Vortex
Flow Meters

VN2000 Flow Meters

Hot Tap Insertion Meter

Badger Meter

VRX-UM-02217-EN-05 (August 2018)

User Manual

CONTENTS

PURPOSE OF THIS DOCUMENT

The purpose of this document is to provide you with an overview of the installation and wiring of the VN2000 Hot Tap Insertion Meter. For information on basic configuration, see the *VN2000 Transmitter User Manual* supplied with the meter or download the manual at *www.badgermeter.com*.

IMPORTANT

Read this manual carefully before attempting any installation or operation.
Keep the manual in an accessible location for future reference.

UNPACKING AND INSPECTION

Upon opening the shipping container, visually inspect the product and applicable accessories for any physical damage such as scratches, loose or broken parts, or any other sign of damage that may have occurred during shipment.

NOTE: If damage is found, request an inspection by the carrier's agent within 48 hours of delivery and file a claim with the carrier. A claim for equipment damage in transit is the sole responsibility of the purchaser.

Storage

If the meter is not scheduled for installation soon after delivery and must be stored:

- After inspection, re-pack the meter into its original packing.
- If the meter being stored has been previously installed, remove all process fluids and corrosives.
- Store in a clean, dry site free of mechanical vibration, shock and chemical corrosives.

SAFETY

Safety Symbol Explanations

⚠DANGER

INDICATES A HAZARDOUS SITUATION, WHICH, IF NOT AVOIDED IS ESTIMATED TO BE CAPABLE OF CAUSING DEATH OR SERIOUS PERSONAL INJURY.

⚠WARNING

INDICATES A HAZARDOUS SITUATION, WHICH, IF NOT AVOIDED COULD RESULT IN SEVERE PERSONAL INJURY OR DEATH.

⚠CAUTION

INDICATES A HAZARDOUS SITUATION, WHICH, IF NOT AVOIDED IS ESTIMATED TO BE CAPABLE OF CAUSING MINOR OR MODERATE PERSONAL INJURY OR DAMAGE TO PROPERTY.

Safety Precautions

⚠CAUTION

IF THE EQUIPMENT IS USED IN A MANNER NOT SPECIFIED BY THE MANUFACTURER, THE PROTECTION PROVIDED BY THE EQUIPMENT MAY BE IMPAIRED.

PRODUCT LABEL

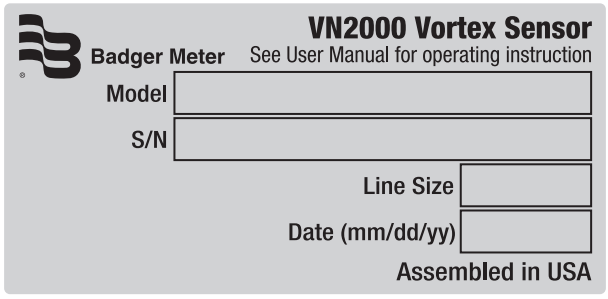

Figure 1: VN2000 meter label

INTRODUCTION

The VN2000 Hot Tap Insertion Vortex Flow Meter measures the volumetric flow rate, mass flow rate or BTU/energy of steam, gas or liquids over a large flow range. The meter is a heavy duty design engineered to stand up to the most abusive environments inside and outside the pipe.

Principles of Operation

An everyday example of a vortex shedding phenomenon is a flag waving in the breeze: the flag waves due to the vortices shed by air moving across the flagpole. Within the flow meter, as flowing fluid moves across the tiny strut or "bluff bar", vortices are shed on a smaller scale. The frequency of the vortices shedding is proportional to the fluid velocity.

Through the use of an internal RTD, the flow meter software compensates for changes in temperature, to achieve an accurate mass flow measurement.

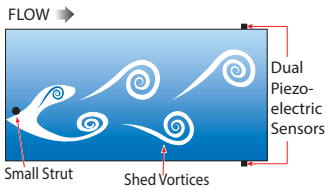

Figure 2: Vortex shedding

Sensor Operation

Two piezoelectric pressure-sensing crystals are mounted internally in the insertion vortex meter in proximity to the vortex-generating element, called the shedder bar. Two sensors sense the vortex signals. The crystals convert the pressure pulses created by the vortices into voltage signals without the need of excitation current or voltage. The sensor crystals are never in contact with the fluid. The piezo crystals are encapsulated in a stainless steel module.

Calibration Factor

The frequency at which vortices are shed is a linear function of fluid velocity, and therefore, a measure of flow. In the range covered by the particular flowmeter, vortex frequency is insensitive to specific gravity, viscosity, and temperature of the fluid, and depends only upon the width (d) in inches and shape of the flow element, and the inside diameter (D) of the pipeline in inches.

The frequency is $F = SV/d$

Where:
F = Karman vortex frequency
S = constant (Strouhal Number)
V = fluid velocity at the flow element
D = face width of the element

INSTALLING A VN2000 METER

The Badger Meter VN2000 Insertion Vortex Meter is designed to operate under a wide variety of conditions. To ensure its longevity of operation, precautions should be taken before and during its installation.

Preinstallation Considerations

Selecting the Installation Site

The meter requires a minimum of 10 straight diameters upstream and 5 straight unobstructed diameters of downstream piping. One diameter is equal to the internal pipe diameter. This is necessary to ensure regulated formation of vortices.

- Choose a site with minimal mechanical vibrations.
- Do not install the transmitter and cables in close proximity with large transformers, arc-welding equipment, large electric motors, or similar industrial equipment that emits excessive electromagnetic interference
- Avoid areas of extreme temperature change. The signal conditioner works ideally between temperatures of 32…140° F (0…60° degrees C).
- Avoid areas of high humidity or corrosive atmosphere, where possible.
- When installing the meter, choose a site that is accessible and allows ease of wiring and maintenance.

Piping Guidelines

Straight Run Piping Requirements	Upstream Pipe Diameters	Downstream Pipe Diameters
One 90° elbow before flow meter	10	5
Two 90° elbows before flow meter	15	5
Two 90° elbows out of plane before flow meter	30	5
Reduction before flow meter	10	5
Regulator, valve or header before flow meter	30	5
Tee connection before flow meter	30	5

Table 1: Piping requirements

If the minimum straight run is not possible, install the meter with 80% of the straight run upstream and 20% downstream.

To provide the high accuracy of flow measurement specified on the identification sheet, piping and installation instructions must be followed carefully.

- The pipe immediately upstream and downstream of the flow meter must be straight, of sufficient length and free of obstructions. See *Table 1* for exact dimensions.
- If recommended piping cannot be found, use straightening vanes on vortex meters.
- Locate any valves downstream of the meter.
- Before installing the meter, make sure nothing (such as weld beads or flange gaskets) protrudes from the internal wall of the pipe that could interrupt the flow stream and affect the reading.

Temperature Taps

For BTU/Energy Meters: Install temperature transducers in accordance with the manufacturer's specifications and 2.5…3.5 diameters from the downstream side of the meter body.

Orientation

The VN2000 insertion meter uses dual piezoelectric sensing elements with no moving parts. This eliminates wear and allows for vertical or horizontal pipe installation. For vertical pipes, the meter can be located in any position.

For horizontal pipe orientations, install the meter above the centerline of the pipe. To prevent condensate from running into the pipe assembly, mount the flow meter at 0…80° off of the top center of the pipe. For high temperature applications, avoid mounting the transmitter over the pipe to keep it out of the path of heat rising from the pipe. Insulate all pipes surrounding the meter.

Installation Procedure

The hot-tap method involves inserting the flow meter through a full port valve and requires greater clearance space for removal and installation.

NOTE: For pipes under pressure, use the Insertion/Extraction Tool. See *"Using the Optional Insertion/Extraction Tool" on page 11*.

The flow meter is shipped completely assembled, tested and ready to install and operate in its permanent location. These instructions assume the pipe has been fitted with a 1-1/2 in. hole, a Weldolet®, nipple and valve. The valve must be threaded full bore.

When the flange version is used, a flange is supplied. This flange has an overall height of 3 in. This must be taken into account when installing the nipple.

IMPORTANT

There is a sensor mounted on the end of the insertion probe. Do not stand the meter on its end. Be careful not to hit or push this end, or damage to the sensor may occur.

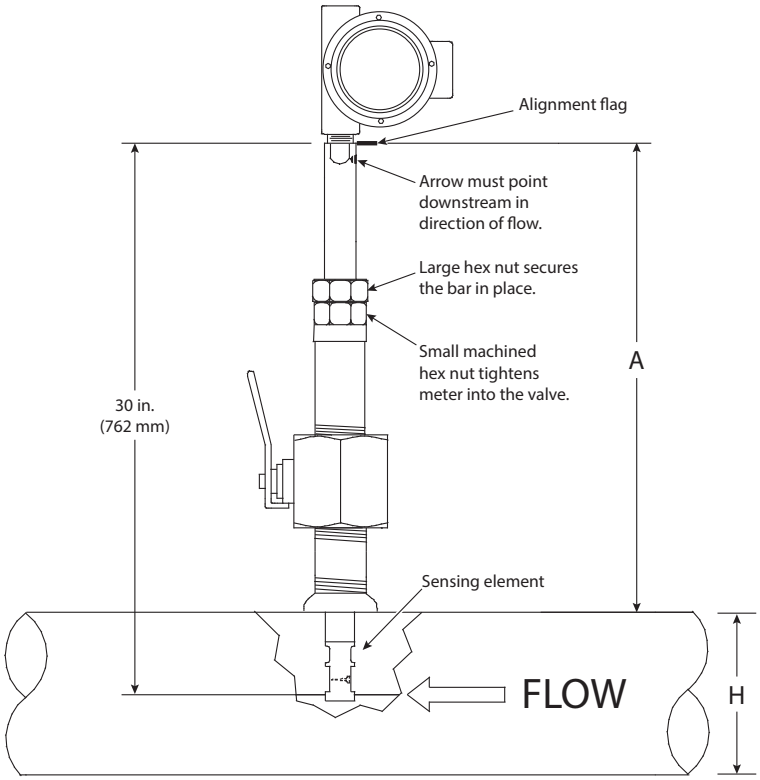

Figure 3: Calculate insertion depth

The probe must be inserted until the shedder bar in the sensing element is at the midpoint of the pipe.

1. Calculate the required insertion depth of the vortex meter by dividing the pipe diameter (H) by 2.
2. Calculate how far the alignment flag at the top of the insertion shaft should be from the outside of the pipe wall, for proper insertion depth: A = 30 inch – (1/2 * H)
3. Fully retract the probe until the insertion end is within the sealing unit.
4. Hand-tighten the large hex nut to hold the meter shaft in place during installation.

⚠CAUTION

THE NUT IS NOT A SEALING NUT. THE NUT IS ONLY DESIGNED TO HOLD THE BAR IN PLACE DURING PRESSURIZED APPLICATIONS. DO NOT OVER TIGHTEN THE NUT BECAUSE GALLING WILL OCCUR. TIGHTEN THE NUT BY HAND, THEN TIGHTEN WITH A 24 IN. WRENCH AFTER THE BAR IS INSERTED TO THE DESIRED INSERTION DEPTH.

5. Apply plumber's tape to the threaded ends of the meter shaft.
6. Align the meter to the valve and turn the machined hex of the seal assembly to screw the meter into the valve.

NOTE: When screwing the 1-1/2 in. NPT threads into the valve, do not use the large nut on the top of the seal assembly. Use the machined hex on the seal assembly. The large nut is only used to tighten down on the split ring, which holds the bar in place, keeping it from being pushed out of the line under pressure. It is not a sealing nut.

7. After the meter is sealed into the valve, slowly open the valve and check for possible leaks between the valve and meter seal assembly. If there are any leaks, close the valve and retry sealing the valve and meter seal assembly.
8. After the valve is completely opened, you are ready to insert the meter sensing element.
9. Loosen the large hex nut to allow the meter shaft to move.

⚠CAUTION

DO NOT LOOSEN THE NUT UNLESS THE LINE IS DEPRESSURIZED OR A HOT-TAP MECHANISM HAS BEEN INSTALLED PROPERLY ON THE METER SHAFT.

10. Insert the meter shaft until the distance from the alignment flag at the top of the insertion shaft to the top of the pipe = A.

Check the Alignment

After installing the meter, check for alignment. There is an arrow on the flats on the top of the bar nearest to the electronics, which should point EXACTLY DOWNSTREAM.

This arrow is aligned with the element and will give proper alignment of the element. If this arrow does not point downstream after installing the meter, rotate the bar.

1. The flats on the top of the bar next to the electronics will accommodate a 1 in. open-ended wrench. Rotate the bar until the arrow faces downstream. If the assembly is too tight to rotate the bar, loosen the large nut on the seal assembly. The bar will not slide out.
2. After aligning the arrow, keep the 1 in. open-ended wrench on the flats on top of the bar. Hold it in place and tighten down on the larger nut on the seal. This will prevent the bar from turning when completing the final tightening on the split-ring nut.

IMPORTANT

For a final check, make certain that the meter has not come loose from its 1-1/2 in. NPT connection and that the split ring nut and seal assembly are firmly in place.

⚠CAUTION

STAY CLEAR OF THE METER WHEN THE LINE IS BEING PRESSURIZED. THIS IS GOOD SAFETY PROCEDURE FOR THE INSTALLATION OF ANY EQUIPMENT IN A PRESSURIZED LINE.

USING THE OPTIONAL INSERTION/EXTRACTION TOOL

The insertion/extraction tool is an optional, separate device that can be used on any VN2000 Hot Tap Insertion Vortex meter, regardless of whether it is metering liquids, gases or steam. The purpose of the tool is to aid in installing or removing a meter from flow that is under pressure. Attach the tool to the meter before making any adjustments to the meter itself.

The tool has two clamp assemblies:

- The clamp assembly with the larger cradle, located at the bottom of the tool, secures the meter's seal assembly and prevents it from moving.
- The clamp assembly with the smaller cradle, located at the top of the tool, secures the meter's shaft.

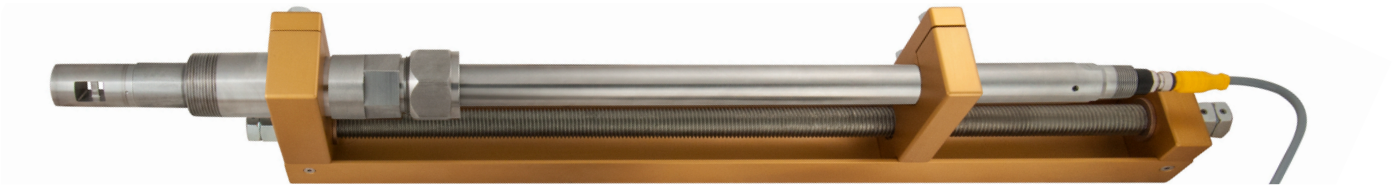

Figure 4: Insertion tool attached to VN2000 meter and seal assembly

Using the Tool to Install a Meter

1. Lay the tool on its side with the threaded spindle facing you and the cradles of the clamp assemblies facing up.
2. Lay the insertion meter into the clamp cradles, with the bottom (larger) clamp assembly around the meter's seal assembly, just below the machined step on the seal, and the upper (smaller) clamp assembly around the meter shaft, 2 in. down from the top of the shaft.
3. Secure the tops of the clamp assemblies to the cradles with the bolts provided. Make sure both bolts are tightly secured.
4. Loosen the large hex nut to allow the probe to move. Make sure the large hex nut is completely off the threads of the seal assembly
5. Use a standard 1-1/8 in. socket wrench to turn the nut on the end of the threaded spindle to retract the probe until the insertion end is within the sealing unit.
6. Apply plumber's tape to the threaded end of the meter shaft.

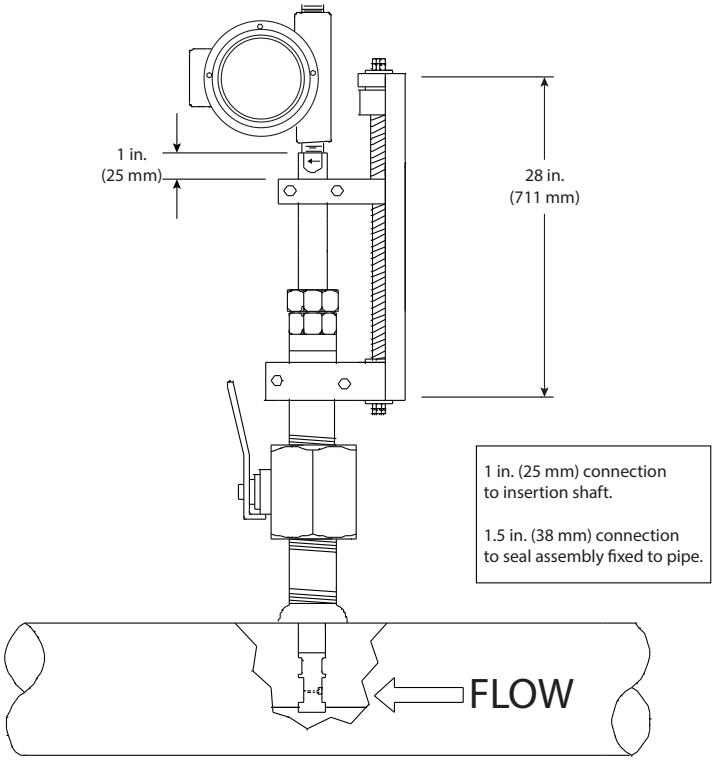

Figure 5: Insertion tool attached to VN2000 meter and seal assembly

IMPORTANT

The tool bolts must be securely tightened onto the meter shaft and seal assembly.

7. After installing the tool, completely remove the seal assembly nut from the threads.

⚠ WARNING

FOLLOW THE NEXT STEP CAREFULLY TO PREVENT LEAKAGE, WHICH COULD CAUSE INJURY.

8. When the insertion tool is securely fastened, loosen the nut on the top of the seal assembly, making sure not to loosen the entire seal assembly that is connected to the piping. (The larger of the hex nuts houses the split-ring assembly.) This should be completely loosened off the top of the seal assembly with NO threads engaged. This can be done by holding the seal assembly in place and then loosening the large hex nut on the split-ring assembly. The split-ring nut should be loosened completely (you may have to tap the nut with a hammer to free the split ring).

Using the Tool to Remove a Meter

⚠WARNING

BURN HAZARD. THE PROBE MAY BE HOT TO THE TOUCH IF THE FLUID IS HOT.

Attach the tool to the insertion meter:

1. Holding the back of the tool, place the tool behind the meter with the bottom (larger) clamp assembly in line with the meter's seal assembly.
2. Place the clamp cradles, with the bottom (larger) clamp assembly around the meter's seal assembly, just below the machined step on the seal, and the upper (smaller) clamp assembly around the meter shaft, 2 in. down from the top of the shaft.
3. Secure the tops of the clamp assemblies to the cradles with the bolts provided.

IMPORTANT

To make sure the seal assembly does not turn while the large hex nut is loosened, use two wrenches. Turn the wrench on the seal assembly clockwise as you turn the wrench on the hex nut counterclockwise.

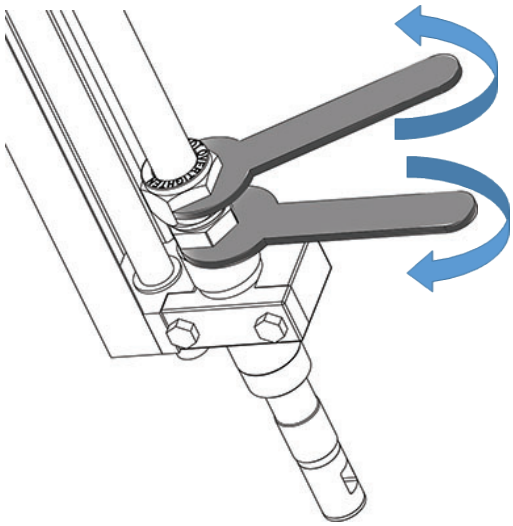

Figure 6: Removing the hex nut

4. Loosen the large hex nut and split ring (you may have to tap the nut with a hammer to free the split ring).
5. Completely back off the hex nut from the threads.

⚠WARNING

AFTER THE NUT IS COMPLETELY REMOVED, THE PRESSURE IS AGAINST THE INSERTION TOOL. DO NOT STAND IN THE DIRECTION OF EXTRACTION AS PERSONAL INJURY COULD OCCUR.

7. Attach a wrench or a 1-1/8 in. socket wrench to the top of the threaded spindle of the insertion tool and turn the spindle until the sensing element is extracted from the pipe and retracted up into the seal assembly.

⚠CAUTION

MAKE SURE THE METER IS WELL PAST THE VALVE AND INTO THE SEAL ASSEMBLY BEFORE TRYING TO CLOSE THE VALVE. IF FLOW METER SENSOR IS STILL IN THE VALVE WHILE IT IS BEING CLOSED, DAMAGE CAN OCCUR TO THE SENSOR ELEMENT.

8. Close and purge the valve.
9. Remove the seal assembly slowly. There may be an amount of pressurized fluid in the nipple, or the valve may not be sealing properly.

WIRING A REMOTE TRANSMITTER

To wire remote electronics, use the supplied cable with the multi-pin connectors. The cable is a double-sided, molded cordset with a single-keyway, threaded connection. The cable ends are the same. See the VN2000 Transmitter user manual for instructions on installing, wiring and troubleshooting the transmitter.

IMPORTANT

Do not hook up electronics with the power on.

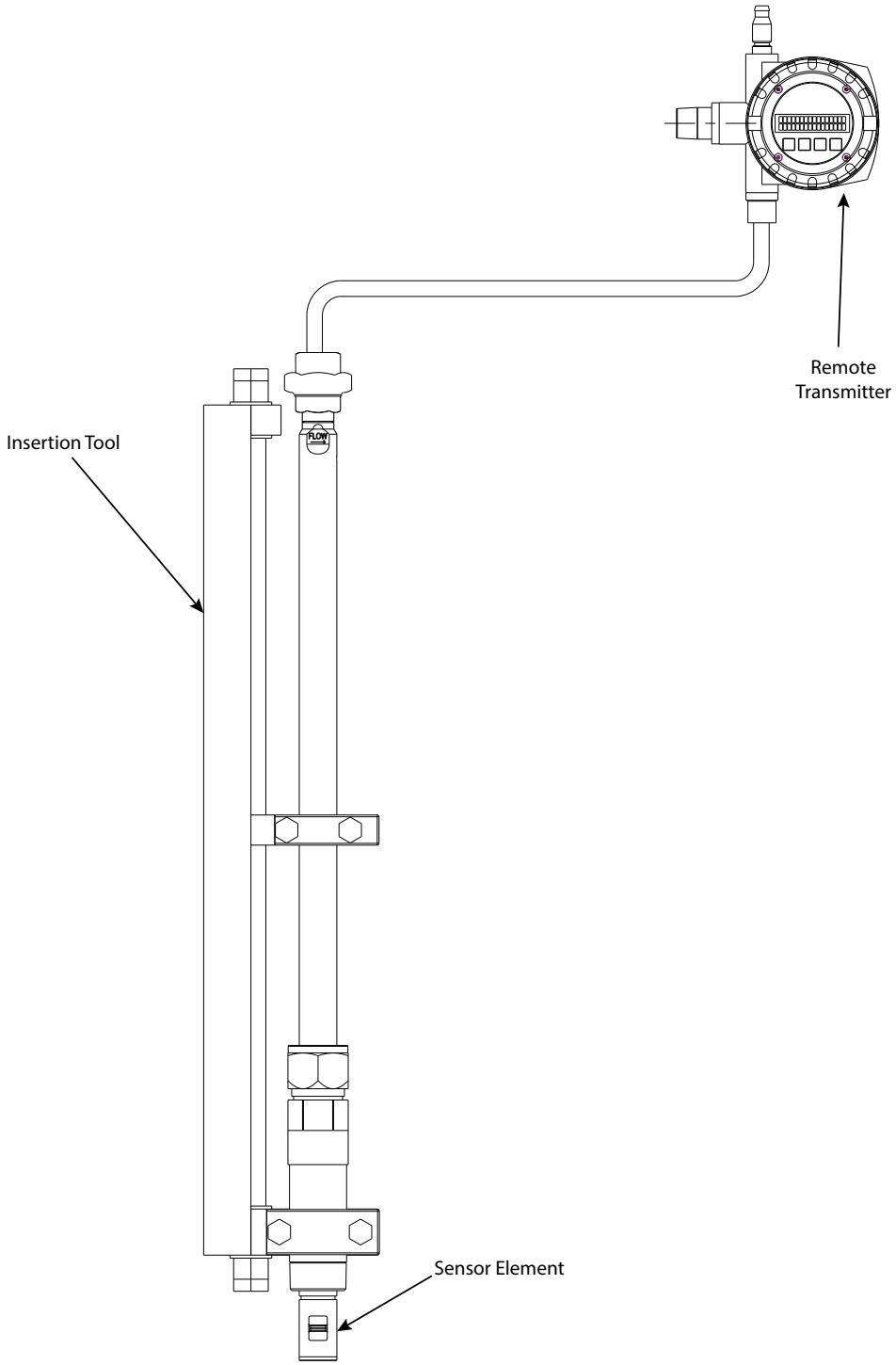

Figure 7: Remote version

TROUBLESHOOTING

Screen is blank (No display)	Verify that you have 24V DC.
	Verify that power polarity is correct (Black +24V DC & Blue -24V DC).
Screen shows no flow rate during flow	Check arrow and alignment hole on the top of the probe. They must be pointing down the pipe in the direction of flow.
	Take a measurement from the top of the stainless steel probe to the top hole in the center of the pipe. The overall length of the meter from the shedder bar to the hole is XX. The length of XX minus the length measured is the distance the meter is in the pipe. Make sure the meter is in the center of the pipe and not sitting inside the valve assembly or close to the inside wall of the pipe.
Flow rate is erratic	Check to see what is installed upstream of the flow meter. Other instruments or devices before the flow meter can shed vortices of their own causing a disruption in flow reading.
	Check to see if there are any valve, tees or elbows upstream of flow meter. If these items are too close to the flow meter then they can cause disruption in flow reading.
	Check to see what size hole is drilled into the pipe for insertion. If an existing hole larger than 1.5 inch was used, the larger hole can create turbulence directly above the flow sensor.
Flow rate seems incorrect	Review the program settings and make sure the correct line size is chosen for your application. If this is a multi-variable MASS unit, make sure the correct pressure and temperature is being displayed on the screen. If this is a fixed MASS unit, make sure the correct operating pressure is entered into the electronics for calculations.

Table 2: Troubleshooting

SPECIFICATIONS

	Uncertainty	
	Volumetric Flow	**Repeatability**
Liquids	±1.0% of reading	±0.25% of reading
Steam	±1.0% of reading	±0.25% of reading
Gas	±1.0% of reading	±0.25% of reading
	Mass or Heat Flow	**Repeatability**
Liquids	±1.0% of reading	±0.25% of reading
Steam	±1.0% of reading	±0.25% of reading
Gas	±1.0% of reading	±0.25% of reading
Velocity – Liquid	1.32…32 ft/s (0.402…9 m/s)	
Velocity – Gas	cube root (140/ρ) ft/s… 300 ft/sec (91 m/sec)	
Reynolds Range	10,000…7,000,000 depending on fluid density	
Straight Run Pipe	Upstream 10 diameters; downstream 5 diameters with one 90° elbow before the meter	
Pipe sizes	2…36 in. (50…900 mm)	
Fluid temperature	–250…400° F (–120…204°C)	
Maximum Pressure	1000 psi (68.9 bar)	
Wetted Materials	Stainless steel 304L	
Hot Tap Connections	1-1/2 in: NPT, ASME/ANSI 150, 300 flanges Sealing assembly: Two ethylene propylene O-rings Optional removable extractor	

Measurement Options	**Sensors**			
Volumetric flow rate	Dual piezo vortex sensors			
Mass flow rate based on velocity and temperature	Dual piezo vortex sensors RTD embedded in sensor: 100 Ohm, 3 wire			
BTU/Energy	Dual piezo vortex sensors RTD embedded in sensor: 100 Ohm, 3 wire External 100 Ohm RTD input			
Units of measure	**Steam** Pounds Kilograms Tons Metric Tons Cubic Feet Cubic Meters Gallons Liters	**Gases** Pounds Kilograms Tons Metric Tons Cubic Feet Actual Cubic Feet Natural Cubic Meters Actual Cubic Meters U.S. Gallons Natural Liters Actual Liters	**Liquids** Pounds Kilograms Tons Metric Tons Cubic Feet Cubic Meters Gallons Liters	**Energy (Any Fluid)** BTU
	Units of measure are used for flow rate, mass flow rate, heat/energy flow rate; volume total, mass total, heat/energy total			
Measurement interval	Second, minute, hour, day			

Figure 8: Specifications

PARTS LIST

If the meter was installed, then removed, replace the O-rings before reinstalling the meter. Instructions are included with the O-Ring Replacement Kit.

VNF O-Ring Kit PN VNA-RNG-VNF Contents

O-ring, ethylene propylene with 90 durometer (quantity 2)	22650-077
Silicone grease	68559-001

Table 3: Parts list

PART NUMBER CONFIGURATION

Model	
VN2000 Hot Tap Insertion Vortex Meter	VF
Pipe Line Size (used for meter configuration only)	
2 inch	A020
3 inch	A030
4 inch	A040
5 inch	A050
6 inch	A060
8 inch	A080
10 inch	A100
12 inch	A120
14 inch	A140
16 inch	A160
18 inch	A180
20 inch	A200
24 inch	A240
26 inch	A260
28 inch	A280
30 inch	A300
32 inch	A320
36 inch	A360
Material	
Stainless Steel, Commerical	C
End Fittings	
1-1/2 inch NPT	NTS
1-1/2 Flange ANSI 150	FAS
1-1/2 Flange ANSI 300	FBS
Process Temperature & Pressure	
Standard	S
Reserved	
None	W
Measurement	
Volumetric flow rate	V
Mass flow, temperature	T
Heat energy/BTU (not available for sensor replacement) [1]	E
Transmitter Type	
Integral, 24V DC	E
Remote, 24V DC	F
Cable Length	
None (integral/meter mount or replacement sensor)	WW
10 feet/3 m (remote transmitter) [2]	AB
30 feet/9 m (remote transmitter) [2]	AF
Fluid & Pipe Type	
Liquid-Chilled (not available with Measurement option V)	C
Liquid-Heating (not available with Measurement option V)	H
Liquid (available with Measure option V only)	L
Steam	S
Gas	G
Display	
Standard	S
Communication/Output	
4-20 mA and Pulse Output	S
Modbus RTU	M
BACnet MS/TP	B
Testing & Tagging	
Standard Testing	G

1 One internal temperature sensor and one external temperature sensor included.

2 Specify cable length from sensor to transmitter. Transmitter power 10 foot cable included.

Metric Pipes

Model	
VN2000 Hot Tap Insertion Vortex Meter	VF
Pipe Line Size (used for meter configuration only)	
50 mm	D050
80 mm	D080
100 mm	D100
150 mm	D150
200 mm	D200
250 mm	D250
300 mm	D300
350 mm	D350
400 mm	D400
450 mm	D450
500 mm	D500
550 mm	D550
600 mm	D600
650 mm	D650
700 mm	D700
750 mm	D750
800 mm	D800
850 mm	D850
900 mm	D900
Material	
Stainless Steel, Commerical	C
End Fittings	
DN40 Flange PN16	PAS
DN40 Flange PN40	PCS
Process Temperature & Pressure	
Standard	S
Certification	
None	W
Measurement	
Volumetric flow rate	V
Mass flow, temperature	T
Heat energy/BTU [1]	E
Transmitter Type	
Integral, 24V DC	E
Remote, 24V DC	F
Cable Length	
None (integral/meter mount or replacement sensor)	WW
10 feet/3 m (remote transmitter) [2]	AB
30 feet/9 m (remote transmitter) [2]	AF
Fluid & Pipe Type	
Liquid-Chilled (not available with Measurement option V)	C
Liquid-Heating (not available with Measurement option V)	H
Liquid (available with Measurement option V only)	L
Steam	S
Gas	G
Display	
Standard	S
Communication/Output	
4-20 mA and Pulse Output	S
Modbus RTU	M
BACnet MS/TP	B
Testing & Tagging	
Standard Testing	G

1 One internal temperature sensor and one external temperature sensor

2 Specify cable length from sensor to transmitter. Transmitter power 10 foot cable included.

Control. Manage. Optimize.

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