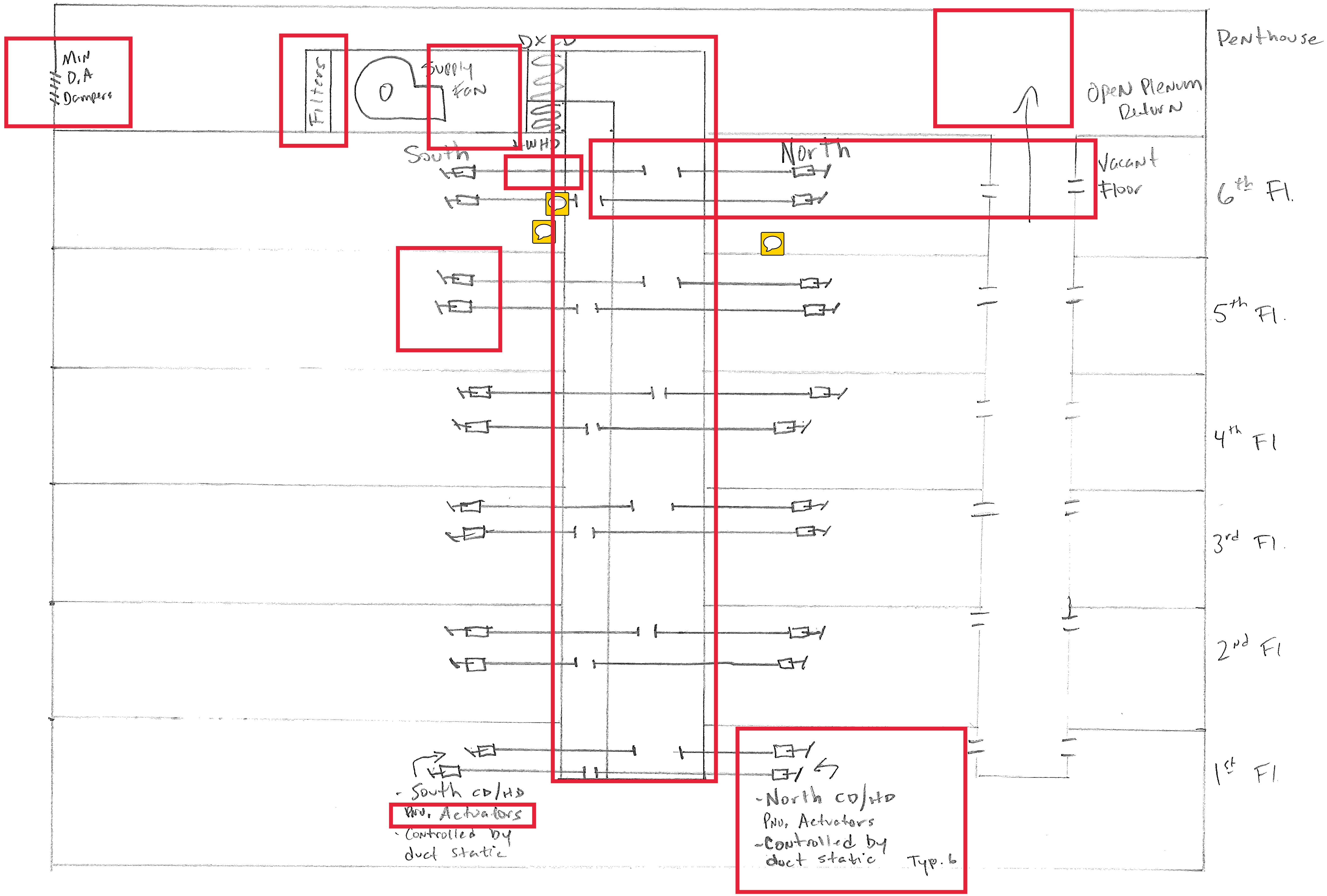
5801 Christie Ave. System Diagram



General Notes

1. Note that there are comments associated with the shapes I put on the drawing as a markup.

2. This is a really good first draft for your air handling systems. A good next step would be to field verify it if you have not done that already.

3. Most of the comments that I made are targeted at next steps and ways to improve this first pass in specific ways. In addition, in general terms, consider adding all of the control system sensors and adding equipment capacities and performance data.

4. Another desirable feature to add would be a symbols list.

AG-AeroCross-00
March 4, 2002

Application Guide

AeroCross

Flow Sensor

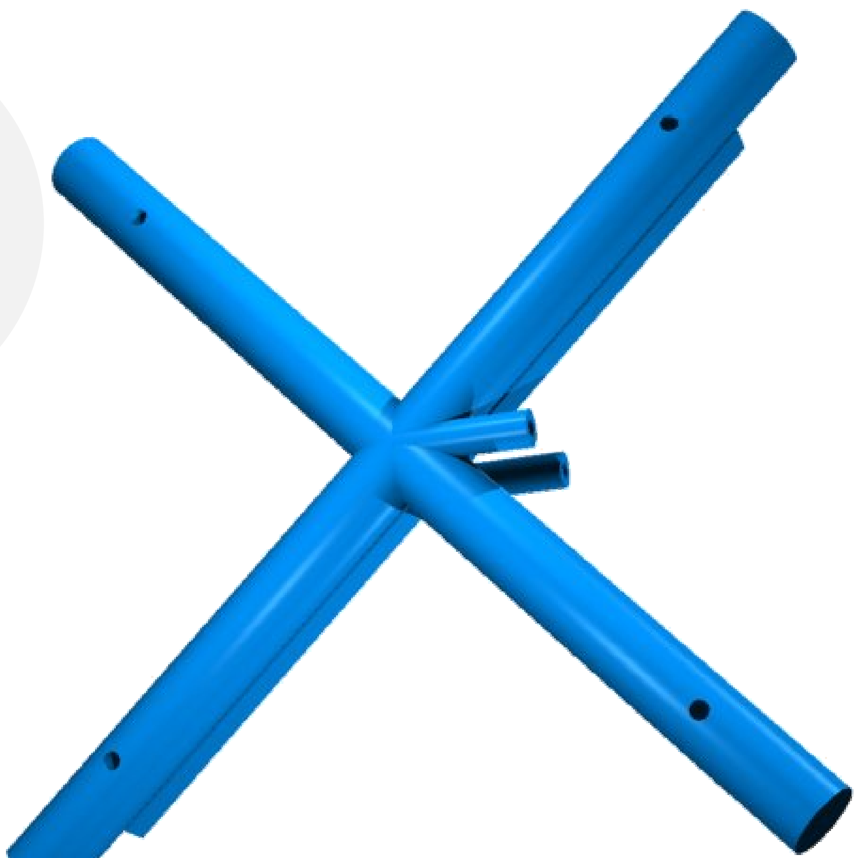


Table of Contents

Introduction

Accuracy of airflow control is critical to terminal unit performance, because of its impact on many important aspects ranging from acoustics to occupant comfort. The key to accurate flow control from a terminal unit is well-designed and repeatable airflow sensor. While there have been many improvements to both flow transducers and controller software/algorithms from the HVAC controls industry, all are dependent on an accurate flow signal from a flow sensor. A flow sensor that can measure accurately regardless of inlet conditions simplifies and takes much of the guesswork out of the balancing and commissioning process.

The Titus multi-point center averaging flow sensor is the number one sensor on the market because it is accurate regardless of inlet conditions. A flow sensor should provide flow signal amplification and immunity from poor inlet conditions, while keeping pressure drop and sound levels to a minimum. In addition, a flow sensor should have a high degree of repeatability and sturdy construction.

The original flow sensor design required a trade-off between amplification (accuracy) and pressure drop (sound), resulting in a very accurate sensor that was occasionally louder than the competitions' sensors. Using Computational Fluid Dynamics (CFD) software, we were able to design a new flow sensor that maximized amplification and minimized pressure drop.

We are happy to introduce the AeroCross™ flow sensor.

Description

The flow sensor is the most important component of a VAV terminal. The flow sensor measures the total and static pressure in a terminal so that a controller can calculate the cfm through the unit. If the flow sensor does not provide accurate information to the controller, the controller cannot determine actual cfm, and therefore cannot maintain comfort in the space.

The AeroCross™ is a multi-point center averaging flow sensor. The new sensor has a narrower profile than the original sensor. To visibly differentiate the new sensor, the AeroCross™ will be blue. The flow label on the terminal will also be blue to allow for easy identification from the outside of the unit. Like the original Titus flow sensor, the AeroCross™ is injection molded out of a high impact plastic material.

Performance

Amplification:
Amplification is the ability of a flow sensor to produce a signal greater than the velocity pressure. Pitot tubes read true velocity pressure, which requires 4005 FPM to produce a 1" wg signal. Velocity pressure is the difference between total pressure (taken from the tip of the probe) and static pressure taken from the side of the probe). Amplified flow sensors improve upon this signal by taking the difference between total pressure (from the front of the probe) and a reduced static pressure (from the rear of the probe). Amplification is critical to accurate control of minimum flow rates. While many

digital controllers have made great gains in processing low pressure signals accurately, a sensor should be capable of providing a signal of sufficient magnitude for any type of controller to monitor easily.

The AeroCross™ sets the standard for amplification, with performance ranging from 1.7 to 2.9, depending upon the inlet size.

Multi-point Center Averaging:
Multi-point center averaging flow sensors are more accurate than linear averaging flow sensors. Linear averaging sensors are not always linear in shape. They come in a variety of shapes such as round and diamond. Multi-point center averaging flow sensors take the pressure readings at the center of the sensor. (See Figure 1.) Center averaging sensors are not affected by poor inlet conditions as linear averaging sensors are.

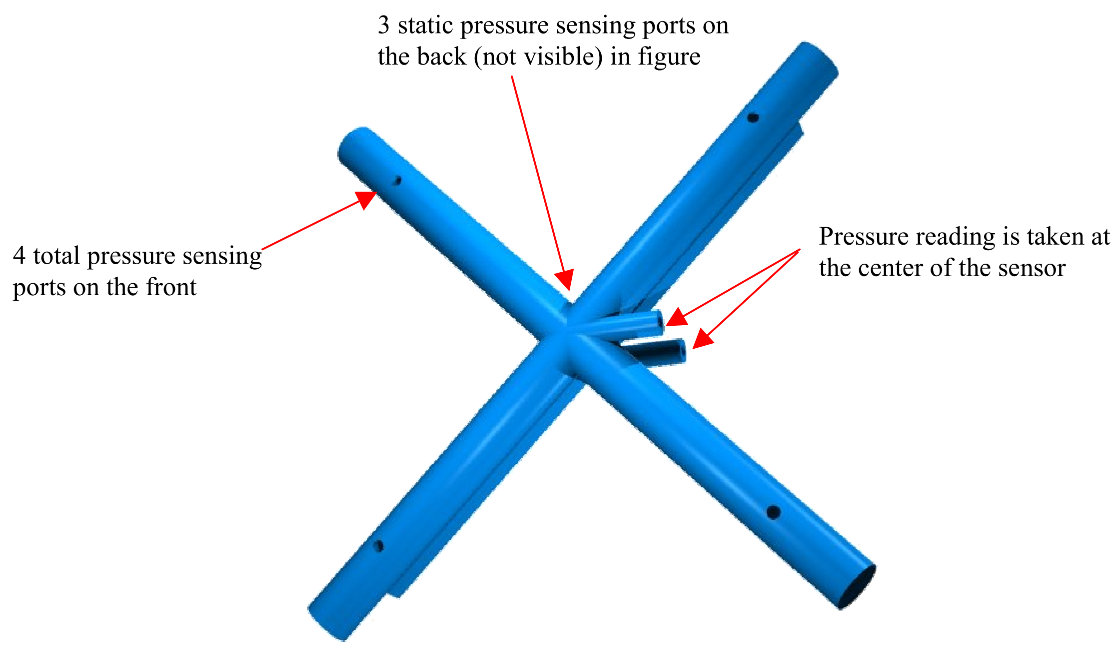


Figure 1. AeroCross™ Multi-point Center Averaging Flow Sensor

As you can see from figure 1, each total pressure port has the same "weight" in determining the pressure reading. In a linear averaging sensor, the port closest to the point where the reading is taken, will have a higher "weight" than the port farthest away from the reading. Tests have shown linear averaging sensors can be up to 30% incorrect with poor inlet conditions. Figure 2 shows a typical linear averaging flow sensor.

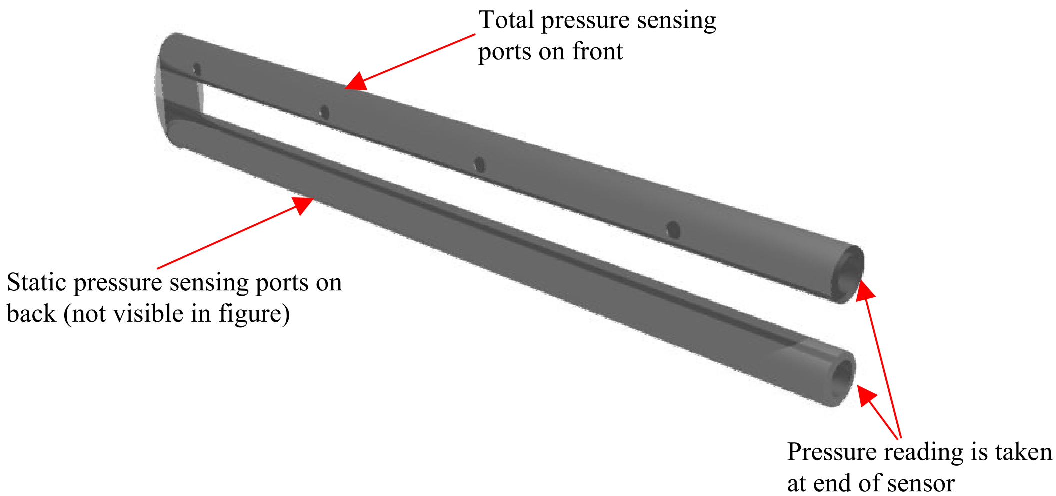


Figure 2. Linear Averaging Flow Sensor

Inlet Sensitivity:
Inlet sensitivity is a measure of flow sensing accuracy that can be lost to 'less than ideal' inlet conditions. Although SMACNA recommends a minimum of three duct diameters of straight duct in front of any flow-measuring device, this is often not the case. Obstructions such as plumbing, conduit, and structural members result in jogs and turns in both rigid and flexible supply ductwork. Real world conditions require that a good flow sensor is able to read air volume to a +/-5% accuracy, no matter what the inlet conditions may be. This is critical to guarantee the accuracy of factory calibrated controls, that would otherwise require a field calibration. It be noted that if excessive inlet sensitivity results in a reduced flow signal for a given flow volume, the benefit of amplification has been lost. No controller, regardless of its sophistication, can overcome less than adequate accuracy from a flow sensor under common field conditions.

The AeroCross™ has less inlet sensitivity than any flow probe on the market, with no more than +/-5% error regardless of inlet condition. While other center-averaging designs are capable of +/-10% error, linear averaging designs can range from +/-10% to 35% depending upon the exact condition and angle of approach.

Sound Performance:
The greatest impact of the AeroCross™ flow sensor is the effect on sound performance of the terminal units. The narrower profiles resulted in a reduced pressure drop for the flow sensor. This resulted in significant sound reductions in the many of the terminals.

The greatest effect is in the ESV product line. Table 1 shows the comparison between the NC values for the original flow sensor and the new AeroCross™ sensor for the ESV.

Table 1. NC Comparison

Sound Noise Criteria (NC)

Inlet Size	cfm	Discharge				Radiated			
		ΔPs				ΔPs			
		0.5"	1.0"	2.0"	3.0"	0.5"	1.0"	2.0"	3.0"
4	175	-	+1	-1	-2	-	-2	-3	-4
5	300	-	-1	-3	-3	-	-1	+1	+2
6	300	-	-	0	+1	-	-4	-3	-2
	500	-1	-4	-1	0	-7	-5	-3	0
7	350	-	-	-1	-2	-	-	-5	-4
	650	-	-6	-4	-3	-2	-4	-2	0
8	450	-	-	-	-1	-	-	-3	-5
	800	-	-1	-4	-2	-4	-8	-9	-6
9	600	-	-	-2	-6	-	-3	-3	-1
	1000	-	-1	-3	-2	-8	-11	-6	-3
10	700	-	-	-	+2	-3	-5	+1	+3
	1400	-	-3	-5	-4	-16	-13	-7	-2
12	1000	-	-	-	0	-	-3	-2	0
	2000	-	-	+2	+3	-11	-9	-6	-3
14	1500	-	-	-	+1	-8	-11	-6	-4
	3000	-	-	-4	-4	-26	-23	-17	-14
16	2000	-	-	-	-	-	-4	-5	-4
	4000	-	-	-6	-5	-9	-8	-6	-4
24 x 16	4000	-6	-10	-12	-11	+4	+3	+2	+1
	8000	NA	-18	-14	-13	NA	+2	0	-1

As you can see from table 1, the sound reduction was significant in many sizes and cfm ranges.

K-factors:

The AeroCross™ sensor has different k-factors than the original sensor. Titus will provide the major controls companies with the new k-factors to update their software. Until the software updates are made, the control contractors will need to be aware of the new constants. Table 2 shows the new k-factors.

Table 2. K-factors

AeroCross™ K-Factors

Inlet Size	K-Factor
4	273
5	360
6	448
7	667
8	904
9	1167
10	1436
12	1891
14	3015
16	3839
24 x 16	7176

Because the k-factors are different between the AeroCross™ and original sensor, replacing an original sensor with an AeroCross™ sensor will result in different airflow readings. Table 3 compares the AeroCross™ k-factors to the original sensor k-factors and shows the % difference in cfm reading between the two sensors.

For example, if you replaced a size 8 original sensor with a size 8 AeroCross™ sensor, the same pressure reading would result in 2.6% lower cfm calculation in the controller, if the k-factor was not updated to the AeroCross™ k-factor.

Table 3. K-factor Comparison

Inlet Size	AeroCross™	Original Sensor	% Difference
4	273	269	-1.5%
5	360	404	10.9%
6	448	474	5.5%
7	667	625	-6.7%
8	904	881	-2.6%
9	1167	1094	-6.7%
10	1436	1371	-4.7%
12	1891	1931	2.1%
14	3015	2795	-7.9%
16	3839	3677	-4.4%
40	7176	6986	-2.7%

Suggested Specification

The following is the suggested specification for the AeroCross™ flow sensor.

Differential pressure sensor shall be cross shaped multi-point center averaging type. Single axis sensor shall not be acceptable for duct diameters 6" or larger. A sensor that delivers the differential pressure signal from one end of the sensor is not acceptable. The sensor shall output an amplified differential pressure signal that is at least 1.5 times the equivalent velocity pressure signal obtained from a conventional pitot tube. Balancing taps and airflow calibration charts shall be provided for field airflow measurements.

AeroCross^{TM} K-Factors

AeroCross Sensor - Calibration Curves

Inlet Sensor Applications (All Units Except QCV)

Unit Size	Duct Area SQ FT	K-Factor CFM	K-Factor FPM	Sensor Qty.	Sensor Size
04	0.087	273	3138	1	4/5
05	0.136	390	2647	1	4/5
06	0.196	448	2286	1	6
07	0.267	667	2498	1	7
08	0.349	904	2590	1	8
09	0.442	1167	2640	1	9
10	0.545	1436	2635	1	10
12	0.785	1891	2409	1	12
14	1.069	3015	2820	1	14
16	1.395	3839	2752	1	16
20	0.778	2106	2707	1	8
22	0.778	2106	2707	1	8
26	1.000	2498	2498	1	8
40	2.667	7176	2691	2	14

Equations:

$$CFM = K\sqrt{\Delta P}$$

$$\Delta P = \left(\frac{CFM}{K}\right)^2$$

ΔP = Differential Pressure On AeroCross, IN WG

K = Flow Required To Produce A 1.0 IN WG Differential Pressure On AeroCross, CFM

Discharge Sensor Applications (For Dual Ducts)

Unit Size	Duct Area SQ FT	K-Factor CFM	K-Factor FPM	Sensor Qty.	Sensor Size
04	0.098	240	2444	1	4/5
05	0.157	384	2444	1	6
06	0.222	538	2423	1	7
07	0.292	733	2509	1	8
08	0.395	997	2525	1	9
09	0.625	1254	2007	1	12
10	0.773	1640	2122	1	12
12	1.003	2619	2611	1	14
14	1.401	3808	2718	1	16
16	1.680	4810	2863	1	16

Inlet Sensor Applications (For QCV's)

Unit Size	Damper SQ FT	K-Factor CFM	K-Factor FPM	Sensor Quantity	Sensor Size
A	0.174	320	1837	1	4/5
B	0.250	477	1908	1	4/5
C	0.333	629	1890	1	4/5
D	0.555	1047	1886	1	8
E	0.778	1539	1978	1	8
F	0.750	1472	1962	2	4/5
G	0.833	1676	2012	1	10
H	1.250	2619	2095	2	10
J	1.500	3036	2024	1	12
K	1.944	4385	2256	1	16
L	2.500	5582	2233	2	12
M	2.444	5847	2392	1	16
N	3.000	7413	2471	1	16
P	4.167	11224	2693	2	16
R	5.555	16496	2970	2	16