VorCone™ Installation Guide

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Customer Notice for Oxygen Service

Unless you have specifically ordered VorTek's optional O_2 cleaning, this flow meter may not be fit for oxygen service. Some models can only be properly cleaned during the manufacturing process. VorTek Instruments, LLC., is not liable for any damage or personal injury, whatsoever, resulting from the use of VorTek Instruments standard mass flow meters for oxygen gas.

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1.0 General

1.1 Introduction

VorTek Instruments' VorCone flowmeters utilize two different flow meter technologies in combination; vortex and differential pressure. The design has blended the two separate flow metering principles into one hybrid system where the two meters complement each other's performance. This combination allows for the prediction of the fluid density, volumetric flow rate and mass flow rate without any fluid density information being required from an external source.

This ability to measure fluid density allows the meter to provide several valuable outputs. The VorCone meter can calculate the density of changing gas mixtures. For example, natural gas is typically a composition of many different gases which can vary over time and vary by application. In saturated steam service, the meter produces a reliable steam quality (dryness) measurement, and steam mass flow rate reading. In wet natural gas service, the meter is able to provide a reliable liquid loading measurement, and gas mass flow rate reading. These are a few examples of the unique capabilities of the VorCone meter. The VorCone product line is available with a wide range of options and meter configurations to meet your specific application requirements.

1.2 Principles of Operation

With a single-phase flow, a vortex meter measures the actual volumetric flow rate (Q). The vortex meter reads the vortex shedding frequency off the bluff body (f) and relates it via the meter factor (K) to the volume flowrate (Q), see equation 1. This volumetric flow rate measurement is **density (ρ) insensitive.**

$$Q = \frac{f}{K} \quad \text{--- (1)}$$

With a single-phase flow, a differential pressure (DP) flow meter measures the volumetric flowrate once the density is supplied from an external source. The DP meter volume flowrate calculation is **density (ρ) sensitive**. Equation 2 shows the cone DP meter volumetric flow equation, where E and A_t are fixed geometry terms, C_d is the discharge coefficient, and ΔP_t is the cone meter DP primary signal.

$$Q = EA_tC_d\sqrt{\frac{2\Delta P_t}{\rho}} \quad \text{--- (2)}$$

As described by Boden's work in the 1950's, if a density sensitive meter (cone DP meter) is cross referenced with a density insensitive meter (vortex meter) the density can be derived internally by the system, i.e. see equation 3.

$$\rho = 2\Delta P_t \left\{ \frac{K}{f} E A_t C_d \right\}^2 \quad \text{--- (3)}$$

The VorCone mass flowrate calculation is now calculated via equation 4, where the vortex meter volumetric flow prediction (Q) and this internal density prediction (ρ) are used. No external density measurement is required.

$$m = \rho Q \quad \text{--- (4)}$$

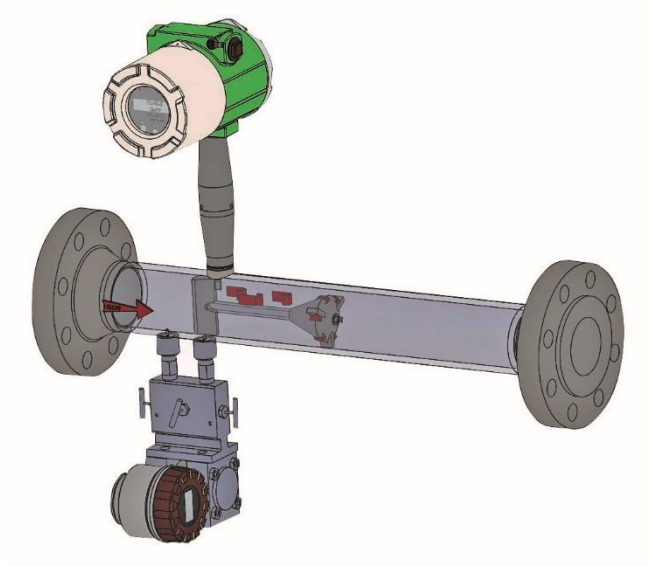


Figure 1. Schematic Diagram of a VorCone Flow Meter
For illustrative purposes only.
Not representative of a correct installation orientation.

2.0 Installation

2.1 Safety

Flow meter, impulse lines and DP transmitter shall only be installed with experienced qualified technicians.

- The impulse lines in the pressure taps should never be dissimilar metals as this can cause corrosion and may cause failure of the system.
- At installation make sure that the pressure taps and impulse lines are unobstructed and dry.
- On delivery the pressure taps may have thread protection caps. These must be removed before installation.
- Use good practices for handling and lifting VorCone flow meters.
- Follow company safety procedures when pressurizing the piping system.
- For flammable applications the VorCone meter needs to properly grounded.

2.2 Unpacking

On delivery, inspect the VorCone flow meter and accessories for any damage that may have occurred during shipment. Questions regarding the VorCone flow meter or paperwork should be addressed to your VorTek Instruments representative.

The VorCone meter is a relatively rugged and sturdy flow meter. However, like all flow meters it is an instrument, and hence as with all flow meter designs it is good practice to take due care when transporting and handling the VorCone meter.

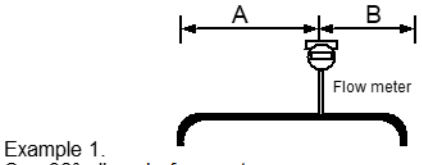
2.3 Flow Direction

When installing the meter make sure the flange marked with a flow arrow is positioned upstream of the outlet flange, with the arrow head pointing in the direction of flow. (The mark is on the flange adjacent to the enclosure mounting neck.) This ensures that the sensor head is positioned downstream of the vortex shedder bar and is correctly aligned to the flow. Installing the meter opposite this direction will result in completely inaccurate flow measurement.

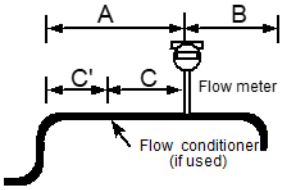
2.4 Unobstructed Flow Requirements

Select an installation site that will minimize possible distortion in the flow profile. Valves, elbows, control valves and other piping components may cause flow disturbances. Check your specific piping condition against the examples shown below. In order to achieve accurate and repeatable performance install the flow meter using the recommended number of straight run pipe diameters upstream and downstream of the sensor.

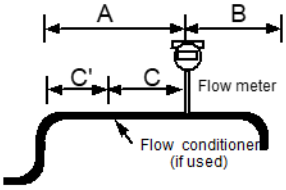
Note: For liquid applications in vertical pipes, avoid installing with flow in the downward direction because the pipe may not be full at all points. Choose to install the meter with flow in the upward direction if possible.



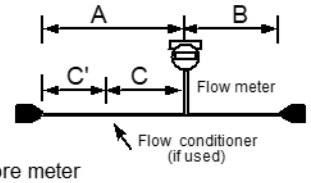
Example 1.
One 90° elbow before meter



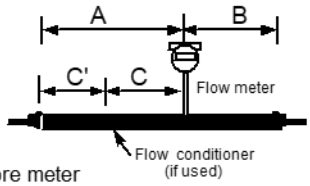
Example 2.
Two 90° elbows before meter in one plane



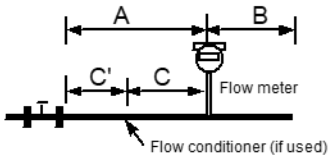
Example 3.
Two 90° elbows before meter out of plane (if three 90° bends present, double recommended length)



Example 4.
Reduction before meter



Example 5.
Expansion before meter



Example 6.
Regulator or valve partially closed before meter (If valve is always wide open, base length requirements on fitting directly preceding it)

Minimum Required Upstream Diameters					Minimum Required Downstream Diameters	
	No Flow Conditioner	With Flow Conditioner			No Flow Conditioner	With Flow Conditioner
Example	A	A	C	C´	B	B
1	10 D	N/A	N/A	N/A	5 D	5 D
2	15 D	10 D	5 D	5 D	5 D	5 D
3	30 D	10 D	5 D	5 D	10 D	5 D
4	10 D	10 D	5 D	5 D	5 D	5 D
5	20 D	10 D	5 D	5 D	5 D	5 D
6	30 D	10 D	5 D	5 D	10 D	5 D
D = Internal diameter of channel. N/A = Not applicable						

Figure 2. Recommended Pipe Length Requirements for Installation, VorCone

2.5 Valve Manifolds

Three (3) or five (5) valve manifolds are recommended for use with the VorCone flow meters. Benefits of the manifold include:

a) Isolation of the DP transmitter from the impulse lines.
b) Ease of zeroing of the DP Transmitter.
c) To allow the in-situ calibration of the DP transmitter.

2.6 Differential Pressure Measurement

The VorCone requires a differential pressure measurement. This measurement is normally provided via a differential pressure transmitter. The differential pressure transmitter provides a 4-20mA signal to the flow computer for computation. VorTek Instruments has no preference as to which differential pressure transmitter manufacturer is used with the VorCone meter. However, please ensure all hazardous area approvals are in accordance with use.

It is important that the DP transmitters used are appropriate for the range of DP's expected for the meter's application. If the lower end of the flow range produces DP's that are below the acceptable DP reading uncertainties then that DP should be read with stacked DP transmitters, i.e. the lower DP should be read by a second DP transmitter spanned to read a lower range of DP values.

2.7 General Impulse Line Installation Recommendations

NOTE: VorCone meter impulse piping should be kept as short as possible for accurate measurement.

Good practice should be followed regarding orientation of the impulse lines to allow draining of liquids and venting of gasses.

For vertical installation any pressure head due to the difference in the elevation of the pressure taps must be zeroed before service. For vertical installation radial position of the pressure taps is irrelevant.

U-Bends in impulse lines should be avoided. In gas applications they may trap liquids. In liquid applications they may trap gas. U bends impede gas venting or liquid draining of impulse lines.

2.8 Impulse Lines: Liquid Applications

Liquid applications in a horizontal installation should position the impulse lines 90° from top dead center in order to avoid gas entrapment and particulate collection in the impulse lines.

For liquid applications the impulse lines slope downward in elevation to facilitate the venting of gas.

Figure 3 below shows a typical example of impulse lines for a liquid application. The differential pressure transmitter is located below the differential pressure output port of the process pipe.

After installation ensure that the entire system is free from pressure leaks.

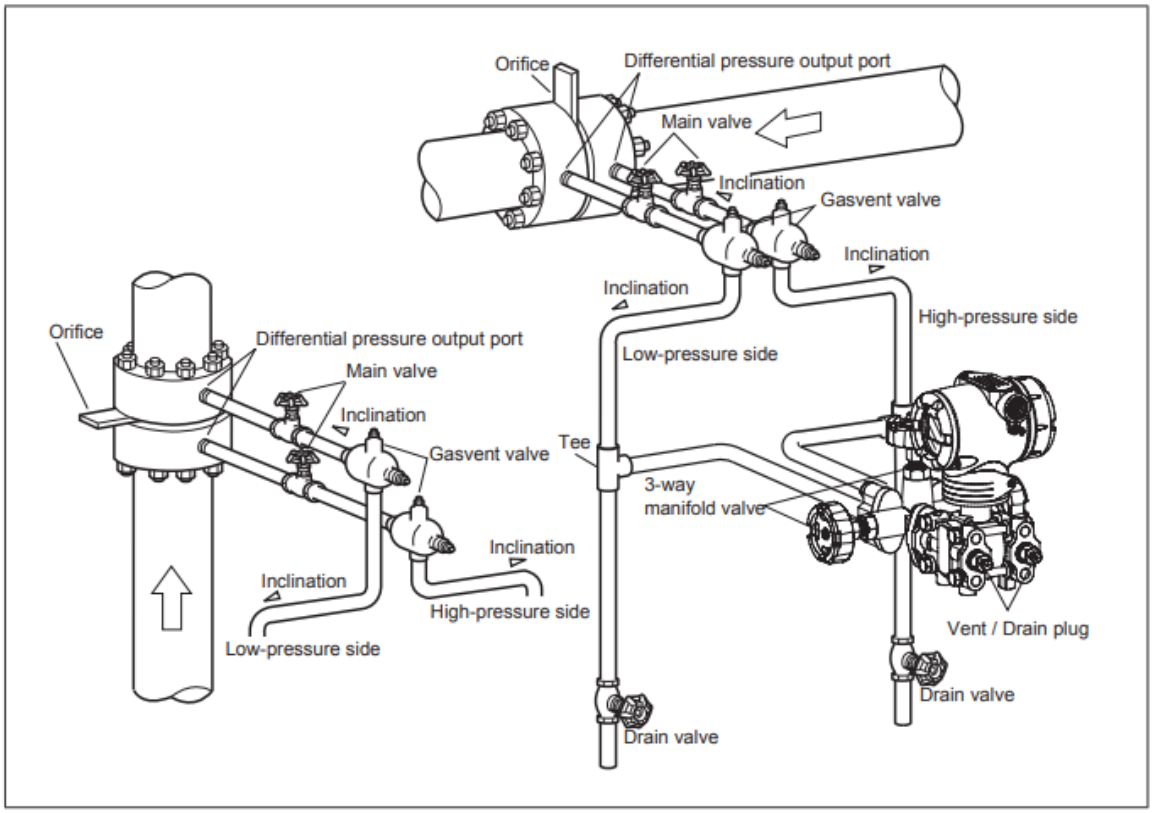


Figure 3. Example impulse line piping for liquid applications

2.9 Impulse Lines: Dry Gas Applications

Dry gas applications should position the DP transmitter above the pipe to ensure that condensate does not collect on the transmitter diaphragm.

Dry gas applications in horizontal installations should position the impulse lines within 60° from top dead center in either direction.

For dry gas applications the impulse lines slope upward in elevation to allow condensation to drain away from the DP transmitter.

Figure 4 below shows a typical example of impulse lines for a dry gas application. The differential pressure transmitter is located above the differential pressure output port of the process pipe. The condensate drains away from the transmitter.

After installation ensure that the entire system is free from pressure leaks.

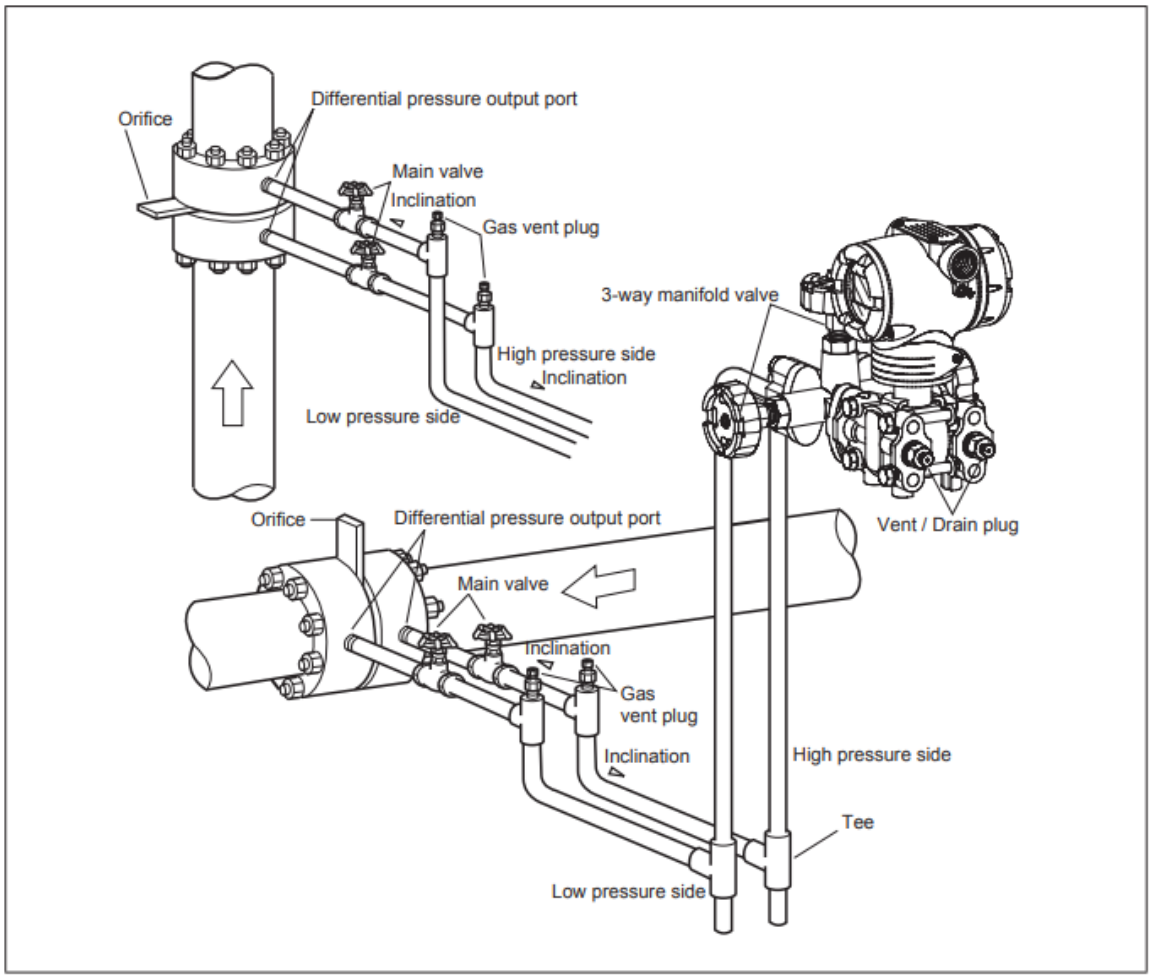


Figure 4. Example impulse line piping for dry gas applications

2.10 Impulse Lines: Wet Gas Applications

Wet gas applications should position the DP transmitter above the pipe to ensure that condensate does not collect on the transmitter diaphragm.

Wet gas applications in horizontal installations should position the impulse lines within 60° from top dead center in either direction.

For wet gas applications the impulse lines slope upward in elevation to allow condensation to drain away from the DP transmitter.

Figure 5 below shows a typical example of impulse lines for a wet gas application. The differential pressure transmitter is located above the differential pressure output port of the process pipe. The condensate drains away from the transmitter.

After installation ensure that the entire system is free from pressure leaks.

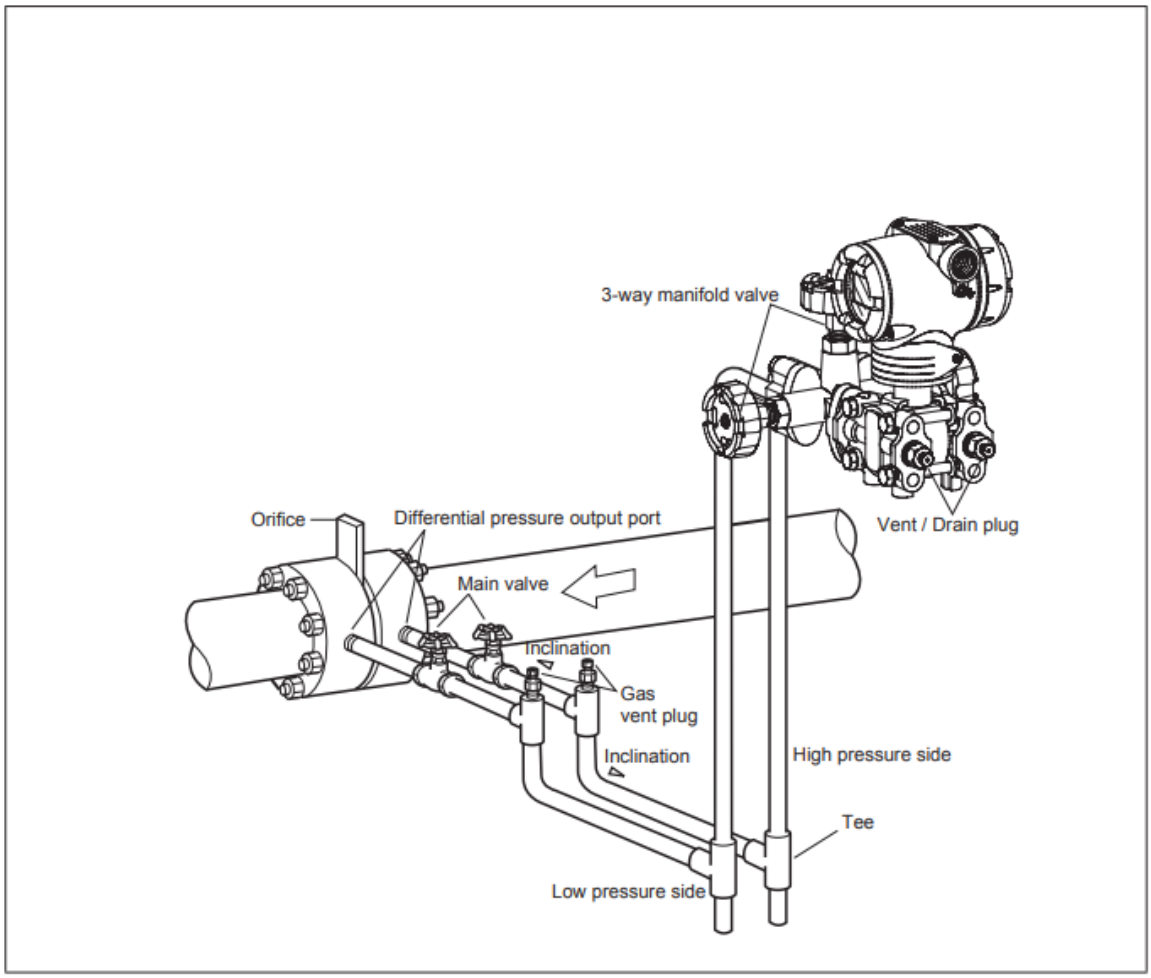


Figure 5. Example impulse line piping for wet gas applications

2.11 Impulse Lines: Saturated Steam (Wet Steam) Applications

Process steam flow is typically at temperatures in excess of that which can be tolerated by DP transmitters. The DP transmitter is therefore isolated from the process temperature. This isolation is achieved by either condensation pots or sufficiently long impulse lines.

It is the operator's responsibility to assure that the DP transmitter is not exposed to excessive temperatures.

If the operator opts for isolating the DP transmitter from the process temperature by use of extended impulse lines care must be taken to assure that uneven evaporation or condensation in the impulse lines does not produce an artificial pressure head which would falsely appear to the DP transmitter as a differential pressure produced by the process flow.

For saturated steam applications the impulse lines slope downward in elevation.

Figure 6 below shows a typical example of impulse lines for saturated steam applications. It is recommended that the differential pressure transmitter is located below the differential pressure output port of the process pipe.

After installation ensure that the entire system is free from pressure leaks.

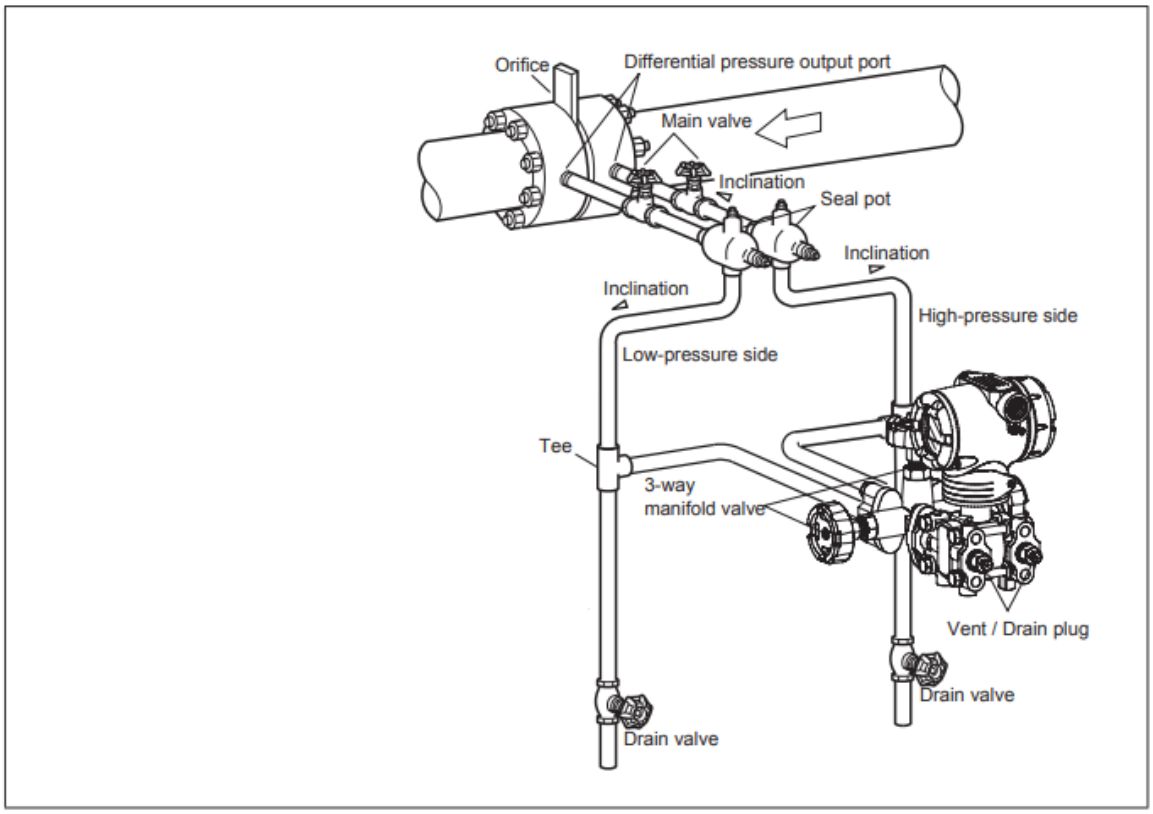


Figure 6. Example impulse line piping for saturated steam (wet steam) applications

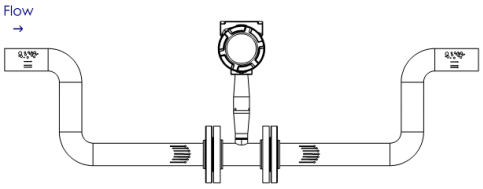
2.12 Saturated Steam (Wet Steam) / Wet Gas Installation Requirements

The VorCone meter must be installed in horizontal piping for saturated steam (wet steam) and wet gas applications. Vertical piping installations are not acceptable for these applications.

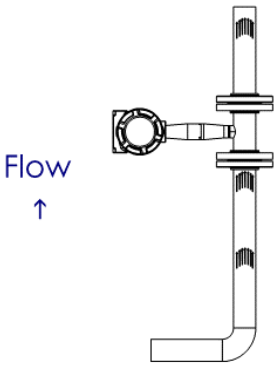
2.13 Recommended Meter Locations

Application List
Liquids
Dry Gas
Saturated Steam (Wet Steam)
Wet Gas

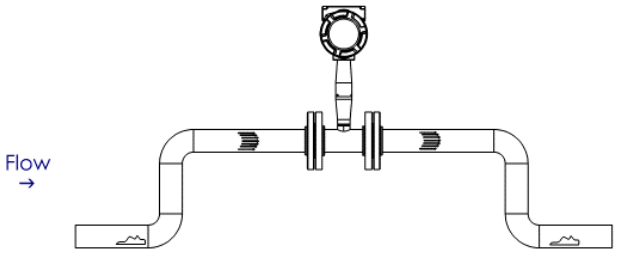
Horizontal - Liquids



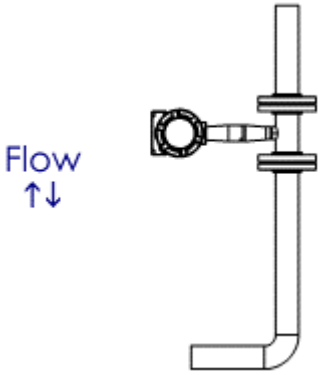
Vertical – Liquids or Dry Gas



Horizontal – Dry Gas, Saturated Steam (Wet Steam), Wet Gas



Vertical – Dry Gas



2.14 Wiring

Please see Chapter 2 of Pro-V™ Vortex Instruction Manual for the full list of flow computer wiring options.

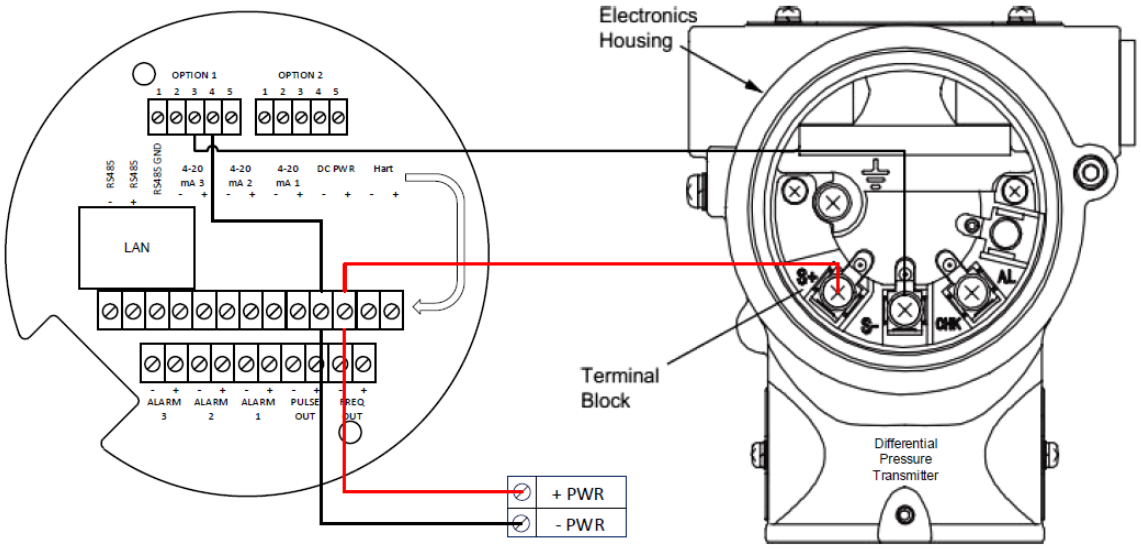


Figure 7. Wiring Diagram - Differential pressure transmitter to flow computer

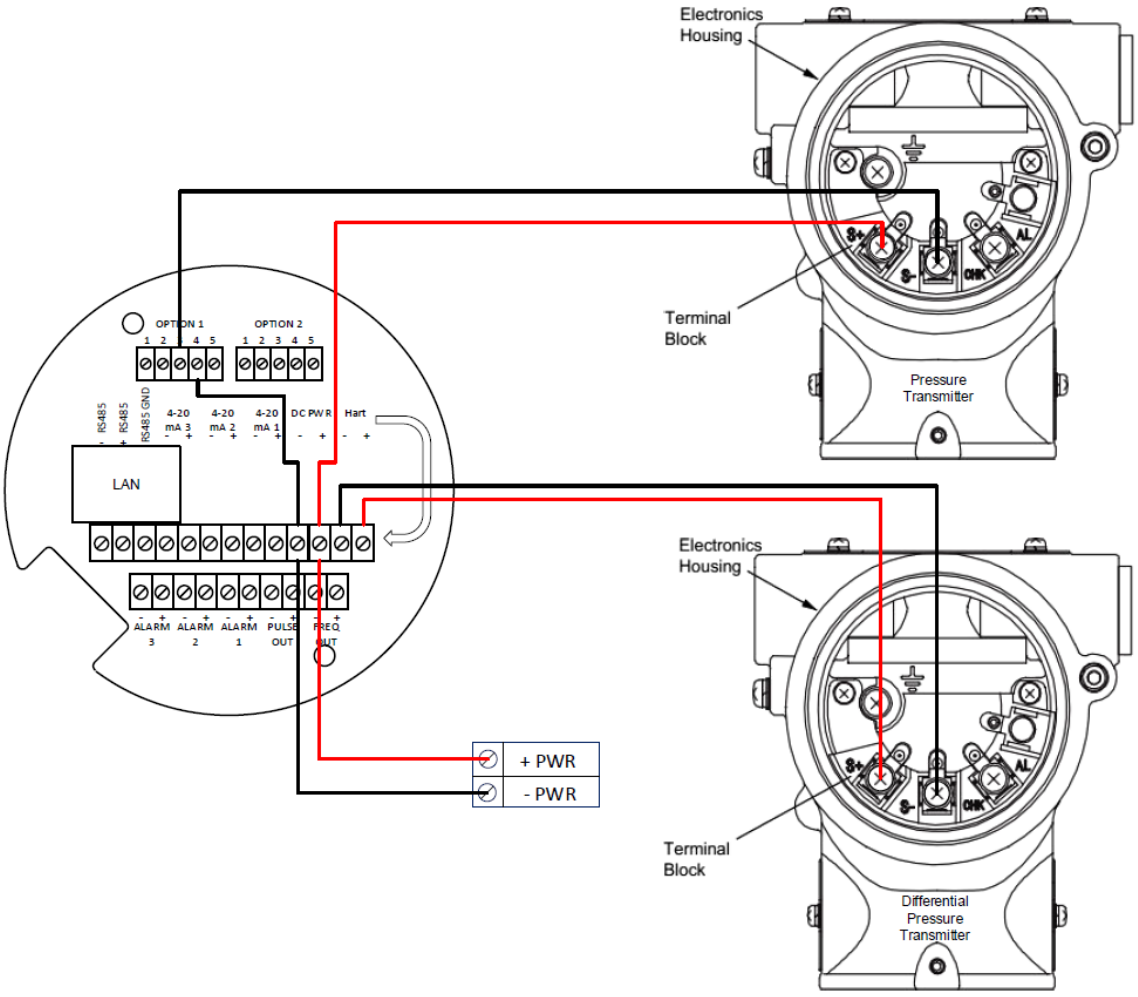


Figure 8. Wiring Diagram - Differential pressure transmitter & pressure transmitter to flow computer

3.0 Troubleshooting

This guide is intended to help troubleshoot a VorCone meter. Several points to note as you proceed are:

1. VorCone meters are calibrated at the factory prior to shipping. Therefore the VorCone meter has already been powered on and operated prior to shipping. Therefore, any significant issue should have been found before the meter arrives on site.
2. A VorCone meter is part of a metering system that includes secondary equipment (DP transmitter). Flow measurement problems can arise due to not

only issues with the VorCone meter but issues related to the secondary equipment.

3. This guide assumes a simple system of VorCone meter, manifold, DP transmitter. Systems can be much more complex. The following is offered as an aid to troubleshooting but it should not be considered as all encompassing. Each application can have unique troubleshooting requirements.

4. If you discover a problem / solution not listed in this guide, please contact VorTek Instruments: (303) 682-9999

3.1 Troubleshooting Matrix

This matrix separates the flow measurement system into areas.
During troubleshooting, make a preliminary assessment of the symptoms of the problem and consult the following matrix:

Symptom	Area	Possible Problem
No Signal (0 mA)	VorCone	No power to metering system. Analog output not powered.
Minimum Signal (4 mA)	VorCone	No flow
	Manifold	Manifold / impulse lines closed / blocked.
	Impulse Lines	Impulse line is blocked by closed valve or foreign matter.
DP Signal Seems Too High	VorCone	VorCone is installed backwards to the flow direction.
	VorCone	Foreign object lodged at cone element.
	Impulse Lines	Low pressure impulse line leaking, or inlet pressure impulse line blocked at too high a pressure, or low pressure impulse line blocked at too low a pressure.
	DP Transmitter	Leak on DP transmitter low pressure vent valve.
	DP Transmitter	Transmitter has suffered 'zero drift', such that a positive DP is read at no flow.
DP Signal Seems Too Low	Manifold	Manifold equalization valve is leaking.
	Impulse Lines	High pressure impulse line leaking, or inlet pressure impulse line blocked at too low a pressure, or low pressure impulse line blocked at too high a pressure.
	DP Transmitter	Leak on DP transmitter high pressure vent valve.
	DP Transmitter	Transmitter has suffered 'zero drift', such that a negative DP is read at no flow.
Unsteady Signals	VorCone	Flow is unsteady, e.g. pulsation flow due to compressors / pumps.
	Transmitter	Low power or faulty wire connection to DP transmitter creating intermittent DP signal.

Recommended VorCone Meter On-Site Troubleshooting Equipment:
1. 4 to 20 mA loop simulator
2. Pressure calibrator
3. Digital multi meter
4. Handheld Communicator for smart instruments
5. Hand tools: Screwdriver (+), Screwdriver (-), 12” & 4” crescent wrenches