

EASTERN INSTRUMENTS



VAP³/PA

VAP³/SA

VAP³[®]
INSERTION
STYLE PITOTS

EI

Precision Air Flow Measurement

Eastern Instruments

Precision Flow Measurement

About Eastern Instruments

Eastern Instruments, a Certified Women's Business Enterprise, is an engineered solutions company located adjacent to the North Carolina International State Port in Wilmington, North Carolina. Since 1984, we have been engaged in the design and manufacture of devices that accurately measure and profile the flow of air and gases in the industrial and power sectors. These devices have been integrated into a variety of systems for regulating operations and improving efficiency across nearly every industry. Every device within Eastern Instruments' air flow measurement product line provides a high degree of accuracy, easy installation and an extremely simple and intuitive operation and maintenance schedule that is perfect for nearly every application.

The following catalog is an overview of our air flow measurement pitots, however we also offer a complete line of flow elements, conditioners and air flow measurement equipment for the power industry, as well as a complete line of solids flow meters, feeders and fillers, so if you are in need of equipment other than those found within this catalog, Eastern Instruments can help. Contact us today.

Mildred R. Brandt
President and CEO

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Options

Accurate Air Flow Measurement and the VAP³® Insertion Style Pitot

Whether inserted directly into a duct or mounted into an air flow conditioning device such as the High Beta® Flow Conditioner, VAP³® Pitot technology underlies all of Eastern Instruments' industrial air flow measurement devices. How are the air flow measurement devices from Eastern Instruments so accurate? The accuracy lies within the proprietary design of the VAP³® Insertion Style Pitot.

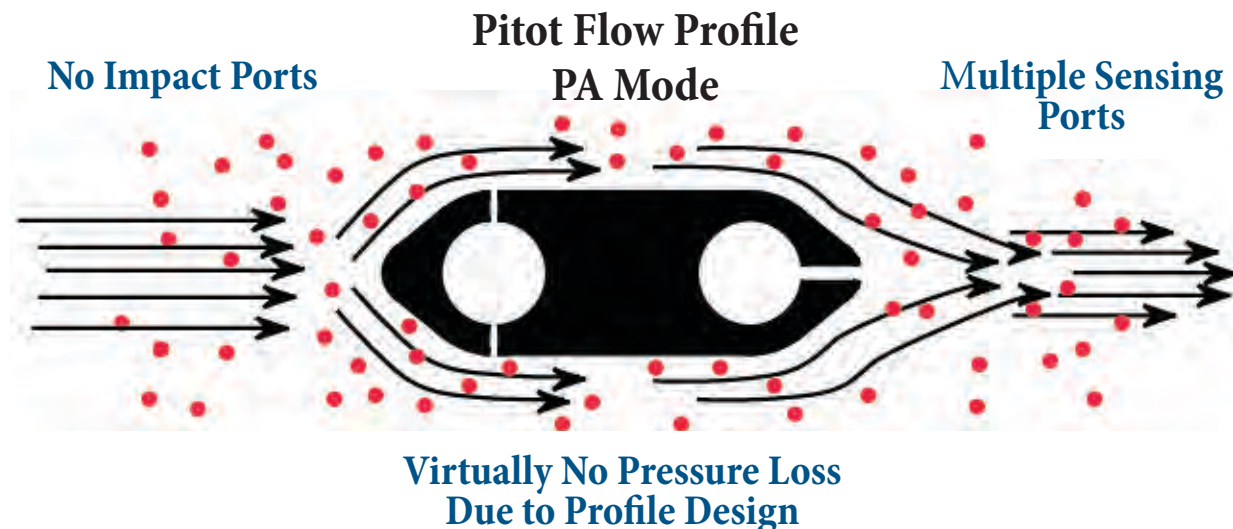
One of the most important aspects of proper air flow measurement is choosing the correct measurement technology. Insertion style pitot tubes are a time-tested method of measuring air flow in ducts. Pitots are cost-effective, easily maintained and can be installed in nearly any duct work. One significant advantage of pitot tubes over other technologies such as orifice plates, venturis or airfoils is that pitots offer a minimal unrecovered pressure drop across the flow element which can result in significant cost-savings associated with reduction in fan horsepower requirements.

The VAP³® Pitot from Eastern Instruments utilizes differential pressure based measurement technology in order to measure the velocity of air in a duct. When coupled with a Multivariable Transmitter, the pitots will offer a true mass flow measurement.

Unlike some pitot tube technologies which offer only single-port measurement, the VAP³® Pitot technology from Eastern Instruments ensures that each pitot installation has multiple sensing ports which average the velocity across the entire traverse of the duct, thus providing a more representative sample of duct velocity.

In most cases, pitot tubes have one port facing into the air stream (high port) and one port at 90° to the air stream (low port). The differential pressure between the high port and the low port represents the velocity. This configuration works well in air with no particulate in the air stream, however the high port is very susceptible to plugging if any airborne particulate is present.

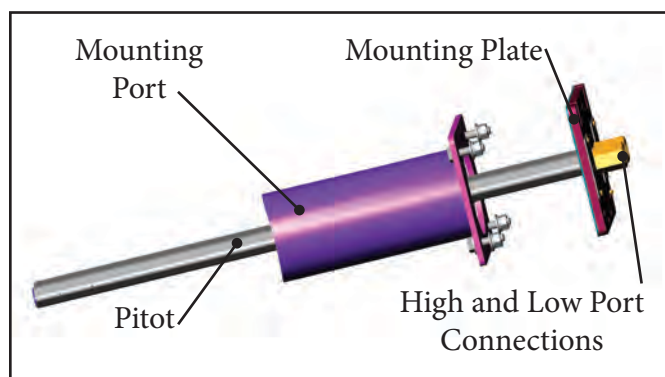
A notable exception to the plugging issues plaguing many air flow measurement technologies is the VAP³® Pitot technology from Eastern Instruments. For applications in which airborne particulate is present, the VAP³® Pitot is mounted so that the high port is in-line with the airflow, not facing it, so that the pitot has no impact ports. Because the pitot has no impact ports when mounted in this orientation, it is not subject to plugging and so costly purge systems are rarely required.



Applications

What is a VAP?

The VAP³® Pitot comes in a variety of models, each designed to accurately measure the flow of air or gas under particular circumstances. Whether measuring clean air, or air that is particulate-laden, the VAP³® pitot delivers an extremely accurate differential pressure output. The standard VAP³® pitot is constructed out of Anodized Aluminum for maximum durability, however, both PVC and Stainless Steel versions are available for caustic applications or where temperatures within the duct may reach up to 900° F. All models of VAP Pitots can be used in round or square/rectangular ducts.



Process Applications

- Coating/Drying
- Process Exhaust
- Dust Collection
- Pneumatic Systems
- Cooling
- Ventilation
- Fluid Bed Dryers
- Stack Flow

Industries Served

- Food Industry
- Petrochemical Industry
- Industrial Chemicals
- Pet Product Industry
- Agricultural Industry
- Recycled Materials

Power Applications

- Burner Flow
- Primary Air
- Secondary Air
- Stack Flow
- Tempering Air
- Overfire Air
- HVAC

Industries Served

- Coal-Fired Power
- Waste-To-Energy
- Oil-Fired
- Nuclear
- Cyclone Burner

The VAP³® Insertion Pitot:
Exceeding Expectation in Every Industry.

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Why choose Eastern Instruments?

Accuracy

Because all Eastern Instruments' flow measurement devices are based on the accuracy delivered by the VAP³® Pitot, all of our devices are extremely accurate and can measure flow to within $\pm 2.00\%$ for either clean or particulate-laden applications when calibrated.

Plug-Resistance

When installed in the PA (Particulate Application) mode, the VAP³® Pitot has no impact ports which offer a plug resistant design that rarely requires the use of expensive purging systems.

Parallel Plate Cross Sectional Design

The VAP³® Pitot's unique cross sectional design minimizes disturbances of the air flow at and around the sensing ports, thus minimizing the potential for particulate to build up on and around the ports.

Material of Construction

The standard VAP³® Pitot is constructed of 6063 Anodized Aluminum, however pitots can also be constructed of Stainless Steel or PVC for increased temperatures or resistance to the corrosive properties of the air/gas flowing through the duct.

No "K" Factor is Required

Because the flow measurement of the VAP³® Pitot is not dependant on velocity, no "K" factor is required in the calculation of flow (the flow coefficient is not Reynolds Number dependent).

Multiple Sensing Ports

With multiple sensing ports on each pitot, VAP³® Pitots ensure velocity averaging across the full traverse of the duct.

Special Engineered Solutions

For extremely large ducts (up to 240 inches in width) Eastern Instruments offers VAP³®-AEX Pitots with a larger, more robust profile.

Heated Pitots are also available in which heater elements are inserted into the pitot in order to prevent the pitot from freezing.

Low Unrecovered Pressure Loss

When utilizing the VAP³® Insertion Style Pitot, the unique low profile design ensures that pressure loss due to the pitots themselves is negligible. Even when utilizing the High Beta® Flow Conditioner, pressure loss is remarkably low.



Insertion Style Pitots

ROUND DUCTS

The VAP³® Pitot comes in a variety of models, each designed to accurately measure the flow of air or gas under particular circumstances. Whether measuring clean air, or air that is particulate-laden, the VAP³® pitot delivers an extremely accurate differential pressure output. The standard VAP³® pitot is constructed out of Anodized Aluminum for maximum durability, however, both PVC and Stainless Steel versions are available for applications where the air/gas being measured may be caustic to Aluminum, or where the temperature within the duct may reach up to 900° F. The following section illustrates the use of VAP³® Pitots installed within round ducts, but these pitots can certainly be used within square/rectangular ducts as well. For more information on square/rectangular duct installations, please see the corresponding section of this catalog which begins on page 16.

Industrial Air Flow Pitot Models

VAP³®-AES: Aluminum Pitot

- Anodized Aluminum Pitot
- Perfect for most applications
- Moderate Heat Applications
- Port Mounted

VAP³®-PES: PVC Pitot

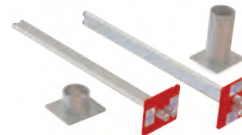
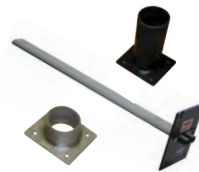
- Extruded PVC Pitot
- Perfect for Corrosive Gases
- Low Heat Applications
- Port Mounted

VAP³®-SFS: Stainless Steel Pitot

- Stainless Steel Pitot
- Perfect for Corrosive Gases
- High Heat Applications
- Port Mounted

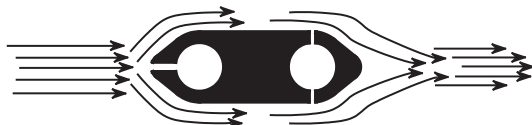
VAP³®-AEX: Extra Large Pitot

- Anodized Aluminum Pitot
- Profile twice the VAP³®-AES
- Perfect for Extra Large Ducts
- Port Mounted



VAP³®/SA CLEAN AIR

When mounted in SA (Superior Accuracy) mode, all of the models mentioned above will accurately measure the flow of relatively clean air through nearly any duct. While positioning the High Port so that it faces into the air stream (shown below) makes the measurement more accurate, it also limits the use of SA mode to particulate-free air. Mounted in SA mode, VAP³® pitots provide an accurate differential pressure output that allows for precise air flow measurement and control of your process to within $\pm 0.50\%$ accuracy when calibrated.



VAP³®/SA PITOT PROFILE: "CLEAN" AIR

VAP³®/PA PARTICULATE-LADEN AIR

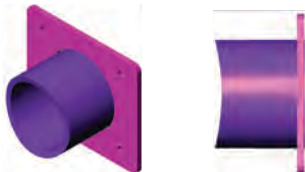
When mounted in PA (Particulate-laden Air) mode, all of the models mentioned above will accurately measure the flow of "dirty" or particulate-laden air through nearly any duct. In PA mode, the High Port is positioned so that it faces away from the oncoming air stream, making the pitot resistant to plugging. Mounted in PA mode, VAP³® pitots provide an accurate differential pressure output which allows for precise air flow measurement and control of your process to within $\pm 2.00\%$ accuracy when calibrated.



VAP³®/PA PITOT PROFILE: "DIRTY" AIR

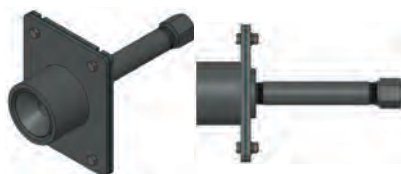
Pitot Installation: Round Ducts

Insertion Port: Curved Radius



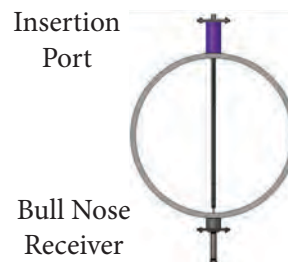
An insertion port is typically welded to the exterior of a duct and pitots are then bolted to the insertion port. A curved radius allows the port to be easily mounted to round ducts.

Bull Nose Receiver: Round Duct

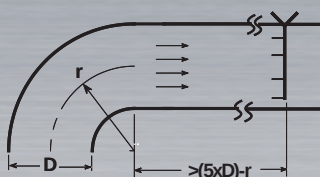


A Bull Nose receiver and port is typically used on round ducts over 34" in diameter and helps to stabilize and support the pitot inside the duct. The Bull Nose Receiver is welded to the exterior of the duct just like the insertion port.

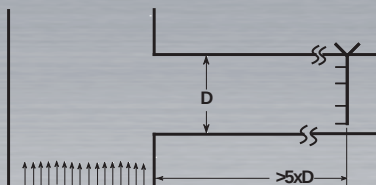
Pitot Installation with Insertion Port and Bull Nose Receiver.



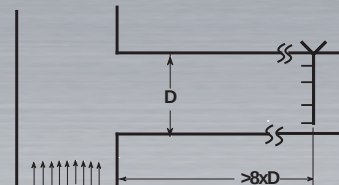
Recommended Upstream Duct Run Requirements



Upstream Radius 45° or 90°



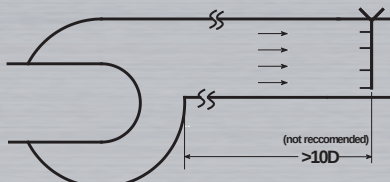
Upstream Plenum



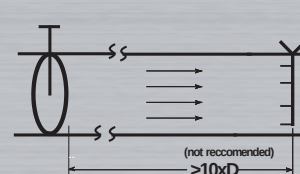
Upstream Tee



Upstream Obstruction

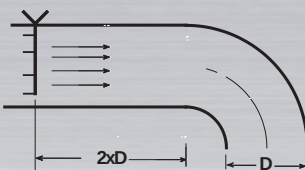


Upstream Fan

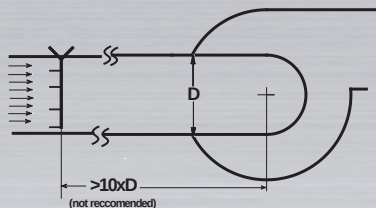


Upstream Damper

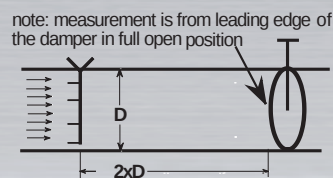
Recommended Downstream Duct Run Requirements



Downstream Radius 45° or 90°



Downstream Fan



Downstream Damper

Recommended Pitot Array Installation Orientation



Single Pitot:
8" Duct or less



Two Pitots:
10" - 18" Duct

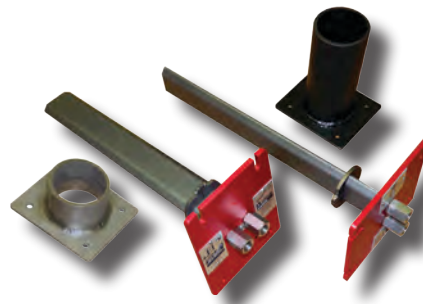


Three Pitots:
20" - 240" Duct

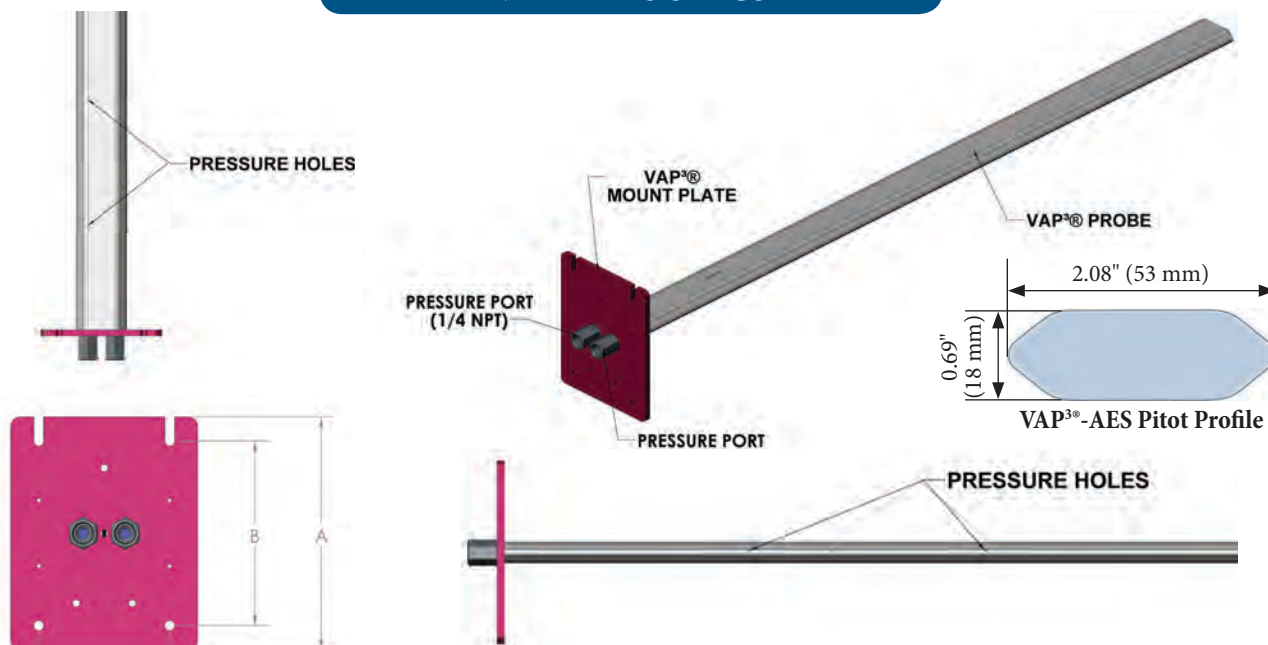
VAP³® - Anodized Aluminum

The VAP³-Anodized Aluminum (VAP³-AES) Pitot is designed as an extremely accurate, low-cost solution for air flow measurement in clean or particulate-laden industrial air applications. VAP³-AES pitots are constructed entirely out of Anodized Aluminum and are ideal for most applications. VAP³-AES Pitots are insertion style pitots that are mounted to the exterior of up to 72" duct work. When inserted into air or gas flow ducts with the required upstream and downstream straight duct runs, VAP³-AES Pitots deliver extremely accurate differential pressure outputs that allow for precise flow measurement and control of your system.

- **ROUND DUCTS**
- **Non-Corrosive Air/Gas**
- **Standard Temperature**



VAP³-AES SPECS



System Requirements: "Clean" Air

- **Duct Configuration:** Round
- **Duct Size:** 6" to 72"
- **MOC:** Anodized Aluminum
- **Duct Pressure:** -7 to 7 PSI (-48 to 48 kPa)
- **Temperature:** -40 to 700 F (-40 to 371 C)
- **Medium:** Clean Air or Gas
- **Velocity Clean Air:** (250 - 12,500 ft/min)

System Requirements: "Dirty" Air

- **Duct Configuration:** Round
- **Duct Size:** 6" to 72"
- **MOC:** Anodized Aluminum
- **Duct Pressure:** -7 to 7 PSI (-48 to 48 kPa)
- **Temperature:** -40 to 700 F (-40 to 371 C)
- **Medium:** Particulate-Laden Air or Gas
- **Velocity Air:** (1,500 - 12,500 ft/min)

Model No: VAP-AES PITOT

D1	D2	D3	D4	D5	D6	D7
D1 Pitot Orientation						
SA		Standard App. - Clean Air				
PA		Particulate-laden App. - Dirty Air				
D2 Probe Size						
#		Based on Duct Diameter				
D3 Duct Configuration						
RD		Round (Curved Surface)				
D4 Port Mounting Length						
NIP		Direct Duct Mount (No Port)				
2IP		2" Long Insertion Port				
6IP		6" Long Insertion Port				
D5 Pitot Mounting Plate						
425		4.25" Mounting Plate: Rated 7 PSI 1/4" thick (Port MOC): (20" Pitots or smaller)				
625		6.25" Mounting Plate: Rated 7 PSI 1/4" thick (Port MOC): (22" Pitots or larger)				
D6 End Support Type						
NS		No End Support				
BN		Bull Nose: 6" long support rod (34" - 40" Pitots)				
BN2		Bull Nose 12" long support rod (40" Pitots or longer)				
D7 Additional Options						
N		No Option Recommended				
STF		Integral SS Probe Stiffener (Required if temp. exceeds 600° F)				
Pitots in an Array						
01	1 Pitot per installation: (Ducts 8" or less)					
02	2 Pitots per installation: (Ducts 10" - 18")					
03	3 Pitots per installation: (Ducts 20" - 72")					

Model No: VAP-AES PORT

D1	D2	D3	D4	D5		
D1 Material of Construction						
304	304 Stainless Steel					
316	316 Stainless Steel					
AL	Aluminum					
CS	Carbon Steel					
D2 Port Mounting Design						
CS4	Curved (6" Duct)					
CS5	Curved (7-8" Duct)					
CS6	Curved (9-11" Duct)					
CS7	Curved (12-13" Duct)					
CS8	Curved (14-15" Duct)					
CS9	Curved (16-17" Duct)					
CS12	Curved (18-20" Duct)					
CS14	Curved (22-26" Duct)					
CS16	Curved (28-30" Duct)					
CS18	Curved (32" Duct)					
FT	Flat (34-72" Duct)					
D3 Port Mounting Length						
2IP	2" Long Insertion Port					
6IP	6" Long Insertion Port					
D4 Pitot Mounting Plate						
425	4.25" Mounting Plate: Rated 7 PSI 1/4" thick Anodized AL: (20" Pitots or smaller)					
625	6.25" Mounting Plate: Rated 7 PSI 1/4" thick Anodized AL: (22" Pitots or larger)					
D5 Port Type						
IP	Insertion Port: No End Support (Less than 34" Pitot - IP only)					
BN	Insertion Port & End Support: (34" Pitots or larger - IP & BN)					

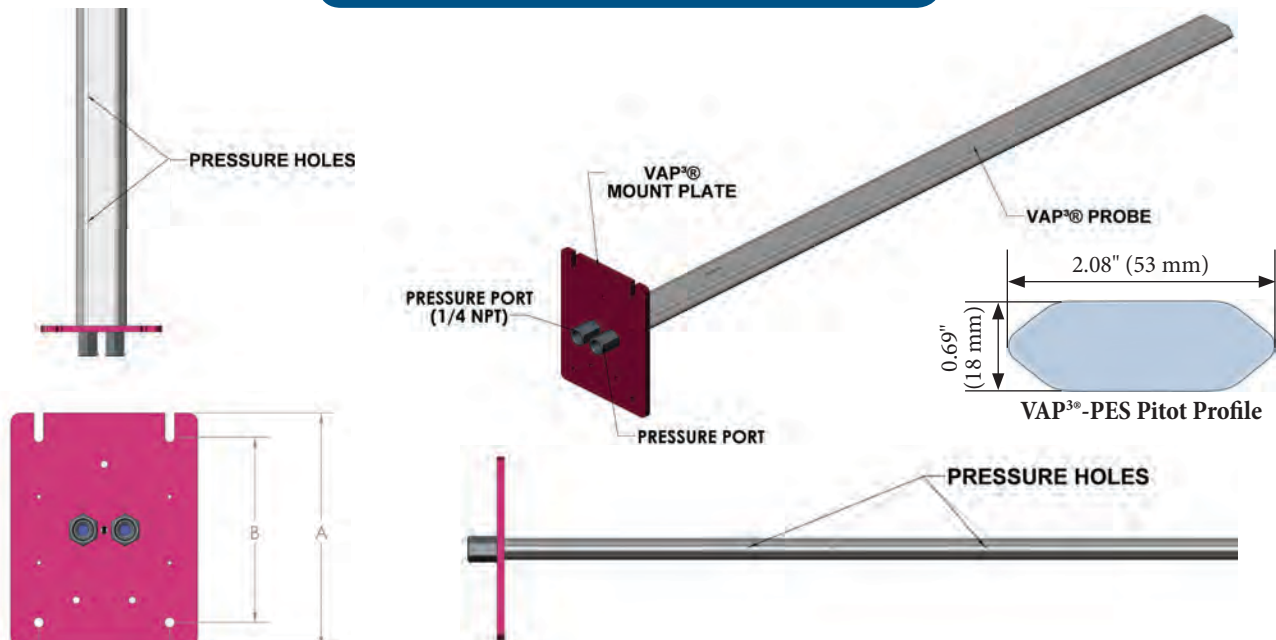
VAP³® - PVC

The VAP³-PVC pitot (VAP³-PES) is designed as an extremely accurate, low-cost solution for air flow measurement in clean or particulate-laden air for industrial process applications where corrosive gases are present. VAP³-PES pitots are constructed entirely out of PVC for corrosive resistance to a variety of gases. Just as all VAP³ pitots, the VAP³-PES Pitot is an insertion style pitot mounted via welded ports. When inserted into air or gas flow ducts with the required upstream and downstream straight duct runs, VAP³-PES Pitots deliver an accurate differential pressure output for the precise flow measurement and control of your system.

- **ROUND DUCTS**
- **Corrosive Gases**
- **Ambient Temperature**



VAP³-PES SPECS



System Requirements: "Clean" Air

- **Duct Configuration:** Round
- **Duct Size:** 6" to 24"
- **MOC:** PVC
- **Duct Pressure:** -7 to 7 PSI (-48 to 48 kPa)
- **Temperature:** -40 to 140 F (-40 to 60 C)
- **Medium:** Clean Air or Gas
- **Velocity Clean Air:** (250 - 12,500 ft/min)

System Requirements: "Dirty" Air

- **Duct Configuration:** Round
- **Duct Size:** 6" to 24"
- **MOC:** PVC
- **Duct Pressure:** -7 to 7 PSI (-48 to 48 kPa)
- **Temperature:** -40 to 140 F (-40 to 60 C)
- **Medium:** Particulate-Laden Air or Gas
- **Velocity Air:** (1,500 - 12,500 ft/min)

Model No: VAP-PES PITOT

D1	D2	D3	D4	D5	D6	D7
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D1 Pitot Orientation	
SA	Standard App. - Clean Air
PA	Particulate-laden App. - Dirty Air
D2 Probe Size	
#	Based on Duct Diameter
D3 Duct Configuration	
RD	Round (Curved Surface)
D4 Port Mounting Length	
NIP	Direct Duct Mount (No Port)
2IP	2" Long Insertion Port
6IP	6" Long Insertion Port
D5 Pitot Mounting Plate	
425	4.25" Mounting Plate: Rated 7 PSI 1/4" thick (Port MOC): (20" Pitots or smaller)
625	6.25" Mounting Plate: Rated 7 PSI 1/4" thick (Port MOC): (22" Pitots or larger)
D6 End Support Type	
NS	No End Support
D7 Additional Options	
N	No Option Recommended

Pitots in an Array

- 01 1 Pitot per installation: (Ducts 8" or less)
- 02 2 Pitots per installation: (Ducts 10" - 18")
- 03 3 Pitots per installation: (Ducts 20" - 24")

Model No: VAP-PES PORT

D1	D2	D3	D4	D5		
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D1 Material of Construction	
304	304 Stainless Steel
316	316 Stainless Steel
AL	Aluminum
CS	Carbon Steel
D2 Port Mounting Design	
CS4	Curved (6" Duct)
CS5	Curved (7-8" Duct)
CS6	Curved (9-11" Duct)
CS7	Curved (12-13" Duct)
CS8	Curved (14-15" Duct)
CS9	Curved (16-17" Duct)
CS12	Curved (18-20" Duct)
CS14	Curved (22-26" Duct)
D3 Port Mounting Length	
2IP	2" Long Insertion Port
6IP	6" Long Insertion Port
D4 Pitot Mounting Plate	
425	4.25" Mounting Plate: Rated 7 PSI 1/4" thick Anodized AL: (20" Pitots or smaller)
625	6.25" Mounting Plate: Rated 7 PSI 1/4" thick Anodized AL: (22" Pitots or larger)
D5 Port Type	
IP	Insertion Port: No End Support (Less than 34" Pitot - IP only)

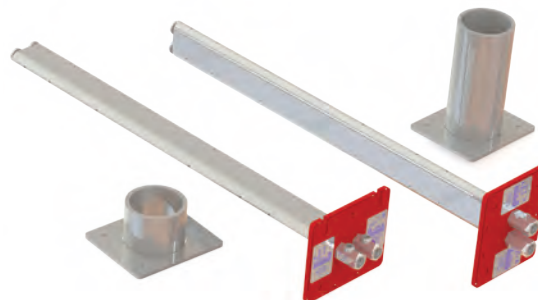
NOTES

For applications where PVC pitots are to be used in duct work larger than 24" in diameter, the pitots can be mounted from opposite directions in order to traverse the larger duct diameters.

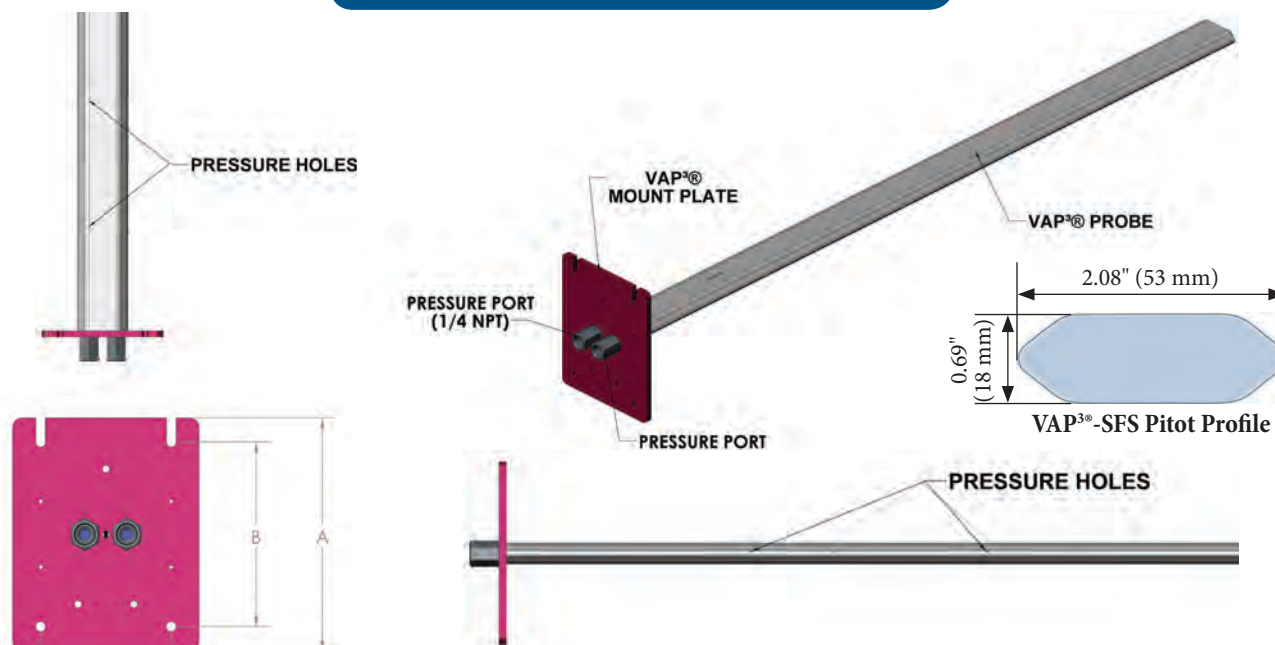
VAP³® - Stainless Steel

The VAP³®-Stainless Steel pitot (VAP³®-SFS) is designed as an extremely accurate, low-cost solution for air flow measurement in industrial process applications where corrosive gases or extremely high temperatures are present. VAP³®-SFS' are constructed out of Stainless Steel which offers corrosive resistance and a resistance to high heat. The VAP³®-SFS is an insertion style pitot mounted via welded ports. When inserted into air or gas flow ducts with the required upstream and downstream straight duct runs, VAP³®-SFS' deliver an extremely accurate differential pressure output that allows for precise flow measurement and control.

- **ROUND DUCTS**
- **Corrosive Gases**
- **High Temperatures**



VAP³®-SFS SPECS



System Requirements: "Clean" Air

- **Duct Configuration:** Round
- **Duct Size:** 6" to 48"
- **MOC:** Stainless Steel
- **Duct Pressure:** -7 to 7 PSI (-48 to 48 kPa)
- **Temperature:** -40 to 1500 F (-40 to 815 C)
- **Medium:** Clean Air or Gas
- **Velocity Clean Air:** (250 - 12,500 ft/min)

System Requirements: "Dirty" Air

- **Duct Configuration:** Round
- **Duct Size:** 6" to 48"
- **MOC:** Stainless Steel
- **Duct Pressure:** -7 to 7 PSI (-48 to 48 kPa)
- **Temperature:** -40 to 1500 F (-40 to 815 C)
- **Medium:** Particulate-Laden Air or Gas
- **Velocity Air:** (1,500 - 12,500 ft/min)

Model No: VAP-SFS PITOT

D1	D2	D3	D4	D5	D6	D7
D1 Pitot Orientation						
SA		Standard App. - Clean Air				
PA		Particulate-laden App. - Dirty Air				
D2 Probe Size						
#		Based on Duct Diameter				
D3 Duct Configuration						
RD		Round (Curved Surface)				
D4 Port Mounting Length						
NIP		Direct Duct Mount (No Port)				
2IP		2" Long Insertion Port				
6IP		6" Long Insertion Port				
D5 Pitot Mounting Plate						
425		4.25" Mounting Plate: Rated 7 PSI 1/4" thick (Port MOC): (20" Pitots or smaller)				
625		6.25" Mounting Plate: Rated 7 PSI 1/4" thick (Port MOC): (22" Pitots or larger)				
D6 End Support Type						
NS		No End Support				
BN		Bull Nose: 6" long support rod (34" - 40" Pitots)				
BN2		Bull Nose 12" long support rod (40" Pitots or longer)				
D7 Additional Options						
N		No Option Recommended				
Pitots in an Array						
01	1 Pitot per installation: (Ducts 8" or less)					
02	2 Pitots per installation: (Ducts 10" - 18")					
03	3 Pitots per installation: (Ducts 20" - 48")					

Model No: VAP-SFS PORT

D1	D2	D3	D4	D5		
D1 Material of Construction						
304	304 Stainless Steel					
316	316 Stainless Steel					
D2 Port Mounting Design						
CS4	Curved (6" Duct)					
CS5	Curved (7-8" Duct)					
CS6	Curved (9-11" Duct)					
CS7	Curved (12-13" Duct)					
CS8	Curved (14-15" Duct)					
CS9	Curved (16-17" Duct)					
CS12	Curved (18-20" Duct)					
CS14	Curved (22-26" Duct)					
CS16	Curved (28-30" Duct)					
CS18	Curved (32" Duct)					
FT	Flat (34-48" Duct)					
D3 Port Mounting Length						
2IP	2" Long Insertion Port					
6IP	6" Long Insertion Port					
D4 Pitot Mounting Plate						
425	4.25" Mounting Plate: Rated 7 PSI 1/4" thick Anodized AL: (20" Pitots or smaller)					
625	6.25" Mounting Plate: Rated 7 PSI 1/4" thick Anodized AL: (22" Pitots or larger)					
D5 Port Type						
IP	Insertion Port: No End Support (Less than 34" Pitot - IP only)					
BN	Insertion Port & End Support: (34" Pitots or larger - IP & BN)					

NOTE: For applications where SS pitots are to be used in duct work larger than 48" in diameter, the pitots can be mounted from opposite directions in order to traverse the larger duct diameters.

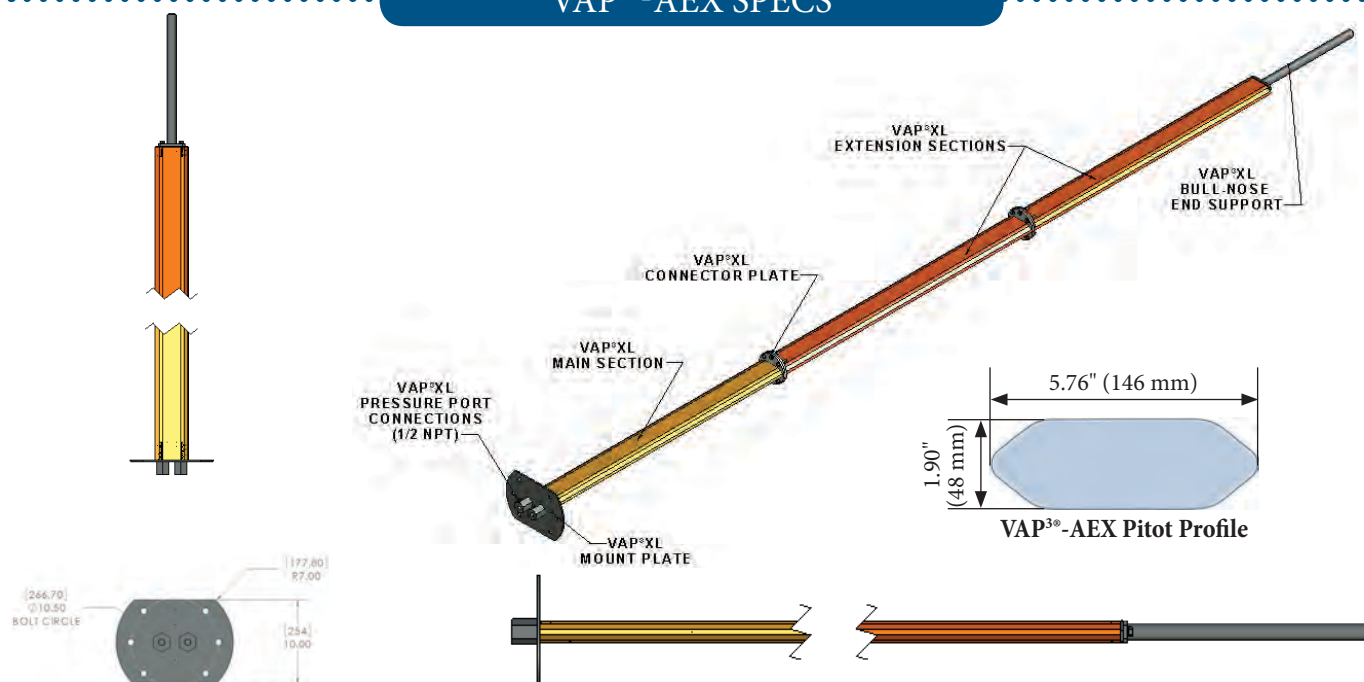
VAP³® - Large Ducts

The VAP³®-Extra Large Pitot or VAP³®-AEX is designed as an extremely accurate, low-cost solution for air flow measurement in industrial process applications where extremely large ducts are present. VAP³®-AEX pitots are constructed out of Anodized Aluminum, much like the AES pitot, however, the VAP³®-AEX Pitot's cross sectional dimensions are more than twice that of the standard AES pitot in both width and height. The VAP³®-AEX is an insertion style pitot that is mounted via welded ports and delivers an extremely accurate differential pressure output that allows for precise flow measurement and control of your system.

- **ROUND DUCTS**
- **Large Ducts**
- **Standard Temperatures**



VAP³®-AEX SPECS



System Requirements: "Clean" Air

- **Duct Configuration:** Round
- **Duct Size:** 72" and larger
- **MOC:** Anodized Aluminum
- **Duct Pressure:** -7 to 7 PSI (-48 to 48 kPa)
- **Temperature:** -40 to 700 F (-40 to 371 C)
- **Medium:** Clean Air or Gas
- **Velocity Clean Air:** (250 - 12,500 ft/min)

System Requirements: "Dirty" Air

- **Duct Configuration:** Round
- **Duct Size:** 72" and larger
- **MOC:** Anodized Aluminum
- **Duct Pressure:** -7 to 7 PSI (-48 to 48 kPa)
- **Temperature:** -40 to 700 F (-40 to 371 C)
- **Medium:** Particulate-Laden Air or Gas
- **Velocity Air:** (1,500 - 12,500 ft/min)

Model No: VAP-AEX PITOT

D1	D2	D3	D4	D5	D6	D7
D1 Pitot Orientation						
SA		Standard App. - Clean Air				
PA		Particulate-laden App. - Dirty Air				
D2 Probe Size						
#		Based on Duct Diameter				
D3 Duct Configuration						
RD		Round (Curved Surface)				
D4 Port Mounting Length						
XL		10" Long XL Insertion Port Mounted Directly to Duct				
D5 Pitot Mounting Plate						
XL		XL Mounting Plate: Rated 7 PSI 1/4" thick 304 Stainless Steel (72" Pitots or larger)				
D6 End Support Type						
BNX		Bull Nose Support Rod - XL Pitots				
D7 Additional Options						
N		No Option Recommended				
STFX		Integral SS Probe Stiffener XL Pitot (Required if temp. exceeds 600° F)				

Model No: VAP-AEX PORT

D1	D2	D3	D4	D5		
D1 Material of Construction						
304	304 Stainless Steel					
316	316 Stainless Steel					
AL	Aluminum					
CS	Carbon Steel					
D2 Port Mounting Design						
FT	Flat (72" Ducts or larger)					
D3 Port Mounting Length						
XL	10" Long XL Insertion Port Mounted Directly to Duct					
D4 Pitot Mounting Plate						
XL	XL Mounting Plate: Rated 7 PSI 1/4" thick Stainless Steel: (72" Pitots or larger)					
D5 Port Type						
BNX	Insertion Port & End Support: (72" Pitots or larger)					
Pitots in an Array						
03	3 Pitots per installation: (Ducts over 72")					

FEATURES AND BENEFITS

- Anodized Aluminum Pitot resists corrosion and wear from airborne particulate
- Manufactured in sections for easy Bolt-Together Assembly
- Over 2X larger than the AES pitot profile for increased rigidity and structural integrity in larger ducts
- Perfect for Clean Air/Particulate-laden Air Streams
- Will work with both DP only and Multivariable Transmitters (nearly any model)
- Easy weld-on ports for installation in nearly any duct

Insertion Style Pitots

RECTANGULAR AND SQUARE DUCTS

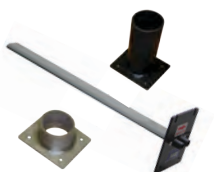
The VAP³ Pitot comes in a variety of models, each designed to accurately measure the flow of air or gas under particular circumstances. Whether measuring clean air, or air that is particulate-laden, the VAP³ pitot delivers an extremely accurate differential pressure output. The standard VAP³ pitot is constructed out of Anodized Aluminum for maximum durability, however, both PVC and Stainless Steel versions are available for applications where the air/gas being measured may be caustic to Aluminum, or where the temperature within the duct may reach up to 900° F. The following section documents the use of VAP³ Pitots installed within square or rectangular ducts. For more information on round duct installations and the corresponding pitot arrays and configurations for round ducts, please see the corresponding section of this catalog, or visit our website.

Industrial Air Flow Pitot Models



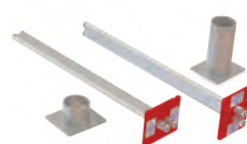
VAP³-AES: Aluminum Pitot

- Anodized Aluminum Pitot
- Perfect for most applications
- Moderate Heat Applications



VAP³-PES: PVC Pitot

- Extruded PVC Pitot
- Perfect for Corrosive Gases
- Low Heat Applications



VAP³-SFS: Stainless Steel Pitot

- Stainless Steel Pitot
- Perfect for Corrosive Gases
- High Heat Applications

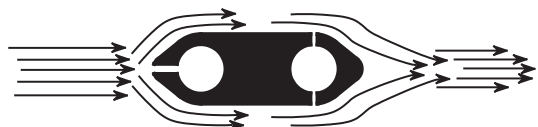


VAP³-AEX: Extra Large Pitot

- Anodized Aluminum Pitot
- Profile twice the VAP³-AES
- Great for Extra Large Ducts

VAP³/SA CLEAN AIR

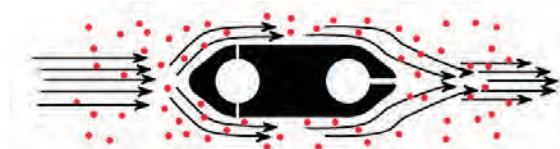
When mounted in SA (Superior Accuracy) mode, all of the models mentioned above will accurately measure the flow of relatively clean air through nearly any duct. While positioning the High Port so that it faces into the air stream (shown below) makes the measurement more accurate, it also limits the use of SA mode to particulate-free air. Mounted in SA mode, VAP³ pitots provide an accurate differential pressure output that allows for precise air flow measurement and control of your process to within $\pm 0.50\%$ accuracy when calibrated.



VAP³/SA PITOT PROFILE: "CLEAN" AIR

VAP³/PA PARTICULATE-LADEN AIR

When mounted in PA (Particulate-laden Air) mode, all of the models mentioned above will accurately measure the flow of "dirty" or particulate-laden air through nearly any duct. In PA mode, the High Port is positioned so that it faces away from the oncoming air stream, making the pitot resistant to plugging. Mounted in PA mode, VAP³ pitots provide an accurate differential pressure output which allows for precise air flow measurement and control of your process to within $\pm 2.00\%$ accuracy when calibrated.



VAP³/PA PITOT PROFILE: "DIRTY" AIR

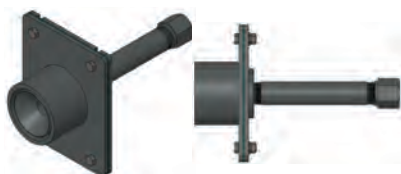
Pitot Installation: Rectangular Ducts

Insertion Port: Flat Mount



An insertion port is typically welded to the exterior of a duct and pitots are then bolted to the insertion port. A flat surface allows the port to be easily mounted to the exterior of rectangular/square ducts.

Bull Nose Receiver: Flat Mount



A Bull Nose receiver and port is typically used on square/rectangular ducts where pitots are over 34". The pitot's Bull Nose is inserted into the Bull Nose Receiver which is welded to the exterior of the duct.

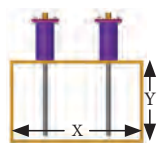
Pitot Installation: Insertion Port and Bull Nose Receiver

Insertion Port



Bull Nose Receiver

Recommended Pitot Array Installation Orientation



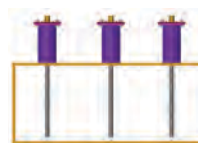
"X" long side;
"Y" shorter side



Single Pitot:
"X" is 8" or less



Two Pitots:
"X" is 10" - 26"



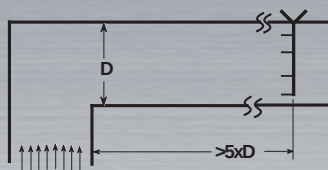
Three Pitots:
"X" is 28" - 36"

Four Pitots:
"X" is 38" - 60"

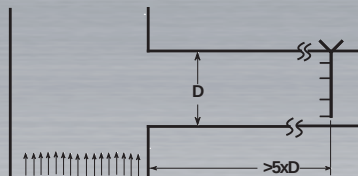
Five Pitots:
"X" is 62" - 116"

Six Pitots:
"X" is 116" - 240"

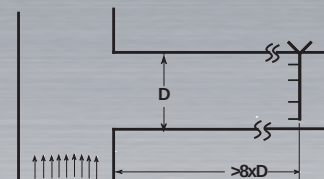
Recommended Upstream Duct Run Requirements



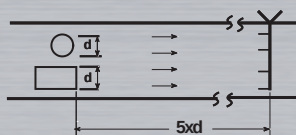
Upstream 45° or 90°



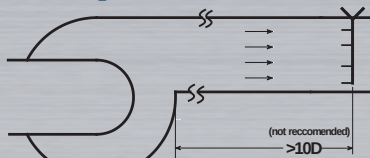
Upstream Plenum



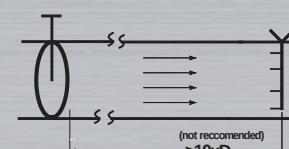
Upstream Tee



Upstream Obstruction

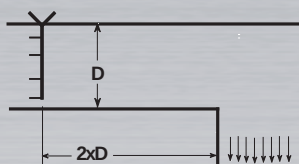


Upstream Fan

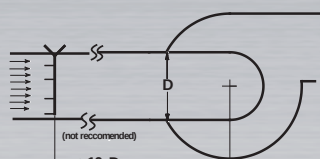


Upstream Damper

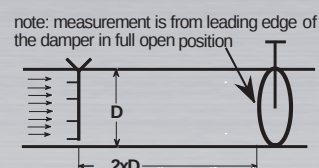
Recommended Downstream Duct Run Requirements



Downstream 45° or 90°



Downstream Fan



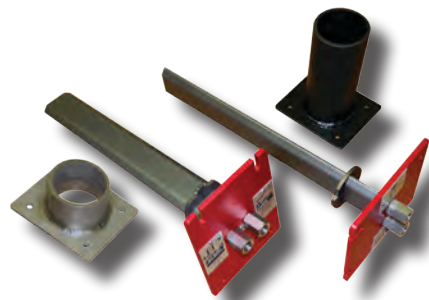
Downstream Damper

note: measurement is from leading edge of the damper in full open position

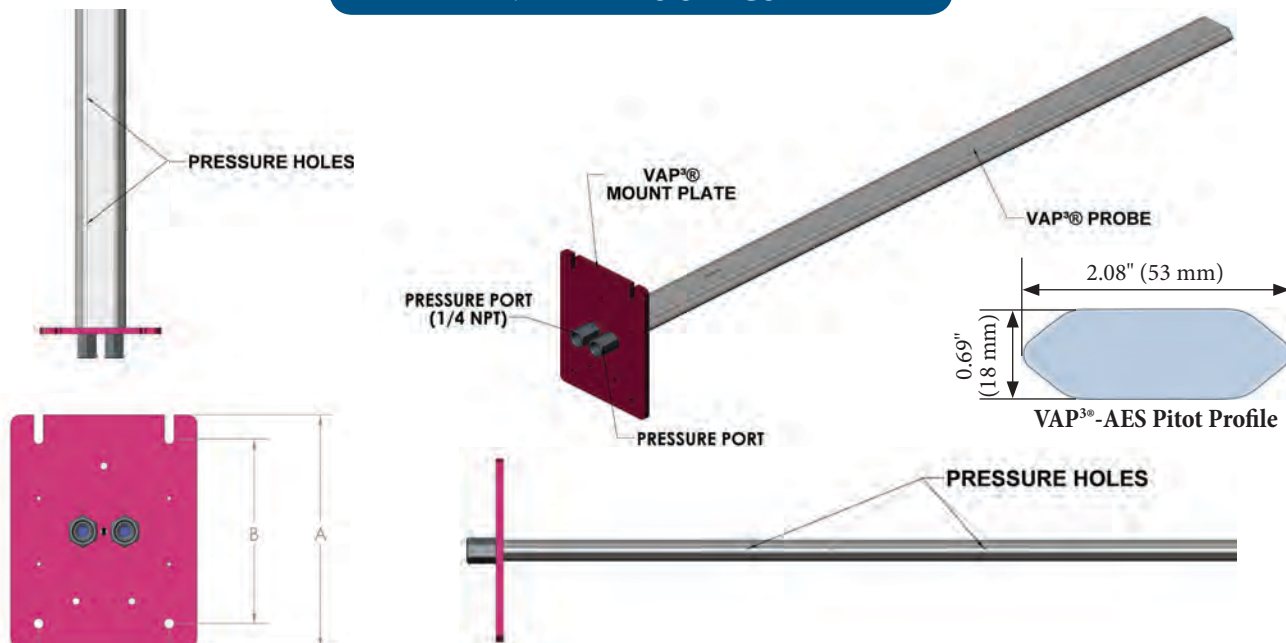
VAP³® - Anodized Aluminum

The VAP³®-Anodized Aluminum Pitot (VAP³®-AES) is designed as an extremely accurate, low-cost solution for air flow measurement in clean or particulate-laden industrial air applications. VAP³®-AES pitots are constructed entirely out of Anodized Aluminum and are ideal for most applications. VAP³®-AES Pitots are insertion style pitots that are mounted to the exterior of your new or existing square or rectangular duct work. When inserted into air or gas flow ducts with the required upstream and downstream straight duct runs, VAP³®-AES Pitots deliver an extremely accurate differential pressure outputs for precise flow measurement.

- **RECTANGULAR DUCTS**
- **Non-Corrosive Air/Gas**
- **Standard Temperature**



VAP³®-AES SPECS



System Requirements: "Clean" Air

- **Duct Configuration:** Rectangular/Square
- **Duct Size:** 6" to 72"
- **MOC:** Anodized Aluminum
- **Duct Pressure:** -7 to 7 PSI (-48 to 48 kPa)
- **Temperature:** -40 to 700 F (-40 to 371 C)
- **Medium:** Clean Air or Gas
- **Velocity Clean Air:** (250 - 12,500 ft/min)

System Requirements: "Dirty" Air

- **Duct Configuration:** Rectangular/Square
- **Duct Size:** 6" to 72"
- **MOC:** Anodized Aluminum
- **Duct Pressure:** -7 to 7 PSI (-48 to 48 kPa)
- **Temperature:** -40 to 700 F (-40 to 371 C)
- **Medium:** Particulate-Laden Air or Gas
- **Velocity Air:** (1,500 - 12,500 ft/min)

Model No: VAP-AES PITOT

D1	D2	D3	D4	D5	D6	D7
D1 Pitot Orientation						
SA		Standard App. - Clean Air				
PA		Particulate-laden App. - Dirty Air				
D2 Probe Size						
#		Based on Duct Width				
D3 Duct Configuration						
RT		Rectangular/Square Duct				
D4 Port Mounting Length						
NIP		Direct Duct Mount (No Port)				
2IP		2" Long Insertion Port				
6IP		6" Long Insertion Port				
D5 Pitot Mounting Plate						
425		4.25" Mounting Plate: Rated 7 PSI 1/4" thick Anodized AL: (20" Pitots or smaller)				
625		6.25" Mounting Plate: Rated 7 PSI 1/4" thick Anodized AL: (22" Pitots or larger)				
D6 End Support Type						
NS		No End Support				
BN		Bull Nose: 6" long support rod (34" - 40" Pitots)				
BN2		Bull Nose 12" long support rod (40" Pitots or longer)				
D7 Additional Options						
N		No Option Recommended				
STF		Integral SS Probe Stiffener (Required if temp. exceeds 600° F)				

Model No: VAP-AES PORT

D1	D2	D3	D4	D5		
D1 Material of Construction						
304	304 Stainless Steel					
316	316 Stainless Steel					
AL	Aluminum					
CS	Carbon Steel					
D2 Port Mounting Design						
FT	Flat (34-72" Duct)					
D3 Port Mounting Length						
2IP	2" Long Insertion Port					
6IP	6" Long Insertion Port					
D4 Pitot Mounting Plate						
425	4.25" Mounting Plate: Rated 7 PSI 1/4" thick Anodized AL: (20" Pitots or smaller)					
625	6.25" Mounting Plate: Rated 7 PSI 1/4" thick Anodized AL: (22" Pitots or larger)					
D5 Port Type						
IP	Insertion Port: No End Support (Less than 34" Pitot - IP only)					
BN	Insertion Port & End Support: (34" Pitots or larger - IP & BN)					
No of Pitots "X" Dimension p.17)						
01	1 Pitot per installation (Ducts 8" or less)					
02	2 Pitots per installation (Ducts 10" - 26")					
03	3 Pitots per installation (Ducts 28" - 36")					
04	4 Pitots per installation (Ducts 38" - 60")					
05	5 Pitots per installation (Ducts over 60")					

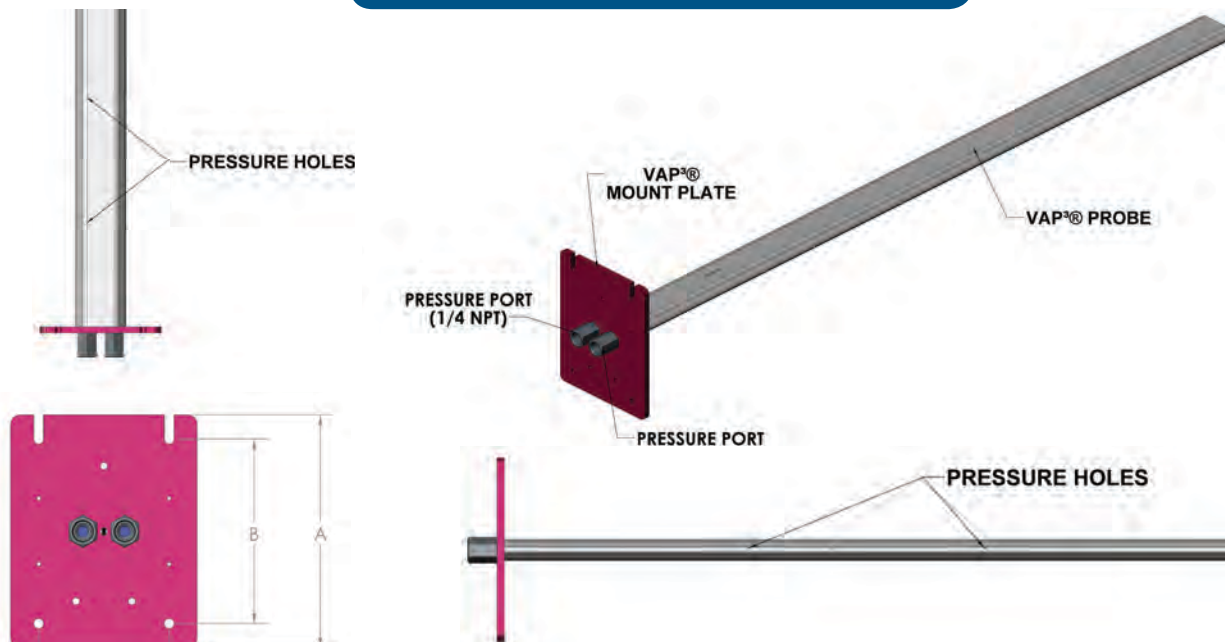
VAP³® - PVC

The VAP³-PVC pitot (VAP³-PES) is designed as an extremely accurate, low-cost solution for air flow measurement in clean or particulate-laden air for industrial process applications where corrosive gases are present. VAP³-PES pitots are constructed entirely out of PVC for corrosive resistance to a variety of gases. Just as all VAP³ pitots, the VAP³-PES Pitot is an insertion style pitot mounted via welded ports. When inserted into air or gas flow ducts with the required upstream and downstream straight duct runs, VAP³-PES Pitots deliver an extremely accurate differential pressure outputs for precise flow measurement.

- **RECTANGULAR DUCTS**
- **Corrosive Air/Gas**
- **Ambient Temperature**



VAP³-PES SPECS



System Requirements: "Clean" Air

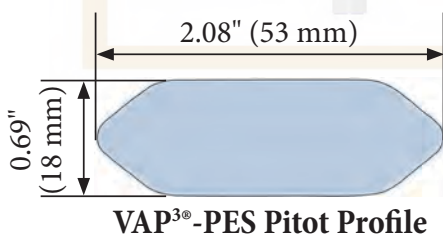
- **Duct Configuration:** Rectangular/Square
- **Duct Size:** 6" to 24"
- **MOC:** PVC
- **Duct Pressure:** -7 to 7 PSI (-48 to 48 kPa)
- **Temperature:** -40 to 140 F (-40 to 60 C)
- **Medium:** Clean Air or Gas
- **Velocity Clean Air:** (250 - 12,500 ft/min)

System Requirements: "Dirty" Air

- **Duct Configuration:** Rectangular/Square
- **Duct Size:** 6" to 24"
- **MOC:** PVC
- **Duct Pressure:** -7 to 7 PSI (-48 to 48 kPa)
- **Temperature:** -40 to 140 F (-40 to 60 C)
- **Medium:** Particulate-Laden Air or Gas
- **Velocity Air:** (1,500 - 12,500 ft/min)

Model No: VAP-PES PITOT

D1	D2	D3	D4	D5	D6	D7
D1 Pitot Orientation						
SA	Standard App. - Clean Air					
PA	Particulate-laden App. - Dirty Air					
D2 Probe Size						
#	Based on Duct Width					
D3 Duct Configuration						
RT	Rectangular/Square Duct					
D4 Port Mounting Length						
NIP	Direct Duct Mount (No Port)					
2IP	2” Long Insertion Port					
6IP	6” Long Insertion Port					
D5 Pitot Mounting Plate						
425	4.25” Mounting Plate: Rated 7 PSI 1/4” thick PVC: (16” Pitots or smaller)					
625	6.25” Mounting Plate: Rated 7 PSI 1/4” thick PVC: (18” Pitots or larger)					
D6 End Support Type						
NS	No End Support					
D7 Additional Options						
N	No Option Recommended					



Model No: VAP-PES PORT

D1	D2	D3	D4	D5		
D1 Material of Construction						
PVC	Sch 80 PVC					
304	304 Stainless Steel					
316	316 Stainless Steel					
AL	Aluminum					
CS	Carbon Steel					
D2 Port Mounting Design						
FT	Flat Port Mount					
D3 Port Mounting Length						
2IP	2” Long Insertion Port					
6IP	6” Long Insertion Port					
D4 Pitot Mounting Plate						
425	4.25” Mounting Plate: Rated 5 PSI 1/4” thick PVC: (16” Pitots or smaller)					
625	6.25” Mounting Plate: Rated 7 PSI 1/4” thick PVC: (18” Pitots or larger)					
D5 Port Type						
IP	Insertion Port: No End Support (Less than 34” Pitot - IP only)					

No of Pitots "X" Dimension p.17)

- | | |
|----|---|
| 01 | 1 Pitot per installation (Ducts 8" or less) |
| 02 | 2 Pitots per installation (Ducts 10" - 26") |
| 03 | 3 Pitots per installation (Ducts 28" - 36") |
| 04 | 4 Pitots per installation (Ducts 38" - 60") |
| 05 | 5 Pitots per installation (Ducts over 60") |

SQUARE DUCTS: CORROSIVE GASES

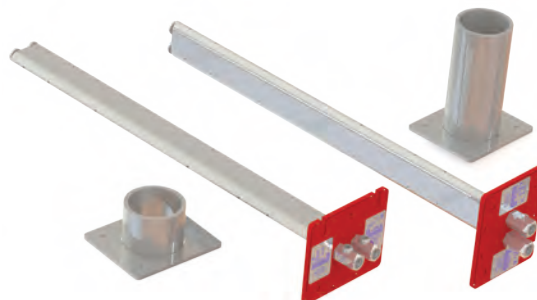
NOTES

For PVC Pitot applications in duct work where the duct's shortest side is larger than 24", the pitots can be mounted from opposite directions in order to traverse larger duct diameters.

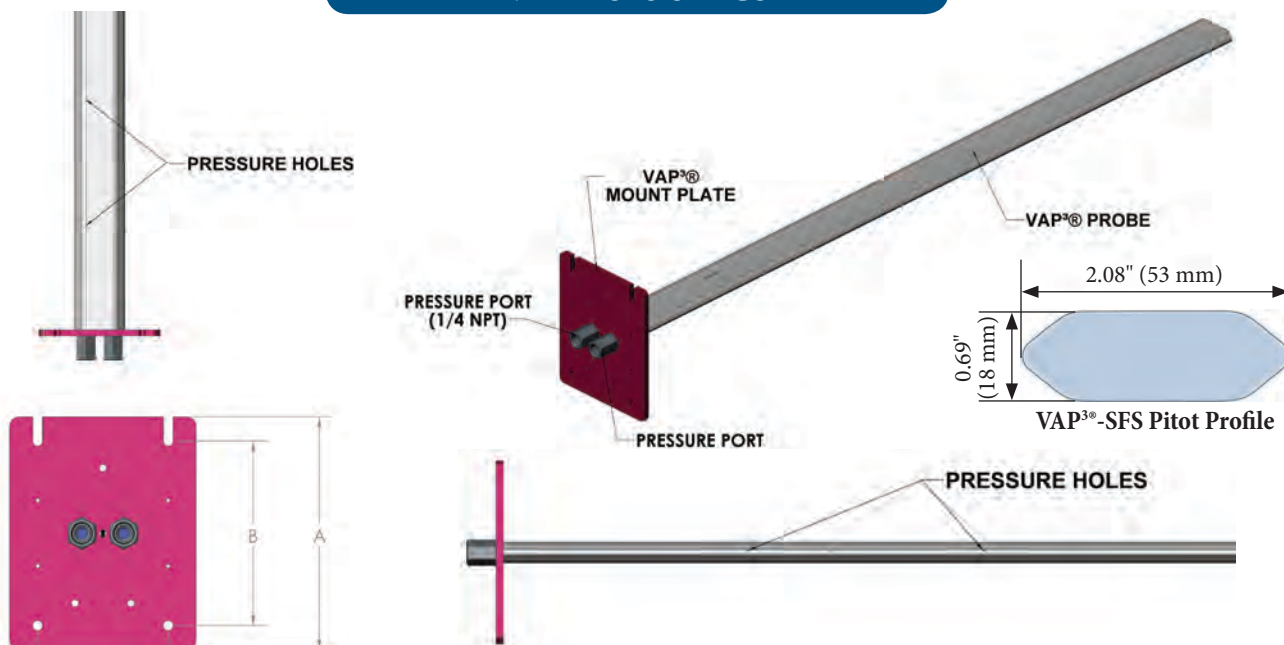
VAP³® - Stainless Steel

The VAP³®-Stainless Steel Pitot (VAP³®-SFS) is an accurate and low-cost solution for air flow measurement in industrial process applications where corrosive gases or extremely high temperatures are present. VAP³®-SFS pitots are constructed out of Stainless Steel for enhanced corrosion resistance and resistance to high heat. The VAP³®-SFS Pitot is an insertion style pitot mounted via welded ports and, when inserted into air or gas flow ducts with the required upstream and downstream straight runs, will deliver an extremely accurate differential pressure output for precise flow measurement.

- **RECTANGULAR DUCTS**
- **Corrosive Air/Gas**
- **High Temperature**



VAP³®-SFS SPECS



System Requirements: "Clean" Air

- **Duct Configuration:** Rectangular/Square
- **Duct Size:** 6" to 48"
- **MOC:** Stainless Steel
- **Duct Pressure:** -7 to 7 PSI (-48 to 48 kPa)
- **Temperature:** -40 to 1500 F (-40 to 815 C)
- **Medium:** Clean Air or Gas
- **Velocity Clean Air:** (250 - 12,500 ft/min)

System Requirements: "Dirty" Air

- **Duct Configuration:** Rectangular/Square
- **Duct Size:** 6" to 48"
- **MOC:** Stainless Steel
- **Duct Pressure:** -7 to 7 PSI (-48 to 48 kPa)
- **Temperature:** -40 to 1500 F (-40 to 815 C)
- **Medium:** Particulate-Laden Air or Gas
- **Velocity Air:** (1,500 - 12,500 ft/min)

Model No: VAP-SFS PITOT

D1	D2	D3	D4	D5	D6	D7
D1 Pitot Orientation						
SA		Standard App. - Clean Air				
PA		Particulate-laden App. - Dirty Air				
D2 Probe Size						
#		Based on Duct Width				
D3 Duct Configuration						
RT		Rectangular/Square Duct				
D4 Port Mounting Length						
NIP		Direct Duct Mount (No Port)				
2IP		2” Long Insertion Port				
6IP		6” Long Insertion Port				
D5 Pitot Mounting Plate						
425		4.25” Mounting Plate: Rated 7 PSI 1/4” thick Anodized AL: (20” Pitots or smaller)				
625		6.25” Mounting Plate: Rated 7 PSI 1/4” thick Anodized AL: (22” Pitots or larger)				
D6 End Support Type						
NS		No End Support				
BN		Bull Nose: 6” long support rod (34” - 40” Pitots)				
BN2		Bull Nose 12” long support rod (40” Pitots or longer)				
D7 Additional Options						
N		No Option Recommended				

Model No: VAP-SFS PORT

D1	D2	D3	D4	D5		
D1 Material of Construction						
304	304 Stainless Steel					
316	316 Stainless Steel					
AL	Aluminum					
CS	Carbon Steel					
D2 Port Mounting Design						
FT	Flat (34-72" Duct)					
D3 Port Mounting Length						
2IP	2" Long Insertion Port					
6IP	6" Long Insertion Port					
D4 Pitot Mounting Plate						
425	4.25" Mounting Plate: Rated 7 PSI 1/4" thick Anodized AL: (20" Pitots or smaller)					
625	6.25" Mounting Plate: Rated 7 PSI 1/4" thick Anodized AL: (22" Pitots or larger)					
D5 Port Type						
IP	Insertion Port: No End Support (Less than 34" Pitot - IP only)					
BN	Insertion Port & End Support: (34" Pitots or larger - IP & BN)					
No of Pitots "X" Dimension p.17)						
01	1 Pitot per installation (Ducts 8" or less)					
02	2 Pitots per installation (Ducts 10" - 26")					
03	3 Pitots per installation (Ducts 28" - 36")					
04	4 Pitots per installation (Ducts 38" - 60")					
05	5 Pitots per installation (Ducts over 60")					

NOTES

NOTE: For SS Pitot applications in duct work where the duct's shortest side is larger than 48", the pitots can be mounted from opposite directions in order to traverse the larger duct diameters.

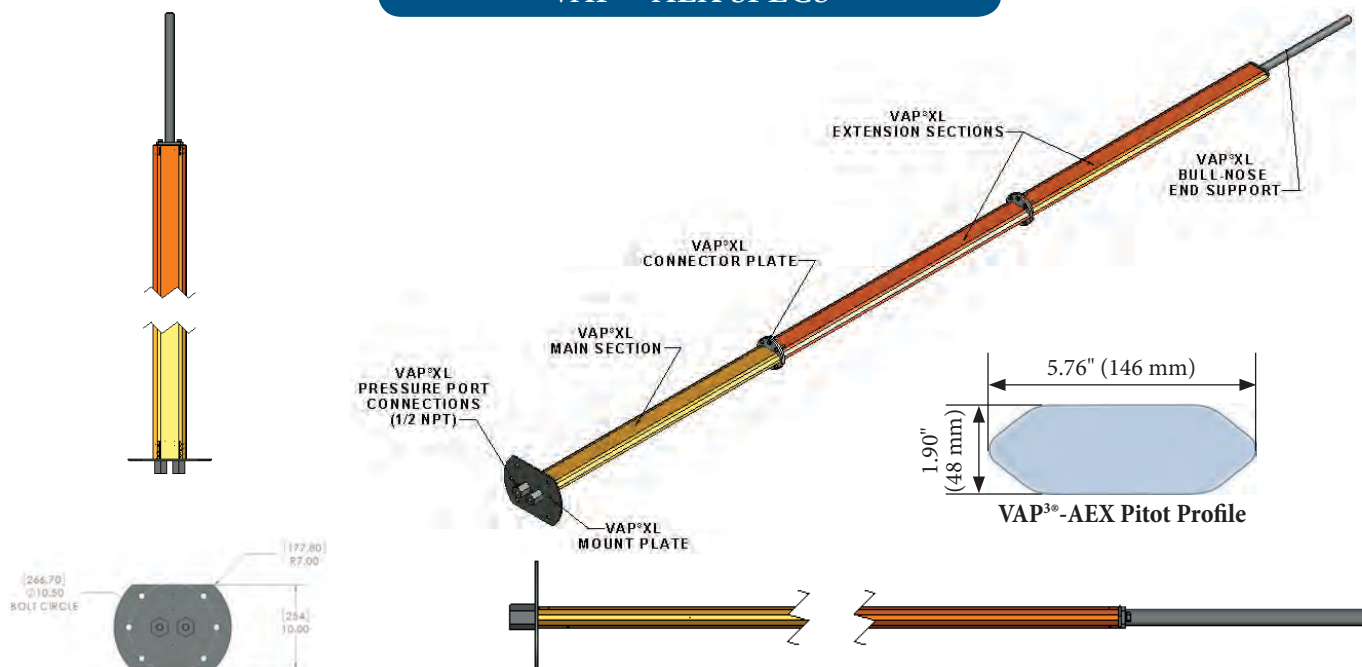
VAP³® - Large Ducts

The VAP³-Extra Large Pitot or VAP³-AEX is designed as an extremely accurate, low-cost solution for air flow measurement for industrial process applications where extremely large ducts are present. VAP³-AEX pitots are constructed out of Anodized Aluminum, much like the AES pitot, however, the VAP³-AEX pitot's cross sectional dimensions are more than twice that of the standard AES pitot in both width and height. The VAP³-AEX is an insertion style pitot that is mounted via welded ports and delivers an accurate differential pressure output for precise flow measurement.

- **RECTANGULAR DUCTS**
- **Large Ducts**
- **Standard Temperature**



VAP³-AEX SPECS



System Requirements: "Clean" Air

- **Duct Configuration:** Rectangular/Square
- **Duct Size:** 72" and larger
- **MOC:** Anodized Aluminum
- **Duct Pressure:** -7 to 7 PSI (-48 to 48 kPa)
- **Temperature:** -40 to 700 F (-40 to 371 C)
- **Medium:** Clean Air or Gas
- **Velocity Clean Air:** (250 - 12,500 ft/min)

System Requirements: "Dirty" Air

- **Duct Configuration:** Rectangular/Square
- **Duct Size:** 72" and larger
- **MOC:** Anodized Aluminum
- **Duct Pressure:** -7 to 7 PSI (-48 to 48 kPa)
- **Temperature:** -40 to 700 F (-40 to 371 C)
- **Medium:** Particulate-Laden Air or Gas
- **Velocity Air:** (1,500 - 12,500 ft/min)

Model No: VAP-AEX PITOT

D1	D2	D3	D4	D5	D6	D7
D1 Pitot Orientation						
SA	Standard App. - Clean Air					
PA	Particulate-laden App. - Dirty Air					
D2 Probe Size						
#	Based on Duct Width					
D3 Duct Configuration						
RT	Rectangular/Square Duct					
D4 Port Mounting Length						
XL	10" Long XL Insertion Port Mounted Directly to Duct					
D5 Pitot Mounting Plate						
XL	XL Mounting Plate: Rated 7 PSI 1/4" thick 304 Stainless Steel (72" Pitots or larger)					
D6 End Support Type						
BNX	Bull Nose Support Rod - XL Pitots					
D7 Additional Options						
N	No Option Recommended					
STFX	Integral SS Probe Stiffener XL Pitot (Required if temp. exceeds 600° F)					

Model No: VAP-AEX PORT

D1	D2	D3	D4	D5		
D1 Material of Construction						
304		304 Stainless Steel				
316		316 Stainless Steel				
AL		Aluminum				
CS		Carbon Steel				
D2 Port Mounting Design						
FT		Flat (72" Ducts or larger)				
D3 Port Mounting Length						
XL		10" Long XL Insertion Port Mounted Directly to Duct				
D4 Pitot Mounting Plate						
XL		XL Mounting Plate: Rated 7 PSI 1/4" thick Stainless Steel: (72" Pitots or larger)				
D5 Port Type						
BNX		Insertion Port & End Support: (72" Pitots or larger)				
No of Pitots "X" Dimension p.17)						
01	1 Pitot per installation (Ducts 8" or less)					
02	2 Pitots per installation (Ducts 10" - 26")					
03	3 Pitots per installation (Ducts 28" - 36")					
04	4 Pitots per installation (Ducts 38" - 60")					
05	5 Pitots per installation (Ducts over 60")					

FEATURES AND BENEFITS

- Perfect for Clean or Particulate-laden Air
- Over 2X larger than the AES pitot profile for increased rigidity and structural integrity in larger ducts
- Anodized Aluminum Pitot resists corrosion and wear
- Manufactured in sections for easy Bolt-Together Assembly
- Will work with both DP only and Multivariable Transmitters (nearly any model)
- Simple weld-on ports for easy installation

Options

MATERIAL OF CONSTRUCTION

Pitots and Ports

Depending on the application, most of the DP Based flow measurement pitots and/or ports in this catalog can be constructed out of Carbon Steel or Stainless Steel (either 304 or 316). If your ducts are constructed of another material or if your flows contain caustic materials that will react with these materials, other materials of construction may also be available.



Pitots and Ports with Various MOC

AIRBORNE PARTICULATE

Line Mounted Purge

For heavily particulate-laden air streams a line mounted purge is available. The line mounted purge discharges a steady stream of clean, dry instrument air either through the impulse lines of the transmitter, or as positive pressure through the ports of the pitots in order to reduce the possibility of particulate or moisture disrupting the measurement devices' measurement accuracy.



Line Mounted Purge Block

EASY INSTALLATION

Duct Section VAP (DSV)

The Duct Section VAP³® (DSV) is a flanged duct section which includes an integral array of VAP³® pitots. The DSV allows for the easy installation of pitots within nearly any duct work and the customizable flange patterns allow easy connection to nearly any duct work.

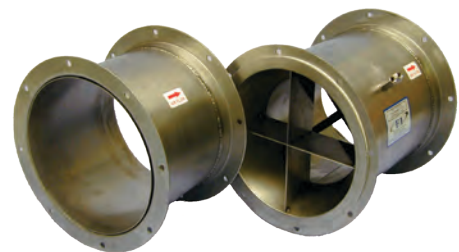


Round and Rectangular DSV

FLOW CONDITIONING

High Beta® Process (HBP)

The High Beta® (HBP) Flow Conditioner incorporates both a nozzled duct section for flow profiling, as well as an integral flow straightener in order to eliminate cyclonic flow at the point of measurement. The air, once straightened, passes through the element and across the integral pitot array which accurately measures the flow of air in any circular duct in a fraction of the space that alternative technologies require.



High Beta Flow Conditioner

QVT Multivariable Transmitter



The QVT Multivariable Transmitter from Eastern Instruments is a Smart Transmitter that can be used for the accurate measurement of up to four separate process variables including Differential Pressure, Temperature and Absolute Pressure. When coupled with any DP based flow measurement element, the QVT will calculate the fully compensated mass flow of air/gas travelling through any process which is at or near atmospheric pressure (5 - 25 psia). The QVT is uniquely designed for high accuracy at ultra low DP ranges and can accurately measure differential pressures from 0.001 up to 10 in WC. This broad operating range is unique among multivariable transmitters and allows a single QVT transmitter to replace multiple transmitters when covering this large range. Another feature of the QVT is its unique process seal that requires no diaphragm seal. Diaphragm seals often cause inaccuracies in transmitter's sensor readings due to condensate.

FEATURES AND BENEFITS

- **Modes of Operation:** Multivariable Transmitter (Measurement of two or more of DP, Temperature and Absolute Pressure), DP Transmitter (DP Measurement only)
- **DP Measurement:** Operating Range is 10000:1 (0.0009 in WC to 9.0 in WC) measuring Differential Pressure across any primary flow element such as VAP Averaging Pitot or HBP Flow Conditioner
- **AP Measurement:** Measurement of Absolute Pressure (integral sensor tied to low port of primary flow element)
- **Temperature Measurement:** Measurement of Temperature via 100 ohm 3-Wire Class A DIN RTD
- **Process Seal:** Our unique method of isolating sensors from the process requires no diaphragm seal and can be further enhanced with a Purge Seal (Low Volume Continuous Purge coupled directly to transmitter)
- **Flow Accuracy:** The accuracy of the flow measurement can be as high as $\pm 0.50\%$ of Reading over 100:1 DP (10:1 flow) range
- **Rangeability:** the span of the 4-20 mA signal corresponding to DP can be ranged from 0 to 0.05 in WC up to 0 to 8 in WC (160:1)
- **Response Time:** Updates flow calculation 10 times a second
- **Functionality:** All measured and calculated variables are available on LCD panel
- **Output:** 4-20 mA Compensated flow output using measured/input values for Differential Pressure, Absolute Pressure and Temperature (Can also be a single variable output only)
- **Simplicity:** Ae and the 4-20 mA full scale value are set from LCD panel's push buttons
- **Zero:** Differential pressure can be zeroed from the LCD/push button interface
- **Power Supply:** Loop Power 8.8 - 42.5 vDC range
- **Versatility:** LCD can be rotated independently of the head (LCD rotates 270° and head can rotate 180°) for ultimate adjustability



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6,640,158; 6,814,108; 6,679,125. Other patents pending.

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