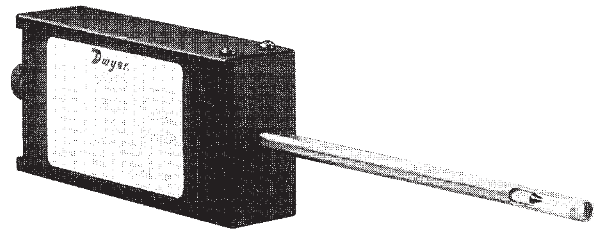
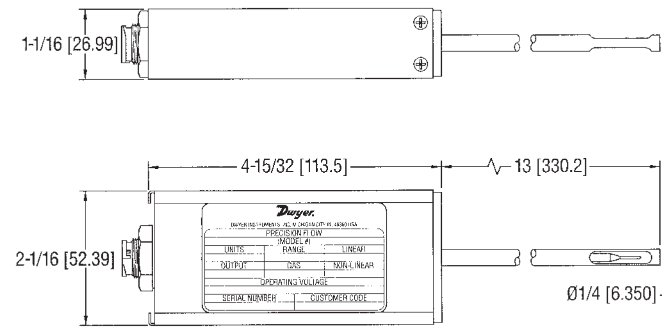
SERIES PF AIR VELOCITY TRANSMITTER

Specifications – Installation and Operating Instructions





The Series PF Air Velocity Transmitter monitors the mass flow rate of air and process gases and delivers a 4 to 20 mA output signal proportional to total mass gas mass flow rate. Each probe has a velocity sensor and a temperature sensor. Both sensors are reference-grade platinum resistance temperature detectors (RTD's). The platinum RTD wire is wound on a rugged ceramic mandrel for strength and stability. The circuit heats the velocity sensor at a temperature differential, above ambient and measures the cooling effect of the gas flow. The heated sensor directly measures gas mass velocity, referenced to standard conditions of 70° F (21.1°C) and atmosphere.

INSTALLATION

A common method of mounting the probe through a wall or duct is with a compression fitting. Mount the probe so the plane of the window is perpendicular to the axis of the pipe or duct within a ±5° azimuthal angle and a ±5° yaw angle. Allow 20 pipe diameters straight run upstream and 5 pipe diameters straight run downstream. The sensing point should be mounted in the center line of the pipe or duct.

ELECTRICAL CONNECTIONS

The Series PF Air Velocity Transmitters are supplied in a NEMA 2 enclosure. Field wiring is via a connector mounted on the enclosure. See figure 1. Check the label on the unit for the correct input power. The transmitter is not a loop powered device. The 4 to 20 mA output signal must be referenced to ground.

Pin Number	Function
1	Signal Ground
2	Output Signal
3	+15 VDC
4	No Connection
5	No Connection
6	Power Ground
7	Factory Test Point

PHYSICAL DATA

Accuracy: ±1% F.S., +0.5% of reading over 32 to 122°F (0 to 50°C) and 5 to 30 psia (0.35 to 2 kg/cm²).
Repeatability: 0.2% F.S.
Response Time: 0.2 seconds to 63% of final velocity value.
Gas Pressure: 150 psig (10 kg/cm² G) max.
Gas Temperature: –40 to 250°F (–40 to 121°C).
Supply Voltage: 15-18 VDC, 300 mA max.
Output: 4-20 mA, linear.
Loop Resistance: 400Ω max.
Operating Temperature: 32 to 122°F (0 to 50°C).
Wetted Parts: 304 stainless steel probe, glass coated sensor, epoxy.
Storage Temperature: 32 to 158°F (0 to 70°C).
Probe Dimensions: 1/4″ (6.35 mm) O. D., 13″ (33 cm) length.
Electrical Connection: Four wire standard connector.
Weight: 0.7 lbs. (0.30 kg).

Circuit Connector

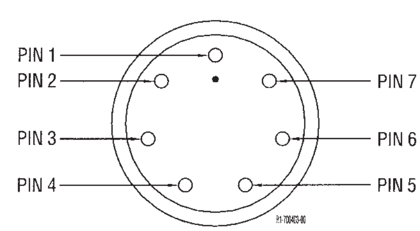


FIGURE 1

OPERATION

Before powering up for the first time, check all wiring to ensure it is in compliance with OSHA, NFPA, and other safety requirements. When power is first applied to the transmitter, the output will momentarily go high. It is normal for this condition to persist for a few seconds until the velocity sensor is heated. The flow indication will rapidly approach a zero value (or the value of the flow, if present) when warm-up is completed.

The transmitter may be turned on or off with flow present without damaging the unit. Check the label on the unit for calibration gas and output signal. The signal represents a linear proportional analog of flow ranging from 0-100% of full scale.

MAINTENANCE

WARNING! Before attempting any maintenance make sure there is no pressure in the line and the power is off.

WARNING! Gas leaks are possible during probe maintenance. If there is a toxic or combustible gas in the line, be sure the lines are completely purged before removing the probe.

To access the printed circuit assembly (PCA) within the NEMA 2 enclosure, remove the small screws holding the extruded enclosure to the base of the transmitter. Orient the top cover to allow the extruded enclosure to slide over the circuit boards and carefully slide it away from the base. The enclosure is attached to the transmitter via the wires connecting the PCAs to the connector. Amble room is available to allow access to all internal components.

PROBE CLEANING

Probes are insensitive to small amounts of contamination or dirt and will not cause accuracy errors. However, continued use in dirty air or stacks will necessitate periodic cleaning. To inspect the sensor element, remove the probe from the pipe or duct, exposing the sensor element (ceramic mandrel with tip diameter of approximately .040 inches). If the sensor element is visibly dirty, clean with water or alcohol (ethanol) and an artist's brush. Use a light touch while cleaning. Avoid touching the sensor element with any solid objects.

CALIBRATION

Calibration must be performed by qualified personnel. To insure the continuing high accuracy of the Series PF Air Velocity Transmitter we suggest returning the unit to the factory for recalibration.

TROUBLESHOOTING

Problem	Possible Cause	Action
Velocity measurement seems low	a) Probe not oriented properly b) dirty sensor	a) Orient probe with respect to flow b) Clean sensor
Velocity measurement is erratic or fluctuating	a) Very turbulent flow b) dirty sensor c) Sensor broken d) Not mounted securely	a) mount in less turbulent area b) Clean sensor c) Return for repair d) Secure mounting without vibration
Reading pegs plus or minus	a) Sensor not connected b) Sensor broken	a) Check wiring b) Return for repair
Reading won't zero	a) Out of calibration b) Sensor broken	a) Recalibrate b) Return for repair
Output not indicating 4 mA at zero flow	a) Excessive current loop resistance. Loop resistance must be between 50 and 400 ohms	a) Use larger gauge wire or change load resistance

MONITORING FLOW RATE

General Relationships

The Series PF Air Velocity Transmitter can be used to measure free air velocity in open spaces or monitor the total air flow rate of gases in pipes, ducts, and stacks. The total standard volumetric flow rate Q_S (SCFM) in a pipe or duct is determined by the following relationship:

$$Q_S = V_S A$$

where:

V_S = the average standard mass velocity over the cross-sectional area of the pipe or duct.(SFPM or SMPS)

A = the cross-sectional area of the pipe or duct (ft^2 or m^2).

The Series PF monitors the standard mass velocity at a single point in the cross section. Usually the sensor is located at the center line of the pipe or duct and measures the standard center line mass velocity $V_{S,C}$. The unit does not directly measure the average velocity V_S. The total standard volumetric flow rate is determined by the following relationship:

$$Q_S = KV_{S,C} A$$

where:

$$K = V_S / V_{S,C}$$

If the velocity profile in the pipe or duct is perfectly flat, or uniform, then K=1, and the unit is directly monitoring the average mass velocity. In most applications, the velocity profile is not uniform. The flow in pipes, ducts, and stacks, is almost always turbulent and has a nonuniform profile. The velocity decreases as the gas approaches the pipe wall (gas velocity is zero at the wall's surface). In a straight run of pipe or duct, twenty to thirty diameters in length, the velocity profile will be fully developed at the downstream end of the pipe. This is a desirable location to mount the transmitter because the profile is predictable and the flow is unidirectional down the pipe's axis. In some cases, due to extreme mounting constraints, the unit must be mounted downstream of an elbow, in which case the velocity profile is greatly skewed. The gas's momentum speeds up the flow along the outer radius of the elbow. Secondary vortex flows are also created in elbows.

Due to flow distribution, K generally does not equal one. Fortunately, K usually is essentially constant over a flow range, or Reynold's number range, of 4:1 to 10:1. The normalized shape of velocity profiles is essentially constant over a wide turndown ratio. This allows K to be determined by the traversal method. The traversal method divides the cross-sectional area at the monitoring location into equal areas, maintain a constant flow rate in the middle of the range of interest, and insert or traverse the transmitter into the pipe so the mass flow sensor measures the local mass velocity at the geometric center of each equal area.

Divide the cross section into four equal areas. Via traversing, measure each area's velocity as $V_{S,1}$, $V_{S,2}$, $V_{S,3}$, and $V_{S,4}$ and the center-line velocity as Vs,c. The average velocity and K are:

$$V_S = 1/4\ (V_{S,1} + V_{S,2} + V_{S,3} + V_{S,4})$$

$$K = (1/4V_{S,C})\ (V_{S,1} + V_{S,2} + V_{S,3} + V_{S,4})$$

Divide the cross section into n equal areas, then K is expressed as:

$$V_S = (1/n)\ \Sigma^{n}_{i=1}\ V_{S,i}$$

$$K = V_S\ /\ V_{S,C}$$

For fully developed turbulent flows, K varies from (0.8 to 0.95).

Equal Area Traversal Method

The ″ equal area method is recommended for most flow measurement applications. Traversing in round ducts with diameters of six inches or less should be made as shown in Figure 2 below. The traverse should consist of twelve readings taken along two diameters at 90° to each other and at centers of equal areas.

Equal Area Traverse for Round Ducts (6 inch diameter or less)

Tube Markings From Wall		
1	″ Dia. × 0.043 =	″
2	″ Dia. × 0.146 =	″
3	″ Dia. × 0.296 =	″
4	″ Dia. × 0.704 =	″
5	″ Dia. × 0.854 =	″
6	″ Dia. × 0.957 =	″

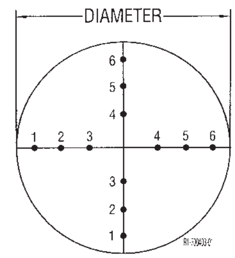


FIGURE 2

Traversing in round ducts with a diameter larger than six inches should be made as shown in Figure 3 below. In this case, the traverse should consist of a total of twenty readings along two diameters at 90° to each other, and at centers of equal areas.

Equal Area Traverse for Round Ducts (larger than 6 inch diameter)

Tube Markings From Wall		
1	″ Dia. × 0.026 =	″
2	″ Dia. × 0.082 =	″
3	″ Dia. × 0.146 =	″
4	″ Dia. × 0.226 =	″
5	″ Dia. × 0.342 =	″
6	″ Dia. × 0.658 =	″
7	″ Dia. × 0.774 =	″
8	″ Dia. × 0.854 =	″
9	″ Dia. × 0.918 =	″
10	″ Dia. × 0.974 =	″

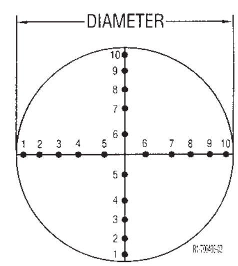


FIGURE 3

For rectangular ducts, at least sixteen, but not more than sixty-four readings should be taken at centers of equal areas. If fewer than sixty-four readings are taken, the traverse points should be no more than six inches center-to-center. The traverse points may be over six inches center-to-center if sixty-four readings are taken.

Stack and Flue Monitoring

For stack monitoring, the U.S. EPA Method 1 is usually specified. This method requires that: (1) the stack is not cyclonic or swirling; (2) the stack is at least twelve inches in diameter or 113 square inches in cross-sectional area; and (3) the measurement location is at least eight diameters downstream and at least two diameters upstream from the nearest flow turbulence. EPA allows for relaxation of these requirements. The number of monitoring points specified by EPA Method 1 is given below.

Stack Diameter (or Equivalent Diameter)	Number of Monitoring Points
12-24 inches	8 (Circular stacks)
12-24 inches	9 (Rectangular stacks)
Over 24 inches	12 (Circular or rectangular)

After the number of monitoring points is determined, divide the stack's cross-section into equal areas. The sensor should be located at the center of each equal area. The EPA'S recommendation for the size of each equal area for square or rectangular cross-sections. The dimensions of each area can be modified provided the cross-sectional area is the same.

Number of Monitoring Points	Size of each Individual Equal Area
9	3×3
12	4×3
16	4×4
20	5×4
25	5×5
30	6×5
36	6×6
42	7×6
49	7×7

Calculating Actual Flow Rate

The Series PF measures the "standard" volumetric flow rate, Q_S, referenced to 70°F (21.1°C) and 1 atmosphere (760 mm of mercury). The units of measurement are standard cubic feet per minute (SCFM).

In most monitoring applications, the mass flow (Q_S) is the quantity of direct interest. However, in some cases, the actual flow rate Q is desired. This is obtained by applying a correction factor given by the following equation:

where:

$$Q = Q_S (p_s/p) = Q_S (P_S/P) (T/T_S) \qquad (1)$$

where:

Q = "actual" volumetric flow rate at conditions of P and T (m^3/h, ACFM),

Q_S = "standard" volumetric flow rate referenced to standard conditions of P_S and T_S, (Sm^3/hr, SCFM),

p = gas mass density at actual conditions, lb/ft^3,

p_s = gas mass density at standard conditions (0.0748 lb/ft^3 for air at 70°F),

T = gas temperature at actual conditions, °R,

T_S = standard gas temperature, 70°F = 529.67°R,

P = gas pressure at actual conditions, mm of mercury (psia),

P_S = standard gas pressure, 760 mm of mercury (14.7psia).

Example Calculation:

Your reading shows 800 SCFM. The gas temperature is 150°F. The gas pressure is 200 psig. From equation 1, the actual volumetric flow rate Q is calculated as:

$$Q = 800 (14.7/ 14.7 + 200) (150 + 459.67/ 529.67) =$$

63.0 ACFM

Printed in U.S.A. 11/96

FR R1-440893-00

DYWER INSTRUMENTS, INC.
P.O. Box 373, Michigan City, Indiana 46361, U.S.A.
Phone: 219/879-8000 Fax: 219/872-9057