for No. 1 and No. 2 fuel oil. Measure the higher heating value of the test fuel with an error no greater than one percent.

2.3.5 Electrical supply. For auxiliary electric components of a vented heater, maintain the electrical supply to the test unit within one percent of the nameplate voltage for the entire test cycle. If a voltage range is used for nameplate voltage, maintain the electrical supply within one percent of the midpoint of the nameplate voltage range.

2.4 Burner adjustments.

2.4.1 Gas burner adjustments. Adjust the burners of gas fueled vented heaters to their maximum Btu ratings at the test pressure.

2.4.1 Oil burner adjustments. Adjust the burners of oil fueled vented heaters to give lower CO reading recommended by the manufacturer and an hourly Btu rating specified by the manufacturer as measured after 15 minutes of operation starting with all parts of the vented heater at air temperature and with the thermostat sensing element in a temperature control bath which is held at a temperature below the maximum set point temperature of the control.

For gas fueled heaters with modulating controls adjust the controls to operate the heater at the maximum fuel input rate. Set the thermostat control to the maximum setting. Start the heater by turning the safety control valve to the “on” position. In order to prevent modulation of the burner at maximum input, place the thermostat sensing element in a temperature control bath which is held at a temperature below the maximum set point temperature of the control.

For gas fueled heaters with modulating controls adjust the controls to operate the heater at the reduced fuel input rate. Set the thermostat control to the minimum setting. Start the heater by turning the safety control valve to the “on” position. In order to prevent modulation of the burner at maximum input, place the thermostat sensing element in a temperature control bath which is held at a temperature below the maximum set point temperature of the control.

2.5 Circulating air adjustments.

For units employing a direct vent system, locate at least one thermocouple at the center of each flue way exiting the heat exchanger. Provide radiation shields if the thermocouples are exposed to burner radiation.

For units which employ a draft hood or units which employ a direct vent system which does not significantly preheat the incoming combustion air, install nine thermocouples, wired in parallel, in a horizontal plane located within 12 inches (304.8 mm) of the heater outlet and upstream of the draft hood on units so equipped. Locate one thermocouple in the center of the stack. Locate eight thermocouples along imaginary lines intersecting at right angles in this horizontal plane at points one third and two thirds of the distance between the center of the stack and the stack wall.

For units which employ a direct vent system, place apparatus for this test are described in section 6.3 of ANSI standard Z91.1-1972.
Use bead-type thermocouples having wire size not greater than No. 24 American Wire Gauge (AWG). If there is a possibility that the thermocouples could receive direct radiation on the fire side of the thermocouples only and position the shields so that they do not touch the thermocouple junctions.

Install thermocouples for measuring conditioned warm air temperature as described in ANSI Z21.49-1975, section 2.14. Establish the temperature of the inlet air by means of a single No. 24 AWG bead-type thermocouple, suitably shielded from direct radiation and located in the center of the plane of each inlet air opening.

Install nine thermocouples, wired in parallel and having equal length leads, in a plane perpendicular to the axis of the flue pipe. Locate this plane at the position shown in Figure 34.4 of UL 730–1974, or Figures 35.1 and 35.2 of UL 729-1976 for a single thermocouple, except that on direct vent systems which significantly preheat the incoming combustion air, it shall be located within 6 inches (152.5 mm) of the outlet of the vent/air intake terminal. Locate one thermocouple in the center of the flue pipe and eight thermocouples along imaginary lines intersecting at right angles in this plane at points one third and two thirds of the distance between the center of the pipe and pipe wall.

Use bead-type thermocouples having a wire size not greater than No. 24 AWG. If there is a possibility that the thermocouples could receive direct radiation from the fire, install radiation shields on the fire side of the thermocouples only and position the shields so that they do not touch the thermocouple junctions.

Install thermocouples for measuring the conditioned warm air temperature as described in sections 35.12 through 35.17 of UL 730–1974. Establish the temperature of the inlet air by means of a single No. 24 AWG bead-type thermocouple, suitably shielded from direct radiation and located in the center of the plane of each inlet air opening.

Install thermocouples for measuring the steady-state stack gas temperature within ±5°F (±2.8°C) of the value $T_{S,SS}$ measured during the steady-state performance test. At no time during these tests shall the room temperature exceed 100°F (37.8°C) or fall below 50°F (10°C).

Temperature ($T_{R,A}$) shall be the arithmetic average temperature of the test area, determined by measurement with four No. 24 AWG bead-type thermocouples with junctions shielded against radiation, located approximately at 90-degree positions on a circle circumscribing the heater or heater enclosure under test, in a horizontal plane approximately at the vertical midpoint of the appliance or test enclosure, and with the junctions approximately 24 inches from sides of the heater or test enclosure and located so as not to be affected by other than room air. Locate a thermocouple at each elevation of draft relief inlet opening and combustion air inlet opening at a distance of approximately 24 inches from the inlet openings. The temperature of the air for combustion and the air for draft relief shall not differ more than ±5°F from room temperature as measured above.

Equipment used to measure mass flow rate in flue and stack. The tracer gas chosen for this task should have a density which is less than or approximately equal to the density of air. Use a gas unreactive with the environment to be encountered. Using instrumentation of either the batch or continuous type, measure the concentration of tracer gas with an error no greater than 2 percent of the value of the concentration measured.

3.1 Steady-state testing.
3.1.1 Gas fueled vented home heating equipment (including direct vent systems). Set up the vented heater as specified in sections 2.1, 2.2, and 2.3 of this appendix. The draft diverter shall be in the normal open condition and the stack shall not be insulated. (Insulation of the stack is no longer required for the vented heater test.) Begin the steady-state performance test by operating the burner and the circulating air blower, on units so equipped, with the adjustments specified by sections 2.4.1 and 2.5 of this appendix, until steady-state conditions are attained as indicated by a temperature variation of not more than 3°F (1.7°C) in the stack gas temperature for vented heaters equipped with draft diverters or 5°F (2.8°C) in the flue gas temperature for vented heaters equipped with either draft hoods or direct vent systems; in three successive readings taken 15 minutes apart.

On units employing draft diverters, measure the room temperature ($T_{R,A}$) as described in section 2.9 of this appendix and measure the steady-state stack gas temperature ($T_{S,SS}$) using the nine thermocouples located in the 5-foot test stack as specified in section 2.6.1 of this appendix. Secure a sample of the room temperature within ±5°F (±2.8°C) of the value $T_{R,A}$ measured during the steady-state performance test. At no time during these tests shall the room temperature exceed 100°F (37.8°C) or fall below 50°F (10°C).
stack gases in the plane where \( T_{s,ss} \) is measured or within 3.5 feet downstream of this plane. Determine the concentration by volume of carbon dioxide (\( X_{CO2} \)) present in the dry stack gases in the plane where \( T_{s,ss} \) measured differs from the temperature measurement plane, there shall be no air leaks through the stack between these two locations.

On units employing draft hoods or direct vent systems, measure the room temperature (\( T_{r,ss} \)) as described in section 2.9 of this appendix and measure the steady-state flue gas temperature (\( T_{fl,ss} \)), using the nine thermocouples located in the flue pipe as described in section 2.6 of this appendix. Secure a sample of the flue gas in the plane of temperature measurement and determine the concentration by volume of \( CO_2 \) (\( X_{CO2} \)) present in dry flue gas. In addition, for units employing draft hoods, secure a sample of the stack gas in a horizontal plane in the five foot test stack located one foot from the test stack inlet, and determine the concentration by volume of \( CO_2 \) (\( X_{CO2} \)) present in dry stack gas.

Determine the steady-state heat input rate (\( Q_{j,ss} \)) including pilot gas by multiplying the measured higher heating value of the test gas by the steady-state gas input rate correct to standard conditions of 60 °F and 30 inches of mercury. Use measured values of gas temperature and pressure at the meter and the barometric pressure to correct the metered gas flow rate to standard conditions.

After the above test measurements have been completed on units employing draft diverters, secure a sample of the flue gases at the exit of the heat exchanger(s) and determine the concentration of \( CO_2 \) (\( X_{CO2} \)) present. In obtaining this sample of flue gas, move the sampling probe around or use a sample probe with multiple sampling ports in order to assure that an average value is obtained for the \( CO_2 \) concentration. For units with multiple heat exchanger outlets, measure the \( CO_2 \) concentration in a sample from each outlet to obtain the average \( CO_2 \) concentration for the unit. A manifold (parallel connected sampling tubes) may be used to obtain this sample.

For heaters with single stage thermostat control (wall mounted electric thermostat), determine the steady-state efficiency at the maximum fuel input rate as specified in section 2.4.1 of this appendix. Determine the steady-state efficiency at a fuel input rate that is within ±5 percent of 50 percent of the maximum fuel input rate. If the heater is designed to use a control that precludes operation at other than maximum output (single firing rate) determine the steady-state efficiency at the maximum input rate only.

3.1.2 Oil fueled vented home heating equipment. For manually controlled oil fueled vented home heating equipment (including direct vent systems). Set up and adjust the vented heater as specified in sections 2.1, 2.2, and 2.3.4 of this appendix. Begin the steady-state performance test by operating the burner and the circulating air blower, on units so equipped, with the adjustments specified by sections 2.4.2 and 2.5 of this appendix until steady-state conditions are attained as indicated by a temperature variation of not more than 5 °F (2.8 C) in the flue gas temperature in three successive readings taken 15 minutes apart.

Do not allow smoke in the flue, for units equipped with power burners, to exceed a No. 1 smoke during the steady-state performance test as measured by the procedure described in ANSI standard Z11.182–1965 (R1971) (ASTM D 2156–65 (1970)). Maintain the average draft over the fire and in the breeching during the steady-state performance test at that recommended by the manufacturer ±0.005 inches of water gauge.

Measure the room temperature (\( T_{r,ss} \)) as described in section 2.9 of this appendix and measure the steady-state flue gas temperature (\( T_{fl,ss} \)) as described in section 2.6.2 of this appendix. Secure a sample of the flue gas in the plane of temperature measurement and determine the concentration by volume of \( CO_2 \) (\( X_{CO2} \)) present in dry flue gas. Measure and record the steady-state heat input rate (\( Q_{j,ss} \)).

For manually controlled oil fueled vented heaters, determine the steady-state efficiency at a fuel input rate that is within ±5 percent of 50 percent of the maximum fuel input rate.

3.1.3 Auxiliary Electric Power Measurement. Allow the auxiliary electrical system of a gas or oil vented heater to operate for at least five minutes before recording the maximum auxiliary electric power measurement from the wattmeter. Record the maximum electric power (\( P_e \)) expressed in kilowatts.

For vented heaters with modulating controls, the recorded (\( P_e \)) shall be maximum measured electric power multiplied by the following factor (R). For two stage controls, R=1.3. For step modulating controls, R=1.4 when the ratio of minimum-to-maximum fuel input is greater than or equal to 0.7, R=1.7 when the ratio of minimum-to-maximum fuel input is less than 0.7 and greater than or equal to 0.5, and R=2.2 when the ratio of minimum-to-maximum fuel input is less than 0.5.

3.2 Jacket loss measurement. Conduct a jacket loss test for vented floor furnaces. Measure the jacket loss (\( L_j \)) in accordance with section 2.9 of this appendix.

3.3 Measurement of the off-cycle losses for vented heaters equipped with thermal stack dams. For vented thermal stack damers, according to the manufacturer's instructions. Unless specified otherwise, the thermal stack damper should be at the draft diverter exit collar. Attach a five foot length of bare stack to the outlet of the damper. Install thermocouples as specified in section 2.6.1 of this appendix.

For vented heaters equipped with single stage thermostats, measure the off-cycle losses at the maximum fuel input rate. For vented heaters equipped with two stage thermostats, measure the off-cycle losses at the maximum fuel input rate and at the reduced fuel input rate. For vented heaters equipped with step-modulating thermostats, measure the off-cycle losses at the reduced fuel input rate.

Let the vented heater heat up to a steady-state condition. Feed a tracer gas at a constant metered rate into the stack directly above and within one foot above the stack damper. Record tracer gas flow rate and temperature. Measure the tracer gas concentration in the stack at several locations in a horizontal plane through a cross section of the stack at a point sufficiently above the stack damper to ensure that the tracer gas is well mixed in the stack.

Continuously measure the tracer gas concentration and temperature during a 10 minute cool down period. Shut the burner off and immediately begin measuring tracer gas concentration in the stack, stack temperature, room temperature, and barometric pressure. Record these values as the midpoint of each one-minute interval between burner shut down and ten minutes after burner shut down. Meter response time and sampling delay time shall be considered in timing these measurements.

3.4 Measurement of the effectiveness of electro-mechanical stack dampers. For vented heaters equipped with electro-mechanical stack dampers, measure the cross sectional area of the stack (A_s), the net area of the damper plate (A_p), and the angle that the damper plate makes when closed with a plane perpendicular to the axis of the stack (θ). The net area of the damper plate means the area of the damper plate minus the area of any holes through the damper plate.

3.5 Pilot light measurement.

3.5.1 Measure the energy input rate to the pilot light (Q_p) with an error no greater than 3 percent for vented heaters so equipped.

3.5.2 For manually controlled heaters where the pilot light is designed to be turned off by the user when the heater is not in use, that is, turning the control to the OFF position will shut off the gas supply to the burner(s) and to the pilot light, the measurement of Q_p is not needed. This provision applies only if an instruction to turn off the unit is provided on the heater near the gas control valve (e.g. by label) by the manufacturer.

3.6 Optional procedure for determining D_T, D_s and D_r, for systems for all types of vented heaters. For all types of vented heaters, D_T, D_s and D_r can be measured by the following optional cool down test.

Conduct a cool down test by letting the unit heat up until steady-state conditions are reached, as indicated by temperature variation of not more than 5°F (2.8°C) in the flue gas temperature in three successive readings taken 15 minutes apart, and then shutting the unit off with the stack or flue damper controls by-passed or adjusted so that the stack or flue damper remains open during the resulting cool down period. If a draft was maintained on oil fueled units in the flue pipe during the steady-state performance test described in section 3.1 of this appendix, maintain the same draft (within a range of 0.001 to 0.005 inches of water gauge of the average steady-state draft) during this cool down period.

Measure the flue gas mass flow rate (m_{F,SS}) during the cool down test described above at a specific off-period flue gas temperature and corrected to obtain its value at the steady-state flue gas temperature (T_{F,SS}), using the procedure described below.

Within one minute after the unit is shut off to start the cool down test for determining D_T, begin feeding a tracer gas into the combustion chamber at a constant flow rate of V_T, and at a point which will allow for the best possible mixing with the air flowing through the chamber. (On units equipped with an oil fired power burner, the best location for injecting this tracer gas appears to be through a hole drilled in the air tube.) Periodically measure the value of V_T with an instantaneously reading flow meter having an accuracy of ±5 percent of the quantity measured. Maintain V_T at less than 1 percent of the air flow rate through the furnace. If a combustible tracer gas is used, there should be a delay period between the time the burner gas is shut off and the time the tracer gas is first injected to prevent ignition of the tracer gas.

Between 5 and 6 minutes after the unit is shut off to start the cool down test, measure the exit of the heat exchanger the average flue gas temperature, T_{F,SS}. At the same instant the flue gas temperature is measured, also measure the percent volumetric concentration of tracer gas C_r in the flue gas in the same plane where T_{F,SS} is determined. Obtain the concentration of tracer gas using an instrument which will result in an accuracy of ±5 percent in the value of C_r measured. If use of a continuous reading type instrument results in a delay time between drawing of a sample and its analysis, this delay should be taken into account so that...
the temperature measurement and the measurement of tracer gas concentration coincide. In addition, determine the temperature of the tracer gas entering the flow meter (T_{F,F}) and the barometric pressure (P_{B}).

The rate of the flue gas mass flow through the vented heater and the factors D_{h}, D_{s}, and D_{c} are calculated by the equations in sections 4.5.1 through 4.5.3 of this appendix.

4.0 Calculations.

4.1 Annual fuel utilization efficiency for gas or oil fueled vented home heating equipment equipped without manual controls and without thermal stack dampers. The following procedure determines the annual fuel utilization efficiency for gas or oil fueled vented home heating equipment equipped without manual controls and without thermal stack dampers.

4.1.1 System number. Obtain the system number from Table 1 of this appendix.

4.1.2 Off-cycle flue gas draft factor. Based on the system number, determine the off-cycle flue gas draft factor (D_{h}) from Table 1 of this appendix.

4.1.3 Off-cycle stack gas draft factor. Based on the system number, determine the off-cycle stack gas draft factor (D_{s}) from Table 1 of this appendix.

4.1.4 Pilot fraction. Calculate the pilot fraction (P_{f}) expressed as a decimal and defined as:

\[ P_{f} = Q_{p} / Q_{m} \]

where:

- \( Q_{p} \) as defined in 3.5 of this appendix
- \( Q_{m} \) as defined in 3.1 of this appendix at the maximum fuel input rate

4.1.5 Jacket loss for floor furnaces. Determine the jacket loss (L_{j}) expressed as a percent and measured in accordance with section 3.2 of this appendix. For other vented heaters \( L_{j} = 0.0 \).

4.1.6 Latent heat loss. Based on the fuel, obtain the latent heat loss (L_{A,s}) from Table 2 of this appendix.

4.1.7 Ratio of combustion air mass flow rate to stoichiometric air mass flow rate. Determine the ratio of combustion air mass flow rate to stoichiometric air mass flow rate (R_{T,P}), and defined as:

\[ R_{T,P} = A + B / X_{CO2F} \]

where:

- \( A \) as determined from Table 2 of this appendix
- \( B \) as determined from Table 2 of this appendix
- \( X_{CO2F} \) as defined in 3.1 of this appendix

4.1.8 Ratio of combustion and relief air mass flow rate to stoichiometric air mass flow rate. For vented heaters equipped with either an integral draft diverter or a draft hood, determine the ratio of combustion and relief air mass flow rate to stoichiometric air mass flow rate (R_{T,S}), and defined as:

\[ R_{T,S} = A + (B / X_{CO2S}) \]

where:

- \( A \) as determined from Table 2 of this appendix
- \( B \) as determined from Table 2 of this appendix
- \( X_{CO2S} \) as defined in 3.1 of this appendix

4.1.9 Sensible heat loss at steady-state operation. For vented heaters equipped with either an integral draft diverter or a draft hood, determine the sensible heat loss at steady-state operation (L_{S,SS,A}) expressed as a percent and defined as:

\[ L_{S,SS,A} = C(T_{F,SS} + D)(T_{F,SS} + T_{RA}) \]

where:

- \( C \) as determined from Table 2 of this appendix
- \( D \) as determined from Table 2 of this appendix
- \( T_{F,SS} \) as defined in 3.1 of this appendix
- \( T_{RA} \) as defined in 2.9 of this appendix

For vented heaters equipped without an integral draft diverter, determine (L_{S,SS,A}) expressed as a percent and defined as:

\[ L_{S,SS,A} = C(T_{F,SS} + D)(T_{F,SS} + T_{RA}) \]

where:

- \( C \) as determined from Table 2 of this appendix
- \( D \) as determined from Table 2 of this appendix
- \( T_{F,SS} \) as defined in 3.1 of this appendix
- \( T_{RA} \) as defined in 2.9 of this appendix

4.1.10 Steady-state efficiency. For vented heaters equipped with single stage thermostats, calculate the steady-state efficiency (excluding jacket loss, \( \eta_{SS} \), expressed in percent and defined as:

\[ \eta_{SS} = 100 - L_{A,A} - L_{S,SS,A} \]

where:

- \( L_{A,A} \) as defined in 4.1.6 of this appendix
- \( L_{S,SS,A} \) as defined in 4.1.9 of this appendix

For vented heaters equipped with two stage thermostats, calculate the steady-
4.1.11 Reduced heat output rate. For vented heaters equipped with either two stage thermostats or step-modulating thermostats, calculate the reduced heat output rate (Q_red-out) defined as:

\[ Q_{\text{red-out}} = \eta_{SS-L} \cdot Q_{\text{red-in}} \]

where:
\( \eta_{SS-L} \) as defined in 4.1.10 of this appendix
\( Q_{\text{red-in}} \) the reduced fuel input rate

4.1.12 Maximum heat output rate. For vented heaters equipped with either two stage thermostats or step-modulating thermostats, calculate the maximum heat output rate (Q_max-out) defined as:

\[ Q_{\text{max-out}} = \eta_{SS-H} \cdot Q_{\text{max-in}} \]

where:
\( \eta_{SS-H} \) as defined in 4.1.10 of this appendix
\( Q_{\text{max-in}} \) the maximum fuel input rate

For vented heaters equipped with step-modulating thermostats, calculate the weighted-average steady-state efficiency in the modulating mode, \( \eta_{SS-MOD} \), expressed in percent and defined as:

\[ \eta_{SS-MOD} = \left[ \eta_{SS-H} - \eta_{SS-L} \right] \frac{T_C - T_{OA^*}}{T_C - 15} + \eta_{SS-L} \]

where:
\( \eta_{SS-H} \) as defined in 4.1.10 of this appendix
\( \eta_{SS-L} \) as defined in 4.1.10 of this appendix
\( T_C \) balance point temperature which represents a temperature used to apportion the annual heating load between the reduced input cycling mode and either the modulating mode or maximum input cycling mode and is obtained from Table 3 or Figure 1 of this appendix
\( T_{OA^*} \) average outdoor temperature for vented heaters

4.1.13 Ratio of reduced to maximum heat output rates. For vented heaters equipped with either two stage thermostats or step-modulating thermostats, calculate the ratio of reduced to maximum heat output rates (R) expressed as a decimal and defined as:

\[ R = \frac{Q_{\text{red-out}}}{Q_{\text{max-out}}} \]

where:
\( Q_{\text{red-out}} \) as defined in 4.1.11 of this appendix
\( Q_{\text{max-out}} \) as defined in 4.1.12 of this appendix

4.1.14 Fraction of heating load at reduced operating mode or noncycling mode. For vented heaters equipped with either two stage thermostats or step-modulating thermostats, determine the fraction of heating load at the reduced operating mode \( X_1 \) expressed as a decimal and listed in Table 3 of this appendix or obtained from Figure 2 of this appendix.

4.1.15 Fraction of heating load at maximum operating mode or noncycling mode. For vented heaters equipped with single stage thermostats, the weighted-average steady-state efficiency \( \eta_{SS-WT} \) is equal to \( \eta_{SS-H} \), as defined in section 4.1.10 of this appendix. For vented heaters equipped with two stage thermostats, \( \eta_{SS-WT} \) is defined as:

\[ \eta_{SS-WT} = X_1 \eta_{SS-L} + X_2 \eta_{SS-H} \]

where:
\( X_1 \) as defined in 4.1.14 of this appendix
\( \eta_{SS-L} \) as defined in 4.1.10 of this appendix
\( X_2 \) as defined in 4.1.15 of this appendix
\( \eta_{SS-H} \) as defined in 4.1.10 of this appendix

4.1.16 Weighted-average steady-state efficiency. For vented heaters equipped with single stage thermostats, the weighted-average steady-state efficiency \( \eta_{SS-WT} \) is equal to \( \eta_{SS-H} \) as defined in section 4.1.10 of this appendix. For vented heaters equipped with two stage thermostats, \( \eta_{SS-WT} \) is defined as:

For vented heaters equipped with step-modulating thermostats, \( \eta_{SS-WT} \) is defined as:

\[ \eta_{SS-WT} = X_1 \eta_{SS-L} + X_2 \eta_{SS-MOD} \]

where:
4.1.17 Annual fuel utilization efficiency. Calculate the annual fuel utilization efficiency (AFUE) expressed as percent and defined as:

\[ AFUE = 0.968 \cdot \eta_{\text{SS-WT}} - 1.78D_T - 1.89D_S - 129P_T - 2.8 L_u + 1.81 \]

where:
- \( \eta_{\text{SS-WT}} \): as defined in 4.1.16 of this appendix
- \( D_T \): as defined in 4.1.2 of this appendix
- \( D_S \): as defined in 4.1.3 of this appendix
- \( P_T \): as defined in 4.1.4 of this appendix
- \( L_u \): as defined in 4.1.5 of this appendix

4.2 Annual fuel utilization efficiency for gas or oil fueled vented home heating equipment equipped with manual controls. The following procedure determines the annual fuel utilization efficiency for gas or oil fueled vented home heating equipment equipped with manual controls.

4.2.1 Average ratio of stack gas mass flow rate to flue gas mass flow rate at steady-state operation. For vented heaters equipped with either direct vents or direct exhaust or are outdoor units, the average ratio of stack gas mass flow rate to flue gas mass flow rate at steady-state operation (S/F) shall be equal to unity. (S/F=1) For all other types of vented heaters, calculate (S/F) defined as:

\[ S/F = 1.3R_{TF} \]

where:
- \( R_{TF} \): as defined in 4.1.8 of this appendix with
- \( X_{\text{CO}_2} \): measured at 50% fuel input rate
- \( X_{\text{CO}_2} \): measured at 50% fuel input rate

4.2.2 Multiplication factor for infiltration loss during burner on-cycle. Calculate the multiplication factor for infiltration loss during burner on-cycle (\( K_{\text{CON}} \)) defined as:

\[ K_{\text{CON}} = 100 \cdot (0.24 \cdot (S/F) \cdot 0.7 \cdot [1 + R_{TF} \cdot (A/F)]) / \text{HHV}_A \]

where:
- 100 = converts a decimal fraction into a percent
- \( 0.24 \) = specific heat of air
- \( A/F \) = stoichiometric air/fuel ratio, determined in accordance with Table 2 of this appendix
- \( S/F \) = as defined in 4.2.1 of this appendix at 50 percent of rated maximum fuel input
- \( 0.7 \) = infiltration parameter

4.2.3 On-cycle infiltration heat loss. Calculate the on-cycle infiltration heat loss (\( L_{\text{I,ON}} \)) expressed as a percent and defined as:

\[ L_{\text{I,ON}} = K_{\text{CON}} \cdot (70 - 45) \]

where:
- \( K_{\text{CON}} \): as defined in 4.2.2 of this appendix
- 70 = average indoor temperature
- 45 = average outdoor temperature

4.2.4 Weighted-average steady-state efficiency.

4.2.4.1 For manually controlled heaters with various input rates the weighted average steady-state efficiency (\( \eta_{\text{SS-WT}} \)) is determined as follows:

(1) at 50 percent of the maximum fuel input rate as measured in either section 3.1.1 of this appendix for manually controlled gas vented heaters or section 3.1.2 of this appendix for manually controlled oil vented heaters, or

(2) at the minimum fuel input rate as measured in either section 3.1.1 to this appendix for manually controlled gas vented heaters or section 3.1.2 to this appendix for manually controlled oil vented heaters if the design of the heater is such that the \( \pm \) percent of 50 percent of the maximum fuel input rate cannot be set, provided this minimum rate is no greater than \( \% \) of maximum input rate of the heater.

4.2.4.2 For manually controlled heater with one single firing rate the weighted average steady-state efficiency is the steady-state efficiency measured at the single firing rate.

4.2.5 Part-load fuel utilization efficiency. Calculate the part-load fuel utilization efficiency (\( \eta_u \)) expressed as a percent and defined as:

\[ \eta_u = \eta_{\text{SS-WT}} - L_{\text{I,ON}} \]

where:
- \( \eta_{\text{SS-WT}} \): as defined in 4.2.4 of this appendix
- \( L_{\text{I,ON}} \): as defined in 4.2.3 of this appendix

4.2.6 Annual Fuel Utilization Efficiency.

4.2.6.1 For manually controlled vented heaters, calculate the AFUE expressed as a percent and defined as:

\[ AFUE = \frac{2.950 \cdot \eta_{\text{SS}} \cdot \eta_u \cdot Q_{\text{in-max}}}{2.950 \cdot \eta_{\text{SS}} \cdot Q_{\text{in-max}} + 2.083(4.600) \cdot \eta_u \cdot Q_P} \]

where:
- \( 2.950 \) = average number of heating degree days
4.3 Annual fuel utilization efficiency by the tracer gas method. The annual fuel utilization efficiency shall be determined by the following tracer gas method for all vented heaters equipped with thermal stack dampers. All other types of vented heaters can elect to use the following tracer gas method, as an optional procedure.

\[
L_{S,SS,A\text{-avg}} = \left[ L_{S,SS,A\text{-max}} - L_{S,SS,A\text{-red}} \right] \left( \frac{T_C - T_{OA^*}}{TC - 15} \right) + L_{S,SS,A\text{-red}}
\]

where:
- \(L_{S,SS,A\text{-avg}}\) as defined in 4.3.1 of this appendix
- \(T_C\) as defined in 4.1.10 of this appendix
- \(T_{OA^*}\) as defined in 4.1.11 of this appendix

4.3.1 On-cycle sensible heat loss. For vented heaters equipped with single stage thermostats, calculate the on-cycle sensible heat loss \(L_{I,ON}\) expressed as a percent and defined as:

\[
L_{I,ON} = \eta_{I,ON-Max}(70 - T_{OA^*}) + \eta_{I,ON-Red}(70 - T_{OA^*})
\]

where:
- \(\eta_{I,ON-Max}\) as defined in 4.4.1 of this appendix
- \(\eta_{I,ON-Red}\) as defined in 4.4.2 of this appendix

For vented heaters equipped with two stage thermostats, calculate \(L_{I,ON}\) defined as:

\[
L_{I,ON} = \eta_{I,ON-Max}(70 - T_{OA^*}) + \eta_{I,ON-Red}(70 - T_{OA^*})
\]

where:
- \(\eta_{I,ON-Max}\) as defined in 4.4.1 of this appendix
- \(\eta_{I,ON-Red}\) as defined in 4.4.2 of this appendix

4.3.2 On-cycle infiltration heat loss. For vented heaters equipped with single stage thermostats, calculate the on-cycle infiltration heat loss \(L_{I,ON}\) expressed as a percent and defined as:

\[
L_{I,ON} = \eta_{I,ON-Max}(70 - T_{OA^*}) + \eta_{I,ON-Red}(70 - T_{OA^*})
\]

where:
- \(\eta_{I,ON-Max}\) as defined in 4.4.1 of this appendix
- \(\eta_{I,ON-Red}\) as defined in 4.4.2 of this appendix

For vented heaters equipped with two stage thermostats, calculate \(L_{I,ON}\) defined as:

\[
L_{I,ON} = \eta_{I,ON-Max}(70 - T_{OA^*}) + \eta_{I,ON-Red}(70 - T_{OA^*})
\]

where:
- \(\eta_{I,ON-Max}\) as defined in 4.4.1 of this appendix
- \(\eta_{I,ON-Red}\) as defined in 4.4.2 of this appendix

For vented heaters equipped with step-modulating thermostats, calculate \(L_{I,ON}\) defined as:

\[
L_{I,ON} = \eta_{I,ON-Max}(70 - T_{OA^*}) + \eta_{I,ON-Red}(70 - T_{OA^*})
\]

where:
- \(\eta_{I,ON-Max}\) as defined in 4.4.1 of this appendix
- \(\eta_{I,ON-Red}\) as defined in 4.4.2 of this appendix
4.3.3 Off-cycle sensible heat loss. For vented heaters equipped with single stage thermostats, calculate the off-cycle sensible heat loss (\( L_{S,\text{OFF}} \)) at the maximum fuel input rate. For vented heaters equipped with step-modulating thermostats, calculate \( L_{S,\text{OFF}} \) defined as:

\[
L_{S,\text{OFF}} = x_1 L_{S,\text{OFF,red}}
\]

where:

- \( x_1 \) as defined in 4.1.14 of this appendix
- \( L_{S,\text{OFF,red}} \) as defined in \( L_{S,\text{OFF}} \) in 4.3.3 of this appendix at the reduced fuel input rate

For vented heaters equipped with two stage thermostats, calculate \( L_{S,\text{OFF}} \) defined as:

\[
L_{S,\text{OFF}} = x_1 L_{S,\text{OFF,red}} + x_2 L_{S,\text{OFF,\text{Max}}}
\]

where:

- \( x_1 \) as defined in 4.1.14 of this appendix
- \( L_{S,\text{OFF,red}} \) as defined in \( L_{S,\text{OFF}} \) in 4.3.3 of this appendix at the reduced fuel input rate
- \( x_2 \) as defined in 4.1.15 of this appendix
- \( L_{S,\text{OFF,\text{Max}}} \) as defined in \( L_{S,\text{OFF}} \) in 4.3.3 of this appendix at the maximum fuel input rate

Calculate the off-cycle sensible heat loss (\( L_{S,\text{OFF}} \)) expressed as a percent and defined as:

\[
L_{S,\text{OFF}} = \frac{100(0.24)}{Q_{in}} \sum m_{\text{S,OFF}} (T_{S,\text{OFF}} - T_{RA})
\]

where:

- 100 = conversion factor for percent
- 0.24 = specific heat of air in Btu per pound \( \cdot \) \( ^\circ \text{F} \)
- \( Q_{in} \) = fuel input rate, as defined in 3.1 of this appendix in Btu per minute (as appropriate for the firing rate)
- \( t_{on} \) = average burner on-time per cycle and is 20 minutes
- \( \Sigma m_{\text{S,OFF}} (T_{S,\text{OFF}} - T_{RA}) \) = summation of the twenty values of the quantity, \( m_{\text{S,OFF}} (T_{S,\text{OFF}} - T_{RA}) \), measured in accordance with 3.3 of this appendix
- \( m_{\text{S,OFF}} \) = stack gas mass flow rate pounds per minute

\[
m_{\text{S,OFF}} = \frac{1.325 P_B V_T (100 - C_T)}{C_T (T_T + 460)}
\]

- \( T_{S,\text{OFF}} \) = stack gas temperature measured in accordance with 3.3 of this appendix
- \( T_{RA} \) = average room temperature measured in accordance with 3.3 of this appendix
- \( P_B \) = barometric pressure in inches of mercury
- \( V_T \) = flow rate of the tracer gas through the stack in cubic feet per minute
- \( C_T \) = concentration by volume of the active tracer gas in the mixture in percent and is 100 when the tracer gas is a single component gas
- \( C_T' \) = concentration by volume of the active tracer gas in the diluted stack gas in percent

4.3.4 Average outdoor temperature. For vented heaters equipped with single stage thermostats, the average outdoor temperature (\( T_{OA} \)) is 45 \( ^\circ \text{F} \). For vented heaters equipped with either two stage thermostats or step-modulating thermostats, \( T_{OA} \) during the reduced operating mode is obtained from Table 3 or Figure 1 of this appendix. For vented heaters equipped with two stage thermostats, \( T_{OA} \) during the maximum operating mode is obtained from Table 3 or Figure 1 of this appendix.

4.3.5 Off-cycle infiltration heat loss. For vented heaters equipped with single stage thermostats, calculate the off-cycle infiltration heat loss (\( L_{I,\text{OFF}} \)) at the maximum fuel input rate. For vented heaters equipped with either two stage thermostats or step-modulating thermostats, calculate \( L_{I,\text{OFF}} \) defined as:

\[
L_{I,\text{OFF}} = x_1 L_{I,\text{OFF,red}}
\]

where:

- \( x_1 \) as defined in 4.1.14 of this appendix
- \( L_{I,\text{OFF,red}} \) as defined in \( L_{I,\text{OFF}} \) in 4.3.3 of this appendix at the reduced fuel input rate
For vented heaters equipped with two stage thermostats, calculate $L_{I,OFF}$ defined as:

$$L_{I,OFF} = X_1 L_{I,OFF,red} + X_2 L_{I,OFF,max}$$

where:

- $X_1$ as defined in 4.1.14 of this appendix
- $X_2$ as defined in 4.1.15 of this appendix
- $L_{I,OFF,red}$ as defined as $L_{I,OFF}$ in 4.3.3 of this appendix at the reduced fuel input rate
- $L_{I,OFF,max}$ as defined as $L_{I,OFF}$ in 4.3.3 of this appendix at the maximum fuel input rate

Calculate the off-cycle infiltration heat loss ($L_{I,OFF}$) expressed as a percent and defined as:

$$L_{I,OFF} = \frac{100(0.24)(1.3)(0.7)(70-T_{OA})}{Q_{in} t_{on}} \sum m_{S,OFF}$$

where:

- $100$ = conversion factor for percent
- $0.24$ = specific heat of air in Btu per pound –°F
- $1.3$ = dimensionless factor for converting laboratory measured stack flow to typical field conditions
- $0.7$ = infiltration parameter
- $70$ = assumed average indoor air temperature, °F
- $T_{OA}$ = average outdoor temperature as defined in 4.3.4 of this appendix

4.3.6 Part-load fuel utilization efficiency. Calculate the part-load fuel utilization efficiency ($\eta_u$) expressed as a percent and defined as:

$$\eta_u = 100 - L_{L,A} - C_j L_j \left[ \frac{t_{on}}{t_{on} + P_F t_{off}} \right] + \left[ L_{S,ON} + L_{S,OFF} + L_{I,ON} + L_{I,OFF} \right]$$

where:

- $C_j$ = 2.8, adjustment factor
- $L_{L,A}$ = jacket loss as defined in 4.1.5
- $L_{L,A}$ = as defined in 4.1.5 of this appendix
- $L_{S,ON}$ = as defined in 4.3.1 of this appendix
- $L_{S,OFF}$ = as defined in 4.3.3 of this appendix
- $L_{I,ON}$ = as defined in 4.3.2 of this appendix
- $L_{I,OFF}$ = as defined in 4.1.4 of this appendix
- $P_F$ = as defined in 4.1.4 of this appendix
- $t_{off} = $ average burner off-time per cycle and is 20 minutes

4.3.7 Annual Fuel Utilization Efficiency. Calculate the AFUE expressed as a percent and defined as:

$$AFUE = \frac{2.950 \eta_{SS-WT} \eta_u Q_{in-max}}{2.950 \eta_{SS-WT} Q_{in-max} + 2.083(4,600) \eta_u Q_P}$$

where:

- $2,950$ = average number of heating degree days
- $\eta_{SS-WT}$ = as defined in 4.1.16 of this appendix
- $\eta_u$ = as defined in 4.3.6 of this appendix
- $Q_{in-max}$ = as specified in 4.2.6 of this appendix
- $Q_P$ = as defined in 4.2.6 of this appendix

4.4 Stack damper effectiveness for vented heaters equipped with electro-mechanical stack dampers. Determine the stack damper effectiveness for vented heaters equipped with electro-mechanical stack dampers ($D_o$), defined as:

$$D_o = 1.62 \left[ 1 - A_o \cos \Omega A_1 \right]$$

where:
National average number of burner operating hours (BOH) is defined as:

\[ \text{BOH}_{\text{tot}} = 1.416A_{\text{HR}} \cdot \text{DHR} - 1.416B \]

where:

- 1.416 = national average heating load hours for vented heaters based on 2,950 degree days and 15 °F outdoor design temperature
- \( A_{\text{HR}} = 0.7067 \) = adjustment factor to adjust the calculated design heating requirement and heating load hours to the actual

**4.5 Addition requirements for vented home heating equipment using indoor air for combustion and draft control.** For vented home heating equipment using indoor air for combustion and draft control, \( D_o \) as described in section 4.1.7 of this appendix, shall be determined from Table 1 of this appendix.

\[
M_{F,\text{OFF}}(T_{F,\text{SS}}) = M_{F,\text{OFF}}(T^*_{F,\text{OFF}}) \left[ \frac{T_{F,\text{SS}} - T_{RA}}{T^*_{F,\text{OFF}} - T_{RA}} \right]^{0.56} \left[ \frac{T^*_{F,\text{OFF}} + 460}{T_{F,\text{SS}} + 460} \right]^{1.19}
\]

For oil fueled vented heaters in which an imposed draft is maintained, as described in section 3.6 of this appendix, \( M_{F,CRT}(T_{F,\text{SS}}) \) is defined as:

\[
M_{F,CRT}(T_{F,\text{SS}}) = \frac{M_{F,\text{OFF}}(T_{F,\text{SS}}) \cdot \Delta F_{\text{CRT}}}{M_{F,\text{OFF}}(T^*_{F,\text{OFF}}) \cdot \Delta F_{\text{CRT}}}
\]

where:

- \( T_{F,\text{SS}} \) = as defined in 3.1.1 of this appendix
- \( T^*_{F,\text{OFF}} \) = flue gas temperature during the off-period measured in accordance with 3.6 of this appendix in degrees Fahrenheit
- \( T_{RA} \) = as defined in 2.9 of this appendix
- \( M_{F,\text{OFF}}(T_{F,\text{SS}}) \) = as defined in 3.4 of this appendix
- \( M_{F,\text{OFF}}(T^*_{F,\text{OFF}}) \) = as defined in 3.4 of this appendix

4.5.1 Optional procedure for determining \( D_o \) for vented home heating equipment. Calculate the ratio \( (D_o) \) of the rate of flue gas mass flow during the on-period, \( M_{F,\text{SS}}(T_{F,\text{SS}}) \), to the rate of flue gas mass flow during the off-period, \( M_{F,\text{SS}}(T_{F,\text{SS}}) \), and defined as:

\[
D_o = \frac{M_{F,\text{SS}}(T_{F,\text{SS}})}{M_{F,\text{SS}}(T_{F,\text{SS}})}
\]

For vented heaters in which no draft is maintained during the steady-state or cool down tests, \( M_{F,CRT}(T_{F,\text{SS}}) \) is defined as:

\[
M_{F,CRT}(T_{F,\text{SS}}) = \frac{M_{F,\text{SS}}(T_{F,\text{SS}})}{M_{F,\text{SS}}(T^*_{F,\text{SS}})}
\]

4.5.2 Optional procedure for determining off-cycle draft factor for flue gas flow for vented heaters. For systems numbered 7 or 8 and if \( D_o = D_o \), the off-cycle draft factor for flue gas flow \( (D_o) \) defined as:

\[
D_o = \frac{M_{F,\text{SS}}(T_{F,\text{SS}})}{M_{F,\text{SS}}(T_{F,\text{SS}})}
\]

For systems numbered 1 thru 10, calculate the off-cycle draft factor for flue gas flow \( (D_o) \) defined as:

\[
D_o = \frac{M_{F,\text{SS}}(T_{F,\text{SS}})}{M_{F,\text{SS}}(T_{F,\text{SS}})}
\]

For systems numbered 3 or 4 and 5 or 6:

\[
D_o = \frac{M_{F,\text{SS}}(T_{F,\text{SS}})}{M_{F,\text{SS}}(T_{F,\text{SS}})}
\]

For systems numbered 7 or 8 and if \( D_o < 1 \):

\[
D_o = \frac{M_{F,\text{SS}}(T_{F,\text{SS}})}{M_{F,\text{SS}}(T_{F,\text{SS}})}
\]

For systems numbered 1 or 2 and 4:

\[
D_o = \frac{M_{F,\text{SS}}(T_{F,\text{SS}})}{M_{F,\text{SS}}(T_{F,\text{SS}})}
\]

For systems numbered 3 or 4:

\[
D_o = \frac{M_{F,\text{SS}}(T_{F,\text{SS}})}{M_{F,\text{SS}}(T_{F,\text{SS}})}
\]

For systems numbered 5 or 6:

\[
D_o = \frac{M_{F,\text{SS}}(T_{F,\text{SS}})}{M_{F,\text{SS}}(T_{F,\text{SS}})}
\]

For systems numbered 7 or 8 and if \( D_o > 1 \):

\[
D_o = \frac{M_{F,\text{SS}}(T_{F,\text{SS}})}{M_{F,\text{SS}}(T_{F,\text{SS}})}
\]

4.5.3 Optional procedure for determining off-cycle draft factor for stack gas flow for vented heaters. Calculate the off-cycle draft factor for stack gas flow \( (D_o) \) defined as:

\[
D_o = \frac{M_{F,\text{SS}}(T_{F,\text{SS}})}{M_{F,\text{SS}}(T_{F,\text{SS}})}
\]

For systems numbered 1 thru 10, calculate the off-cycle draft factor for stack gas flow \( (D_o) \) defined as:

\[
D_o = \frac{M_{F,\text{SS}}(T_{F,\text{SS}})}{M_{F,\text{SS}}(T_{F,\text{SS}})}
\]

For systems numbered 3 or 4 and 5 or 6:

\[
D_o = \frac{M_{F,\text{SS}}(T_{F,\text{SS}})}{M_{F,\text{SS}}(T_{F,\text{SS}})}
\]

For systems numbered 7 or 8 and if \( D_o > 1 \):

\[
D_o = \frac{M_{F,\text{SS}}(T_{F,\text{SS}})}{M_{F,\text{SS}}(T_{F,\text{SS}})}
\]
heating load experienced by the heating system

DHR=typical design heating requirements

based on $Q_{oect}$ from Table 4 of this appendix.

$Q_{oect}=[(L_{\text{in}}/100) - C_{\text{E}}(L_{\text{in}}/100)] Q_{o}$

$L_{\text{in}}$=jacket loss as defined in 4.1.5 of this appendix

$C_{\text{E}}$=steady adjustment factor as defined in 4.3.6 of this appendix

$\eta_{\text{ss}}$=steady-state efficiency as defined in 4.1.10 of this appendix, percent

$Q_{o}$=as defined in 3.1 of this appendix at the

maximum fuel input rate

$A=100,000/[341,300 P_{E} R+(Q_{o} - Q_{o}) \eta_{\text{in}}]$

$B=2.938(Q_{o}) \eta_{\text{in}} A/100,000$

$100,000=\text{factor that accounts for percent and}

kBtu

$P_{E}$=as defined in 3.1.3 of this appendix

$\eta_{\text{in}}$=as defined in 4.3.6 of this appendix for

vented heaters using the tracer gas method, percent

=as defined in 4.2.5 of this appendix for manually controlled vented heaters, percent

=2.938 $\left(\text{AFUE}/2.083(4,600/Q_{o})\right)$, for vented heaters equipped without manual controls and

without thermal stack dampers and not using the optional tracer gas method, where:

$\text{AFUE}$=as defined in 4.1.17 of this appendix, percent

2,950=average number of heating degree days

as defined in 4.2.6 of this appendix

4,600=average number of non-heating season

hours per year as defined in 4.2.6 of this appendix

2.938=as defined in 4.6.1 of this appendix

ratio of the average length of the heating season in hours to the

average heating load hours

2.083=as specified in 4.2.6 of this appendix

4.6.1.1 For vented heaters equipped with

two stage or step modulating controls the national average number of burner operating

hours at the reduced operating mode is defined as:

$\text{BOH}_{\text{R}}=X_{2} (E_{\text{R}} - Q_{o})$

where:

$X_{2}$=as defined in 4.1.14 of this appendix

$E_{\text{R}}$=average annual energy used during the heating season

$=((Q_{o} - Q_{o}) \text{BOH}_{\text{R}}+(8,760 - 4,600) Q_{o}$

$Q_{o}$=as defined in 3.1 of this appendix at the maximum fuel input rate

$\text{BOH}_{\text{R}}$=as defined in 4.6.1 of this appendix

with the term $P_{E}$ in the factor $A$ is increased by the factor $R$, which is defined in 3.1.3 of this appendix as:

$R=1.3$ for two stage controls

=1.4 for step modulating controls when the ratio of minimum-to-maximum fuel

input is greater than or equal to 0.7

=1.7 for step modulating controls when the ratio of minimum-to-maximum fuel

input is less than 0.7 and greater than or equal to 0.5

=2.2 for step modulating controls when the

ratio of minimum-to-maximum fuel input is less than 0.5

A=100,000/[341,300 P_{E} R+(Q_{o} - Q_{o}) \eta_{\text{in}}]$

8,760=total number of hours per year

4,600=as specified in 4.2.6 of this appendix

4.6.1.2 For vented heaters equipped with

two stage or step modulating controls the national average number of burner operating

hours at the maximum operating mode (BOH$\text{M}$) is defined as:

$\text{BOH}_{\text{M}}=X_{2} (E_{\text{M}} - Q_{o})$

where:

$X_{2}$=as defined in 4.1.15 of this appendix

$E_{\text{M}}$=average annual energy used during the heating season

$=(Q_{o} - Q_{o}) \text{BOH}_{\text{M}}+(8,760 - 4,600) Q_{o}$

$Q_{o}$=as defined in 3.1 of this appendix at the maximum fuel input rate

4.6.2 Average annual fuel energy for gas or

oil fueled vented heaters. For vented heaters

equipped with single stage controls or manual

controls, the average annual fuel energy

consumption ($E_{\text{M}}$) is expressed in Btu per year and defined as:

$E_{\text{M}}=\text{BOH}_{\text{M}}((Q_{o} - Q_{o})+8,760 Q_{o}$

where:

$\text{BOH}_{\text{M}}$=as defined in 4.6.1 of this appendix

$Q_{o}$=as defined in 3.1 of this appendix

$Q_{o}$=as defined in 3.5 of this appendix

8,760=as specified in 4.6.1 of this appendix

4.6.2.1 For vented heaters equipped with

either two stage or step modulating controls

$E_{\text{M}}$ is defined as:

$E_{\text{M}}=\text{BOH}_{\text{M}}+4,600 Q_{o}$

where:

$\text{BOH}_{\text{M}}$=as defined in 4.6.1.2 of this appendix

4,600=as specified 4.2.6 of this appendix

$Q_{o}$=as defined in 3.5 of this appendix

4.6.3 Average annual auxiliary electrical

energy consumption for vented heaters. For vented

heaters with single stage controls or manual

controls the average annual auxiliary electrical consumption ($E_{\text{AR}}$) is expressed in kilowatt-hours and defined as:

$E_{\text{AR}}=\text{BOH}_{\text{AR}} P_{E}$

where:

$\text{BOH}_{\text{AR}}$=as defined in 4.6.1 of this appendix

$P_{E}$=as defined in 3.1.3 of this appendix

4.6.3.1 For vented heaters equipped with

two stage or modulating controls $E_{\text{AR}}$ is defined as:
\[ E_{\text{FR}} = (E_{F} - 8,760 Q_{P})(HHL/1,416) + 8,760 Q_{P} \]

where:
- \( E_{F} \) is as defined in 4.6.2 of this appendix
- 8,760 is as specified in 4.6.1 of this appendix
- \( Q_{P} \) is as defined in 3.5 of this appendix
- \( HHL \) is heating load hours for a specific geographic region determined from the heating load hour map in Figure 3 of this appendix
- 1,416 is as specified in 4.6.1 of this appendix

### Table 1—Off-Cycle Draft Factors for Flue Gas Flow (D\(_{F}\)) and for Stack Gas Flow (D\(_{S}\)) for Vented Home Heating Equipment Equipped Without Thermal Stack Dampers

<table>
<thead>
<tr>
<th>System number</th>
<th>(D(_{F}))</th>
<th>(D(_{S}))</th>
<th>Burner type</th>
<th>Venting system type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.0</td>
<td>1.0</td>
<td>Atmospheric</td>
<td>Draft hood or diverter.</td>
</tr>
<tr>
<td>2</td>
<td>0.4</td>
<td>1.0</td>
<td>Power</td>
<td>Draft hood or diverter.</td>
</tr>
<tr>
<td>3</td>
<td>1.0</td>
<td>1.0</td>
<td>Atmospheric</td>
<td>Barometric draft regulator.</td>
</tr>
<tr>
<td>4</td>
<td>0.4</td>
<td>0.85</td>
<td>Power</td>
<td>Barometric draft regulator.</td>
</tr>
<tr>
<td>5</td>
<td>1.0</td>
<td>D(_{S})</td>
<td>Atmospheric</td>
<td>Draft hood or diverter with damper.</td>
</tr>
<tr>
<td>6</td>
<td>0.4</td>
<td>D(_{S})</td>
<td>Power</td>
<td>Draft hood or diverter with damper.</td>
</tr>
<tr>
<td>7</td>
<td>1.0</td>
<td>D(_{S})</td>
<td>Atmospheric</td>
<td>Barometric draft regulator with damper.</td>
</tr>
<tr>
<td>8</td>
<td>0.4</td>
<td>D(_{S})</td>
<td>Power</td>
<td>Barometric draft regulator with damper.</td>
</tr>
<tr>
<td>9</td>
<td>1.0</td>
<td>D(_{S})</td>
<td>Atmospheric</td>
<td>Direct vent.</td>
</tr>
<tr>
<td>10</td>
<td>0.4</td>
<td>D(_{S})</td>
<td>Power</td>
<td>Direct vent with damper.</td>
</tr>
<tr>
<td>11</td>
<td>0.4</td>
<td>D(_{S})</td>
<td>Atmospheric</td>
<td>Direct vent with damper.</td>
</tr>
<tr>
<td>12</td>
<td>0.4</td>
<td>D(_{S})</td>
<td>Power</td>
<td>Direct vent with damper.</td>
</tr>
</tbody>
</table>

1 Venting systems listed with dampers means electro-mechanical dampers only.

### Table 2—Values of Higher Heating Value (HHV\(_{A}\)), Stoichiometric Air/Fuel (A/F), Latent Heat Loss (L\(_{L,A}\)) and Fuel-Specified Parameters (A, B, C, and D) for Typical Fuels

<table>
<thead>
<tr>
<th>Fuels</th>
<th>HHV(_{A}) (Btu/lb)</th>
<th>A/F</th>
<th>L(_{L,A})</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 1 oil</td>
<td>19,800</td>
<td>14.56</td>
<td>6.55</td>
<td>0.0679</td>
<td>14.22</td>
<td>0.0179</td>
<td>0.167</td>
</tr>
<tr>
<td>No. 2 oil</td>
<td>19,500</td>
<td>14.49</td>
<td>6.50</td>
<td>0.0667</td>
<td>14.34</td>
<td>0.0181</td>
<td>0.167</td>
</tr>
<tr>
<td>Natural gas</td>
<td>20,120</td>
<td>14.45</td>
<td>9.55</td>
<td>0.0919</td>
<td>10.96</td>
<td>0.0175</td>
<td>0.171</td>
</tr>
<tr>
<td>Manufactured gas</td>
<td>18,500</td>
<td>11.81</td>
<td>7.99</td>
<td>0.0841</td>
<td>12.60</td>
<td>0.0177</td>
<td>0.151</td>
</tr>
<tr>
<td>Propane</td>
<td>21,500</td>
<td>15.58</td>
<td>7.79</td>
<td>0.0808</td>
<td>12.93</td>
<td>0.0180</td>
<td>0.143</td>
</tr>
<tr>
<td>Butane</td>
<td>20,000</td>
<td>15.36</td>
<td>7.79</td>
<td>0.0808</td>
<td>12.93</td>
<td>0.0180</td>
<td>0.143</td>
</tr>
</tbody>
</table>
Table 3—Fraction of Heating Load at Reduced Operating Mode (X1) and at Maximum Operating Mode (X2), Average Outdoor Temperatures (TOA and TOA*), and Balance Point Temperature (TC) for Vented Heaters Equipped With Either Two-Stage Thermostats or Step-Modulating Thermostats

<table>
<thead>
<tr>
<th>Heat output ratio</th>
<th>X1</th>
<th>X2</th>
<th>TOA</th>
<th>TOA*</th>
<th>TC</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.20 to 0.24</td>
<td>.12</td>
<td>.88</td>
<td>57</td>
<td>40</td>
<td>53</td>
</tr>
<tr>
<td>0.25 to 0.29</td>
<td>.16</td>
<td>.84</td>
<td>56</td>
<td>39</td>
<td>51</td>
</tr>
<tr>
<td>0.30 to 0.34</td>
<td>.20</td>
<td>.80</td>
<td>54</td>
<td>38</td>
<td>49</td>
</tr>
<tr>
<td>0.35 to 0.39</td>
<td>.30</td>
<td>.70</td>
<td>53</td>
<td>36</td>
<td>46</td>
</tr>
<tr>
<td>0.40 to 0.44</td>
<td>.36</td>
<td>.64</td>
<td>52</td>
<td>35</td>
<td>44</td>
</tr>
<tr>
<td>0.45 to 0.49</td>
<td>.43</td>
<td>.57</td>
<td>51</td>
<td>34</td>
<td>42</td>
</tr>
<tr>
<td>0.50 to 0.54</td>
<td>.52</td>
<td>.48</td>
<td>50</td>
<td>32</td>
<td>39</td>
</tr>
<tr>
<td>0.55 to 0.59</td>
<td>.60</td>
<td>.40</td>
<td>49</td>
<td>30</td>
<td>37</td>
</tr>
<tr>
<td>0.60 to 0.64</td>
<td>.70</td>
<td>.30</td>
<td>48</td>
<td>29</td>
<td>34</td>
</tr>
<tr>
<td>0.65 to 0.69</td>
<td>.76</td>
<td>.24</td>
<td>47</td>
<td>27</td>
<td>32</td>
</tr>
<tr>
<td>0.70 to 0.74</td>
<td>.84</td>
<td>.18</td>
<td>46</td>
<td>25</td>
<td>29</td>
</tr>
<tr>
<td>0.75 to 0.79</td>
<td>.88</td>
<td>.12</td>
<td>46</td>
<td>22</td>
<td>27</td>
</tr>
<tr>
<td>0.80 to 0.84</td>
<td>.94</td>
<td>.06</td>
<td>45</td>
<td>20</td>
<td>23</td>
</tr>
<tr>
<td>0.85 to 0.89</td>
<td>.96</td>
<td>.04</td>
<td>45</td>
<td>18</td>
<td>21</td>
</tr>
<tr>
<td>0.90 to 0.94</td>
<td>.98</td>
<td>.02</td>
<td>44</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td>0.95 to 0.99</td>
<td>.99</td>
<td>.01</td>
<td>44</td>
<td>13</td>
<td>17</td>
</tr>
</tbody>
</table>

*a The heat output ratio means the ratio of minimum to maximum heat output rates as defined in 4.1.13.

Table 4—Average Design Heating Requirements for Vented Heaters With Different Output Capacities

<table>
<thead>
<tr>
<th>Vented heaters output capacity G_{out} (Btu/hr)</th>
<th>Average design heating requirements (kBtu/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,000–7,499</td>
<td>5.0</td>
</tr>
<tr>
<td>7,500–10,499</td>
<td>7.5</td>
</tr>
<tr>
<td>10,500–13,499</td>
<td>10.0</td>
</tr>
<tr>
<td>13,500–16,499</td>
<td>12.5</td>
</tr>
<tr>
<td>16,500–19,499</td>
<td>15.0</td>
</tr>
<tr>
<td>19,500–22,499</td>
<td>17.5</td>
</tr>
<tr>
<td>22,500–26,499</td>
<td>20.5</td>
</tr>
<tr>
<td>26,500–30,499</td>
<td>23.5</td>
</tr>
<tr>
<td>30,500–34,499</td>
<td>26.5</td>
</tr>
<tr>
<td>34,500–38,499</td>
<td>30.0</td>
</tr>
<tr>
<td>38,500–42,499</td>
<td>33.5</td>
</tr>
<tr>
<td>42,500–46,499</td>
<td>36.5</td>
</tr>
<tr>
<td>46,500–51,499</td>
<td>40.0</td>
</tr>
<tr>
<td>51,500–56,499</td>
<td>44.0</td>
</tr>
<tr>
<td>56,500–61,499</td>
<td>48.0</td>
</tr>
<tr>
<td>61,500–66,499</td>
<td>52.0</td>
</tr>
<tr>
<td>66,500–71,499</td>
<td>56.0</td>
</tr>
<tr>
<td>71,500–76,500</td>
<td>60.0</td>
</tr>
</tbody>
</table>
FIGURE 1
Average Outdoor Air Temperature vs. Balance Point Temperature for Modulating Vented Heaters

This figure is based on 4500 degree-days and 15°F outdoor design temperature
FIGURE 2
Fraction of Total Annual Heating Load Applicable to Reduced Operating Mode ($X_1$) and to Maximum Operating Mode or Modulating Mode ($X_2$) vs. Balance Point Temperature for Modulating Vented Heaters.

This figure is based on 4500 degree-days and 5°F outdoor design temperature.
This map is reasonably accurate for most parts of the United States but is necessarily generalized, and consequently not too accurate in mountainous regions, particularly in the rockies.

FIGURE 3- HEATING LOAD HOURS (HLH) FOR THE UNITED STATES
APPENDIX O TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF VENTED HOME HEATING EQUIPMENT

NOTE: The procedures and calculations that refer to standby mode and off mode energy consumption, (i.e., sections 3.7 and 4.7 of this appendix) need not be performed to determine compliance with energy conservation standards for vented heaters at this time. However, on or after June 17, 2013, any representation related to standby mode and off mode energy consumption of these products must be based upon results generated under this test procedure, consistent with the requirements of 42 U.S.C. 62301(c)(2). For vented home heating equipment, the statute requires that after July 1, 2010, any adopted energy conservation standard shall incorporate standby mode and off mode energy consumption, and upon the compliance date for such standards, compliance with the applicable provisions of this test procedure will also be required.

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.


1.22 “Off mode” means the condition during the non-heating season in which the vented heater is connected to the power source, and neither the burner nor any electrical auxiliary is activated.

3.7 Measurement of electrical standby mode and off mode power.

3.7.1 Standby power measurements. With all electrical auxiliaries of the vented heater not activated, measure the standby power (P_{W,SB}) in accordance with the procedures in IEC 62301 (Second Edition) (incorporated by reference, see § 430.3), except that section 2.9, Room ambient temperature, and the voltage provision of section 2.3.5, Electrical supply, of this appendix shall apply in lieu of the IEC 62301 (Second Edition) corresponding sections 4.2, Test room, and 4.3, Power supply. Clarifying further, the IEC 62301 (Second Edition) sections 4.4, Power measuring instruments, and section 5, Measurements, shall apply in lieu of section 2.8, Energy flow instrumentation, of this appendix. 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. The recorded standby power (P_{W,SB}) shall be rounded to the second decimal place, and for loads greater than or equal to 10W, at least three significant figures shall be reported.

3.7.2 Off mode power measurement. If the unit is equipped with a seasonal 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 (Second Edition) (incorporated by reference, see § 430.3), except that section 2.9, Room ambient temperature, and the voltage provision of section 2.3.5, Electrical supply, of this appendix shall apply in lieu of the IEC 62301 (Second Edition) corresponding sections 4.2, Test room, and 4.3, Power supply. Clarifying further, the IEC 62301 (Second Edition) sections 4.4, Power measuring instruments, and section 5, Measurements, shall apply in lieu of section 2.8, Energy flow instrumentation, of this appendix. 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}.

470
P_{W,SB}, in which case no separate measurement of off mode power is necessary. The recorded off mode power (P_{W,OFF}) shall be rounded to the second decimal place, and for loads greater than or equal to 10W, at least three significant figures shall be reported.

4.0 * * *

4.6.3 Average annual auxiliary electrical energy consumption for vented heaters. For vented heaters with single-stage controls or manual controls, the average annual auxiliary electrical consumption (E_{AE}) is expressed in kilowatt-hours and defined as:

\[ E_{AE} = BOH_{SB} P_e + E_{SO} \]

Where:

- BOH_{SB} = as defined in 4.6.1 of this appendix
- P_e = as defined in 3.1.3 of this appendix
- E_{SO} = as defined in 4.7 of this appendix

4.6.3.1 For vented heaters with two-stage or modulating controls, E_{AE} is defined as:

\[ E_{AE} = (BOH_{SB} + BOH_{OPT}) P_e + E_{SO} \]

Where:

- BOH_{SB} = as defined in 4.6.1 of this appendix
- BOH_{OPT} = as defined in 4.6.1 of this appendix
- P_e = as defined in 3.1.3 of this appendix
- E_{SO} = as defined in 4.7 of this appendix

* * * * *

4.7 Average annual electric standby mode and off mode energy consumption.

Calculate the annual electric standby mode and off mode energy consumption, E_{SO}, defined as, in kilowatt-hours:

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

Where:

- P_{W,SB} = vented heater standby mode power, in watts, as measured in section 3.7 of this appendix
- 4160 = average heating season hours per year
- P_{W,OFF} = vented heater off mode power, in watts, as measured in section 3.7 of this appendix
- 4600 = average non-heating season hours per year
- K = 0.001 kWh/Wh, conversion factor for watt-hours to kilowatt-hours

BOH = burner operating hours as calculated in section 4.6.1 of this appendix where for single-stage controls or manual controls vented heaters BOH = BOH_{SB} and for vented heaters equipped with two-stage or modulating controls BOH = (BOH_{SB} + BOH_{OPT}).

APPENDIX P TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF POOL HEATERS


3. Measurements. Measure the quantities delineated in section 2.9 of ANSI Z21.56-1994. The measurement of energy consumption for oil-fired pool heaters in Btu is to be carried out in appropriate units, e.g., gallons.

4. Calculations

4.1 Thermal efficiency. Calculate the thermal efficiency, E (expressed as a percent), as specified in section 2.9 of ANSI Z21.56-1994. The expression of fuel consumption for oil-fired pool heaters shall be in Btu.

4.2 Average annual fossil fuel energy for pool heaters. The average annual fuel energy for pool heater, E_{F}, is defined as:

\[ E_{F} = BOH_{q_{r}}*(POH - BOH)Q_{r} \]

where:

- BOH = average number of burner operating hours = 104 h
- POH = average number of pool operating hours = 4464 h
- Q_{r} = rated fuel energy input as defined according to 2.9.1 or 2.9.2 of ANSI Z21.56-1994, as appropriate
- Q_{r} = energy consumption of continuously operating pilot light if employed, in Btu/h.

4.3 Average annual auxiliary electrical energy consumption for pool heaters. The average annual auxiliary electrical energy consumption for pool heaters, E_{AE}, is expressed in Btu and defined as:

\[ E_{AE} = BOH P_{E} \]

where:

- PE = 2E, if heater tested according to 2.9.1 of ANSI Z21.56-1994
- = 3.412 PE_{max}, if heater tested according to 2.9.2 of ANSI Z21.56-1994, in Btu/h
- E_{AE} = Electrical consumption of the heater (converted to equivalent unit of Btu), including the electrical energy to the circulating pump if used, during the 30-minute thermal efficiency test, as defined in 2.9.1 of ANSI Z21.56-1994, in Btu per 30 min.
- PE_{max} = nameplate rating of auxiliary electrical equipment of heater, in Watts
- BOH = as defined in 4.2 of this appendix

4.4 Heating seasonal efficiency.

4.4.1 Calculate the seasonal useful output of the pool heater as:

\[ E_{OUT} = BOH ([E_{AE}/100]Q_{r} + PE) \]

where:

- BOH = as defined in 4.2 of this appendix
- E_{AE} = thermal efficiency as defined in 4.1 of this appendix
- Q_{r} = as defined in 4.2 of this appendix