WHITE PAPER

Air Flow Measurement Instruments: How Precise and Accurate?

Calculating flow rates through ducts, pipes, hoods and stacks (collectively called ducts for our purposes), has never been difficult. The cross-sectional area of the duct is multiplied by the average velocity of the fluid to find the volume per time or flow rate. Simple.

Data collection, accurately and precisely measuring air velocity across ducts, has been a difficult task. And, poor data collection procedures produce the errors in duct balancing. Air flow measurement instruments, anemometers, have been limited in the past by time.

The newest microprocessor-based anemometers complete duct air flow measurement data collection accurately even before the patience of the HVAC tech wears out.

HOW TO MEASURE VELOCITY OF AIR

The more precise question is how to measure the average velocity of air across differing cross-sections of duct.

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The physics are relatively simple:

- Air is slowed by friction with contact to the edge of the duct
- The greatest velocity is achieved under laminar flow conditions in the frictionless middle of the cross-section
- The velocity profile of the duct is dependent on the shape of the duct (minimizing perimeter walls to achieve cross-sectional area) and the force pushing the air

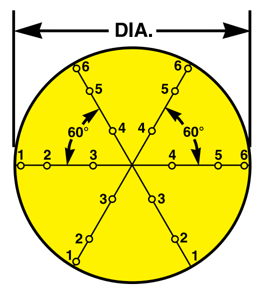
The preferential shapes of ducts then are round, square, and rectangular in that order of efficiency.

Given these facts, how many measurements make a good database?

The grid lines which lay out the duct flow measurement points are traverses. The log-linear method provides high accuracy (±3%) in flow totalization by measuring air flow closest the edges of the duct space preferentially.

ROUND DUCTS

Three traverses, diameters, evenly spaced at 60° create six pieces of pie in a round duct. Three measurements are taken per radius: on the edge; one-third toward the center; two-thirds toward the center. Note the air most affected by friction is seemingly over-represented.

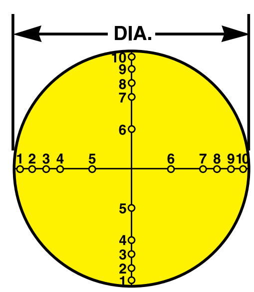


Log linear-traverse for round ducts, three-diameter approach.

A total of eighteen readings accurately describes the air flow velocity.

In the case where only two traverses can be measure, set them at 90 degrees and take five samples on each radius. The first four evenly spread over the first half of the radius starting at the edge and moving toward the center. The fifth point is two-thirds toward the center.

These twenty data points will not produce as accurate an average as the eighteen with three traverses, but the results are acceptable.

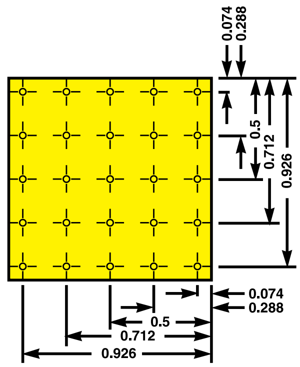


Log-linear traverse for round ducts, two-diameter approach.

RECTANGULAR OR SQUARE DUCTS

Accuracy demands a minimum of twenty-five data points to a maximum of forty-nine. A duct side of less than thirty inches requires five traverses. A duct side of greater than thirty-six requires seven traverses. Six for lengths in the middle.

Example of a 25-point log linear-traverse for rectangular ducts.



These ducts require the sixteen readings at a minimum near the edge (about 7% total distance) with the other nine evenly spread along the grid. Notice sixty-four percent of the rectangular duct data points will be close to the walls of the duct while only thirty-three percent of round duct data points reflect the friction from the walls. This measurement demonstrates the efficiency of the round duct. Which, by the way, does not mean round is always the best solution.

Gather the data from these readings and simply calculate the mean average. Or, let your microprocessor do the work. You have calculated the air flow velocity.

HOW TO MEASURE CROSS-SECTIONAL AREA

Sounds easy enough, length multiplied by width or the radius squared times pi.

Three words: remember the grille.

If no grille is used, the application factor is 1.00. So the cross-sectional area of the duct is unmodified.

If the grille is square punched, multiply the gross area by .88. A bar grille is modified by a factor of .78; and a steel strip grille by .73.

The grille serves to slow the velocity of air as well as disperse it. Be mindful of this factor.

DEVICES TO CALCULATE FLOW RATES

You have calculated the air flow, cross-sectional net area and multiplied them together for a flow rate.

$Q = FA\overline{v}$, where:

F = application factor (see table)

A = designated area in square feet

Grille Type	Application Factor, F	Designated Area
None	1.00	Full duct area
Square Punched	0.88	Free (daylight) area
Bar	0.78	Core Area
Steel Strip	0.73	Core Area

Modern air flow measurement instruments like handheld anemometers which offer digital read outs in cubic feet per minute: a self-contained calculator to save time and frustration for HVAC professionals.

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We believe it is important for technicians to understand the theory of air flow measurement, to recognize when a data point is unlikely to be correct, a false reading, or a calculation does not seem correct and should be double checked. In today's results-now environment, these new technologies speed the process along. Your experience will double-check the process, but this instrumentation collects and double checks raw data quickly.

The new models are sophisticated in flow rate calculation and output in a readily-usable format. Air duct balancing has become less time consuming and more efficient, more science than art.