

# ***INSTRUCTION MANUAL***

## **TRIO-WIRL Flowmeter**

**Swirl ST4000/SR4000**

**Vortex VT4000/VR4000**



PN25080

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## Read First

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### WARNING

#### INSTRUCTION MANUALS

Do not install, maintain or operate this equipment without reading, understanding and following the proper ABB Inc. instructions and manuals, otherwise injury or damage may result.

#### RETURN OF EQUIPMENT

All equipment being returned to ABB Inc. for repair must be free of any hazardous materials (acids, alkalis, solvents, etc.). A Material Safety Data Sheet (MSDS) for all process liquids must accompany returned equipment. Contact ABB Inc. for authorization prior to returning equipment.

Read these instructions before starting installation;  
save these instructions for future reference.

### Contacting ABB Inc.

Should assistance be required with any ABB Instrumentation product, contact the following:

**Telephone:**

24-Hour Call Center  
1 (800) HELP-365

**E-Mail:**

[ins.techsupport@us.abb.com](mailto:ins.techsupport@us.abb.com)



## TRIO-WIRL INSTRUCTION MANUAL

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The NEMA 4X rating applies to the meter body and electronics enclosure only. The following accessories (if supplied) may not meet NEMA 4X unless specifically ordered as NEMA 4X:

- \* meter flanges
- \* meter installation hardware: studs, nuts, bolts
- \* enclosure mounting hardware for pipe or wall mounting
- \* conduit hardware

This product is painted with a high performance epoxy paint. The corrosion protection provided by this finish is only effective if the finish is unbroken. It is the users' responsibility to "touch-up" any damage that has occurred to the finish during shipping or installation of the product. Special attention must be given to: meter flange bolting, pipe mounting of electronics, conduit entries and covers that are removed to facilitate installation or repair. For continued corrosion protection throughout the product life, it is the users' responsibility to maintain the product finish. Incidental scratches and other finish damage must be repaired and promptly re-painted with approved touch-up paint. Provide the model number and size of your product to the nearest ABB Automation representative to obtain the correct touch-up paint.

# CHAPTER 1 Introduction

## 1.1 Description

The ABB Inc. TRIO-WIRL family of flowmeters consists of the TRIO-WIRL V vortex flowmeter and the TRIO-WIRL S swirlmeter. The TRIO-WIRL V is available in two models in either flanged or wafer styles. A compact or integral Model VT4000 and a remote Model VR4000. Similarly, the TRIO-WIRL S is available in ST4000 and SR4000 models but only in flanged style.

The VT4000 Vortex and ST4000 Swirlmeters are supplied with an integrally mounted microprocessor-based signal converter using state-of-the-art Digital Signal Processor (DSP) technology for superior flow and vibration noise immunity. This combination of flowmeter and electronics allows maximum flexibility for on-site configuration and maintenance. Database interrogations and changes at the flowmeter may be performed using the three pushbuttons or by activating three magnetic switches using a magnetic "stick". The

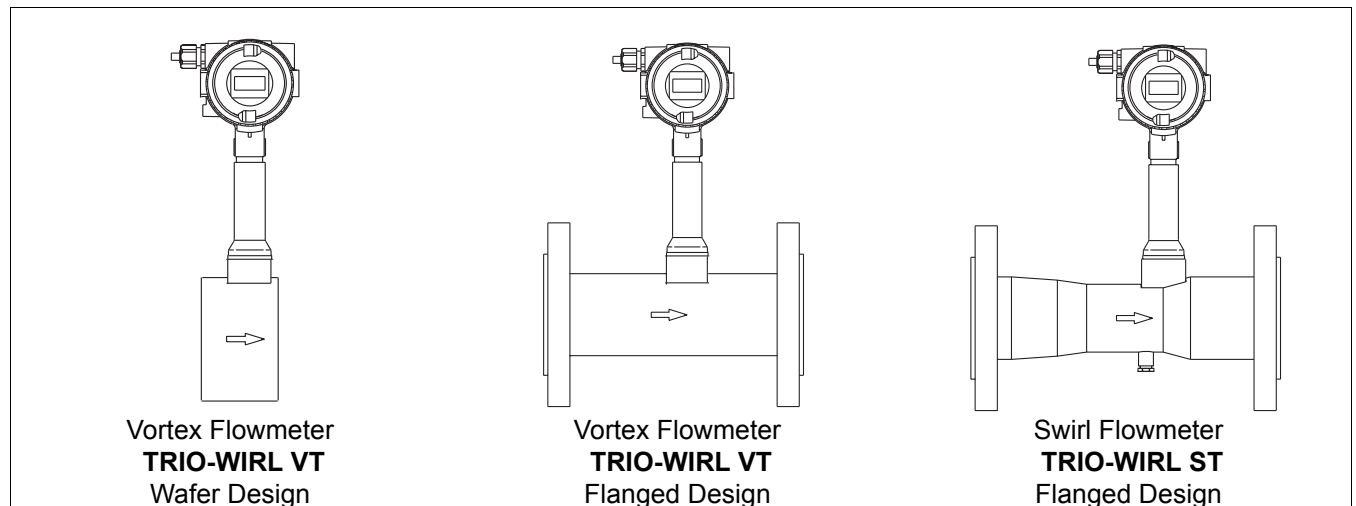
two line, 16 character LCD display permits continuous monitoring of the flow rate or other flow parameters.

The flowmeters are suitable for service with gas and liquid processes. The meters' extended temperature range permits accurate metering of saturated and superheated steam.

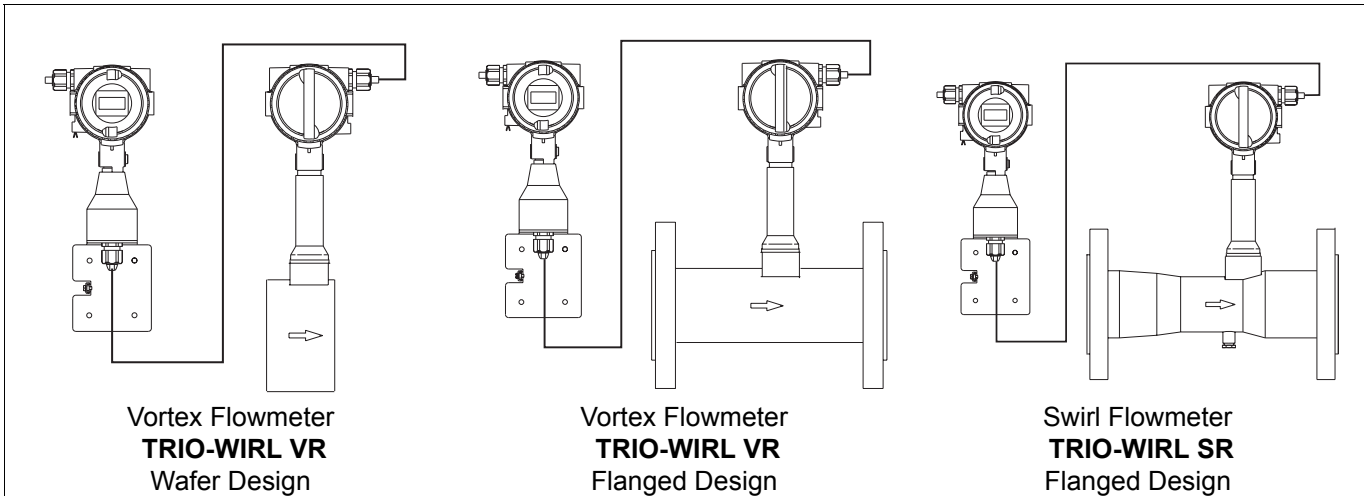
The meter body, sensor and process connections are made of 316L stainless steel or Hastalloy C. Because the meter has no moving parts, routine maintenance or recalibration is not required.

The TRIO-WIRL model and body style variations are shown in the illustrations below.

**Compact or Integral Design:** Converter mounted directly on the flowmeter primary



**Remote Mounted Design:** The converter remotely mounted up to 10m from the flowmeter primary..



## 1.2 Features

- \* No Moving Parts
- \* Common meter for liquid, gas and steam.
- \* DSP Converter with state-of-the-art digital filtering technology provides immunity to the effects of hydraulic noise and vibration.
- \* Selectable operating modes for volumetric or mass flow rate.
- \* Configuration in hazardous areas by magnetic stick without removing housing covers.
- \* Digital Communications using HART<sup>®</sup>, Profibus or Foundation Fieldbus protocols.
- \* Common sensor and electronics for all size meters
- \* Optional integrated PT100 for temperature monitoring or mass calculations
- \* High accuracy / wide turndowns

## 1.3 Organization

The remainder of this instruction manual is organized into four main sections:

- \* Swirlmeter (TRIO-WIRL S) Primaries
- \* Vortex (TRIO-WIRL V) Primaries
- \* TRIO-WIRL Converter
- \* Start-Up & Operation

Refer to the appropriate section for your meter for details on the following:

- \* Operating principles
- \* Assembly & Installation
- \* Electrical Interconnections
- \* Start-up Procedures

# CHAPTER 2 Swirlmeter (TRIO-WIRL S)

## 2.1 General

The volumetric flowrate of steam, gases and liquids can be measured over wide flow ranges independent of the fluid properties with this newest member to the Swirlmeter line.

Special features of this Swirlmeter are:

- \* Accuracy:  $\leq \pm 0.5\%$  of rate
- \* Minimal piping
- \* Wide flow range
- \* Suitable for liquids with viscosities up to 30 cst
- \* Selectable operating modes for volume and mass rates

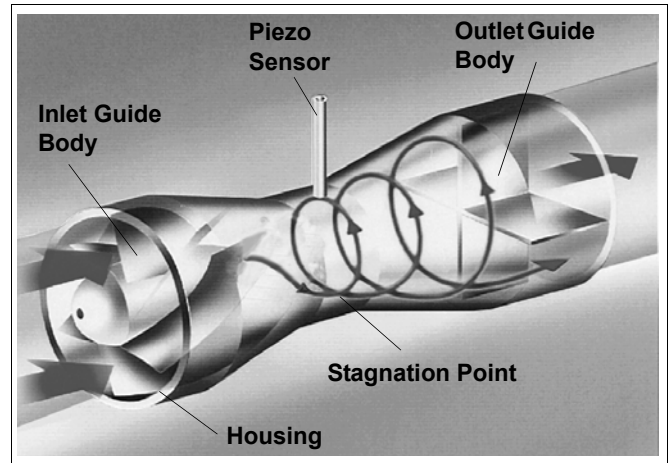


FIGURE 2-1 MEASUREMENT PRINCIPLE, TRIO-WIRL S

## 2.2 Measurement Principle

The Swirlmeter body contains stationary swirler blades at the meter inlet. The design of these blades forces the axial flow of the fluid into a rotational movement. Due to this "swirling" of the fluid, a vortex is generated at the center of the rotation and forced by a backflow into a secondary rotation whose frequency is proportional to the flow rate. The generation of the vortex is shown pictorially in Figures 2-1 & 2-2. The generated frequency is linear over a wide flow range due to the optimized internal geometry of the instrument and is measured using a piezoelectric sensor. The sensor's frequency signal is converted by the Converter electronics into a 4 - 20mA DC output current

### 2.2.1 Liquid Flow Back Pressure

In order to prevent cavitation in the meter it is necessary to maintain a minimum back pressure in the system. The required back pressure is determined using the following formula:

$$P_b > 1.3P_v + 2.6\Delta P$$

Where:

- $P_b$  = minimum required back pressure (psia)
- $P_v$  = vapor pressure of the fluid at specified conditions (psia)
- $\Delta P$  = pressure drop (psia)

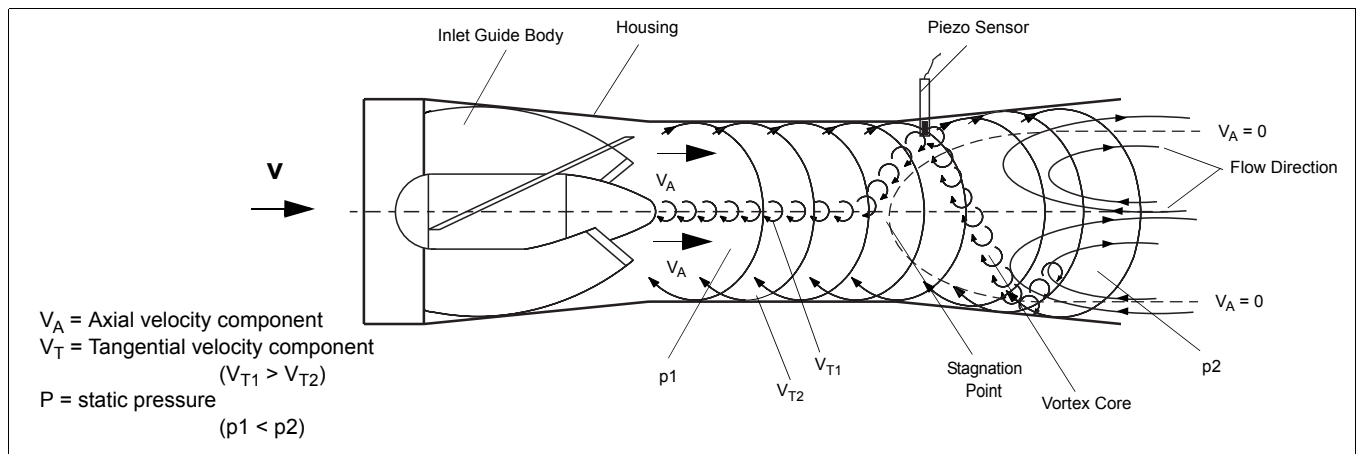


FIGURE 2-2 OPERATING PRINCIPLE, TRIO-WIRL S

## 2.3 Swirlmeter Model Number Breakdown

Refer to the ABB Inc. data sheet or the data tag on the equipment for the model number of the equipment fur-

nished. The details of a specific number are shown on the following pages.

TRIO-WIRL S			-	4	-	-	-	1	--	-	-	-	-	2	E	A	-	A	B
<b>Flowmeter Design</b>																			
Compact			T																
Remote			R																
<b>Series</b>				4															
<b>Agency Approvals / Power Supply</b>																			
None / 14 - 46V DC								0											
FM / CSA-Approval / 14 - 46V DC								3											
Others <sup>(2)</sup>								9											
<b>Process Connections</b>																			
Flanged								1											
Others								9											
<b>Fluid</b>																			
Liquid								1											
Gas								2											
Steam								3											
Oxygen <sup>(1)</sup>								6											
<b>Materials <sup>(2)</sup></b>																			
<b>Housing</b>	<b>Shedder</b>	<b>Sensor</b>																	
SS 316Ti/1.4571	SS 316Ti/1.4571	SS 316Ti/1.4571						1											
<b>Meter Sizes</b>																			
DN 15 / 1/2"																			15
DN 25 / 1"																			25
DN 32 / 1 1/4"																			32
DN 40 / 1 1/2"																			40
DN 50 / 2"																			50
DN 80 / 3"																			80
DN 100 / 4"																			1H
DN 150 / 6"																			1F
DN 200 / 8"																			2H
DN 300 / 12"																			3H
DN 400 / 16"																			4H

(1) Cleaned and suitable for Oxygen service

(2) Consult Factory

## Swirlmeter Model Number Breakdown (Cont.)

TRIO-WIRL S	-	4	-	-	-	1	--	-	-	-	-	2	E	A	-	A	B
<b>Pressure Rating</b>																	
ANSI CL 150																	Q
ANSI CL 300																	R
ANSI CL 600																	S
Other																	Z
<b>Sensor Design</b>																	
Standard, single sensor																	1
Standard, single sensor with integr. temperature sensor																	2
<b>Temperature Range Fluid/Gaskets</b>																	
Kalrez O-Ring	32 °F to 536 °F (0 °C to 280 °C)																3
Viton O-Ring	-67 °F to 446 °F (-55 °C to 230 °C) (not for steam)																4
PTFE O-Ring	-67 °F to 392 °F (-55 °C to 200 °C)																5
<b>Certificates</b>																	
None																	A
EN 10204 (DIN 50049-3.1b)																	C
<b>Communication</b>																	
With Display and HART																	2
<b>Instrument Tag</b>																	
English																	E
<b>Design Level/Software Level</b>																	
																B	
<b>Accessories</b>																	
None																	0
2" Pipe mount (only SR)																	1
<b>Operating Mode</b>																	
Continuous flowrate																	A
<b>Cable Conduit</b>																	
½" NPT																	B

## 2.4 Installation

### 2.4.1 Inspection

All equipment should be inspected for damage that may have occurred during shipment. All damage should be reported to the shipping agent. If the equipment is damaged to the extent that faulty operation may result, contact ABB Inc. before installation. Always reference the complete instrument serial number and model number in all correspondence concerning the equipment supplied.

### 2.4.2 Location & Mounting

#### 2.4.2.1 Installation

The Swirlmeter may be installed at virtually any location in a pipeline. The meter may be installed at any angle and is available in a flange style body that mounts between adjacent pipe flanges of the process piping. Since the meter is unidirectional, it must be oriented in accordance with the direction of the process flow. A flow direction arrow is provided on the meter body to assure correct orientation.

Take care to observe the following guidelines:

- \* Do not exceed the ambient temperature requirements
- \* Observe the recommended inlet and outlet straight sections piping requirements (Refer to Figure 2-3).
- \* Make sure the flow direction corresponds to the direction indicated by the arrow on the flowmeter primary.
- \* Make sure that the required minimum distance for removing the converter and exchanging sensors is provided.
- \* The inside diameters of the flowmeter primary and the pipeline should be identical.
- \* Pressure fluctuations at zero flowrate in long pipelines should be eliminated by installing intermediate gate valves.
- \* Flow pulsations resulting from piston pump or compressor operation should be reduced by using appropriate dampeners.
- \* When metering liquids, the flowmeter primary must always be completely filled with fluid and cannot drain.
- \* For high fluid temperatures the flowmeter primary is installed so that the electronic assembly is

mounted at the side or bottom of the flowmeter (Refer to Figure 2-7).

- \* If the possibility of gas bubble formation exists, gas separators should be provided.
- \* Assuming a properly supported pipeline and the converter's DSP signal processing technology, vibration problems should not be encountered in normal industrial applications. However, it is good practice to minimize mechanical vibrations using supports if required. When installing in long pipelines which have a tendency to vibrate, eliminators should be installed upstream and downstream of the flowmeter.
- \* In vertical and sloping installations, the electrical conduit entries should face downward to retard the entry of condensation.

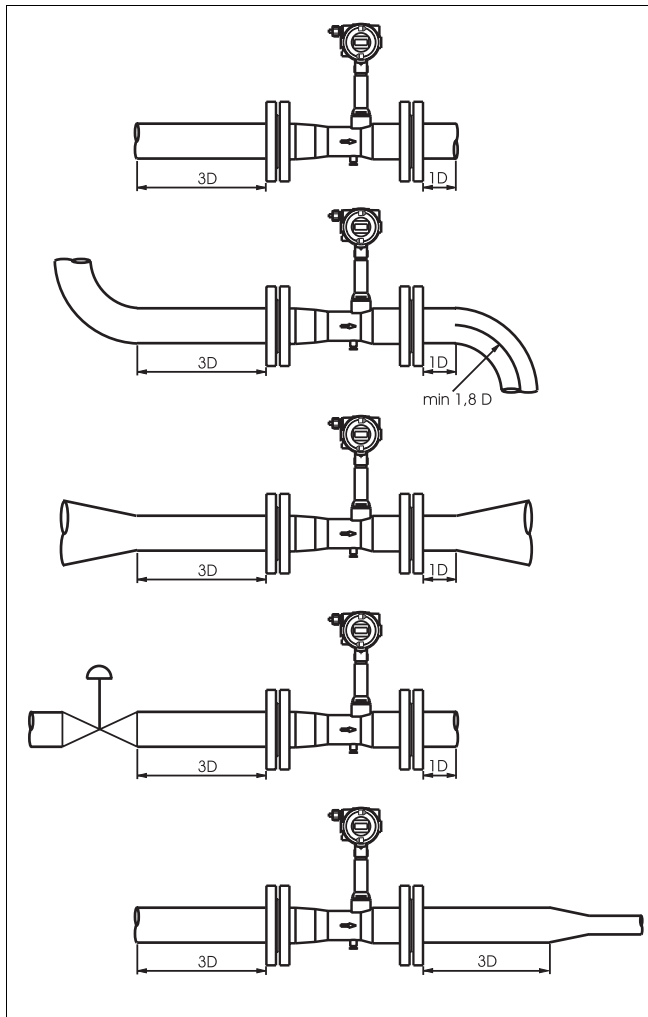
#### 2.4.2.2 Recommended Inlet & Outlet Sections

Due to the measurement principles of the Swirl Flowmeter it can be installed with very minimal inlet and outlet straight section lengths. Strainers and flow straighteners are not required. Figure 2-3 shows the recommended lengths for the inlet and outlet straight sections for various installation conditions. No inlet and outlet straight sections are required when single or double elbows are installed upstream or downstream from the flowmeter primary when the radius of the elbow is greater than  $1.8 \times D$ .

To assure optimum meter performance, the meter should be installed in accordance with the upstream and downstream straight run piping requirements shown in Figure 2-3. The straight run piping should be schedule 80 or lighter pipe. Process flanges should be raised face.

Remove the covers used to protect the meter inlet and outlet surfaces from damage during shipment.

Place the two flange gaskets (supplied) against the upstream and downstream flange faces (Refer to Table 7-5 for replacement flange gaskets). Align the gasket holes with the flange hole pattern. When installing the flange gaskets, make sure that the gaskets fit properly and are aligned properly so that they don't project into the pipe line causing an alteration of the flow profile. A change in flow profile can adversely affect meter accuracy.



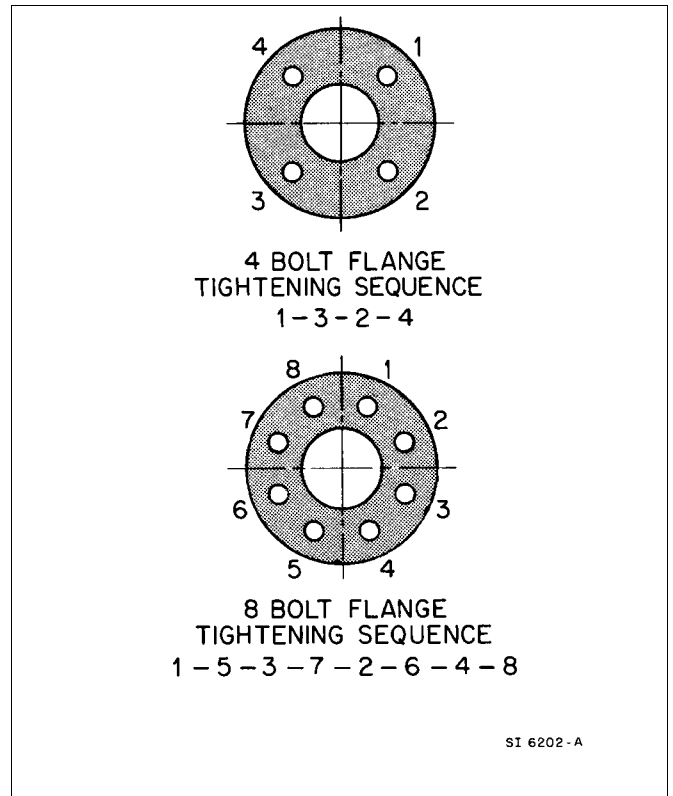
**FIGURE 2-3 METER PIPING REQUIREMENTS**

**Mounting bolts and nuts are supplied by the user.** During installation, make certain that the flow direction arrow on the meter body is oriented in accordance with the process flow.

With the meter safely supported, install the bolts through the meter and process flanges. Bolts and nuts should be lubricated with a graphite based lubricant. Assemble the nuts to the bolts hand tight. Tighten the flange nuts in a diagonal or "star" pattern as shown in Figure 2-4 to equalize pressure on the flange face and gaskets. Bolt/nut torque should be limited to that which will provide a leakproof seal.

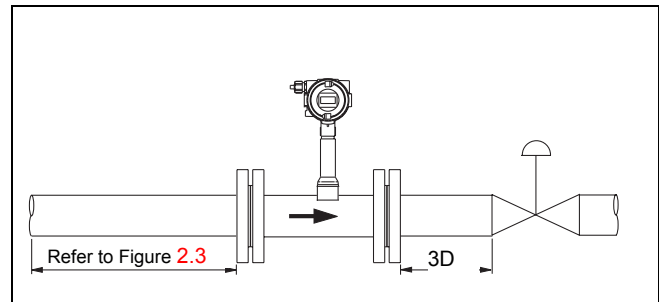
**2.4.2.3 Control Valve Installation**

Control valves should preferably be installed downstream from the flowmeter as shown in Figure 2-5.



**FIGURE 2-4 RECOMMENDED FLANGE BOLT TIGHTENING SEQUENCE**

When this is not possible, the control valve should be located  $\geq 3D$  upstream of the flowmeter.



**FIGURE 2-5 CONTROL VALVE INSTALLATION**

**2.4.2.4 Extreme Temperature Applications**

For process temperatures above 160° F (71° C) or below 0° F (-18° C), it is critical that the meter be pressurized and placed into service gradually, i.e., with sufficient time delay to minimize thermal shock. Steam should be introduced gradually so that the meter is brought up to operating temperature over a ten to fifteen minute period.

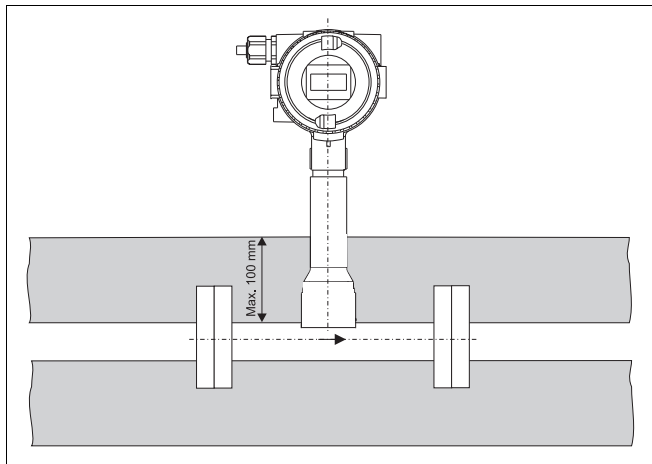


**WARNING**  
**WHEN THE METER IS USED IN A VERY HIGH OR LOW TEMPERATURE PROCESS, THE TEMPERATURE OF THE METER BODY MAY BE EXTREMELY HOT OR COLD. IF IT IS NECESSARY TO TOUCH THE SENSOR HOUSING OR METER BODY, INSULATED GLOVES MUST BE WORN TO PREVENT SERIOUS INJURY.**

**INSULATING THE SWIRLMETER**

The flowmeter primary can be insulated to a max. thickness of 4 inches (100 mm) [Refer to Figure 2-6].

**CAUTION**  
 THE PIPELINE AND METER BODY MAY BE INSULATED BY THE USER UP TO A THICKNESS OF 4 IN. (100 MM) BUT THE METER INTERCONNECTION WIRING BOX AND SENSOR HOUSING TOWER MUST NOT BE INSULATED. AMBIENT AIR IS REQUIRED TO DISSIPATE HEAT OR COLD BUILD-UP WITHIN THE INTERCONNECTION WIRING BOX.

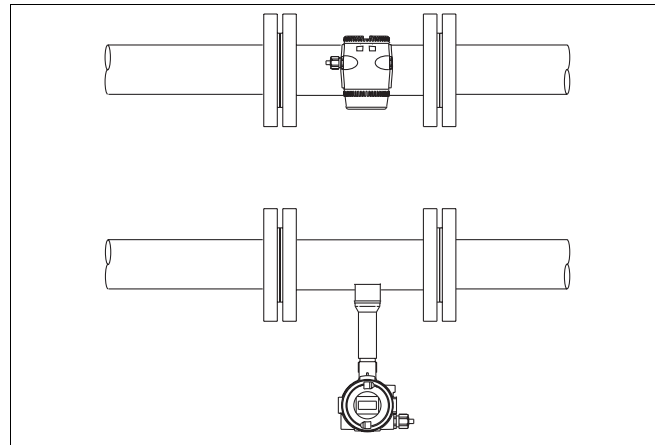


**FIGURE 2-6 INSULATING THE PIPELINE**

**FLOWMETER PRIMARY INSTALLATIONS FOR FLUID TEMPERATURES > 300° F (150° C)**

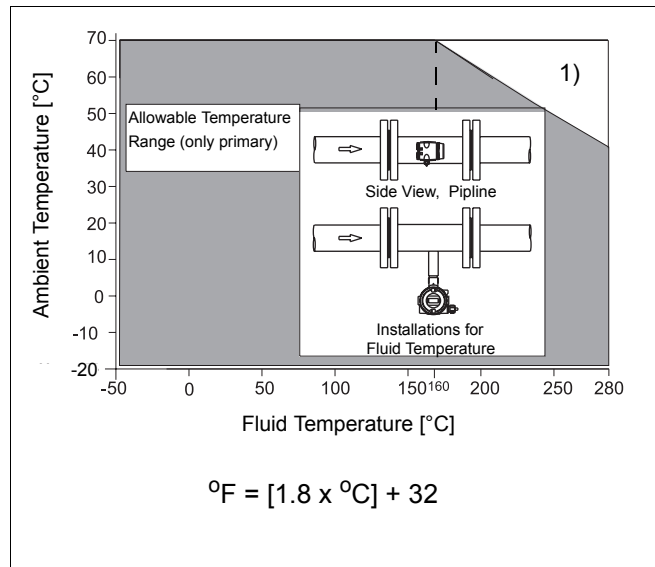
In horizontal installations, when process temperatures above 300° F (150° C) are encountered, the meter must be oriented so that the junction box is located to the side or below meter body, not above.

Refer to Figure 2-7 for an example of the recommended high-temperature application orientation.



**FIGURE 2-7 ORIENTATION FOR TEMPERATURES >300° F (150° C)**

**NOTE:** The interrelationship between the fluid and ambient temperatures must be considered (Refer to Figure 2-8).



**FIGURE 2-8 AMBIENT/FLUID TEMPERATURE RELATIONSHIP**

1) Cables suitable for use to 230° F (110°C) can be used for power supply terminals 31 & 32 and contact output terminals 41 & 42 without any reduction in the temperature range specifications. Cables suitable only for temperatures of 175° F (80°C) reduce the temperature range of the flowmeter as shown in Figure 2-8.

### 2.4.3 Temperature/Pressure Monitoring

Provisions for temperature and/or pressure monitoring are the responsibility of the user. The temperature sensor should be located a minimum of three pipe diameters downstream of the flowmeter. Measurement is from the downstream face of the meter.

An option is available for the Swirlmeter for direct Pt100 temperature measurements. These temperature measurements can be used to monitor the fluid temperature or for the measurement of saturated steam in mass units. The pressure tap is located in the Swirlmeter body as shown in Figure 2-9.

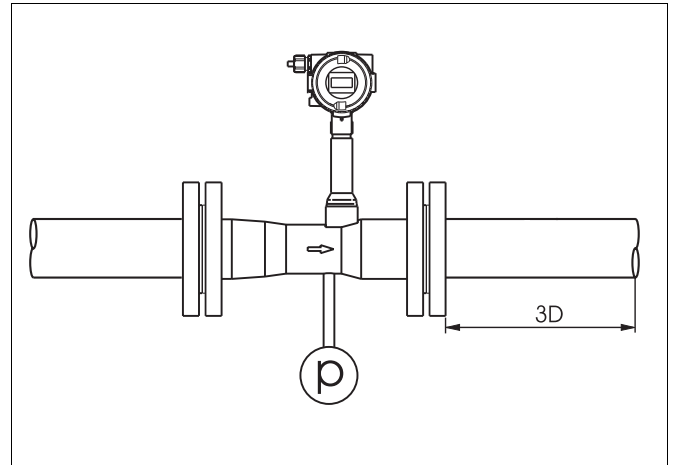


FIGURE 2-9 MEASURING PRESSURE

## 2.5 Swirlmeter Size Selection

### 2.5.1 Gas

The maximum required flowrate should not be less than  $0.5 \times Q_{vmax}$  if possible, but can be set as low as  $0.15 Q_{vmax}$  if required

The flowmeter size selection is made using the **maximum actual volume flowrate (Q<sub>v</sub>)**, at operating conditions. If the flowrate to be metered is expressed as a standard flowrate (conditions = 14.7 psia, 70°F) or as a mass flowrate, it will be necessary to first convert these values to their equivalent actual volume flowrate at operating conditions before selecting the most suitable flowmeter size from the Flow Range Table below..

TABLE 2-1. SWIRL FLOW RANGES, AIR

Meter Size		Flow Range [acfh]		Frequency [Hz] at Q <sub>vmax</sub>
Inch	DN	Q <sub>vmin</sub>	Q <sub>vmax</sub>	
1/2	15	90	565	1900
1	25	180	1770	1200
1-1/4	32	290	4600	1300
1-1/2	40	430	7070	1400
2	50	640	12370	1200
3	80	2120	30020	690
4	100	2350	52980	700
6	150	5500	127140	470
8	200	8830	173050	330
12	300	18720	353150	160
16	400	37090	706300	150

Air at 70 °F, 14.7 psi,  $\rho = 0.075 \text{ lb/ft}^3$

#### 2.5.1.1 Q<sub>vmin</sub> for Gases with $\rho < 0.0749 \text{ lb/ft}^3$

The minimum actual volume flowrate Q<sub>vmin</sub> for gases with lower densities can be calculated using the following equations.

$$Q'_{vmin} = Q_{vmin} \sqrt{\frac{0.0749}{\rho}}$$

Q<sub>vmin</sub> Min. volume flowrate from Table 2-1  
 $\rho$  Density at operating conditions lb/ft<sup>3</sup>

#### 1. Convert standard density( $\rho_s$ ) to operating density ( $\rho$ )

$$\rho = \rho_s \times \frac{14.7 + p}{14.7} \times \frac{530}{460 + T}$$

#### 2. Convert to actual volume flowrate (Q<sub>v</sub>)

a) Starting from standard flowrate (Q<sub>s</sub>) to

$$Q_V = Q_s \frac{14.7}{14.7 + p} \times \frac{460 + T}{530} = \frac{\rho_s}{\rho} \times Q_s$$

b) Starting from mass flowrate (Q<sub>m</sub>) to Q<sub>v</sub>

$$Q_V = \frac{Q_m}{\rho}$$

#### 3. Dynamic Viscosity, $\mu$ (cps) to kinematic viscosity, $\nu$ (cst)

$$\nu = \frac{\mu}{\rho}$$

- $\rho$  = Density at operating conditions [lb/ft<sup>3</sup>]
- $\rho_s$  = Density at standard conditions [lb/ft<sup>3</sup>]
- $p$  = Pressure at operating conditions [psig]
- $T$  = Temperature at operating conditions [°F]
- $Q_v$  = Actual volume flowrate [acfh]
- $Q_s$  = standard flowrate [scfh]
- $Q_m$  = Mass flowrate [lb/h]

**2.5.1.2 Example for Gases:**

Determine the flowmeter size for metering 35,000 scf/h ( $Q_s$ ) carbon dioxide; temp. = 100 °F, press. = 70 psig.

$\rho_s = 0.123 \text{ lb/ft}^3$  (CO<sub>2</sub>, see Table 2-2)

1. Convert  $\rho_s$  to  $\rho$ :

$$\rho = 0.123 \left[ \frac{14.7 + 70}{14.7} \times \frac{530}{460 + 100} \right] = 0.67 \text{ lb/ft}^3$$

2. Convert from  $Q_s$  (ft<sup>3</sup>/h) to  $Q_v$  (ft<sup>3</sup>/h) :

$$Q_v = 35060 \times \frac{0.123}{0.67} = 6425 \text{ acfh}$$

Refer to Table 2-1 to see that a 1-1/2" / DN 40 meter has the following flow range: 430 to 7070 acfh

3. Using Figure 2-10, find the pressure drop at  $Q_v = 6425 \text{ ft}^3/\text{h}$  and  $\rho = 0.67 \text{ lb/ft}^3$ :

$$\Delta p' = \frac{0.67}{0.0749} \times 0.85 = 7.6 \text{ psi}$$

**TABLE 2-2. STANDARD DENSITIES FOR SELECTED GASES**

Gas	Standard Density [lb/ft <sup>3</sup> ]
Acetylene	0.0732
Air	0.0749
Ammonia	0.0481
Argon	0.1111
Butane	0.1686
Carbon Dioxide	0.1230
Carbon Monoxide	0.0780
Ethane	0.0843
Ethylene	0.0787
Hydrogen	0.0056
Methane	0.0448
Natural Gas	0.045
Neon	0.0556
Nitrogen	0.0780
Oxygen	0.0893
Propane	0.1261
Propylene	0.1196

**2.5.1.3 Pressure Drop, Gas & Steam (psi)**

Refer to Figure 2-10 for air ( @70° F, 14.7 psi,  $\rho=0.075 \text{ lb/ft}^3$  ). For other fluid densities the pressure drop can be calculated using the following equation:

$$\Delta p' = \frac{\rho}{0.075} \times \Delta p$$

$\Delta p'$  = Fluid pressure drop [psi]

$\Delta p$  = Air pressure drop (from Figure 2-10) [psi]

$\rho$  = Fluid density [lb/ft<sup>3</sup>] (at operating conditions)

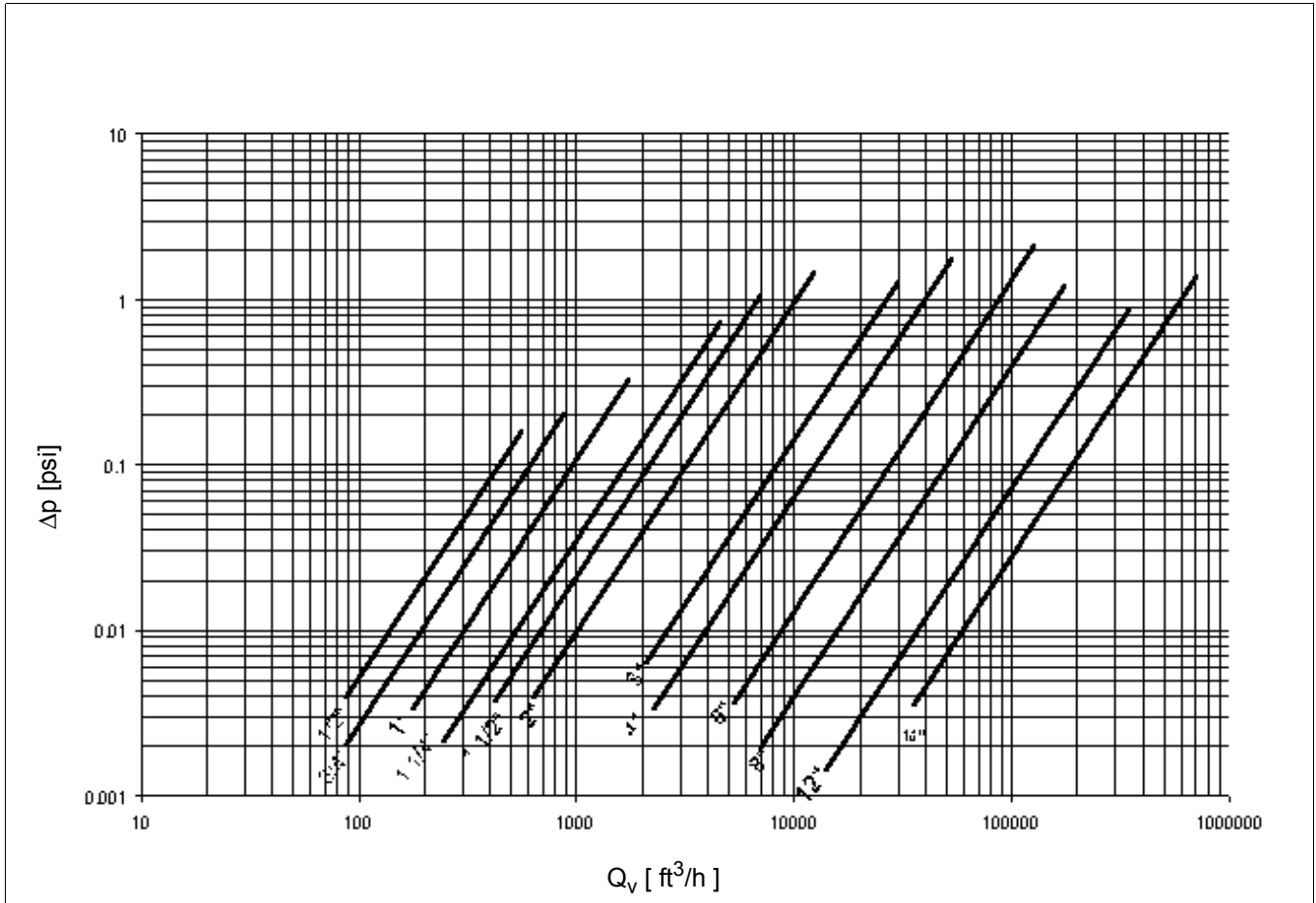


FIGURE 2-10 PRESSURE DROP, AIR ( @70° F, 14.7 PSI, P=0.075 LB/FT<sup>3</sup> )

### 2.5.2 Liquid

The maximum required flowrate should not be less than 0.5 x Qvmax if possible, but can be set as low as 0.15 Qvmax if required.

**TABLE 2-3. SWIRL FLOW RANGES, LIQUID**

Meter Size		Flow Range GPH		Frequency at Qvmax [Hz]	Re min
Inch	DN	Qvmin	Qvmax		
1/2	15	30	420	185	2100
1	25	120	1560	135	5200
1-1/4	32	240	2640	107	7600
1-1/2	40	420	4200	110	13500
2	50	660	6600	90	17300
3	80	1320	26400	78	15000
4	100	2100	39600	77	17500
6	150	4740	97800	50	35000
8	200	6600	132000	30	44000
12	300	26400	264000	16	118000
16	400	47400	475500	13	160000

**1. Convert mass flowrate Qm to actual volume flowrate Qv:**

$$Q_v = \frac{Q_m}{\rho}$$

$\rho$  = Operating density [lb/ft<sup>3</sup>]

$Q_v$  = Actual volume flowrate [ft<sup>3</sup>/h]

$Q_m$  = Mass flowrate [lb/h]

**2. Pressure Drop [psi]**

See Figure 2-11 for water ( $\rho = 8.34$  lb/gal)

For other fluid densities the pressure drop can be calculated using the following equation:

$$\Delta p' = \frac{\rho}{8.34} \times \Delta p$$

$\Delta p'$  = Pressure drop fluid [psi]

$\Delta p$  = Pressure drop water [psi] (from Figure 2-11)

$\rho$  = Fluid density [lb/gal] (at operating conditions)

**3. Static Pressure**

To prevent cavitation when metering liquids a positive static pressure (back pressure) is required. Its value can be estimated using the following equation:

$$p_2 \geq (1.3 \times p_{Vapor}) + (2.6 \times \Delta p')$$

$p_2$  = Positive downstream static pressure [psia]

$p_{Vapor}$  = Fluid vapor pressure at operating temperature [psia]

$\Delta p'$  = Fluid pressure drop [psia]

**2.5.2.1 Example for Liquids:**

Determine the flowmeter size and pressure drop for metering 18000 gph liquid with a density of 7.50 lb/gal.

1. Refer to Table 2-3 to see 3" DN 80 meter has a range of 1320 - 26400 gph

2. Using Figure 2-11, find pressure drop at  $Q_v = 18000$  gph and  $\rho = 7.50$  lb/gal

$$\Delta p' = \frac{7.5}{8.34} \cdot 7 \text{ psi} = 6.3 \text{ psi}$$

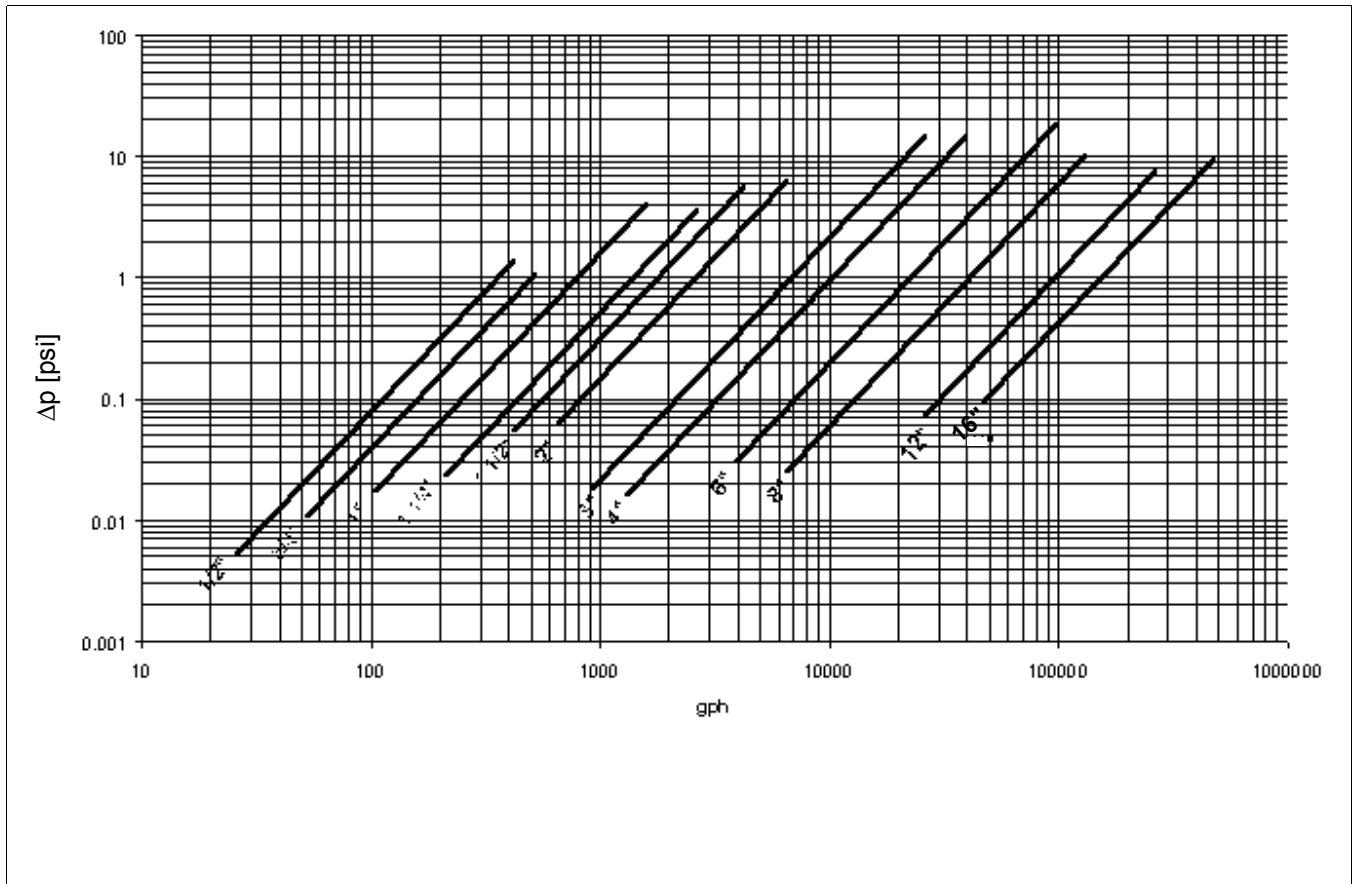


FIGURE 2-11 PRESSURE DROP, WATER ( @ P = 8.34 LB/GAL )

## 2.5.3 Saturated Steam [lb/h]

### 2.5.3.1 Example for Saturated Steam:

Find the flow range for a 2" /DN50 meter size at 60 psig.

1. Table 2-4 shows the range for a 2" / DN50 meter is 110 - 2120 lb/h (always use the next highest pressure rating).

Additional information: Sat. steam temp.= 307 °F

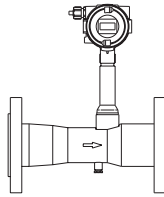
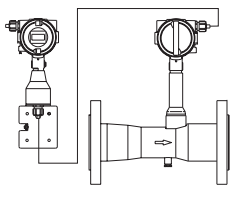
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**TABLE 2-4. SWIRL FLOW RANGES, SATURATED STEAM**

Meter Size		[psig]	15	30	60	100	125	150	200	250	300
Inch	DN										
1/2	15	min	5	10	15	25	30	35	45	55	60
		max	40	60	100	145	145	205	265	325	385
1	25	min	15	20	30	45	55	65	85	105	125
		max	130	190	305	455	550	645	830	1015	1205
1-1/4	32	min	20	30	50	75	90	105	135	165	200
		max	330	490	790	1175	1425	1675	2160	2640	3125
1-1/2	40	min	30	45	75	110	135	160	205	250	295
		max	510	750	1215	1805	2190	2575	3315	4060	4800
2	50	min	45	70	110	165	200	235	300	370	435
		max	890	1310	2130	3155	3830	4505	5805	7100	8400
3	80	min	155	225	365	540	660	775	995	1220	1440
		max	2160	3185	5165	7655	9310	10930	14080	17230	20385
4	100	min	170	250	405	600	730	855	1105	1350	1600
		max	3815	5615	9115	13510	16425	19285	24850	30410	35975
6	150	min	400	585	945	1405	1705	2005	2580	3160	3735
		max	9155	13480	21870	32420	39415	46280	59630	72980	86330
8	200	min	635	935	1520	2255	2740	3215	4140	5070	6000
		max	12460	18345	29765	44130	53650	62990	81160	99330	117500
12	300	min	1350	1985	3220	4775	5805	6815	8780	10745	12710
		max	25430	37435	60745	90055	109480	128550	165630	202710	239790
16	400	min	2670	3935	6380	9460	11500	13500	17395	21290	25185
		max	50855	74870	121485	180110	218955	257095	331255	405415	479580
Density	$\rho_{\text{sat}}$ [lb/ft <sup>3</sup> ]		0.072	0.106	0.172	0.255	0.31	0.364	0.469	0.574	0.679
Temp.	T <sub>sat</sub> [°F]		250	275	307	338	353	366	388	406	422

## 2.6 Specifications

### 2.6.1 Model Overview

		 <b>ST4000</b>	 <b>SR4000</b>
<b>MODEL</b>			
Accuracy	Liquids	≤ ± 0.5 % of rate	
	Gases and Steam	≤ ± 0.5 % of rate	
Reproducibility		≤ ± 0.2 % of rate	
Allowable viscosity for liquids		to 2"/DN50 ≤ 10 cps	
		≥ 3"/DN80 ≤ 30 cps	
Typical flow range		1:18	
Typical up-/downstream straight lengths		3 x D / 1 x D	
<b>Flowmeter Primary</b>			
Process Connections	Flanges (DIN, ANSI, JIS)	1/2"-16"/DN15-DN400	
Sensor Design	Single sensor	YES, optional with integrated temperature measurement	
Fluid Temperature	Standard	-67 °F to 536 °F	
Protection Class		NEMA 4X (IP67)	
Materials	Sensor	316Ti/1.4571 or Hast C	
	Inlet/Outlet Body Guide	1.4571 opt. Hast. C	
	Meter Housing	316Ti/1.4571/CF3M or Hast C	
	Sensor Gasket	Kalrez, Viton, PTFE	
<b>Approvals / Certifications</b>			
Intrinsically Safe & Explosion-Proof Design	FM / CSA Approved	Explosion-Proof Class I; Division 1; Groups B-D Intrinsically Safe Class I; Division 1; Groups A-D Non-Incendive for Class I; Division 2; Groups A-D Dust Ignition Proof Class II; Division 1; Groups E-G	



## 2.6.2 Detailed Specifications

### ACCURACY & REPRODUCIBILITY OF FLOW MEASUREMENT

Accuracy (incl. converter):  $\leq \pm 0.5\%$  of rate  
(at reference conditions)  
Reproducibility:  $\leq 0.2\%$  of rate

### ACCURACY & REPRODUCIBILITY OF THE TEMPERATURE MEASUREMENT

Accuracy (incl. converter):  $\leq \pm 2^{\circ}\text{C}$  /  $\leq \pm 3.6^{\circ}\text{F}$   
Reproducibility:  $\leq 0.2\%$  of rate

### OVERRANGE:

Gases: 15% over maximum flowrate  
Liquids: 15% over maximum flowrate

Note: Cavitation may not occur.

### OPERATING PRESSURE:

Flanged Design: ANSI CL 150/300/600, options to CL 900

### CONNECTIONS:

Process Connections: Flanges per ANSI or other upon request

Electrical Connections: Screw terminals, Connector NPT 1/2" (w/o cable connector)

### PROTECTION CLASS:

NEMA 4X (IP67)

### MATERIALS:

Housing: SS 316  
Option: Hastelloy-C

Flanges: SS 316 Ti/No. 1.4571,  
Option: Hastelloy-C

In-Outlet Guide Body: SS 316 Ti/No. 1.4571  
Option: Hastelloy-C

Sensor: SS 316 Ti/No. 1.4571,  
Option: Hastelloy-C

Sensor Gaskets:

Kalrez O-ring: 32°F to 536°F (0°C to 280°C)  
Viton O-ring: -67°F to 446°F (-55°C to 230°C)  
PTFE O-ring: -67°F to 392°F (-55°C to 200°C)

Converter Housing: Cast Aluminum, painted.

### WEIGHTS:

Refer to the dimensional outline drawing (Figure 2-14)

### FLUID TEMPERATURE:

- 67°F to 536°F (-55°C to +280°C) (Standard)

Allowable temperature range for the gasket material must be considered. The flange gaskets supplied with the meter are KLINGERSil material. These gaskets are rated to a temperature of 536 °F (280 °C) for liquid applications and 450 °F (232 °C) for gas & steam applications, at internal pressures of 400 psi max.

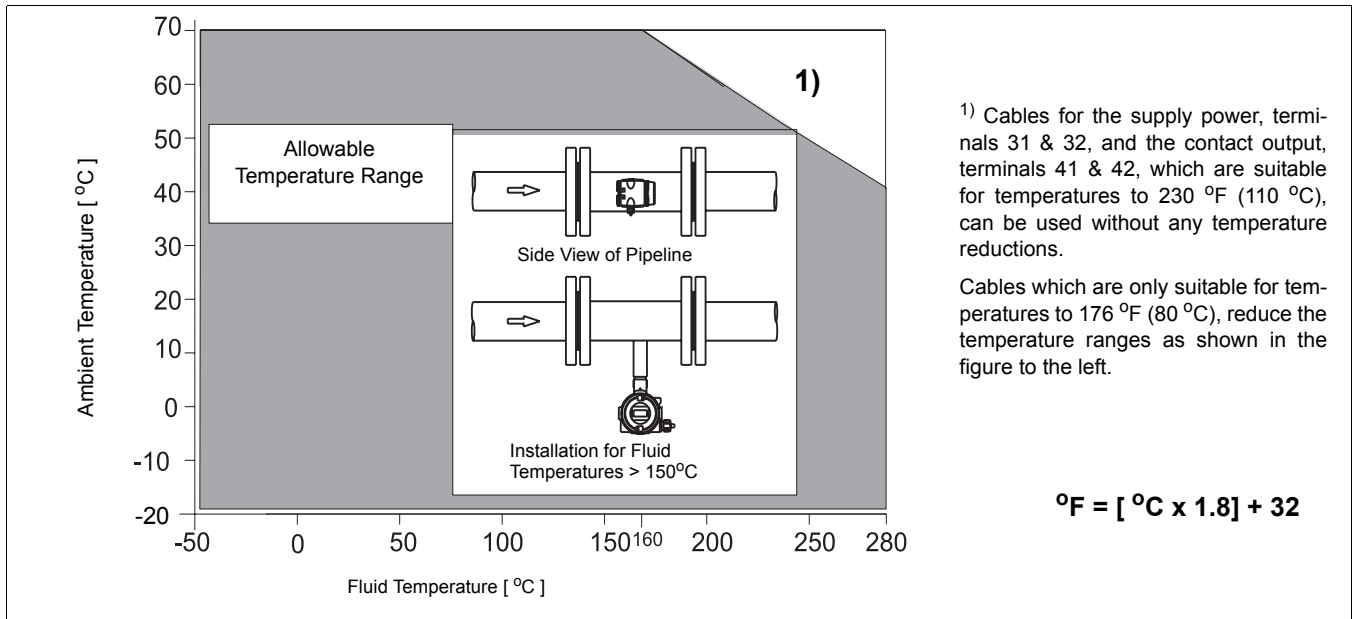
### AMBIENT CONDITIONS:

Climate Resistance (per DIN 40040): GSG  
Relative humidity: 95% Max.  
100% with cover in place

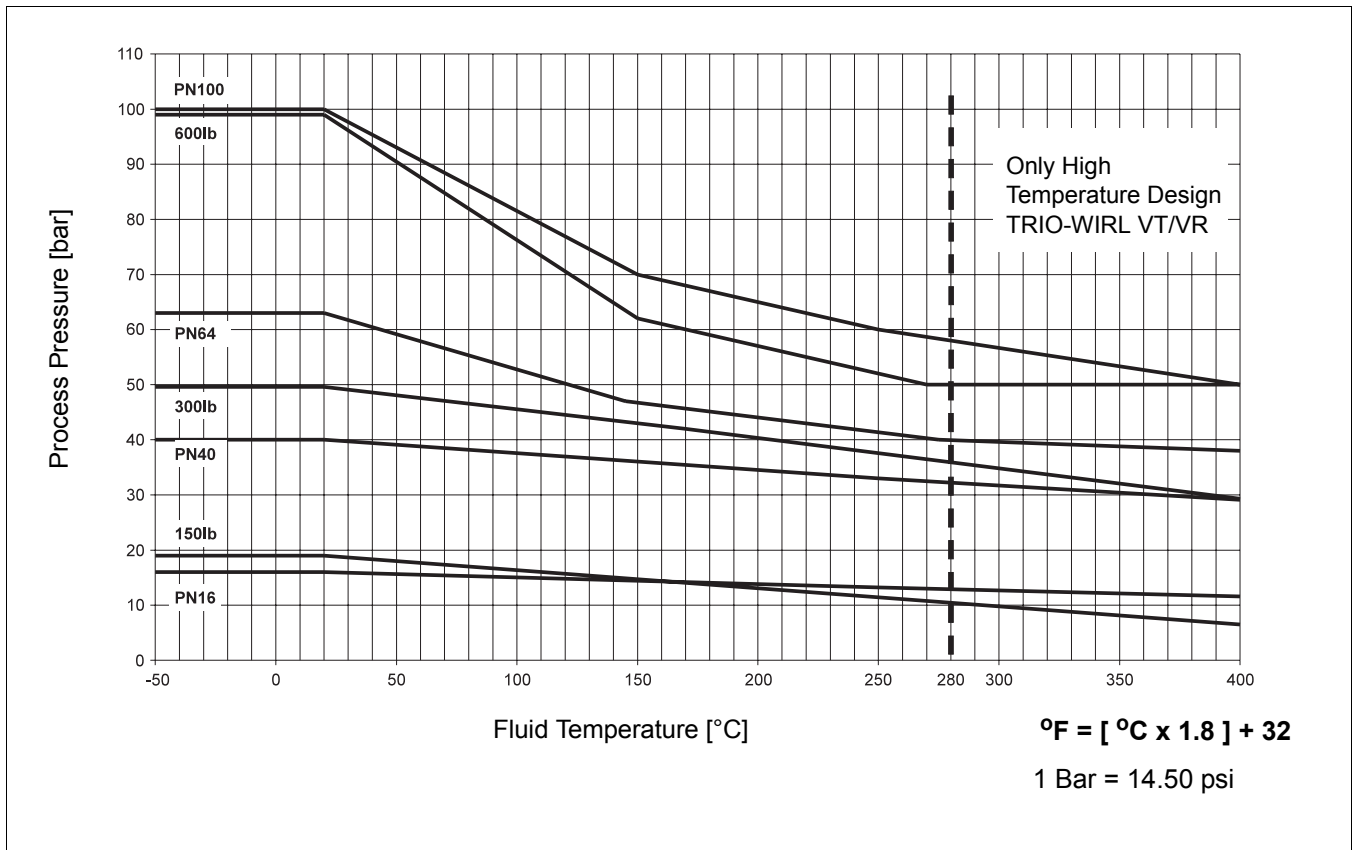
### AMBIENT TEMPERATURE:

-4°F ( -20°C ) to 158°F ( 70°C )

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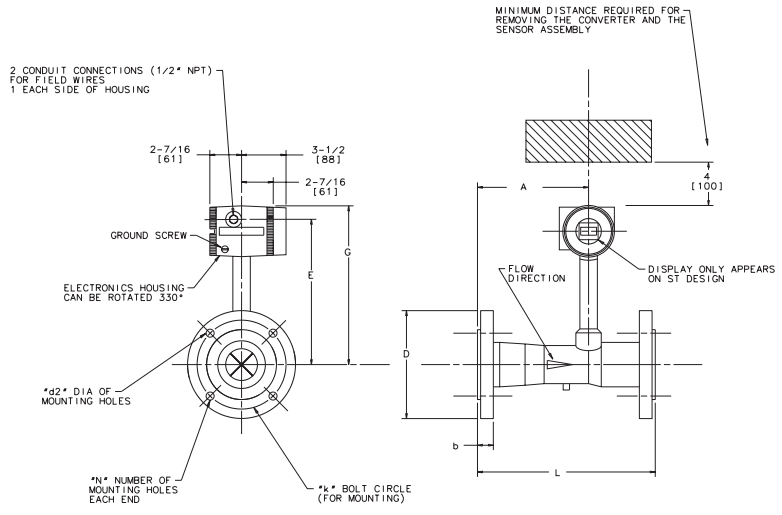
**FIGURE 2-12 AMBIENT / FLUID TEMPERATURE RELATIONSHIP**



**FIGURE 2-13 PROCESS PRESSURE vs. PROCESS FLUID TEMPERATURE**

**FIGURE 2-14 OUTLINE DIMENSIONS, ST/SR PRIMARY**

METER SIZE	ANSI RATING	∅D	L	A	G	E	b	k	d2	N	WEIGHT lb[kg]
1/2 [12]	150	3-1/2 [88.9]	7-7/8 [200]	3-17/64 [83]	12-9/16 [319]	11-13/16 [300]	7/16 [11]	2-3/8 [60.3]	5/8 [16]	4	11-3/4 [30.3]
	300	3-3/4 [95.3]					9/16 [14.3]	2-5/8 [66.7]			12-3/4 [32.8]
	600	3.75 [95.3]									
3/4 [20]	150	3-7/8 [98.4]	4-25/32 [120]	2-43/64 [68]	12-43/64 [322]	11-59/64 [303]	1/2 [12.7]	2-3/4 [70]	5/8 [16]	4	4-3/4 [2.1]
	300	4-5/8 [117.5]					5/8 [16]	3-1/4 [82.6]	3/4 [19]		6-3/4 [3]
	600	4-5/8 [117.5]									
1 [25]	150	4-1/4 [108]	5-29/32 [150]	3-5/32 [80]	13-13/16 [351]	4-57/64 [302]	9/16 [14.3]	3-1/8 [79.4]	5/8 [16]	4	7-1/2 [3.4]
	300	4-7/8 [125.8]					11/16 [17.5]	3-1/2 [88.9]	3/4 [19]		8 [3.6]
	600	4-7/8 [125.8]									
1-1/4 [32]	150	4-5/8 [117.5]	5-29/32 [150]	3-35/64 [90]	12-9/16 [319]	11-13/16 [300]	5/8 [16]	3-1/2 [89]	5/8 [16]	4	8-1/4 [3.7]
	300	5-1/4 [133.4]					3/4 [19]	3-7/8 [98.4]	3/4 [19]		12 [5.4]
	600	5-1/4 [133.4]					13/16 [20.6]	3-7/8 [98.4]			
1-1/2 [40]	150	5 [127]	7-7/8 [200]	4-21/64 [110]	12-43/32 [323]	11-31/64 [304]	11/16 [17.5]	3-7/8 [98.4]	5/8 [16]	4	15 [6.8]
	300	6-1/8 [155.6]					13/16 [20.6]	4-1/2 [114.3]	7/8 [22]		19-3/4 [8.9]
	600	6-1/8 [155.6]					7/8 [22]				
2 [50]	150	6 [152.4]	7-7/8 [200]	5 [127]	12-13/64 [310]	11-29/64 [291]	3/4 [19]	4-3/4 [119.4]	3/4 [19]	8	18-3/4 [7.1]
	300	6-1/2 [165.1]					7/8 [220]	5 [127]			21-1/2 [9.8]
	600	6-1/2 [165.1]					1 [25.4]				
3 [80]	150	7-1/2 [190.5]	11-13/16 [300]	7-19/32 [193]	12-55/64 [329]	12-13/64 [310]	5/16 [24]	6 [152.4]	3/4 [19]	8	25-3/4 [11.7]
	300	8-1/4 [209.6]					1-7/8 [28.6]	6-5/8 [168.3]	7/8 [22]		35-3/4 [16.2]
	600	8-1/4 [209.6]					1-1/4 [28.6]				
4 [100]	150	9 [228.6]	13-25/32 [350]	8-55/64 [225]	12-23/32 [323]	12-23/64 [314]	15/16 [24]	7-1/2 [190.5]	3/4 [19]	8	39-3/4 [18]
	300	10 [254]					1-1/4 [32]	7-7/8 [200]	7/8 [22]		60-1/2 [18]
	600	10-3/4 [273]					1-1/2 [38.1]	8-1/2 [216]	1 [25.4]		
6 [150]	150	11 [279.4]	18-7/8 [480]	12-29/32 [328]	14-1/16 [357]	13-5/16 [338]	9-1/2 [241.3]	10-5/8 [269.9]	7/8 [22]	12	66 [30]
	300	12-1/2 [317.5]					1-7/16 [36.5]	11-1/2 [292]	1-1/8 [28.6]		101-1/4 [46]
	600	14 [355.6]					1-7/8 [47.6]	11-1/2 [292]	1-1/8 [28.6]		
8 [200]	150	13-1/2 [342.9]	23-5/8 [600]	17-5/32 [436]	14-27/32 [377]	14-3/32 [358]	1-1/8 [28.6]	11-3/4 [298.5]	7/8 [22]	8	89 [45]
	300	15 [381]					1-5/8 [41.3]	13 [330.2]	1 [25.4]		165 [75]
	600	16-1/2 [419.1]					2-3/16 [62]	13-3/4 [349]	1-1/4 [32]		
12 [300]	150	19 [482.6]	39-3/8 [1000]	26-1/16 [662]	16-21/32 [423]	15-29/32 [404]	1-1/4 [32]	17 [432]	1 [25.4]	12	400-1/2 [182]
16 [400]	150	23-1/2 [596.9]	50 [1270]	33-7/64 [841]	18-1/16 [459]	17-21/64 [440]	1-7/16 [36.5]	21-1/4 [540]	1-1/8 [28.6]	16	572 [260]



- NOTES
- 1) ALL DIMENSIONS ARE IN INCHES. DIMENSIONS IN PARENTHESIS [ ] ARE IN MILLIMETERS [mm].
  - 2) DIMENSIONS ARE GUARANTEED ONLY IF THIS PRINT IS CERTIFIED.
  - 3) THIS DRAWING IS A THIRD ANGLE PROJECTION AS SHOWN.
  - 4) FLANGE BOLT HOLES STRADDLE CENTERLINES.
  - 5) FLOW MUST BE IN SAME DIRECTION AS FLOW ARROW.
  - 6) METER MUST BE COMPLETELY FILLED WITH LIQUID TO INSURE ACCURACY.
  - 7) ALL DIMENSIONS SUBJECT TO MANUFACTURING TOLERANCES OF +/-1/8 [3] .

REF. OD-10-2829\_r0

## CHAPTER 3 Vortex Meter (TRIO-WIRL V)

### 3.1 General

The volumetric flowrate of steam, gases and liquids can be measured over wide flow ranges independent of the fluid properties with this newest member to the Vortex Meter line.

Special features of this Vortex meter are:

- \* Accuracy: Liquids:  $\leq \pm 0.75\%$  of rate  
Gas/Steam:  $\leq \pm 1\%$  of rate
- \* Rugged and simple flowmeter primary design.
- \* Wafer design.
- \* High temperature design to 400°C (750°F).
- \* High pressure design to ANSI CL 900.
- \* operating modes for volume and mass rate

### 3.2 Measurement Principle

The operation of the TRIO-WIRL V vortex meter is based on the Karman Vortex Street. Vortices are formed as the fluid flows around a shedder body. These vortices are alternately shed from the sides of the shedder body. The fluid flow causes these vortices to be released forming a "vortex street" (Karman Vortex Street), refer to Figures 3-1 & 3-3.

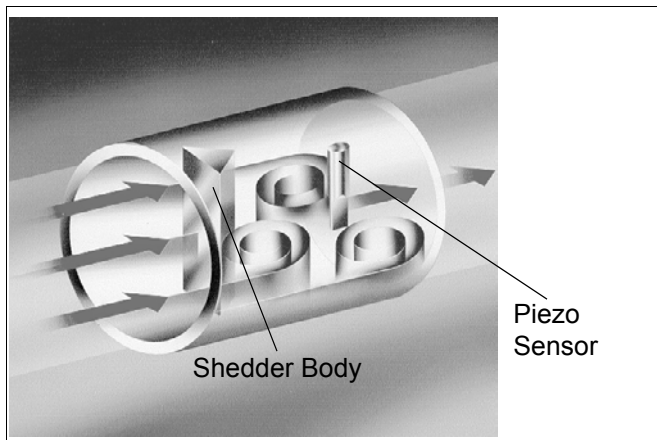


FIGURE 3-1 FLOW MEASUREMENT PRINCIPLE, TRIO-WIRL V

The frequency  $f$  of the vortex shedding is proportional to the flow velocity  $v$  and inversely proportional to the width of the shedder body  $d$ :

$$f = St \times \frac{v}{d}$$

The quality of the vortex flowrate measurements is determined by the dimensionless Strouhal Number ( $St$ ). By appropriate design of the shedder body,  $St$  is constant over a wide Reynolds Number ( $Re$ ) range as shown in Figure 3-2.

$$Re = \frac{v \times D}{\mu}$$

$\mu$  = Kinematic viscosity  
 $D$  = Meter tube diameter  
 $v$  = Flow Velocity

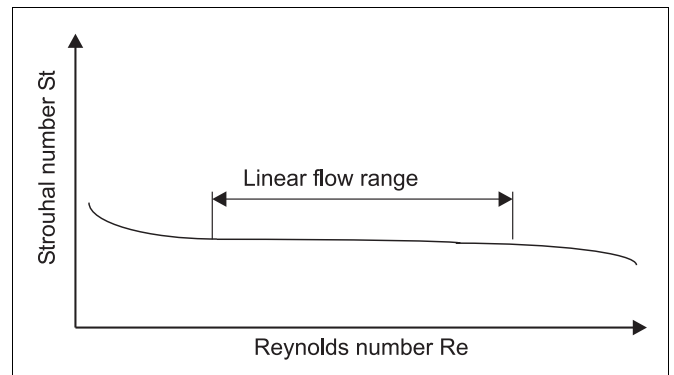


FIGURE 3-2 STROUHAL NUMBER / REYNOLDS NUMBER RELATIONSHIP

As a result, the vortex shedding frequency to be evaluated, is only a function of the flow velocity and is independent of the fluid density and viscosity.

The local pressure changes resulting from the vortex shedding are detected by a Piezo sensor and converted into electrical pulses corresponding to the vortex shedding frequency. The flowrate proportional frequency signal generated in the flowmeter primary is processed in the converter into a current output (4 - 20 mA) signal.

Figure 3-3 shows a cross-sectional view of the Karman Vortex Street and the generated vortices.

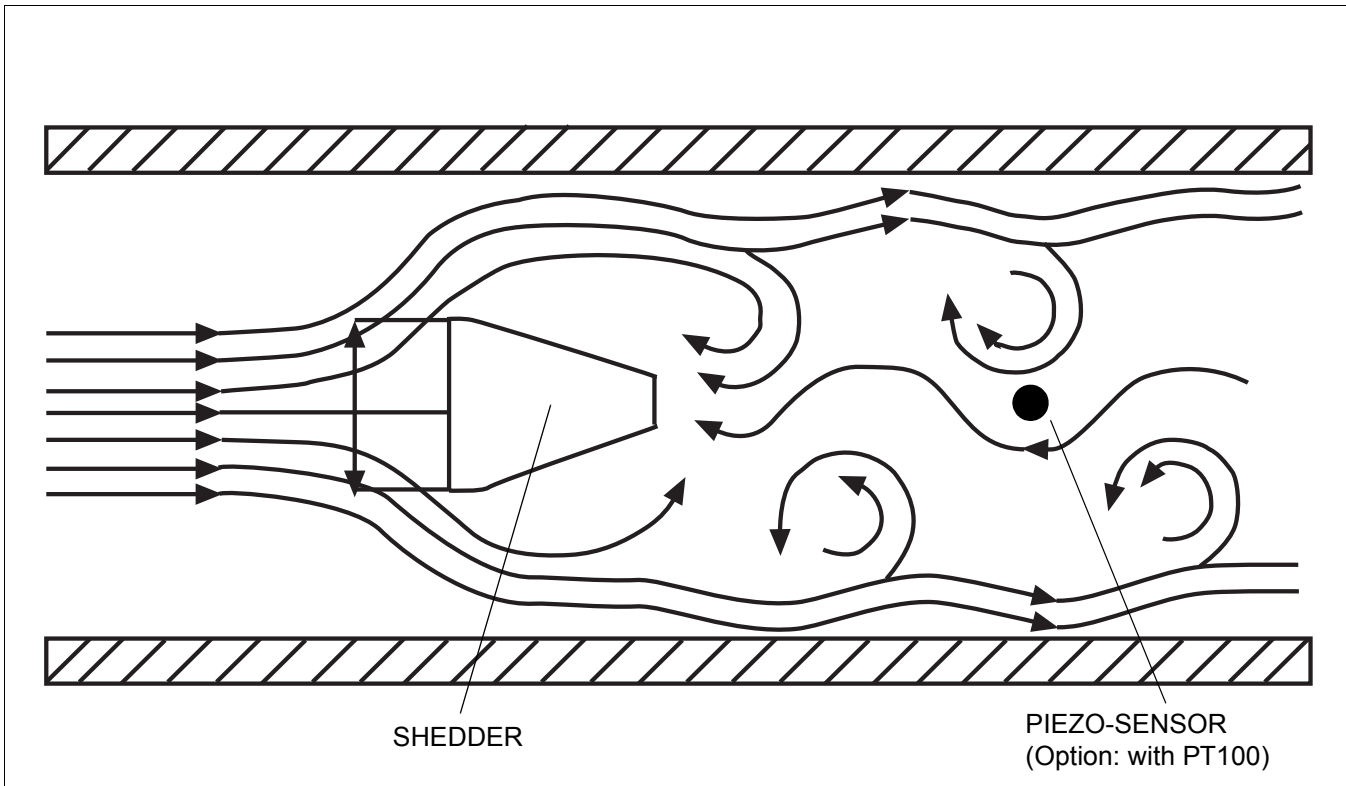


FIGURE 3-3 OPERATING PRINCIPLE, TRIO-WIRL V

### 3.3 Vortex Model Number Breakdown

Refer to the ABB Inc. data sheet or the data tag on the equipment for the model number of the equipment fur-

nished. The details of a specific number are shown on the following pages.

TRIO-WIRL V			-	4	-	-	-	-	-	-	-	-	-	-	E	A	-	A	B
<b>Flowmeter Design</b>																			
Compact																			
Remote			T																
<b>Series</b>				4															
<b>Agency Approvals / Power Supply</b>																			
None / 14 - 46V DC																			0
FM / CSA-Approval / 14 - 46V DC																			3
Others <sup>(2)</sup>																			9
<b>Process Connections</b>																			
Flanged																			1
Wafer																			3
Others																			9
<b>Fluid</b>																			
Liquid																			1
Gas																			2
Steam																			3
Oxygen <sup>(1)</sup>																			6
<b>Materials</b>																			
<b>Housing</b>	<b>Shedder</b>	<b>Sensor</b>																	
SS 316Ti/1.4571	SS 316Ti/1.4571	SS 316Ti/1.4571																	1
Hastalloy C	Hastalloy C	Hastalloy C																	3
<b>Meter Sizes</b>																			
DN 15 /	1 1/2"																		15
DN 25 /	1"																		25
DN 40 /	1 1/2"																		40
DN 50 /	2"																		50
DN 80 /	3"																		80
DN 100 /	4"																		1H
DN 150 /	6"																		1F
DN 200 /	8"																		2H
DN 250 /	10"																		2F
DN 300 /	12"																		3H

(1) Cleaned and suitable for Oxygen service

(2) Consult Factory

## Vortex Model Number Breakdown (Cont.)

TRIO-WIRL V		-	4	-	-	-	-	-	-	-	E	A	-	A	B
<b>Pressure Rating</b>															
ANSI CL 150		Q													
ANSI CL 300		R													
ANSI CL 600 <sup>(2)</sup>		S													
Other		Z													
<b>Sensor Design</b>															
Standard sensor		1													
Standard sensor with integral temperature sensor		2													
High Temperature [ $<750^{\circ}\text{F}$ ( $400^{\circ}\text{C}$ )] sensor <sup>(2)</sup>		5													
<b>Temperature Range Fluid/Gaskets</b>															
Graphite	$-67^{\circ}\text{F}$ to $536^{\circ}\text{F}$ ( $-55^{\circ}\text{C}$ to $280^{\circ}\text{C}$ ) <sup>(2)</sup>	1													
Graphite Special	$-67^{\circ}\text{F}$ to $750^{\circ}\text{F}$ ( $-55^{\circ}\text{C}$ to $400^{\circ}\text{C}$ ) <sup>(2)</sup>	2													
Kalrez O-Ring	$32^{\circ}\text{F}$ to $536^{\circ}\text{F}$ ( $0^{\circ}\text{C}$ to $280^{\circ}\text{C}$ )	3													
Viton O-Ring	$-67^{\circ}\text{F}$ to $446^{\circ}\text{F}$ ( $-55^{\circ}\text{C}$ to $230^{\circ}\text{C}$ ) (not for steam)	4													
PTFE O-Ring	$-67^{\circ}\text{F}$ to $392^{\circ}\text{F}$ ( $-55^{\circ}\text{C}$ to $200^{\circ}\text{C}$ )	5													
<b>Certificates</b>															
None		A													
EN 10204 (DIN 50049-3.1b)		C													
<b>Communication</b>															
With Display and HART		2													
<b>Instrument Tag</b>															
English		E													
<b>Design Level/Software Level</b>															
		B													
<b>Accessories</b>															
None		0													
2" Pipe Mount (only VR)		1													
<b>Operating Mode</b>															
Continuous flowrate		A													
<b>Cable Conduit</b>															
$\frac{1}{2}$ " NPT		B													

(1) Cleaned and suitable for Oxygen service

(2) Consult Factory

## 3.4 Installation

### 3.4.1 Inspection

All equipment should be inspected for damage that may have occurred during shipment. All damage should be reported to the shipping agent. If the equipment is damaged to the extent that faulty operation may result, contact ABB Inc. before installation. Always reference the complete instrument serial number and model number in all correspondence concerning the equipment supplied.

### 3.4.2 Location & Mounting

#### 3.4.2.1 Installation

The Vortex meter may be installed at virtually any location in the pipeline. The meter may be installed at any angle and is available in either a wafer-style or flange-style body that mounts between adjacent pipe sections of the process piping. Since the meter is unidirectional, it must be oriented in accordance with the direction of the process flow. A flow direction arrow is provided on the meter body to assure correct orientation.

Take care to observe the following guidelines:

- \* Do not exceed the ambient temperature requirements
- \* Observe the recommended inlet and outlet straight sections piping requirements (Refer to Figure 3-4).
- \* Make sure the flow direction corresponds to the direction indicated by the arrow on the flowmeter primary.
- \* Make sure that the required minimum distance for removing the converter and exchanging sensors is provided.
- \* The inside diameters of the flowmeter primary and the pipeline should be identical.
- \* Pressure fluctuations at zero flowrate in long pipelines should be eliminated by installing intermediate gate valves.
- \* Flow pulsations resulting from piston pump or compressor operation should be reduced by using appropriate dampeners.
- \* When metering liquids, the flowmeter primary must always be completely filled with fluid and cannot drain.
- \* For high fluid temperatures the flowmeter primary is installed so that the electronic assembly is

mounted at the side or bottom of the flowmeter (Refer to Figure 3-12).

- \* If the possibility of gas bubble formation exists, gas separators should be provided.
- \* Assuming a properly supported pipeline and the converter's DSP signal processing technology, vibration problems should not be encountered in normal industrial applications. However, it is good practice to minimize mechanical vibrations using supports if required. When installing in long pipelines which have a tendency to vibrate, eliminators should be installed upstream and downstream of the flowmeter.
- \* In vertical and sloping installations, the electrical conduit entries should face downward to retard the entry of condensation.

#### 3.4.2.2 Recommended Inlet & Outlet Sections

Due to the measurement principles of the Vortex Flowmeter it can be installed with minimal inlet and outlet straight section lengths. Strainers and flow straighteners are not required. Figure 3-4 shows the recommended lengths for the inlet and outlet straight sections for various installation conditions. No inlet and outlet straight sections are required when single or double elbows are installed upstream or downstream from the flowmeter primary when the radius of the elbow is greater than  $1.8 \times D$ .

To assure optimum meter performance, the meter should be installed in accordance with the upstream and downstream straight run piping requirements shown in Figure 3-4. The straight run piping should be schedule 80 or lighter pipe. Process flanges should be raised face.

Remove the covers used to protect the meter inlet and outlet surfaces from damage during shipment.



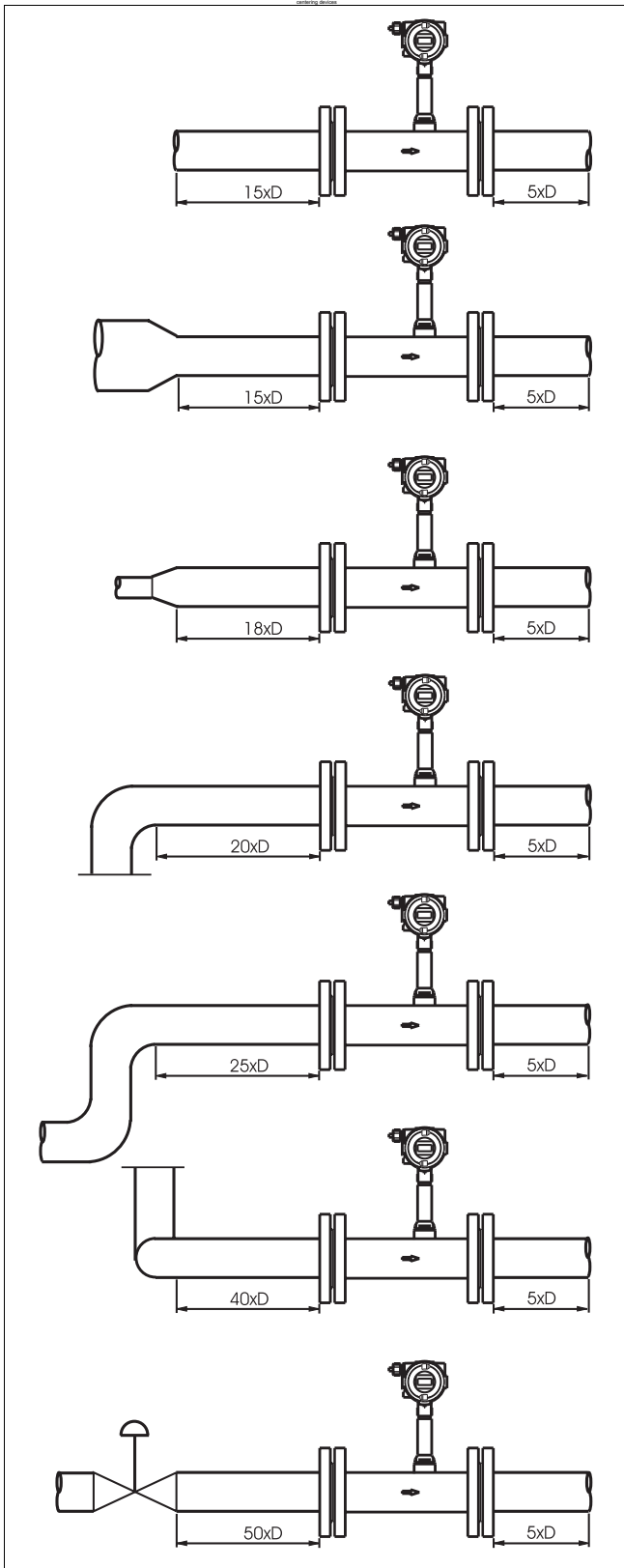


FIGURE 3-4 METER PIPING REQUIREMENTS

### 3.4.2.3 Wafer-Style Installation

The wafer type meter body mounts inside the pipe flange bolt circle and ranges in size from 1/2 to 8 inches. To assure optimum meter performance, the meter should be installed in accordance with the upstream and downstream straight run piping requirements given in Figure 3-4. The straight run piping should be schedule 80 or lighter pipe. Either flat or raised face flanges may be used.

Remove the shipping covers used to protect the meter inlet and outlet surfaces from damage during transit and handling.

#### WAFER STYLE, SIZES 1 THROUGH 2 INCHES

Optional centering devices, mounting studs and nuts (Refer to Tables 7-3 & 7-4 for replacement parts) are supplied when specified at time of order. The centering devices have an internal diameter that permits the ring to be mounted via an undercut face on the inlet and outlet ends of the meter body. Regardless of whether the meter will be installed in a horizontal, sloping, or vertical pipeline, one ring is used at the inlet end and the other ring at the outlet end of the meter. Use of the centering devices is illustrated in Figure 3-5. The rings will have several bolt alignment hole patterns that are spaced and located on different bolt circle radii. This permits the centering device for a particular meter size to be adapted for various flange ratings, e.g., ANSI Class 150, 300 or 600 lb. flanges. When installing the centering devices, orient them so that the flange rating values stamped on the rings will face the meter body, i.e., markings must be visible. Position the centering device so that the mounting studs will pass through the appropriate set of bolt circle radii, as designated according to the flange rating.

Place the two flange gaskets (supplied) against the upstream and downstream flange faces (Refer to Table 7-5 for replacement flange gaskets). Align the gasket holes with the flange bolt pattern. When installing the flange gaskets, use care to assure that the gaskets fit properly and do not project into the pipe line causing an alteration of the flow profile. A change in flow profile can adversely affect meter accuracy.

Install the meter in the pipeline, between the inlet and outlet gaskets. Make certain that the flow direction arrow on the meter body is oriented in accordance with the process flow. If the meter is installed in a horizontal pipeline, insert two studs in the bottom two flange holes to support the meter. When installing the meter in a vertical pipe run, some temporary support may be required until mounting studs and nuts have been installed.

Install the remaining mounting studs, as required. Studs and nuts should be lubricated with a graphite based lubricant. Assemble a nut on each end of the mounting studs hand tight. Tighten the stud nuts in a

diagonally opposite pattern, as shown in Figure 3-8, to equalize pressure on the meter face. Nut torque should be limited to that which will provide a leakproof seal.

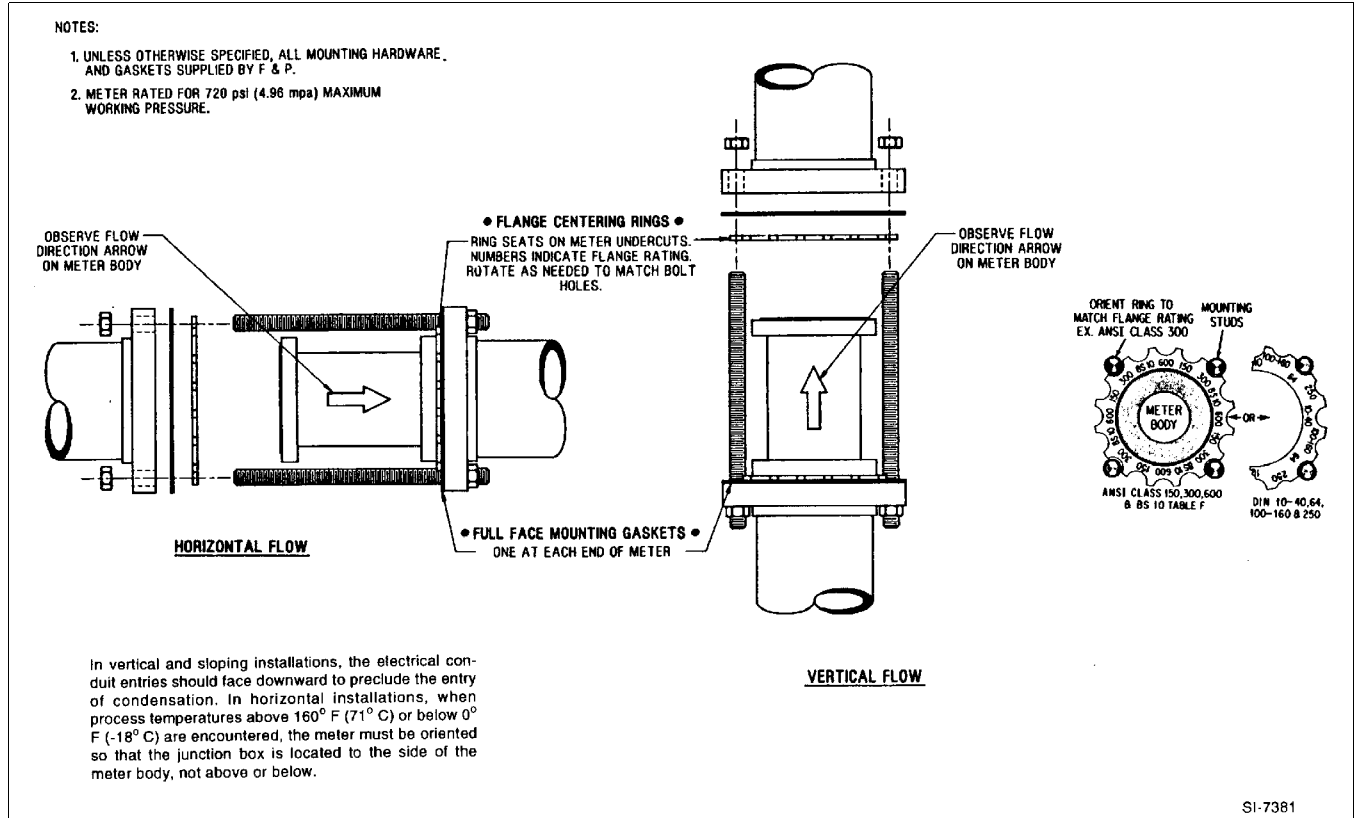


FIGURE 3-5 WAFER PROCESS CONNECTIONS, SIZES 1/2 THROUGH 2 INCHES

**WAFER STYLE, SIZES 3 THROUGH 8 INCHES**

Place the two flange gaskets (supplied) against the upstream and downstream flange faces (Refer to Table 7-5 for replacement flange gaskets). Align the gaskets holes with the flange bolt pattern. When installing the flange gaskets, use care to assure that the gaskets fit properly and do not project into the pipe line causing an alteration of the flow profile. A change in flow profile can adversely affect meter accuracy.

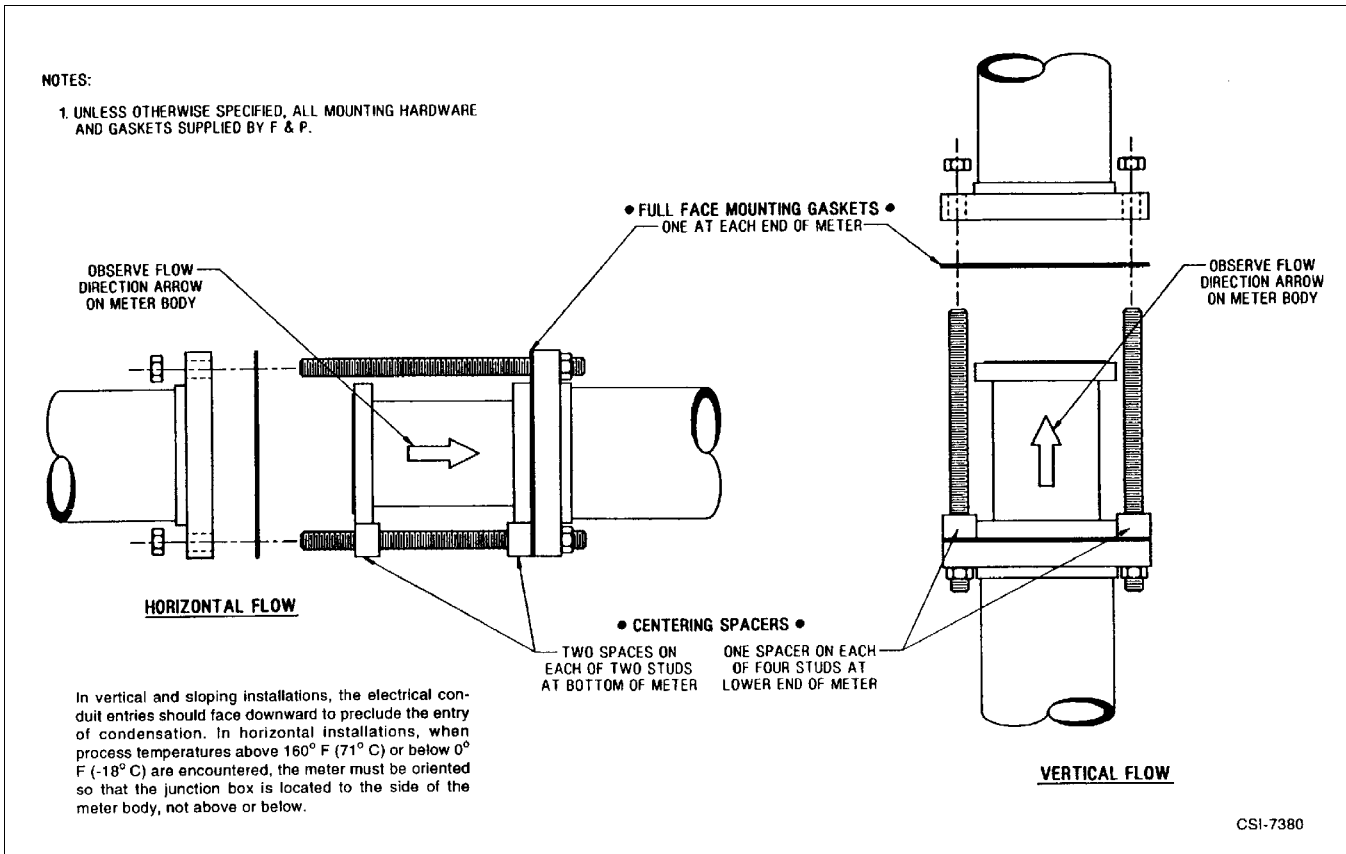
Optional centering sleeves (spacers), mounting studs and nuts are supplied (Refer to Tables 7-3 & 7-4 for replacement parts) when specified at time of order.

Placement of the sleeves is dependent on the type of installation (vertical/horizontal/sloping). If the meter is installed in a vertical pipeline, select four equally spaced bolt holes for placement of the four sleeves and studs (refer to Figure 3-6). If the meter is installed in a

horizontal or sloping pipeline, select the bottom two holes of the flanges on each end of the meter for placement of the four sleeves and studs.

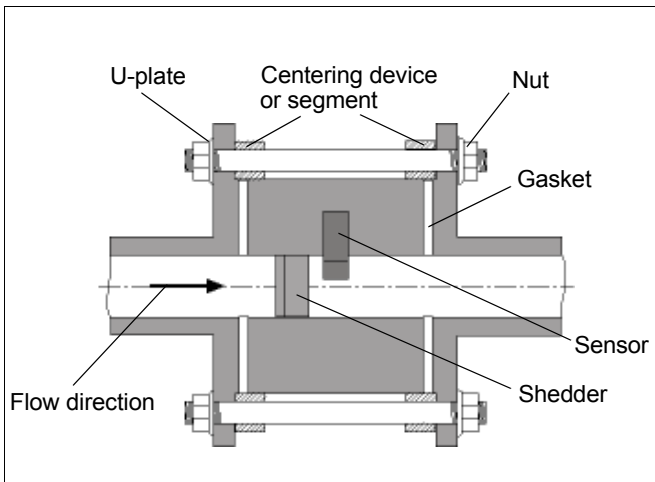
Install the meter in the pipeline between the inlet and outlet gaskets. Make certain that the flow direction arrow on the meter body is oriented in accordance with the process flow. In horizontal pipe runs the meter will be supported by the upstream and downstream sleeves. When installing the meter in a vertical pipe run, some temporary support may be required until mounting studs and nuts have been installed.

Install the remaining mounting studs, as required. Studs and nuts should be lubricated with a graphite based lubricant. Place a hex nut on each end of the mounting stud. Tighten the stud nuts in a diagonally opposite pattern, as shown in Figure 3-8, to equalize pressure on the meter face. Nut torque should be limited to that which will provide a leakproof seal.



**FIGURE 3-6 WAFER PROCESS CONNECTIONS, SIZES 3 THROUGH 8 INCHES**

When properly installed, the installation should look like that shown in Figure 3-7 below.



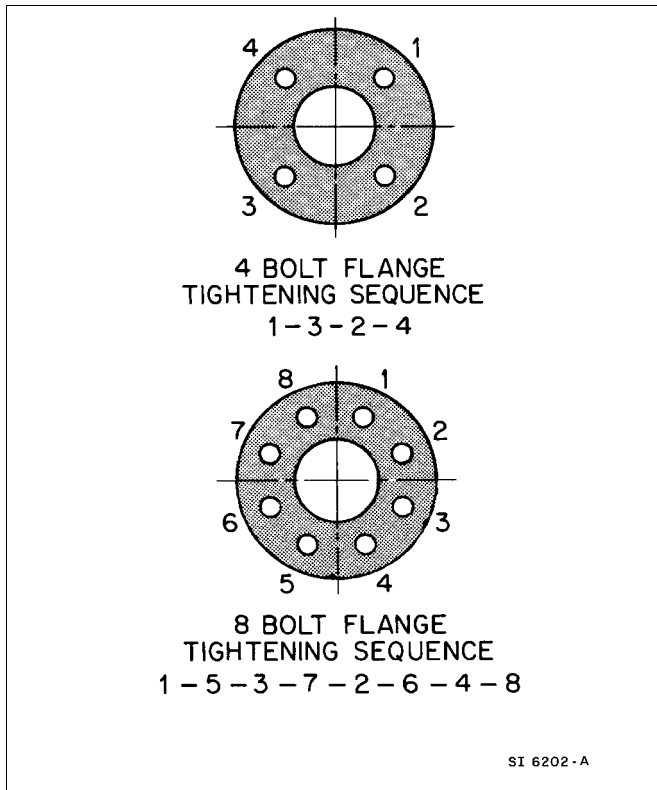
**FIGURE 3-7 WAFER STYLE ASSEMBLY**

**3.4.2.4 Flanged-Style Installation**

Place the two supplied flange gaskets against the upstream and downstream flange faces (Refer to Table 7-5 for replacement flange gaskets). Align the gasket holes with the flange hole pattern. When installing the flange gaskets, make sure that the gaskets fit properly and are aligned properly so that they don't project into the pipe line causing an alteration of the flow profile. A change in flow profile can adversely affect meter accuracy.

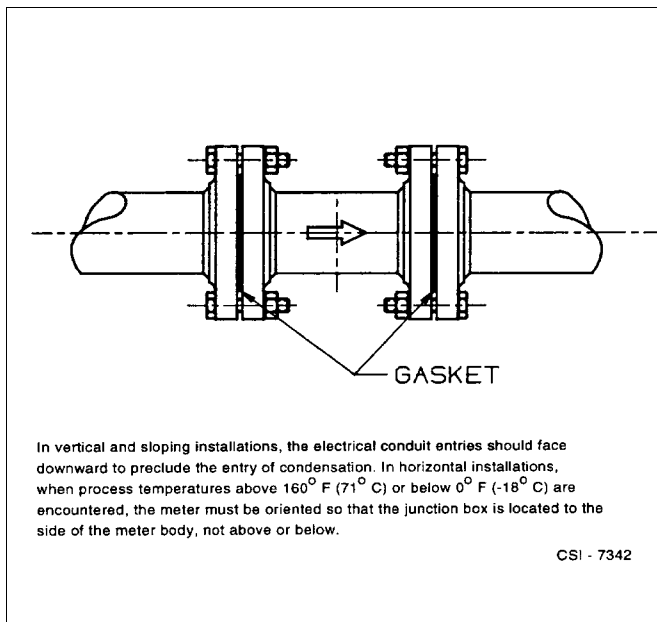
**Mounting bolts and nuts are supplied by the user.** During installation, make certain that the flow direction arrow on the meter body is oriented in accordance with the process flow.

With the meter safely supported, install the bolts through the meter and process flanges. Bolts and nuts should be lubricated with a graphite based lubricant. Assemble the nuts to the bolts hand tight. Tighten the flange nuts in a diagonal or "star" pattern as shown in Figure 3-8 to equalize pressure on the flange face and gaskets. Bolt/nut torque should be limited to that which will provide a leakproof seal.



**FIGURE 3-8 RECOMMENDED FLANGE BOLT TIGHTENING SEQUENCE**

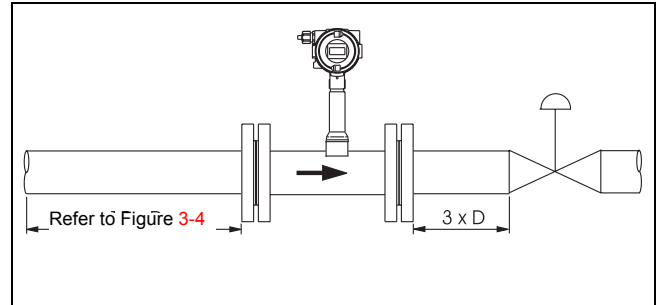
When correctly installed, the installation should look like that shown in Figure 3-9 below



**FIGURE 3-9 FLANGE PROCESS CONNECTIONS**

**3.4.2.5 Control Valve Installation**

Control valves should be installed downstream from the flowmeter as shown in Figure 3-10. When this is not possible, the control valve should be located  $\geq 50D$  upstream from the flowmeter.



**FIGURE 3-10 CONTROL VALVE INSTALLATION**

**3.4.2.6 Extreme Temperature Applications**

For process temperatures above 160° F (71° C) or below 0° F (-18° C), it is critical that the meter be pressurized and placed into service gradually, i.e., with sufficient time delay to minimize thermal shock. Steam should be introduced gradually so that the meter is brought up to operating temperature over a ten to fifteen minute period.

**WARNING**  
**WHEN THE METER IS USED IN A VERY HIGH OR LOW TEMPERATURE PROCESS, THE TEMPERATURE OF THE METER BODY MAY BE EXTREMELY HOT OR COLD. IF IT IS NECESSARY TO TOUCH THE SENSOR HOUSING OR METER BODY, INSULATED GLOVES MUST BE WORN TO PREVENT SERIOUS INJURY.**

**INSULATING THE VORTEX METER**

The flowmeter primary can be insulated to a max. thickness of 4 inches (100 mm) [Refer to Figure 3-11].

**CAUTION**  
**THE PIPELINE AND METER BODY MAY BE INSULATED BY THE USER UP TO A THICKNESS OF 4 IN. (100 MM) BUT THE METER INTERCONNECTION WIRING BOX AND SENSOR HOUSING TOWER MUST NOT BE INSULATED. AMBIENT AIR IS REQUIRED TO DISSIPATE HEAT OR COLD BUILD-UP WITHIN THE INTERCONNECTION WIRING BOX.**

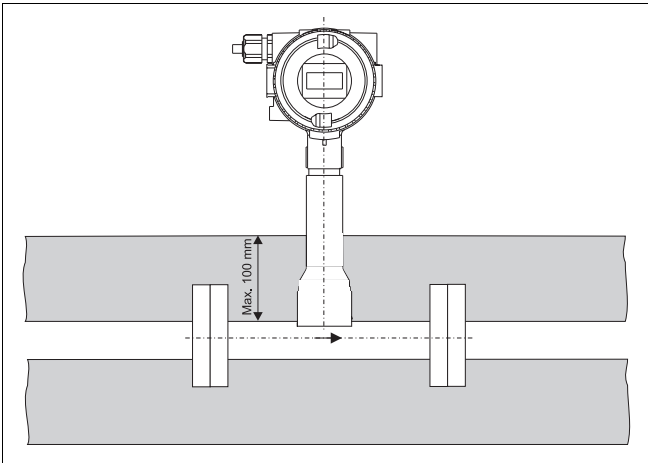


FIGURE 3-11 INSULATING THE PIPELINE

**FLOWMETER PRIMARY INSTALLATIONS FOR FLUID TEMPERATURES > 300° F (150° C)**

In horizontal installations, when process temperatures above 300° F (150° C) are encountered, the meter must be oriented so that the junction box is located to the side or below meter body, not above.

Refer to Figure 3-12 for an example of the recommended high-temperature application orientation.

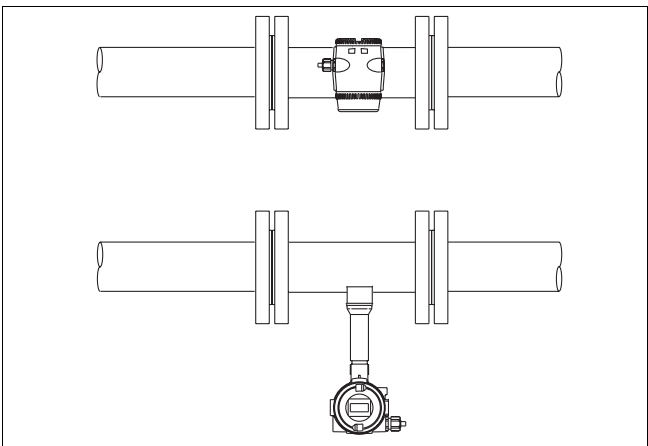


FIGURE 3-12 Orientation for Temperatures >300° F (150° C)

When operating at elevated temperatures, the interrelationship between the fluid and ambient temperatures must be taken into consideration. Figure 3-13 shows the allowable operating range for ambient vs. process fluid temperatures.

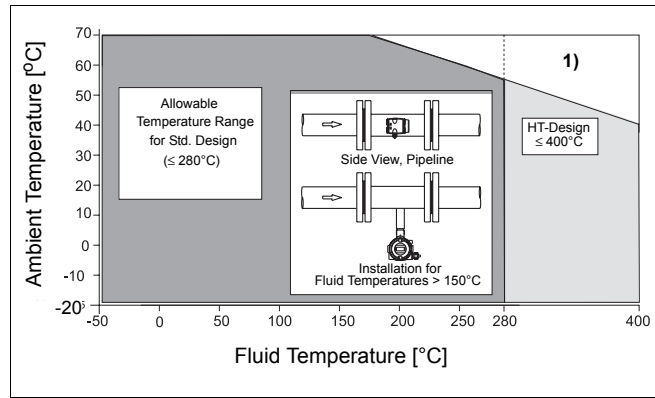


FIGURE 3-13 AMBIENT/FLUID TEMPERATURE RELATIONSHIP

1) Cables suitable 230° F (110°C) can be used for the power supply terminals 31, 32 and the contact output terminals 41, 42 without any reduction in the temperature range specifications. Cables suitable only for temperatures of 175° F (80°C) reduce the temperature range of the flowmeter as shown in Figure 3-13.

**3.4.3 Temperature/Pressure Monitoring**

Provisions for temperature and/or pressure monitoring are the responsibility of the user. The temperature sensor should be located five to eight pipe diameters downstream of the flowmeter. Measurement is from the downstream face of the meter. The pressure tap should be located three to five pipe diameters downstream of the flowmeter. Measurement is from the downstream face of the meter.

An option is available for the vortex meter for direct Pt100 temperature measurements. These temperature measurements can be used to monitor the fluid temperature or for the measurement of saturated steam in mass units.

### 3.5 Vortex Meter Size Selection

The maximum required actual volume flowrate  $Q_v$  at operating conditions is the basis for the flowmeter size selections. In order to utilize the maximum flow range this value should not be less than one half of the maximum flowrate for the meter size ( $Q_{Vmax}$ ). The linear flow range (see Accuracy Specifications) corresponds to the Reynolds Number ( $R_e$ ) range from 20,000 (or 40,000 for 6" / DN 150) to 7,000,000.

If the flowrate to be metered is expressed as a standard flowrate (70 °F, 14.7 psia) or as a mass flowrate, it will be necessary to first convert these values to their equivalent actual volume flowrate at operating conditions before selecting the most suitable flowmeter size from the Flow Range Tables (Tables 3-1 & 3-4 to 3-6).

#### 1. Convert standard density ( $\rho_s$ ) to operating density ( $\rho$ ).

$$\rho = \rho_s \times \frac{14.7 + p}{14.7} \times \frac{530}{460 + T}$$

#### 2. Convert to actual volume flowrate ( $Q_v$ ).

a) Starting from standard flowrate ( $Q_s$ ) :

$$Q_v = Q_s \left( \frac{\rho_s}{\rho} \right) = Q_s \left( \frac{14.7}{14.7 + p} \times \frac{460 + T}{530} \right)$$

b) Starting from mass flowrate ( $Q_m$ ) :

$$Q_v = \frac{Q_m}{\rho}$$

#### 3. Dynamic viscosity, $\mu$ (cps) to kinematic viscosity, $\nu$ (cst)

$$\nu = \frac{\mu}{\rho}$$

#### 4. Reynolds Number ( $R_e$ )

$$R_e = \frac{3160 \times gpm}{\nu}$$

Where:

- $\rho$  = Density at operating conditions (lb/ft<sup>3</sup>)
- $\rho_s$  = Density at standard conditions (lb/ft<sup>3</sup>)
- $p$  = Pressure at operating conditions (psig)
- $T$  = Temperature at operating conditions (°F)
- $Q_v$  = Actual volume flowrate (acfh)
- $Q_s$  = Standard flowrate (scfh)
- $Q_m$  = Mass flowrate (lb/hr)

#### 3.5.1 Gas

**TABLE 3-1. VORTEX FLOW RANGES, AIR**

Meter Size		Flow Range [acfh]		Frequency [Hz] at Qvmax
Inch	DN	Qvmin	Qvmax	
1/2	15	180	780	1840
1	25	425	2900	1825
1-1/2	40	740	12000	2000
2	50	1500	15900	1250
3	80	2750	33500	760
4	100	4240	63500	650
6	150	9200	143000	425
8	200	14800	240000	310
10	250	29000	424000	235
12	300	45900	600000	190

Air at 70 °F, 14.7 psi,  $\rho = 0.075$  lb/ft<sup>3</sup>

**TABLE 3-2. STANDARD DENSITIES FOR SELECTED GASES**

Gas	Standard Density [lb/ft <sup>3</sup> ]
Acetylene	0.0732
Air	0.0749
Ammonia	0.0481
Argon	0.1111
Butane	0.1686
Carbon Dioxide	0.1230
Carbon Monoxide	0.0780
Ethane	0.0843
Ethylene	0.0787
Hydrogen	0.0056
Methane	0.0448
Natural Gas	0.045
Neon	0.0556
Nitrogen	0.0780
Oxygen	0.0893
Propane	0.1261
Propylene	0.1196

**TABLE 3-3. MINIMUM & MAXIMUM FLOWRATES VS. DENSITY, GASES & STEAM**

Density		Q <sub>vmin</sub> [ACFH]													Q <sub>vmax</sub> [ACFH]	Freq. [Hz] at Q <sub>vmax</sub>	
		≤0.08 <sup>1</sup>	0.09	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	≥2.0			
Meter Size																	
Inch	DN																
1/2	15	180	180	170	110	90	78	70	62	58	55	52	48	35	780	1840	
1	25	425	320	310	220	190	170	150	130	120	110	100	95	70	2900	1825	
1-1/2	40	740	700	680	480	390	320	290	280	250	220	210	200	160	12000	2000	
2	50	1500	1500	1500	950	790	680	600	540	500	480	440	410	300	15900	1250	
3	80	2750	2600	2400	1800	1400	1200	1100	970	900	820	790	730	680	33500	760	
4	100	4240	4000	3900	2800	2200	1900	1800	1700	1600	1400	1300	1200	1100	63500	650	
6	150	9200	8200	8000	7000	7000	7000	7000	7000	7000	7000	7000	7000	7000	143000	425	
8	200	14800	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	240000	310	
10	250	29000	29000	29000	29000	29000	29000	29000	29000	29000	29000	29000	29000	29000	424000	235	
12	300	45900	45900	45900	45900	45900	45900	45900	45900	45900	45900	45900	45900	45900	600000	190	

<sup>1</sup> Valid for 0.03 ≤ Density ≤ 0.08. Consult factory for densities < 0.03 lb/ft<sup>3</sup>.

**3.5.1.1 Example for Gases:**

Determine the flowmeter size for metering 98,700 scfh (Q<sub>s</sub>) CO<sub>2</sub>; temperature 185 °F, pressure = 72 psia. Refer to Section 3.5 for equations.

ρ<sub>s</sub> = 0.1149 lb/ft<sup>3</sup>(CO<sub>2</sub>) (From Table 3-2)

**1. Convert ρ<sub>s</sub> to ρ :**

$$\rho = 0.1149 \left[ \frac{72}{14.7} \times \frac{530}{460 + 185} \right] = 0.46 \text{ lb/ft}^3$$

**2. Convert Q<sub>s</sub> to Q<sub>v</sub>:**

$$Q_v = 98700 \left( \frac{0.1149}{0.46} \right) = 24653 \text{ acfh}$$

Select 3 in. meter size (Q<sub>vmax</sub> = 33,500 acfh). Refer to Table 3-1.

**3. Pressure drop at ρ = 0.462 lb/ft<sup>3</sup> :**

Q<sub>v</sub> = 24,653 acfh

$$\Delta p' = \frac{0.46}{0.0745} \times 0.4 = 2.5 \text{ psi}$$

**4. Range start value at ρ = 0.46 lb/ft<sup>3</sup> (see Table 3-3)**

Q<sub>vmin</sub> = 1138 acfh

**3.5.1.2 Pressure Drop, Gas/Superheated Steam**

See Figure 3-14 for Air (at 70 °F, 14.7 psia, ρ = 0.0749 lb/ft<sup>3</sup>). For other fluid densities the pressure drop can be calculated using the following equation:

$$\Delta p' = \frac{\rho}{0.0749} \times \Delta p$$

Where:

Δp' = Pressure drop, fluid [psi]

Δp = Pressure drop, air [psi] (from Figure 3-14)

**3.5.1.3 Flowrate Saturated Steam [lb/h]**

Example: Determine the flow range for a 2"/DN50 at 100 psig

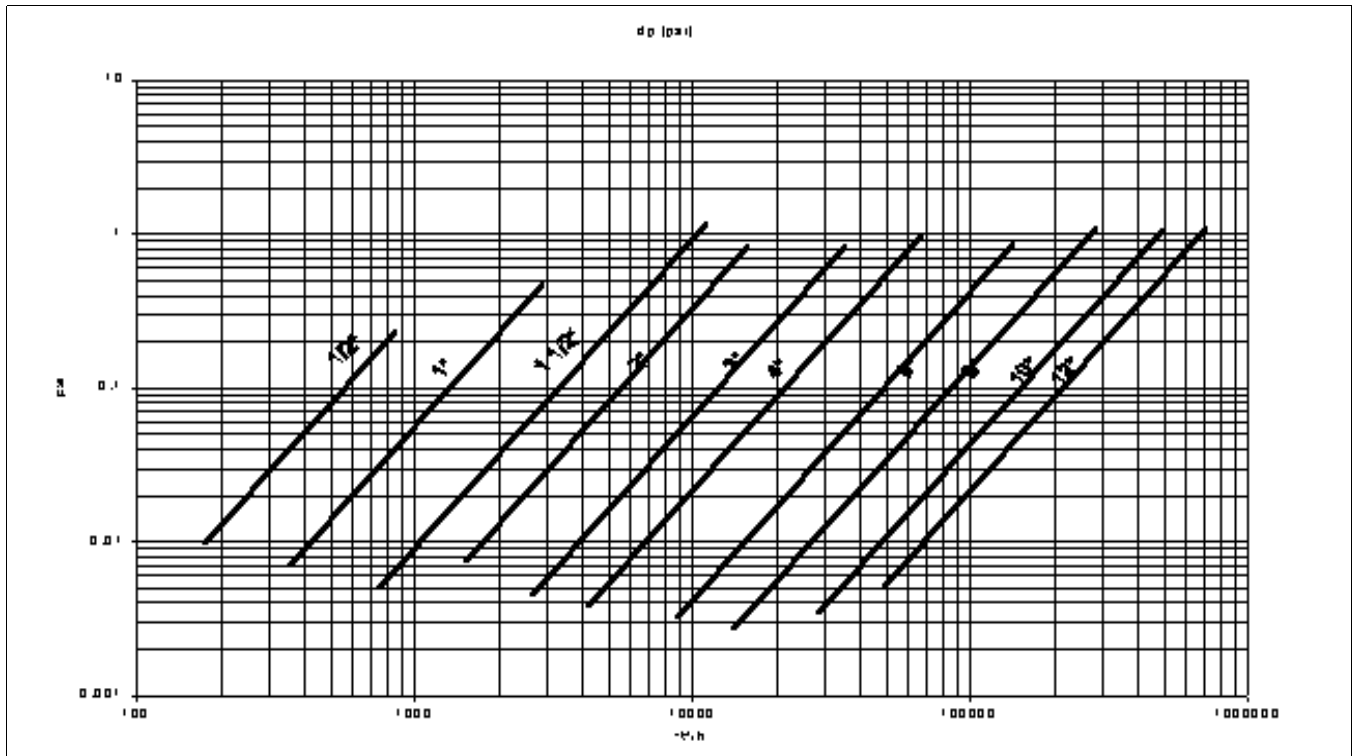
From Table 3-4: 2"/DN50: 385 - 4,055 lb/hr

Additional information:

Sat. steam temp. = 338 °F

Saturated Steam Density = 0.255 lb/ft<sup>3</sup>

# TRIO-WIRL INSTRUCTION MANUAL



**FIGURE 3-14 PRESSURE DROP, AIR @70° F & 14.7 psia**

**TABLE 3-4. VORTEX FLOW RANGES, SATURATED STEAM [LB/H]**

Meter Size		[psig]	15	30	60	100	125	150	200	250	300
Inch	DN										
1/2	15	min	15	20	30	45	55	65	85	105	125
		max	60	85	135	200	245	285	365	450	530
1	25	min	30	45	75	110	135	155	200	245	290
		max	210	310	500	740	900	1055	1360	1665	1970
1-1/2	40	min	55	80	130	190	230	270	350	425	505
		max	865	1275	2065	3060	3720	4370	5630	6890	8150
2	50	min	110	160	260	385	465	545	705	860	1020
		max	1145	1685	2735	4055	4930	5790	7460	9130	10800
3	80	min	200	295	475	700	855	1000	1290	1580	1865
		max	2415	3550	5765	8545	10385	12195	15715	19230	22750
4	100	min	305	450	730	1080	1315	1545	1990	2435	2880
		max	4575	6730	10925	16195	19685	23115	29785	36450	43120
6	150	min	665	975	1585	2345	2855	3350	4315	5280	6250
		max	10300	15160	24600	36465	44330	52050	67070	82085	97100
8	200	min	1065	1570	2545	3775	4590	5390	6940	8495	10050
		max	17280	25440	41280	61200	74400	87360	112560	137760	162960
10	250	min	2090	3075	4990	7395	8990	10555	13600	16645	19690
		max	30530	44945	72930	108120	131440	154335	198860	243375	287900
12	300	min	3305	4865	7895	11705	14330	16710	21530	26350	31165
		max	43200	63600	103200	153000	186000	218400	281400	344400	407400
Density	$\rho_{\text{sat}}$ [lb/ft <sup>3</sup> ]	0.072	0.106	0.172	0.255	0.31	0.364	0.469	0.574	0.679	
Temp.	Tsat [°F]	250	275	307	338	353	366	388	406	422	



3.5.2 Liquid.

**TABLE 3-5. VORTEX FLOW RANGES, WATER**

Meter Size		Flow Range GPH		Frequency at Q <sub>v</sub> max [Hz]
Inch	DN	Q <sub>v</sub> min	Q <sub>v</sub> max	
1/2	15	130	1450	450
1	25	420	4700	400
1-1/2	40	660	12670	280
2	50	800	17400	180
3	80	2650	42300	130
4	100	3100	57000	80
6	150	8700	140000	55
8	200	18500	247000	43
10	250	21600	382000	28
12	300	35600	540000	23

3.5.2.1 Static Pressure, Liquid

To prevent cavitation when metering liquids a positive static pressure (back pressure) is required. Its value can be estimated using the following equation:

$$p_2 \geq (1.3 \times p_{\text{vapor}}) + (2.6 \times \Delta p')$$

Where:

- p<sub>2</sub> = Positive downstream static pressure [psi]
- p<sub>vapor</sub> = Fluid vapor pressure at operating temp. [psi]
- Δp' = Fluid pressure drop [psi] (See Figure 3-15)

3.5.2.2 Pressure Drop, Liquids

See Figure below for water (70°F, 14.67 psia, ρ - 8.34 lb/gal). For other fluid densities (ρ) the pressure drop can be calculated using the following equation:

$$\Delta p' = \frac{\rho}{8.34} \times \Delta p$$

Where:

- Δp' = Pressure drop, fluid [psi]
- Δp = Pressure drop, water (Refer to Figure 3-15)
- ρ = Operating Density lb/gal

**EXAMPLE FOR LIQUIDS**

Determine the flowmeter size for metering 14,000 gph of a liquid with a density of 7.10 lb/gal and a kinematic viscosity of 2 cSt.

1. Find Q<sub>v</sub> = maximum

Q<sub>v</sub>MAX = 17,400 gph for 2 in. meter (from Table 3-5)

2. Using 2" meter size with viscosity of 2 cSt

Q<sub>v</sub>MIN = 1,800 gph (Refer to Table 3-6)

3. Calculate Pressure drop (Q<sub>v</sub> = 14,000 gph) at

ρ = 7.10 lb/gal

$$\Delta p' = \frac{7.10}{8.34} \times 9 = 7.6 \text{ psi}$$

**TABLE 3-6. MINIMUM & MAXIMUM FLOWRATES VS. VISCOSITY, LIQUID**

Centistokes		≤ 1	Q <sub>v</sub> min [gph]							Q <sub>v</sub> max [gph]	Frequency @ Q <sub>v</sub> max [Hz]
			2	3	4	5	6	7			
Meter Size											
Inch	DN										
1/2	15	130	250	350	450	550	650	750	1450	450	
1	25	420	850	1300	1800	2100	2600	3000	4700	400	
1-1/2	40	660	1400	2000	2700	3200	3900	4400	12670	280	
2	50	800	1800	2400	3200	4000	4800	5600	17400	180	
3	80	2650	5000	7000	9400	12000	15000	18000	42300	130	
4	100	3100	6100	9200	14000	18000	21000	25000	57000	80	
6	150	8700	18000	28000	38000	48000	58000	69000	140000	55	
8	200	18500	33000	47000	60000	70000	81000	93000	247000	43	
10	250	21600	39000	58000	78000	100000	130000	150000	382000	28	
12	300	35600	65000	90000	120000	160000	180000	190000	540000	23	

Conditions @ 70°F, 14.67 psig & ρ=8.34 lb/gal

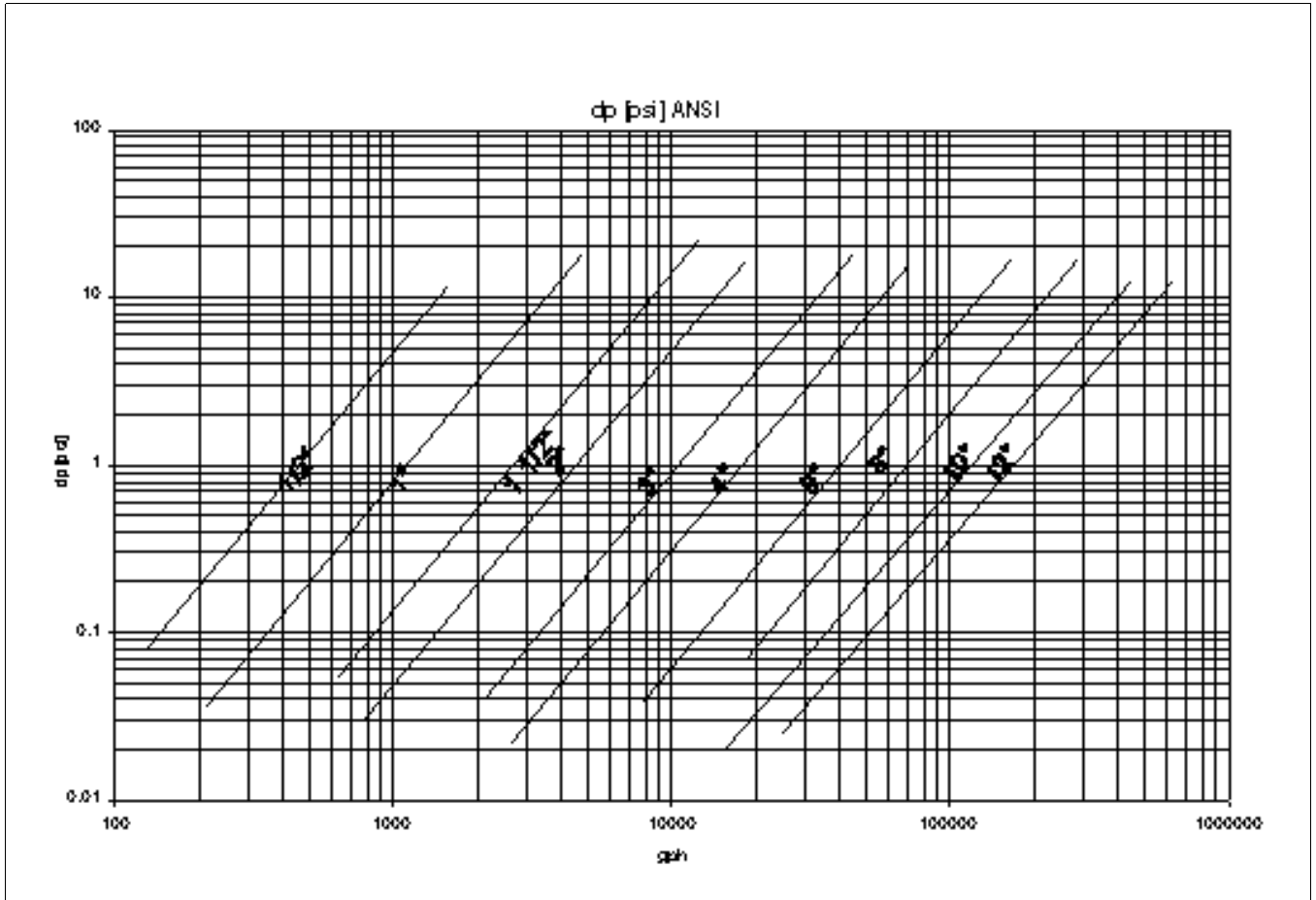
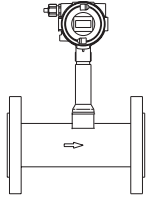
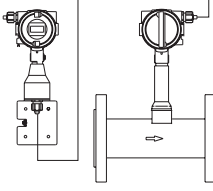


FIGURE 3-15 PRESSURE DROP, WATER (70° F, 14.67 psia,  $\rho=8.34$  lb/gal)

## 3.6 Specifications

### 3.6.1 Model Overview

	MODEL	 VT4000	 VR4000
Accuracy	Liquids	$\leq \pm 0.75\%$ of rate	
	Gases and Steam	$\leq \pm 1\%$ of rate	
Reproducibility		$\leq \pm 0.2\%$ of rate	
Allowable viscosity for liquids		$\leq 7.5$ cps	
Typical flow range		1:20	
Typical up-/downstream straight lengths		15 x D / 5 x D	
<b>Flowmeter Primary</b>			
Process Connections	Flanges (DIN, ANSI, JIS)	1/2"-12"/DN15-DN300	
	Wafer Style (DIN, ANSI, JIS)	1/2"-8"/DN15-DN200	
Sensor Design	Single sensor	YES, optional with integrated temperature measurement	
Fluid Temperature	Standard	-67 °F to 536 °F	
	High Temperature (available soon)	-67 °F to 750 °F	
Protection Class		NEMA 4X (IP67)	
Materials	Sensor	316 SS or Hast C	
	Shedder Body	316L SS or Hast C	
	Meter Housing	316L SS or Hast C	
	Sensor Gasket	Graphite, Kalrez, Viton, PTFE	
<b>Approvals / Certifications</b>			
Intrinsically Safe & Explosion-Proof Design	FM / CSA Approved	Explosion-Proof Class I; Div. 1; Groups B-D Intrinsically Safe Class I; Div. 1; Groups A-D Non-Incendive for Class I; Div. 2; Groups A-D Dust Ignition-proof Class II; Div. 1; Groups E-G	

### 3.6.2 Detailed Specifications

#### ACCURACY AND REPRODUCIBILITY OF FLOW MEASUREMENT

Accuracy (incl. converter), linear flow range  
(Re > 20,000 for 6"/DIN 150 > 40,000):

Gas/Steam:  $\leq \pm 1\%$  of rate  
Liquids:  $\pm 0.75\%$  of rate

Reproducibility:  $\leq 0.2\%$  of rate

#### ACCURACY AND REPRODUCIBILITY OF THE TEMPERATURE MEASUREMENT

Accuracy (incl. converter):  $\leq \pm 2\text{ }^\circ\text{C} / \leq 3.6\text{ }^\circ\text{F}$   
Reproducibility:  $\leq 0.2\%$  of rate

#### OVERRANGE:

Gases: 15% over maximum flowrate  
Liquids: 15% over maximum flowrate

Note: Cavitation may not occur.

#### PRESSURE RATING:

Flanged Design: ANSI CL 150/300/600, option to CL 900  
Wafer Style: ANSI CL 150/300/600

Additional designs upon request.

#### CONNECTIONS:

Process Connections: ANSI, Flanged & Wafer Design.

Electrical Connections: Screw terminals, NPT 1/2  
(w/o cable connector)

#### PROTECTION CLASS:

NEMA 4X (IP67)

#### MATERIAL:

Wetted parts: 316L SS, optional Hast. C

Sensor: SS 316 Ti/No. 1.4571, optional Hast. C

Sensor Gaskets:

Kalrez O-Ring: 32°F to 536°F (0°C to 280°C)  
Viton O-Ring: -67°F to 446°F (-55°C to 230°C)  
PTFE O-Ring: -67°F to 392°F (-55°C to 200°C)  
Graphite: -67°F to 536°F (-55°C to 280°C)  
Graphite-Special: -67°F to 750°F (-55°C to 400°C)

Additional materials upon request

Converter Housing: Cast Aluminum, painted

#### WEIGHTS:

Refer to the dimensional outline drawing (Figure 3-18)

#### FLUID TEMPERATURE

- 67°F to 536°F (-55°C to +280°C) (Standard)  
- 67°F to 750°F (-55°C to +400°C) (HT-Design - Available Soon))

Allowable temperature range for the gasket material must be considered. The flange gaskets supplied with the meter are KLINGERSil material. These gaskets are rated to a temperature of 536 °F (280 °C) for liquid applications and 450 °F (232 °C) for gas & steam applications, at internal pressures of 400 psi max.

#### AMBIENT CONDITIONS:

Climate Resistance (per DIN 40040): GSG  
Relative humidity: 95% Max.  
100% with cover in place

#### AMBIENT TEMPERATURE:

-4° F (-20° C) to 158° F (70° C)

#### ALLOWABLE PROCESS PRESSURE:

Process pressure limitations vs. process fluid temperatures are shown in Figure 3-17.

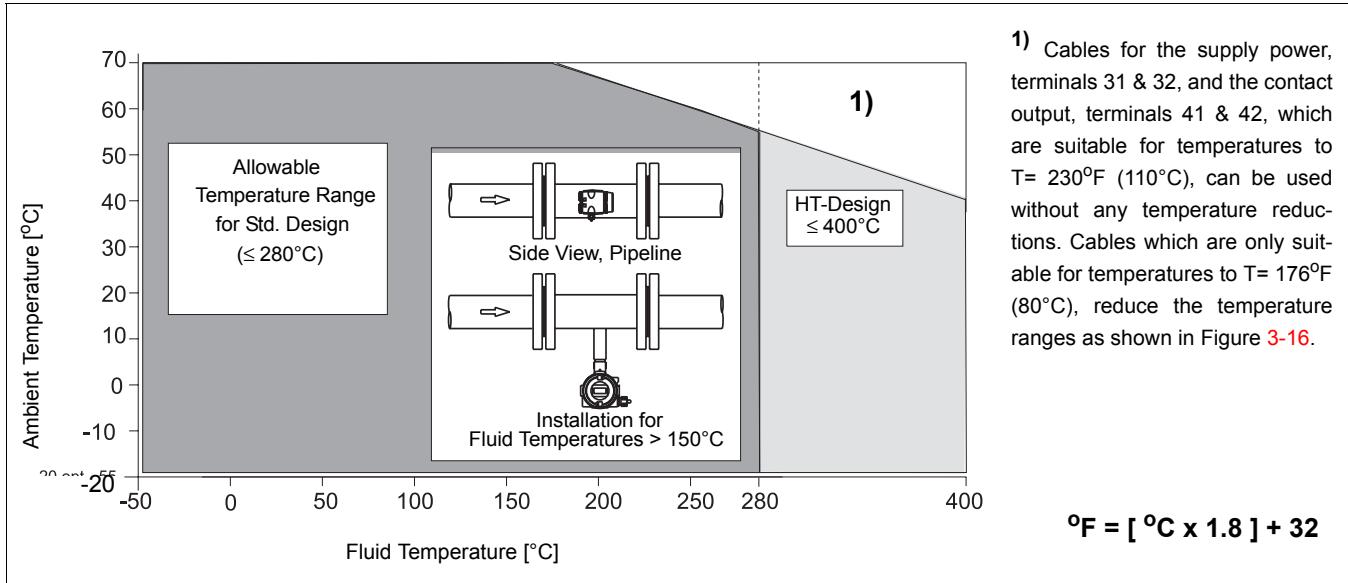


FIGURE 3-16 AMBIENT / FLUID TEMPERATURE RELATIONSHIP

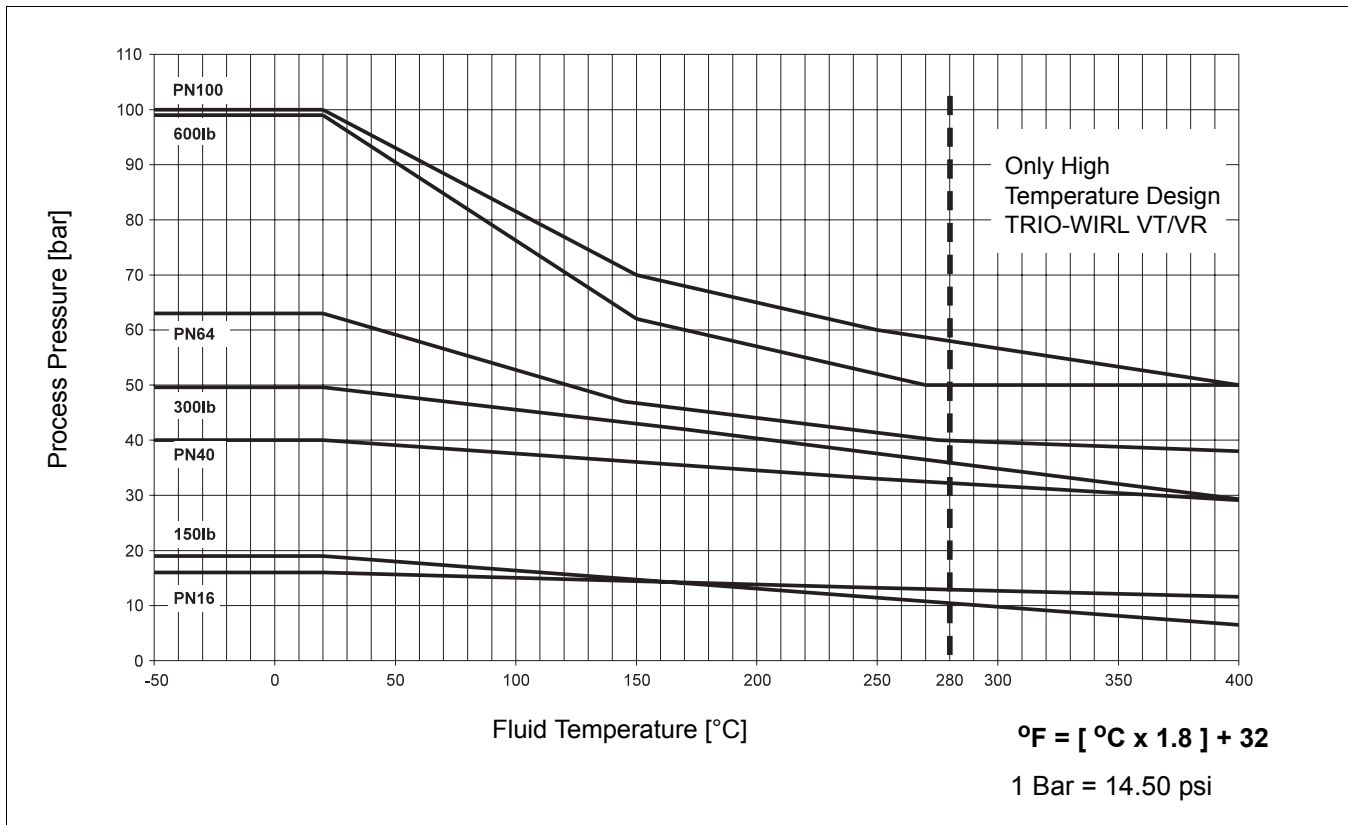
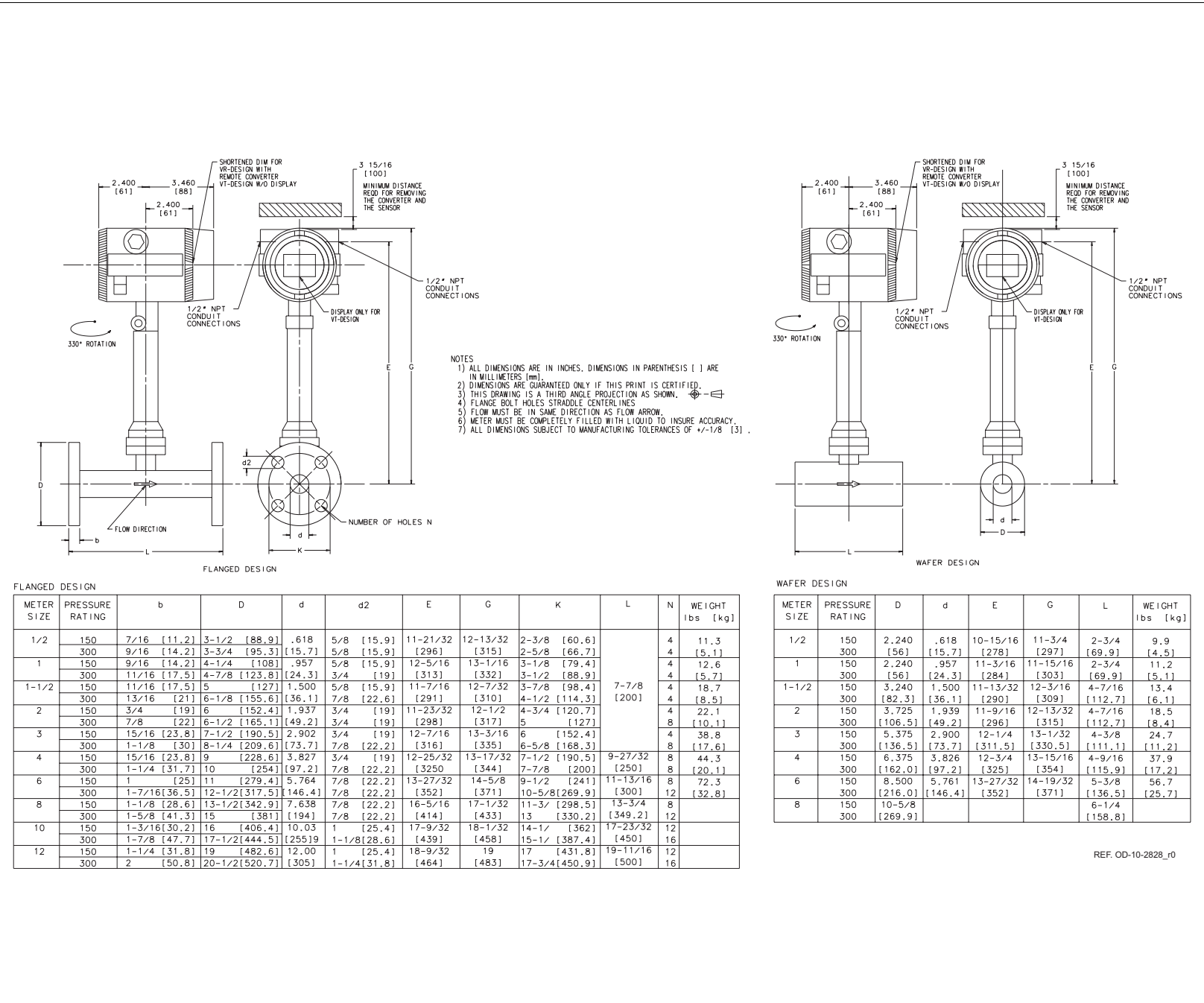


FIGURE 3-17 PROCESS PRESSURE vs. PROCESS FLUID TEMPERATURE

FIGURE 3-18 OUTLINE DIMENSIONS, VTVR PRIMARY



FLANGED DESIGN

METER SIZE	PRESSURE RATING	b	D	d	d2	E	G	K	L	N	WEIGHT lbs [kg]
1/2	150	7/16 [11.2]	3-1/2 [88.9]	.618	5/8 [15.9]	11-21/32	12-13/32	2-3/8 [60.6]		4	11.3
	300	9/16 [14.2]	3-3/4 [95.3]	[15.7]	5/8 [15.9]	[296]	[315]	2-5/8 [66.7]		4	[5.1]
1	150	9/16 [14.2]	4-1/4 [108]	.957	5/8 [15.9]	12-5/16	13-1/16	3-1/8 [79.4]		4	12.6
	300	11/16 [17.5]	4-7/8 [123.8]	[24.3]	3/4 [19]	[313]	[332]	3-1/2 [88.9]		4	[5.7]
1-1/2	150	11/16 [17.5]	5 [127]	1.500	5/8 [15.9]	11-7/16	12-7/32	3-7/8 [98.4]		4	18.7
	300	13/16 [21]	6-1/8 [155.6]	[36.1]	7/8 [22.6]	[291]	[310]	4-1/2 [114.3]	7-7/8 [200]	4	[8.5]
2	150	3/4 [19]	6 [152.4]	1.937	3/4 [19]	11-23/32	12-1/2	4-3/4 [120.7]		4	22.1
	300	7/8 [22]	6-1/2 [165.1]	[49.2]	3/4 [19]	[298]	[317]	5 [127]		8	[10.1]
3	150	15/16 [23.8]	7-1/2 [190.5]	2.902	3/4 [19]	12-7/16	13-3/16	6 [152.4]		4	38.8
	300	1-1/8 [30]	8-1/4 [209.6]	[73.7]	7/8 [22.2]	[316]	[335]	6-5/8 [168.3]		8	[17.6]
4	150	15/16 [23.8]	9 [228.6]	3.827	3/4 [19]	12-25/32	13-17/32	7-1/2 [190.5]	9-27/32 [250]	8	44.3
	300	1-1/4 [31.7]	10 [254]	[97.2]	7/8 [22.2]	[325]	[344]	7-7/8 [200]		8	[20.1]
6	150	1 [25]	11 [279.4]	5.764	7/8 [22.2]	13-27/32	14-5/8	9-1/2 [241]	11-13/16 [300]	8	72.3
	300	1-7/16 [36.5]	12-1/2 [317.5]	[146.4]	7/8 [22.2]	[352]	[371]	10-5/8 [269.9]		12	[32.8]
8	150	1-1/8 [28.6]	13-1/2 [342.9]	7.638	7/8 [22.2]	16-5/16	17-1/32	11-3/4 [298.5]	13-3/4 [349.2]	8	72.3
	300	1-5/8 [41.3]	15 [381]	[194]	7/8 [22.2]	[414]	[433]	13 [330.2]		12	[32.8]
10	150	1-3/16 [30.2]	16 [406.4]	10.03	1 [25.4]	17-9/32	18-1/32	14-1/4 [362]	17-23/32 [450]	12	112.0
	300	1-7/8 [47.7]	17-1/2 [444.5]	[255.9]	1-1/8 [28.6]	[439]	[458]	15-1/4 [387.4]		16	[50.0]
12	150	1-1/4 [31.8]	19 [482.6]	12.00	1 [25.4]	18-9/32	19	17 [431.8]	19-11/16 [500]	12	112.0
	300	2 [50.8]	20-1/2 [520.7]	[305]	1-1/4 [31.8]	[464]	[483]	17-3/4 [450.9]		16	[50.0]

WAFER DESIGN

METER SIZE	PRESSURE RATING	D	d	E	G	L	WEIGHT lbs [kg]
1/2	150	2.240	.618	10-15/16	11-3/4	2-3/4	9.9
	300	[56]	[15.7]	[278]	[297]	[69.9]	[4.5]
1	150	2.240	.957	11-3/16	11-15/16	2-3/4	11.2
	300	[56]	[24.3]	[284]	[303]	[69.9]	[5.1]
1-1/2	150	3.240	1.500	11-13/32	12-3/16	4-7/16	13.4
	300	[82.3]	[36.1]	[290]	[309]	[112.7]	[6.1]
2	150	3.725	1.939	11-9/16	12-13/32	4-7/16	18.5
	300	[106.5]	[49.2]	[296]	[315]	[112.7]	[8.4]
3	150	5.375	2.900	12-1/4	13-1/32	4-3/8	24.7
	300	[136.5]	[73.7]	[311.5]	[330.5]	[111.1]	[11.2]
4	150	6.375	3.826	12-3/4	13-15/16	4-9/16	37.9
	300	[162.0]	[97.2]	[325]	[354]	[115.9]	[17.2]
6	150	8.500	5.761	13-27/32	14-19/32	5-3/8	56.7
	300	[216.0]	[146.4]	[352]	[371]	[136.5]	[25.7]
8	150	10-5/8				6-1/4	
	300	[269.9]				[158.8]	

REF. OD-10-2828\_r0

## CHAPTER 4 Converter

### 4.1 General

The TRIO-WIRL flow metering system is designed as a 2-wire instrument, i.e. the supply power and the current output signal (4-20 mA) both use the same pair of connection leads.

Two converter mounting versions are available, integral (models ST/VT) and remote (models SR/VR).

#### INTEGRAL

The TRIO-WIRL VT/ST models are supplied with an integrally mounted microprocessor-based signal converter as shown in Figure 4-1. The converter uses state-of-the-art Digital Signal Processor (DSP) technology for superior flow and vibration noise immunity. This combination of flowmeter and electronics allows maximum flexibility for on-site calibration and maintenance. Database interrogations and changes at the flowmeter may be performed using the three pushbuttons or by activating three magnetic switches using a magnetic "stick". The two line, 16 character LCD display permits continuous monitoring of the flow rate and totalizer using multiplexing, if desired.

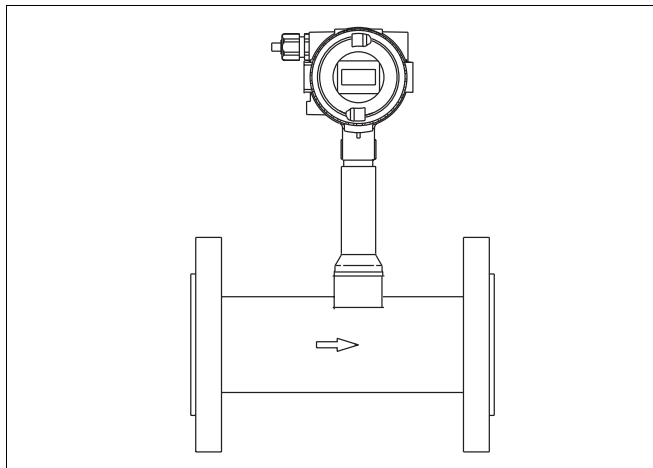


FIGURE 4-1 INTEGRAL TRIO-WIRL MODEL VT

#### REMOTE

The TRIO-WIRL VR/SR models (Figure 4-2) are based on the VT/ST converter technology and include all the options available in the VT/ST models. The difference is that the converter is mounted remotely from the flowmeter primary when the primary is installed in a location difficult to access. The converter may be either

wall-mounted or pipe-mounted (pipe-mounting hardware is shown in Figure 4-3). The remote design also offers advantages when the ambient conditions at the flowmeter primary are extreme. The maximum distance between the converter and the flowmeter primary is 10 meters. A special cable is supplied with the meter to interconnect the flowmeter primary and the converter and is permanently attached to the converter.

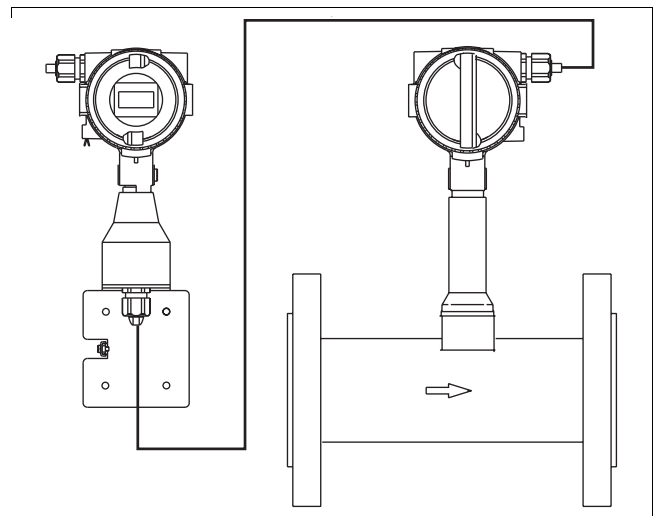


FIGURE 4-2 REMOTE TRIO-WIRL MODEL VR

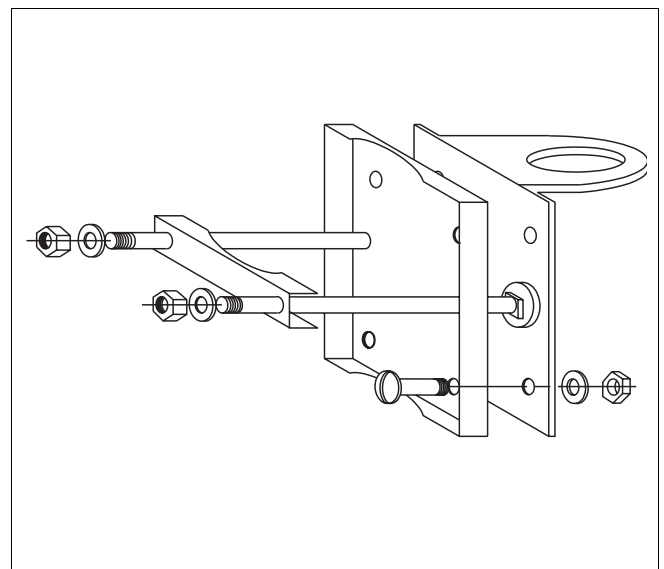


FIGURE 4-3 VR/SR PIPE-MOUNT BRACKET

After the installation has been completed, the cable can be cut to the length required to reach the flowmeter primary. Because the signals between the flowmeter primary and converter are not amplified all connections

must be made with care and the leads positioned in the connection box so that they are not affected by vibrations.

## 4.2 Converter Positioning

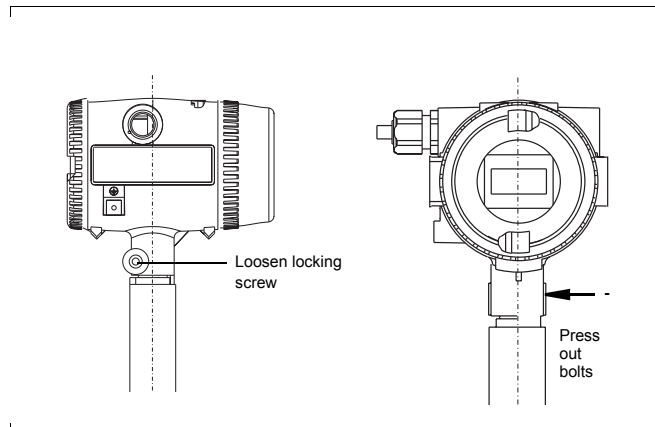
During installation, the converter housing may be rotated and positioned for optimal readability. A simple mechanical block prevents the housing from being rotated more than 330°. This protects the cable which is connected to the flowmeter primary.

The procedure to rotate the converter is as follows (refer to Figure 4-4):

1. Loosen the locking screw on the converter housing with a 4 mm hex wrench.
2. Press out the locking bolt.
3. Rotate the converter housing to the desired position.
4. Reinsert the locking bolt.
5. Tighten the locking screw.

Additional versatility is provided by the ability to rotate the display 90° for applications which require the meter to be mounted in a vertical pipeline. The procedure to rotate the display is as follows:

1. Unscrew and remove the display housing cover.
2. Remove the display bezel by un-clipping the two tabs on the sides of the bezel. Pull the tabs slightly outward and upward to remove the bezel and provide access to the PCB mounting screws.



**FIGURE 4-4 CONVERTER HOUSING ROTATION**

3. Remove the 4 mounting screws that secure the display PCB assembly to the converter PCB stack.
4. Rotate the display either 90° clockwise or counter-clockwise, depending on the desired orientation.
5. Resecure the display PCB by re-installing the 4 mounting screws.
6. Re-attach both the display bezel and the display housing cover.

## 4.3 Data Entry

Figure 4-5 shows the converter's display and programming pushbutton locations. The data may be entered using either the 3 pushbuttons (DATA, STEP & C/CE)

on the converter or by activating the magnetic sensors with the Magnetic Stick when the housing cover is closed



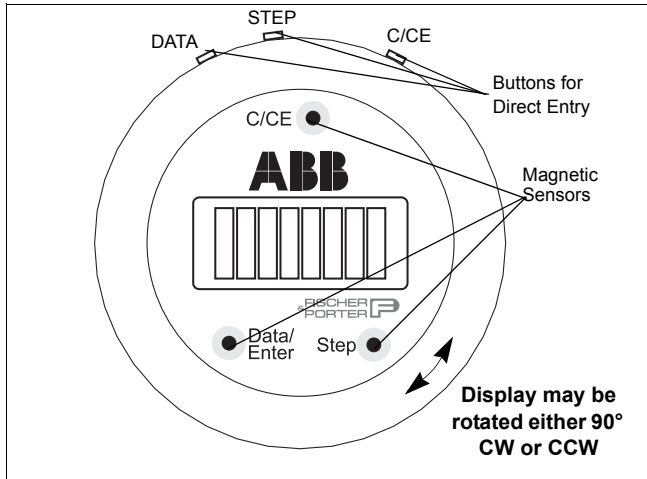


FIGURE 4-5 CONVERTER KEYPAD & DISPLAY

### 4.3.1 ENTER Function for Magnetic Stick Operation

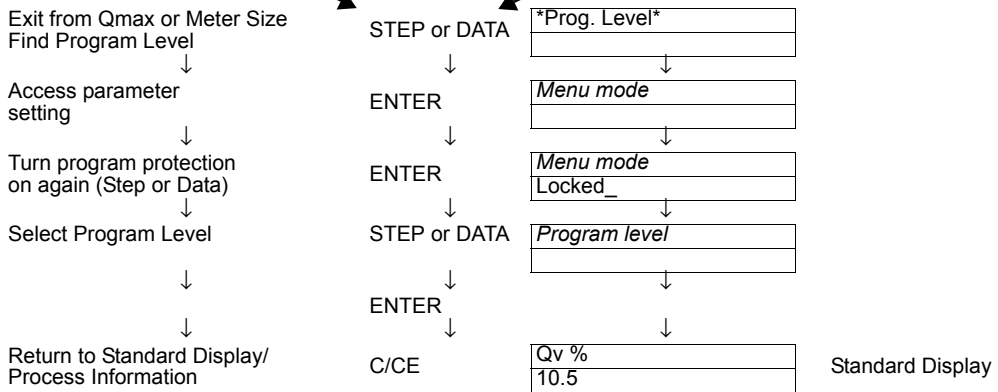
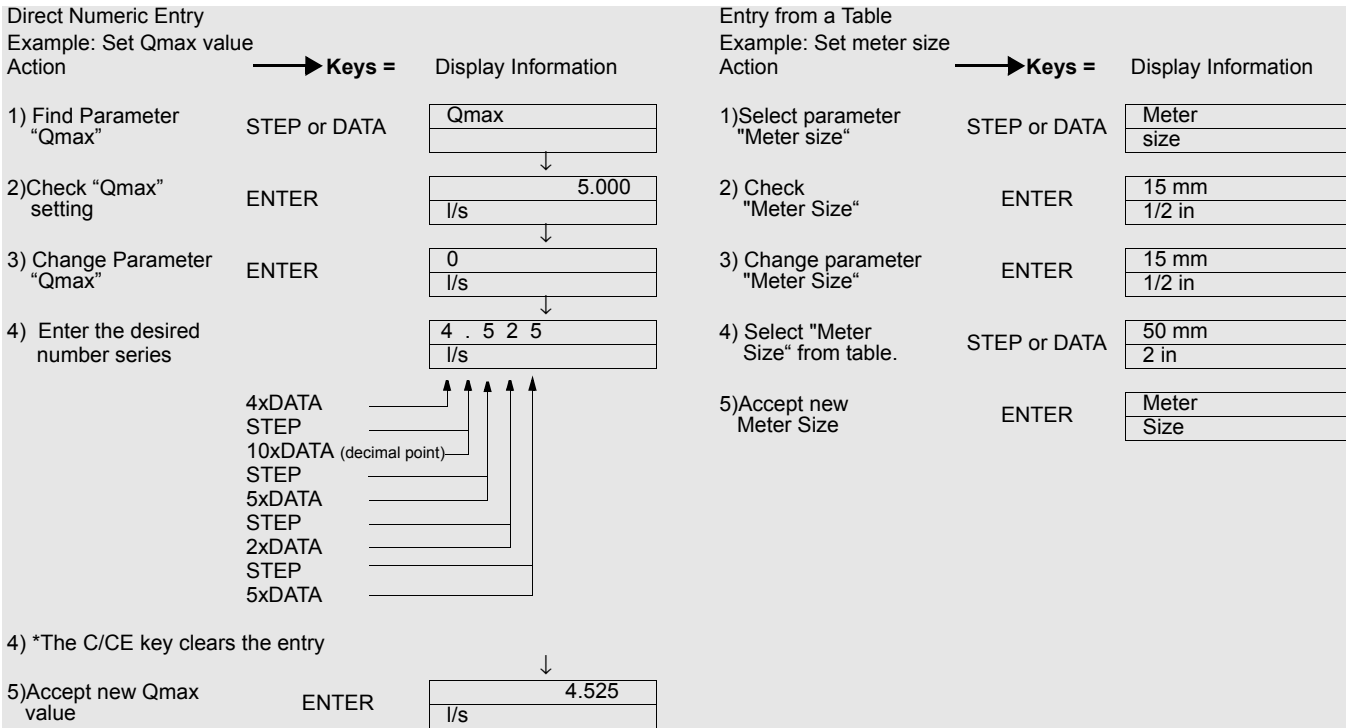
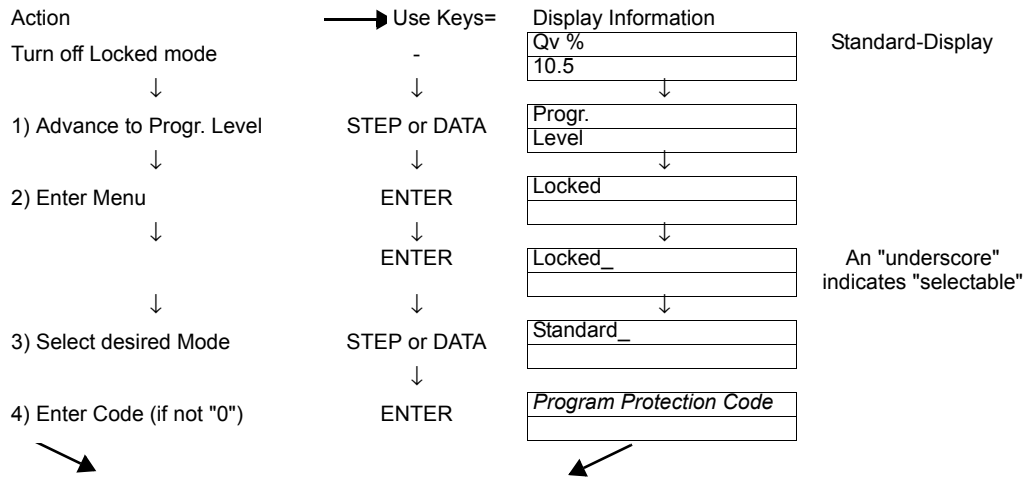
The ENTER function is initiated when the DATA/ENTER magnetic sensor is activated for more than 3 seconds. The display blinks to indicate that the function is active.

The converter remains on-line during data entry, i.e., the current output continues to indicate the actual instantaneous flowrate values and the pulse output continues to totalize. The individual button functions are described in the following table:

- C/CE** The C/CE-key is used to toggle back and forth between the operating mode and the menu display. It is also used for the "exit" function to exit from the menus.
- STEP ↑** The STEP-key is one of two arrow keys. **STEP is used to scroll forward through the menu.** All desired parameters can be accessed.
- DATA ↓** The DATA-key is one of two arrow keys. **DATA is used to scroll backward through the menu.** All desired parameters can be accessed.
- ENTER** The ENTER function requires that both arrow keys, STEP and DATA, be pressed simultaneously. ENTER is utilized to access the values in the parameter to be changed and to accept the new values or selections. The ENTER function is only active for approx. 10 Sec. If no entries are made during this 10 Sec. time interval the old value is redisplayed on the converter. If an additional 10 seconds elapses without any action, the standard process display reappears.
- STEP**
- DATA**

4.3.2 Data Entry Overview

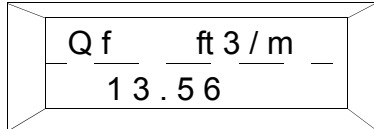
**!** Note:  
The program protection must be turned off before data can be entered (refer to Section 5.5.2)



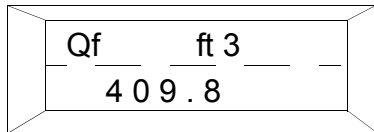
## 4.4 Operation and Configuration

After the power is applied to the instrument, it automatically executes several self test routines. After they have successfully completed, the process information is displayed on the LCD display. The operator may configure which units are to be displayed:

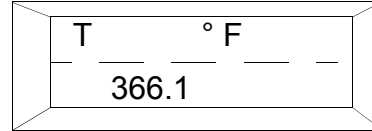
Actual flowrate in direct reading engineering units:



Totalized actual flow:



Fluid temperature:



A Multiplex-Mode is also selectable for the display. In this mode it is possible to display several parameters. The parameter shown on the display alternates every 10 seconds.

## 4.5 Digital Communications Protocols

TRIO-WIRL is available (or will be available) with the following communications protocols:

- \* HART
- \* Profibus
- \* Fieldbus Foundation
- \* SmartVision

### 4.5.1 HART Protocol

The HART-Protocol provides for digital communication between a process control system/PC, handheld terminal and the TRIO-WIRL. All parameters, such as meter location specific data, can be transmitted from the converter to the process control system or PC. In the reverse direction it is possible to reconfigure the converter.

The digital communication utilizes an ac signal superimposed on the current output (4-20 mA) which does not affect any other instruments connected to the output.

The Microsoft WINDOWS-based software program SMART VISION<sup>®</sup> may be used to operate and configure the converter using HART-Communication. SMART VISION is a universal communication software tool for intelligent field instruments, which uses a vari-

ety of communication methods to provide for data exchange and includes a complete field instrument palette. The main elements include parameter display, configuration, diagnosis, recording and data management for all intelligent field instruments which satisfy the communication requirements.

#### 4.5.1.1 Communication

1. Over FSK-Modem with Point-to-Point or Multidrop operation.
2. Over ABB Automation Products HART-Multiplexer.

SMART VISION is compatible with standard modern PC's or notebook computers running MS Windows Version 3.1 and higher, Windows 95/98 and Windows NT.

#### 4.5.1.2 Transmission Mode

FSK-Modulation on the 4-20 mA current output per Bell 202 Standard. Maximum signal amplitude 1.2 mA<sub>PP</sub>.

Load, Current Output

Minimum = 250 Ω, maximum = 750 Ω

Maximum cable length = 1500 m AWG 24 twisted and shielded

4.5.1.3 Baudrate

1200 Baud

Logic 1: 1200 Hz

Logic 0: 2200 Hz

Current Output During an Alarm Condition = 22.4 mA

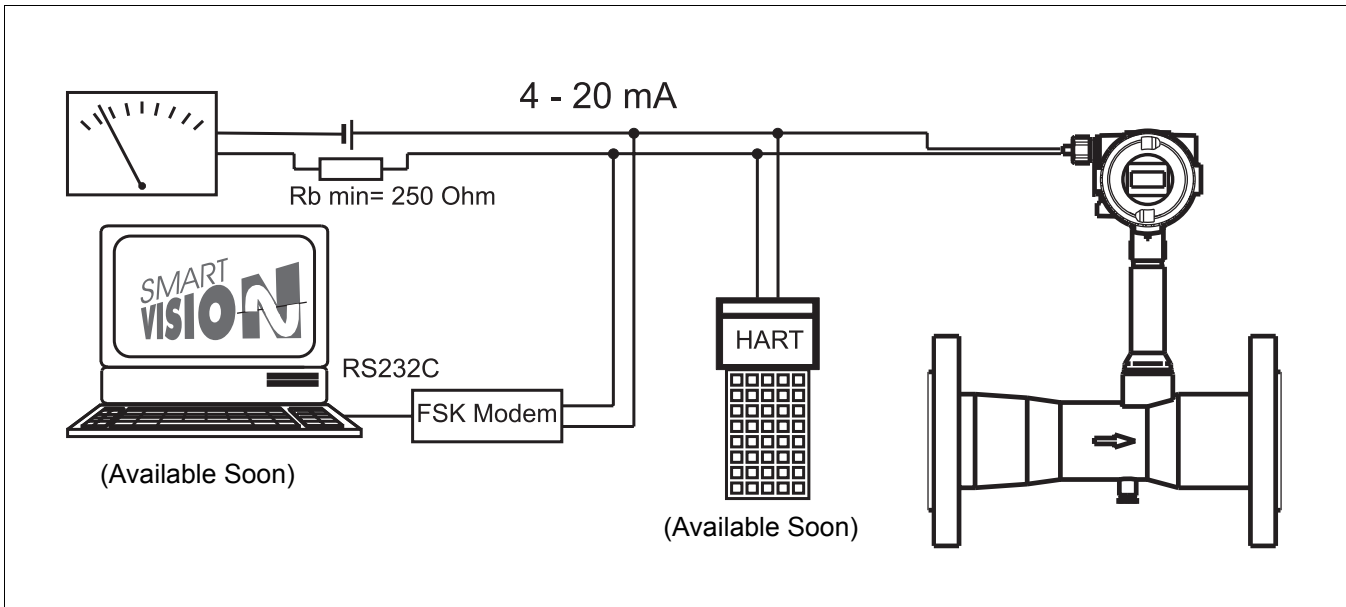
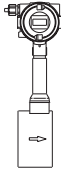
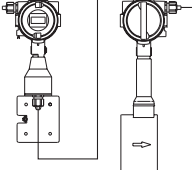

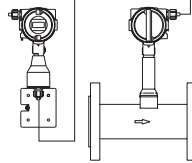
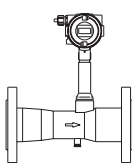
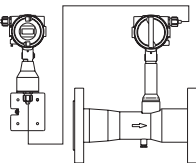


FIGURE 4-6 HART-Communication

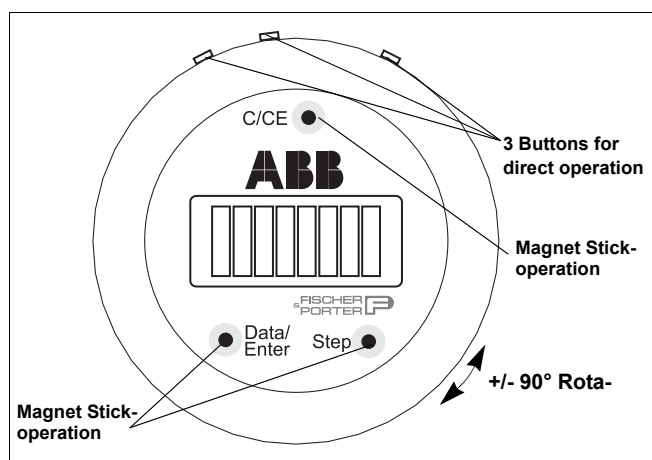
## 4.6 Specifications

### 4.6.1 Overview

					
					
		<b>TRIO-WIRL VT</b>	<b>TRIO-WIRL VR</b>	<b>TRIO-WIRL ST</b>	<b>TRIO-WIRL SR</b>
<b>CONVERTER</b>					
<b>Supply Power</b>	For analog output 4-20 mA	14-46 V (EEx < 28 V)			
	For Profibus PA (in prep.)	< 10 mA			
<b>Self Monitor</b>	yes				
<b>Display</b>	2 x 8 character	Local display/totalization and Magnet Stick operation			
<b>Contact Output</b>	(Optocoupler for standard and Ex "d" or Current-limited contact for Ex "ib")	Can be configured as alarm limit contact (flowrate or temperature), system alarm output or pulse output (Refer to Figure 5-13)			
<b>Communication</b>	HART-Protocol				
	Profibus PA & Fieldbus Foundation available soon				
<b>TRIO-WIRL VR or SR</b>	2" pipe mount for converter.	-	yes, optional	-	Yes, optional
	Signal cable length between primary and converter	-	30 ft. (10 m) max.	-	30 ft. (10 m) max.
<b>APPROVALS / CERTIFICATIONS</b>					
<b>Intrinsically Safe &amp; Explosionproof Design</b>	<b>FM / CSA</b>	Explosion-Proof Class I; Div.1; Groups B-D Intrinsically Safe Class I; Div. 1; Groups A-D Non-Incendive for Class I; Div. 2; Groups A-D Dust Ignition-proof Class II; Div. 1; Groups E-G			

## 4.6.2 Detailed Specifications

### KEYPAD & DISPLAY



**FIGURE 4-7 Converter Keypad and Display**

### FLOW RANGES:

The flow range end value can be continuously set between  $0.15 \times Q_{vmax}$  and  $Q_{vmax}$ .

### PARAMETER SETTING:

Data is entered using the 3 pushbuttons or using the magnetic stick when the housing is closed.

The data is entered in a clear text dialog with the display or through digital communication utilizing HART-Protocol, Profibus PA or Fieldbus Foundation (in preparation).

### DATA PROTECTION:

The totalizer values and the meter location specific parameters are stored for a period of up to 10 years in an EEPROM when the power is turned off or during a power interruption.

### FUNCTION TESTS:

The individual internal subassemblies of the converter can be checked using the built in function tests in the software. Simulated current output values can be entered during start-up (manual process control). The contact output can also be manually actuated for testing purposes.

### DAMPING:

Can be set between 0.5 and 100 sec., equivalent to  $5T @ Q_{vmin}$

### $Q_{vmin}$ (LOW FLOW CUTOFF):

Can be set between 0 and 10% of  $Q_{vmax}$  (maximum actual volume flowrate for the flowmeter size).

### SUPPLY POWER:

Standard:	14 to 46 V DC
Ex-Design:	14 to 28 V DC
Ripple:	max. 5 % or $\pm 1.5 V_{pp}$

### POWER:

< 1 W

### PROTECTION CLASS:

NEMA 4x / IP 67

### OUTPUT SIGNALS:

Current output for flowrate signal (volume or mass):  
4-20 mA, load  $\leq 750 \Omega$

### CONTACT OUTPUT:

The following functions for the contact output can be selected in the software:

- Limit alarm, flowrate: Min, Max or Min-Max
- Limit alarm, temperature: Min, Max or Min-Max
- System alarm
- Pulse output \* : fmax: 100 Hz;  
Pulse width: 1 - 256 ms

\* The pulse output is intended to interface with a Totalizer. The interval between any two pulses may not represent the instantaneous flow rate.

### CONTACT CONFIGURATION:

Standard and Ex "d":	Optocoupler $U_H = 16-30 V$ , $I_L = 2-15 mA$
-Ex "ib":	Current-limited-Contact (Refer to Figure 5-14)

### DISPLAY:

High contrast LC-Display, 2 x 8 characters. For display of the instantaneous flowrate, totalized flow or fluid temperature values (option).

Using the multiplex function it is possible to alternately display two values (e.g. flowrate and totalizer values) alternately.

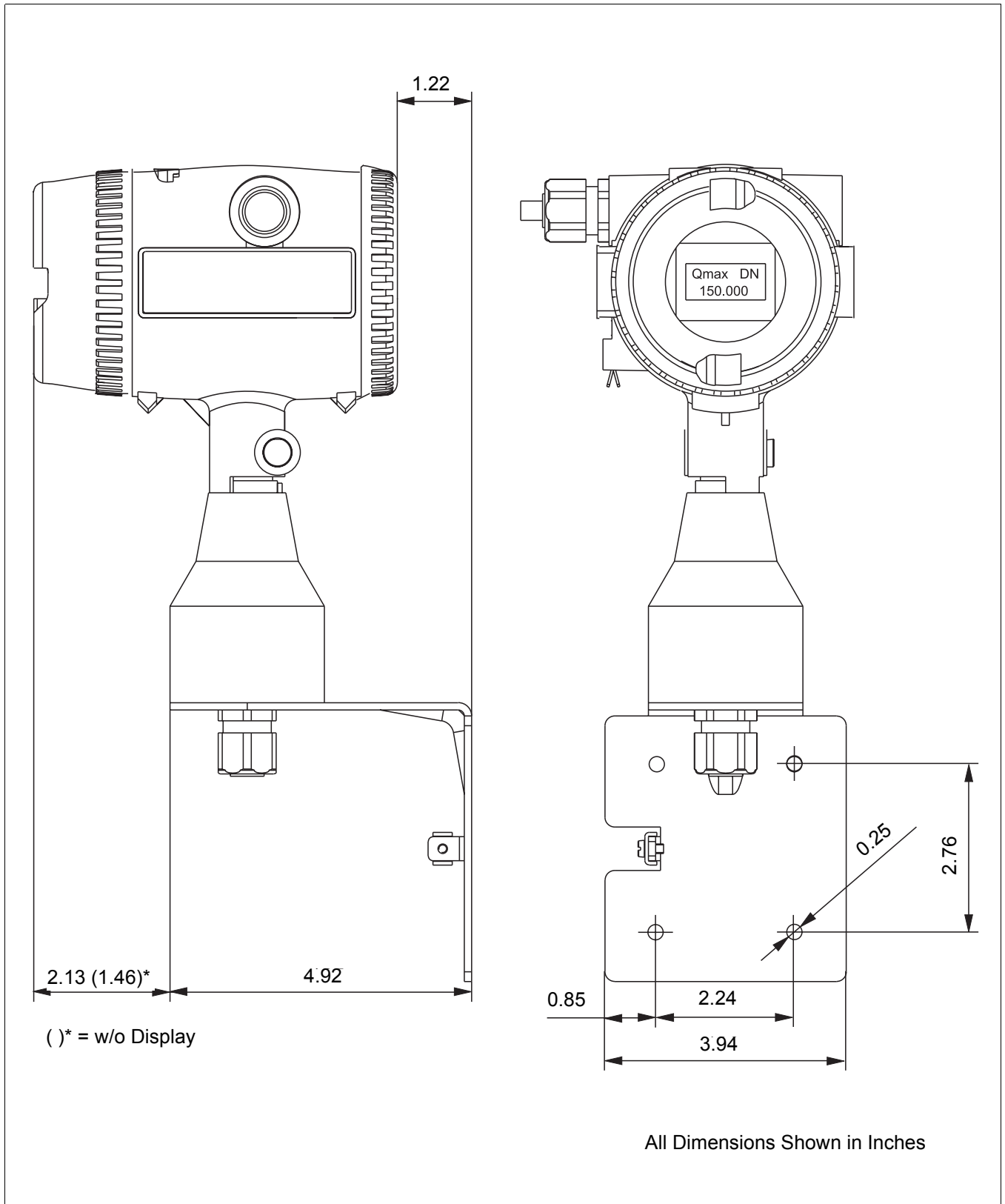


FIGURE 4-8 OUTLINE DIMENSIONS, VR/SR IN WALL-MOUNT HOUSING

# CHAPTER 5 Start-Up & Operation

## 5.1 Start-Up

Prior to initial system start-up, verify that the meter is properly installed. Check flow direction as indicated on the meter body and wiring interconnections as shown in Figures 5-2, 5-4 & 5-5.

Verify that the power supply is the correct value according to the power requirements of the signal converter and that it is connected with the proper polarity.

If everything is properly installed and connected, turn on the power to the meter. The LCD display should become active and display the selected information in two lines.

Using the pushbuttons located in the signal converter housing (see Section 4.3), verify that the correct operating parameters have been entered as described in this section.

If everything appears to be operating properly, initiate process flow through the flowmeter. Flow measurement and output signal transmission should begin as the process fluid flows through the meter.

### 5.1.1 Calibration Parameters

The TRIO-WIRL flowmeter is precision-calibrated at the factory for the values specified at the time of order. The meter data is noted on a paper data tag located on the customer connection lid. A metal data tag is located on the outside of the instrument with additional data. A sample of this tag is shown in Figure 5-1.



FIGURE 5-1 INSTRUMENT DATA TAG

### 5.1.2 Firmware Version

The firmware level and the model number are shown in the display with the model number and firmware release date on the top line and the EPROM identification and firmware level on the bottom line. Changes to the firmware can only be made by replacing the EPROM. When communicating with ABB Inc., please reference the firmware version of the instrument.

The Functional Flowchart shown in Figure 4-1 gives a pictorial overview of the top-level menu structure of this version of firmware. Functions of these menu parameters and their sub-menu breakdowns are explained in more detail following the flowchart.

This procedure has been prepared based on firmware version **699F004U01 A.11**. Other versions will be similar, but not identical and may have features different from those discussed in this section.

### 5.1.3 Program Protection

The Program Protection is automatically turned ON during power-up. Parameters cannot be changed when Program Protection is ON. Refer to Section 4.3.2 to change Program Protection from ON to OFF (or vice-versa).

### 5.1.4 Error Messages

Error messages replace the flow rate indication in the top line of the display when certain failure conditions exist or when an attempt has been made to enter an unacceptable value.

Refer to Chapter 6 for definitions of displayed error messages.

## 5.2 Electrical Interconnections

### 5.2.1 TRIO-WIRL VT/ST4000 Integral

The flow metering system TRIO-WIRL is designed as a 2-wire instrument, i.e. the supply power and the current output signal (4-20 mA) both use the same pair of connection leads as shown in Figure 5-2.



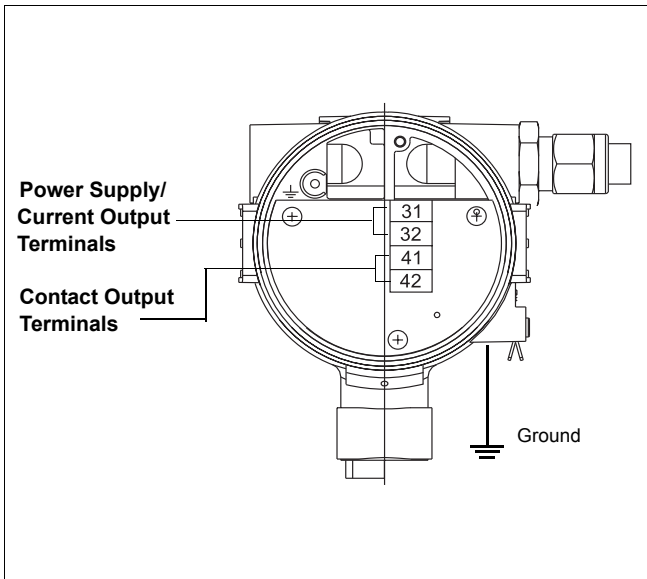


FIGURE 5-2 CONNECTION BOX TRIO-WIRL

### 5.2.2 TRIO-WIRL VR/SR4000 Remote

The TRIO WIRL VR/SR (Figure 5-3) is based on the VT/ST technology and includes all the options available in the VT/ST models. The converter is mounted remotely from the flowmeter primary when it is installed in a location difficult to access. This design also offers advantages when the ambient conditions at the flowmeter primary are extreme. The meter should be connected using Figures 5-4 & 5-5 as guidelines. The maximum distance between the converter and the flowmeter primary is 33 ft. (10 m). A special cable is utilized to interconnect the flowmeter primary and the converter (this cable is permanently attached to the converter).

After the installation has been completed, the cable may be cut to the length required to reach the flowmeter primary. Because the signals between the flowmeter primary and converter are not amplified, all connections must be made with care and the leads positioned in the connection box so that they are not affected by vibrations.

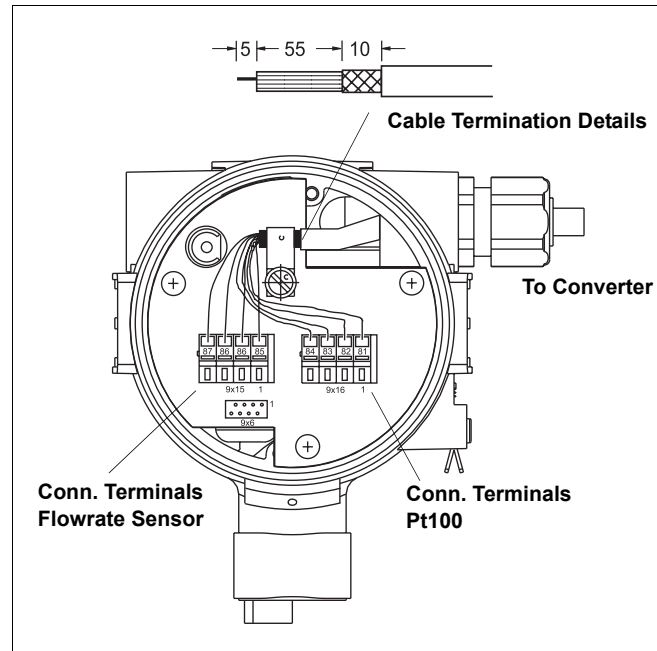


FIGURE 5-4 CONNECTION BOX TRIO-WIRL VR/SR FLOWMETER PRIMARY

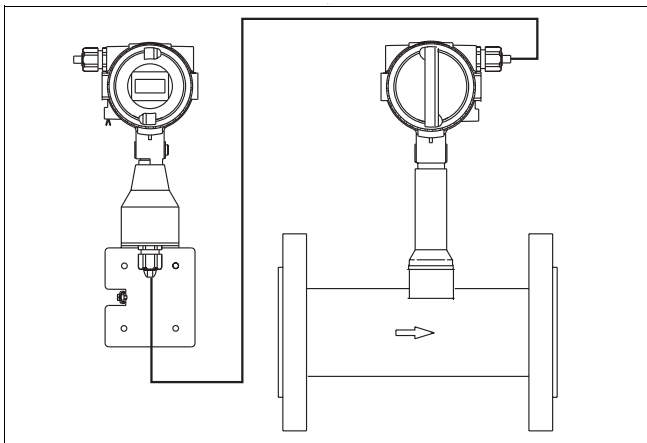


FIGURE 5-3 TRIO-WIRL VR/SR

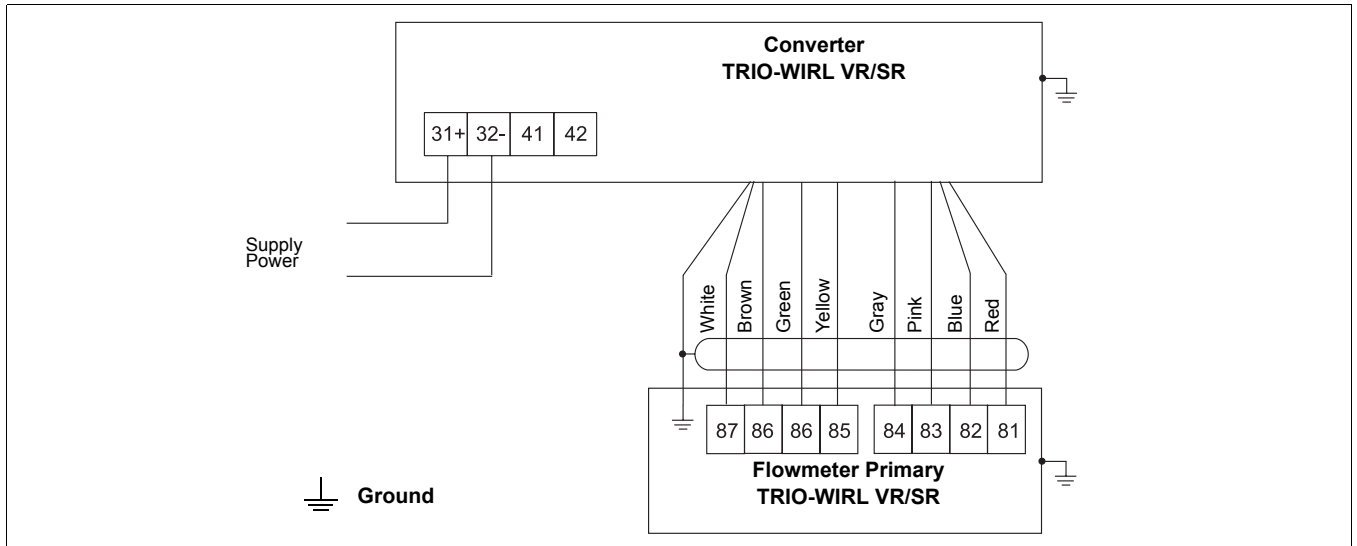


FIGURE 5-5 INTERCONNECTIONS BETWEEN CONVERTER AND FLOWMETER PRIMARY

### 5.2.3 Power Supply Interconnections

#### 5.2.3.1 Power Supplied from a Central Power Supply

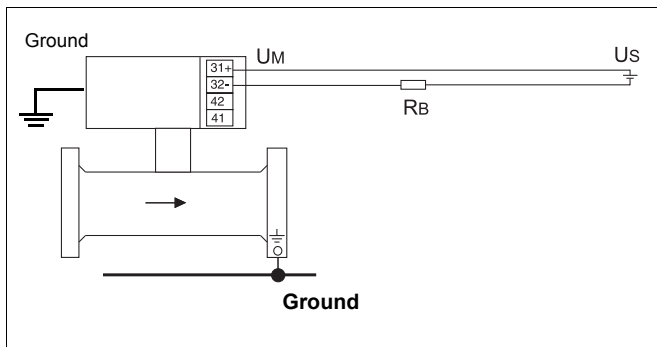


FIGURE 5-6 CENTRAL POWER SUPPLY

$U_M$  = Supply voltage TRIO-WIRL = min. 14 V DC  
 $U_S$  = Supply voltage, 14 - 46 V DC  
 $R_B$  = Max. allow. load for Transmitter Power Supply (e.g. recorder, cable resistor (refer to Figure 5-8))  
 $R$  = Max. allow. load for the output circuit is determined by the Transmitter Power Supply (e.g. indicator, recorder, etc.)

#### 5.2.3.2 Power Supplied from Transmitter Power Supply

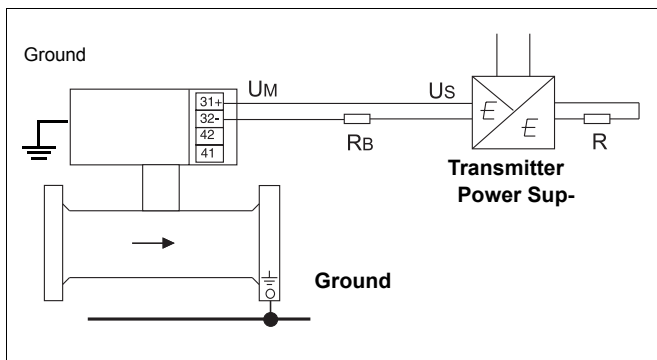


FIGURE 5-7 TRANSMITTER POWER SUPPLY

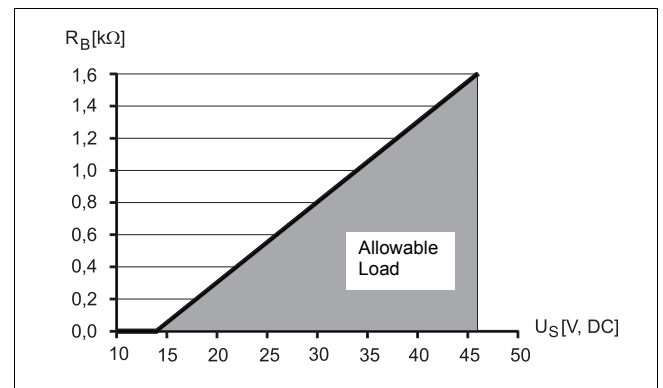
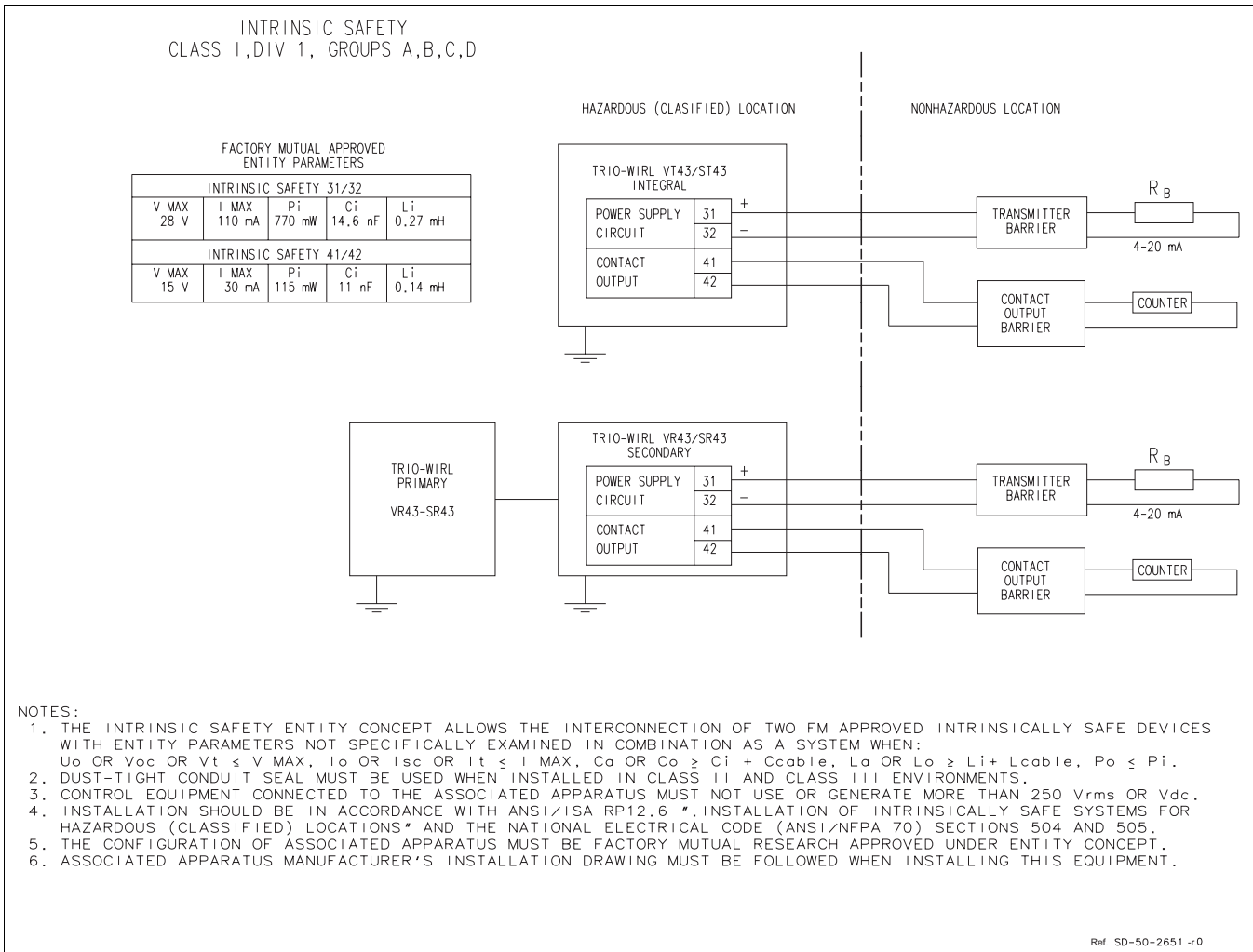


FIGURE 5-8 LOAD DIAGRAM

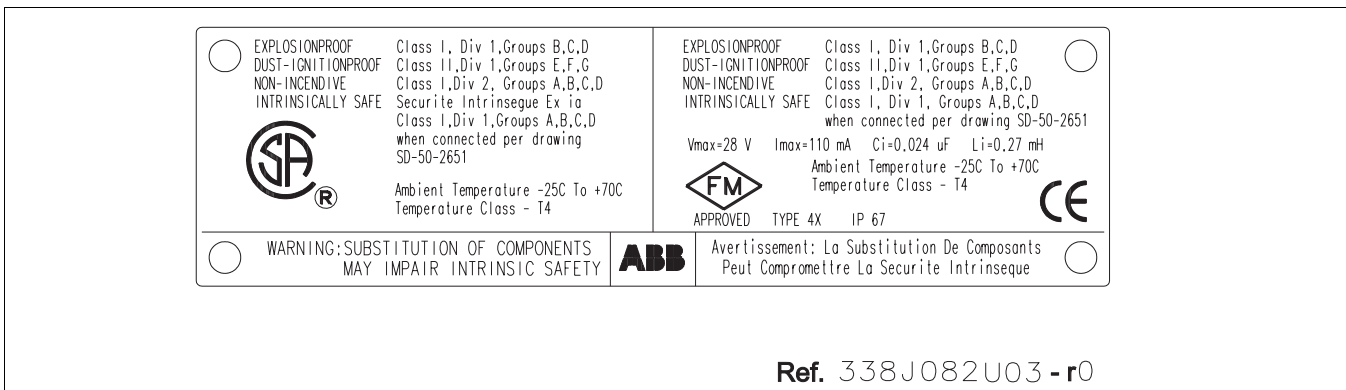
#### 5.2.3.3 Hazardous Location Installation

TRIO-WIRL meters are FM/CSA approved for intrinsically safe & explosion proof operation. Refer to Figure 5-9 for wiring requirements and Figure 5-10 for labelling.

# TRIO-WIRL INSTRUCTION MANUAL



**FIGURE 5-9 POWER SUPPLY INTERCONNECTION DIAGRAM, HAZARDOUS LOCATIONS**



**FIGURE 5-10 FM / CSA LABEL**

### 5.2.4 Contact Output Connections

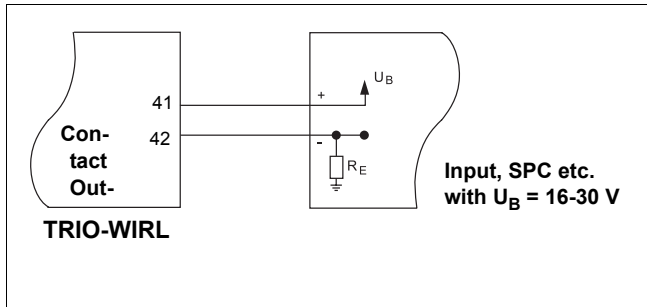


FIGURE 5-11 CONTACT OUTPUT CONNECTION

The value of the resistance  $R_E$  is a function of the supply power  $U_B$  and the selected signal current  $I_B$  (refer to Figure 5-12).

$$R_E = \frac{U_B}{I_B}$$

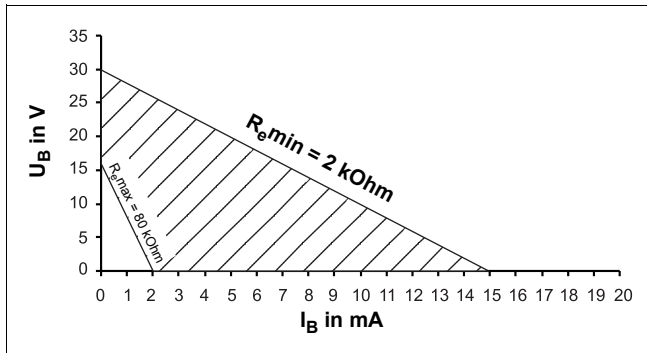


FIGURE 5-12 RELATIONSHIP  $R_E$  AT THE CONTACT OUTPUT AS A FUNCTION OF

## 5.3 Converter Configuration

### 5.3.1 Data-Entry Check

The measurement system has been configured by the factory prior to shipment based on the information included with the customer order. All the required values have been entered. Because the instruments can be installed to measure liquids or gases, it is recommended that the following software parameter settings be checked at start-up:

Parameter	Action
1. Meter size	Select Meter Size. The displayed value must be identical to the size listed on the Instr. Tag
2. Operating mode	
3. k-Factor	Select k-Factor. The displayed value must be identical to the value listed on the Instr. Tag.

4. Which flowrate units are to be used for the display indications and for the totalizer values?

Mass Units		Volume Units	
Parameter	Action	Parameter	Action
Operating mode Mass	select	Operating mode Volume, Normal Standard, Actual	select from table
Density units Qm	from table	Units Qv/Qn/Qs/ l/min	select from table
Operating density	enter	Normal factor (only for Qs, Qn)	enter value
Units Qm kg/s	from table		

5. Enter the desired flow range in the units selected above in the parameter **Qmax Operating Mode**.

Entry range: 0.15 to 1.15 x  $Range_{max}$  actual.

6. Check the low flow cutoff value in the parameter **Qmin Actual**

Entry range: 0 to 0.1 x  $Range_{max}$ .

7. Select the units for the internal and external totalizers in the parameter **Units Totalizer**.

8. The response time of the converter can be set in the parameter **Damping**. Default setting is 3 sec.

9. Select submenu **Display** and select desired values, e.g.:

For main display select percent

For multiplex display select totalizer values

The measurement system is now ready for operation.

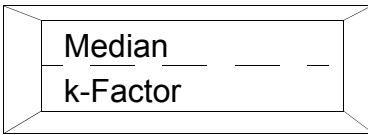
### 5.3.2 Additional Configuration Information

#### 5.3.2.1 Meter Size

This parameter is used to define the size of the installed flowmeter since the same converter can be used for all flowmeter sizes.

The meter size is set at the factory for the converter's assigned flowmeter primary (see Instrument Tag).

5.3.2.2 Calibration K-Factor



The median (average) k-Factor value is displayed by navigating to the above menu item and pressing **Enter**.

Each flowmeter is calibrated on a test stand at 5 flow-rate values. The 5 calibration factors are entered into the converter and recorded on a calibration report and on a paper tag located in the customer connection lid.

Typical calibration factor values and the signal frequencies for liquids and gases are listed in the following table. These values are approximate guidelines only:

Vortex Flowmeter TRIO-WIRL V

Meter Size		Typ. k-Factor	Liquid $f_{max}$ at $Q_{vmax}$ [Hz]	Gas $f_{max}$ at $Q_{vmax}$ [Hz]
Inch	DN	max [1/m <sup>3</sup> ]		
1/2	15	30000	450	1840
1	25	80000	400	1825
1-1/2	40	21100	280	2000
2	50	10000	180	1250
3	80	2900	130	760
4	100	1300	80	650
6	150	380	55	425
8	200	166	43	310
10	250	66	28	235
12	300	39	23	190

Swirl Flowmeter TRIO-WIRL S

Meter Size		Typ. k-Factor	Liquid $f_{max}$ at $Q_{vmax}$ [Hz]	Gas $f_{max}$ at $Q_{vmax}$ [Hz]
Inch	DN	max [1/m <sup>3</sup> ]		
1/2	15	440000	185	1900
1	25	86000	135	1200
1-1/4	32	33000	107	1300
1-1/2	40	21000	110	1400
2	50	11100	90	1200
3	80	2900	78	690
4	100	1620	77	700
6	150	460	50	470
8	200	194	30	330
12	300	54	16	160
16	400	upon request	13	150

The converter calculates the actual flowrate using the following equations:

$$Q = \frac{f}{k}$$

Where:

Q= Actual flowrate at operating conditions [m<sup>3</sup>/s]

f = Frequency [1/s]

k = Calibration k-Factor [1/m<sup>3</sup>]

5.3.2.3 Current Output

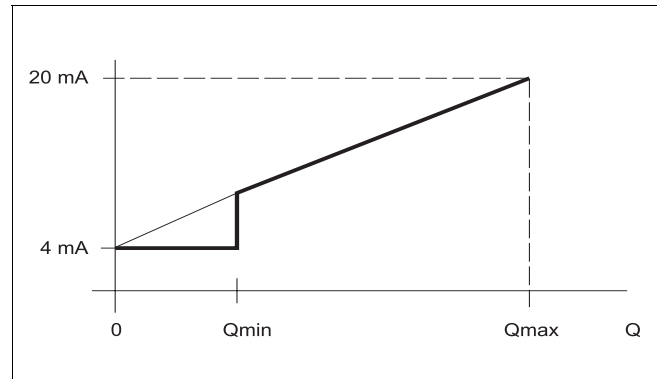


FIGURE 5-13 OUTPUT CURRENT CHARACTERISTICS

The measurement value output characteristic for the current output is shown in Figure 5-13. Above the Qmin (operating mode) value the curve is a straight line whose value at 4 mA is Q = 0 and whose value at 20 mA is the value of Qmax (operating mode). The current output for flowrates less than the low flow cutoff value Qmin is set 4 mA equivalent to Q = 0.

5.3.2.4 Hardware Configuration

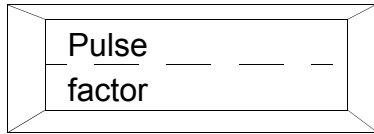
The function assigned to the contact output (terminals 41 & 42) is selected in this submenu. The menus **Pulse width, Min and Max Q\_Alarm** or **Min and Max T\_Alarm** are displayed based on the selection of the output function. „

Selections	Contact Output Function	Menus Displayed
I/HART	None	None
I/HART/Pulse_Bin	Pulse output	Pulse width
I/HART/Q_Alarm_	Flow alarm	Min. and Max. Q_Alarm
I/HART/T_Alarm_	Temperature alarm	Min. and Max. T_Alarm
I/HART/S_Alarm_	System alarm	None

**5.3.2.5 Submenu Pulse Output**

**PULSE FACTOR**

This menu is used to configure the scaled pulse output to the user requirements.

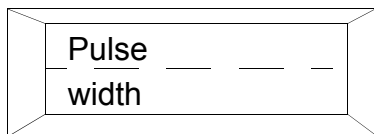


Pulse Factor range is 0.001 - 100

The pulse factor is the number of pulses per selected flow unit.

**PULSE WIDTH**

If the pulse output function is to be assigned to the contact output it is necessary that the parameter "I/HART/Pulse\_Bin" be selected in the menu „Hardware Config“. Otherwise this menu is hidden.



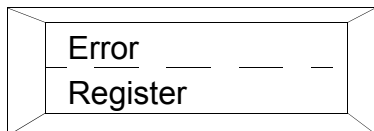
Pulse Width range is 1 - 256 ms

The pulse width (length of the pulses) for the scaled pulse output can be set between 1 and 256 ms.

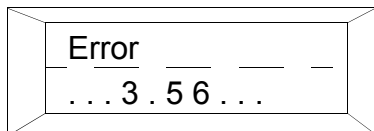
The program monitors the relationship of the pulse width to the period of the maximum pulse frequency (at 115 % flowrate). If an on/off ratio ≥ 50 % results, a warning is displayed and the old value is retained.

**SUBMENU ERROR REGISTER**

This menu contains the error register and the supply power interruption counter.



**ERROR REGISTER**



Displays the error register contents.

All errors detected are permanently stored in the error register, whether they occurred momentarily or for a long time period.

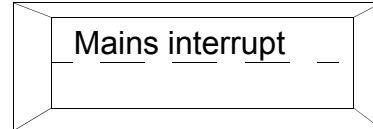
Every number in the error register display represents a specific error type.

Display: ..... = OK  
 .... 3.56... = Error codes

The error register can be cleared by pressing the "ENTER" key.

Error No.	Error	Priority
0	Steam calculations	7
1	Front End	0
2	Not Assigned	N/A
3	Flowrate > 115 %	2
4	Not Assigned	N/A
5	M-Data Base	0
6	Totalizer defective	1
7	Temperature	7
8	Not Assigned	N/A
9	Qv > 115 % QmaxDN	2
A	Kit-FRAM	9
B	B-Data Base	0

**MAINS INTERRUPT**



The Mains Interrupt display shows the number of times power was turned off or interrupted to the converter. The converter counts the number of times the supply power was turned off or interrupted and displays the total. The mains interrupt counter can be reset with the command "Reset Error". This parameter is located at the Service level and requires entry of the Service Code number for access.

**5.3.2.6 Normal Factor (see Section 5.4.1)**

$$\frac{Q_N}{Q_V} = \frac{(1.013bar + p)}{1.013bar} \times \frac{273}{(273 + T)}$$

When Normal conditions are:

$$P = 1.013 \text{ bar (14.5 psi)}$$

$$T = 0 \text{ }^\circ\text{C (32 }^\circ\text{F)}$$

Since the mass flowrate at both conditions is equal the following equation is also applicable:

$$\frac{Q_N}{Q_V} = \frac{\rho_V}{\rho_N}$$

Where:

- $Q_N$  = Normal flowrate at normal conditions
- $Q_V$  = Actual flowrate at operating conditions
- $p$  = Pressure at operating conditions
- $T$  = Temperature at operating conditions [ $^{\circ}C$ ]
- $\rho_V$  = Density at operating conditions
- $\rho_N$  = Density at normal conditions

### 5.3.3 Configuring the Contact Output

The contact output of the converter is configured at the factory based on the specified Model Number.

Model Number Code	Agency Approvals	Contact Design
VT/VR43, ST/SR43	FM/CSA	Optocoupler

If desired, the contact output configuration may be changed. Disconnect power from the flowmeter and remove the cover. In order to change the switch positions, the converter electronics module must be removed from the housing. Unscrew the 3 Phillips head mounting screws and remove the converter from the housing. Set the switch as shown in Figure 5-14. Carefully reinstall the converter in the housing, making certain that it is centered and tighten the 3 mounting screws. Replace the converter cover

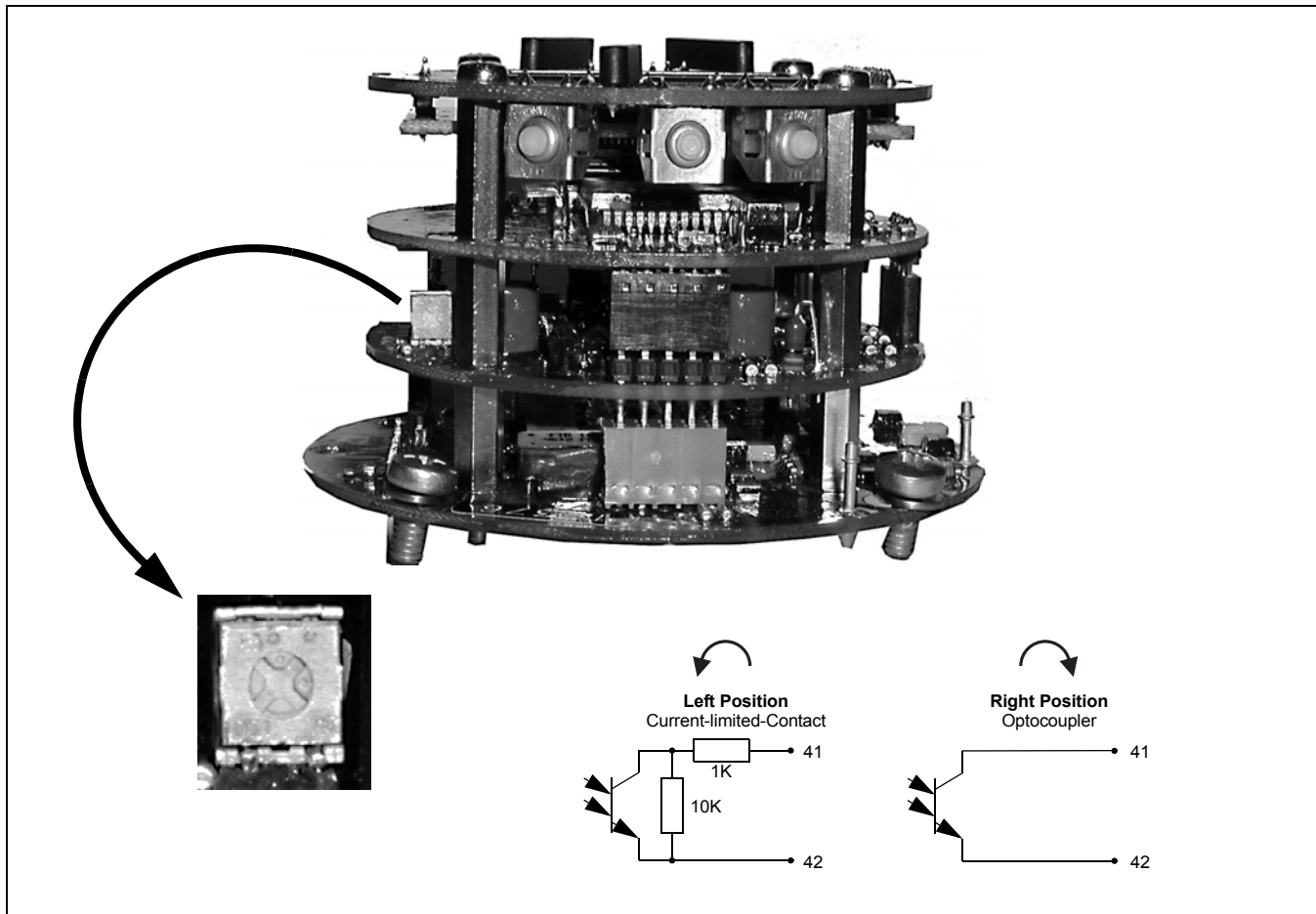


FIGURE 5-14 CONTACT OUTPUT CIRCUITS

## 5.4 TRIO-WIRL Menu Structure

The menu structure is subdivided into four user levels. Refer to Table 5-1 for menu items available in each level.

### 1ST LEVEL: STANDARD

The standard menu provides a quick means for configuring the instrument. All user specific menu entries required for operating the instrument can be set in this menu.

### 2ND LEVEL: SPECIALIST

In contrast to the standard menu the **complete** set of user specific parameters are accessible in this menu.

### 3RD LEVEL: SERVICE

The Service-Menu is only accessible to ABB Inc. Customer Service personnel.

### 4TH LEVEL: LOCKED

Same menus displayed as in STANDARD mode. Allows displaying or verifying instrument parameters and settings but does not allow entering new data or making changes.

### 5.4.1 Configuring Gases, Steam or Liquids

The following table lists selections for the available operating modes, required parameters and additional menus displayed.

Operating Mode <sup>1)</sup>	Fluid	Measurement Method	Equations	Correction Parameters	Additional Menus Displayed
Liquid Qv	Liquid	Volume flowrate	—	—	—
Liquid Qm (D)	Liquid	Mass flowrate	$Qm = Qv \cdot \rho_{oper}$	Constant operating density $\rho_{oper}$	Units Density Operating density Units Qm
Liquid <sup>2)</sup> Qm(D,T)	Liquid	Mass flowrate	$Qm = Qv \cdot \rho(T)$ $\rho(T) = \rho_0 \cdot (1 + (T_{oper} - T_0) \cdot \beta_2)$	Ref. density $\rho_0$ ; Ref. temp. $T_0$ °C Operating temp. $T_{oper}$ °C Density Expansion Coefficient $\beta_2$	Units density Operating density Operating temperature Units Qm (Temperature is measured)
Liquid <sup>2)</sup> Qm (V, T)	Liquid	Mass flowrate	$Qm = Qn \cdot \rho_0$ $Qn = \frac{Qv}{(1 + (T_{oper} - T_0) \cdot \beta_1)}$	Volume Expansion Coefficient [%/K] $\beta_1$ <sup>3)</sup> Ref. temp. $T_0$ °C Operating temp. $T_{oper}$ °C Ref. density $\rho_0$	Units Density Operating density Operating temperature Vol. Exp_coef Units Qm (Temperature is measured)
Gas Qv	Gas	Volume flowrate at operating conditions	—	—	—
Gas Normal <sup>2)</sup> Qn (pT)	Gas	Normal flowrate 1.013 bar / 0°C 0 - 1.013 bar / 20°C	$Qn = Qv \cdot \frac{P_{noper}}{1,013bar} \cdot \frac{273K + T_n}{273K + T_{oper}}$	Operating press. $P_{oper}$ abs Operating temp. $T_{oper}$ °C	Operating pressure Units Pressure (Temperature is measured)
Gas Std <sup>2)</sup> Qs (pT)	Gas	Standard flowrate 14.7psia / 70°F 14.7psia / 60°F	$Qs = Qv \cdot \frac{P_{soper}}{14.7} \cdot \frac{460 + T_s}{460 + T_{oper}}$	Operating press. $P_{oper}$ abs Operating temp. $T_{oper}$ °F	Standard density (Temperature is measured)
Gas Std Qs (cmp)	Gas		$Qn = Qv \cdot (Standard) factor$ Standard factor = $\frac{\rho_{oper}}{\rho_0}$	Standard factor as a constant (Compressibility Factor)	Standard factor
Gas Mass <sup>2)</sup> Qm (pT)	Gas	Mass flowrate Standard conditions 14.7 psia @ 70 °F	$Qm = \rho_0 \cdot Qs$ $Qs = Qv \cdot \frac{P_s}{14.7} \cdot \frac{460 + T_s}{460 + T_{oper}}$	Operating press. $P_{oper}$ abs Standard density $\rho_0$ Operating temp. $T_{oper}$ °F	Units Density Standard density Standard conditions Operating temperature Press_Poper_abs Units Qm (Temperature is measured)
Gas Mass Qm (D)	Gas	Mass flowrate	$Qm = Qv \cdot \rho_{oper}$	Constant operating density $\rho_{oper}$	Units Density Operating density Units Qm
Sat. Steam <sup>2)</sup> Qm	Saturated steam	Mass flowrate	$Qm = Qv \cdot \rho_{oper}(T_{oper})$ Corrections using Saturated Steam Tables	Operating temp. $T_{oper}$	Units Qm
Sat. Steam Qv	Saturated steam	Volume flowrate at operating conditions	—	—	—



Qs = Standard flowrate [scfh]

Qm = Mass flowrate [lb/h]

Qv = Actual volume flowrate [acfh]

Qn = Normal flowrate [ncfh]

P<sub>oper</sub> = Operating pressure (psia)

P<sub>n</sub> = Operating normal pressure (bars absolute)

P<sub>s</sub> = Operating standard pressure (psia)

β<sub>1</sub> = Volume Expansion Coefficient <sup>3)</sup>

β<sub>2</sub> = Density Expansion Coefficient <sup>3)</sup>

ρ<sub>0</sub> = Normal density (lbs/ft<sup>3</sup>)

ρ<sub>oper</sub> = Operating density (lbs/ft<sup>3</sup>)

T<sub>o</sub> = Reference temp., °C

T<sub>oper</sub> = Operating temp., °C

T<sub>s</sub> = Standard temp. (60 or 70 °F)

T<sub>n</sub> = Normal temp. (0 or 20 °C)

1) The possible measurement methods are a function of the type of flowmeter calibration.

2) These measurement methods can only be selected when a temperature measurement is integrated in the flowmeter.

3) Units are in mils (0.1%)

## 5.5 Trio-Wirl Menu Display and Selections

### 5.5.1 Changing The Displayed Language

If the display should activate in German-language mode rather than English upon start-up or applying power to the converter, use the following procedure to change the displayed language to English. **Maintain power to the Trio-Wirl electronics for a minimum of 60 seconds after making any changes to the configuration data base, otherwise the changes will not be stored.**

Action	⇒	Key	=	Display Information
First, turn <b>Locked</b> mode off		-		<div style="border: 1px solid black; padding: 2px; display: inline-block;">                     Qv %                      - 10.5 - -                 </div> Standard Display
↓		↓		↓
1) Advance to programming level		STEP or DATA		<div style="border: 1px solid black; padding: 2px; display: inline-block;">                     Progr.                      - Ebene - -                 </div>
↓		↓		↓
2) Enter menu		ENTER		<div style="border: 1px solid black; padding: 2px; display: inline-block;">                     - G<span style="text-decoration: underline;">e</span>sperrt - -                 </div>
↓		↓		↓
3) Make selection display „Programming Level“		ENTER		<div style="border: 1px solid black; padding: 2px; display: inline-block;">                     - G<span style="text-decoration: underline;">e</span>sperrt - -                 </div> Mode is selectable when "underscore" is displayed
↓		↓		↓
4) Advance to " Standard" Program- ming Level		STEP or DATA		<div style="border: 1px solid black; padding: 2px; display: inline-block;">                     Standard_ - -                 </div>
↓		↓		↓
4) Select " Standard" Programming Level		ENTER		<div style="border: 1px solid black; padding: 2px; display: inline-block;">                     Progr_ - -                      - Ebene - -                 </div>
↓		↓		↓
5) Menu item Find "Language"		STEP or DATA		<div style="border: 1px solid black; padding: 2px; display: inline-block;">                     Sprache - -                 </div>
↓		↓		↓
6) Make selection display "Language"		ENTER		<div style="border: 1px solid black; padding: 2px; display: inline-block;">                     Deutsch_ - -                 </div>
↓		↓		↓
7) Menu item Find "English"		STEP or DATA		<div style="border: 1px solid black; padding: 2px; display: inline-block;">                     Englisch - -                 </div>
↓		↓		↓
8) Select "English"		ENTER		<div style="border: 1px solid black; padding: 2px; display: inline-block;">                     Language - -                 </div> Menus are now displayed in English

### 5.5.2 Turning Locked Mode On/ Off

After power-up, the converter operates in the **Locked** mode and data may not be entered. In order to enter or change data, the mode must be changed to either the **Standard**, **Specialist** or **Service** mode. The mode-change is made in the **Program Level** menu. After the mode is changed, a **program protection code** must be entered using the **Data & Step** buttons, unless the code has been set to "0".

If the **Service** mode is selected, a **service code** is required to enable entry into the **Service Mode**. The mode hierarchy is **Standard** → **Specialist** → **Service** and the number of changeable parameters shown in the menus increases with each mode level.

Entry into **Service** mode is required to gain access to the following parameters:

- \* PT100 Sensor enable
- \* Fluid selections
- \* K-factor
- \* Flow & temperature calibration data entry
- \* Service data entry

**!** Note:  
 Before a parameter can be changed or entered the Locked-mode must be turned off (Also refer to Section 5.5.2).

Action	⇒ Key	= Display Information	
Turn <b>Locked</b> mode OFF	-	Qv % 10.5	Standard Display
↓	↓	↓	
1) Advance to <b>Progr. Level</b>	STEP or DATA	Progr. Level	
↓	↓	↓	
2) Enter Menu	ENTER	Locked	
↓	↓	↓	
3) Display <b>Programming Level</b>	ENTER	Locked	Mode is selectable when "underscore" is displayed
↓	↓	↓	
4) Select desired <b>Programming Level</b> for processing	STEP or DATA	Standard_ Speciali st_ Service_	
↓	↓	↓	
5) Return to Menu Level	ENTER	Progr. Level	<b>Locked</b> mode is now OFF

# TRIO-WIRL INSTRUCTION MANUAL

After completing the programming/configuration of the converter, the Program Protection should be turned on again



Action	⇒	Key	=	Display Information
Turn <b>Locked</b> mode ON		-		<div style="border: 1px solid black; padding: 2px; display: inline-block;">                     Qv %                      10.5    — —                 </div> Standard Display
↓		↓		↓
1) Advance to <b>Progr. Level</b>		STEP or DATA		<div style="border: 1px solid black; padding: 2px; display: inline-block;">                     Progr.                      Level    — —                 </div>
↓		↓		↓
2) Enter Menu		ENTER		<div style="border: 1px solid black; padding: 2px; display: inline-block;">                     Standard                      — — — —                 </div> Display shows present programming level
↓		↓		↓
3) Display <b>Programming Levels</b>		ENTER		<div style="border: 1px solid black; padding: 2px; display: inline-block;">                     Standard                      — — — —                 </div> Mode is selectable when "underscore" is displayed
↓		↓		↓
4) Select Locked programming level		STEP or DATA		<div style="border: 1px solid black; padding: 2px; display: inline-block;">                     Locked                      — — — —                 </div>
↓		↓		↓
5) Return to Menu Level		ENTER		<div style="border: 1px solid black; padding: 2px; display: inline-block;">                     Progr.                      Level    — —                 </div> Locked mode is now ON

- !** Note:  
 Locked-mode must be turned off before data can be entered or changed.

5.5.3 Top-Level Menu Structure

The table to the right lists all of the top-level menus contained in the TRIO-WIRL firmware vs. the four menu programming modes:

TABLE 5-1. TOP-LEVEL MENU STRUCTURE

 Indicates the available menus for the given programming mode.  
 Indicates **Menu Items** that appear depending on other menu selections.

Menu Item	Menu Programming Levels/Modes			
	Locked	Standard	Specialist	Service
Program Level				
Prog. Protection Code				
Language				
Primary				
Meter Size				
Median K-Factor				
Schedule Correction				
Flow Mode				
Unit Density				
Reference Density				
Normal Density				
Compressibility				
Standard Conditions				
Unit Temperature				
Reference Temperature				
Unit Pressure				
Pressure P <sub>oper</sub> ABS				
Volume Extension				
Unit Q <sub>vol</sub>				
Unit Q <sub>m</sub>				
QmaxDN Oper				
Qmax				
Qmin Operating				
Totalizer				
Damping				
Hardware Config.				
Iout at Alarm				
Pulse Factor				
Pulse Width				
Display				
Error Register				
Self Check				
Instr. Address				
Instrument No.				
Order No.				
PT100 Sensor				
Linearization				
D-Base Handling				
Init Flash				
Flash Checksum				
Adjust I=4mA				
Adjust I=20mA				
Min. Current				
DSP Par				
Vib Par				
Temp Par				
Service Display				
TRIO-WIRL Firmware ID				

### 5.5.4 Complete Menu Structure Overview and Data Entry

Menus shown shaded are included in the **Standard** Level.

Key	Submenu/Parameter	Submenu/Parameter Setting	Submenu/Select Parameter	Selections	Entry Type	Comments		
↓ ↑	Progr. Level	Enter	Locked	Standard	Standard	from table	<p><b>Standard:</b> This menu includes all the user specific menu parameters for operating the instrument;</p> <p><b>Specialist:</b> This menu includes the complete set of user specific menu parameters;</p> <p><b>Service:</b> This menu includes additional parameters which can be accessed after entering the correct Service Code No. (only for ABB Service)</p>	
			ENTER	Specialist				Specialist
			ENTER	Service				Enter SRV-Code
↓ ↑	Pg.Prot Code	2x ENTER	Old Code	0	0	from table	<p>If a number differing from "0" (Factory setting) has been selected for the Program Protection Code, then this code (1-9999) must be entered to turn the protection off.</p>	
			ENTER	New Code				9999
↓ ↑	Language	Enter	English	English	English/German	from table	Language for the display text	
↓ ↑	Primary	Enter	VORTEX VT/VR				<p>Display of the Flowmeter primary selection</p> <p>SWIRL = TRIO-WIRL S</p> <p>VORTEX = TRIO-WIRL V</p>	
↓ ↑	Meter size	Enter	A 80 mm 3in				<p>Display of the flowmeter primary size</p> <p>A=ANSI D=DIN</p>	
↓ ↑	Median k-factor	Enter	52000.0 1/m3				<p>Display of the calibration factor value; k-Factor</p>	
↓ ↑	Schedule Correct	Enter	Sched.80	Sched.40 Sched. 80			<p>Parameter is only displayed for a flowmeter primary with ANSI process connections: Correction for the inside diameter differences between Sched. 40 and 80</p>	

# TRIO-WIRL INSTRUCTION MANUAL

Key	Submenu/Parameter	Submenu/Parameter Setting	Submenu/Select Parameter	Selections	Entry Type	Comments
↓ ↑	Flow mode	Enter Liquid QV	↓ ↑ ENTER Liquid Qv		from table	Flow Mode: Fluid = Liquid (Refer to Section 5.4.1)
			Liquid Qm(D)			Fluid = Liquid Flow Mode: Mass (Refer to Section 5.4.1)
			Liquid Qm(D,T)			Fluid = Liquid Flow Mode: Mass (Refer to Section 5.4.1)
			Liquid Qm(V,T)			Fluid = Liquid Flow Mode: Mass (Refer to Section 5.4.1)
			Gas Qv			Fluid = Gas (Refer to Section 5.4.1) Flow mode: Actual flow
			Gas Norm Qn(pT)			Normal flowrate = Gas (Refer to Section 5.4.1)
			Gas Stnd Qs(pT)			Standard flowrate: Gas (Refer to Section 5.4.1)
			Gas Stnd Qs(CMP)			Normal flowrate: Gas (Refer to Section 5.4.1)
			Gas Mass Qm(pT)			Mass flowrate: Gas (Refer to Section 5.4.1)
			Gas Mass Qm(D)			Mass flowrate: Gas (Refer to Section 5.4.1)
			Steam satu Qm			Mass flowrate: Sat. steam (Refer to Section 5.4.1)
			Steam satu Qv			Actual flowrate: Sat. steam
↓ ↑	Unit Density	Enter kg/l	↓ ↑ ENTER lb/ft3	g/l, g/cm3, g/l, kg/l, kg/l, kg/m3, lb/ft3, lb/ugl, g/ml	from table	Menu displayed for selection: Liquid Qm (D,T), Liquid Qm (V,T), Gas Mass Qm (pT), Gas Mass Qm(D)
↓ ↑	Referenc density	Enter 1.000 kg/l	↓ ↑ ENTER 0 kg/l	0.001 - 0,100	from table	Menu displayed for selection: Liquid Qm (D,T), Liquid Qm (V,T), Gas Mass Qm(D)
↓ ↑	Standard Density	Enter 0.001 kg/l	↓ ↑ ENTER 0 kg/l	0.001 - 0.100	from table	Menu displayed for selection: Gas Mass Qm (pT)
↓ ↑	Compressibility	Enter 1.000	↓ ↑ ENTER 0	0.001 - 1000.000	numeric	Menu displayed for selection: Gas Stnd. Qs(CMP) Factor of compressibility = $\rho b : \rho 0$

**Notes:**

1. The Operating Mode selections displayed are a function of the fluid and the sensor design. (See Ordering Information)
2. The fluid selection is in the **Service** mode's **K-Linearity** submenu. The PT100 sensor enabling selection is in the Service mode's **100PT** submenu
3. The entry of a service code is required to enter the **Service** mode.

# TRIO-WIRL INSTRUCTION MANUAL

Key	Submenu/Parameter	Submenu/Parameter Setting	Submenu/Select Parameter	Selections	Entry Type	Comments
↓ ↑	standard Conditions	Enter 14.7 psi abs 70F	↓ ↑ ENTER 1.0133 bara 20 °C			Menu displayed for selection: Gas Mass Qm(pT) Gas Norm Qn (pT)
			↓ ↑ ENTER 1.0133 bara 0 °C			
			↓ ↑ ENTER 14.7 psi abs 70F			
			↓ ↑ ENTER 14.7 psi abs 60F			
↓ ↑	Unit Tempera.	Enter F	↓ ↑ ENTER C	°C, F, K	from table	
↓ ↑	Reference Temp	Enter 68.0 F		-200.0 - 500.0		Menu displayed for selection: 2, 3 and 7. See flow symbol legends in Section
↓ ↑	Unit Pressure	Enter psi abs	↓ ↑ ENTER bar abs		from table	Menu displayed for selection: Gas Stnd Qs (pT), Gas Norm Qn (pT), Gas Mass Qm (pT)
↓ ↑	Pressure Poper abs	Enter 14.7 psi				Menu displayed for selection: Gas Stnd Qs (pT), Gas Norm Qn (pT), Gas Mass Qm (pT)
↓ ↑	Vol. Extension	Enter 1.00 %/K				Menu displayed for selection: Liquid Qm (V,T) Enter value based on 10 °K change (units are in mils)
↓ ↑	Unit Qvol	Enter ft3/h	↓ ↑ ENTER ft3/d	Qvol and Qm function of the „Flow mode“ selection! l/s, l/m, l/h, m3/s, m3/m, m3/h, m3/d ft3/s, ft3/m, ft3/h, ft3/d, usgps, usgpm, usgph, usmgd, igps, igpm, igph, igpd, bbl/s, bbl/h, bbl/d		Selection of the volume flowrate units for Qv, Qn and Qs  1 bbl = 42 gal
↓ ↑	Unit Qm	Enter lb/h	↓ ↑ ENTER kg/h	kg/s, g/h, kg/s, kg/m, kg/h, kg/d, t/m, t/h, t/d, lb/s, lb/m, lb/h, lb/d, g/s g/m, g/h	from table	Menu displayed for selection: 2, 3, 7, 8, 9 See flow symbol legends in Section 1t = 1000 kg
↓ ↑	QmaxDn Operat.	Enter 84.000	↓ ↑ ENTER			Display of the max. flowrate for the selected flowmeter size
↓ ↑	Qmax	Enter 84.000 ft3/h	↓ ↑ ENTER 0 ft3/d	0.15-1.15x RangeMax numeric Operating Mode	numeric	RangeMax end value of the selected flowrate mode (=20 mA)
↓ ↑	Qmin Operat.	↓ ↑ ENTER 1.000 ft3/h	↓ ↑ ENTER 0 ft3/h	0-10% RangeMax Volume	numeric	The low-flow cutoff value cannot be changed in standard flow mode.

# TRIO-WIRL INSTRUCTION MANUAL

Key	Submenu/Parameter	Submenu/Parameter Setting	Submenu/Select Parameter	Selections	Entry Type	
↓ ↑	Totalizer	Totalizer Value	ENTER	0.0000 ft3	numeric	Set the totalizer to a pre-defined value
		Overflow	Enter	10		Display of the totalizer overflows; max. 65,535 1 overflow = 10,000,000
		Unit Totalizer	ENTER	ft3 m3	from table	Selection of the units for the totalizer as a function of the Operating Mode, Volume or Mass flowrate
		Totalizer reset	Enter	Reset -> Enter	Enter	Reset the totalizer and overflow counter
↓ ↑	Damping	s 50.0	ENTER	s 0	numeric	Damping for the current output Response time $1\tau$ (=63 %) for a step change in the flowrate
		Enter		0.5 - 100 s		
↓ ↑	Hardware Config.	I/HART	ENTER	I/HART I/HART/Pulse_Bin I/HART/Q_Alarm I/HART/T_Alarm I/HART/S-Alarm	from table	Contact Output Configuration Current, HART-Protocol. Current, HART-Protocol Contact output: pulse Current output, HART-Protocol, Contact output: Flowrate alarm closes at alarm Current output, HART-Protocol, Contact output: Temperature alarm closes at alarm Current output, HART-Protocol, Contact output: General alarm closes at alarm
<p><b>Note: Menus Min. and Max. Q_Alarm</b> Only displayed for the I/HART/T_Alarm selection.</p>						
↓ ↑	Min. Q_Alarm	Enter	% 10.000	ENTER	% 0	0 - 100 % of Qmax numeric Min-Alarm Flowrate 0 % = Off
↓ ↑	Max. Q_Alarm	Enter	% 80.000	ENTER	% 0	0 - 100 % of Qmax numeric Max-Alarm Flowrate 100 % = Off
<p><b>Note: Menus Min. and Max. T_Alarm</b> Only displayed for the I/HART/T_Alarm selection.</p>						
↓ ↑	Min. T_Alarm	Enter	F 10	ENTER	F 32	-60 °C to 410 °C numeric Min Alarm Temperature -60 °C = Off
↓ ↑	Max. T_Alarm	Enter	F 200.00	ENTER	F 300.00	-60 °C to 410 °C numeric Max Alarm Temperature 410 °C = Off
↓ ↑	Out at Alarm	Enter	22.4	ENTER	mA 0	21-26 mA numeric Current output value during an alarm condition Programmable



# TRIO-WIRL INSTRUCTION MANUAL

Key	Submenu/Parameter	Submenu/ Parameter Setting	Submenu/ Select Parameter	Selections	Entry Type	Comments
↓ ↑	Pulse Factor	Enter 100.000	↓ ↑ ENTER 5 1/ft3	0.001 - 1000 pulses/unit	numeric	For internal and external flow totalizers
<p><b>Note: The Pulse Width menu is only displayed for the I/HART/Pulse_Bin selection.</b></p>						
↓ ↑	Pulse Width	Enter ms 10	↓ ↑ ENTER 0 ms	1 - 256 ms	numeric	Selected units for output Max. 50 % on/off. A warning is displayed if exceeded.
↓ ↑	Display	Enter Main Display	↓ ↑ ENTER Q flow mode		from table	Selection for the Main Display
			Qv operate	Qv operate		
			Percent	Normal, standard		
			Totalizer	Qm Mass		
			Temperature	Percent		
			Frequency	Totalizer		
				Temperature		
				Frequency		
↓ ↑	Multipl. Display	↓ ↑ ENTER Q flow mode			from table	Selections for the value to be displayed in the multiplex mode
			Qv Operate			
			Percent			
			Totalizer			
			Temperature			
			Frequency			
	2 LineMulti. Off	Enter Off On				Multiplex mode for the 2nd line „On“ or „Off“
↓ ↑ ENTER	Error Register	↓ ↑ ENTER Error ... 3 ...				Display of detected errors Clear with „ENTER“ (see also Notes Section 5.5.5)
	Mains in terrupt	Enter 10				Counter for the number of times the power was turned off since start-up

## TRIO-WIRL INSTRUCTION MANUAL

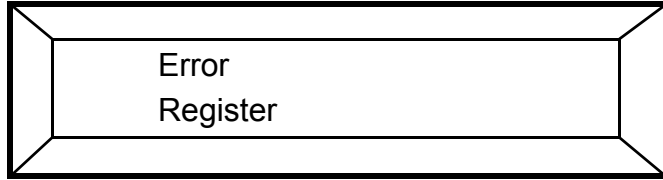
Key	Submenu/Parameter	Submenu/Parameter Setting	Submenu/Select Parameter	Selections	Entry Type	Comments		
↓ ↑ ENTER	Self check	↓ ↑ ENTER	lout	Enter	0 %	0 to 115 %	numeric	Test current output manual control (100 % = 20 mA)
			Q Simulation		0 Hz	0 to 2500 Hz	Sensor frequency	Simulation (current and pulse outputs). Initiate by entering a start value in "Hz". Turn off by entering "0" Hz. After switch to Process Display the frequency can be changed using Data/Step (+/-5Hz) .
			Main FRAM				Automatic test	Test Main and Backup FRAM (used to save the meter location parameters)
			Backup FRAM					
			Contact Output					Select „open“ or „closed“
			Pulse Output					Selection = 4 Hz rate on
			HART-Trans					
			HART-Command				--	Test HART-Receiver
↓ ↑	Instr. Address						0-15	- for HART-Protocol 1-15 - 1-15 Multiplex operation
↓ ↑	Instrument No.							
↓ ↑	Order Number							Allows recording of the customer Order Number for future reference.
↓ ↑	50VT4 26/02/01	↓ ↑ ENTER	D699F004 U01 A.11					Display of the installed software level and its revision date Entry = display actual Number

### Flow Symbol Legends for Liquid, Gas and Steam Calculations:

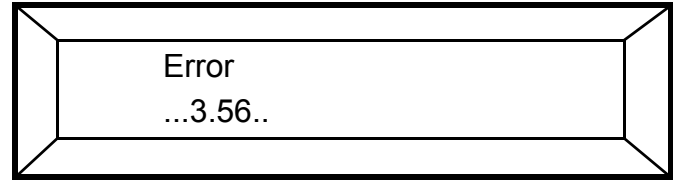
- |                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                             |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ol style="list-style-type: none"> <li>1) Liquid QV = Volume flowrate</li> <li>2) Liquid Qm (D) = Mass flowrate</li> <li>3) Liquid Qm (D,T) = Mass flowrate</li> <li>4) Liquid Qm (V,T)= Mass flowrate</li> <li>5) Gas Qv= Operating flowrate</li> <li>6) Gas Normal Qn (pT)= Normal flowrate</li> </ol> | <ol style="list-style-type: none"> <li>7) Gas Std. Qs (pT) = Standard flowrate</li> <li>8) Gas Std. Qs (CMP)= Standard flowrate</li> <li>9) Gas Mass Qm (pt) = Mass flowrate</li> <li>10) Gas Mass Qm (D)= Mass flowrate</li> <li>11) Steam satu. Qm= Saturated steam mass flowrate</li> <li>12) Steam satu. Qm= Saturated steam volume flowrate</li> </ol> |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

### 5.5.5 Submenu Error Register

This menu contains the error register and the power supply interruption counter.



#### 5.5.5.1 Error Display



All errors detected are permanently stored in the error register, whether they occurred momentarily or for a longer time period. Every character in the error register display represents a specific error: **Error.....3.56....**

The Error Register may be cleared by pressing the „ENTER“-Key

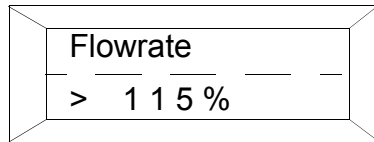
A table of error codes is shown in Table 5-2 below. For additional information, refer to Chapter 6..

**TABLE 5-2. ERROR CODE LISTING**

Error No.	Error Text	Priority	Description
0	Steam calculations	7	Incorrect saturated steam mass flowrate calculations
1	Front End	1	Preamplifier board problem
2	Not assigned	N/A	
3	Flowrate > 115%	2	The value set in Qmax was exceeded by 15%
4	Not assigned	N/A	
5	M-Data Base	0	Main Data Base corrupted, loss of the internal data base in the converter
6	Totalizer defective	1	Flow totalizer defective. Indicated values are invalid
7	Temperature (only displayed when PT100 is installed in the flowmeter primary)	7	Temperature measurements defective
8	Not assigned	N/A	
9	Qv > 115% QmaxDN	2	Max. flow range (QmaxDN) exceeded
A	Kit-FRAM	9	Data in KIT-FRAM are invalid (Error only relevant for Kit-components)
B	B-Data Base	0	Backup Data Base corrupted, loss of the external data base (Sensor board)

## CHAPTER 6 Troubleshooting

Should the flowmeter encounter an error condition, an error message is shown on the display. Current output is always forced to 22.4 mA during an error condition as shown below:



This message is shown with its error code number and alternates with the normal flow data. The error text message is displayed only for the error with the highest

priority while all the active errors are indicated by their error code numbers.

**WARNING**

**ALL FLOWMETERS AND/OR SIGNAL CONVERTERS BEING RETURNED TO ABB INC. FOR REPAIR MUST BE FREE OF ANY HAZARDOUS MATERIALS (ACIDS, ALKALIS, SOLVENTS, ETC.). A MATERIAL SAFETY DATA SHEET (MSDS) FOR ALL PROCESS LIQUIDS MUST ACCOMPANY RETURNED EQUIPMENT.**

Error No.	Error Text	Priority	Description	Possible Cause	Corrective Measures
0	Steam calculations	7	Incorrect saturated steam mass flowrate calculations	Steam temperature < 55°C	Increase steam temperature
				Steam temperature > 370°C	Decrease steam temperature
1	Front End	1	Preamplifier board problem	Preamplifier board defective	Exchange converter module / contact ABB Inc. Service Dept.
2	Not assigned	N/A			
3	Flowrate > 115%	2	The value set in Qmax was exceeded by 15 %	Flow range setting too small	Increase Qmax flow range
				Flowrate too large	Reduce flowrate
4	Not assigned	N/A			
5	M-Data Base	0	Main Data Base corrupted, loss of the internal data base in the converter	Internal data base corrupted	Turn instrument off and on Exchange converter module if necessary Contact ABB Inc. Service Dept.
6	Totalizer defective	1	Flow totalizer defective. Indicated values are invalid		Reprogram totalizer
7	Temperature (Error is only displayed when a PT100 is installed in the flowmeter primary)	7	Temperature measurements defective	PT100 defective	Exchange sensor
				For Models VR/SR wiring error between flowmeter primary and converter	Check interconnections
8	Not assigned	N/A			
9	Qv > 115% QmaxDN	2	Max. flow range (QmaxDN) exceeded	-	Reduce flowrate
A	Kit-FRAM	9	Data in KIT-FRAM are invalid (Error only relevant for Kit-components)	Kit FRAM defective	Order a new KIT-FRAM from factory in Göttingen, Germany
B	B-Data Base	0	Backup Data Base corrupted, loss of the external data base (Sensor board)	External Data Base corrupted	Turn instrument off and on Sensor board may be defective Contact ABB Inc. Service Dept.

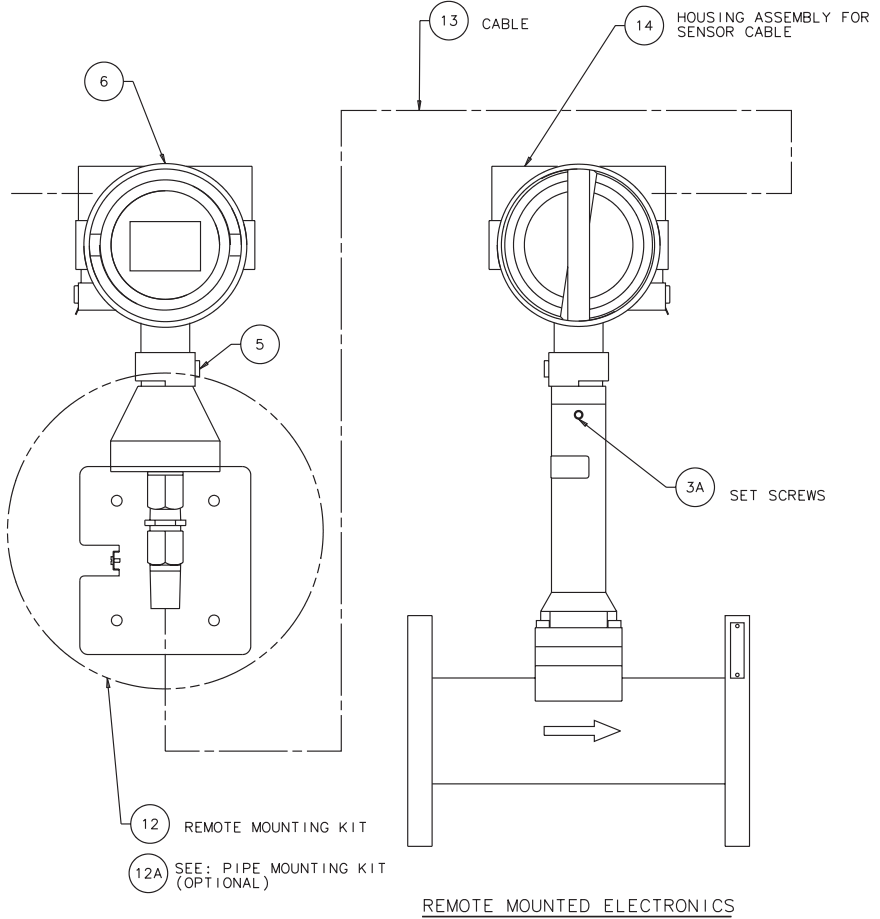
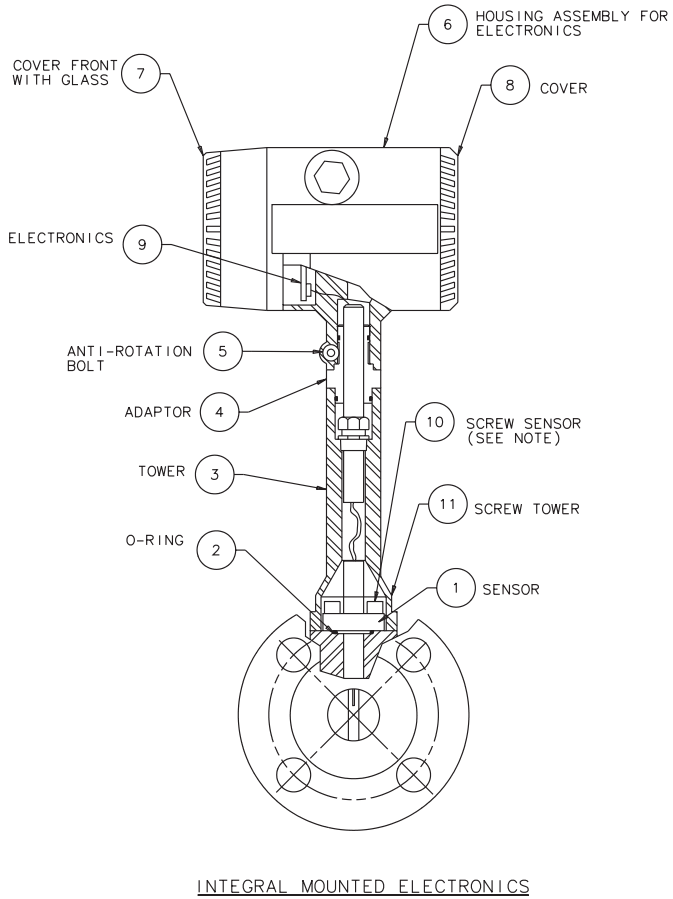
## CHAPTER 7 Parts List

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### 7.1 Replacement Parts

The following pages show a cutaway view of the flowmeters and indicate replacement parts that are available for the meters along with their ABB Inc. ordering numbers.

**FIGURE 7-1 FLOWMETER/SIGNAL CONVERTER PARTS  
(REFER TO TABLE 7-1 FOR ORDERING INFORMATION)**



NOTE: DUE TO CHANGE OF THE SENSOR SCREW THREAD IN THE METER BODY FROM 5 mm TO 6 mm, ON SOME OLDER INSTALLATION, USE ITEM-11 INSTEAD OF ITEM-10.

REF. SD-10-3680 REV 0

**TRIO-WIRL INSTRUCTION MANUAL**

**7.1.1 Flowmeter/Signal Converter Parts**

Refer to Figure 7-1 for location of item numbers.

**TABLE 7-1. FLOWMETER/SIGNAL CONVERTER PARTS LIST**

ITEM	QTY.	DESCRIPTION	PART NUMBER
<b>1</b>	1	<b>SENSOR</b>	
		Stainless Steel:	
		Sensor w/Remote Electronics	D693B042U06
		Sensor w/PT100 w/Remote Electronics	D693B043U06
		Sensor w/Integral Electronics	D693B042U14
		Sensor w/PT100 w/Integral Electronics	D693B043U14
		Hastelloy C:	
		Sensor w/Remote Electronics	D693B042U07
		Sensor w/PT100 w/Remote Electronics	D693B043U07
		Sensor w/Integral Electronics	D693B042U15
Sensor w/PT100 w/Integral Electronics	D693B043U15		
<b>2</b>	1	<b>SENSOR O-RING</b>	
		O-Ring, Kalrez	102E077U56
		O-Ring, Viton	101W709U01
		O-Ring, PTFE	101C709U01
<b>3</b>	1	<b>TOWER ASSEMBLY</b>	612A708U01
<b>3A</b>	1	<b>SET SCREWS</b> Spare set-screws, Tower Assembly	D020J106AU20
<b>4</b>	1	<b>ADAPTER</b>	
		Adapter, Plain	D633A043U01
		Adapter, Bartek w/3-Wire Std. Sensor	D633A043U02
		Adapter, Bartek w/5-Wire Std. Sensor w/PT100	D633A043U03
<b>5</b>	1	Anti-Rotation Dress Bolt	D395A006U01
		M5 x 25 Screw, Hex Sock. Hd., DIN912	09H116AU20
<b>6</b>	1	<b>HOUSING ASSEMBLY</b>	
	1	Body	D670A026U03
	1	Sensor Connection Board	D685A899U03
	1	Connection Board (Customer Side)	D685A903U03
	4	Feed-Through	D634A029U01
	2	Ground-Connection Plates	D405B086U01
	1	M4 x 10mm Cheese Hd Screw, DIN84	02G108AU20
	5	M4 x 8 Phillips, Phillister Hd. Screw	04G107AU20
	5	M4 Split Lock-Washer, DIN 127	85C021EU20
	1	1/2 Hex Socket, Pipi-Plug, 316 SS	112A352U21
1	Pipe-Plug, 1/2-14 NPT, Ploy.	114B081U03	
<b>7</b>	1	<b>FRONT COVER WITH EX-PROOF GLASS &amp; O-RING</b>	
		Cover	D612A162U02
		O-Ring	1951779A042

## TRIO-WIRL INSTRUCTION MANUAL

**TABLE 7-1. FLOWMETER/SIGNAL CONVERTER PARTS LIST** *(cont.)*

ITEM	QTY.	DESCRIPTION	PART NUMBER
8	1	<b>REAR COVER</b> Cover Tag O-Ring	D612A167U02 338C686U01 1951779A042
9	1	<b>ELECTRONICS MODULE</b> Electronics 4-PCB Assembly With Display	D674A659U01 (Design Level A) D674A629U07 (Design Level B)
10	4	<b>SCREWS &amp; LOCKWASHER, SENSOR</b> M6 X 16 Screw, Hex Sock. Hd., DIN912 M6 Lockwasher, DIN 7980	09J112AU20 85L027EU20
10A	4	Sleeve, Required When Item 11 is Used	371B605U01
11	4	<b>SCREWS &amp; LOCK WASHER, TOWER</b> M5 x 16 Screw, Hex Sock. Hd., DIN912 M5 Lockwasher	09H112AU20 85C024EU20
12	1	<b>REMOTE-MOUNTING KIT W/CABLE</b> Remote Tower, X-Proof, 4-Wire Remote Tower, X-Proof, 8-Wire	D612A163U09 D612A163U10
12A	1	Pipe Mounting Hardware (Optional)	612B091U07
13		<b>SPARE CABLE, 30 FT.</b> 4-Wire for Standard Sensors 8-Wire for Sensors w/PT100	431C081U01 431C081U02
14		<b>REMOTE MODEL ELECTRONICS HOUSING ASSEMBLY</b> 1 Body, Used for Sensor & Cable Connection on Primary 1 Cable Connection Board 2 Ground Connection Plates 1 M4 x 10mm Cheese Hd Screw, DIN84 3 M4 x 8 Phillips, Phillister Hd Screw 3 M4 Split Lockwasher, DIN127 1 1/2 Hex Socket, Pipi-Plug, 316 SS 1 Pipe Plug, 1/2-14 NPT, Poly.	D670A027U02 D685A944U01 D405B086U01 02G108AU20 04G107AU20 85C021EU20 112A352U21 114B081U03

### 7.1.2 Kits / Accessories

**TABLE 7-2. KITS / ACCESSORIES**

DESCRIPTION	PART NUMBER
Magnetic Stick Kit	D614L537U01



**TRIO-WIRL INSTRUCTION MANUAL**

**TABLE 7-3. CENTERING DEVICES, VORTEX WAFER**

DESCRIPTION			PART NUMBER
	SIZE [in.]	ANSI FLANGE RATING [lb]	
Centering Devices, Wafer-Style Meter	1	150	376D055U07
		300	
	1-1/2	150	376D055U03
		300	
	2	150	376D056U01
		300	
	3	150	430E014U01
		300	430E014U10
	4	150	430E014U05
		300	430E014U11
	6	150	430E014U08
		300	430E014U14
	8	150	430E014U09
		300	430E014U20

**TABLE 7-4. METER MOUNTING KITS, VORTEX WAFER**

DESCRIPTION			PART NUMBER
	SIZE	ANSI FLANGE RATING [lb]	
Mounting Kits, Wafer-Style Meter [Includes Studs, Nuts, Gaskets and Centering Devices]	1	150	614B656U85
		300, 600	614B656U86
	1-1/2	150	614B656U16
		300	614B656U17
		600	614B656U18
	2	150	614B656U12
		300	614B656U13
		600	614B656U14
	3	150	614B656U01
		300, 600	614B656U02
	4	150	614B656U03
		300	614B656U04
		600	614B656U05
	6	150	614B656U06
		300	614B656U07
		600	614B656U08
	8	150	614B656U09
300		614B656U10	
600		614B656U11	

7.1.3 Flange Gaskets

TABLE 7-5. FLANGE GASKETS

METER SIZE		ANSI FLANGE RATING (POUNDS)	MAX. PRESSURE * @ T <sub>Proc</sub> ≤ 68°F (20°C) ( PSI )	QTY.	PART NUMBER.	
INCHES	MM				VORTEX	SWIRL
1/2	15	150	276	2	333J089U01	
		300	725		333J089U02	
1	25	150	276		333J089U10	
		300	725		333J089U11	
1-1/4	32	150	276		N/A	333J089U68
		300	725		333J089U69	
1-1/2	40	150	276		333J089U15	
		300	725		333J089U16	
2	50	150	276		333J089U19	
		300/600	725/1436		333J089U25	
3	80	150	276		333J089U22	
		300/600	725/1436		333J089U26	
4	100	150	276		333J089U29	
		300	725		333J089U30	
		600	1436		N/A	333J083U28
6	150	150	276		333J083U33	
		300	725	333J083U42		
		600	1436	333J083U43		
8	200	150	276	333J083U38		
		300	725	333J083U46		
		600	1436	333J083U47		
10	250	150	276	333J083U54	N/A	
		300	725	333J083U55		
12	300	150	276	333J083U56		
		300	725	333J083U57		
16	400	150	276	N/A	333J083U58	
		300	725		333J083U59	

\* For higher process temperatures, refer to Figure 2-13 or 3-17 for Swirl and Vortex respectively.

Specifications for KLINGERSil C-4401 gasket material:

Liquids:

Operating Temperature Limit: 750°F

Gases & Steam:

Operating Temperature Limit: 450°F

Notes:

\* Different O-Ring materials may be required for high process temperature applications

\* Temperature limits are valid at internal pressures of ≤ 400 psi

\* The use of **KLINGERexpert** software system is recommended for these extreme temperature applications.

PN25080



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