ENERGY STAR® Program Requirements Product Specification for Furnaces

Interim Approach for Determining Furnace Fan Energy Use Rev. Jun-2011

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1 SCOPE

The following test method shall be used to calculate furnace fan efficiency (e) to determine product compliance with requirements in the ENERGY STAR Eligibility Criteria for Furnaces. The ENERGY STAR furnace eligibility requirements will eventually reference the DOE furnace fan test procedure, currently under development. The final rule for the DOE test procedure is required to be published by December 2013. Prior to the publication of the DOE test procedure, the ENERGY STAR furnace eligibility requirements will reference this test approach. This test approach duplicates that stipulated in EISA 2007.

2 DEFINITIONS

A) Advanced Main Circulating Fan: A fan used in a furnace which is more efficient than a standard Furnace Fan (defined below). It is a high efficiency class of Furnace Fan, which includes those that have an annual electricity use of no more than two percent of the total annual energy use of the furnace.

B) ANSI/ASHRAE Standard 103–1993: The test standard published in 1993 by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), approved by the American National Standards Institute (ANSI) on October 4, 1993, and entitled "Method of Testing for Annual Fuel Utilization Efficiency of Residential Central Furnaces and Boilers" (with errata of October 24, 1996).

C) Burner Operating Hours for Furnaces Equipped with Single Stage Controls (BOHss): The national average number of burner operating hours for furnaces equipped with single-stage controls.

D) Control Configurations:

1) Single Stage Control: A control that cycles a burner between the maximum heat input rate and "off".

2) Step Modulating Control: A modulating control that cycles a burner between the reduced input rate and "off" if the heating load is light. If a higher heating load is encountered that cannot be met with the reduced input rate, the control goes into a modulating mode where it either gradually or incrementally increases the input rate to meet the higher heating load. At that point, if a lower heating load is encountered, the control either gradually or incrementally decreases to the reduced input rate.

3) Two Stage Control: A modulating control that both cycles a burner between reduced heat input rate and "off" and between the maximum heat input rate and "off". It may also switch from "off" to reduced fire to high fire to "off" under certain load conditions.

E) e: The ratio of the furnace fan electrical consumption to the total energy consumption of the furnace during the heating mode.

F) E_{AE}: Average annual auxiliary electrical energy consumption for gas or oil-fired furnaces, expressed in kilowatt hours (kWh).

G) E_F: *A*verage annual fuel energy consumption for gas or oil fueled furnaces expressed in British thermal units (Btu), *and calculated using the equations defined in Section 3, Test Approach and Calculation Methodology*.

H) E_{Fan}: Annual electricity use of the Advanced Main Circulating Fan, expressed in kilowatt hours (kWh).

I) $E_{Furnace}$: Average annual auxiliary electrical energy consumption for gas or oil-fired furnaces excluding the average annual electric standby mode and off mode energy consumption, expressed in kWh.

J) E_M: Average annual energy use during the heating season, expressed in Btu.

K) E_{SO}: Average annual electric standby mode and off mode energy consumption, expressed in kWh.

L) Furnace Fan: An electrically powered device used in residential central heating, ventilation, and air conditioning (HVAC) systems for the purposes of circulating air through duct work. A furnace fan consists of a fan motor and its controls, an impeller, and sheet metal housing.

M) Natural Gas Furnace: A furnace with natural gas as the energy source.

N) Oil Furnace: A furnace with oil as the energy source.

O) Operation Modes:

1) Active Mode: The mode of operation during which the Furnace Fan is powered and the impeller is in motion. A Furnace Fan is in active mode during the heating season in which the furnace or boiler is connected to the power source, and the burner, electric resistance elements, or any electrical auxiliaries such as blowers or pumps, are activated.

2) Standby mode: The mode of operation during which the Furnace Fan is powered and the impeller is not in motion. A Furnace Fan is in standby mode during the heating season in which the furnace or boiler is connected to the power source, and the burner, electric resistance elements, or any electrical auxiliaries such as blowers or pumps, are not activated.

3) Off mode: The mode of operation during which the Furnace Fan is not powered. A Furnace Fan is in off mode during the non-heating season in which the furnace or boiler is connected to the power source, and the burner, electric resistance elements, and any electrical auxiliaries such as blowers or pumps, are not activated.

P) Propane Furnace: A furnace with propane as an energy source.

Q) Q_{IN}: Fuel energy maximum nameplate input rate at steady-state operation, including any pilot light input, expressed in Btu/h.

R) Q_P: Fuel energy input rate to pilot light, expressed in Btu/h.

3 TEST APPROACH[1] AND CALCULATION METHODOLOGY

The annual electricity use of the Advanced Main Circulating Fan (E_{Fan}) shall not exceed a defined percent, e, of the total annual energy use of the furnace:

$$\boldsymbol{E_{Fan} = e \times E_F} \quad (1)$$

where[2]:

For furnaces fueled by gas or oil and equipped with single stage controls

$$\boldsymbol{e = \frac{E_{Furnace} \times 3,412}{(E_{Furnace} \times 3,412) + (E_F)}} \quad (2)$$

$$\boldsymbol{E_F = BOH_{SS} \times (Q_{IN} - Q_P) + 8,760 \times Q_P} \quad (3)$$

$$\boldsymbol{E_{Furnace} = E_{AE} - E_{SO}} \quad (4)$$

For furnaces fueled by gas or oil and equipped with two-stage or step modulating controls

$$\boldsymbol{e = \frac{E_{Furnace} \times 3,412}{(E_{Furnace} \times 3,412) + (E_F)}} \quad (5)$$

$$\boldsymbol{E_F = E_M + 4,600 \times Q_P} \quad (6)$$

$$\boldsymbol{E_{Furnace} = E_{AE} - E_{SO}} \quad (7)$$

Additional information, including a full set of detailed equations, is available in the following locations:

1. In the Code of Federal Regulations (CFR), Title 10, Appendix N to Subpart B of Part 430, found here: http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=91ed077a2062df92f6e8cb313723a981&rgn=div9&view=text&node=10:3.0.1.4.16.2.9.6.14&idno=10.
2. In ANSI/ASHRAE Standard 103–1993, which is available for purchase here: http://www.techstreet.com/cgi-bin/detail?doc_no=ASHRAE|103_1993&product_id=4146.

[1] Detailed test set-up and test approach are documented in ANSI/ASHRAE Standard 103-1993.
[2] As defined in the Code of Federal Regulations, Title 10, Appendix N to Subpart B of Part 430. Full summary available here: http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=95cff987bc3e0a1c94bba37afe439cbf&rgn=div9&view=text&node=10:3.0.1.4.16.2.9.6.14&idno=10

4 APPENDICES

A) Additional Equations

The following equations only apply to E_F, the average annual fuel energy consumption for gas or oil fueled furnaces, and are required to complete the calculations for furnaces equipped with two-stage or step modulating controls in the equations above. Constants and variables in these equations not already defined are defined in Table 1 of Appendix 4B.

For furnaces fueled by gas or oil and equipped with two-stage controls

Average Annual Energy Use during the Heating Season:

$$\boldsymbol{E_M = (Q_{IN} - Q_P) \times BOH_{SS} + (8,760 - 4,600) \times Q_P} \quad \text{(A1)}$$

For furnaces fueled by gas or oil and equipped with step modulating controls

Average Annual Energy Use during the Heating Season:

$$\boldsymbol{E_M = (Q_{IN} - Q_P) \times BOH_{SS} + (8,760 - 4,600) \times Q_P} \quad \text{(A2)}$$

B) Additional Constants

The remaining constants for use in Equations (1) through (7), (A1), and (A2) are defined in Table 1, as specified in the CFR, Title 10, Appendix N to Subpart B of Part 430 and ANSI/ASHRAE Standard 103–1993.

Table 1: Equation Constants

Constant	*Definition*
3,412	Conversion to express energy in terms of kWh instead of Btu
4,600	Average non-heating season hours per year
8,760	Total number of hours per year