THE FLOW VERSUS PRESSURE DROP CHARACTERISTICS OF FAMCO WALL AND ROOF VENTS

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EXECUTIVE SUMMARY

The aim of this project was to determine the pressure drop versus flow rate relationship for FAMCO wall and roof vents. This relation was found experimentally for vents in a four, six and eight inch size. Results are presented in a graphical format, and as a loss coefficient K.

INTRODUCTION AND PROJECT GOAL

To design a duct system, an engineer needs to know the relation between flow and pressure drop for each component in the duct. Figure 1 shows a typical example of this relation. Commonly, the curve in Figure 1 is presented in equation form using a single dimensionless number called the minor loss coefficient K:

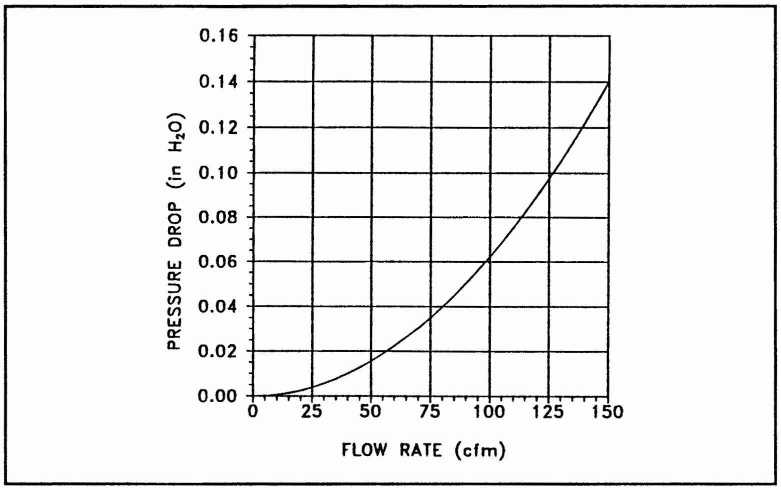


Figure 1 Pressure drop as a function of flow rate for a typical component in a duct system

$$\Delta P = K \rho V^2/2$$

where ΔP is the pressure drop across the component, ρ is fluid density and V is average velocity of fluid in the duct. Volume flow rate Q is related to average velocity V by

$$Q = V(\pi D^2/4)$$

where D is duct diameter. The advantage of equation (1) as compared to a graphical presentation is that the flow versus pressure drop information is embodied in a single number (K).

Additional information about duct design is given in standard engineering texts; see for example reference 1. Specific and detailed information relating to HVAC systems is given by references 2 and 3.

Our goal was to measure the flow versus pressure drop relation for FAMCO wall and roof vents and to present the results in both a graphical form and an equation form (ie. give K). Figure 2 and Table 1 define the vent geometries. In only a few special case can a flow versus pressure drop relation be established analytically. Hence, we selected an experimental method.

EXPERIMENTAL APPARATUS AND METHODS

Figure 3 and Table II describe the experimental apparatus. Two centrifugal fans provided the flow, with a small fan for low flow rates and a large fan for high flow rates. Flow rate was controlled using two dampers, one of which vented to atmosphere.

Flow rate was measured using a Meriam laminar flow element. The unit was factory calibrated to an accuracy of 0.86% of reading, traceable to NIST. Pressure drop across each vent cap was measured with a Dwyer micro-manometer, which has a manufacturer-stated accuracy of 0.00025 in-H_2O.

To provide well conditioned and fully developed flow, flow straighteners and long entrance lengths were used upstream of the laminar flow element and upstream of the vent cap being tested.

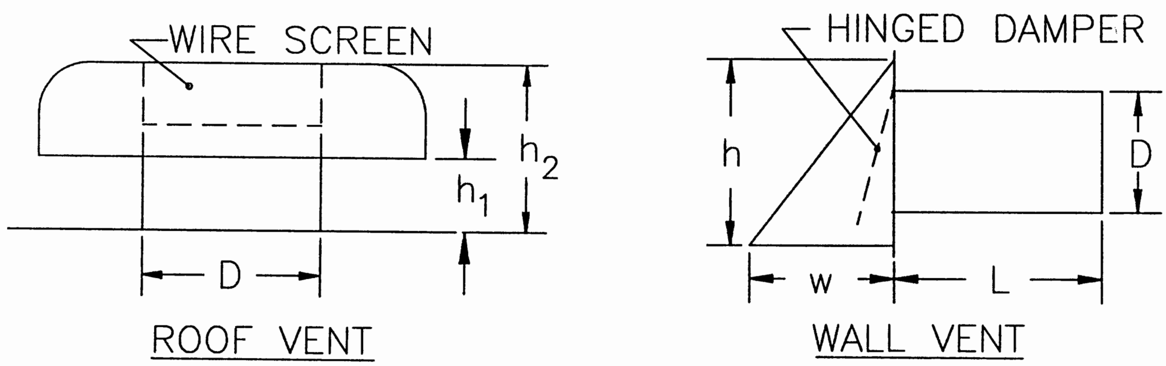
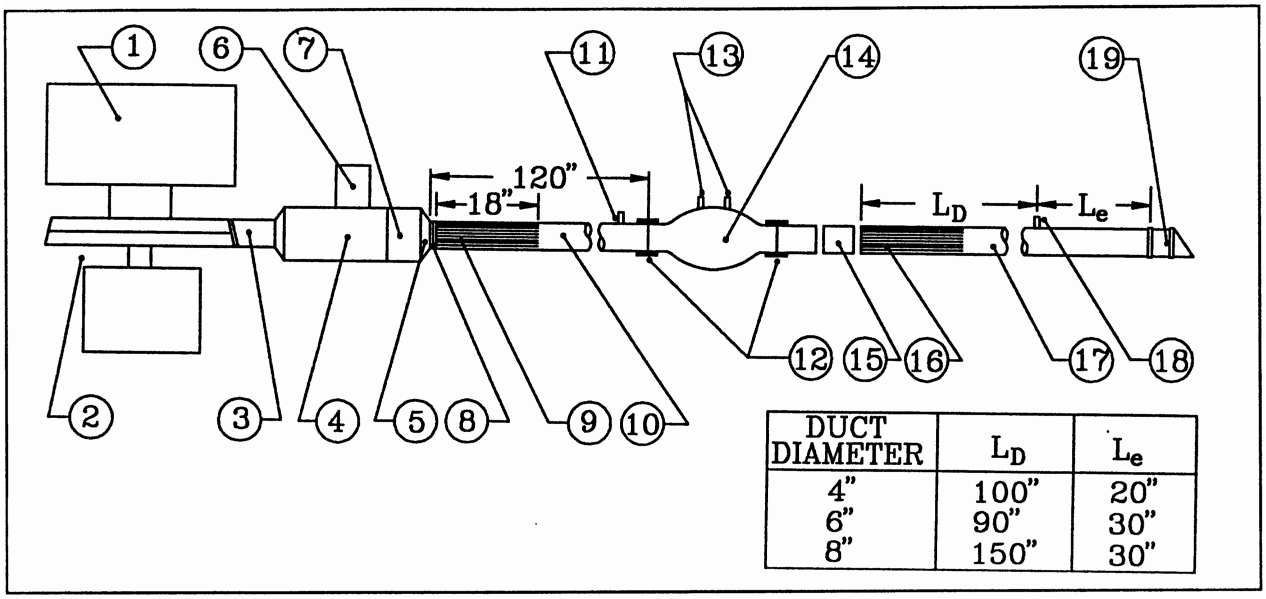


Figure 2 The geometries of the wall and roof vent. Table I gives the dimensions of each vent tested

Table I Dimensions of the tested vents. Figure 2 defines the symbols. All dimensions are in inches

ROOF VENT				WALL VENT			
D	h_1	h_2		D	h	w	L
4	1.75	3.5		4	5	3.25	8.5
6	1.75	5.0		6	7	4.5	8.5
8	2.00	5.5		8	9	6	8.5



DUCT DIAMETER	L_D	L_e
4"	100"	20"
6"	90"	30"
8"	150"	30"

Figure 3 The experimental apparatus. Numbered locations reference components described in Table II.

Table II The components of experimental apparatus shown in Figure 3

1 -- Filter Box.
2 -- High-flow System -- Dayton Model 4C129A Blower driven by a 1.5 hp 220V 3-phase Motor.
-- Low-flow System -- Dayton Model 4C108 Blower With driven by a 1 hp 220V 3-phase Motor.
3 -- 3" x 4" to 8" Expansion.
4 -- 8" x 8" x 6" Tee.
5 -- 8" x 4" Reducer.
6 -- 6" Damper.
7 -- 8" Damper.
8 -- 2 Layers Fine Mesh.
9 -- 4" Diameter Flow Straightener.
10 -- 4" Diameter Duct.
11 -- Temperature measurement location.
12 -- Rubber Couplings.
13 -- Pressure Taps.
14 -- Laminar Flow Element -- Meriam model 50MC2-4.
15 -- 4" to 6" Diameter Expansion or 4" to 8" Diameter Expansion.
16 -- 6" or 8" Diameter Flow Straightener.
17 -- 4", 6", or 8" Diameter Duct.
18 -- Pressure Tap (ΔP_m measured here using a Dwyer micromanometer).
19 -- Vent Cap being tested.

Pressure drop ΔP_v across a vent cap was not directly measured. Rather pressure was measured 20 to 30 inches upstream of the vent cap. The measured data were processed to give ΔP_v. The step in data processing were

Step 1 Measure atmospheric air temperature and pressure; compute the density at lab conditions ρ_m using the ideal gas law.

Step 2 For a given vent cap, measure the pressure drop 20 to 30 inches upstream (ΔP_m) of the vent cap as a function of the air flow rate Q.

Step 3 Using the experimental apparatus with no vent cap in place, measure the pressure drop 20 to 30 inches upstream (ΔP_p) of the exit as a function of Q.

Step 4 Curve fit the data from steps 2 and 3 and process the measured data to give ΔP_v using: $\Delta P_v = \Delta P_m - \Delta P_p$.

Step 5 Plot ΔP_v as a function of $\rho_m V^2/2$. Curve fit this plot using linear regression with a y intercept of zero. The slope of the line is K.

Step 6 Make the final data plots by calculating ΔP_v from: $\Delta P_v = \rho_s V^2/2$, and plotting ΔP_v against Q. Note that ρ_s is density at standard conditions, $\rho_s = 1.197$ kg/m^2.

EXPERIMENTAL RESULTS AND DISCUSSION

Processing the data as outlined in the previous section gave the final results. Figure 3 shows the pressure versus flow rate in graphical form and Table III presents the loss coefficient K.

Two conclusions can be made from the final results. First, the wall vent has about five to eight times less pressure drop than the roof vent. This illustrates the strong influence of vent geometry on pressure drop and suggests that redesign will improve the wall vent. Second, the K value for a vent size increases. This most likely occurs because geometric similarity is not maintained as a given vent style is changed in size.

Table III The loss coefficient K for each vent cap test

Nominal Size (inches)	K (Wall Vent)	K (Roof Vent)
4	0.77	6.52
6	1.36	6.68
8	2.03	10.3

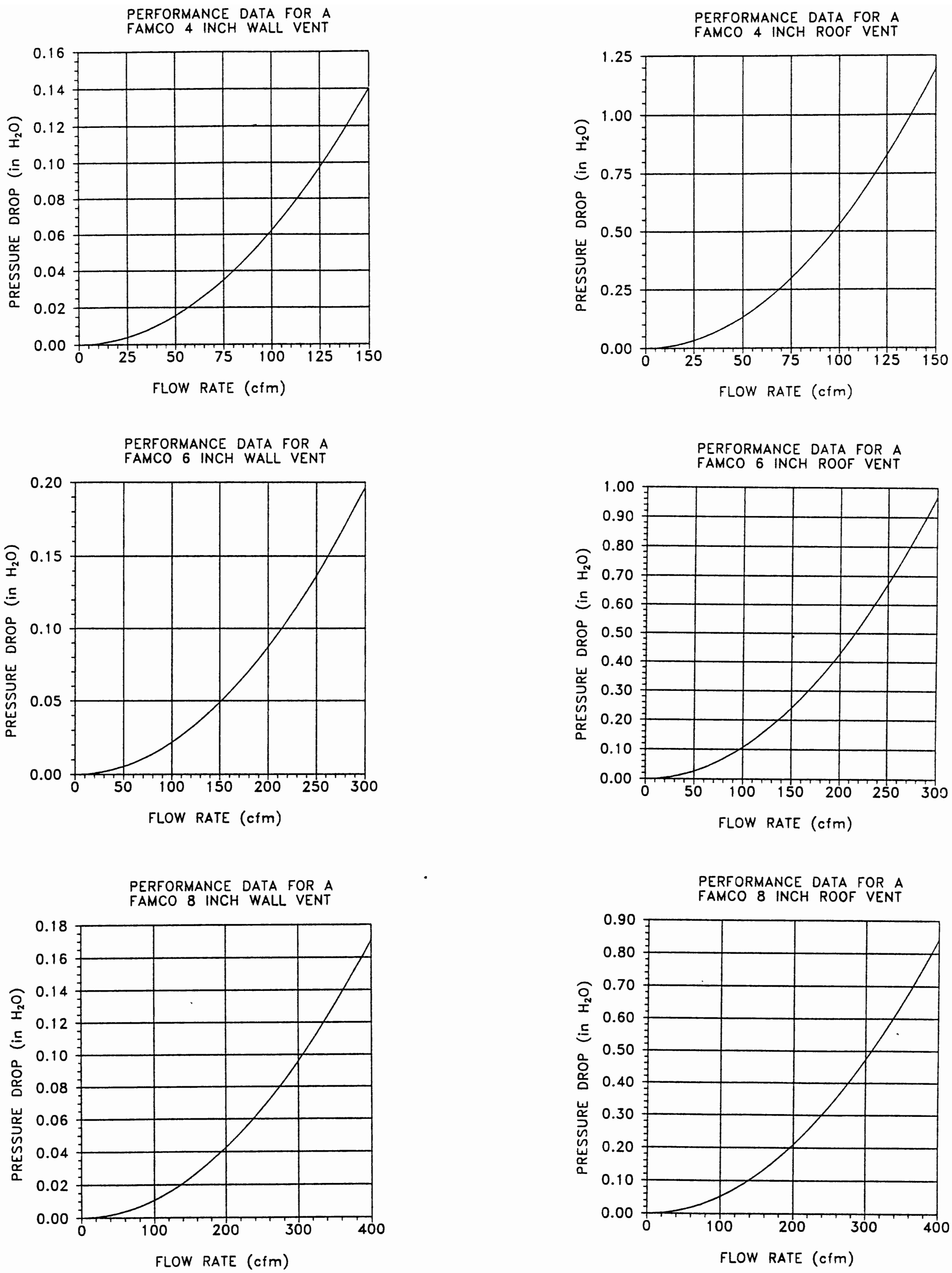


Figure 3 Pressure drop versus air flow rate for each vent cap tested (based on an air density of 1.197 kg/m^3).

RECOMMENDATIONS FOR FUTURE STUDY

Ideas for future study are--

1. Measure the flow versus pressure drop relation for additional FAMCO vents.

2. Develop the technical and product information to provide customers with a ventilation system solution. Given a customer's needs, a system solution specifies all the components and guarantees that the specified ventilation is provided.

3. Develop a marketing strategy to provide the best performing vent caps in the industry. The technical aspect of this strategy would involve testing and designing vents to minimize the pressure drop.

4. Develop better technical information about the system performance of a fan/duct/vent cap system. This involves the testing of a system and comparing the results against the recommended design procedures for a system.

REFERENCES

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