APPENDIX 7.6. OVERALL AIR-MOVING EFFICIENCY

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDIX 7.6. OVERALL AIR-MOVING EFFICIENCY

7.6.1 INTRODUCTION

The overall air-moving efficiency is a variable in the calculation of blower motor electricity consumption. The overall air-moving efficiency is a ratio of the air power divided by the electric power used by the blower motor. Air power is the power embodied in the air due to its motion and pressure increase. Air power at any operating condition can be calculated for any furnace from pressure, airflow, and supply air outlet area, as explained in Chapter 7, section 7.5.3, Overall Air-Moving Efficiency.

In addition to the pressure and airflow data that are available for all furnace models, one manufacturer reports fan motor electricity consumption as well.[1, 2, 3, 4, 5, 6] The model series used for these calculations are Lenox G23 and G40 for non-condensing furnaces and Lenox 90UGF, G26Q, and GHR26Q for condensing furnaces. For these models, DOE calculated air power and overall efficiency for each point in the fan operating tables for each of the models.

The relationships between air power and overall efficiency are only valid for these particular furnace models and vary by airflow capacity. To generalize the relationship of overall air-moving efficiency to airflow in order to calculate efficiency for any furnace type, the Department transformed airflow to a percentage of airflow at free flow. Free flow signifies no pressure difference or drop. The free flow percentage transformation allowed all of the curves to be plotted together independently of cfm measurement. Figures 7.6.1.1 through 7.6.1.6 show the overall air-moving efficiency as a function of airflow, where airflow is indicated as fraction of free flow.

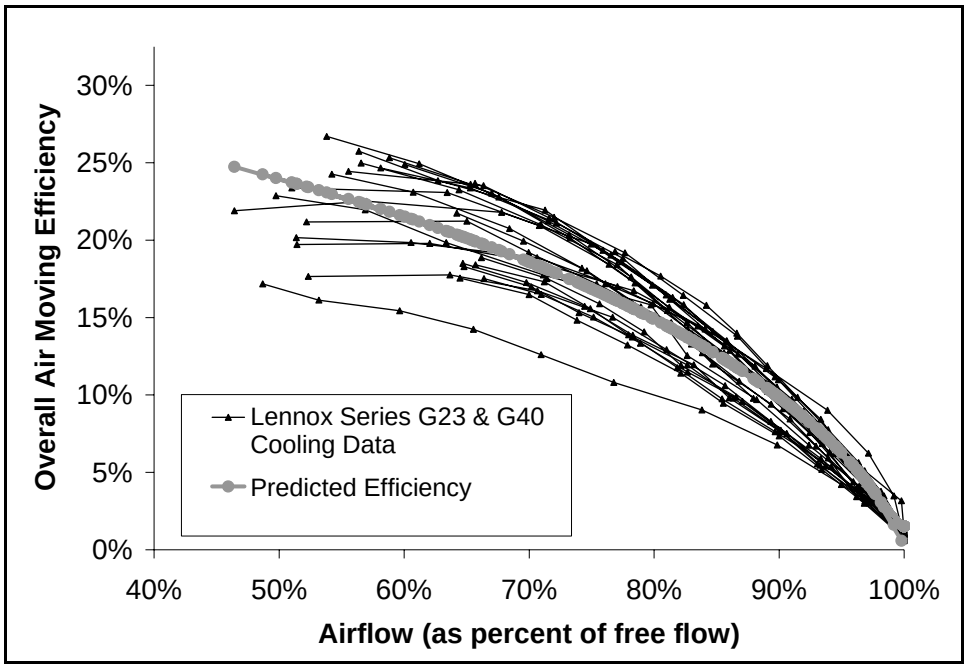

Figure 7.6.1.1 **Overall Air-Moving Efficiency (non-condensing, cooling mode)**

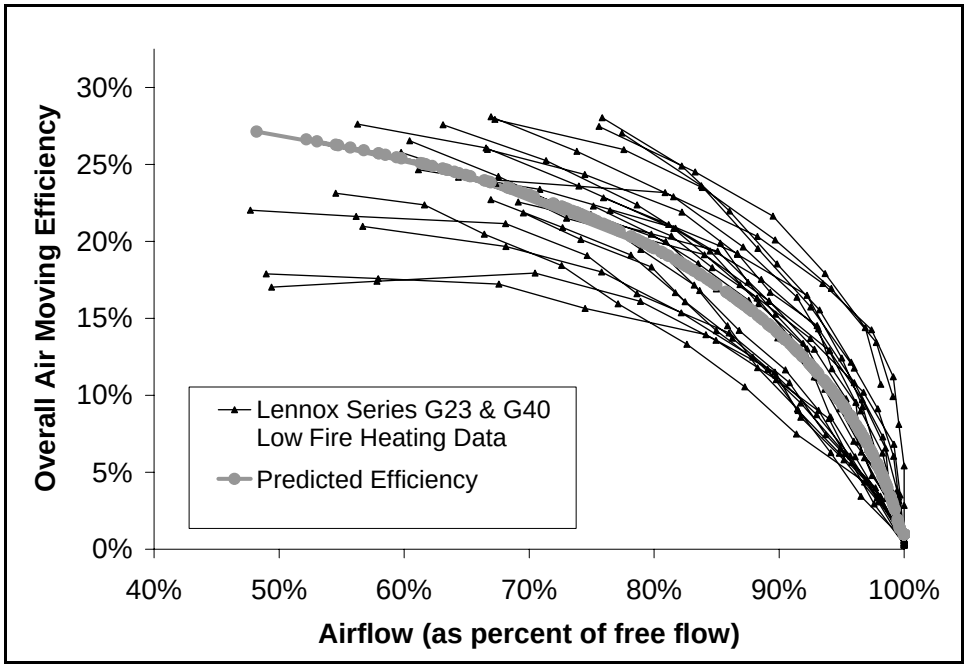

Figure 7.6.1.2 **Overall Air-Moving Efficiency (non-condensing, low-fire mode)**

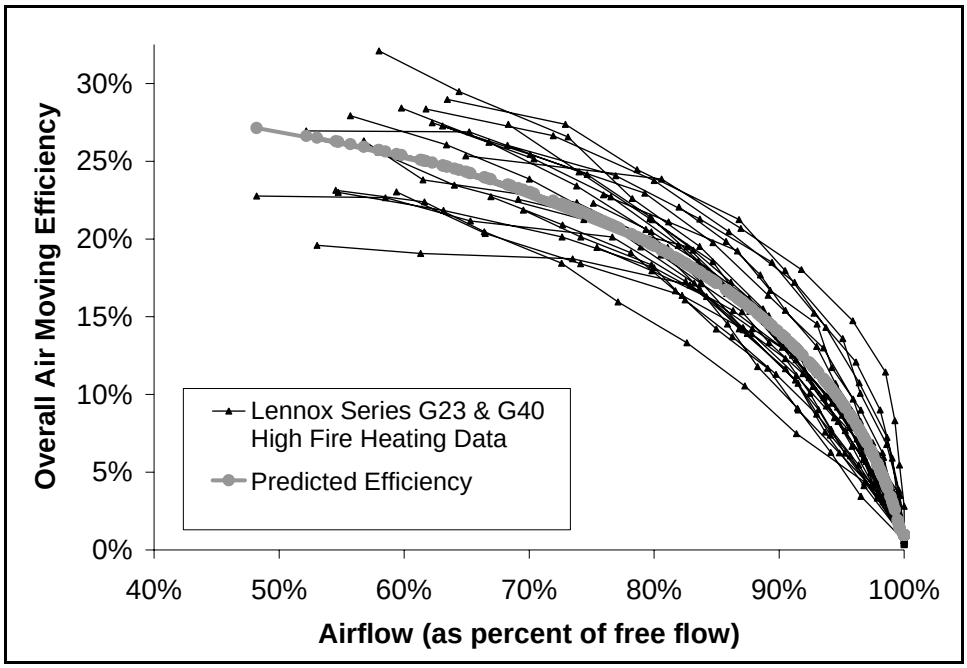

Figure 7.6.1.3 **Overall Air Moving Efficiency (non-condensing, heating mode)**

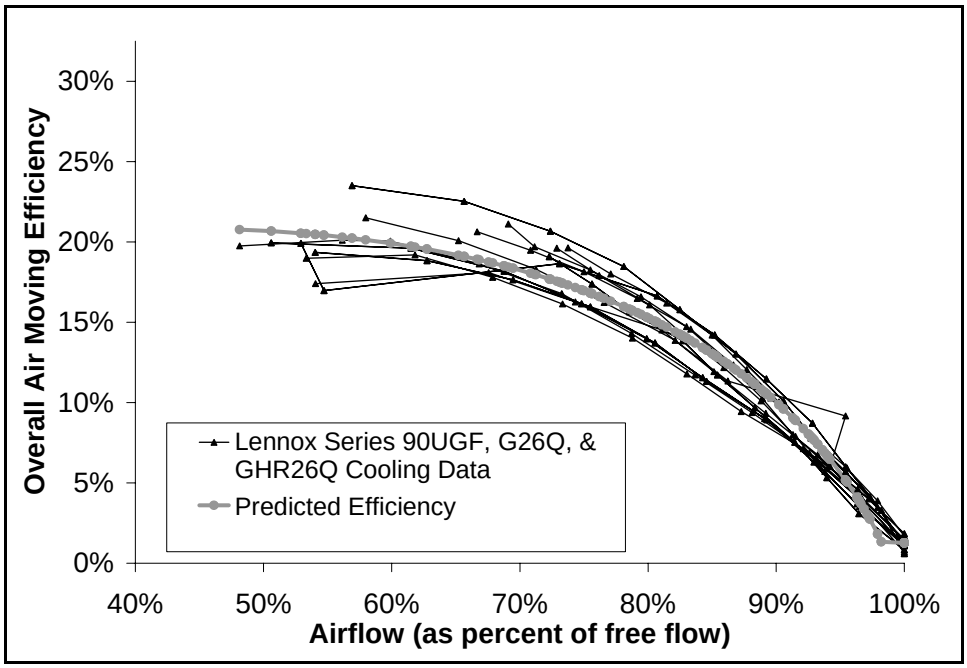

Figure 7.6.1.4 **Overall Air-Moving Efficiency (condensing, cooling mode)**

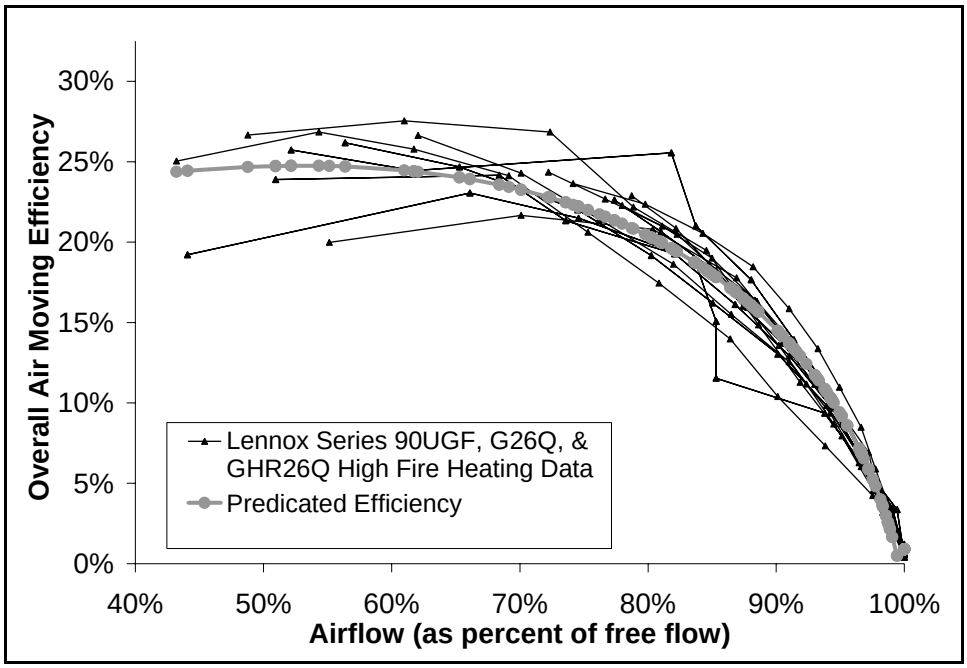

Figure 7.6.1.5 **Overall Air Moving Efficiency (condensing, heating mode)**

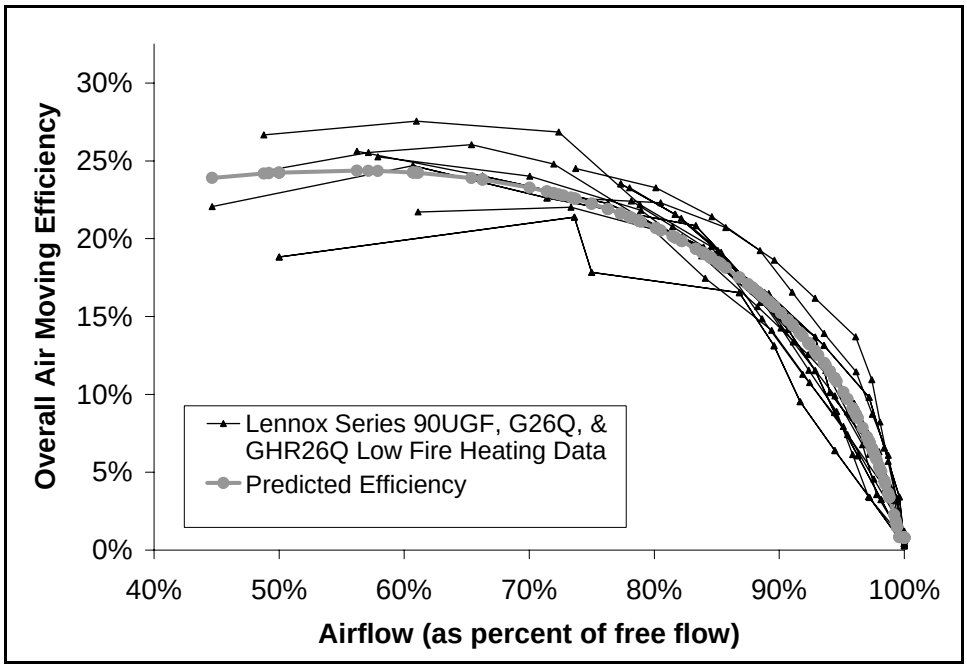

Figure 7.6.1.6 **Overall Air-Moving Efficiency (condensing, low-fire mode)**

Also shown in each figure is a single curve that best fits the other curves in each plot. The Department fit these curves to an equation of overall efficiency as a function of the ratio of airflow to free airflow. The form of the equation was selected to match the general trends of the overall efficiency curves of the specific models. The Department found the best fit between the data points from the manufacturers' literature and the equation by adjusting the coefficients to minimize the root-mean-square error in overall efficiency.

$$\eta overall = c0 + c1 \times (1 - Q0) + c2 \times (1 - Q0)^{(1/2)} + c3 \times (1 - Q0)^{(1/3)}$$

where:

$\eta_{overall}$	=	overall air-moving efficiency,
Q_0	=	ratio of airflow to free flow, and
c_0, c_1, c_2, c_3	=	empirically determined coefficients.

7.6.2 RESULTS

The Department calculated the results separately for condensing and non-condensing furnaces, and for each model. The coefficients for the six equations are shown in Tables 7.6.2.1 and 7.6.2.2.

Table 7.6.2.1 Coefficients for Overall Air-Moving Efficiency of Non-Condensing Generic Model Furnaces

	Cooling	Heating	Low-Fire
Coef0	0.015169	.0096357	0.010040
Coef1	-0.21144	-0.49263	-0.75554
Coef2	0.91056	1.1948	1.4069
Coef3	-0.39518	-0.42712	-0.49662

Table 7.6.2.2 Coefficients for Overall Air-Moving Efficiency of Condensing Generic Model Furnaces

	Cooling	Heating	Low-Fire
Coef0	0.012659	0.0090140	0.0079380
Coef1	-0.74379	-0.94689	-0.90500
Coef2	1.7392	1.8971	1.7061
Coef3	-0.83602	-0.79362	-0.65437

REFERENCES

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