APPENDIX J. FURNACE FAN POWER CURVES

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APPENDIX J. FURNACE FAN POWER CURVES

J.1 Fan Power

Once the operating point of air flow and static pressure is determined by finding the intersection of the fan curve and the system curve, the watts per cubic feet per minute (CFM) of airflow are determined using the equations developed in this appendix. The power consumption of the fan at this operating condition, BE, is calculated by multiplying the Watts/CFM by the CFM at the operating point:

$$BE = \left(\frac{Watts}{CFM}\right) \times Q \qquad \textbf{Eq. 1}$$

where,

BE	=	circulating air fan electrical energy consumption (watts),
Watts/CFM	=	determined by Equation 2 or Equation 3 in section J.1, and
Q	=	airflow (cfm).

For furnaces with air handlers with permanent split capactiro (PSC) blower motors, one manufacturer reports watts across a range of pressures.[1,2,3,4,5,6,7] For these models, the Department divided watts at these pressures by air flow in CFM at these same pressures. These values of watts per CFM across a range of pressures were fit to a fourth order polynomial for the basic furnace models made by the manufacturer. The Department did this separately for each of the four nominal air handlers sizes for both non-condensing and condensing furnaces. The watts per CFM for PSC blower motors is given by the following equation:

$$\frac{Watts}{CFM} = m_0 + m_1 \times (P) + m_2 \times (P^2) + m_3 \times (P^3) + m_4 \times (P^4) \qquad \textbf{Eq. 2}$$

where,

Watts/CFM	=	blower electricity consumption in watts reported by manufacturer divided by the airflow in CFM at the same static pressure,
$m_{0,1,2,3,and4}$	=	coefficients derived from 4th degree polynomial approximation (see Table J.1 for actual coefficient values), and
P	=	external static pressure (in. w.g.).

Table J.1 Coefficients for W/CFM equation for PSC motors

		m_0	m_1	m_2	m_3	m_4
Non-Condensing	2-ton	0.39	-0.01	-0.11	0.22	0.03
	3-ton	0.43	-0.15	0.09	0.02	0.06
	4-ton	0.41	-0.16	0.14	-0.07	0.08
	5-ton	0.44	-0.08	0.01	0.05	0.01
Condensing	2-ton	0.40	-0.19	0.41	-0.50	0.31
	3-ton	0.45	-0.24	0.19	0.02	-0.04
	4-ton	0.41	-0.12	-0.10	0.20	-0.02
	5-ton	0.47	-0.19	0.30	-0.32	0.17

Figure J.1 shows the Watts per CFM curve for 3-ton condensing single-stage furnace fitted to the manufacturers' data. A similar process of fitting curves to data was done for each nominal air handler size for both non-condensing and condensing furnaces.

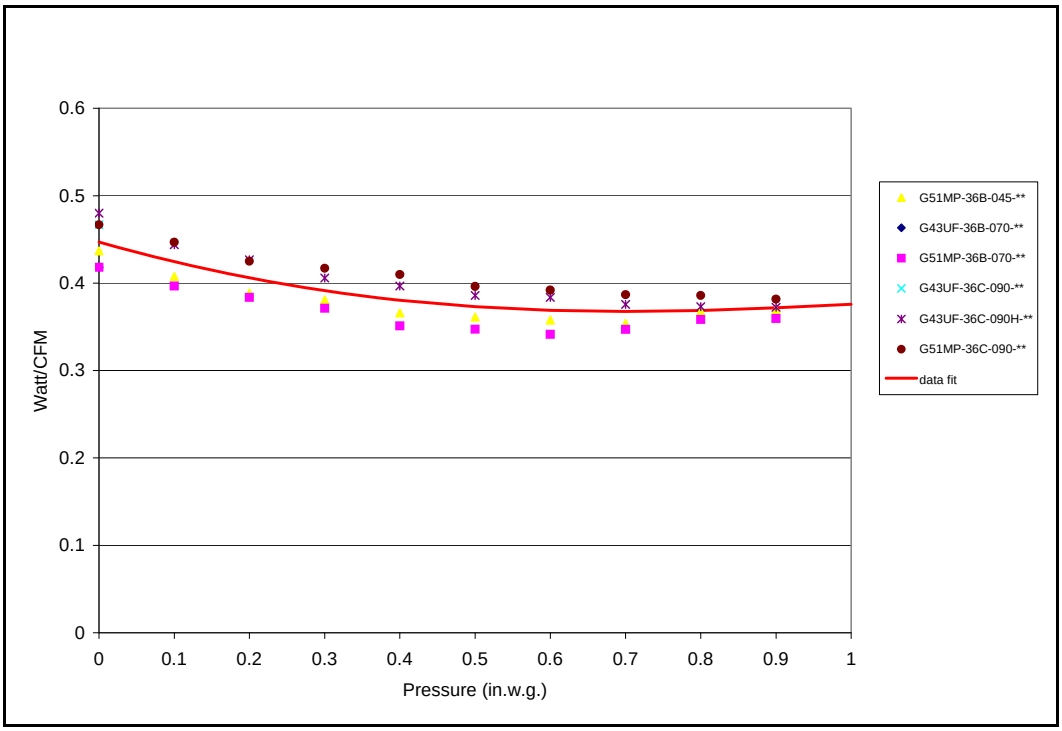

Figure J.1 Example Fit of Watts/CFM for 3-ton Condensing Single-Stage Furnace

Figures J.2 and J.3 show the fit curves of Watts/CFM for pressures from 0 in.w.g. to 1.0 in.w.g. Data from the models that were used to develop these fan curves is shown in Appendix H, Determination of Basic Furnace and Boiler Models.

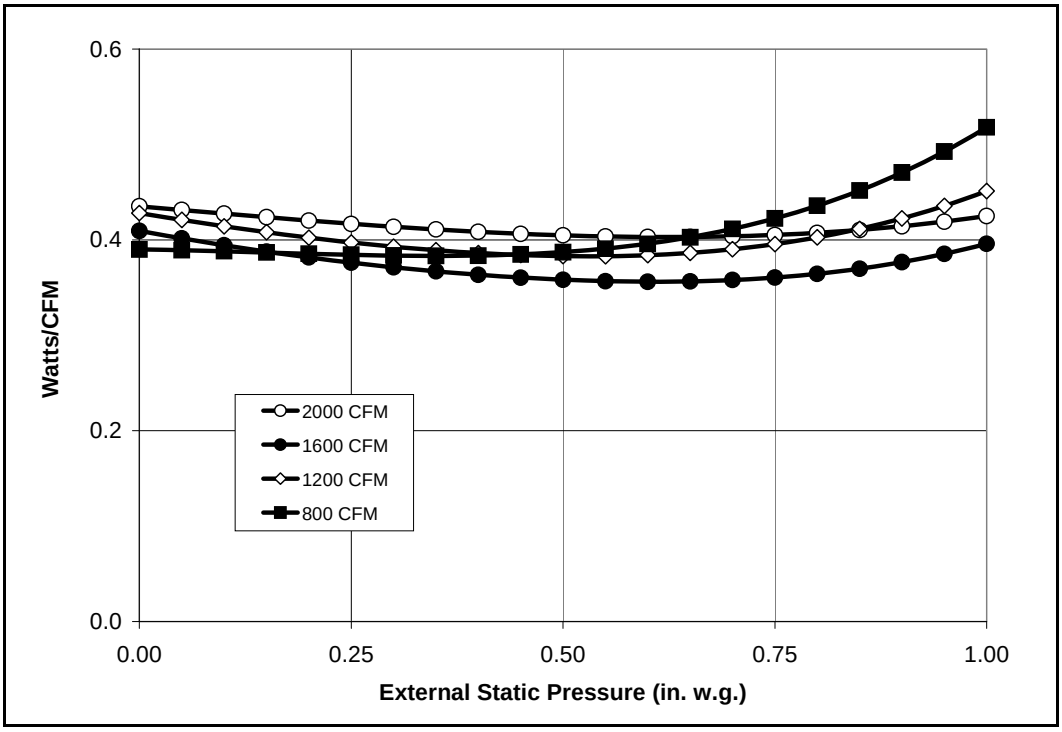

Figure J.2 Watts/CFM vs. Pressure Curves for Non-Condensing Single-Stage Virtual Model Furnaces

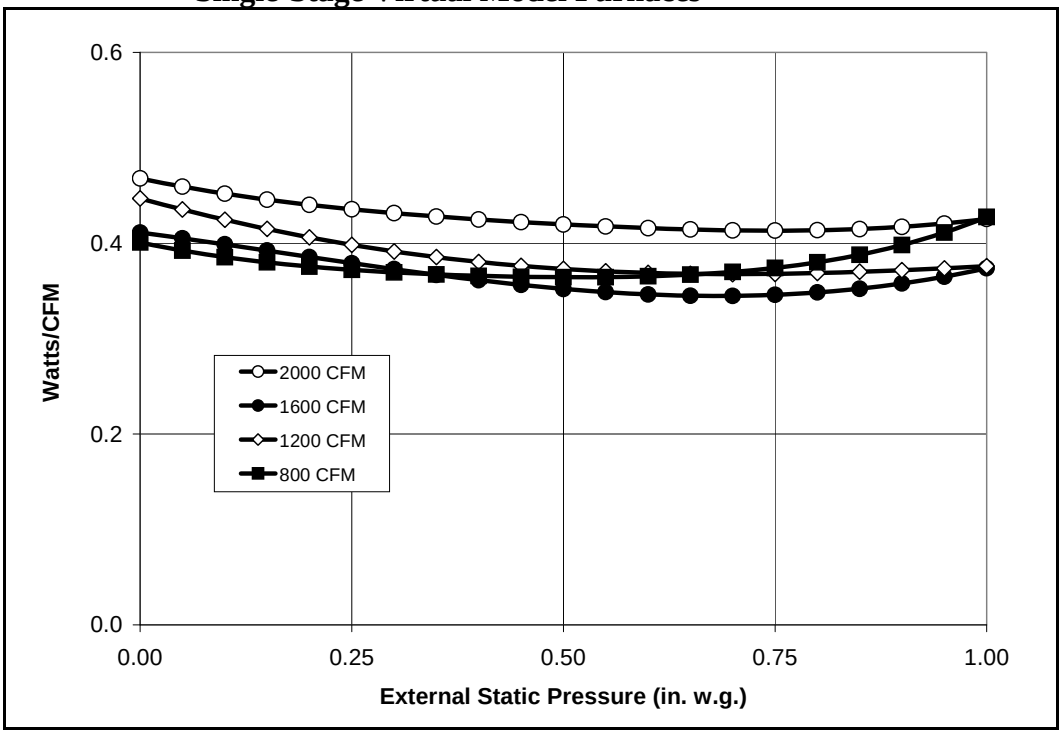

Figure J.3 Watts/CFM vs. Pressure Curves for Condensing Single-Stage Virtual Model Furnaces

For the two-stage and step-modulating furnaces with ECM motors, the Department calculated watts per CFM equations using data from basic models of several manufacturers.[8, 9, 10, 11, 12, 13, 14] These data are in the reduced set of furnace models database.

This was done for basic model furnaces nominally designed for use with 3 ton and 5 ton air conditioners. The watts per CFM data points of these basic models were fit to straight lines using Equation 3. This was done separately for high fire and low fire for both non-condensing and condensing models. To be consistent with other analyses, the Department calculated the slope and intercept for the watts per CFM curves for furnaces intended to operate with 2 ton and 4 ton air conditioners by interpolating from the values for 3 ton and 5 ton air handlers. Figures J.4-J.7 show the lines for the basic models. Table J.2 shows the coefficients for two-stage and step-modulating furnaces with ECM motors using Eq. 3. Data from the models used to develop these fan curves is shown in Appendix H, Determination of Basic Furnace and Boiler Models.

$$\frac{Watts}{CFM} = m_0 + m_1 \times (P) \qquad \textbf{Eq. 3}$$

where,

Watts/CFM	=	blower electricity consumption in watts reported by manufacturer divided by the airflow in CFM at the same static pressure,
$m_{0,1}$	=	coefficients derived from linear approximation (see Table J.2 for actual coefficient values), and
P	=	external static pressure (in. w.g.).

Table J.2 Coefficients for W/CFM equation for Two-Stage and Step-Modulating furnaces with ECM motors

		High Fire		Low Fire	
		m_0	m_1	m_0	m_1
Non-Condensing	2-ton	0.13	0.24	0.06	0.25
	3-ton	0.14	0.24	0.08	0.25
	4-ton	0.15	0.24	0.09	0.25
	5-ton	0.16	0.24	0.11	0.24
Condensing	2-ton	0.12	0.23	0.10	0.24
	3-ton	0.14	0.24	0.10	0.25
	4-ton	0.17	0.25	0.11	0.26
	5-ton	0.20	0.26	0.11	0.27

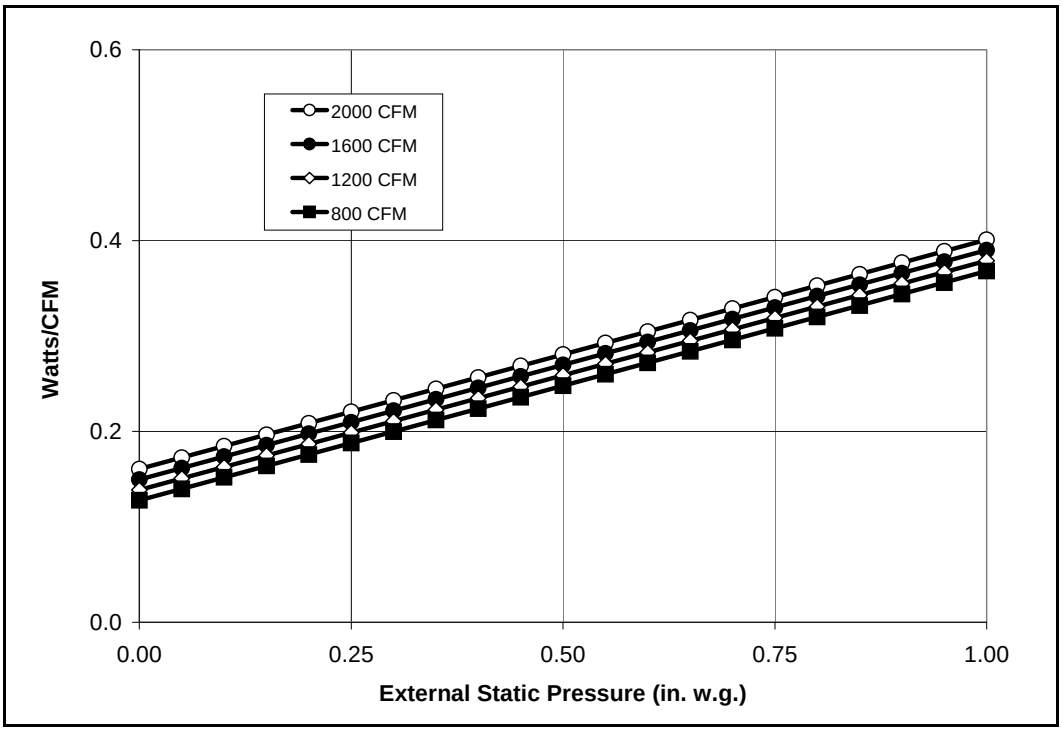

Figure J.4 Watts/CFM vs. Pressure Curves for Non-Condensing Two-Stage Virtual Model Furnaces - High Fire

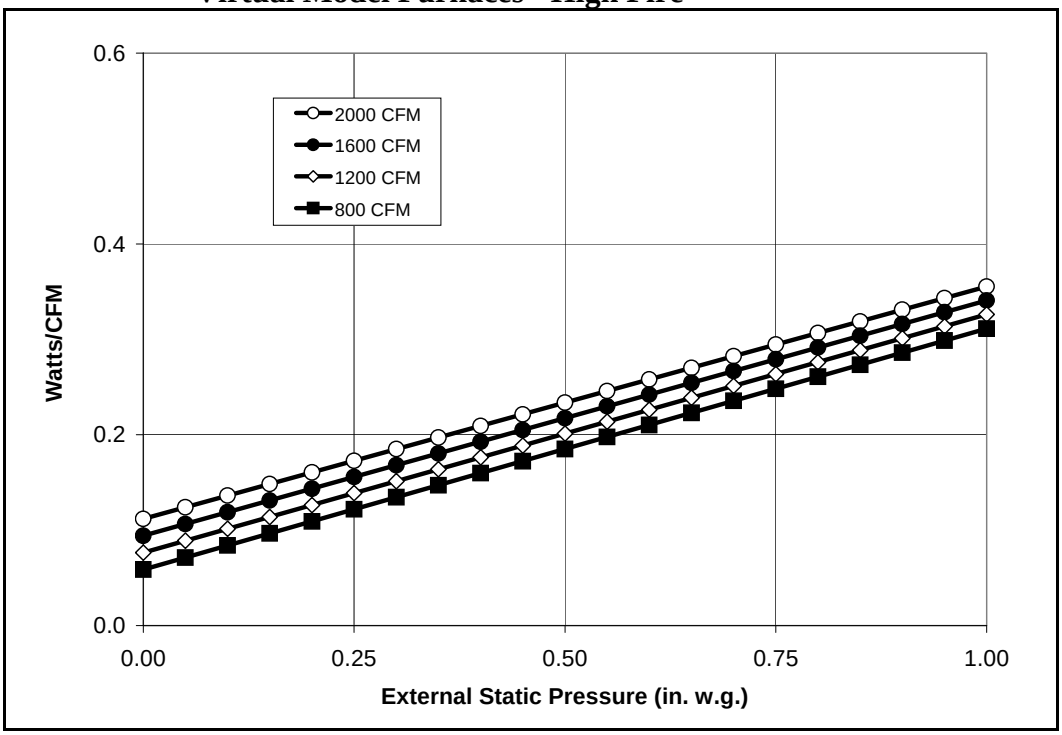

Figure J.5 Watts/CFM vs. Pressure Curves for Non-Condensing Two-Stage Virtual Model Furnaces - Low Fire

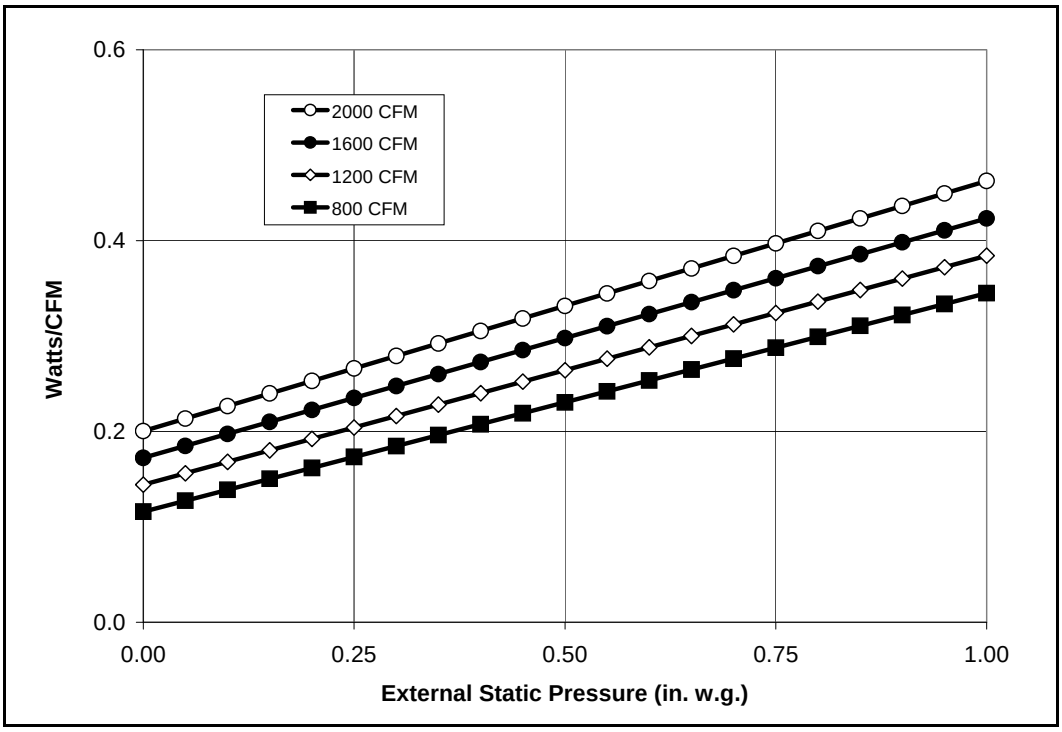

Figure J.6 Watts/CFM vs. Pressure Curves for Condensing Two-Stage Virtual Model Furnaces - High Fire

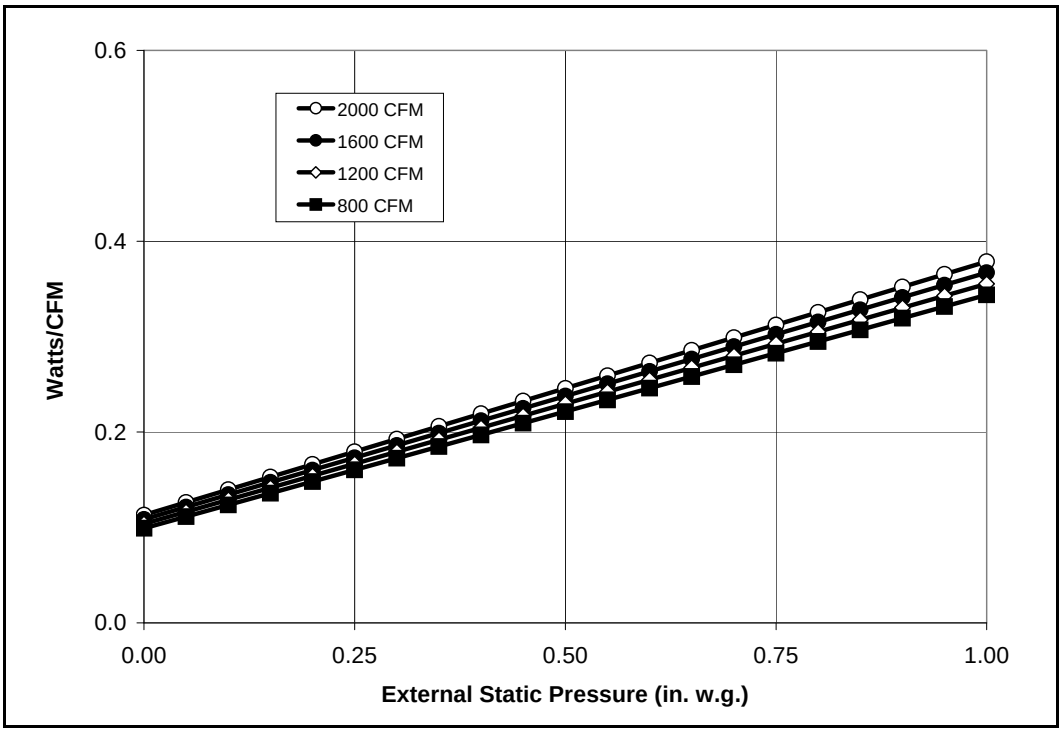

Figure J.7 Watts/CFM vs. Pressure Curves for Condensing Two-Stage Virtual Model Furnaces - Low Fire

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