INSTRUCTION MANUAL

TRIO-WIRL Flowmeter

Swirl ST4000/SR4000
Vortex VT4000/VR4000

PN24993

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WARNING notices as used in this manual apply to hazards or unsafe practices which could result in personal injury or death.

CAUTION notices apply to hazards or unsafe practices which could result in property damage.

NOTES highlight procedures and contain information which assist the operator in understanding the information contained in this manual.

WARNING

POSSIBLE PROCESS UPSETS. Maintenance must be performed only by qualified personnel and only after securing equipment controlled by this product. Adjusting or removing this product while it is in the system may upset the process being controlled. Some process upsets may cause injury or damage.

NOTICE

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TRIO-WIRL Flowmeter
Swirl ST/SR4000
Vortex VT/VR4000

ADDENDUM

The purpose of this addendum is to correct and/or supplement information in the TRIO-WIRL INSTRUCTION MANUAL [PN24993]

SECTION 2.4

Information on PAGE 2-5 should be corrected as follows:

The upstream dimension between a control valve and the Swirlmeter body shown in the second from the bottom illustration in **FIGURE 2-3** should be **3D**, **NOT 30D** as shown.

The last paragraph of Section 2.4.2.3 Control Valve Installation should read: "**When this is not possible, the control valve should be located ≥3D upstream of the flowmeter.**"

SECTION 5.4

The following cautionary statement must be read prior to making any of the menu configuration/selections discussed in SECTION 5.4 of the Instruction Manual:

CAUTION

MAKING ANY MENU OR MENU PARAMETER CHANGES DISCUSSED IN THIS SECTION WILL FORCE THE CONVERTER'S OUTPUT CURRENT TO THE 4mA STATE FOR APPROXIMATELY 5 SECONDS WHEN THE MENU IS EXITED AND THE DATA IS UPDATED.

Table of Contents

Table of Contents (cont.)

Table of Contents (cont.)

List of Figures

List of Figures (cont.)

List of Tables

Read First

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:

ABB Instrumentation Technical Support Center1 (800) 697-9619

E-Mail:

ins.techsupport@us.abb.com

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.

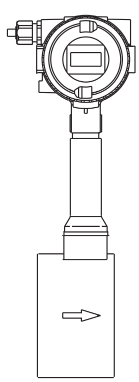
The VT4000 Vortex and ST4000 Swirlmeters are supplied with an integrally mounted microprocessor-based signal converter using state-of-the-art Digital Signal Processor (DSP) technology for superior flow and vibration noise immunity. This combination of flowmeter and electronics allows maximum flexibility 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.

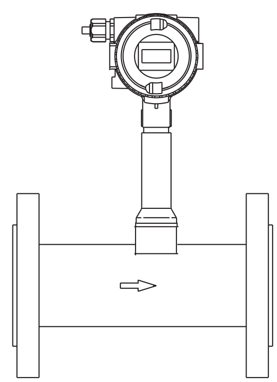
The meter body, sensor and process connections are made of 316L stainless steel or Hastalloy C. Because the meter has no moving parts, routine maintenance or recalibration is not required.

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

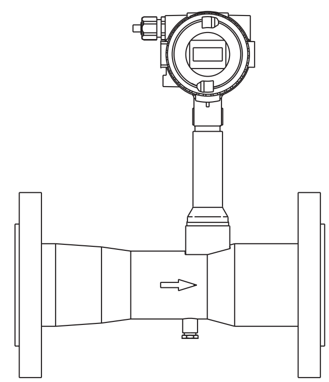
Compact or Integral Design: Converter mounted directly on the flowmeter primary



Vortex Flowmeter
TRIO-WIRL VT
Wafer Design

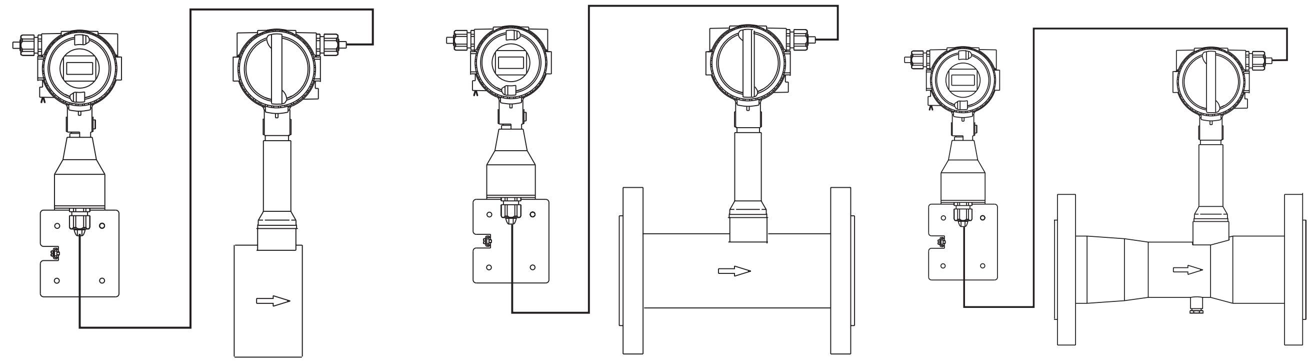


Vortex Flowmeter
TRIO-WIRL VT
Flanged Design



Swirl Flowmeter
TRIO-WIRL ST
Flanged Design

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



Vortex Flowmeter **TRIO-WIRL VR** Wafer Design	Vortex Flowmeter **TRIO-WIRL VR** Flanged Design	Swirl Flowmeter **TRIO-WIRL SR** Flanged Design

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®, 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 fo 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:≤ ±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

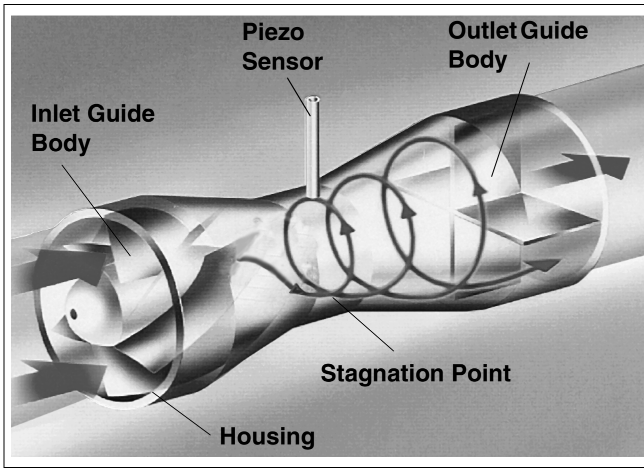


FIGURE 2-1 MEASUREMENT PRINCIPLE, TRIO-WIRL S

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 condi tions (psia)
ΔP = pressure drop (psia)

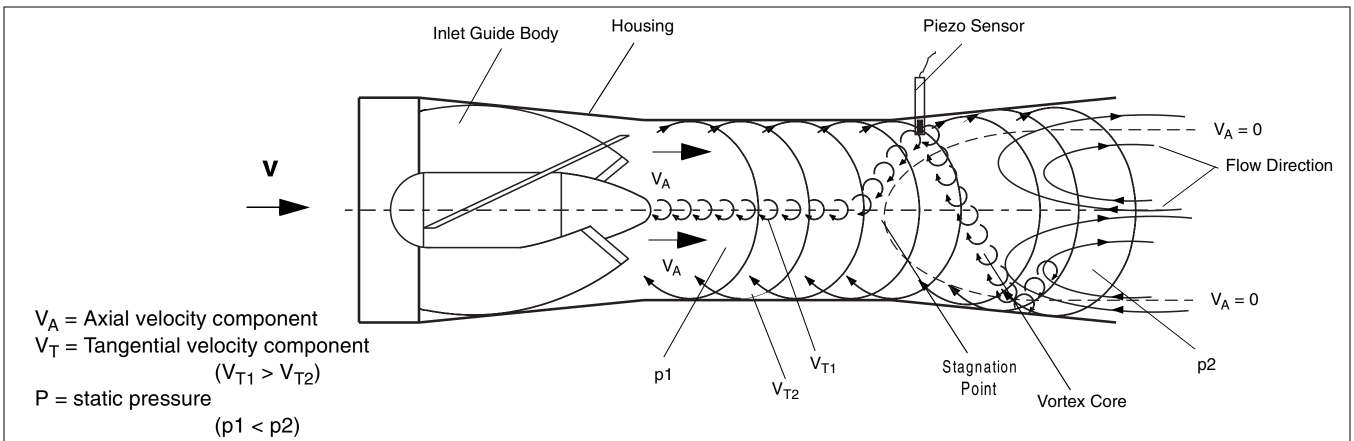


FIGURE 2-2 OPERATING PRINCIPLE, TRIO-WIRL S

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

TRIO-WIRL S	_	4	_	_	_	1	_ _	_	_	_	_	2	E	A	_	A	B

Flowmeter Design			
Compact			T
Remote			R
Series			4
Agency Approvals / Power Supply			
None / 14 - 46V DC			0
FM / CSA-Approval / 14 - 46V DC			3
Others [2]			9
Process Connections			
Flanged			1
Others			9
Fluid			
			1
Liquid			2
Gas			3
Steam			6
Oxygen [1]			
Materials [2]			
Housing	**Shedder**	**Sensor**	
SS 316Ti/1.4571	SS 316Ti/1.4571	SS 316Ti/1.4571	1
Meter Sizes			
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

Description	Code
Pressure Rating	
ANSI CL 150	**Q**
ANSI CL 300	**R**
ANSI CL 600	**S**
Other	**Z**
Sensor Design	
Standard, single sensor	**1**
Standard, single sensor with integr. temperature sensor	**2**
Temperature Range Fluid/Gaskets	
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**
Certificates	
None	**A**
EN 10204 (DIN 50049-3.1b)	**C**
Communication	
With Display and HART	**2**
Instrument Tag	
English	**E**
Design Level/Software Level	**A**
Accessories	
None	**0**
2” Pipe mount (only SR)	**1**
Operating Mode	
Continuous flowrate	**A**
Cable Conduit	
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 x 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 alligned 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.

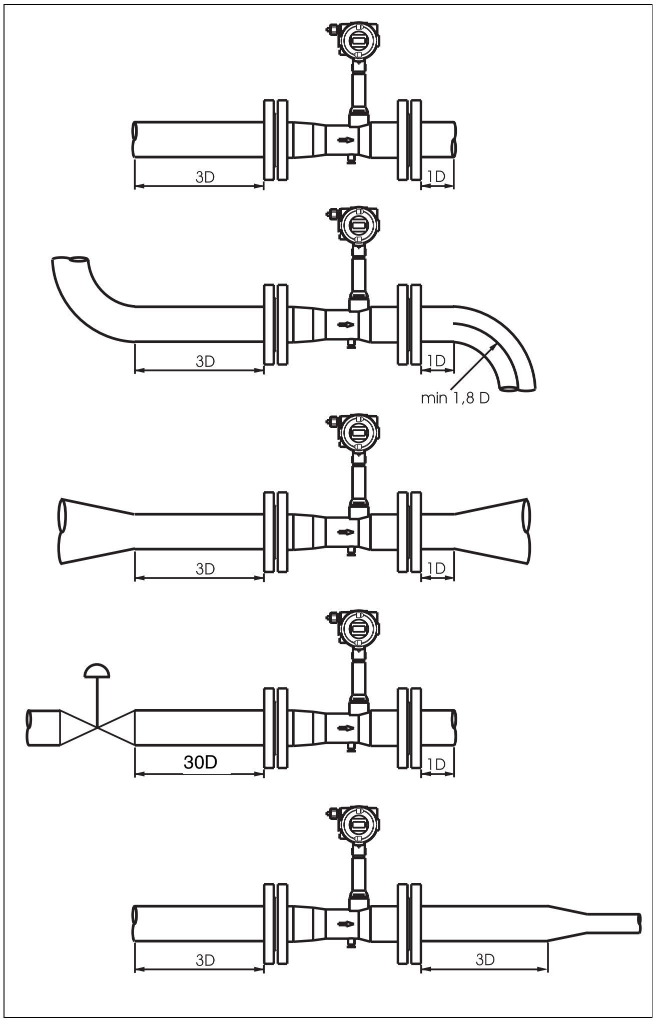


FIGURE 2-3 METER PIPING REQUIREMENTS

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 preferebly be installed downstream from the flowmeter as shown in Figure 2-5.

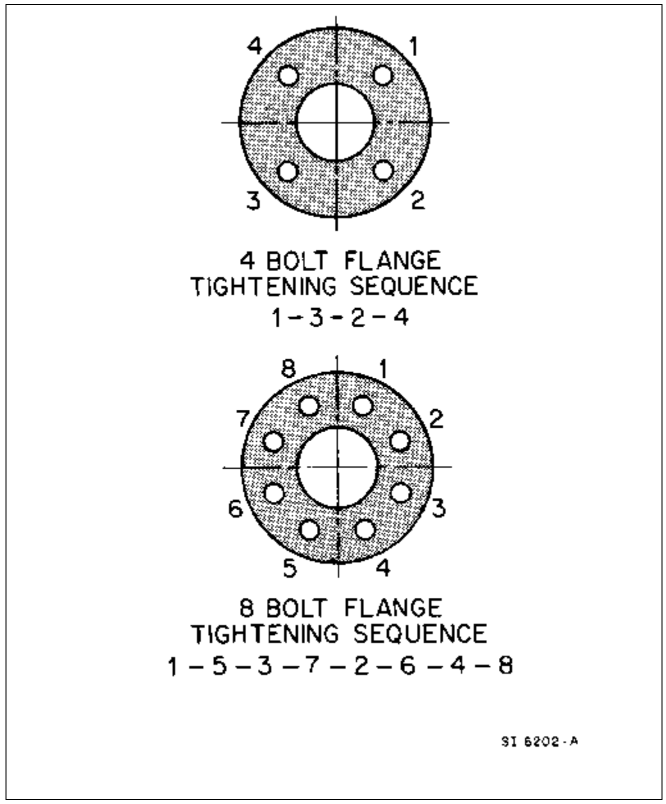


FIGURE 2-4 RECOMMENDED FLANGE BOLT TIGHTENING SEQUENCE

When this is not possible, the control valve should be located ≥ 30D upstream of the flowmeter.

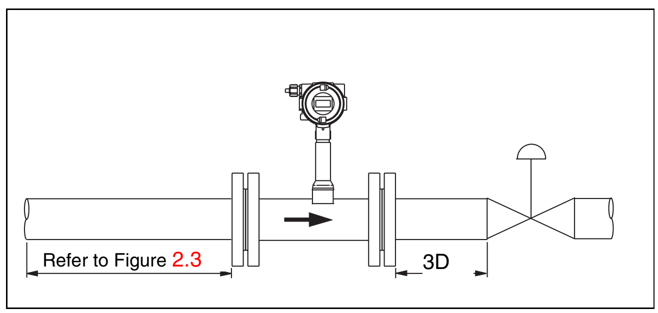


FIGURE 2-5 CONTROL VALVE INSTALLATION

2.4.2.4 Extreme Temperature Applications

For process temperatures above 160^{o} F (71^{o} C) or below 0^{o} F (-18^{o} 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.

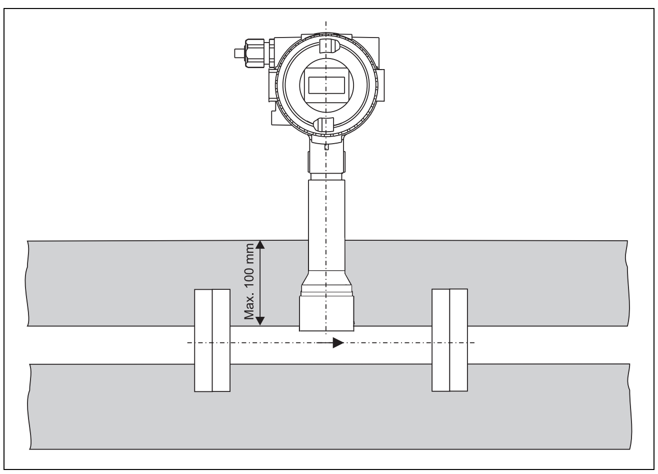


FIGURE 2-6 INSULATING THE PIPELINE

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.

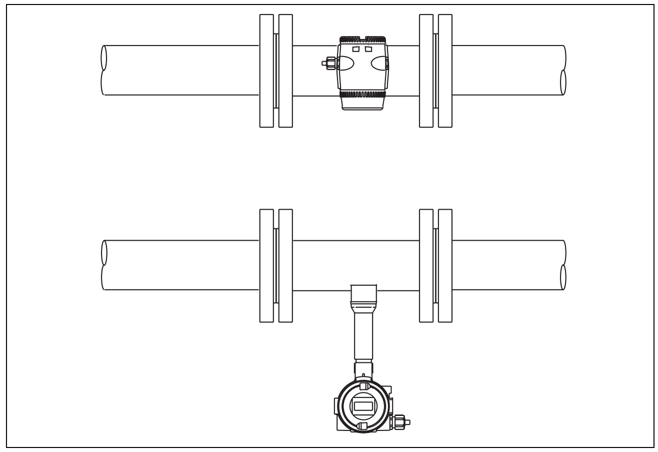
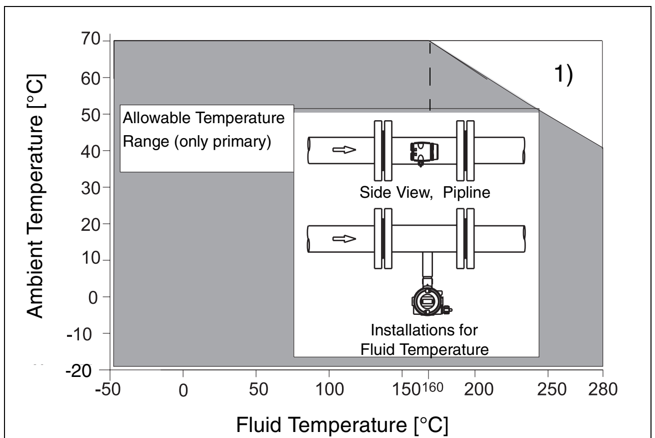


FIGURE 2-7 ORIENTATION FOR TEMPERATURES >300° F (150° C)

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



$^{o}F = [1.8 \times {}^{o}C] + 32$

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.

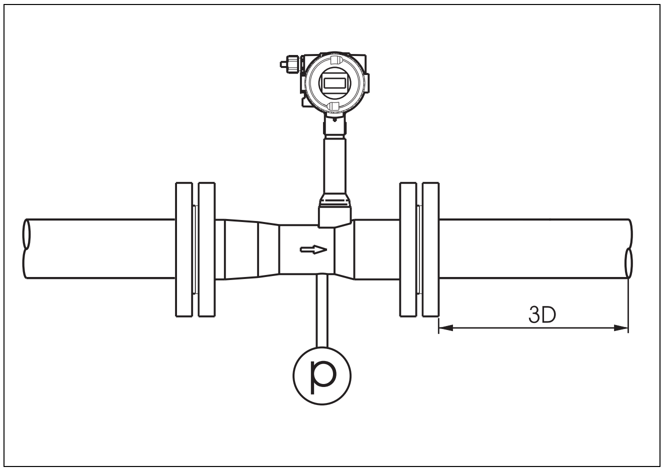


FIGURE 2-9 MEASURING PRESSURE

2.5 Swirlmeter Size Selection

2.5.1 Gas

The maximum required flowrate should not be less than 0.5 x 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_v)**, at operating conditions. If the flowrate to be metered is expressed as a standard flowrate (conditions = 14.7 psia, 70ºF) 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 Qvmax
Inch	DN	Qvmin	Qvmax	
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, $\rho = 0.075$ lb/ft^3

2.5.1.1 Q_{VMIN} for Gases with $\rho < 0.0749$ lb/ft^3

The minimum actual volume flowrate $Q_{VMIN'}$ for gases with lower densities can be calculated using the following equations.

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

Q_{VMIN} Min. volume flowrate from Table 2-1
ρ Density at operating conditions lb/ft^3

1. Convert standard density(ρ_S) to operating density (ρ)

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

2. Convert to actual volume flowrate (Q_V)

a) Starting from standard flowrate (Q_S) 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 (Qm) to Q_v

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

3. Dynamic Viscosity, μ (cps) to kinematic viscosity, ν(cst)

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

ρ = Density at operating conditions [lb/ft^3]

ρ_S = Density at standard conditions [lb/ft^3]

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.

ρ_s = 0.123 lb/ft^3 (CO_2, see Table 2-2)

1. Convert ρ_s to ρ:

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

2. Convert from Q_s (ft^3/h) to Q_v (ft^3/h) :

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

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 ft^3/h and ρ = 0.67 lb/ft^3:

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

TABLE 2-2. STANDARD DENSITIES FOR SELECTED GASES

Gas	Standard Density [lb/ft^3]
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, ρ=0.075 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]

Δp = Air pressure drop (from Figure 2-10) [psi]

ρ = Fluid density [lb/ft^3] (at operating conditions)

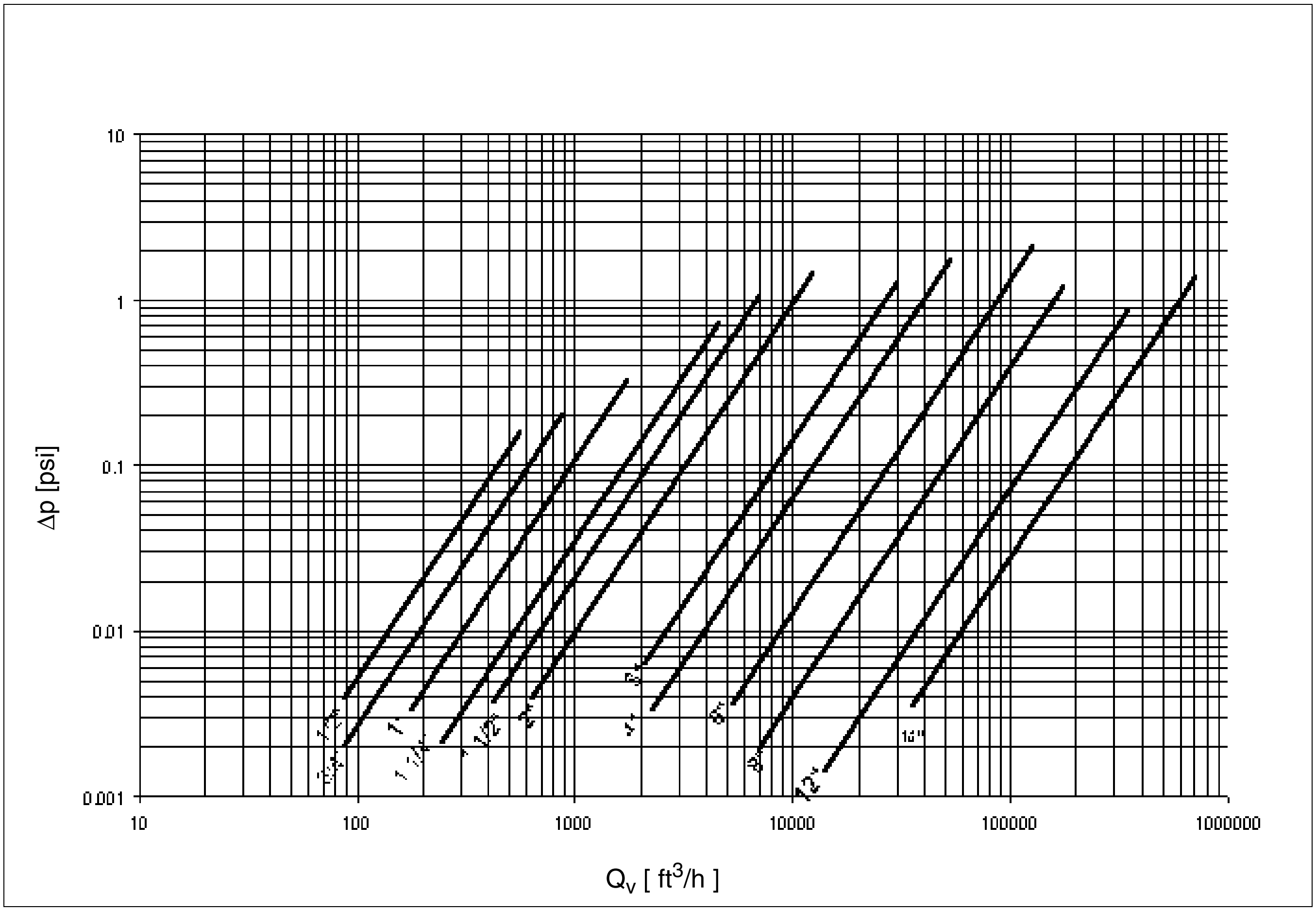


FIGURE 2-10 PRESSURE DROP, AIR (@70^{O} F, 14.7 PSI, Ρ=0.075 LB/FT^{3})

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 $Q_V$max [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:

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

ρ = Operating density [lb/ft^3]

Q_V = Actual volume flowrate [ft^3/h]

Q_m = Mass flowrate [lb/h]

2. Pressure Drop [psi]

See Figure 2-11 for water (ρ= 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]

Δp = Pressure drop water [psi] (from Figure 2-11)

ρ = 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 Qv = 18000 gph and ρ = 7.50 lb/gal

$$\Delta\rho` = \frac{7.5}{8.34} \cdot 7 \text{ psi} = 6.3 \text{ psi}$$

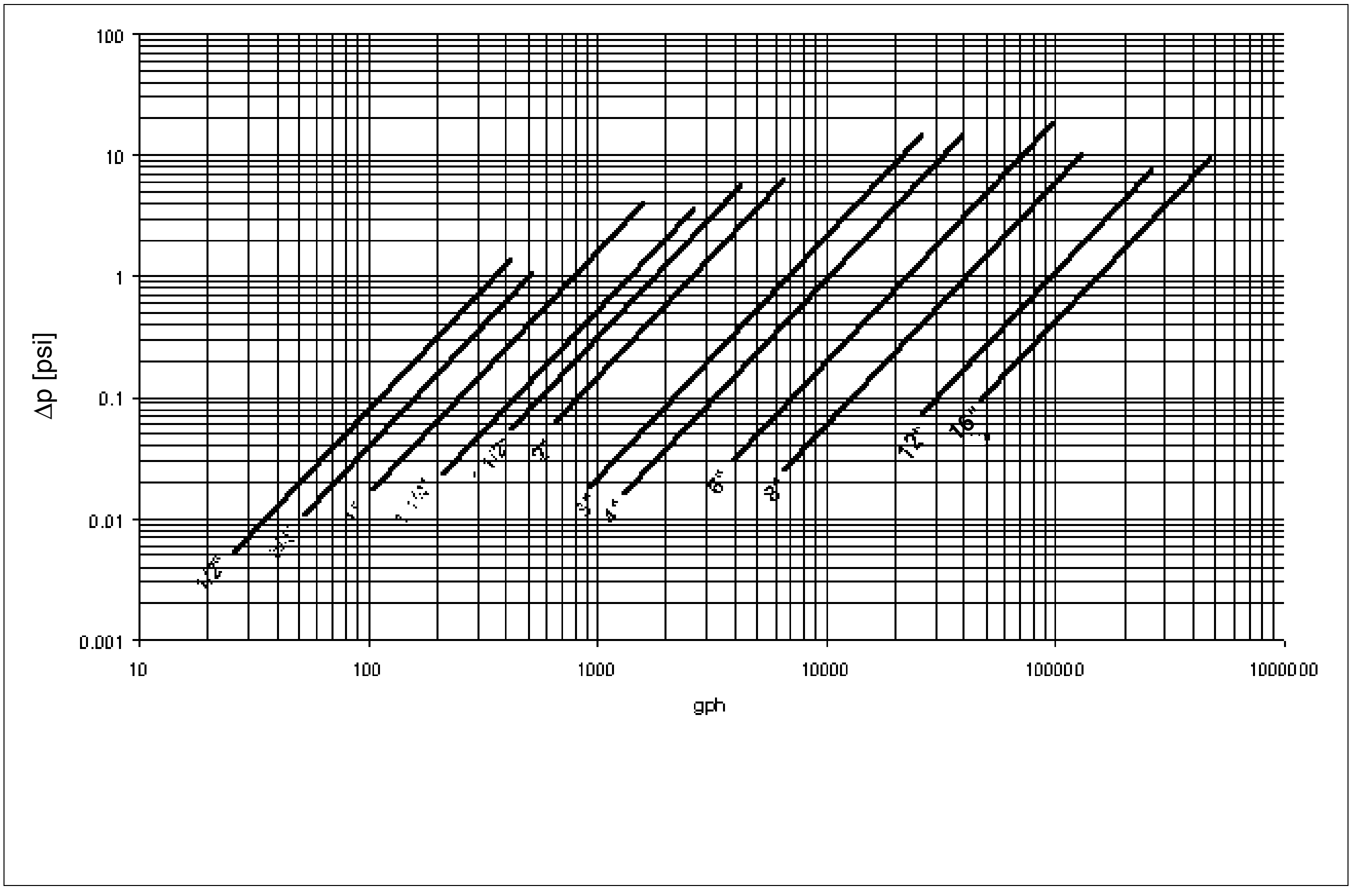


FIGURE 2-11 PRESSURE DROP, WATER (@ ρ = 8.34 LB/GAL)

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).

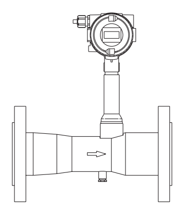
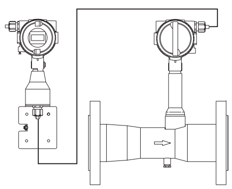
Additional information: Sat. steam temp.= 307 °F

TABLE 2-4. SWIRL FLOW RANGES, SATURATED STEAM

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

2.6 Specifications

2.6.1 Model Overview

	MODEL	 ST4000	 SR4000
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	
Flowmeter Primary			
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	
Approvals / Certifications			
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): ≤ ± 0.5% of rate
(at reference conditions)
Reproducibility: ≤ 0.2% of rate

ACCURACY & REPRODUCIBILITY OF THE TEMPERATURE MEASUREMENT

Accuracy (incl. converter): ≤ ±2ºC / ≤ ± 3.6ºF
Reproducibility: ≤ 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)

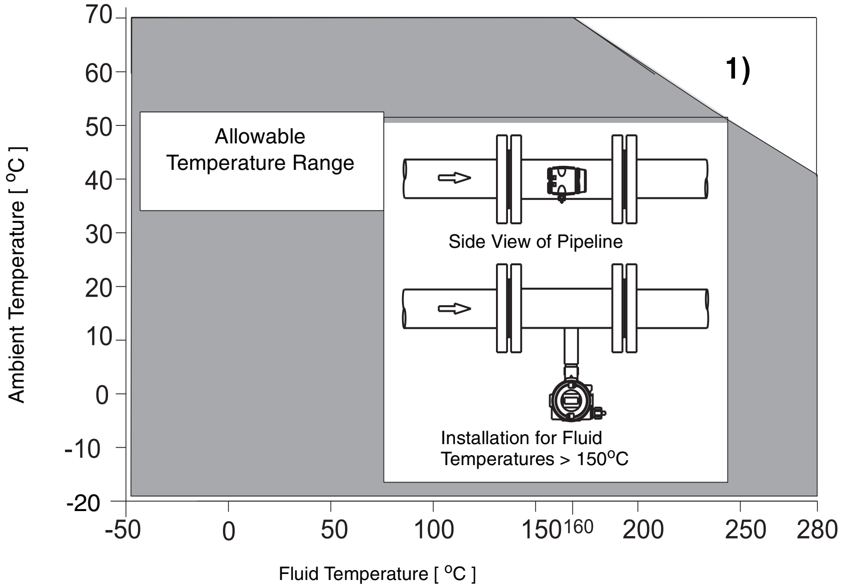
Allowable temperature range for the gasket material must be considered. The flange gaskets supplied with the meter are KLINGERsil material. These gaskets are rated to a temperature of 536 °F (280 °C) for liquid applications and 450 °F (232 °C) for gas & steam applications, at internal pressures of 400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

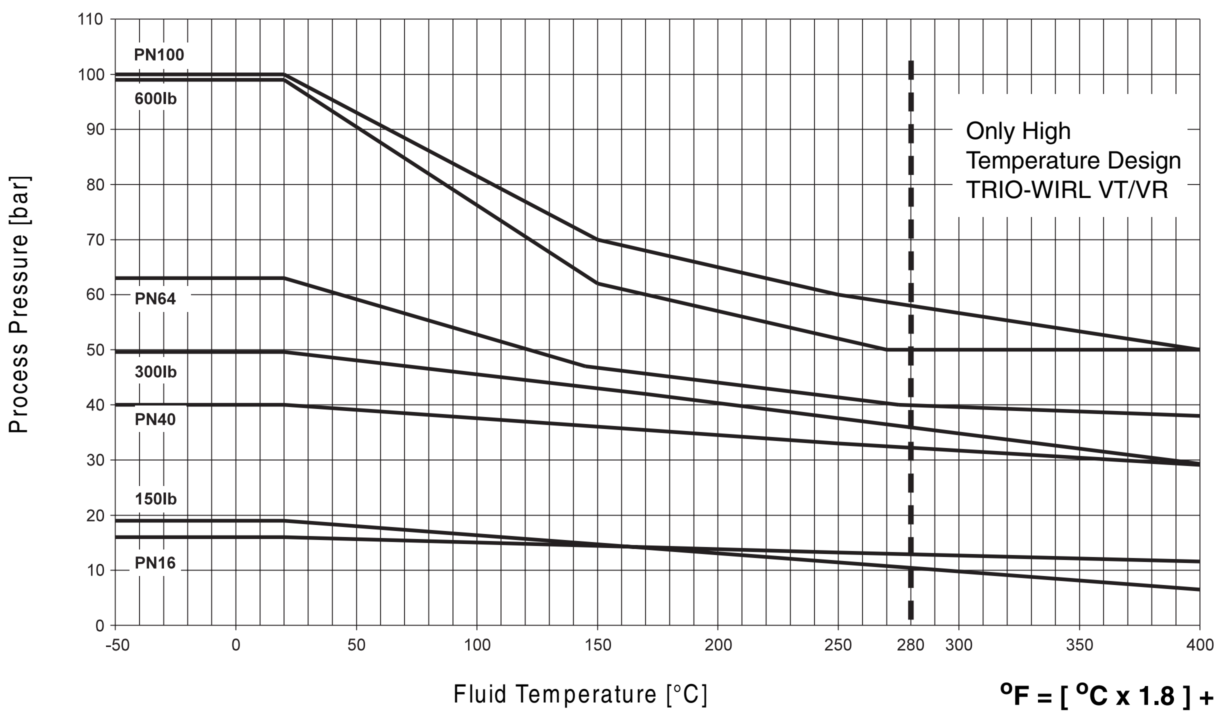


[1)] Cables for the supply power, terminals 31 & 32, and the contact output, terminals 41 & 42, which are suitable for temperatures to 230 °F (110 °C), can be used without any temperature reductions.

Cables which are only suitable for temperatures to 176 °F (80 °C), reduce the temperature ranges as shown in the figure to the left.

°F = [°C x 1.8] + 32

FIGURE 2-12 AMBIENT / FLUID TEMPERATURE RELATIONSHIP



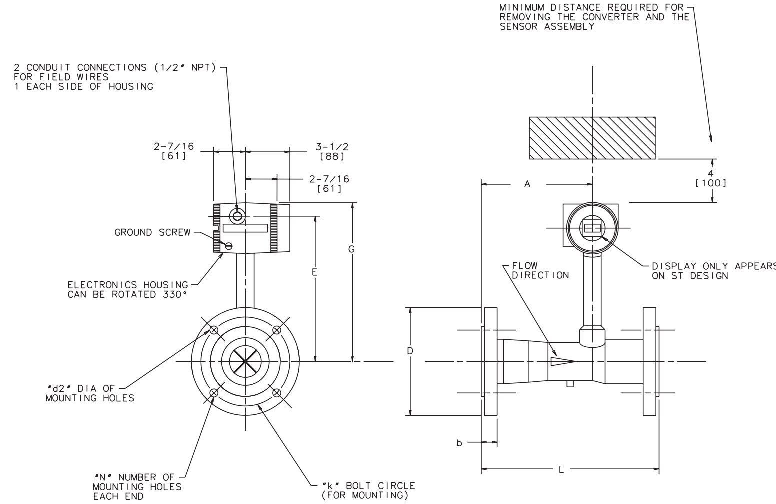
°F = [°C x 1.8] + 32

1 Bar = 14.50 psi

FIGURE 2-13 PROCESS PRESSURE vs. PROCESS FLUID TEMPERATURE

FIGURE 2-14 OUTLINE DIMENSIONS, ST/SR PRIMARY

METER SIZE	ANSI RATING	ØD	L	A	G	E	b	k	d2	N	WEIGHT lb[kg]
1/2 [15]	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 [5.3]
	300	3-3/4 [95.3]					9/16 [14.3]	2-5/8 [66.7]			12-3/4 [5.8]
	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]					58 [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 [123.8]					11/16 [17.5]	3-1/2 [88.9]	3/4 [19]		8 [3.6]
	600	4-7/8 [123.8]									
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]				
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]	4	15-3/4 [7.1]
	300	6-1/2 [165.1]					7/8 [220]	5 [127]		8	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]	15/16 [24]	6 [152.4]	3/4 [19]	4	25-3/4 [11.7]
	300	8-1/4 [209.6]					1-7/8 [28.6]	6-5/8 [168.3]	7/8 [22]	8	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]	1 [25.4]	9-1/2 [241.3]	7/8 [22]	8	66 [30]
	300	12-1/2 [317.5]					1-7/16 [36.5]	10-5/8 [269.9]		12	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	99 [45]
	300	15 [381[					1-5/8 [41.3]	13 [330.2]	1 [25.4]	12	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: ≤ ±0.75% of rate
  Gas/Steam: ≤ ±1% of rate
* Rugged and simple flowmeter primary design.
* Wafer design.
* High temperature design to 400ºC (750ºF).
* 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.

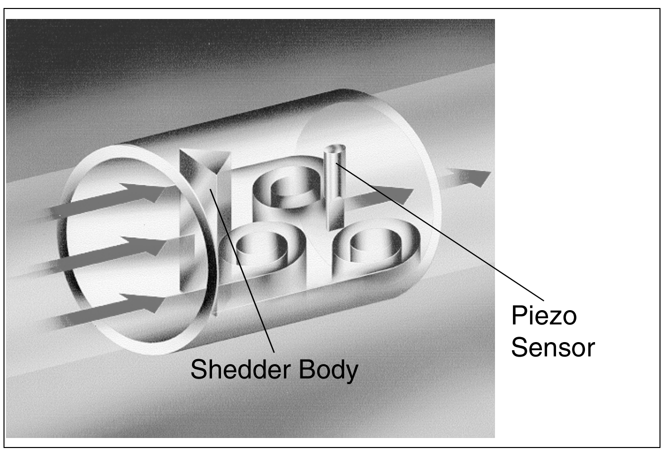


FIGURE 3-1 FLOW MEASUREMENT PRINCIPLE, TRIO-WIRL V

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.

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

μ = Kinematic viscosity
D = Meter tube diameter
v = Flow Velocity

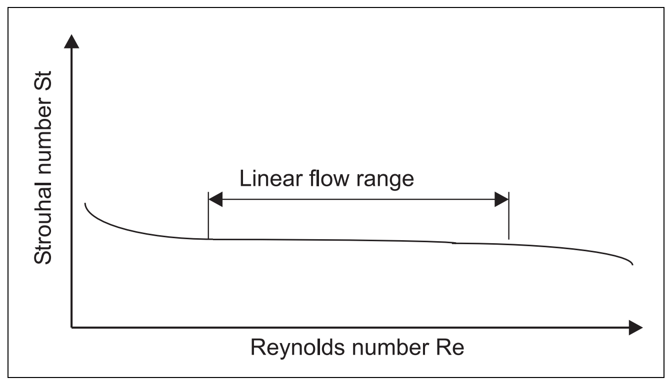


FIGURE 3-2 STROUHAL NUMBER / REYNOLDS NUMBER RELATIONSHIP

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.

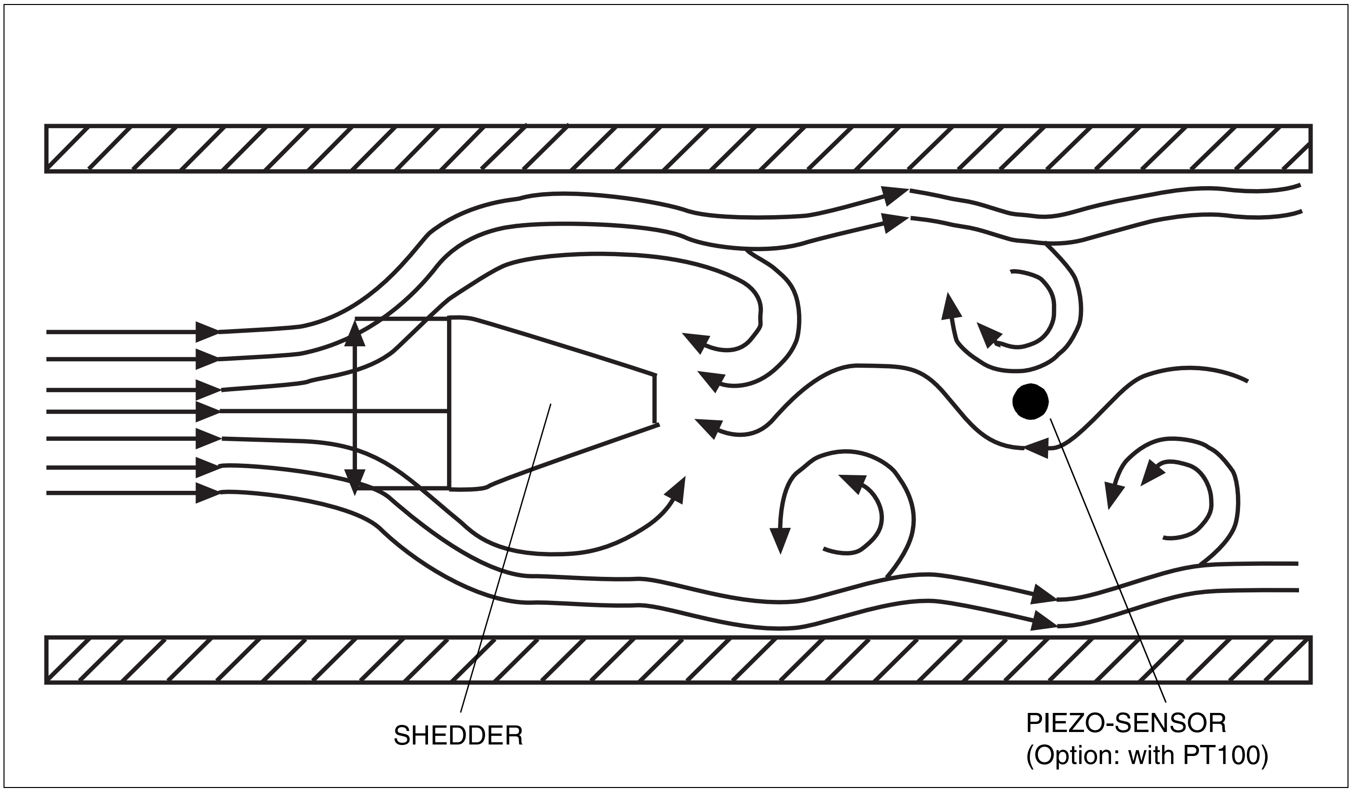


FIGURE 3-3 OPERATING PRINCIPLE, TRIO-WIRL V

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

TRIO-WIRL V _ **4** _ _ _ _ _ _ _ _ _ _ _ _ **E** **A** _ **A** **B**

Flowmeter Design	
Compact	**T**
Remote	**R**

Series	**4**

Agency Approvals / Power Supply	
None / 14 - 46V DC	**0**
FM / CSA-Approval / 14 - 46V DC	**3**
Others (2)	**9**

Process Connections	
Flanged	**1**
Wafer	**3**
Others	**9**

Fluid	
Liquid	**1**
Gas	**2**
Steam	**3**
Oxygen (1)	**6**

Materials

Housing	**Shedder**	**Sensor**	
SS 316Ti/1.4571	SS 316Ti/1.4571	SS 316Ti/1.4571	**1**
Hastalloy C	Hastalloy C	Hastalloy C	**3**

Meter Sizes		
DN 15 /	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

Option		Code
Pressure Rating		
ANSI CL 150		Q
ANSI CL 300		R
ANSI CL 600 (2)		S
Other		Z
Sensor Design		
Standard sensor		1
Standard sensor with integral temperature sensor		2
High Temperature [<750°F (400°C)] sensor (2)		5
Temperature Range Fluid/Gaskets		
Graphite	-67 °F to 536 °F (-55 °C to 280 °C) (2)	1
Graphite Special	-67 °F to 750 °F (-55 °C to 400 °C) (2)	2
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
Certificates		
None		A
EN 10204 (DIN 50049-3.1b)		C
Communication		
With Display and HART		2
Instrument Tag		
English		E
Design Level/Software Level		A
Accessories		
None		0
2” Pipe Mount (only VR)		1
Operating Mode		
Continuous flowrate		A
Cable Conduit		
½“ 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 x 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.

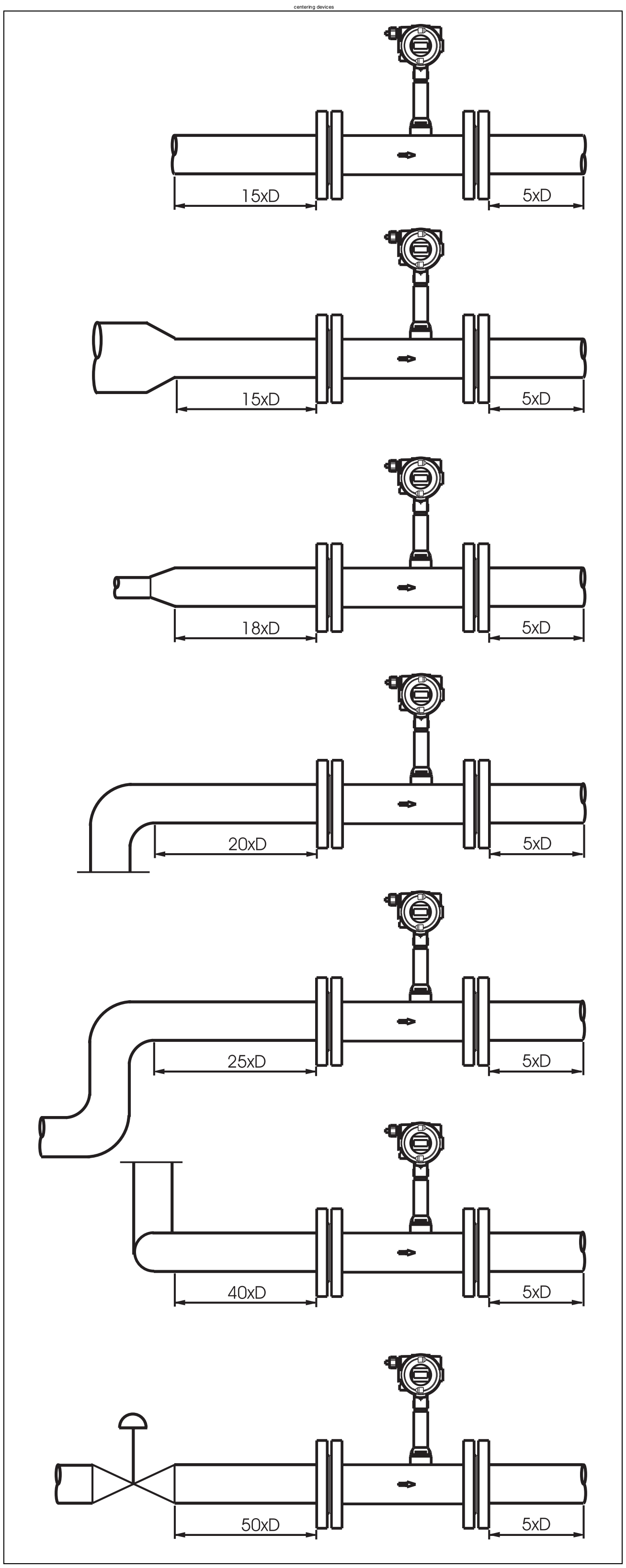


FIGURE 3-4 METER PIPING REQUIREMENTS

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 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.

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.

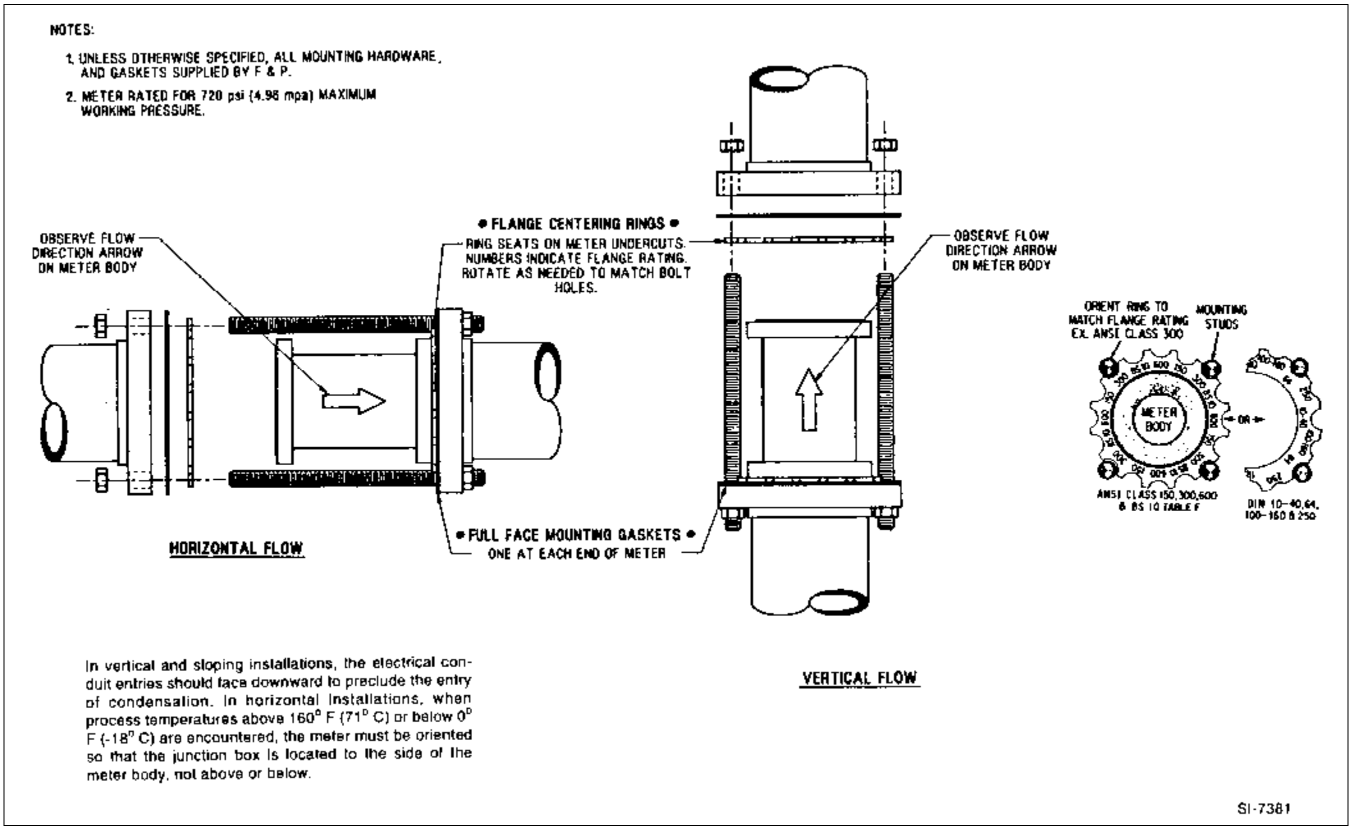


FIGURE 3-5 WAFER PROCESS CONNECTIONS, SIZES 1/2 THROUGH 2 INCHES

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.

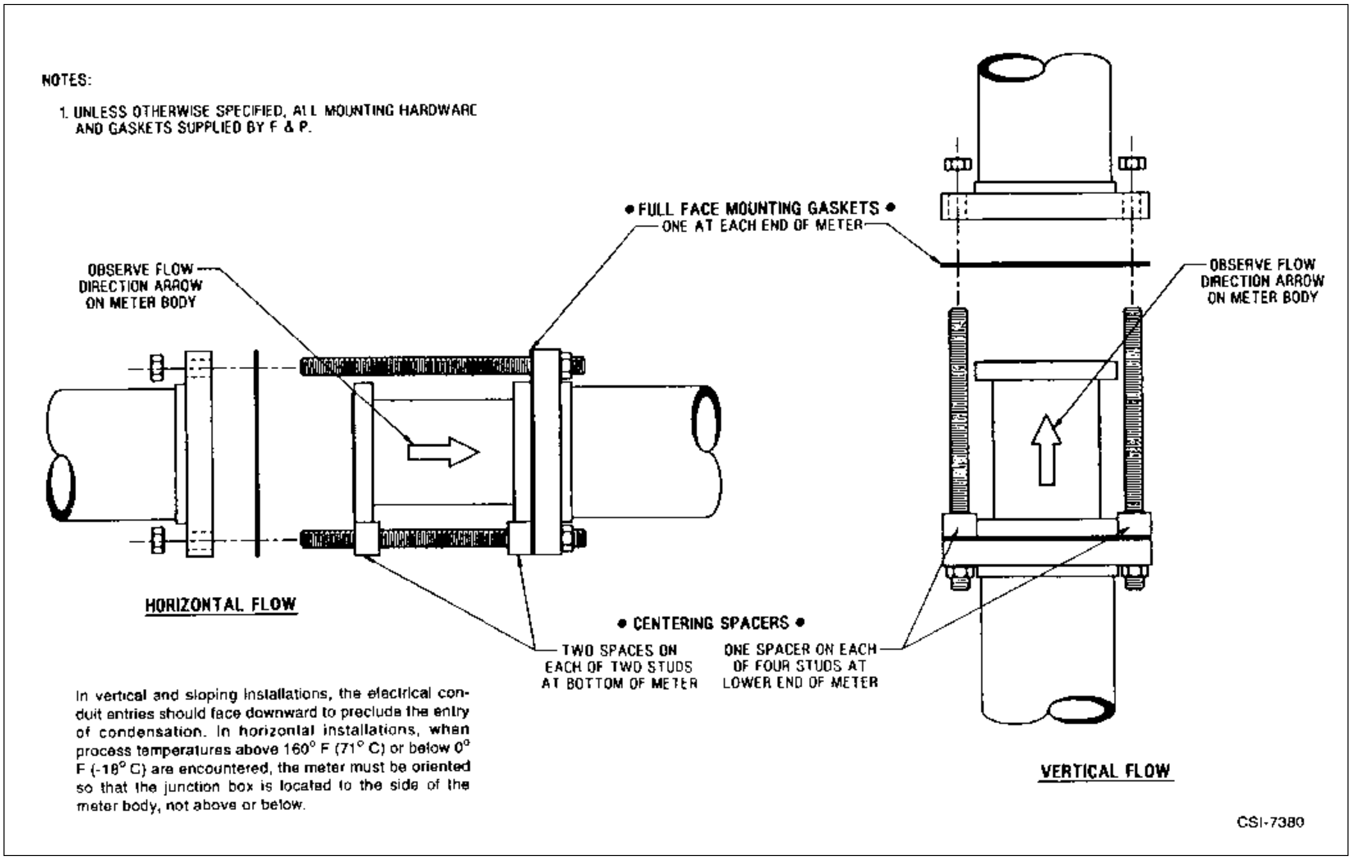


FIGURE 3-6 WAFER PROCESS CONNECTIONS, SIZES 3 THROUGH 8 INCHES

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

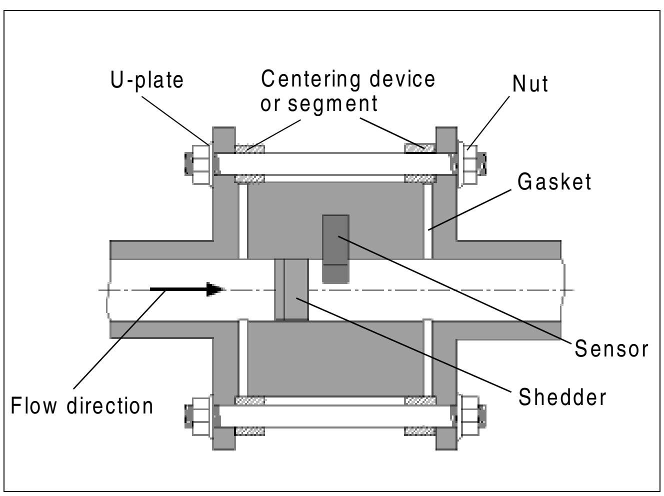


FIGURE 3-7 WAFER STYLE ASSEMBLY

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 alligned 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.

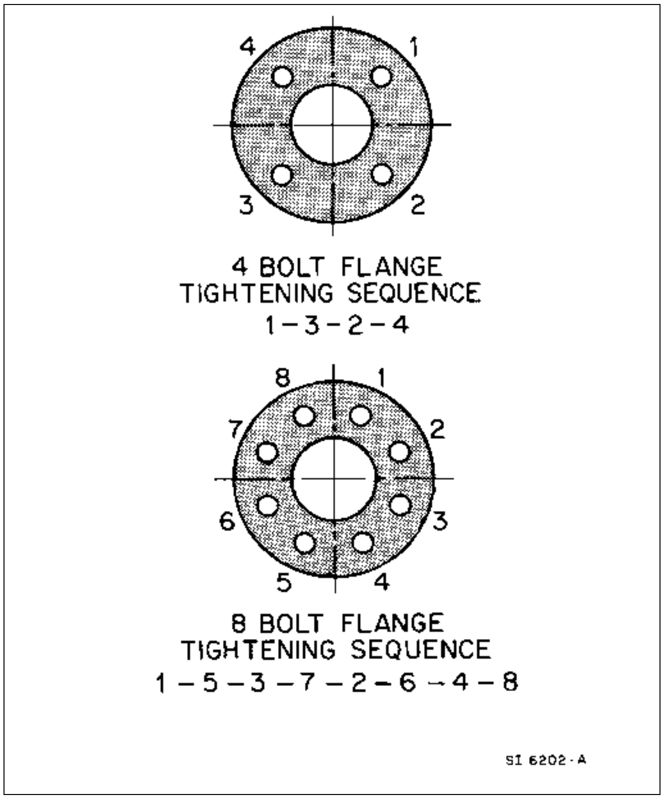


FIGURE 3-8 RECOMMENDED FLANGE BOLT TIGHTENING SEQUENCE

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

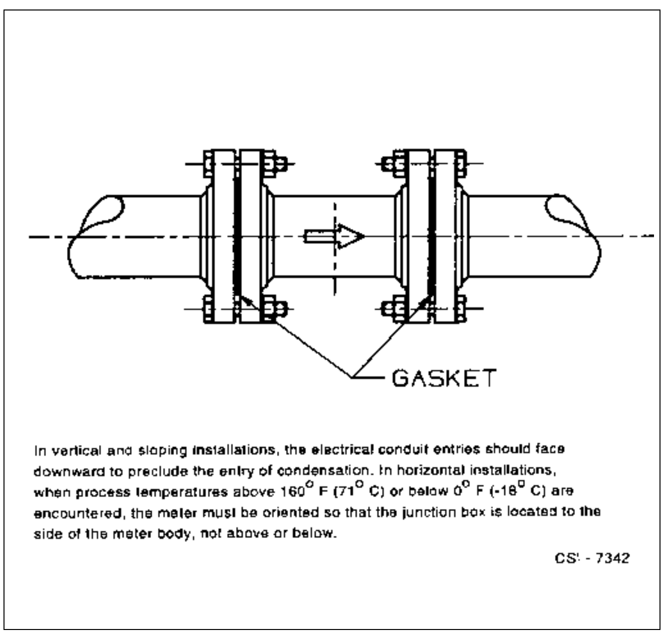


FIGURE 3-9 FLANGE PROCESS CONNECTIONS

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 ≥ 50D upstream from the flowmeter.

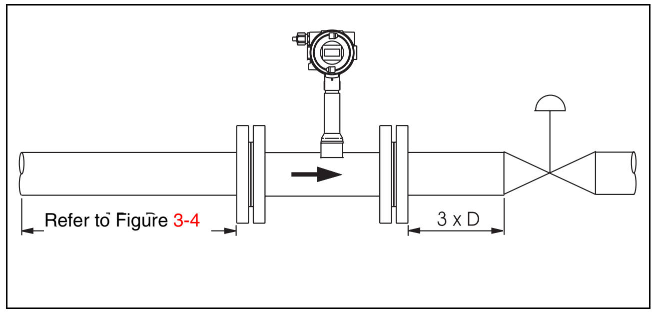


FIGURE 3-10 CONTROL VALVE INSTALLATION

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.

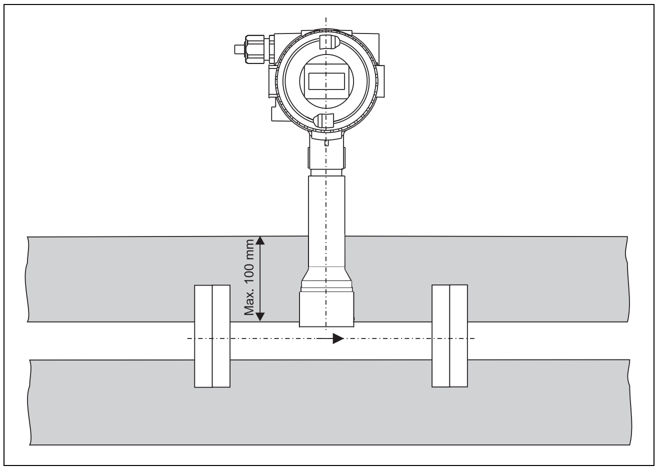


FIGURE 3-11 INSULATING THE PIPELINE

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.

.

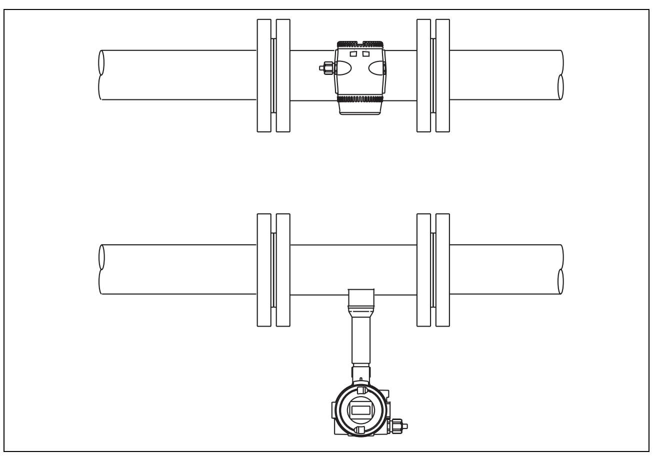


FIGURE 3-12 Orientation for Temperatures >300° F (150° C)

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.

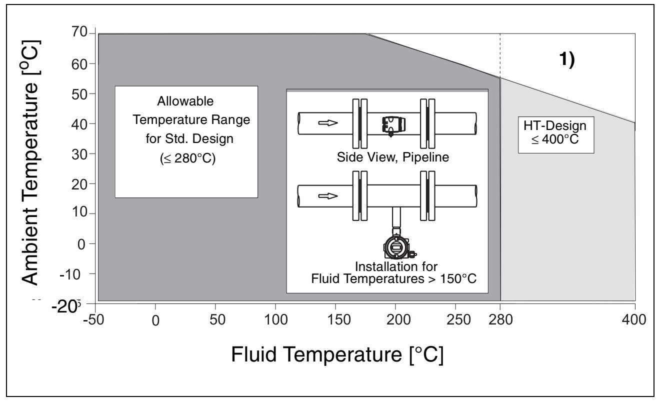


FIGURE 3-13 AMBIENT/FLUID TEMPERATURE RELATIONSHIP

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 ^{o}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 (ρ_s) to operating density (ρ).

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

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, μ (cps) to kinematic viscosity, ν (cst)

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

4. Reynolds Number (R_e)

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

Where:

ρ = Density at operating conditions (lb/ft^3)
ρ_s = Density at standard conditions (lb/ft^3)
p = Pressure at operating conditions (psig)
T = Temperature at operating conditions (ºF)
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, ρ = 0.075 lb/ft^3

TABLE 3-2. STANDARD DENSITIES FOR SELECTED GASES

Gas	Standard Density [lb/ft^3]
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

		Q_{vmin} [ACFH]													Qvmax [ACFH]	Freq. [Hz] at Qvmax
Density		≤0.08 [1]	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

[1] Valid for 0.03 ≤ Density ≤ 0.08. Consult factory for densities < 0.03 lb/ft^3.

3.5.1.1 Example for Gases:

Determine the flowmeter size for metering 98,700 scfh (Q_s) CO_2; temperature 185 ^{o}F, pressure = 72 psia. Refer to Section 3.5 for equations.

ρ_s = 0.1149 lb/ft^3 (CO_2)   (From Table 3-2)

1. Convert ρ_s 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_s to Q_v:

$$Q_V = 98700\left(\frac{0.1149}{0.46}\right) = 24653\,acfh$$

Select 3 in. meter size (Q_{vmax} = 33,500 acfh). Refer to Table 3-1.

3. Pressure drop at ρ = 0.462 lb/ft^3 :

Q_V = 24,653 acfh

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

4. Range start value at ρ = 0.46 lb/ft^3 (see Table 3-3)

Q_{Vmin} = 1138 acfh

3.5.1.2 Pressure Drop, Gas/Superheated Steam

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

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

Where:

$\Delta p'$ = 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 ^{o}F
Saturated Steam Density = 0.255 lb/ft^3

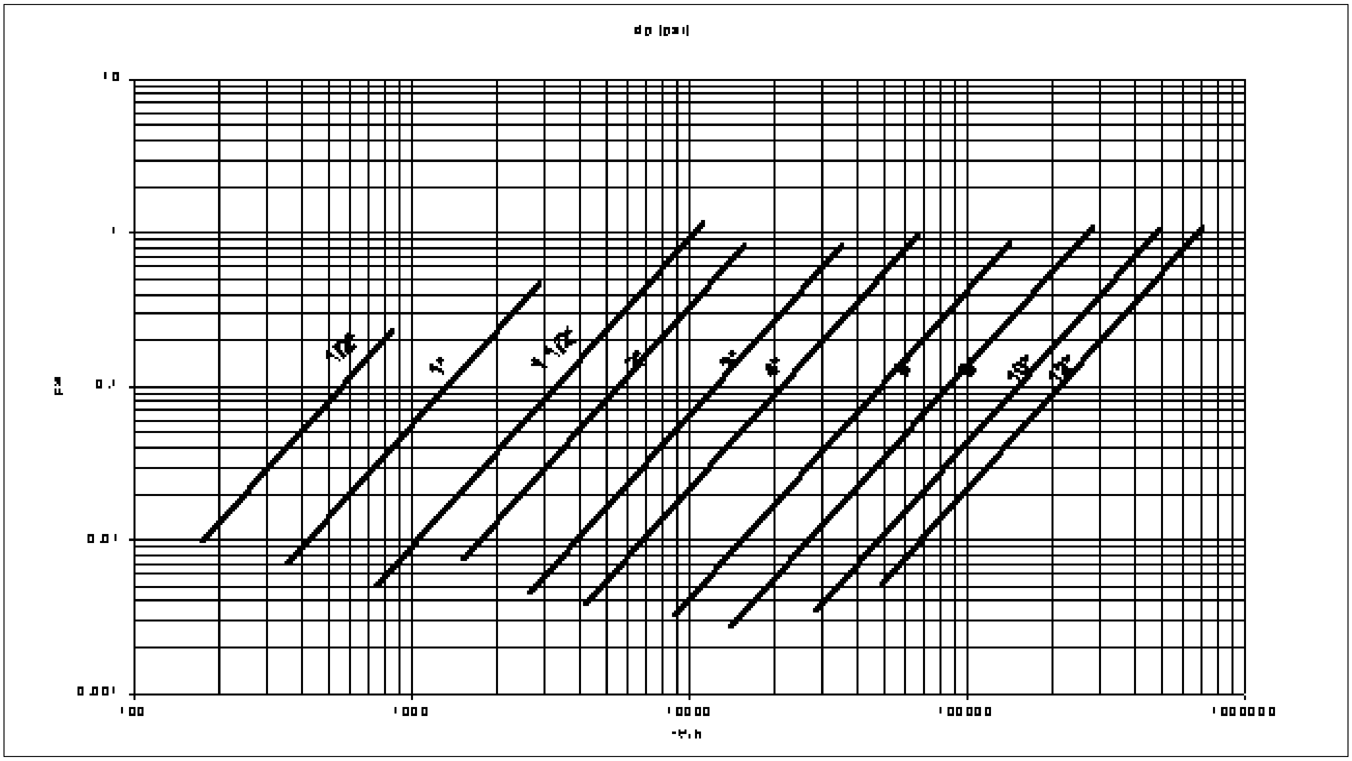


FIGURE 3-14 PRESSURE DROP, AIR @70^{o} F & 14.7 psia

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

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

Where:

p_2 =Positive downstream static pressure [psi]
p_{Vapor} =Fluid vapor pressure at operating temp. [psi]
$\Delta\rho'$ =Fluid pressure drop [psi] (See Figure 3-15)

3.5.2.2 Pressure Drop, Liquids

See Figure below for water (70ºF, 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:

$\Delta p'$ = 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_v = maximum

Q_{VMAX} = 17,400 gph for 2 in. meter (from Table 3-5)

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

Q_{VMIN} = 1,800 gph (Refer to Table 3-6)

3. Calculate Pressure drop (Q_v = 14,000 gph) at

ρ = 7.10 lb/gal

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

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

		Q_{vmin} [gph]							Qvmax [gph]	Frequency @ $Q_V$max [Hz]
Centistokes		≤ 1	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										

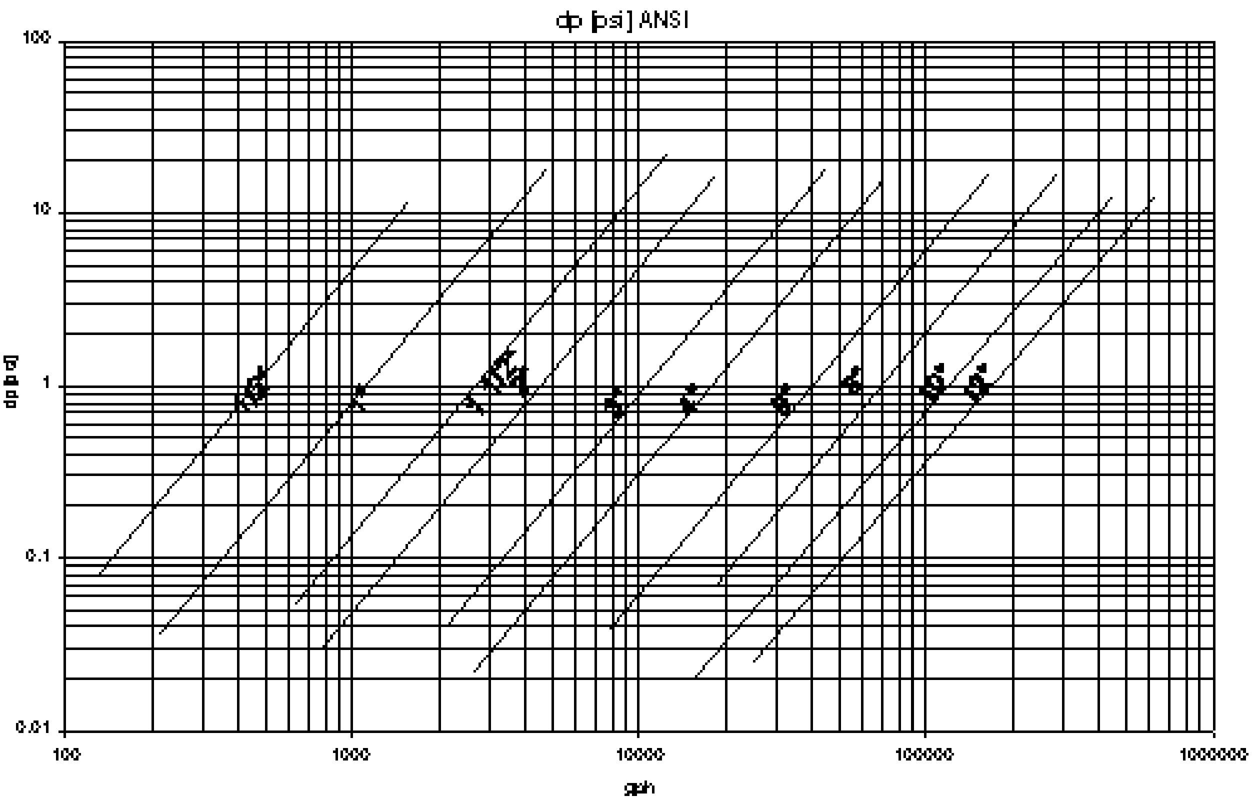
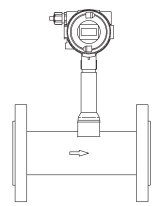
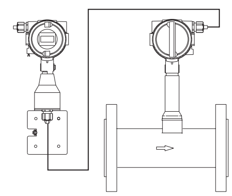


FIGURE 3-15 PRESSURE DROP, WATER (70^{o} F, 14.67 psia, ρ=8.34 lb/gal)

3.6 Specifications

3.6.1 Model Overview

	MODEL	 VT4000	 VR4000
Accuracy	Liquids	≤ ± 0.75 % of rate	
	Gases and Steam	≤ ± 1 % of rate	
Reproducibility		≤ ± 0.2 % of rate	
Allowable viscosity for liquids		≤ 7.5 cps	
Typical flow range		1:20	
Typical up-/downstream straight lengths		15 x D / 5 x D	
Flowmeter Primary			
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	
Approvals / Certifications			
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: ≤ ±1% of rate
Liquids: ± 0.75% of rate

Reproducibility: ≤ 0.2% of rate

ACCURACY AND REPRODUCIBILITY OF THE TEMPERATURE MEASUREMENT

Accuracy (incl. converter): ≤ ± 2 °C / ≤ 3.6 °F
Reproducibility: ≤ 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: 316 SS, 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:

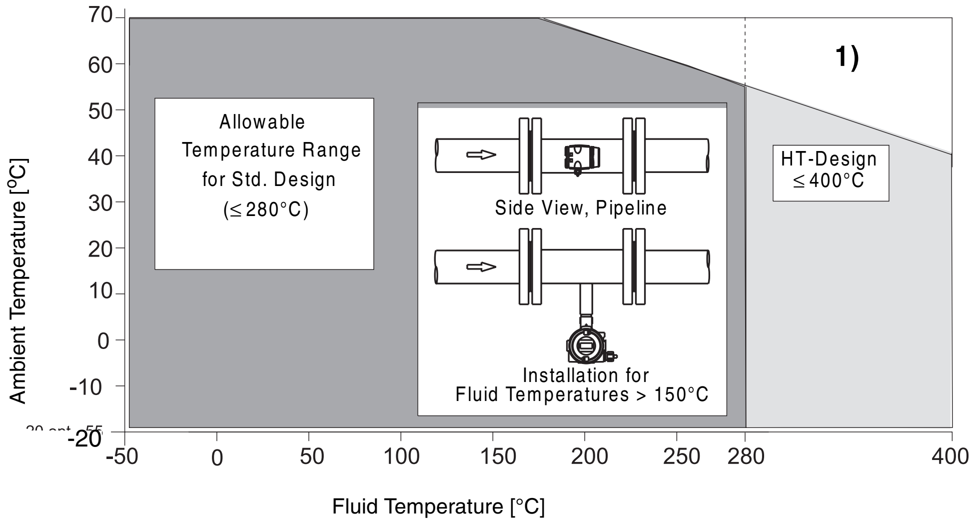
Climate Resistance (per DIN 40040): GSG
Relative humidity: 95% Max.
100% with cover in place

AMBIENT TEMPERATURE:

-4° F (-20° C) to 158° F (70° C)

ALLOWABLE PROCESS PRESSURE:

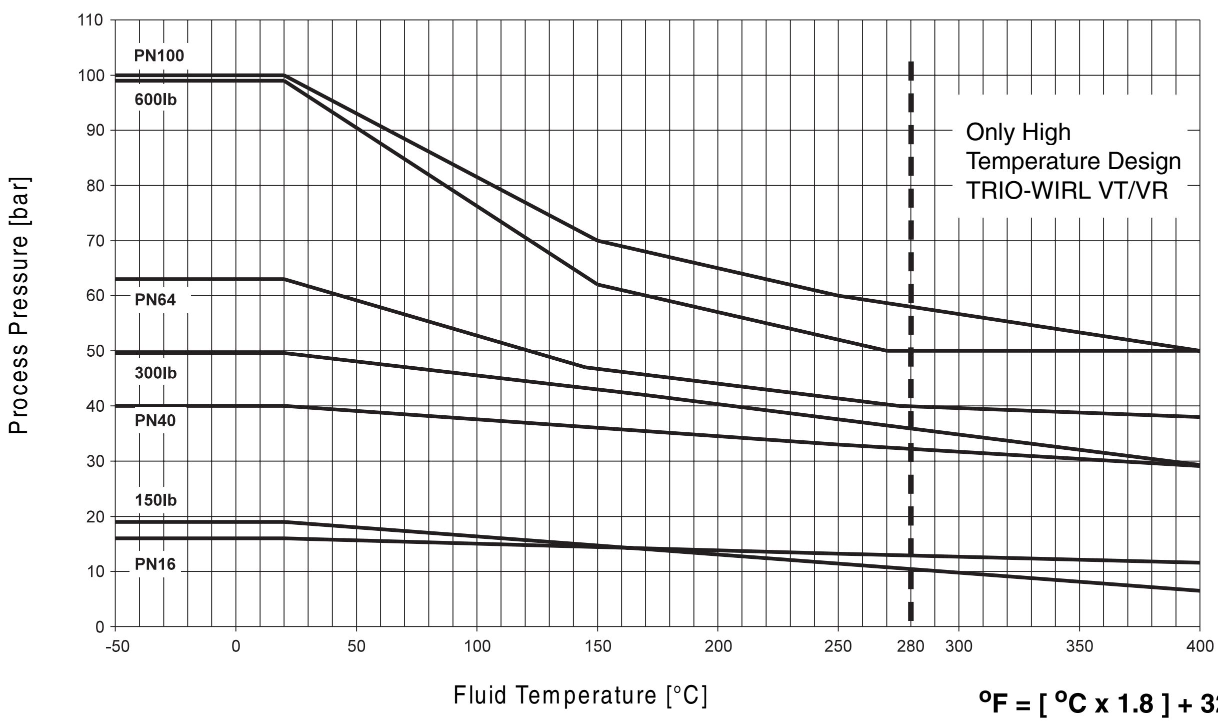
Process pressure limitations vs. process fluid temperatures are shown in Figure 3-17.



1) Cables for the supply power, terminals 31 & 32, and the contact output, terminals 41 & 42, which are suitable for temperatures to T= 230°F (110°C), can be used without any temperature reductions. Cables which are only suitable for temperatures to T= 176°F (80°C), reduce the temperature ranges as shown in Figure 3-16.

°F = [°C x 1.8] + 32

FIGURE 3-16 AMBIENT / FLUID TEMPERATURE RELATIONSHIP

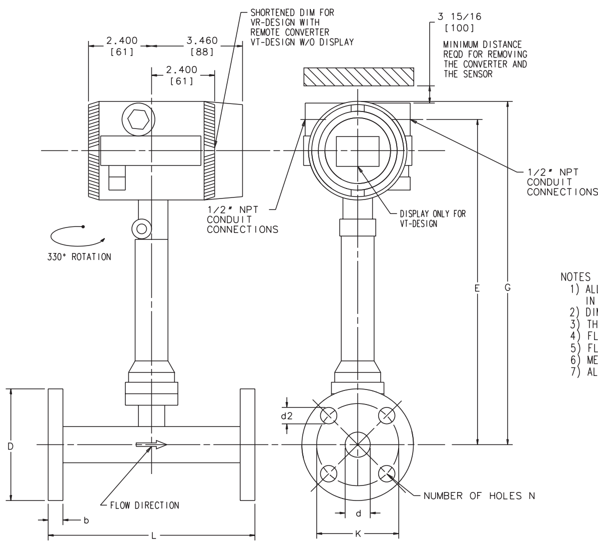


°F = [°C x 1.8] + 32

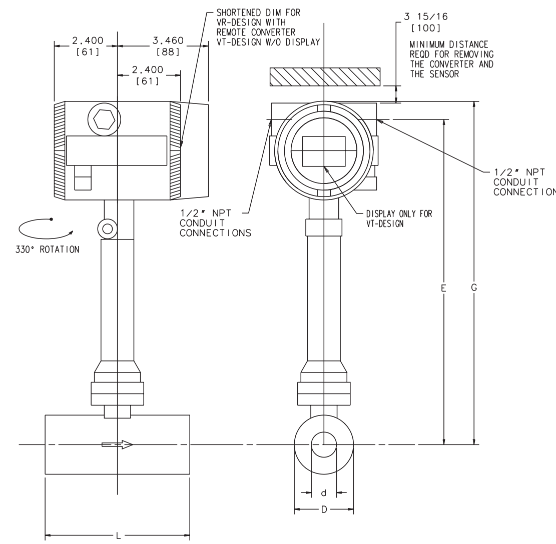
1 Bar = 14.50 psi

FIGURE 3-17 PROCESS PRESSURE vs. PROCESS FLUID TEMPERATURE

FIGURE 3-18 OUTLINE DIMENSIONS, VT/VR PRIMARY



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] .



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]	7-7/8	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]	[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	8	44.3
	300	1-1/4 [31.7]	10 [254]	[97.2]	7/8 [22.2]	[3250	[344]	7-7/8 [200]	[250]	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	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]	[300]	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/ [298.5]	13-3/4	8	
	300	1-5/8 [41.3]	15 [381]	[194]	7/8 [22.2]	[414]	[433]	13 [330.2]	[349.2]	12	
10	150	1-3/16[30.2]	16 [406.4]	10.03	1 [25.4]	17-9/32	18-1/32	14-1/ [362]	17-23/32	12	
	300	1-7/8 [47.7]	17-1/2[444.5]	[255]9	1-1/8[28.6]	[439]	[458]	15-1/ [387.4]	[450]	16	
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	12	
	300	2 [50.8]	20-1/2[520.7]	[305]	1-1/4[31.8]	[464]	[483]	17-3/4[450.9]	[500]	16	

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.

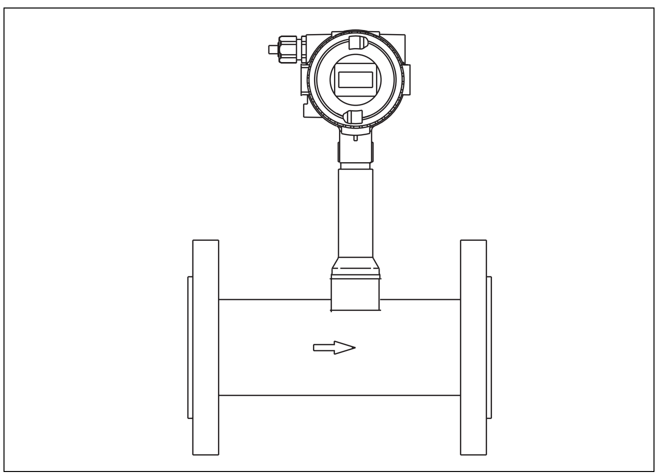


FIGURE 4-1 INTEGRAL TRIO-WIRL MODEL VT

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.

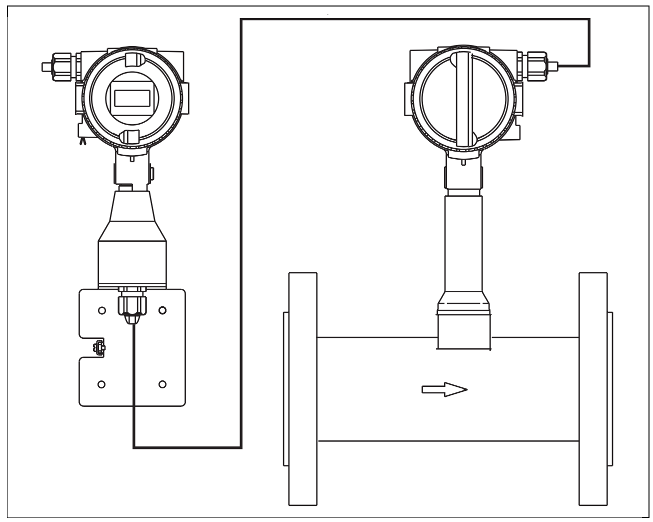


FIGURE 4-2 REMOTE TRIO-WIRL MODEL VR

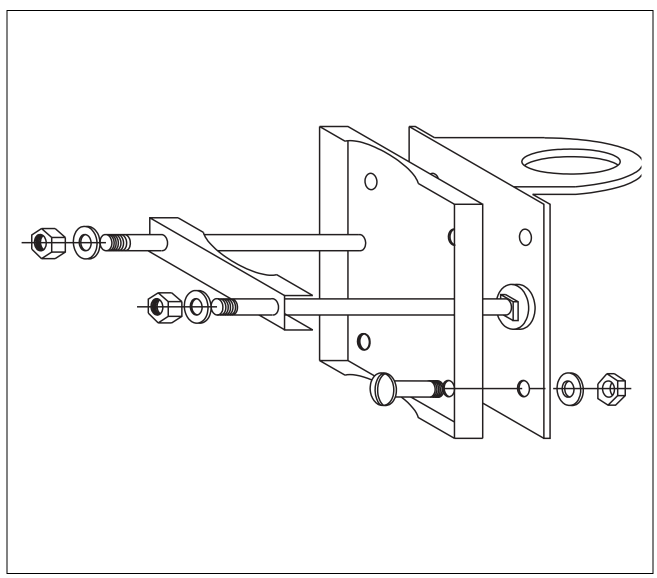


FIGURE 4-3 VR/SR PIPE-MOUNT BRACKET

After the installation has been completed, the cable can be cut to the length required to reach he 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..

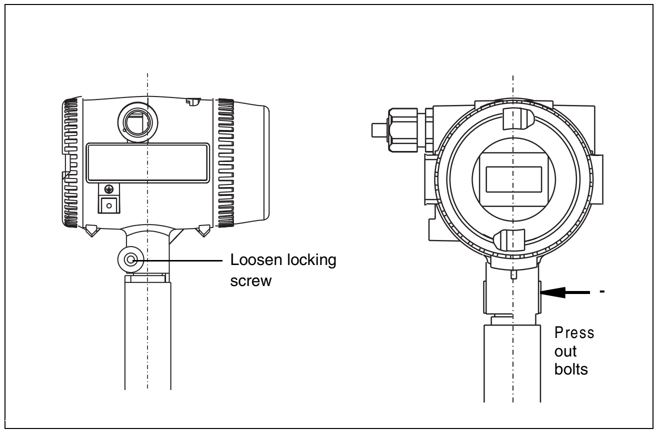


FIGURE 4-4 CONVERTER HOUSING ROTATION

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.

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 counterclockwise, 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

.

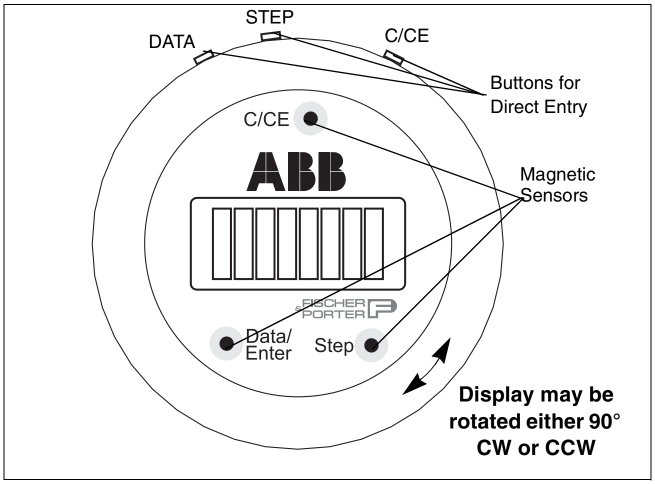


FIGURE 4-5 CONVERTER KEYPAD & DISPLAY

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 and pulse outputs continue to indicate the actual instantaneous flowrate values. 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 STEP DATA	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.

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)

Action	Use Keys=	Display Information	
Turn off Locked mode	-	Qv % / 10.5	Standard-Display
1) Advance to Progr. Level	STEP or DATA	Progr. / Level	
2) Enter Menu	ENTER	Locked	
	ENTER	Locked_	An "underscore" indicates "selectable"
3) Select desired Mode	STEP or DATA	Standard_	
4) Enter Code (if not "0")	ENTER	*Program Protection Code*	

Direct Numeric Entry
Example: Set Qmax value

Action	Keys =	Display Information
1) Find Parameter "Qmax"	STEP or DATA	Qmax
2) Check "Qmax" setting	ENTER	5.000 / l/s
3) Change Parameter "Qmax"	ENTER	0 / l/s
4) Enter the desired number series		4 . 5 2 5 / l/s

Key sequence:
4xDATA
STEP
10xDATA (decimal point)
STEP
5xDATA
STEP
2xDATA
STEP
5xDATA

4) *The C/CE key clears the entry

Action	Keys =	Display Information
5) Accept new Qmax value	ENTER	4.525 / l/s

Entry from a Table
Example: Set meter size

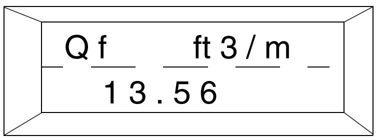
Action	Keys =	Display Information
1) Select parameter "Meter size"	STEP or DATA	Meter / size
2) Check "Meter Size"	ENTER	15 mm / 1/2 in
3) Change parameter "Meter Size"	ENTER	15 mm / 1/2 in
4) Select "Meter Size" from table.	STEP or DATA	50 mm / 2 in
5) Accept new Meter Size	ENTER	Meter / Size

Action	Keys	Display Information	
Exit from Qmax or Meter Size / Find Program Level	STEP or DATA	*Prog. Level*	
Access parameter setting	ENTER	*Menu mode*	
Turn program protection on again (Step or Data)	ENTER	*Menu mode* / Locked_	
Select Program Level	STEP or DATA	*Program level*	
	ENTER		
Return to Standard Display/ Process Information	C/CE	Qv % / 10.5	Standard Display

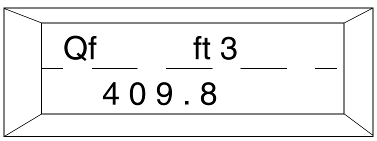
4.4 Operation and Configuration

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:

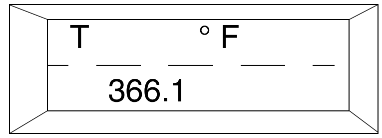
Actual flowrate in direct reading engineering units:



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® 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 variety 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_{PP}.

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

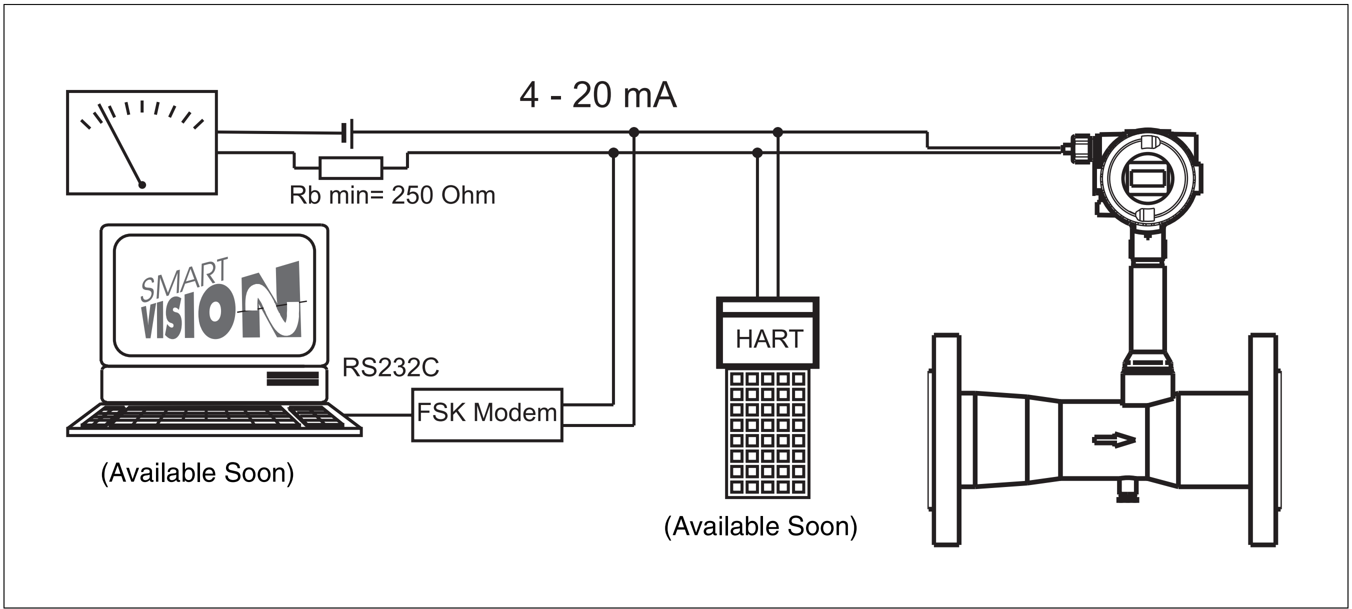
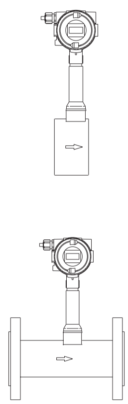
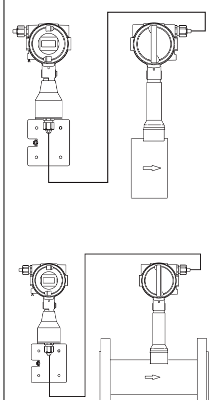
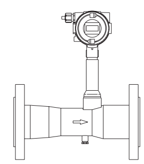
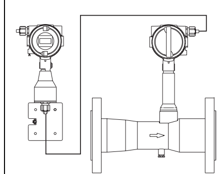


FIGURE 4-6 HART-Communication

4.6 Specifications

4.6.1 Overview

		 TRIO-WIRL VT	 TRIO-WIRL VR	 TRIO-WIRL ST	 TRIO-WIRL SR
CONVERTER					
Supply Power	**For analog output 4-20 mA**	14-46 V (EEx < 28 V)			
	For Profibus PA (in prep.)	< 10 mA			
Self Monitor		yes			
Display	**2 x 8 character**	Local display/totalization and Magnet Stick operation			
Contact Output	**(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)			
Communication		HART-Protocol			
		Profibus PA & Fieldbus Foundation available soon			
TRIO-WIRL VR or SR	**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.
APPROVALS / CERTIFICATIONS					
Intrinsically Safe & Explosionproof Design	**FM / CSA**	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

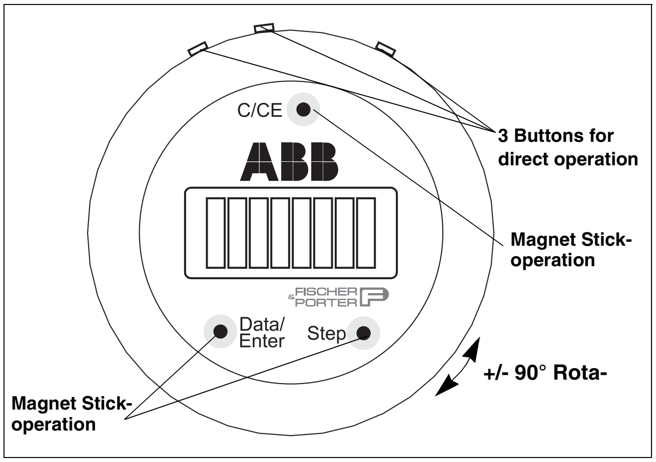


FIGURE 4-7 Converter Keypad and Display

FLOW RANGES:

The flow range end value can be continuously set between 0.15 x 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 though 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 ± 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 ≤ 750 Ω

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

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.

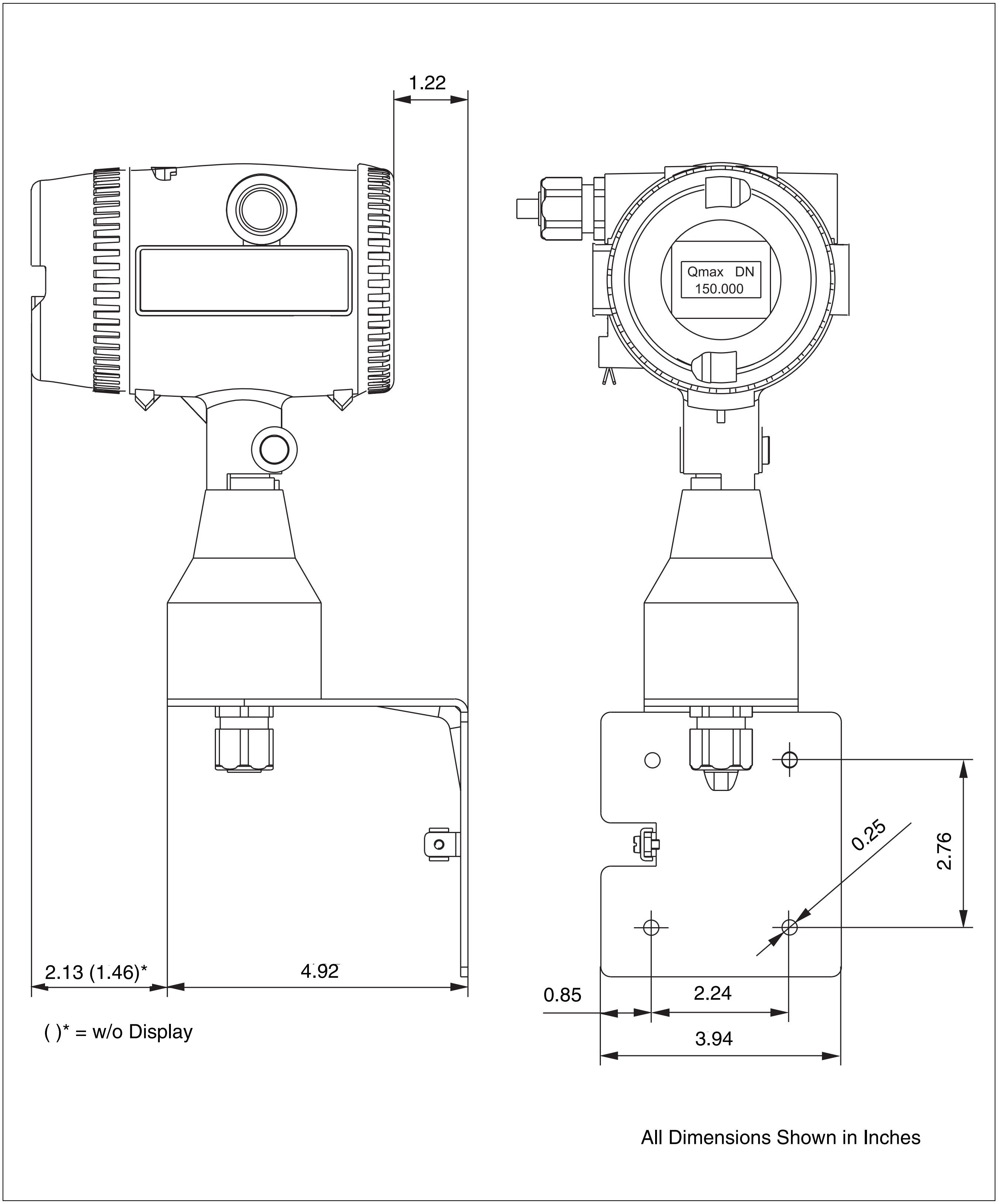


FIGURE 4-8 OUTLINE DIMENSIONS, VR/SR IN WALL-MOUNT HOUSING

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.

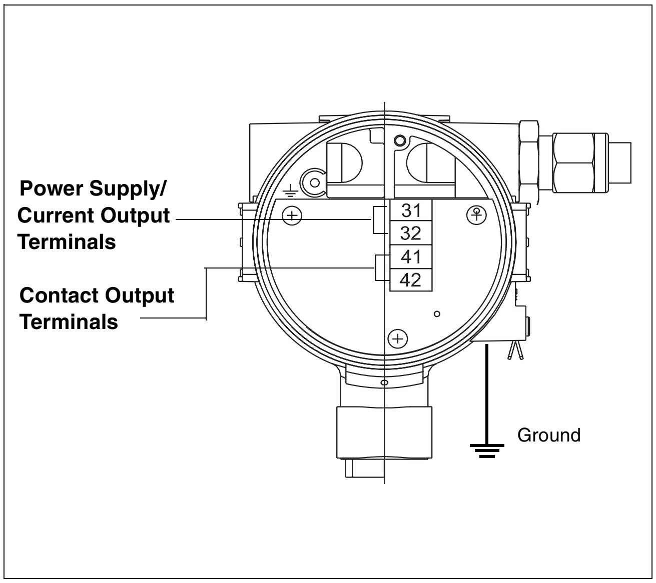


FIGURE 5-2 CONNECTION BOX TRIO-WIRL

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).

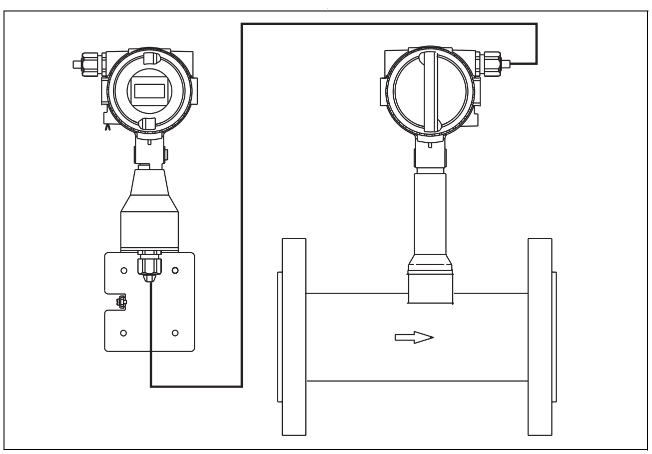


FIGURE 5-3 TRIO-WIRL VR/SR

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.

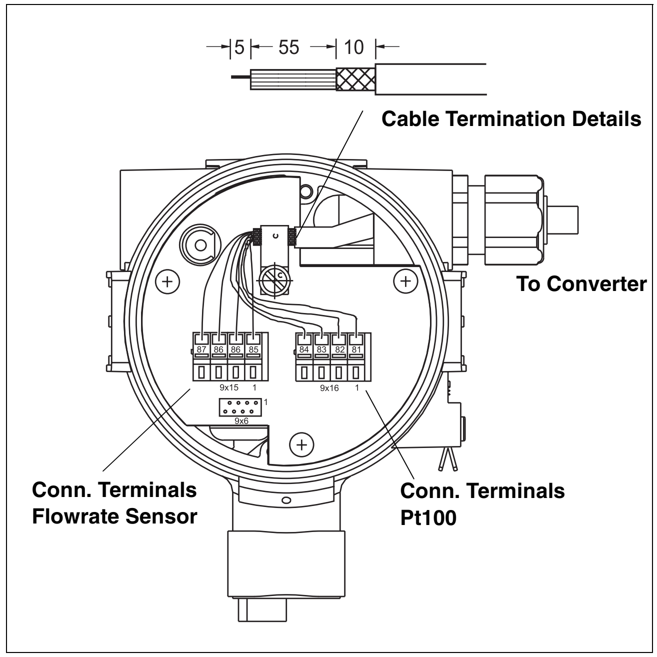


FIGURE 5-4 CONNECTION BOX TRIO-WIRL VR/SR FLOWMETER PRIMARY

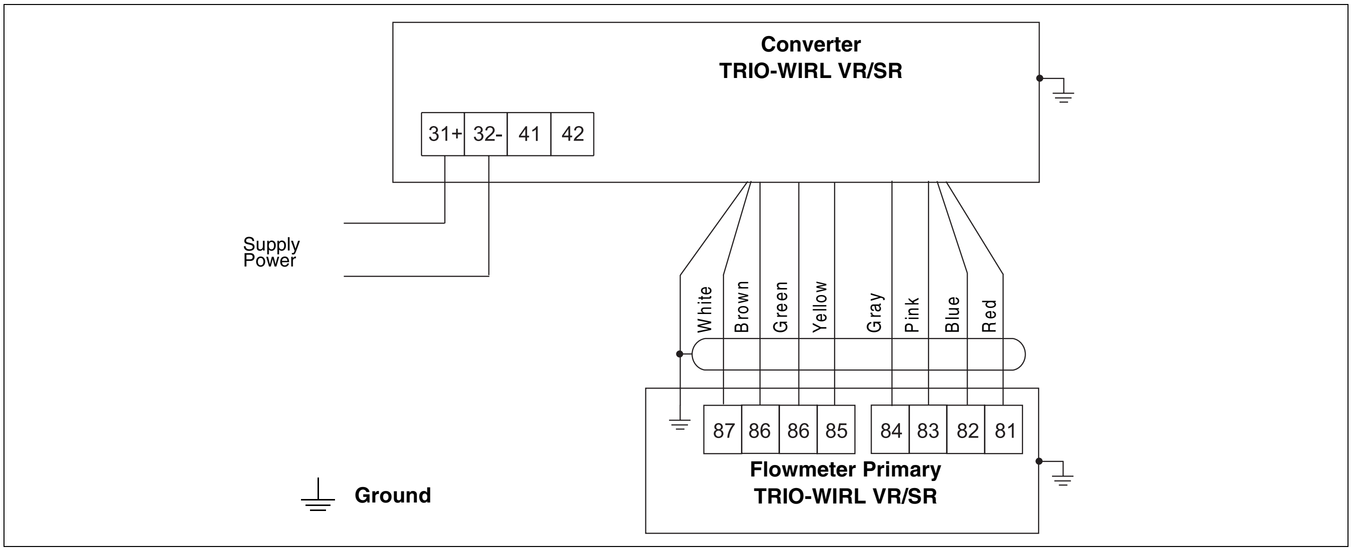


FIGURE 5-5 INTERCONNECTIONS BETWEEN CONVERTER AND FLOWMETER PRIMARY

5.2.3 Power Supply Interconnections

5.2.3.1 Power Supplied from a Central Power Supply

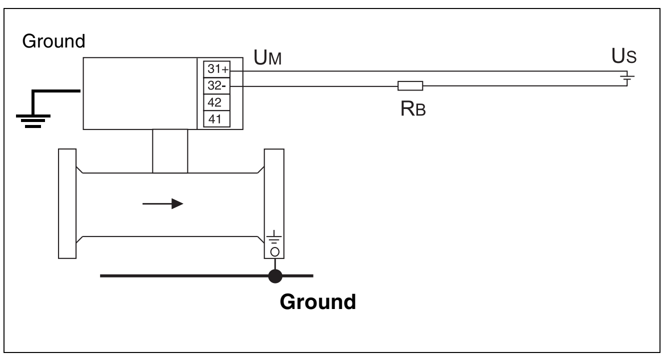


FIGURE 5-6 CENTRAL POWER SUPPLY

5.2.3.2 Power Supplied from Transmitter Power Supply

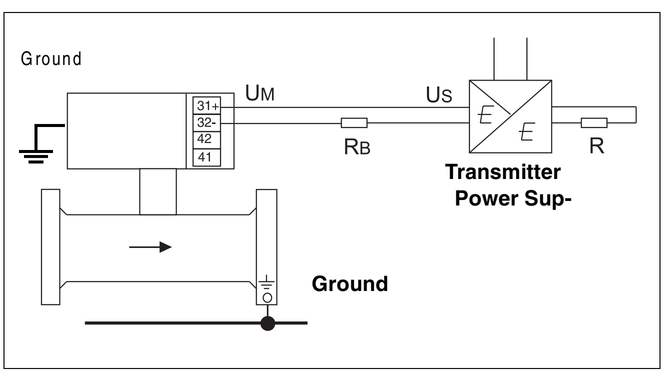


FIGURE 5-7 TRANSMITTER POWER SUPPLY

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.)

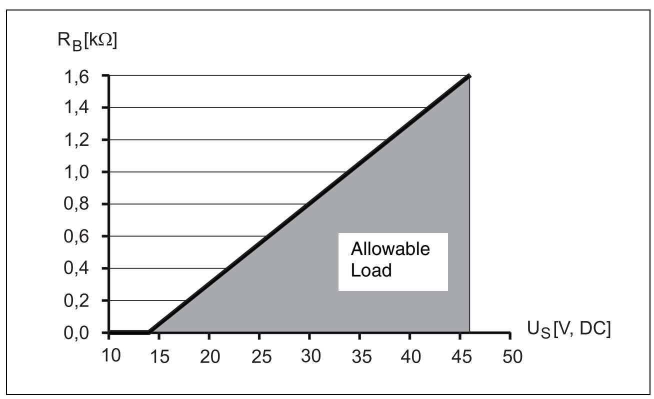


FIGURE 5-8 LOAD DIAGRAM

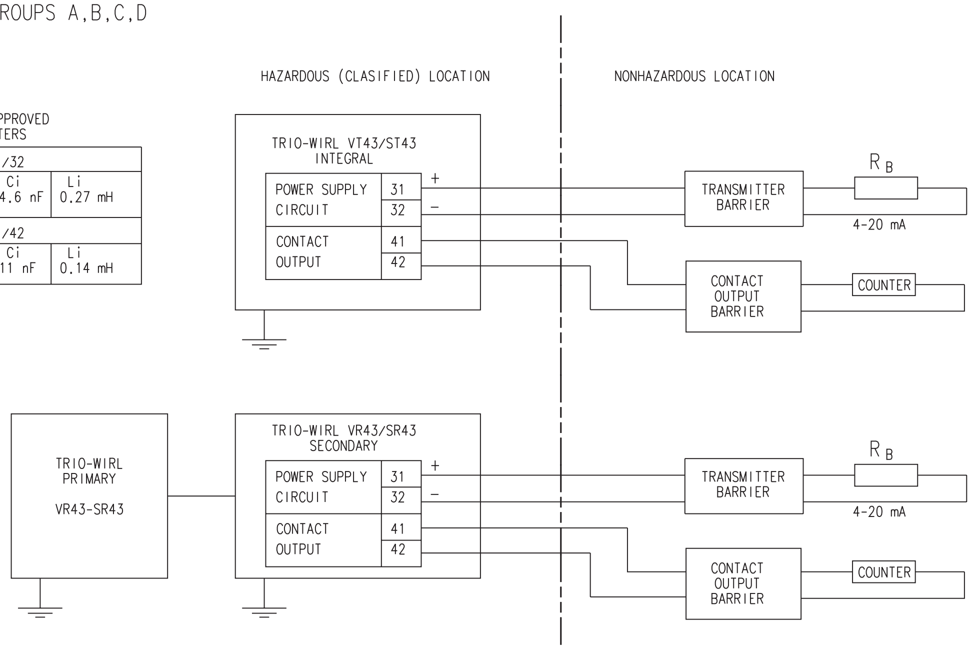
5.2.3.3 Hazardous Location Installation

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.

INTRINSIC SAFETY
CLASS I,DIV 1, GROUPS A,B,C,D

FACTORY MUTUAL APPROVED
ENTITY PARAMETERS

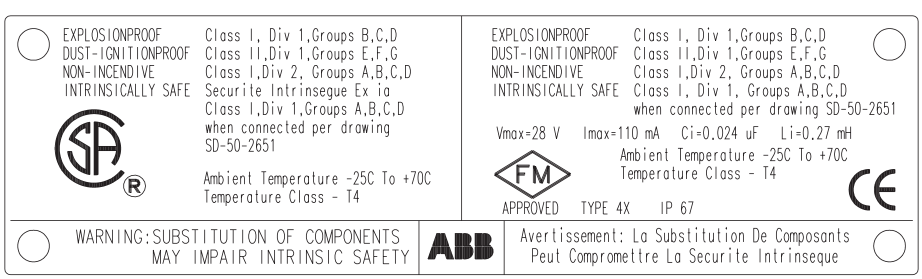
INTRINSIC SAFETY 31/32				
V MAX 28 V	I MAX 110 mA	Pi 770 mW	Ci 14.6 nF	Li 0.27 mH
INTRINSIC SAFETY 41/42				
V MAX 15 V	I MAX 30 mA	Pi 115 mW	Ci 11 nF	Li 0.14 mH



NOTES:
1. THE INTRINSIC SAFETY ENTITY CONCEPT ALLOWS THE INTERCONNECTION OF TWO FM APPROVED INTRINSICALLY SAFE DEVICES WITH ENTITY PARAMETERS NOT SPECIFICALLY EXAMINED IN COMBINATION AS A SYSTEM WHEN:
Uo OR Voc OR Vt ≤ V MAX, Io OR Isc OR It ≤ I MAX, Ca OR Co ≥ Ci + Ccable, La OR Lo ≥ Li+ Lcable, Po ≤ Pi.
2. DUST-TIGHT CONDUIT SEAL MUST BE USED WHEN INSTALLED IN CLASS II AND CLASS III ENVIRONMENTS.
3. CONTROL EQUIPMENT CONNECTED TO THE ASSOCIATED APPARATUS MUST NOT USE OR GENERATE MORE THAN 250 Vrms OR Vdc.
4. INSTALLATION SHOULD BE IN ACCORDANCE WITH ANSI/ISA RP12.6 ",INSTALLATION OF INTRINSICALLY SAFE SYSTEMS FOR HAZARDOUS (CLASSIFIED) LOCATIONS" AND THE NATIONAL ELECTRICAL CODE (ANSI/NFPA 70) SECTIONS 504 AND 505.
5. THE CONFIGURATION OF ASSOCIATED APPARATUS MUST BE FACTORY MUTUAL RESEARCH APPROVED UNDER ENTITY CONCEPT.
6. ASSOCIATED APPARATUS MANUFACTURER'S INSTALLATION DRAWING MUST BE FOLLOWED WHEN INSTALLING THIS EQUIPMENT.

Ref. SD-50-2651 -r.0

FIGURE 5-9 POWER SUPPLY INTERCONNECTION DIAGRAM, HAZARDOUS LOCATIONS



Ref. 338J082U03 - r0

FIGURE 5-10 FM / CSA LABEL

5.2.4 Contact Output Connections

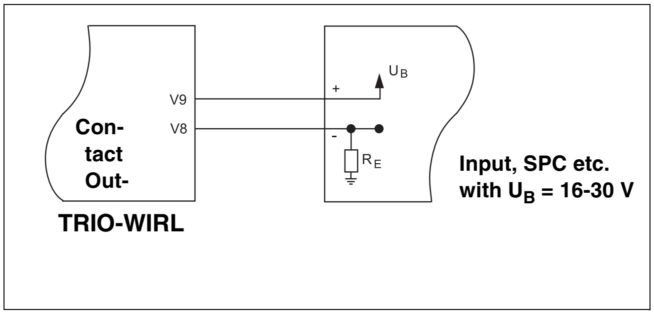


FIGURE 5-11 CONTACT OUTPUT CONNECTION

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).

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

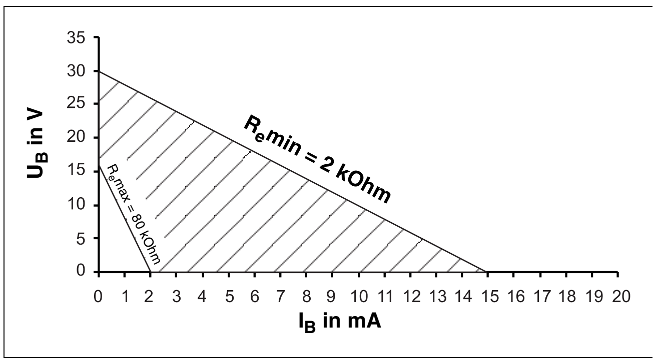


FIGURE 5-12 RELATIONSHIP R_E AT THE CONTACT OUTPUT AS A FUNCTION OF

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.

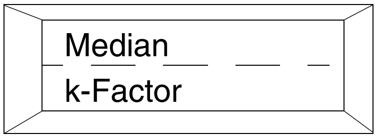
5.3.2 Additional Configuration Information

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 flowrate 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 Inch	DN	Typ. k-Factor max [1/m^3]	Liquid f_{max} at Q_{vmax} [Hz]	Gas f_{max} at Q_{vmax} [Hz]
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 Inch	DN	Typ. k-Factor max [1/m^3]	Liquid f_{max} at Q_{vmax} [Hz]	Gas f_{max} at Q_{vmax} [Hz]
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^3/s]
f = Frequency [1/s]
k = Calibration k-Factor [1/m^3]

5.3.2.3 Current Output

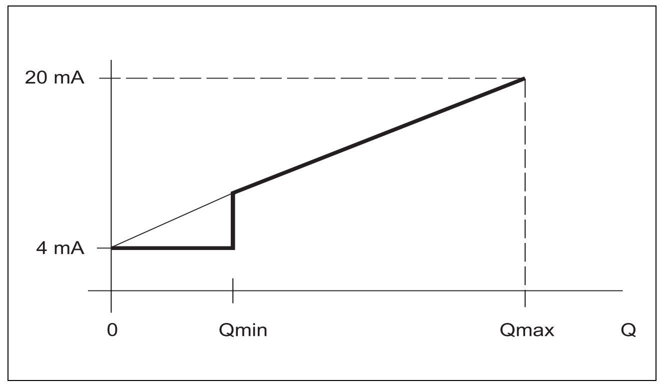


FIGURE 5-13 OUTPUT CURRENT CHARACTERISTICS

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 Q_{max} (operating mode). The current output for flowrates less than the low flow cutoff value Q_{min} 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

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

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

ERROR REGISTER

Error
. . . 3 . 5 6 . . .

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

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)

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

When Normal conditions are:

P = 1.013 bar (14.5 psi)
T = 0 ^{o}C (32 ^{o}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 [°C]
ρV = Density at operating conditions
ρN = 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
.

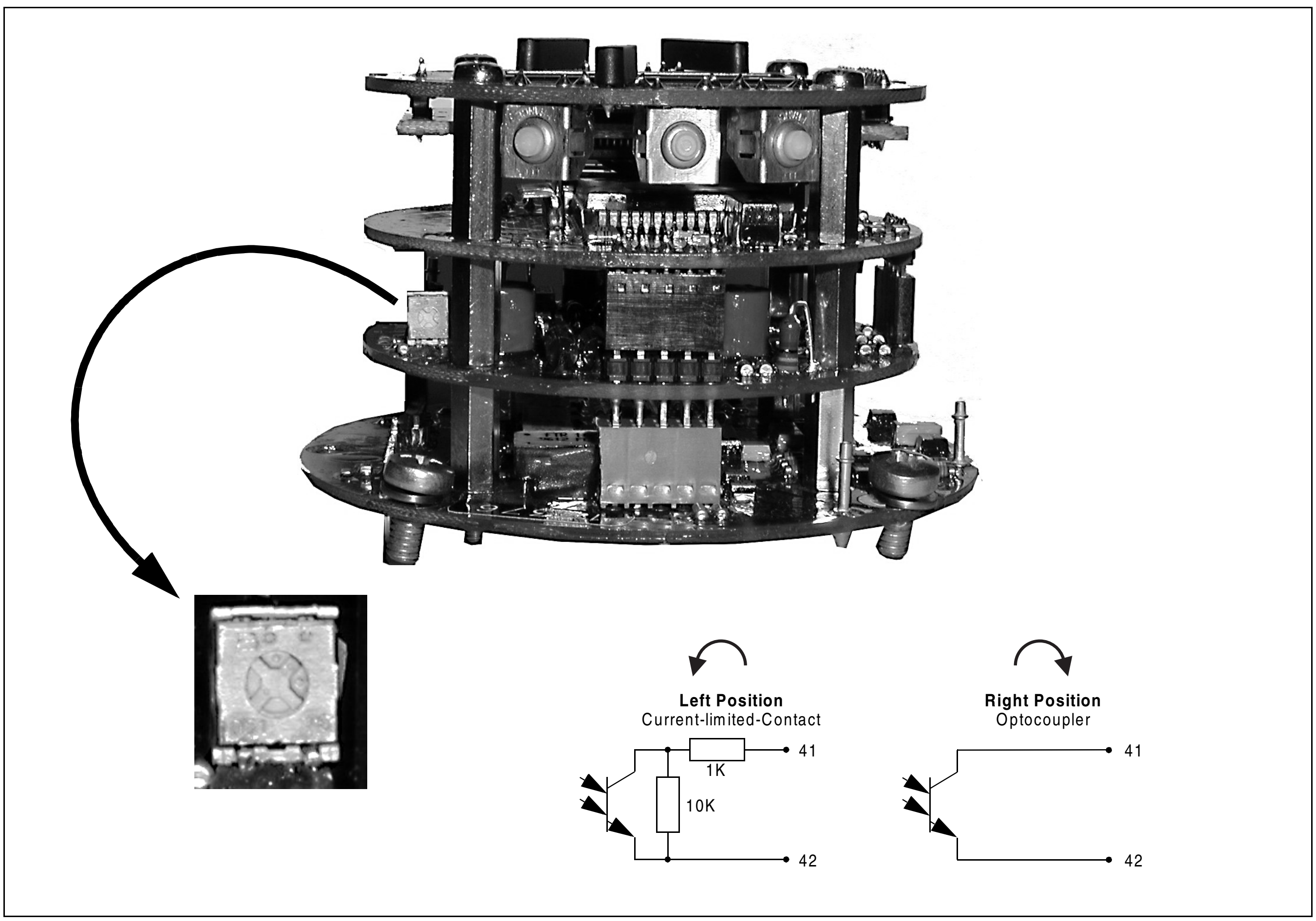


FIGURE 5-14 CONTACT OUTPUT CIRCUITS

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[1)]	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 ρ_{oper}	Units Density Operating density Units Qm
Liquid [2)] 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 ρ_0; Ref. temp. T_0 °C Operating temp. T_{oper} °C Density Expansion Coefficient ß2	Units density Operating density Operating temperature Units Qm (Temperature is measured)
Liquid [2)] 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] ß1 [3)] Ref. temp. T_0 °C Operating temp. T_{oper} °C Ref. density ρ_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 [2)] Qn (pT)	Gas	Normal flowrate 1.013 bar / 0°C 0 - 1.013 bar / 20°C	$Qn = Qv \cdot \frac{P_{noper}}{1,013 bar} \cdot \frac{273K + T_n}{273K + T_{oper}}$	Operating press. P_{oper} abs Operating temp. T_{oper} °C	Operating pressure Units Pressure (Temperature is measured)
Gas Std [2)] Qs (pT)	Gas	Standard flowrate 14. 7psia / 70°F 14. 7psia / 60°F	$Qs = Qv \cdot \frac{\ddot{P}_{soper}}{14.7} \cdot \frac{460 + T_s}{460 + T_{oper}}$	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[2)] Qm (pT)	Gas	Mass flowrate Standard conditions 14.7 psia @ 70 °F	$Qm = \rho_0 \cdot Q_s$ $Qs = Qv \cdot \frac{\ddot{P}_s}{14.7} \cdot \frac{460 + T_s}{460 + Toper}$	Operating press. P_{oper} abs Standard density ρ_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 ρ_{oper}	Units Density Operating density Units Qm
Sat. Steam[2)] 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 [acfhh
Qn = Normal flowrate [ncfh]
P_{oper} = Operating pressure (psia)
P_n = Operating normal pressure (bars absolute)
P_s = Operating standard pressure (psia)
ß1 = Volume Expansion Coefficient 3)
ß2 = Density Expansion Coefficient 3)
ρ_0 = Normal density (lbs/ft^3)

ρ_{oper} = Operating density (lbs/ft^3)
To = Reference temp., oC
Toper = Operating temp., oC
T_s = Standard temp. (60 or 70 ^{o}F)
T_n = Normal temp. (0 or 20 ^{o}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 **Locked** mode off	-	Qv % 10.5	Standard Display
1) Advance to programming level	STEP or DATA	Progr. Ebene	
2) Enter menu	ENTER	Gesperrt	
3) Make selection display „Programming Level"	ENTER	Gesperrt _	Mode is selectable when "underscore" is displayed
4) Advance to " Standard" Programming Level	STEP or DATA	Standard_	
4) Select " Standard" Programming Level	ENTER	Progr._ Ebene	
5) Menu item Find "Language"	STEP or DATA	Sprache	
6) Make selection display "Language"	ENTER	Deutsch_	
7) Menu item Find "English"	STEP or DATA	Englisch _	
8) Select "English"	ENTER	Language	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 **Locked** mode OFF	-	**Qv %** **10.5**	Standard Display
↓	↓	↓	
1) Advance to **Progr. Level**	STEP or DATA	**Progr. Level**	
↓	↓	↓	
2) Enter Menu	ENTER	**Locked**	
↓	↓	↓	
3) Display **Programming Level**	ENTER	**Locked_**	Mode is selectable when "underscore" is displayed
↓	↓	↓	
4) Select desired **Programming Level** for processing	STEP or DATA	**Standard_** **Speciali st_** **Service_**	
	↓	↓	
5) Return to Menu Level	ENTER	**Progr. Level**	**Locked** mode is now OFF

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

Action	⇒ Key	= Display Information	
Turn **Locked** mode ON	-	Qv % 10.5	Standard Display
↓	↓	↓	
1) Advance to **Progr. Level**	STEP or DATA	Progr. Level	
↓	↓	↓	
2) Enter Menu	ENTER	Standard	Display shows present programming level
↓	↓	↓	
3) Display **Programming Levels**	ENTER	Standard	Mode is selectable when "underscore" is displayed
↓	↓	↓	
4) Select Locked programming level	STEP or DATA	Locked_	
	↓	↓	
5) Return to Menu Level	ENTER	Progr. Level	**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:

■ Indicates the available menus for the given programming mode.

□ Indicates **Menu Items** that appear depending on other menu selections.

TABLE 5-1. TOP-LEVEL MENU STRUCTURE

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_{oper} ABS			■	■
□ Volume Extension			■	■
Unit Q_{vol}			■	■
□ Unit Q_m			■	■
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	↓↑ ENTER	Standard_	Standard	from table	**Standard**: This menu includes all the user specific menu parameters for operating the instrument;
					Speciali st	Specialist		**Specialist**: This menu includes the complete set of user specific menu parameters;
					Service_	Enter SRV-Code_ ENTER		**Service**: This menu includes additional parameters which can be accessed after entering the correct Service Code No. (only for ABB Service)
↓↑	Pg.Prot Code	2x ENTER	Old Code	↓↑ ENTER	0			
			New Code	↓↑ ENTER	9999			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.
↓↑	Language	Enter	English	↓↑ ENTER	English_	English/German	from table	Language for the display text
					German_			
↓↑	Primary	Enter	VORTEX VT / VR_					Display of the Flowmeter primary selection SWIRL = TRIO-WIRL S VORTEX = TRIO-WIRL V
↓↑	Meter size	Enter	A 80 mm 3in					Display of the flowmeter primary size A=ANSI D=DIN
↓↑	Median k-factor	Enter	52000.0 1/m3					Display of the calibration factor value; k-Factor
↓↑	Schedule Correct	Enter	Sched.80			Sched.40 Sched. 80		Parameter is only displayed for a flowmeter primary with ANSI process connections: Correction for the inside diameter differences between Sched. 40 and 80

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 kg/l_	↓↑ ENTER	0 kg/l_	0.001 - 0.100	from table	Menu displayed for selection: Gas Mass Qm (pT)
↓↑	Compress ibility	Enter	1.000	↓↑ ENTER	0	0.001 - 1000.000	numeric	Menu displayed for selection: Gas Stnd. Qs(CMP) Factor of compressibility = ρb : ρ0

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.

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 1.0133 bara 0 °C 14,7 psi abs 70F 14,7 psi abs 60F			Menu displayed for selection: Gas Mass Qm(pT) Gas Norm Qn (pT)
↓↑	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. Ex-tension	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/s, bbl/h, bbl/d		Selection of the volume flow-rate 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.

Key	Submenu/Parameter		Submenu/ Parameter Setting		Submenu/ Select Parameter	Selections	Entry Type	
↓↑	Totalizer	↓↑ ENTER	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 Totaliz	↓↑ ENTER	ft3 m3	m3, ft3, usgal, igal, igl, bbl, l, g, kg, t, lb	from table	Selection of the units for the totalizer as a function of the Operating Mode, Volume or Mass flowrate
			Totaliz reset	Enter	Reset -> Enter	Enter		Reset the totalizer and overflow counter
↓↑	Damping	Enter	50.0 s	↓↑ ENTER	0 s	0.5 - 100 s	numeric	Damping for the current output Response time 1 τ (=63 %) for a step change in the flowrate
↓↑	Hardware Config.	Enter	I/HART	↓↑ ENTER	I/HART		from table	Contact Output Configuration Current , HART-Protocol.
					I/HART/ Pulse_Bin			Current , HART-Protocol Contact output: pulse
					I/HART/ Q_Alarm			Current output, HART-Protocol, Contact output: Flowrate alarm closes at alarm
					I/HART/ T_Alarm			Current output, HART-Protocol, Contact output: Temperature alarm closes at alarm
					I/HART/ S-Alarm			Current output, HART-Protocol, Contact output: General alarm closes at alarm
		Note: Menus Min. and Max. Q_Alarm Only displayed for the I/HART/T_Alarm selection.						
↓↑	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
↓↑		**Note: Menus Min.and Max. T_Alarm Only displayed for the I/HART/T_Alarm selection.**					numeric	
↓↑	Min. T_Alarm	Enter	10 F	↓↑ ENTER	32 F	-60 °C to 410 °C	numeric	Min Alarm Temperature -60 °C = Off
	Max. T_Alarm	Enter	200.00 F	↓↑ ENTER	300.00 F	-60 °C to 410 °C	numeric	Max Alarm Temperature 410 °C = Off
↓↑	Iout at Alarm	Enter	22.4	↓↑ ENTER	0 mA	21-26 mA	numeric	Current output value during an alarm condition Programmable

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
	Note: The Pulse Width menu is only displayed for the I/HART/Pulse_Bin selection.					Selected units for output
↓↑	Pulse Width — Enter	10 ms ↓↑ ENTER	0 ms	1 - 256 ms	numeric	Max. 50 % on/off. A warning is displayed if exceeded.
↓↑	Display — Enter	Main Display ↓↑ ENTER	Q flow mode			
			Qv operate	Qv operate Normal, standard Qm Mass Percent Totalizer Temperature Frequency	from table	Selection for the Main Display
			Percent			
			Total-izer			
			Tempera-ture			
			Frequenc y			
	↓↑	Multipl. Display ↓↑ ENTER	Q flow mode		from table	Selections for the value to be displayed in the multiplex mode
			Qv Operate			
			Percent			
			Totalizer			
			Tempera-ture			
			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 2.3)
		Mains in terrupt — Enter	10			Counter for the number of times the power was turned off since start-up

Key	Submenu/Parameter		Submenu/ Parameter Setting		Submenu/ Select Parameter	Selections	Entry Type	Comments
↓↑ ENTER	Self check	↓↑ ENTER	Iout	Enter	0 %	0 to 115 %	numeric	Test current output manual control (100 % = 20 mA)
			Q Simu-lation		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-Com-mand				--	Test HART-Receiver
↓↑	Instr. Address						0-15	- for HART-Protocol 1-15 - 1-15 Multiplex operation
↓↑	Instru-ment No.							
↓↑	Order Number							Allows recording of the cus-tomer Order Number for future reference.
↓↑	50VT4 26/02/01	↓↑ ENTER	D699F004 U01 A.11					Display of the installed soft-ware level and its revision date Entry = display actual Number

Flow Symbol Legends for Liquid, Gas and Steam Calculations:

1) Liquid QV = Volume flowrate
2) Liquid Qm (D) = Mass flowrate
3) Liquid Qm (D,T) = Mass flowrate
4) Liquid Qm (V,T)= Mass flowrate
5) Gas Qv= Operating flowrate
6) Gas Normal Qn (pT)= Normal flowrate
7) Gas Stnd. Qs (pT) = Standard flowrate
8) Gas Stnd. Qs (CMP)= Standard flowrate
9) Gas Mass Qm (pt) = Mass flowrate
10) Gas Mass Qm (D)= Mass flowrate
11) Steam satu. Qm= Saturated steam mass flowrate
12) Steam satu. Qm= Saturated steam volume flow-rate

5.5.5 Submenu Error Register

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

Error
Register

5.5.5.1 Error Display

Error
...3.56..

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

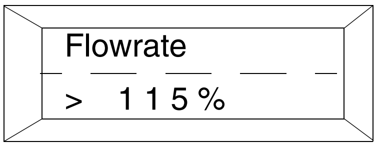
A table of error codes is shown in Table 5-2 below. For additional information, refer to Chapter 6..

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.

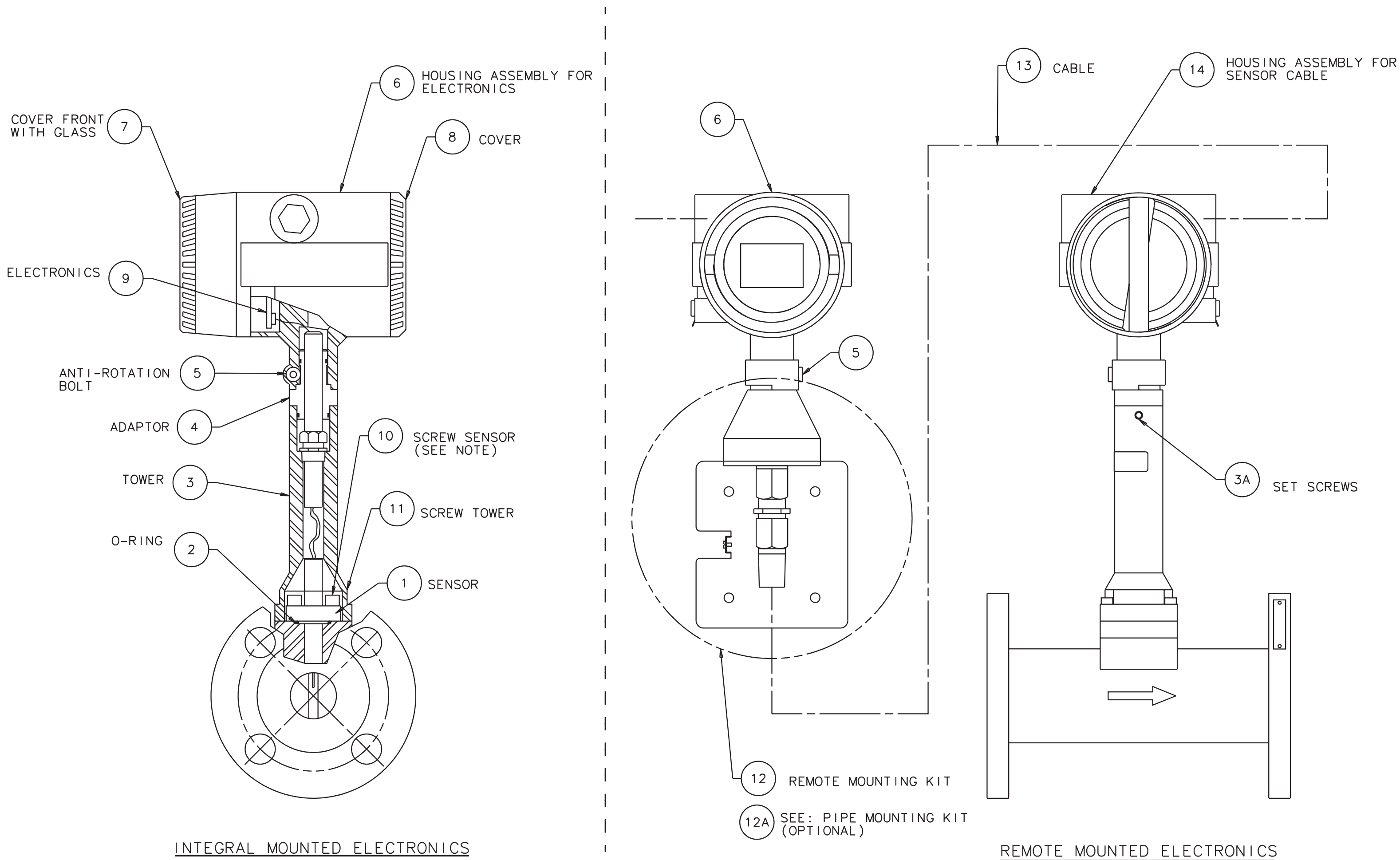
WARNING
ALL FLOWMETERS AND/OR SIGNAL CONVERTERS BEING RETURNED TO ABB INC. FOR REPAIR MUST BE FREE OF ANY HAZARDOUS MATERIALS (ACIDS, ALKALIS, SOLVENTS, ETC.). A MATERIAL SAFETY DATA SHEET (MSDS) FOR ALL PROCESS LIQUIDS MUST ACCOMPANY RETURNED EQUIPMENT.

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

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.



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

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

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
1	1	**SENSOR**	
		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
2	1	**SENSOR O-RING**	
		O-Ring, Kalrez	102E077U56
		O-Ring, Viton	101W709U01
		O-Ring, PTFE	101C709U01
3	1	**TOWER ASSEMBLY**	612A708U01
3A	1	**SET SCREWS**	
		Spare set-screws, Tower Assembly	D020J106AU20
4	1	**ADAPTER**	
		Adapter, Plain	D633A043U01
		Adapter, Bartek w/3-Wire Std. Sensor	D633A043U02
		Adapter, Bartek w/5-Wire Std. Sensor w/PT100	D633A043U03
5	1	Anti-Rotation Dress Bolt	D395A006U01
		M5 x 25 Screw, Hex Sock. Hd., DIN912	09H116AU20
6		**HOUSING ASSEMBLY**	
	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
7	1	**FRONT COVER WITH EX-PROOF GLASS & O-RING**	
		Cover	D612A162U02
		O-Ring	1951779A042

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

ITEM	QTY.	DESCRIPTION	PART NUMBER
8	1	**REAR COVER** Cover Tag O-Ring	 D612A167U02 338C686U01 1951779A042
9	1	**ELECTRONICS MODULE** Electronics 4-PCB Assembly With Display	 D674A659U01
10	4	**SCREWS & LOCKWASHER, SENSOR** 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	**SCREWS & LOCK WASHER, TOWER** M5 x 16 Screw, Hex Sock. Hd., DIN912 M5 Lockwasher	 09H112AU20 85C024EU20
12	1	**REMOTE-MOUNTING KIT W/CABLE** Remote Tower, X-Proof, 4-Wire Remote Tower, X-Proof, 8-Wire	 D612A163U09 D612A163U10
12A	1	Pipe Mounting Hardware (Optional)	612B091U07
13		**SPARE CABLE, 30 FT.** 4-Wire for Standard Sensors 8-Wire for Sensors w/PT100	 431C081U01 431C081U02
14	 1 1 2 1 3 3 1 1	**REMOTE MODEL ELECTRONICS HOUSING ASSEMBLY** Body, Used for Sensor & Cable Connection on Primary Cable Connection Board Ground Connection Plates M4 x 10mm Cheese Hd Screw, DIN84 M4 x 8 Phillips, Phillister Hd Screw M4 Split Lockwasher, DIN127 1/2 Hex Socket, Pipi-Plug, 316 SS 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

TABLE 7-3. CENTERING DEVICES, VORTEX WAFER

DESCRIPTION	SIZE [in.]	ANSI FLANGE RATING [lb]	PART NUMBER
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	SIZE	ANSI FLANGE RATING [lb]	PART NUMBER
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

<table>
<tr><th colspan="2">METER SIZE</th><th rowspan="2">ANSI FLANGE RATING (POUNDS)</th><th rowspan="2">MAX. PRESSURE * @ $T_{Proc} \leq 68^{o}F$ ($20^{o}C$) (PSI)</th><th rowspan="2">QTY.</th><th colspan="2">PART NUMBER.</th></tr>
<tr><th>INCHES</th><th>MM</th><th>VORTEX</th><th>SWIRL</th></tr>
<tr><td>1/2</td><td>15</td><td>150
300</td><td>276
725</td><td rowspan="13">2</td><td colspan="2">333J089U01
333J089U02</td></tr>
<tr><td>1</td><td>25</td><td>150
300</td><td>276
725</td><td colspan="2">333J089U10
333J089U11</td></tr>
<tr><td>1-1/4</td><td>32</td><td>150
300</td><td>276
725</td><td>N/A</td><td>333J089U68
333J089U69</td></tr>
<tr><td>1-1/2</td><td>40</td><td>150
300</td><td>276
725</td><td colspan="2">333J089U15
333J089U16</td></tr>
<tr><td>2</td><td>50</td><td>150
300/600</td><td>276
725/1436</td><td colspan="2">333J089U19
333J089U25</td></tr>
<tr><td>3</td><td>80</td><td>150
300/600</td><td>276
725/1436</td><td colspan="2">333J089U22
333J089U26</td></tr>
<tr><td rowspan="2">4</td><td rowspan="2">100</td><td>150
300</td><td>276
725</td><td colspan="2">333J089U29
333J089U30</td></tr>
<tr><td>600</td><td>1436</td><td>N/A</td><td>333J083U28</td></tr>
<tr><td>6</td><td>150</td><td>150
300
600</td><td>276
725
1436</td><td colspan="2">333J083U33
333J083U42
333J083U43</td></tr>
<tr><td>8</td><td>200</td><td>150
300
600</td><td>276
725
1436</td><td colspan="2">333J083U38
333J083U46
333J083U47</td></tr>
<tr><td>10</td><td>250</td><td>150
300</td><td>276
725</td><td>333J083U54
333J083U55</td><td>N/A</td></tr>
<tr><td>12</td><td>300</td><td>150
300</td><td>276
725</td><td colspan="2">333J083U56
333J083U57</td></tr>
<tr><td>16</td><td>400</td><td>150
300</td><td>276
725</td><td>N/A</td><td>333J083U58
333J083U59</td></tr>
</table>

* 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: $750^{o}F$

Gases & Steam:

Operating Temperature Limit: $450^{o}F$

Notes:

- Different O-Ring materials may be required for high process temperature applications
- Temperature limits are valid at internal pressures of $\leq$ 400 psi
- The use of **KLINGERexpert** software system is recommended for these extreme temperature applications.

PN24993

The Company's policy is one of continuous product improvement and the right is reserved to modify the information contained herein without notice.

Printed in USA

ABB Inc.
Instrumentation Division
125 East County Line Road
Warminster, PA 18974 USA
Tel. 215-674-6000
FAX: 215-674-7183

ABB Instrumentation Ltd
Howard Road, St. Neots
Cambs. England, PE19 3EU
Tel. +44 (0) 1480-475-321
FAX: +44 (0) 1480-217-948

ABB Instrumentation S.p.A
Via Sempione 243
20016 Pero (Milano) Italy
Tel: +39 (02) 33928 1
Fax: +39 (02) 33928 240

ABB Automation Products GmbH
Industriestr. 28
D-65760 Eschborn Germany
Tel: +49 (0) 6196 800 0
Fax: +49 (0) 6196 800 1849