Gas Flow
Measurement Application Guide

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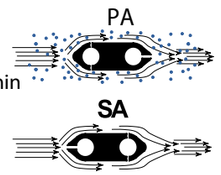
Gas Flow Measurement Application Guide Introduction:

Based on the relevant ASTM standards for Gas Flow Measurement, Eastern Instruments' Gas Flow Application Guide is designed to help you decide the most appropriate place in your duct system to measure flow and how to select the best tool.

VAP$^{3®}$ /PA (Particulate Application) and VAP$^{®}$ /SA (Standard Application) Pitots are designed to provide accurate differential pressure outputs allowing for precise airflow measurement or control of your processes.

The High Beta™ Airflow Measurement System incorporates VAP$^{®}$ technology and is ideal for either new or retrofit industrial applications where insufficient straight duct runs are present and/or accuracy is required.

1 Selection of Pitot Type



1.1 PA (Particulate Application): Particulate laden gas stream, minimum velocity 1500 ft/min, maximum velocity 12,500 ft/min (use of High Beta™ typically doubles velocity). PA should be used whenever possible - impact holes in the SA may eventually plug, even on outside air (unless filtered).

1.2 SA (Standard Application): Clean flow, filtered gas stream, high turndown, minimum velocity 250 ft/min, maximum velocity 12,500 ft/min.

2 Selection of Configuration

2.1 ABSOLUTE ACCURACY (High Beta™): Should be used when an actual measurement is required, o to compare or balance two or more devices such as burners.

2.2 RELATIVE ACCURACY (Duct Mounted VAP$^{®}$): Should be used when there are no comparisons or balances to be made, i.e. flow is to be reduced by 1/2.

2.3 DUCT TRAVERSE METHODS ~~(ASTM D 3154- Standard Method for Average Velocity in a Duct~~): Duct traverse methods which can turn a relative measurement into an absolute measurement, suffer from the same limitations as the Duct Mounted VAP$^{®}$. The requirement is for a minimum upstream distance (six diameters total ~~ASTM D 3154 Sec. 8.5~~) from a disturbance. Additionally, ~~ASTM D 3154 Sec. 8.6~~ requires that the flow profile be reasonably flat and Sec 8.7 requires the flow stream to be parallel to the centerline of the duct (no swirl). Very rarely can the former conditions be met in actual practice. The High Beta™ profiles the flow in its "throat" so that the ~~ASTM D 3154 Sec. 8.6~~ can be met with very poor upstream conditions. Additionally, the vanes in the converging section of the High Beta™ are very effective in stopping swirl, as per ~~ASTM D 3154 Sec 8.7~~, without the risk of plugging or failure of the more common "hexcell" or egg crate straighteners.

2.4 MEASUREMENT CROSS-SECTIONAL AREA: Additionally, High Beta™ provides a correct, constant, known measurement area. Since a pitot or any other DP measurement is a velocity measurement, area errors are directly proportional to flow errors. Fabricated ducts often have unknown and varying cross-sectional areas. Moreover, temperature, pressure, and structural load excursions can cause significant area changes in these ducts. Area changes of 10% are sometimes encountered, especially with high temperature and pressure boiler ducts. Since the "throat" cross-section of the High Beta™ is isolated from these effects, accurate measurement area can be maintained.

2.5 ACCURACY: If the upstream mounting requirements (see section 3) and the downstream requirements (see section 4) are met, the accuracy of the High Beta™ is +/- 2%; Accuracy of the Duct Mounted VAP$^{®}$ is +/- 2% + Duct Error (which can exceed 5%) + Duct Area Change Error (from temperature, pressure, or structural load and can exceed 5%). All Duct Mounted Pitots are subject to these Duct Errors and Duct Area Change Errors, except High Beta™. If required High Beta™ can be calibrated and certified to a Standard (to an accuracy of +/- 0.25%).

2.6 COST: For cost-competitive situations, the Duct Mounted VAP$^{3®}$ is a very good choice over stainless steel probes. High Beta™ may cost up to 2 to 3 times the equivalent Duct Mounted VAP$^{3®}$ alone.

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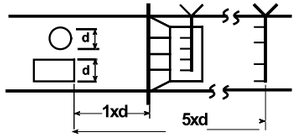
3 Determining Upstream Mounting Requirements

(ASTM D 3154 Sec. 8.5, 8.6, & 8.7 — 8.6 states that no velocity point can be less than 10% of the maximum velocity & 8.7 states that the flow vectors must be parallel to within 10° of the centerline of the duct)

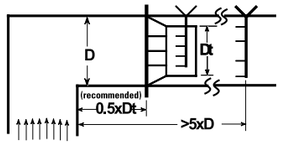
ROUND DUCT RULE: If the duct take-off is as indicated in 3.7 is round and the take-off is smaller in area than the supply header, and velocity in the supply header is 1/2 or more the velocity of the take-off, double the distance requirements if there are no straightening vanes.

DUCT VELOCITY RULE: If the average duct or measurement approach velocity is greater than 4000 ft/min, increase all distances proportionally (i.e. at 8000 ft/min double distances, at 2000 ft/min cut distances in half)

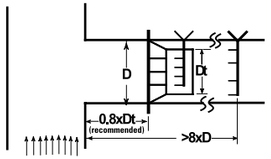
3.1 **UPSTREAM OBSTRUCTION** (minimum)



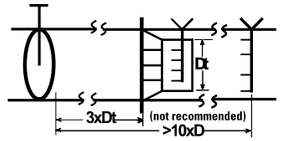
3.2 **UPSTREAM 45° OR 90°** (minimum — with or without turning vanes)



3.3 **UPSTREAM TEE** (minimum)

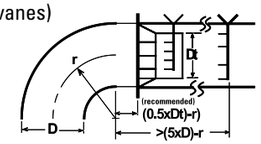


3.4 **UPSTREAM DAMPER** (minimum)

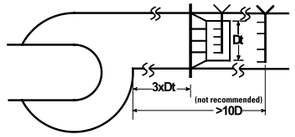


NOTE: If the Duct is square or rectangular, then D = (Length + Width)/2

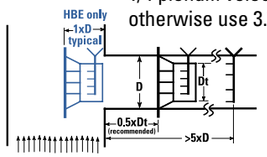
3.5 **UPSTREAM RADIUS 45° OR 90°** (minimum — with or without turning vanes)



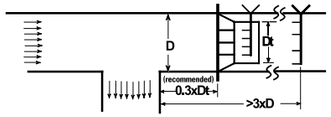
3.6 **UPSTREAM FAN** (minimum)



3.7 **UPSTREAM PLENUM** (minimum — take-off velocity is no more than 1/4 plenum velocity, otherwise use 3.3)



3.8 **UPSTREAM TAKE-OFF** (minimum — take-off velocity is no more than measure velocity, otherwise use 3.3)

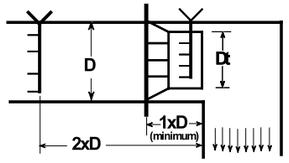


4 Determining Downstream Mounting Requirements

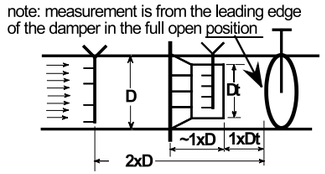
(to meet ASTM D 3154 Sec. 8.5, 8.6, & 8.7)

NOTE: If the Duct is square or rectangular, then D = (Length + Width)/2

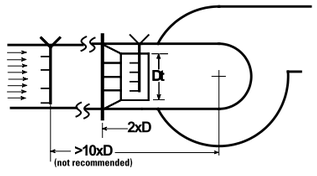
4.1 **DOWNSTREAM 90°** (minimum — with or without turning vanes)



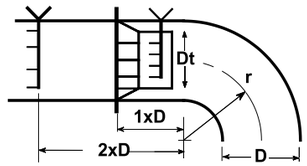
4.2 **DOWNSTREAM DAMPER** (minimum)



4.3 **DOWNSTREAM FAN** (minimum)

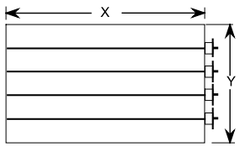


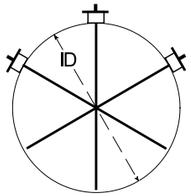
4.4 **DOWNSTREAM RADIUS 45° OR 90°** (minimum)



5 Installation Specifications for VAP³®

- Either VAP³®/PA or VAP³®/SA
- Probes mounted to duct through Insertion Port
- Bull-nose end support available for sizes over 32"
- Available in sizes from 4 to 112" (in 1-inch increments through 18", 2-inch through 40", and 4-inch through 112" — custom sizes are also available)



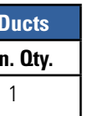


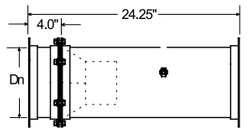
Rectangular or Square Ducts	
Y	**Min. Qty.**
6" to 8"	1
10" to 26"	2
28" to 36"	3
38" to 60"	4
62" to 116"	5
188" +	Consult Factory

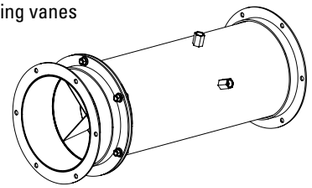
Round or Circular Ducts	
ID	**Min. Qty.**
3.5" to 8"	1
10" to 18"	2
20" to 116"	3

6 Installation Specifications for High Beta™ Pharmaceutical (HBP)

- Typically VAP³®/SA for Standard Application
- High Beta™ primarily for pharmaceutical and chemical applications
- Available in a number of flange and pressure configurations (custom flange and pressure configurations available)
- Typical installation requires minimal 1 Diameter (Dn) upstream of unit
- Unrecovered pressure loss typically 30% of DP
- Calibration can be validated against traceable nozzles
- Available in sizes 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, and 24-inch
- Customer connections on outside of spool section
- Standard integral straightening vanes

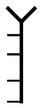


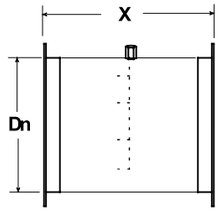




7 Installation Specifications for Duct Section VAP³®

- Either VAP³®/PA or VAP³®/SA
- Duct mounted measurement with the characteristics of probes, no High Beta™
- Standard integral straightening vanes (not as effective as High Beta™)
- Available in sizes from 4 to 48" in 2-inch increments (custom sizes are available)
- Available in a number of material, flange, and pressure configurations
- Length dependent on nominal diameter (Dn) — Sizes 4 to 24 length is 12", sizes 26 to 48 length is 24"





8 Installation Specifications for High Beta™ Engineered (HBE)

- Typically VAP³®/PA for Particulate Application
- High Beta™ engineered specifically for each application
- Can be installed inside round, square, or rectangular ducts
- Little or no upstream or downstream straight runs required
- Unrecovered pressure loss can be minimized
- Accuracy can be maximized by varying the Beta Ratio, Area Ratio, and Location within the duct
- Typically mounted inside the duct, to a mounting flange/plate that is welded to the duct
- Can be supplied inside a duct "spool" section to attach to an existing duct
- Can be engineered to fit in tight access areas by flanging the unit into sections that can be bolted or welded together in the duct
- For muliple HBE configurations, impulse lines are connected to a manifold block for simple customer connections
- Straightening vanes are standard in converging section

NOTE: To determine correct configuration and/or products for the application, CFD Modeling is required if upstream and downstream requirements are not met.