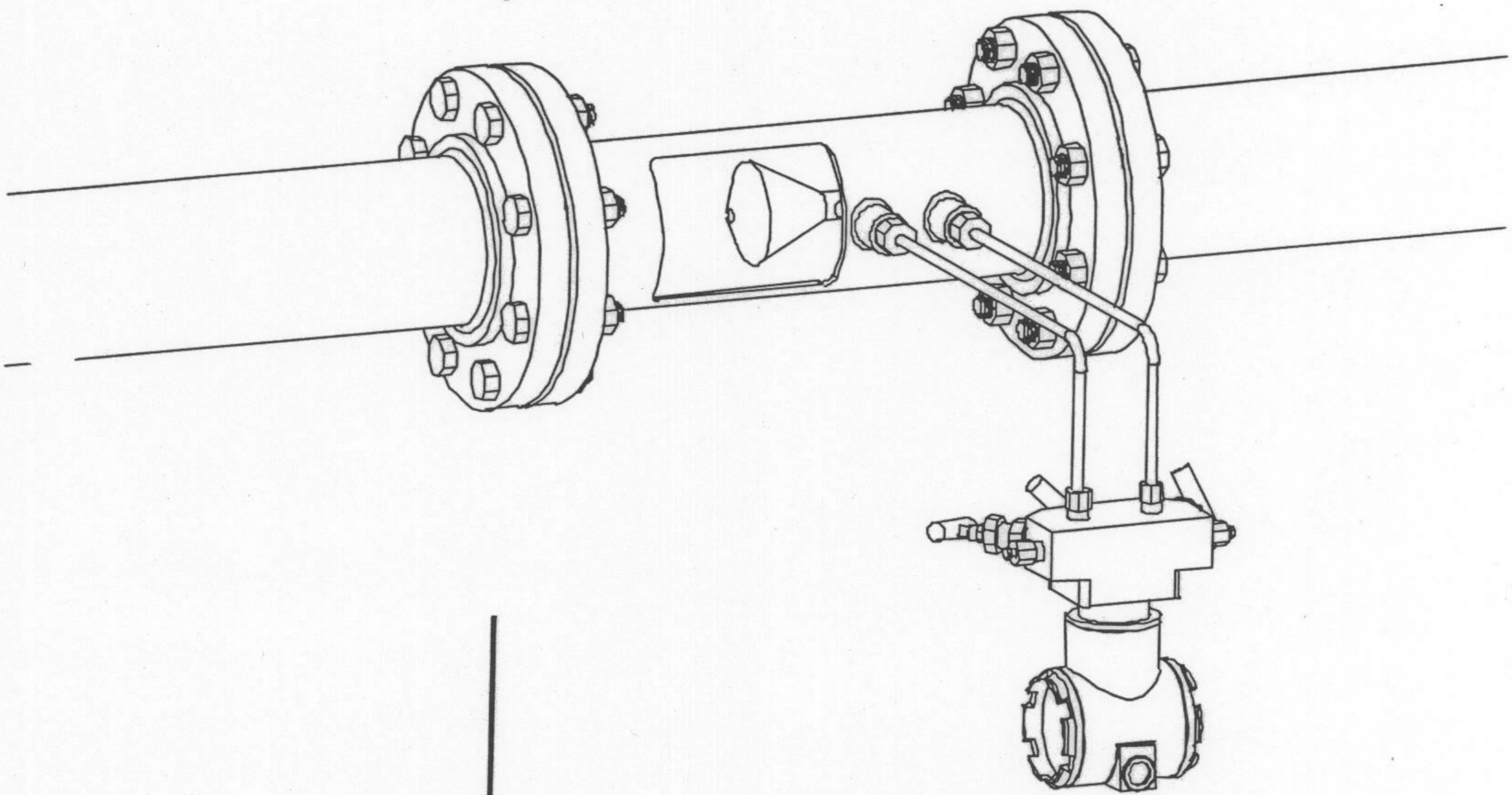
McCROMETER

Advanced
Differential
Pressure
Flowmeter
Technology

√CONE®



INSTALLATION OPERATION & MAINTENANCE MANUAL

Table of Contents

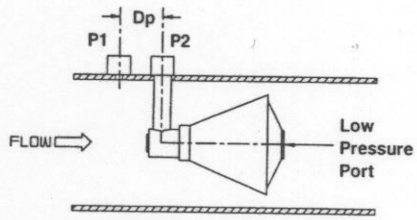
V-CONE ®

1.0 General

1.1 Introduction

The McCrometer V-Cone Flowmeter is a patented technology that accurately measures flow over a wide range of Reynolds numbers, under all kinds of conditions and for a variety of fluids. It operates on the same physical principle as other differential pressure-type flowmeters, using the theorem of conservation of energy in fluid flow through a pipe. The V-Cone's remarkable performance characteristics, however, are the result of its unique design. It features a centrally-located cone inside the tube. The cone interacts with the fluid flow, reshaping the fluid's velocity profile and creating a region of lower pressure immediately downstream of itself. The pressure difference, exhibited between the static line pressure and the low pressure created downstream of the cone, can be measured via two pressure sensing taps. One tap is placed slightly upstream of the cone, the other is located in the downstream face of the cone itself. The pressure difference can then be incorporated into a derivation of the Bernoulli equation to determine the fluid flow rate. The cone's central position in the line optimizes the velocity profile of the flow at the point of measurement, assuring highly accurate, reliable flow measurement regardless of the condition of the flow upstream of the meter.

1.2 Principles of Operation



High and Low Ports
Figure 1

The V-Cone is a differential pressure type flowmeter. Basic theories behind differential pressure type flowmeters have existed for over a century. The principal theory among these is Bernoulli's theorem for the conservation of energy in a closed pipe. This states that for a constant flow, the pressure in a pipe is inversely proportional to the square of the velocity in the pipe. Simply, the pressure decreases as the velocity increases. For instance, as the fluid approaches the V-Cone meter, it will have a pressure of P_1. As the fluid velocity increases at the constricted area of the V-Cone, the pressure drops to P_2, as shown in Figure 1. Both P_1 and P_2 are measured at the V-Cone's taps using a variety of differential pressure transducers. The Dp created by a V-Cone will increase and decrease exponentially with the flow velocity. As the constriction takes up more of the pipe cross-sectional area, more differential pressure will be created at the same flowrates. The beta ratio equals the flow area at the largest cross section of the cone (converted to an equivalent diameter) divided by the meter's inside diameter (see 3.2.3).

McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH 909-652-6811 FAX 909-652-3078 email: info@mccrometer.com

Printed in U.S.A

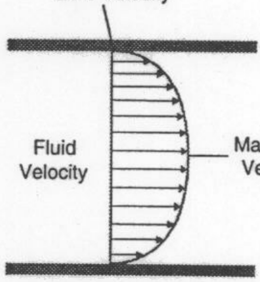
24509-15 Rev. 2.8/09-03

1.3 Reshaping the Velocity Profile

The V-Cone is similar to other differential pressure (Dp) meters in the equations of flow that it uses. V-Cone geometry, however, is quite different from traditional Dp meters. The V-Cone constricts the flow by positioning a cone in the center of the pipe.

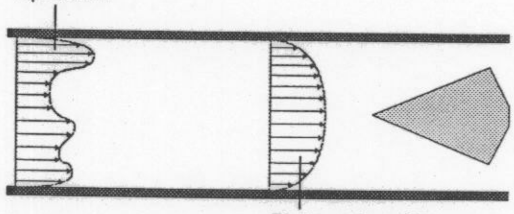
This forces the flow in the center of the pipe to flow around the cone. This geometry presents many advantages over the traditional concentric Dp meter. The actual shape of the cone has been continuously evaluated and tested for over ten years to provide the best performance under differing circumstances.

One must understand the idea of a flow profile in a pipe to understand the performance of the V-Cone. If the flow in a long pipe is not subject to any obstructions or disturbances, it is well-developed flow. If a line passes across the diameter of this well-developed flow, the velocity at each point on that line would be different. The velocity would be zero at the wall of the pipe, maximum at the center of the pipe, and zero again at the opposite wall. This is due to friction at the pipe walls that slows the fluid as it passes. Since the cone is suspended in the center of the pipe, it interacts directly with the "high velocity core" of the flow. The cone forces the high velocity core to mix with the lower velocity flows closer to the pipe walls. Other Dp meters have centrally located openings and do not interact with this high velocity core. This is an important advantage to the V-Cone at lower flowrates. As the flowrate decreases, the V-Cone continues to interact with the highest velocity in the pipe. Other Dp meters may lose their useful Dp signal at flows where the V-Cone can still produce one.



Velocity Profile
Figure 2

The pipe flow profile in actual installations is rarely ideal. There are many installations where a flowmeter exists in flow that is not well developed. Practically any changes to the piping, such as elbows, valves, reductions, expansions, pumps, and tees can disturb well-developed flow. Trying to measure disturbed flow can create substantial errors for other flowmeter technologies. The V-Cone overcomes this by reshaping the velocity profile upstream of the cone. This is a benefit derived from the cone's contoured shape and position in the line. As the flow approaches the cone, the flow profile "flattens" toward the shape of a well-developed profile.



Flattened Velocity Profile
Figure 3

The V-Cone can flatten the flow profile under extreme conditions, such as a single elbow or double elbows out-of-plane, positioned closely upstream of the meter. This means that as different flow profiles approach the cone, there will always be a predictable flow profile at the cone. This ensures accurate measurement even in non-ideal conditions.

McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH 909-652-6811 FAX 909-652-3078 email: info@mccrometer.com

 Printed in U.S.A 24509-15 Rev. 2.8/09-03

2.0 Features

2.1 High Accuracy

The V-Cone primary element can be accurate to ±0.5% of reading. The level of accuracy is dependent to a degree on application parameters and secondary instrumentation.

2.2 Repeatability

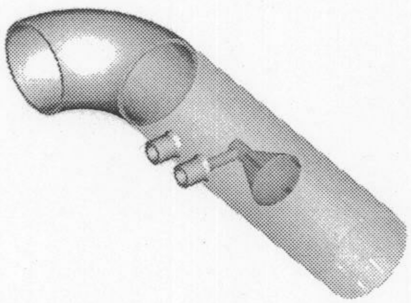
The V-Cone primary element exhibits excellent repeatability of ±0.1% or better.

2.3 Turndown

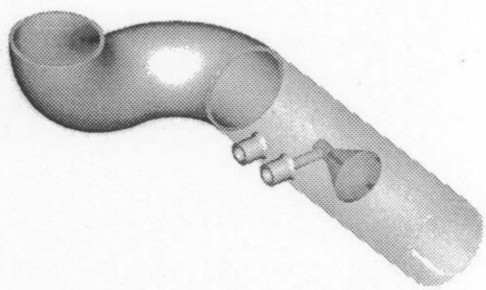
The turndown of the V-Cone can reach far beyond traditional Dp meters. A typical turndown for a V-Cone is 10 to 1. Greater turndowns are attainable. Flows with Reynolds numbers as low as 8000 will produce a linear signal. Lower Reynolds number ranges are measurable and are repeatable by applying a curve fit to the measured Dp, derived from calibration over a specific Reynolds number range.

2.4 Installation Requirements

Since the V-Cone can flatten the velocity profile, it can function much closer to upstream disturbances than other Dp meters. The recommended installation for the V-Cone is zero to three diameters of straight run upstream and zero to one diameters downstream. This can be a major benefit to users with larger, more expensive line sizes or users which have small run lengths. McCrometer conducted performance tests of the V-Cone downstream of a single 90° elbow and two close coupled 90° elbows out of plane. These tests show that the V-Cone can be installed adjacent to either single elbows or two elbows out of plane without sacrificing accuracy.



Single Elbow and V-Cone
Figure 4



Double Elbow and V-Cone
Figure 5

2.5 Long Term Performance

The contoured shape of the cone constricts the flow without impacting the flow against an abrupt surface. A boundary layer forms along the cone and directs the fluid away from the beta edge. This means the beta edge will not be as subject to the usual wear by unclean fluids, as is the case with an orifice plate. The beta ratio will then remain unchanged and the calibration of the meter will be accurate for a much longer time.

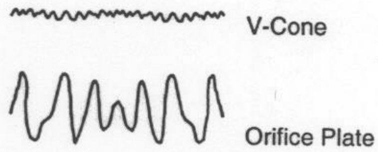
McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH 909-652-6811 FAX 909-652-3078 email: info@mccrometer.com

Printed in U.S.A

24509-15 Rev. 2.8/09-03

2.6 Signal Stability

Every Dp meter has a "signal bounce". This means that even in steady flow, the signal generated by the primary element will fluctuate a certain amount. On a typical orifice plate, the vortices that form just after the plate are long. These long vortices create a high amplitude, low frequency signal from the orifice plate. This could disturb the Dp readings from the meter. The V-Cone forms very short vortices as the flow passes the cone. These short vortices create a low amplitude, high frequency signal. This translates into a signal with high stability from the V-Cone. Representative signals from a V-Cone and from a typical orifice plate are shown in figure 6.



Signal Stability
Figure 6

2.7 Low Permanent Pressure Loss

Without the impact of an abrupt surface, the permanent pressure loss is lower than a typical orifice plate meter. Also, the signal stability of the V-Cone allows the recommended full scale Dp signal to be lower for the V-Cone than other Dp meters. This will lower the permanent pressure loss.

2.8 Sizing

The unique geometry of the V-Cone allows for a wide range of beta ratios. Standard beta ratios range from 0.45, 0.55, 0.65, 0.75, and 0.80.

2.9 No Areas of Stagnation

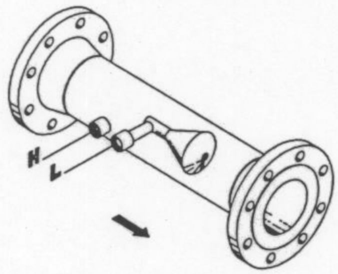
The "swept through" design of the cone does not allow for areas of stagnation where debris, condensation or particles from the fluid could accumulate.

2.10 Mixing

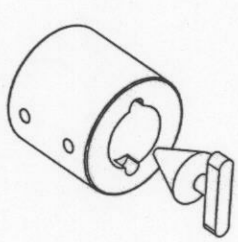
The short vortices described in section 2.6 mix the fluid thoroughly just downstream of the cone. The V-Cone is currently used in many applications as a static mixer where instant and complete mixing are necessary.

2.11 V-Cone Models

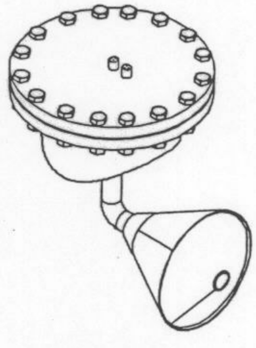
McCrometer offers three types of V-Cone primary elements: the precision tube V-Cone, the Wafer-Cone and the insertion top-plate V-Cone. Precision tube V-Cones range in line sizes from ½" to 72" and larger; Wafer-Cones range from 1/2" to 6"; and insertion top-plate V-Cones range in line size from 6" to 72" and larger.



Precision Tube V-Cone
Figure 7



Wafer-Cone®
Figure 8



Insertion Top-plate V-Cone
Figure 9

McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH 909-652-6811 FAX 909-652-3078 email: info@mccrometer.com

 Printed in U.S.A 24509-15 Rev. 2.8/09-03

3.0

The V-Cone Flow Meas. System

3.1 Application Data

The customer must provide application parameters so that the appropriate V-Cone flowmeter may be selected. McCrometer has an extensive meter performance database of fluid properties which can be utilized for sizing purposes.

3.2 General Calculations

Nomenclature:

ΔP	differential pressure (Dp)	inWC
D	inside diameter	inch
d	cone diameter	inch
β	beta ratio	.
k	isentropic exponent	.
k_1	flow constant	.
k_4	flow constant – without C_D	.
G_C	grav. constant (32.174)	
C_D	flowmeter coefficient	f/s^2
Y	gas expansion factor	.
ρ	flowing density (rho)	.
α	material thermal expansion α, or α_{cone}, α_{pipe} (alpha)	.

P	operating pressure	psia
T	operating temperature	Rankine
Z	gas compressibility	.
S_F	operating specific gravity	.
S_{STP}	specific grav. @ 60°F, 14.696 Psia	.
ρ_{water}	water density (62.3663)	lb/ft^3
P_b	base pressure	psia
T_b	base temperature	Rankine
Z_b	base gas compressibility	.
μ	viscosity	cP
Re	Reynolds Number	.
v	Velocity	fps

3.2.1	Differential Pressure	$\Delta P = P_H - P_L$	ΔP units are in WC
3.2.2	Flowmeter Coefficient	Derived from calibration or from historical data.	Located on sizing and calibration reports.
3.2.3	V-Cone beta ratio	$\beta = \frac{\sqrt{D^2 - d^2}}{D}$	β from sizing report
3.2.4	Flow Constant	$k_1 = \frac{\pi}{576}\sqrt{2G_c}\,\frac{D^2\beta^2}{\sqrt{1-\beta^4}}C_D$	k_1 from sizing report See note 2.
3.2.5	Material Thermal Expansion Factor	$F_a = 1 + 2\alpha(T - 528)$	See note 1.
3.2.6	Material Thermal Expansion Factor If cone and main line pipe are made of different materials.	See note 1. $F_a = \frac{D^2 - d^2}{((1-\alpha_{pipe}\cdot(T-528))\cdot D)^2 - ((1-\alpha_{cone}\cdot(T-528))\cdot d)^2}$	

McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH 909-652-6811 FAX 909-652-3078 email: info@mccrometer.com

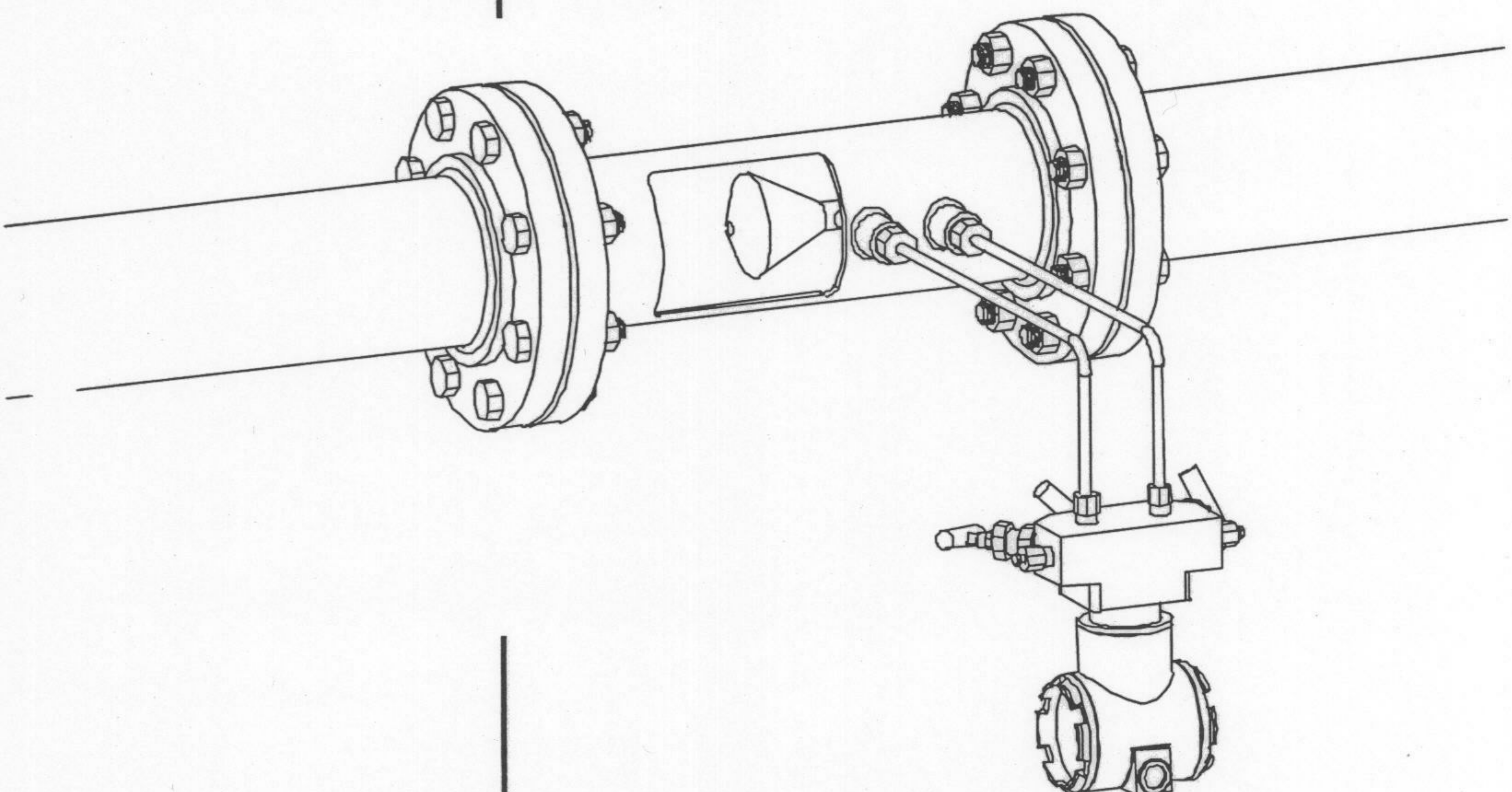
Printed in U.S.A

24509-15 Rev. 2.8/09-03

McCROMETER

Advanced Differential Pressure Flowmeter Technology

V-CONE®



INSTALLATION OPERATION & MAINTENANCE MANUAL

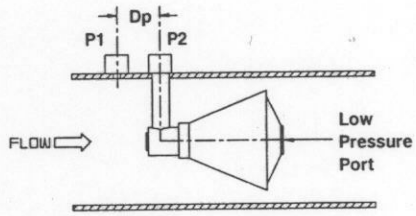
Table of Contents

1.0 General

1.1 Introduction

The McCrometer V-Cone Flowmeter is a patented technology that accurately measures flow over a wide range of Reynolds numbers, under all kinds of conditions and for a variety of fluids. It operates on the same physical principle as other differential pressure-type flowmeters, using the theorem of conservation of energy in fluid flow through a pipe. The V-Cone's remarkable performance characteristics, however, are the result of its unique design. It features a centrally-located cone inside the tube. The cone interacts with the fluid flow, reshaping the fluid's velocity profile and creating a region of lower pressure immediately downstream of itself. The pressure difference, exhibited between the static line pressure and the low pressure created downstream of the cone, can be measured via two pressure sensing taps. One tap is placed slightly upstream of the cone, the other is located in the downstream face of the cone itself. The pressure difference can then be incorporated into a derivation of the Bernoulli equation to determine the fluid flow rate. The cone's central position in the line optimizes the velocity profile of the flow at the point of measurement, assuring highly accurate, reliable flow measurement regardless of the condition of the flow upstream of the meter.

1.2 Principles of Operation



High and Low Ports
Figure 1

The V-Cone is a differential pressure type flowmeter. Basic theories behind differential pressure type flowmeters have existed for over a century. The principal theory among these is Bernoulli's theorem for the conservation of energy in a closed pipe. This states that for a constant flow, the pressure in a pipe is inversely proportional to the square of the velocity in the pipe. Simply, the pressure decreases as the velocity increases. For instance, as the fluid approaches the V-Cone meter, it will have a pressure of P_1. As the fluid velocity increases at the constricted area of the V-Cone, the pressure drops to P_2, as shown in Figure 1. Both P_1 and P_2 are measured at the V-Cone's taps using a variety of differential pressure transducers. The Dp created by a V-Cone will increase and decrease exponentially with the flow velocity. As the constriction takes up more of the pipe cross-sectional area, more differential pressure will be created at the same flowrates. The beta ratio equals the flow area at the largest cross section of the cone (converted to an equivalent diameter) divided by the meter's inside diameter (see 3.2.3).

McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH 909-652-6811 FAX 909-652-3078 email: info@mccrometer.com

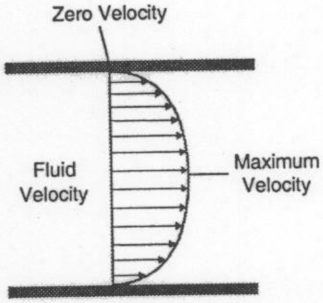
 Printed in U.S.A 24509-15 Rev. 2.8/09-03

1.3 Reshaping the Velocity Profile

The V-Cone is similar to other differential pressure (Dp) meters in the equations of flow that it uses. V-Cone geometry, however, is quite different from traditional Dp meters. The V-Cone constricts the flow by positioning a cone in the center of the pipe.

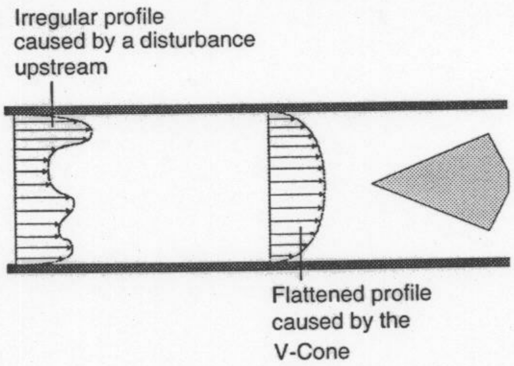
This forces the flow in the center of the pipe to flow around the cone. This geometry presents many advantages over the traditional concentric Dp meter. The actual shape of the cone has been continuously evaluated and tested for over ten years to provide the best performance under differing circumstances.

One must understand the idea of a flow profile in a pipe to understand the performance of the V-Cone. If the flow in a long pipe is not subject to any obstructions or disturbances, it is well-developed flow. If a line passes across the diameter of this well-developed flow, the velocity at each point on that line would be different. The velocity would be zero at the wall of the pipe, maximum at the center of the pipe, and zero again at the opposite wall. This is due to friction at the pipe walls that slows the fluid as it passes. Since the cone is suspended in the center of the pipe, it interacts directly with the "high velocity core" of the flow. The cone forces the high velocity core to mix with the lower velocity flows closer to the pipe walls. Other Dp meters have centrally located openings and do not interact with this high velocity core. This is an important advantage to the V-Cone at lower flowrates. As the flowrate decreases, the V-Cone continues to interact with the highest velocity in the pipe. Other Dp meters may lose their useful Dp signal at flows where the V-Cone can still produce one.



Velocity Profile
Figure 2

The pipe flow profile in actual installations is rarely ideal. There are many installations where a flowmeter exists in flow that is not well developed. Practically any changes to the piping, such as elbows, valves, reductions, expansions, pumps, and tees can disturb well-developed flow. Trying to measure disturbed flow can create substantial errors for other flowmeter technologies. The V-Cone overcomes this by reshaping the velocity profile upstream of the cone. This is a benefit derived from the cone's contoured shape and position in the line. As the flow approaches the cone, the flow profile "flattens" toward the shape of a well-developed profile.



Flattened Velocity Profile
Figure 3

The V-Cone can flatten the flow profile under extreme conditions, such as a single elbow or double elbows out-of-plane, positioned closely upstream of the meter. This means that as different flow profiles approach the cone, there will always be a predictable flow profile at the cone. This ensures accurate measurement even in non-ideal conditions.

McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH 909-652-6811 FAX 909-652-3078 email: info@mccrometer.com

 Printed in U.S.A 24509-15 Rev. 2.8/09-03

2.0 Features

2.1 High Accuracy

The V-Cone primary element can be accurate to ±0.5% of reading. The level of accuracy is dependent to a degree on application parameters and secondary instrumentation.

2.2 Repeatability

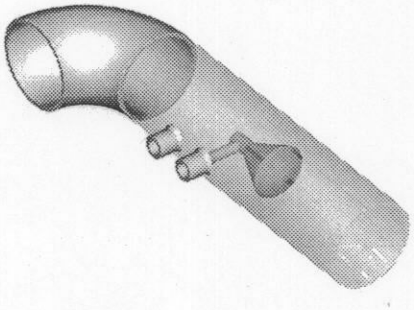
The V-Cone primary element exhibits excellent repeatability of ±0.1% or better.

2.3 Turndown

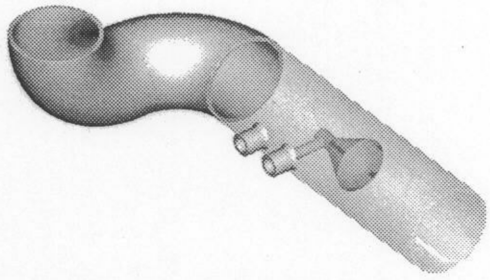
The turndown of the V-Cone can reach far beyond traditional Dp meters. A typical turndown for a V-Cone is 10 to 1. Greater turndowns are attainable. Flows with Reynolds numbers as low as 8000 will produce a linear signal. Lower Reynolds number ranges are measurable and are repeatable by applying a curve fit to the measured Dp, derived from calibration over a specific Reynolds number range.

2.4 Installation Requirements

Since the V-Cone can flatten the velocity profile, it can function much closer to upstream disturbances than other Dp meters. The recommended installation for the V-Cone is zero to three diameters of straight run upstream and zero to one diameters downstream. This can be a major benefit to users with larger, more expensive line sizes or users which have small run lengths. McCrometer conducted performance tests of the V-Cone downstream of a single 90° elbow and two close coupled 90° elbows out of plane. These tests show that the V-Cone can be installed adjacent to either single elbows or two elbows out of plane without sacrificing accuracy.



Single Elbow and V-Cone
Figure 4



Double Elbow and V-Cone
Figure 5

2.5 Long Term Performance

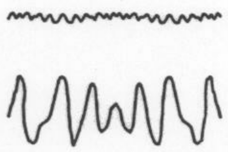
The contoured shape of the cone constricts the flow without impacting the flow against an abrupt surface. A boundary layer forms along the cone and directs the fluid away from the beta edge. This means the beta edge will not be as subject to the usual wear by unclean fluids, as is the case with an orifice plate. The beta ratio will then remain unchanged and the calibration of the meter will be accurate for a much longer time.

McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH 909-652-6811 FAX 909-652-3078 email: info@mccrometer.com

Printed in U.S.A

24509-15 Rev. 2.8/09-03

2.6 Signal Stability



Signal Stability
Figure 6

Every Dp meter has a "signal bounce". This means that even in steady flow, the signal generated by the primary element will fluctuate a certain amount. On a typical orifice plate, the vortices that form just after the plate are long. These long vortices create a high amplitude, low frequency signal from the orifice plate. This could disturb the Dp readings from the meter. The V-Cone forms very short vortices as the flow passes the cone. These short vortices create a low amplitude, high frequency signal. This translates into a signal with high stability from the V-Cone. Representative signals from a V-Cone and from a typical orifice plate are shown in figure 6.

2.7 Low Permanent Pressure Loss

Without the impact of an abrupt surface, the permanent pressure loss is lower than a typical orifice plate meter. Also, the signal stability of the V-Cone allows the recommended full scale Dp signal to be lower for the V-Cone than other Dp meters. This will lower the permanent pressure loss.

2.8 Sizing

The unique geometry of the V-Cone allows for a wide range of beta ratios. Standard beta ratios range from 0.45, 0.55, 0.65, 0.75, and 0.80.

2.9 No Areas of Stagnation

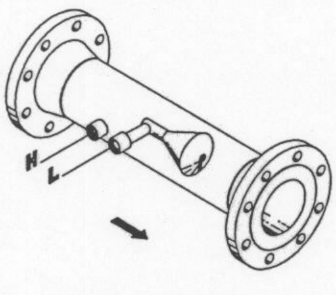
The "swept through" design of the cone does not allow for areas of stagnation where debris, condensation or particles from the fluid could accumulate.

2.10 Mixing

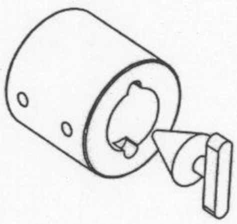
The short vortices described in section 2.6 mix the fluid thoroughly just downstream of the cone. The V-Cone is currently used in many applications as a static mixer where instant and complete mixing are necessary.

2.11 V-Cone Models

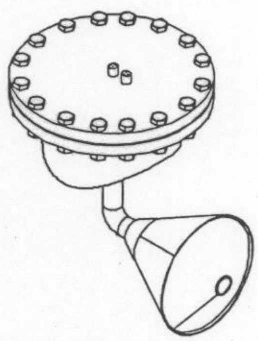
McCrometer offers three types of V-Cone primary elements: the precision tube V-Cone, the Wafer-Cone and the insertion top-plate V-Cone. Precision tube V-Cones range in line sizes from ½" to 72" and larger; Wafer-Cones range from 1/2" to 6"; and insertion top-plate V-Cones range in line size from 6" to 72" and larger.



Precision Tube V-Cone
Figure 7



Wafer-Cone®
Figure 8



Insertion Top-plate V-Cone
Figure 9

McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH 909-652-6811 FAX 909-652-3078 email: info@mccrometer.com

 Printed in U.S.A 24509-15 Rev. 2.8/09-03

3.0 The V-Cone Flow Meas. System

3.1 Application Data

The customer must provide application parameters so that the appropriate V-Cone flowmeter may be selected. McCrometer has an extensive meter performance database of fluid properties which can be utilized for sizing purposes.

3.2 General Calculations

Nomenclature:

ΔP	differential pressure (Dp)	inWC
D	inside diameter	inch
d	cone diameter	inch
β	beta ratio	.
k	isentropic exponent	.
k_1	flow constant	.
k_4	flow constant – without C_D	.
G_C	grav. constant (32.174)	
C_D	flowmeter coefficient	f/s^2
Y	gas expansion factor	.
ρ	flowing density (rho)	.
α	material thermal expansion α, or α_{cone}, α_{pipe} (alpha)	.

P	operating pressure	psia
T	operating temperature	Rankine
Z	gas compressibility	.
S_F	operating specific gravity	.
S_{STP}	specific grav. @ 60°F, 14.696 Psia	.
ρ_{water}	water density (62.3663)	lb/ft^3
P_b	base pressure	psia
T_b	base temperature	Rankine
Z_b	base gas compressibility	.
μ	viscosity	cP
Re	Reynolds Number	.
v	Velocity	fps

3.2.1	Differential Pressure	$\Delta P = P_H - P_L$	ΔP units are in WC
3.2.2	Flowmeter Coefficient	Derived from calibration or from historical data.	Located on sizing and calibration reports.
3.2.3	V-Cone beta ratio	$\beta = \frac{\sqrt{D^2 - d^2}}{D}$	β from sizing report
3.2.4	Flow Constant	$k_1 = \frac{\pi}{576}\sqrt{2G_c}\frac{D^2\beta^2}{\sqrt{1-\beta^4}}C_D$	k_1 from sizing report See note 2.
3.2.5	Material Thermal Expansion Factor	$F_a = 1 + 2\alpha(T - 528)$	See note 1.
3.2.6	Material Thermal Expansion Factor If cone and main line pipe are made of different materials.	See note 1. $F_a = \frac{D^2 - d^2}{((1-\alpha_{pipe}\cdot(T-528))\cdot D)^2 - ((1-\alpha_{cone}\cdot(T-528))\cdot d)^2}$	

McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH 909-652-6811 FAX 909-652-3078 email: info@mccrometer.com

24509-15 Rev. 2.8/09-03

3.2 General Calculations (continued)

3.2.7	Pipeline Velocity	$v = \dfrac{576\,\text{ACFS}}{\pi\, D^2}$	
3.2.8	Reynolds Number	$\text{Re} = 123.9 \dfrac{v\, D\, \rho}{\mu}$	Dimensionless number which can be used to correlate meter calibrations in different fluids.
3.2.9	Flow Constant Used when C_D is not constant.	$k_4 = \dfrac{\pi}{576} \sqrt{2 G_c}\, \dfrac{D^2 \beta^2}{\sqrt{1-\beta^4}}$	This equation can be used in substitute of 3.2.4 when the C_D flow coefficient is not constant. See note 2.

3.3 Calculations for Liquids

3.3.1	Density	$\rho = \rho_{\text{water}}\, S_F$	
3.3.2	Flowrate Conversion	$\text{GPM} = 448.83\,\text{ACFS}$	
3.3.3	Flowrate	$\text{ACFS} = F_a\, k_1 \sqrt{\dfrac{5.197\, \Delta P}{\rho}}$	
3.3.4	Flowrate When C_D is not constant.	$\text{ACFS} = F_a\, k_4 \sqrt{\dfrac{5.197\, \Delta P}{\rho}}\, C_D$	

Notes:

1. Material Thermal Expansion - The thermal expansion equations correct for dimensional changes which occur as the operating temperature deviates from the base temperature of 70° F (see 3.2.5 and 3.2.6 on page 5).

   The F_a factor can be excluded from the flow equation if the operating temperature is:

   < 100° Fahrenheit , < 560° Rankine, < 38° Celsius

   If the F_a factor is significant and the operating temperature is stable then a constant F_a value may be used. If the F_a factor is significant and the temperature varies then an F_a factor should be calculated prior to every flow calculation.

2. Discharge Coefficient - Discharge coefficients can be implemented in the flow equations via several different methods. Following are typical methods: *average C_D* or *C_D look up table.*
If a C_D look up table or fitted data is utilized additional calculations must be made based on the Reynolds number (see example processes 3d and 4b).

3. Liquids - Typical Calculation Processes:
   - 3a. given: D, β, ρ, C_D, and input of ΔP — Calculate: 3.2.4, 3.3.3
   - 3b. given: D, β, ρ, C_D, and input of ΔP, T — Calculate: 3.2.4, 3.2.5 or 3.2.6 if req., 3.3.3
   - 3c. given: D, β, S_F, C_D, and input of ΔP, T — Calculate: 3.2.4, 3.2.5 or 3.2.6 if req., 3.3.1, 3.3.3
   - 3d. given: D, β, μ, ρ, C_D look up, and input of ΔP

     Calculate: initially set C_D = 0.8, 3.2.9, 3.2.5 or 3.2.6 if required,

     → 3.2.7, 3.2.8, look up C_D , 3.3.4 — Iterate until flowrate is < 0.01% different from last calculation.

McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH 909-652-6811 FAX 909-652-3078 email: info@mccrometer.com

 Printed in U.S.A 24509-15 Rev. 2.8/09-03

3.4 Calculations for Compressible Fluids (gases and vapors)

3.4.1 V-Cone Gas Expansion Factor rev. May. 2001	$Y = 1 - (0.649 + 0.696\beta^4)\dfrac{0.03613\,\Delta P}{k \cdot P}$	k - Isentropic Exponent note: 0.03613 converts ΔP (inWC at 4°C) to same units as P (Psia)
3.4.2 Wafer-Cone Gas Expansion Factor rev. Oct. 2001	$Y = 1 - (0.755 + 6.787\beta^8)\dfrac{0.03613\,\Delta P}{k \cdot P}$	
3.4.3 Gas Density	$\rho\ (\text{lb/ft}^3) = 2.6988\dfrac{S_{STP}\,P}{Z\,T}$	
3.4.4 Flowrate Actual Cubic Feet Per Second	$ACFS = F_a\, k_1\, Y\sqrt{\dfrac{5.197\,\Delta P}{\rho}}$	
3.4.5 Flowrate Actual Cubic Feet Per Second When C_D is not constant.	$ACFS = F_a\, k_4\, Y\sqrt{\dfrac{5.197\,\Delta P}{\rho}}\,C_D$	
3.4.6 Flowrate Standard Cubic Feet Per Second	$SCFS = ACFS\left(\dfrac{P\,T_b\,Z_b}{P_b\,T\,Z}\right)$	converts actual flow to standard flow at base conditions

Notes (continued from page 6):

4. Gases and Steam - Typical Calculation Processes:

4a. given: D, β, μ, S_F, Z, k, C_D, and inputs of ΔP, P, T

Calculate: 3.2.4, 3.2.5 or 3.2.6 if needed, 3.4.1 or 3.4.2, 3.4.3, 3.4.4

4b. given: D, β, μ, S_F, Z, k, C_D look up, and inputs of ΔP, P, T

Calculate: initially set $C_D = 0.8$, 3.2.4, 3.2.5 or 3.2.6 if needed, 3.4.1 or 3.4.2, 3.4.3, 3.4.4,

→ 3.2.7, 3.2.8, look up C_D, 3.4.4 — Iterate until flowrate is < 0.01% different from last calculation.

5. Fluid properties - Fluid properties such as viscosity, compressibility and isentropic exponent vary with temperature and to some extent pressure. The viscosity in the calculations above could effect the selected C_D value, the compressibility directly affects the density and the isentropic exponent affects the Y factor, although to a small degree. The instrumentation industry uses many different approaches to calculate flow. Which fluid properties are calculated at each set of flow conditions and which properties are constant must be determined by the customer and McCrometer application engineering.

3.5 Application Sizing

Each V-Cone is tailored to its specific application. Before manufacturing, every V-Cone will have a "sizing" completed according to the physical parameters of the application. The computer generated sizing uses application data as a basis to predict the V-Cone's performance. Full scale DP, working flow range, expected accuracy, and predicted pressure loss are determined by the sizing process.

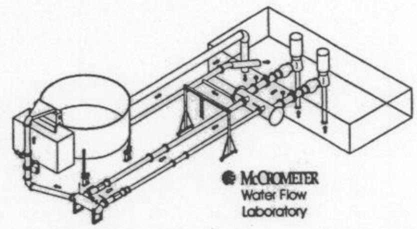
McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH 909-652-6811 FAX 909-652-3078 email: info@mccrometer.com

3.6 Calibration

Wafer-Cone and precision tube flowmeters less than 20" diameter are calibrated in one or more of the following McCrometer calibration facilities:

Calibration Facility	*Size Range*	*Calibration Facility*	*Size Range*
Water 40k lb Gravimetric	3" to 18"	Water 1.5k lb Gravimetric	up to 4"
Water 5k lb Gravimetric	up to 6"	Air 80 cfm	up to 2"

McCrometer recommends that every V-Cone meter be calibrated. A calibration is required when the application requires the best accuracy. Insertion top-plate style flowmeters can be calibrated as an option. If an actual calibration is not requested, the coefficient for the meter can be estimated. Data collected over years of independent testing allows for an estimate of the meter's C_D. For V-Cones intended for use in a compressible fluid with high accuracy requirements, McCrometer recommends calibration in a compressible fluid.



Calibration Facility 40k Gravimetric
Figure 10

3.7 Materials of Construction

All materials used for V-Cone flowmeters are certified. Materials furnished to McCrometer include a certified material test report (CMTR) from the original material manufacturer. The test reports include material composition and applicable material grades. Upon request copies of the material test reports can be supplied to our customers. See section 6.5 for typical materials of construction.

3.8 Valve Manifolds

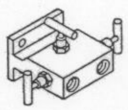
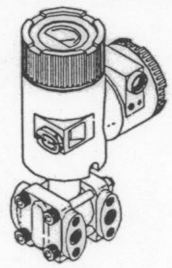


Figure 11

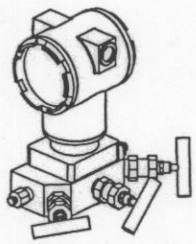
McCrometer recommends a three valve or five valve manifold as part of a V-Cone flow measurement system. Manifolds allow for in-line transmitter calibrations, isolation of the transmitter from the transmission lines, without depressurizing the line, and in-line purging of transmission lines.

3.9 Secondary and Tertiary Instrumentation

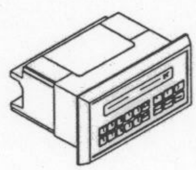
A differential pressure transmitter measures the differential pressure signal from the primary element. Once the signal is measured, the transmitter generates an electronic signal that is then interpreted by a flow monitor or other process control system. For compressible fluids, line pressure and temperature measurements are generally required for accurate flow measurement. McCrometer offers the following flow measurement instrumentation: differential pressure transmitters, flow computers, and pressure and temperature sensors for mass flow measurement.



Typical Dp Trans.
Figure 12



Typ. Dp Transmitter with valve manifold
Figure 13



Flow Computer
Figure 14

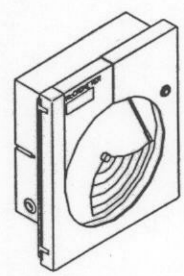


Chart Recorder
Figure 15

McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH 909-652-6811 FAX 909-652-3078 email: info@mccrometer.com

 Printed in U.S.A 24509-15 Rev. 2.8/09-03

4.0 Installation

4.1 Safety

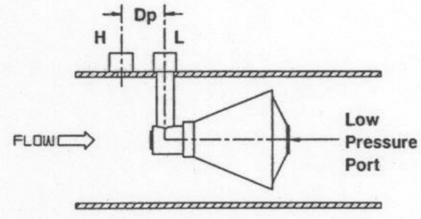
- Any person installing, inspecting, or maintaining a McCrometer flowmeter should have an understanding of piping configurations and systems under pressure.
- Before adjusting or removing any meter, be certain the system has been depressurized completely. Never attempt to remove a meter under pressure!
- Be careful when lifting meters. Meters can cause serious injury if lifted incorrectly or dropped.
- Use only necessary and appropriate tools when working on a meter.
- Properly secure all connections before starting a system. Keep a safe and prudent distance away from the meter during system start-up.

4.2 Unpacking

McCrometer tests and inspects all products during manufacture and before shipment. However, inspect the meter and accessories at the time of unpacking to detect any damage that might have occurred during shipment. If there is a question regarding the paperwork or the flowmeter, please contact your McCrometer representative.

4.3 Orientation

A flow label is placed on each V-Cone to show the direction of flow through the meter. For most line sizes, the centerline of the pressure sensing taps are located 2.12" apart. The high pressure tap is upstream. The low pressure tap is downstream. Please refer to figure 16. This information is necessary when connecting the differential pressure measuring device.



High and Low Ports
Figure 16

4.4 Piping Requirements

The recommended straight, unobstructed pipe run upstream of a V-Cone is zero to three diameters. The recommended run downstream of a V-Cone is zero to one diameter. "Diameter" here refers to the nominal pipe size of the pipe run.

McCrometer, along with several independent testing facilities, has tested the V-Cone in several common piping configurations. These tests have proven the V-Cone to be within accuracy specifications even when close coupled with single 90° elbows or double 90° elbows out-of-plane. The V-Cone can also be used in lines slightly larger than the meter tube.

In applications where the meter tube is larger than the adjacent line, such as with cement lined piping, the user should consult the factory for additional installation requirements.

McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH 909-652-6811 FAX 909-652-3078 email: info@mccrometer.com

 Printed in U.S.A 24509-15 Rev. 2.8/09-03

4.5 Tap Locations

For piping in a horizontal plane, McCrometer recommends the taps be placed on the sides of the pipe in either the three or the nine o'clock position. In vertical pipes, the tap locations are not significant.

4.6 Transmission Lines

If possible install the transmission lines such that at no-flow conditions, there is no differential pressure created. Refer to the instruction manual of the differential pressure measuring device regarding further information on the installation and maintenance of pressure signal transmission lines. Ref. ISO 2186.

TYPICAL INSTALLATIONS

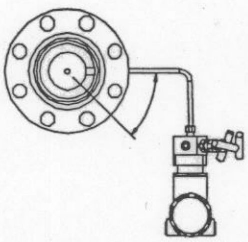


Figure 17
Liquid

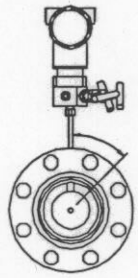


Figure 18
Gas

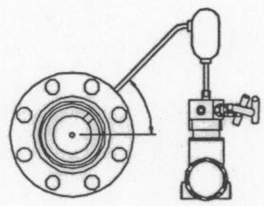


Figure 19
Steam, Wet Gas

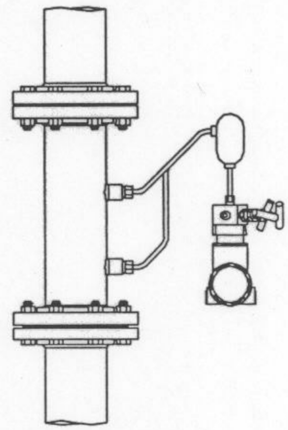


Figure 20
Vertical Steam, Wet Gas

Guidelines for gas or vapor applications where there is the possibility for condensation in the transmission lines.

1. In these instances, the transmission lines from the meter should be installed as shown in Figure 19 to ensure that no vapor will exist in the portions of the transmission lines sloping upward to the condensate pot.

2. Vertical up flow applications require a special V-Cone designed with wall taps. When wet legs are used, you must ensure that the wet legs are equal at all times.

3. Figures 19 and 20 above show condensation pots which may be recommended depending on the flow measurement requirements.

4.7 Valve Manifold

Please refer to the manifold's instructions regarding installation, operation, and maintenance.

4.8 Differential Pressure Transmitters

After the differential transmitter has been installed into a flow measurement system the transmitter zero should be checked and/or set to zero. The transmitter output mode, linear or square root, must be set appropriately. Please refer to the individual instruction manuals for specific information regarding the installation, operation, and maintenance of differential pressure transmitters.

McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH 909-652-6811 FAX 909-652-3078 email: info@mccrometer.com

4.9 Temperature and Pressure Sensors

Please refer to the individual instruction manuals for specific information regarding the installation, operation, and maintenance of temperature and absolute pressure sensors.

4.10 Installation Checklist For The Differential Pressure Transmitter

Verify the following during installation:

✓ Is the differential pressure transmitter full scale correct ?

✓ Has the differential pressure transmitter zero been checked and/or adjusted on site ?

✓ Are the differential pressure transmitter and flow computer both set to the appropriate modes, linear or square root ?

✓ Have the transmission lines to the differential pressure transmitter been purged ?

✓ Are there any leaks in the transmission lines ?

✓ Is the manifold cross valve closed ?

✓ Is the V-Cone high pressure port located upstream of the low pressure port ?

McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH 909-652-6811 FAX 909-652-3078 email: info@mccrometer.com

 Printed in U.S.A 24509-15 Rev. 2.8/09-03

5.0 Dimensions

5.1 Face to Face Dimensions

Please reference the V-Cone configuration sheets for more complete technical data.

Size	Beveled Threaded Plain		Slip On JIS 10K DIN 2576 ANSI 125 ANSI 150,300		Slip On ANSI 600-900		Weld Neck ANSI 150		Weld Neck ANSI 300		Weld Neck ANSI 600	
inch	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm
½	7.75	197	8	203	8	203	11.38	289.1	11.75	298.5	12.25	311.2
¾	7.75	197	8	203	8	203	11.75	298.5	12.13	308.1	12.63	320.8
1	7.75	197	8	203	8	203	12.00	304.8	12.50	317.5	13.00	330.2
1½	9.75	248	10	254	12	305	14.38	365.3	14.88	378.0	15.50	393.7
2	11.63	295	12	305	14	356	16.38	416.1	16.88	428.8	17.63	447.8
2½	11.50	292	12	305	14	356	16.75	425.5	17.25	438.2	18.00	457.2
3	13.50	343	14	356	16	406	18.75	476.3	19.50	495.3	20.25	514.4
4	15.50	394	16	406	18	457	21.25	539.8	22.00	558.8	23.75	603.3
5	21.50	546	22	559	26	660						
6	21.50	546	22	559	26	660	28.25	717.6	29.00	736.6	31.00	787.4
8	25.25	641	26	660	30	762	33.00	838.2	33.75	857.3	36.00	914.4
10	27.25	692	28	711	34	864	35.00	889.0	36.25	920.8	39.50	1003
12	29.25	743	30	762	36	914	38.00	965.2	39.25	997.0	41.75	1060
14	29	737	30	762	34	864	38.75	984.3	40.00	1016	42.25	1073
16	29	737	30	762	34	864	38.75	984.3	40.25	1022	43.25	1099
18	31	787	32	813	36	914	41.75	1061	43.25	1099	45.75	1162
20	35	889	36	914	40	1016	46.13	1171	47.50	1207	50.25	1276
24	47	1194	48	1219	54	1372	58.75	1492	60.00	1524	63.25	1607
30	59	1500	60	1524								
36	59	1500	60	1524								
48	71	1803	72	1829								
60	71	1803	72	1829								

McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH 909-652-6811 FAX 909-652-3078 email: info@mccrometer.com

 Printed in U.S.A 24509-15 Rev. 2.8/09-03

5.2 Face to Face Dimensions

Size	Weld Neck ANSI 900		Weld Neck RTJ 150		Weld Neck RTJ 300		Wafer ANSI		Wafer DIN, JIS	
mm	inch	mm	inch		inch	mm	inch	mm	inch	mm
½	12.88	327.2	-	-	12.19	309.6	2.25	57.2	2.36	60
¾	13.63	346.2	-	-	12.63	320.8	2.25	57.2	2.36	60
1	13.88	352.6	12.50	317.5	13.00	330.2	2.25	57.2	2.36	60
1½	16.50	419.1	14.88	378.0	15.38	390.7	3	76.2	3.15	80
2	19.88	505.0	16.88	428.8	17.50	444.5	3.38	85.9	3.35	85
2½	20.00	508.0	17.25	438.2	17.87	453.9	4	101.6	3.94	100
3	21.75	552.5	19.25	489.0	20.12	511.0	4.75	120.7	4.72	120
4	24.75	628.7	21.75	552.5	22.62	574.5	6	152.4	5.91	150
6	32.75	831.9	28.75	730.3	29.62	752.3	9.5	241.3	9.45	240
8	38.25	971.6	33.50	850.9	34.37	873.0				
10	42.00	1067	35.50	901.7	36.87	936.5				
12	45.25	1149	38.50	977.9	39.87	1013				
14	46.00	1168	39.25	997.0	40.62	1032				
16	46.25	1175	39.25	997.0	40.87	1038				
18	49.25	1251	42.25	1073	43.87	1114				
20	54.75	1391	46.63	1184	48.25	1226				
24	70.25	1784	59.25	1505	60.88	1546				

6.0 Model Selections

6.1 Wafer-Cone® Model Template

Examples:

Model	Description
VH01-A1SN3	Wafer-Cone 1" line size, S316, ANSI Style, 1/8" NPT Ports, Serrated Face
VH01-A2SN3	Wafer-Cone 25mm line size, S316L, DIN 2633 Style, 1/8" NPT Ports, Serrated Face

Size

	Code	Size
VH	**0A**	½"
	0B	¾"
	01	1"
	0C	1½"
	02	2"
	0D	2½"
	03	3"
	04	4"
	05	5"
	06	6"

\-

Materials

Code	Material
P	CPVC
Q	S304
L	S304L
A	**S316L**
T	PTFE
B	Brass
R	CPVC Body S316 Cone
X	Other Mat. ‡

Body Style

Code	Body Style
1	**ANSI CL 150 to 2500**
2	DIN 2633
3	DIN 2635
4	JIS 10k
X	Other Style

Bore

Code	Bore
S	**Standard**
X	Other

Ports

Code	Ports
N	**NPT**
J	RC
X	Other

Face Style

Code	Face Style
1	
2	O-Ring
3	**Serrated**
X	Other

NOTES:

1. Bold items in table above are standard construction.
2. Combinations of two different materials can also be specified.
3. Plastic materials limited to sizes 1" to 3". For other sizes please consult factory.

McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH 909-652-6811 FAX 909-652-3078 email: info@mccrometer.com
 Printed in U.S.A
24509-15 Rev. 2.8/09-03

6.2 Precision Tube V-Cone Model Template

Examples:

Model	Description
VS06QE04N	V-Cone 6" S304 S40 W/ ANSI CL 300 Flanges
VB24SD00N	V-Cone 24" Coated Carbon Steel w/ Beveled Ends

SERIES

VS	SO
VW	WN
VB	Beveled
VT	NPT
VP	Plain
VC	DIN SO
VD	DIN WN
VJ	JIS SO
VN	JIS WN
VG	Gray Type
VR	ANSI RTJ WN
VQ	ANSI RTJ SO

SIZE

0A	1/2"
0B	3/4"
01	1"
0C	1½"
02	2"
0D	2½"
03	3"
04	4"
06	6"
08	8"
10	10"
. . .	. . .

MATERIALS‡

Q	S304
L	S304L
A	S316L
D	DUPLEX 2205
H	HASTELLOY C-276
P	CPVC
T	PTFE
N	S304 tube, cone, support & cplgs CS flanges flanges painted HT silver
U	CS tube & flanges S304 cone, support, & cplgs exterior painted per customer
S	CS tube & flanges S304 cone, support, & cplgs coated blue, excluding cone

SCHEDULE

A	Pipe S10
B	Pipe S20
C	Pipe Bored
D	Pipe Std
E	Pipe S40
F	Pipe S80
J	Pipe S100
K	Pipe S120
L	Pipe S140
G	Pipe S160
H	Pipe XXS
M	Pipe S10S
N	ID 0.437"
P	Pipe XS

END CONNECTIONS

00	VP SMOOTH ENDS
01	VB BEVELED ENDS
02	VT THREADED ENDS
03	VS SO ANSI CL 150 RF
04	VS SO ANSI CL 300 RF
05	VS SO ANSI CL 600 RF
06	VS SO ANSI CL 900 RF
07	VS SO ANSI CL 1500 RF
08	VQ SO ANSI CL 150 RTJ
09	VQ SO ANSI CL 300 RTJ
10	VQ SO ANSI CL 600 RTJ
11	VQ SO ANSI CL 900 RTJ
12	(VQ) SO ANSI CL 1500 RTJ
13	VC SO DIN 2576 PN 10 FF
14	VW WN ANSI CL 150 RF
15	VW WN ANSI CL 300 RF
16	VW WN ANSI CL 600 RF
17	VW WN ANSI CL 900 RF
18	(VW) WN ANSI CL 1500 RF
19	VR WN ANSI CL 150 RTJ
20	VR WN ANSI CL 300 RTJ
21	VR WN ANSI CL 600 RTJ
22	VR WN ANSI CL 900 RTJ
23	(VR) WN ANSI CL 1500 RTJ

END CONNECTIONS

24	VD WN DIN 2633 PN 16 RF
25	VD WN DIN 2635 PN 40 RF
26	VJ SO JIS 10k
27	VJ SO JIS 20k
28	(VN) WN JIS 16K
29	(VN) WN JIS 20K
30	VS B16.1 SO CL 125 RF (>24")
31	VS B16.1 SO CL 250 RF (>24")
32	(VR) WN ANSI CL 2500 RTJ
33	AWWA SO FF CL B PLATE
34	AWWA SO FF CL D PLATE
35	AWWA SO FF CL E PLATE
36	AWWA SO FF CL F PLATE
37	(VD) WN DIN 2637 PN 100 RF
38	not used
39	GRAYLOC
40	SO ANSI CL 150 FF
41	SO NORSK NP16 NS2527/DIN 2501
42	SO B16.1 CL 125 FF (>24")
43	(VW)WN API 605 150# RF (ref 46)
44	(VP)VICTAULIC GROOVED ENDS
45	(VW)WN B16.47 A 150# RF (ref 47)
46	(VW)WN B16.47 B 150# RF (ref 43)
47	(VW)WN MSS SP-44 150# RF(ref 45)

(...) - not in current literature

FITTINGS

N1	¼" NPT	½", ¾", 1"	
S1	¼" Socket	½", ¾", 1"	
J1	¼" RC JIS	½", ¾", 1"	
N2	¼" NPT	3K #	1½"
S2	¼" Socket	3K #	1½"
J3	¼" RC JIS	3K #	1½"
N	½" NPT	3K #	2"+
N3	½" NPT	6K #	
S	½" Socket	3K #	
S3	½" Socket	6K #	
J	½" RC JIS	3K #	
J2	½" 15A JIS	3K #	
N4	¾" NPT	3K #	
S4	¾" Socket	3K #	
N5	1" NPT	3K #	
S5	1" Socket	3K #	
V	Valve	6K #	
S6	½" Sockolet	3K #	

McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH 909-652-6811 FAX 909-652-3078 email: info@mccrometer.com

 Printed in U.S.A 24509-15 Rev. 2.8/09-03

6.3 Insertion Top-plate V-Cone Model Template

Examples:

Model	Description	Pipeline
VI10SD03N	V-Cone 10" Insertion Top-plate CS Coated	16" OD x 15.25" ID
VI24QD30N	V-Cone 24" Insertion Top-plate All S304	48" OD x 47.25" ID

		SADDLE SIZE
VI	06	6"
	08	8"
	10	10"
	12	12"
	14	14"
	16	16"
	18	18"
	20	20"
	24	24"
	30	30"
	36	36"

	MATERIALS‡
Q	S304
L	S304L
A	S316L
S	CS COATED / S304 CONE
U	CS / S304 CONE

	SADDLE PIPE SCHEDULE
A	Pipe S10
B	Pipe S20
D	Pipe Std
E	Pipe S40

	FLANGE TYPE
03	B16.5 CL 150 RF
04	B16.5 CL 300 RF
30	B16.1 CL 125 RF (>24")
31	B16.1 CL 250 RF (>24")
33	AWWA CL B
34	AWWA CL D
35	AWWA CL E
36	AWWA CL F

	FITTINGS
N	½" NPT 3000#
S	½" Socket 3000#
J	½" JIS RC 3000#

6.4 V-Cone Special Models

Series {size} – {serially allocated number starting at 01}

examples:

VW06-02

VS12-05

6.5 V-Cone Materials

‡ Construction materials can include the following:

S304	MONEL K400/K500
S304L	S321H
S316L	INCONEL 625
HASTELLOY C-276	CPVC, PVC
DUPLEX 2205	PTFE
CHROMEMOLY P22/P11	KYNAR

CARBON STEELS A350, A333, API5L, A106B

Combinations of two different materials can also be specified.

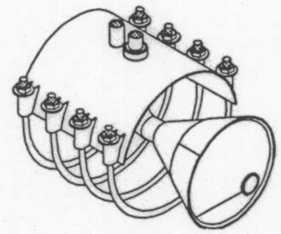
Plastic materials are limited to the VH series and to special VS styles < 8" in size.

McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH 909-652-6811 FAX 909-652-3078 email: info@mccrometer.com

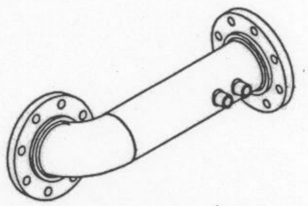
 Printed in U.S.A 24509-15 Rev. 2.8/09-03

6.6 Alternative Constructions

McCrometer has the capability of manufacturing special flowmeter designs incorporating spool sections, reductions, elbows and non-standard end connections. Figure 22 is an example flowmeter with integral 90° elbow and flanges.



V-Cone Bolt On Saddle
Figure 21



V-Cone, Elbow and Flanges
Figure 22

7.0 Maintenance

If the meter is installed correctly, there should be no reason for periodic maintenance or re-calibration. In extreme process conditions, periodically inspect the V-Cone for any significant physical damage. Calibrate and maintain secondary and tertiary instrumentation according to the manufacturer's instructions.

McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH 909-652-6811 FAX 909-652-3078 email: info@mccrometer.com

24509-15 Rev. 2.8/09-03

8.0 Trouble-shooting

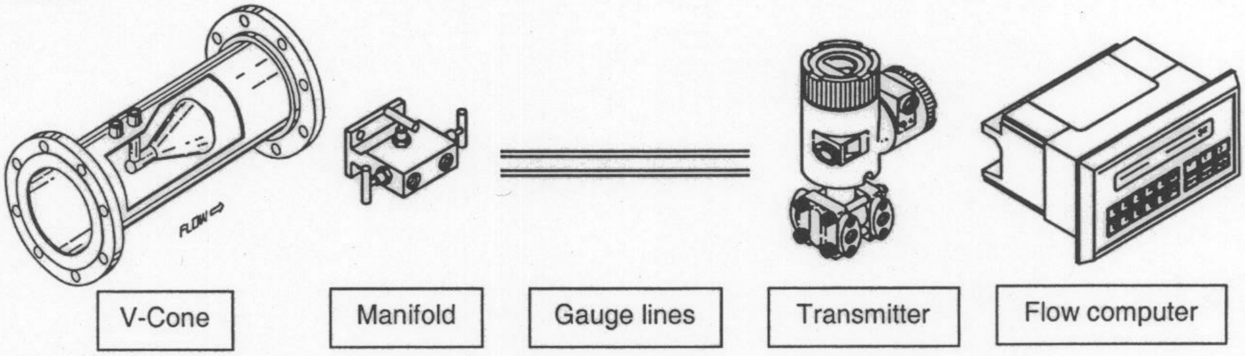
√CONE®

Troubleshooting a V-Cone System On-Site

This guide is intended to help you troubleshoot a V-Cone system. Keep several points in mind as you proceed:

1. Most V-Cones are calibrated devices. The meter has already had flow through it. If a cone is missing or a leak exists inside the meter, this would be discovered during the calibration.
2. A flow measurement requires a system. Do not assume a problem exists with the primary element just because it is called a *V-Cone* system. Most problems occur in the DP transmitter or the flow computer.
3. This guide assumes a simple system of meter, manifold, DP transmitter, and flow computer. Systems can be much more complex with pressure and temperature transmitters, as well as full scale digital control systems. Do not limit your evaluation to just these suggestions.
4. If you discover a problem / solution not listed in this guide, please contact a V-Cone Application Engineer at McCrometer: 1-909-652-6811 or e-mail: mdyer@mccrometer.com.

This guide separates the flow measurement system into areas. These areas are labeled in the diagram below



During troubleshooting, make a preliminary assessment of the symptoms of the problem and consult the chart on the next page.

SYMPTOM	AREA	POSSIBLE PROBLEM / SOLUTION
No signal (0 mA)	Transmitter	No power to transmitter.
	Transmitter	Transmitter not wired correctly. Perform continuity check on wiring.
Negative signal (< 0 mA)	Transmitter	Transmitter wires are reversed.
Low signal (<4 mA)	V-Cone	V-Cone installed backwards, with gauge lines attached as marked. In this case, the high pressure tap would be sensing a lower pressure than the low pressure tap. This negative DP would force the signal below 4 mA.
	Gauge lines	Gauge lines are reversed. Transmitter sees more pressure on low side than high side. Check "H" and "L" marks on V-Cone and transmitter.
	Transmitter	Transmitter is malfunctioning. Some transmitters will send a specified mA signal when a malfunction occurs. This can be set to low values, such as 3.8 mA, or high values, such as 20.1 mA.
Zero signal (4 mA)	V-Cone	Meter has been damaged. Remove meter and visually inspect.
	V-Cone	No flow in pipeline. Check other system locations to verify flow through the meter. The meter could be under pressure but still have no flow.
	Manifold	Manifold / gauge lines closed or blocked. Ensure valves and lines are open. If fluid is safe, open vent valves on transmitter to verify pressure in the gauge lines.

McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH 909-652-6811 FAX 909-652-3078 email: info@mccrometer.com

 Printed in U.S.A 24509-15 Rev. 2.8/09-03

Zero signal (4 mA)	Transmitter	Transmitter is in check mode. Some transmitters allow for system checks by forcing the signal to 4 or 20 mA. Vent low side of transmitter to ensure the signal responds to pressure changes.
Wrong signal – high or low	V-Cone	Process conditions do not match actual conditions. Contact McCrometer or your sales representative to recalculate using the correct process conditions.
	V-Cone	Wrong meter. Verify serial numbers on meters to ensure correct specifications. Sometimes two meters are interchanged. Remember each V-Cone has a unique flow coefficient.
	Gauge lines	Foreign material trapped in gauge lines. Dirt and sediment can settle into the gauge lines. If the fluid is safe, vent the gauge lines and inspect for spurts of solids, gasses, or liquids (whichever should <u>not</u> be there). If the fluid is not safe, open the center manifold valve for several minutes under high DP. Close the valve and compare the signal level to before. In a horizontal, liquid application, install the meter with the taps on the sides of the pipe (3 or 9 o'clock) For a horizontal, gas application, install at top or sides of the pipe (12, 3, or 9 o'clock).
	Flow computer	Flow calculations are in error. Use loop calibrator and apply 4, 12, and 20 mA to computer / system. Each of these points should correlate with the V-Cone sizing information.
	Flow computer	mA signal is read incorrectly. Apply a known current to the loop and read the raw signal in the computer. Most computers allow the user to see the mA signal directly.
Signal too high	V-Cone	V-Cone is installed backwards. Look for a flow direction arrow on the meter body, near the pressure taps. If no arrow is visible and the meter is large than 2 inches, the flow direction can be determined by the location of the pressure taps. The pressure taps will be closer to the upstream side. On meters less than 2 inches, the gauge lines will need to be removed. Look at the base of both pressure taps. One tap will be smooth at the base, the other will be mostly weld material. The smooth tap is on the upstream side. With a meter measuring backward flow, the DP signal will be approximately 30% too high.
	V-Cone	Flow is going in the opposite direction from what was expected. The assumption of flow direction is sometimes wrong. Verify with other system readings. With a meter measuring backward flow, the DP signal will be approximately 30% too high.
	V-Cone	Partially full pipe (liquids only). A partially full pipe will cause the meter to read too high. This can happen even in pressurized systems. • On horizontal pipes: If the fluid is safe, open a pressure tap on the top of the pipe. Air release will indicate partially full pipe. • On vertical pipes: Up flow will guarantee a full pipe. Down flow is difficult to diagnose if the pipe is full.
	V-Cone	Foreign object lodged in meter. This will increase the restriction of the meter and raise the DP. Remove the meter and visually inspect.
	Gauge lines	Leak on low pressure gauge line. Perform a leak check from the meter to the transmitter.
	Transmitter	Leak on low pressure vent valve. Perform a leak check on valve.
	Transmitter	Zero point has shifted positively. This will cause errors more pronounced at the low end of the transmitter range. Verify by closing the manifold side valves and opening the center valve. The reading should go to zero (4 mA). Recalibrate if necessary.
	Transmitter	DP span is set too low. Use pressure calibrator or handheld communicator to verify span point.

McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH.909-652-6811 FAX 909-652-3078 email: info@mccrometer.com

 Printed in U.S.A 24509-15 Rev. 2.8/09-03

Signal too high	Transmitter / flow computer	Both the transmitter and flow computer are set to take the square root of the signal. The signal will be correct at 20 mA. The positive error will increase dramatically as the signal decreases from 20 mA. Use a loop calibrator to check 12 mA point.
	Flow computer	4 mA set to minimum flow. Our calculations assume that 4 mA will be equal to zero flow. Sometimes 4 mA is set to equal the minimum flow on the sizing page. This error will be zero at maximum flow and increase as the flow decreases. The amount of error will depend on the zero offset.
Signal too low	Manifold	Manifold is cross-vented. The center valve must be closed. To test, close the two side valves and watch the transmitter signal. If the signal goes to zero (4 ma), the center valve is not closed completely.
	Gauge lines	Leak on high pressure gauge line. Perform a leak check from the meter to the transmitter.
	Transmitter	Leak on high pressure vent valve. Perform a leak check on valve.
	Transmitter	Zero point has shifted negatively. This will cause errors more pronounced at the low end of the transmitter range. Verify by closing the manifold side valves and opening the center valve. The reading should go to zero (4 mA). Recalibrate if necessary.
	Transmitter	DP span is set too high. Use pressure calibrator or handheld communicator to verify span point.
	Transmitter / flow computer	Neither the transmitter nor flow computer is set to take the square root of the signal. The signal will be correct at 20 mA. The negative error will increase dramatically as the signal decreases from 20 mA. Use a loop calibrator to check 12 mA point.
Unsteady signal	V-Cone	Partially full pipe occurring (liquids only). Periods with a partially full pipe will cause erratic readings. See above for details.
	Transmitter	Power supply not supplying enough power to create signal. Check power specifications for transmitter.
Slow response time	Transmitter	Dampening.
Sudden change in readings	V-Cone	Foreign object lodged in meter. This will increase the restriction of the meter and raise the DP. Remove the meter and visually inspect.
	Gauge lines	Leaks have started.

McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH 909-652-6811 FAX 909-652-3078 email: info@mccrometer.com

 Printed in U.S.A 24509-15 Rev. 2.8/09-03

Recommended Equipment for Troubleshooting a V-Cone Installation On-Site:

1. 4 to 20 mA loop simulator – highly recommended
2. Digital multimeter: with VDC, I, and Ω measurements
3. Pressure calibrator
4. Handheld Communicator for smart instruments
5. Hand tools: Screwdriver(+), Screwdriver (–), 12 inch crescent wrench, 4 inch crescent wrench

Some suggestions for equipment manufacturers and their products follow. A wide range of products is available. We do not necessarily endorse the following products or companies. Please choose a product that fits your needs and resources.

FLUKE.

www.fluke.com

740 Series Documenting Process Calibrators
718 Pressure Calibrator
717 30G Pressure Calibrator
716 Pressure Calibrator
715 Volt/mA Calibrator
714 Thermocouple Calibrator
713 30G/100G Pressure Calibrator
712 RTD Calibrator
787 Process Meter (combination digital multimeter and loop calibrator)
705 Loop Calibrator

9.0 V-Cone Literature

Configuration Sheets:		Configuration Sheets:	
VB Beveled	24509-29	VI Weld On Saddle	24509-46
VP Plain (smooth)	24509-30	w/ Bolt On Top-plate	
VT Threaded	24509-31	VR RTJ Weld Neck	24509-40,41
VS Slip On Flanged	24509-32,33,34	VQ RTJ Slip On	24509-38
VW Weld Neck	24509-35,36		
VD DIN Weld Neck	24509-47		
VC DIN Slip On	24509-42		
VJ JIS Slip On	24509-44		
VH Wafer-Cone	24509-51		

McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH 909-652-6811 FAX 909-652-3078 email: info@mccrometer.com

 Printed in U.S.A 24509-15 Rev. 2.8/09-03

MANUFACTURER'S WARRANTY

This Warranty shall apply to and be limited to the original purchaser consumer of any McCrometer product. Meters or instruments defective because of faulty material or workmanship will be repaired or replaced, at the option of McCrometer, Inc., free of charge, FOB the factory in Hemet, California, within a period of one (1) year from the date of delivery.

Repairs or modifications by others than McCrometer,Inc. or their authorized representatives shall render this Warranty null and void in the event that factory examination reveals that such repair or modification was detrimental to the meter or instrument. Any deviations from the factory calibration require notification in writing to McCrometer,Inc. of such recalibrations or this warranty shall be voided.

In case of a claim under this Warranty, the claimant is instructed to contact McCrometer,Inc. 3255 West Stetson Ave., Hemet, California 92545, and to provide an identification or description of the meter or instrument, the date of delivery, and the nature of the problem.

The Warranty provided above is the only warranty made by McCrometer, Inc. with respect to its products or any parts thereof and is made expressly in lieu of any other warranties, by course of dealing, usages of trade or otherwise, expressed or implied, including but not limited to any implied warranties of fitness for any particular purpose or of merchantability under the uniform commercial code. It is agreed this warranty is in lieu of and buyer hereby waives all other warranties, guarantees or liabilities arising by law or otherwise. Seller shall not incur any other obligations or liabilities or be liable to buyer, or any customer of buyer for any anticipated or lost profits, incidental or consequential damages, or any other losses or expenses incurred by reason of the purchase, installation, repair, use or misuse by buyer or third parties of its products (including any parts repaired or replaced); and seller does not authorize any person to assume for seller any other liability in connection with the products or parts thereof. This Warranty cannot be extended, altered or varied except by a written instruction signed by seller and buyer.

This Warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

McCrometer, Inc. reserves the right to make improvements and repairs on product components which are beyond the warranty period at the manufacturer's option and expense, without obligation to renew the expired warranty on the components or on the entire unit. Due to the rapid advancement of meter design technology, McCrometer, Inc. reserves the right to make improvements in design and material without prior notice to the trade.

All sales and all agreements in relation to sales shall be deemed made at the manufacturer's place of business in Hemet, California and any dispute arising from any sale or agreement shall be interpreted under the laws of the State of California.

McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH 909-652-6811 FAX 909-652-3078 email: info@mccrometer.com

 Printed in U.S.A 24509-15 Rev. 2.8/09-03

OTHER McCROMETER PRODUCTS INCLUDE:

V2 Municipal
The Space Saver

Propeller Liquid Flowmeters

Water Specialties Propeller Meter

Differential Pressure Flowmeters

Wafer-Cone® Differential Pressure Flowmeters

Variable Area Meters

ULTRA MAG® Magnetic Flowmeters

Electronic Instrumentation for Remote Display and Control

FOR MORE INFORMATION CONTACT:

Represented by:

McCROMETER

3255 W. Stetson Avenue, Hemet, CA 92545-7799

Phone: (909) 652-6811 Fax: (909) 652-3078

e-mail: info@mccrometer.com Web Site: http://www.mccrometer.com

Hours: 8 a.m. - 4:30 p.m. PST, Monday-Friday

Canadian Patent 1325113 European Patent 0277121 Japan patent 1,858,116 U.S. Patents 4638672, 4812049, 5363699, 4944190 and 5,814,738 Other U.S. and Foreign patents pending