Instruction

MI 021-137
March 2009

2800 Series
Flanged Magnetic Flowtubes
ptfe, Polyurethane, and Neoprene Lined,
14- through 36-inch Sizes

Flowtube Installation
Style C

MODEL 2814 WITH ptfe LINING SHOWN

FOXBORO

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1. Introduction

General Description

The 2800 Series Magnetic Flowtubes have been designed to operate in harsh in-plant or outdoor environments and are suitable for installation in most hazardous area locations. A selection of High Humidity/Condensate, General Purpose NEMA 4X, and Accidental Submergence Housings are offered.

The stainless steel flowtube is lined with a choice of ptfe, polyurethane, or neoprene lining. Together with the choice of lining materials, a selection of electrode metals and electrode shapes enables these flowtubes to handle a wide variety of liquids such as water, slurries, and sticky, abrasive, and highly corrosive processes. The flowtube is PED qualified in EU applications for SEP (Standard Engineering Practice) Category 1 with Group 2 fluids (nonhazardous).

All flowtubes are wet calibrated to generate a calibration factor with accuracy traceable to the U.S. National Institute of Science and Technology (NIST).

The 2800 series flowtubes can be calibrated for use with different transmitter types. The Model Code of the flowtube controls which types of calibrations are provided. Refer to PL 008-544 for model code description. The transmitter types are:

- IMT96 — which uses an exponential current pulse to excite the flowtube magnetic field coils.
- E96 — where the flowtube coils are powered directly from the power line.

The calibration provides a “calibration factor” which is measurement of the electronic output from the tube generated by a flow through the tube. The factors are needed to configure (adjust) the transmitter to cover the desired flow range, such as 4 mA for zero flow and 20 mA for 100 gpm.

This instruction relates to the installation of the flowtube portion of the magnetic flowmeter system. For installation, wiring, operation, configuration, and maintenance details relating to the transmitter, refer to the applicable transmitter documents.

Reference Documents

Table 1. Reference Documents

Document	Description
DP 021-137	Dimensional Print - 2800 Series Flanged Flowtubes, 14 to 36 in Sizes
MI 021-138	Magnetic Flow System Fault Location Guide (2800 Flowtube/E96 Transmitter)
MI 021-145	Type Y Purging for Class I, Groups A, B, C, and D, Division 1 Hazardous Locations
MI 021-333	E96P and E96S Magnetic Flow Transmitters, Installation and Operation
MI 021-334	E96R Magnetic Flow Transmitters, Installation and Operation
MI 021-335	E96T Magnetic Flow Transmitters, Installation and Operation
MI 021-402	IMT96 Magnetic Flow Transmitters - Installation
MI 021-404	IMT96 Magnetic Flow Transmitters - System Maintenance
MI 021-412	Retrofitting 2800 Flowtubes for use with IMT96 instead of E96 Transmitters.
PL 008-544	Parts List - 2800 Series Flanged Flowtubes, 14 to 36 in Sizes
TI 27-71f	Magnetic Flowtube Materials Selection Guide
TI 027-072	Magnetic Flowmeter Liquid Conductivity Tables

Principle of Operation

The principle of operation of the magnetic flow meter produces a flow signal proportional to the volume flow rate through the tube. The mass flow rate can be inferred if the flowing density of the fluid is known.

The principle of operation of magnetic flow tubes is based on Faraday's law of electromagnetic induction: the voltage Vo induced in a conductor of length De moving through a magnetic field T is proportional to the velocity of the conductor.

$$V_O = D_E v T$$

In this application of Faraday's law, the process fluid is the conductor. The process fluid passes through the magnetic field created by the coils above and below the center section of the metering tube and a voltage is generated across the tube proportional to the average flowing velocity. The liner is necessary to make the I.D. of the tube non-conductive so that the flow signal voltage is not shorted out by the pipe wall. The flow tube has two metallic electrodes that extend through the liner and contact the fluid to detect the generated voltage.

Standard Specifications

Ambient Temperature

Normal Operating Condition Limits: -10 and +50°C (20 and 120°F)
Operative Limits: -30 and +60°C (-20 and +140°F)

— NOTE

If an E96T Transmitter is integrally mounted to the flowtube, the maximum ambient temperature is 38°C (100°F).

Electrodes

Hastelloy C, tantalum-tungsten, 316L ss, platinum-10% iridium, or titanium flat head electrodes. 316L ss and Hastelloy C electrodes are also offered in conical shaped configurations. Refer to TI 27-71f for a process-wetted materials selection guide.

Metering Tube

AISI Type 304 stainless steel.

Process Fluid Conductivity

The minimum process fluid conductivity required is 2 μS/cm.

Maximum Cable Length

With the IMT96 Transmitter

The maximum allowable cable length between the flowtube and transmitter is a function of the cable type, process fluid conductivity, and whether the cables are in the same or separate conduits. for cable lengths greater than 150 m (500 feet) and conductivities less than 20 μS/cm, the system accuracy is affected.

Table 2. Process Fluid Conductivity and Cabling

Fluid Conductivity	Cable Length	Signal and Coil Drive Cables
>20 μS/cm	<150 m (500 ft)	Signal and coil drive cables can be in the same conduit. The signal cable can be either Foxboro cable[a] or good quality 14 to 18 AWG twisted shielded pair[b] cable. The coil wiring should be 14 AWG twisted shielded pair.[c,d]
	150 to 300 m (500 to 1000 ft)	Signal and coil drive cables can be in the same conduit. The signal cable can be either Foxboro cable[a] or good quality 14 to 18 AWG twisted shielded pair[b] cable. For these cable lengths, there is an additional error per every 30 m (100 ft) in excess of 150 m (500 ft): 0.2% when using Foxboro cable[a]. 0.4% when using 14 to 18 AWG twisted shielded pair[b]. The coil cable must be good quality 14 AWG twisted shielded pair[c].

Table 2. Process Fluid Conductivity and Cabling

Fluid Conductivity	Cable Length	Signal and Coil Drive Cables
2 to 20 µS/cm	<150 m (500 ft)	Signal and coil drive cables should be in separate conduits. For fluid conductivity in this range, Foxboro signal cable[a] must be used. For these conductivities there is an additional error in percent equal to 4 divided by the conductivity in µS/cm; for example, for a conductivity of 12 µS/cm the additional error would be 0.3%. The coil wiring should be 14 AWG twisted shielded pair.[c,d]
	150to 300 m (500 to 1000 ft)	Signal and coil drive cables must be in separate conduits. For fluid conductivity in this range, Foxboro signal cable[a] must be used. For these conductivities there is an additional error in percent equal to 4 divided by the conductivity in µS/cm; for example, for a conductivity of 12 µS/cm the additional error would be 0.3%. For these cable lengths, there is also an additional 0.2% error per every 30 m (100 ft) in excess of 150 m (500 ft). The coil cable must be 14 AWG twisted shielded pair[c].

(a) Foxboro Part No. R0101ZS (feet) or B40‘7TE or B4017TE (meters).
(b) Such as Belden 8760 or 9318, Alpha 5610/1801, 5611/1801.
(c) Such as Belden 8720 series or Alpha 5616 series.
(d) 14 AWG 2-core (2-conductor) cable or two separate 14 AWG wires can also be used.
16 AWG can be used for cables shorter than 90 m (300 ft).
18 AWG can be used for cables shorter than 45 m (150 ft).

With the E96 Transmitter

The maximum allowable cable length is a function of the process fluid conductivity and flowtube size. Use the graph in Figure 1 to determine the maximum length of cable.

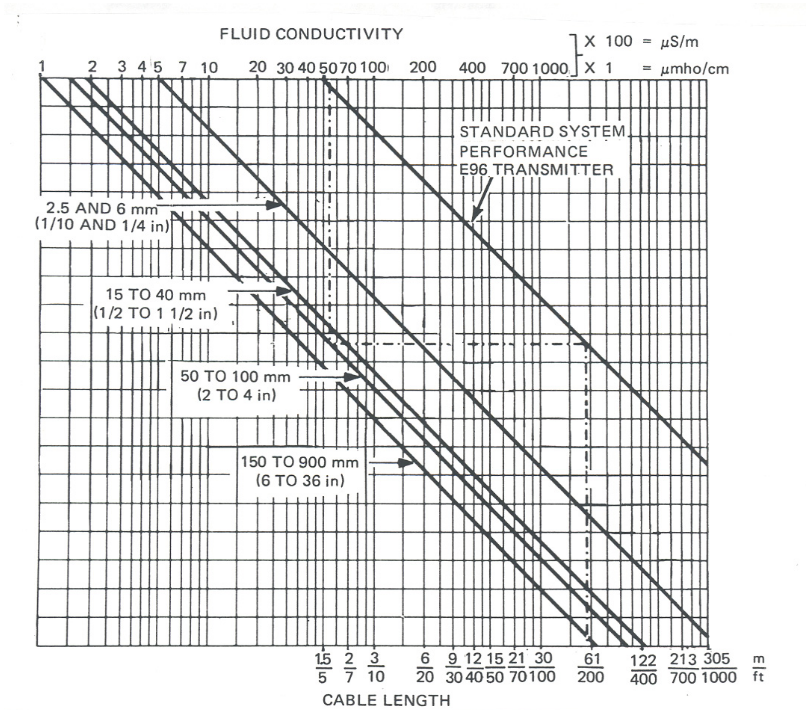

Figure 1. Maximum Signal Cable Length

— NOTE

This graph is only valid for Foxboro cable R0101ZS connecting a 2800 Series flowtube to an E96 Transmitter. An example of how to use this graph follows:

To determine the maximum cable length for a 2802 (2 inch) flowtube when the process fluid conductivity is 55 µS/cm.

1. Draw a vertical line at the fluid conductivity of 55 µS/cm to the 50 to 100 mm (2 to 4 in) flowtube reference line.
2. From this intersection, draw a horizontal line to the E96 Transmitter standard system performance line.
3. From this intersection, draw a vertical line to the cable length scale where approximately 190 feet is read as the maximum cable length.

Minimum and Maximum Upper Range Values (URV) and Nominal Calibration Factors

Minimum and maximum upper range value (URV) flow rates and nominal calibration factors are shown in Table 3 and Table 4 for the different flowtube sizes, transmitter models, and linings.

Table 3. Flowtube Selection for Use with IMT96 Transmitters (14 to 36 inch) Based on Measurement Range and Liner Material

Flowtube Size		Power from IMT96		Nominal Cal Fact	Flow Measurement Range Limits			
					Minimum		Maximum(a,b)	
mm	in	See IMT96 MI 021-402 for wire type & gauge	Liner	Calibration Factor in µV/A/gpm	L/min 0 to:	U.S. gpm 0 to:	L/min 0 to:	U.S. gpm 0 to:
350	14	70 VA Maximum	ALL	0.319	2750	725	54500	14400
400	16			0.190	3600	950	72000	19000
450	18			0.143	4550	1200	91000	24000
500	20			0.094	5680	1500	114000	30000
600	24			0.051	8150	2150	162000	43000
750	30		polyurethane and neoprene	0.021	12900	3400	258000	68000
900	36			0.012	19000	5000	374000	99000

(a) Maximum flow rate is based on nonabrasive fluids. Lower maximum flow rates are recommended for abrasive fluids.

(b) "Maximum flow rate is based on a velocity of 10 m/s (33 ft/s).

Table 4. Flowtube Selection for Use with E96 Transmitters (14 to 36 inch) Based on Measurement Range and Liner Material

Flowtube Line Size		AC Power to Flowtube								Nominal Cal Fact	Flow Measurement Range Limits			
		Available Voltage & Frequency Combinations									Minimum		Maximum(a,b)	
mm	in	120 V 60 Hz	240 V 60 Hz	120 V 50 Hz	220 V 50 Hz	240 V 50 Hz	Watts	VA	Liner	Calibration Factor in mV/gpm	L/min 0 to:	U.S.gpm 0 to:	L/min 0 to:	U.S.gpm 0 to:
350	14	P(c)	S(d)				120	720	ALL	0.00064	6050	1600	54500	14400
			P				550	2880		0.00128	3025	800		
				P	S	S	150	900		0.00077	4900	1300		
					P		550	2880		0.00154	3025	800		
400	16	P	S				150	840	ALL	0.00051	7550	2000	72000	19000
			P				675	3360		0.00102	3875	1000		
				P	S	S	180	1050		0.00061	6450	1700		
					P		675	3360		0.00122	3875	1000		
450	18	P	S				180	960	ALL	0.00035	11000	2900	91000	24000
			P				805	3840		0.00070	5500	1450		
				P	S	S	220	1200		0.00042	9100	2400		
					P		805	3840		0.00084	5500	1450		
500	20	P	S				215	1080	ALL	0.00031	12500	3300	114000	30000
			P				960	4320		0.00062	6250	1650		
				P	S	S	260	1300		0.00037	10200	2700		
					P		960	4320		0.00074	6250	1650		
600	24	P	S				265	1260	ALL	0.00019	20800	5500	162000	43000
			P				1150	5040		0.00038	10400	2750		
				P	S	S	320	1550		0.00023	16650	4400		
					P		1150	5040		0.00046	10400	2750		
750	30	P	S				330	1650	-A(e) -N	0.00013	29000	7700	258000	68000
			P				1465	6240		0.00026	14500	3850		
				P	S	S	400	1900		0.00015	25350	6700		
					P		1465	6240		0.00030	14500	3850		

Table 4. Flowtube Selection for Use with E96 Transmitters (14 to 36 inch) Based on Measurement Range and Liner Material (Continued)

Flowtube Line Size		AC Power to Flowtube								Nominal Cal Fact	Flow Measurement Range Limits			
		Available Voltage & Frequency Combinations									Minimum		Maximum[a,b]	
mm	in	120 V 60 Hz	240 V 60 Hz	120 V 50 Hz	220 V 50 Hz	240 V 50 Hz	Watts	VA	Liner	Calibration Factor in mV/gpm	L/min 0 to:	U.S.gpm 0 to:	L/min 0 to:	U.S.gpm 0 to:
900	36	P	S				420	1800	-A[e] -N	0.00009	45400	12000	374000	99000
			P				1680	7200		0.00017	22700	6000		
				P	S	S	500	2200		0.00010	37850	10000		
					P		1680	7200		0.00020	22700	6000		

(a) Maximum flow rate is based on nonabrasive fluids. Lower maximum flow rates are recommended for abrasive fluids.

(b) Maximum flow rate is based on a velocity of 10 m/s (33 ft/s).

(c) “P” means that the flowtube coils are connected in parallel.

(d) “S” means that the flowtube coils are connected in series (coil connections are field changeable).

(e) “-A” means polyurethane liner; “-N” means neoprene liner.

Process Liquid Reference Signal

Continuity between the flowing liquid and the metal metering tube is required to provide a reference for the measurement signal.

If Connecting Piping Is Unlined Metal

The reference signal is obtained from the connecting piping through the flange bolts and ground straps.

If Connecting Piping Is Lined Metal or Nonmetallic

Grounding rings at each end of the flowtube are needed to contact the fluid and obtain the reference signal. Grounding rings (i.e., orifice plates) are available from Invensys Process Systems, if needed. Refer to Figure 11.

Enclosure Construction

The housing is cast from low-copper aluminum alloy, and silicone rubber sealant is used in all joints. Several flowtube housing selections are offered.

- General Purpose (Code -G and -T): The overall construction is designed to meet the requirements of IEC IP65 and provides the watertight and corrosion resistant protection of NEMA Type 4X.
- High Humidity/Condensate (Code -C): Includes special techniques to help prevent internal condensation of condensate in applications involving cold process temperature and warm ambient.
- Accidental Submergence (Code -H): Enclosure is sealed for accidental operation under water up to 9 m (30 ft) deep for 48 hours. This selection is supplied with a kit for sealing the power and signal connections during installation.

Enclosure Finish

Polyurethane paint.

Electrical Connections

The housing has three 3/4 NPT tapped holes; two for power conduit fittings and one for a signal cable seal.

Mounting Position

The flowtube can be mounted in any orientation, provided that during normal flow it remains full of process liquid and the electrodes are in the horizontal plane. To select a good location for the flowtube, review “Flowtube Location and Mounting Position” on page 15.

End Connections

ANSI Class 150, AWWA Class D; Metric PN 6 and PN 10 flanges as specified.

Approximate Mass

Table 5. Approximate Mass

Flowtube Size		Approximate Flowtube Mass	
mm	in	kg	lb
350	14	170	375
400	16	195	425
450	18	215	475
500	20	285	625
600	24	410	900
750	30	545	1200
900	36	660	1450

Process Pressure and Temperature Limits

See Table 6, Table 7, and Table 8.

Table 6. Process Pressure and Temperature Limits - ptfe-Lined Flowtubes - 2814 - 2824 Sizes Only

Flange Rating	Flowtube Model (Line Size)	Process Pressure Limits		Process Temperature Limits	
		Lower Limit	Upper Limit	Lower Limit	Upper Limit
ANSI Class 150	2814 and 2816	Zero (No Vacuum)	1.38 MPa (200 psig)	-18°C (0°F)	82°C (180°F)
	2818 to 2824	Zero (No Vacuum)	1.03 MPa (150 psig)		
Metric PN 6	2814 to 2824	Zero (No Vacuum)	0.60 MPa (87 psig)		
Metric PN 10	2814 to 2824	Zero (No Vacuum)	1.00 MPa (145 psig)		

Table 7. Process Pressure and Temperature Limits - Polyurethane-Lined Flowtubes

Flange Rating	Flowtube Line Size	Process Pressure Limits		Process Temperature Limits	
		Lower Limit	Upper Limit	Lower Limit	Upper Limit
ANSI Class 150	2814 and 2816	Full Vacuum	1.38 MPa (200 psig)	-18°C (0°F)	71°C (160°F)
	2816 to 2824	Full Vacuum	1.03 MPa (150 psig)		
Metric PN 10	2814 to 2824	Full Vacuum	1.00 MPa (114 psig)		
	2830	Full Vacuum	0.69 MPa (100 psig)		
	2836	Full Vacuum	0.62 MPa (90 psig)		
Metric PN 6	2814 to 2824	Full Vacuum	0.60 MPa (87 psig)		
AWWA Class D	2830	Full Vacuum	0.69 MPa (100 psig)		
	2836	Full Vacuum	0.62 MPa (90 psig)		

Table 8. Process Pressure and Temperature Limits - Neoprene-Lined Flowtubes

Flange Rating	Flowtube Model (Line Size)	Process Pressure Limits		Process Temperature Limits	
		Lower Limit	Upper Limit	Lower Limit	Upper Limit
ANSI Class 150	2814 and 2816	Full Vacuum	1.38 MPa (200 psig)	-18°C (0°F)	82°C (180°F)
	2818 to 2824	Full Vacuum	1.03 MPa (150 psig)		
AWWA Class D	2830	Full Vacuum	0.69 MPa (100 psig)		
	2836	Full Vacuum	0.62 MPa (90 psig)		
Metric PN 6	2814 to 2836	Full Vacuum	0.60 MPa (87 psig)		
Metric PN 10	2814 to 2824	Full Vacuum	1.00 MPa (145 psig)		
	2830	Full Vacuum	0.69 MPa (100 psig)		
	2836	Full Vacuum	0.62 MPa (90 psig)		

Product Safety Specifications

— NOTE

The flowtube has been designed to meet the electrical safety descriptions listed in Table 9. For detailed information or status of testing laboratory approvals or certifications, contact Invensys Process Systems.

Table 9. Electrical Classifications

Testing Laboratory, Types of Protection, and Area Classification	Conditions of Certification	Electrical Safety Design Code
CSA certified for use in Class I, Groups A, B, C, and D, Division 2 hazardous locations.	Models 2814 through 2824, Temperature Class T3.	CS-E/CN-A
FM approved for use in Ordinary Locations and Class I, Groups A, B, C, and D, Division 2 hazardous locations.	Models 2814 through 2824. Temperature Class T3.	CS-E/FN-A

Flowtube Identification

The flowtube can be identified by a data plate located on the housing surface of the flowtube. A typical data plate is shown in Figure 2. For an interpretation of the Model Code, refer to PL 008-544. Refer to the applicable transmitter instruction for information regarding transmitter data plates.

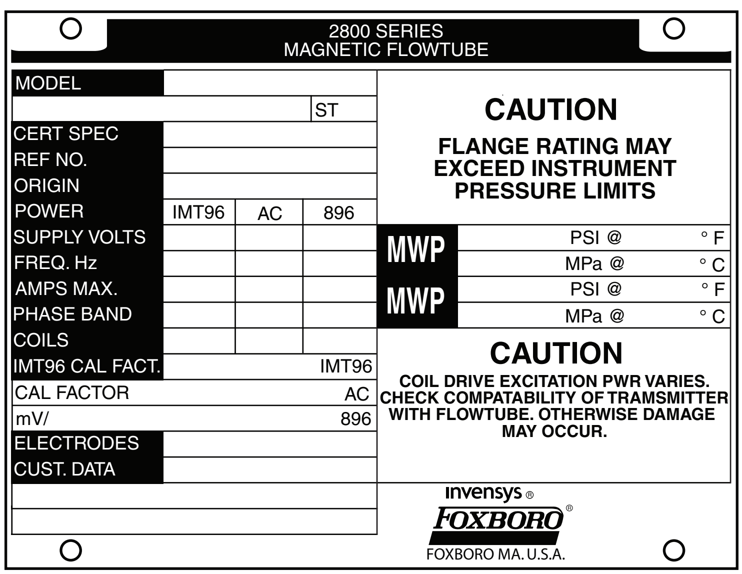

Figure 2. Sample Flowtube Data Plate

2. Installation

Unpacking and Handling Considerations

The 2800 Magnetic Flowtube is built to be durable, but it is also part of a calibrated precision system and should be handled as such. Avoid dropping or otherwise subjecting it to impact, particularly at the flange faces.

The flowtube is shipped from the factory in a sturdy carton and cradled between flange covers for protection. Before removing it from the carton, move it as close as possible to its installation point. If the flowtube must be removed for receiving inspection, **reinstall the end covers after inspection**. This is particularly true with ptfe-lined flowtubes.

Lift flowtube out of carton with rope falls, chain hoist, and so forth, as shown in the "Flowtube Handling" sections that follow. In some instances it may be more convenient to insert bolts into the flange bolt holes and use hooks around the bolts for lifting (rather than tying slings around the flowtube).

⚠ CAUTION

Never put anything through the flowtube to lift it, since this causes damage to the lining.

After removing flowtube from its shipping carton, inspect it for visible damage. If any damage is observed, notify the carrier immediately and request an inspection report. Obtain a signed copy of the report from the carrier.

Avoid touching electrodes with fingers or materials that can contaminate electrodes. Deposit on electrodes will result in high impedance boundary between electrodes and conductive fluid. In case the electrodes have been touched, clean them with isopropyl alcohol just prior to installing the flowtube.

General Precautions

1. Leave end covers installed over flanges any time flowtube is put in storage. Do **not** cut or remove flowtube lining.

NOTE

In ptfe-lined flowtubes, the white material extending over the flanges is the ptfe lining, **not** packaging material. Do **not** attempt to remove or cut the flowtube lining.

2. Check that cable length between flowtube and transmitter is within limit for specified system accuracy.
3. Good piping practice should be used for the installation of all magnetic flowtubes. Gaskets are recommended. Select a gasket material which is compatible with the process liquid.
4. The flowtube lining extends outward and over the raised face of the flange.

⚠ CAUTION

To avoid damage to the lining extension, do not exceed torque values specified when tightening flange bolts.

5. The flowtube lining (especially polyurethane) is susceptible to damage from excessive heat. Avoid such heat sources (such as welding adjacent piping).

⚠ CAUTION

To avoid possible loss of accuracy with a flowtube, it is recommended that the flowtube be connected in a straight section of pipe at least five pipe diameters upstream from the center line of the flowtube and three pipe diameters downstream. The center line of the flowtube is the same location as the electrode location.

To avoid excessive lining wear (especially with ptfe), it is recommended that five pipe diameters of straight section of pipe be connected from the flowtube flange end. If this recommendation cannot be met, it is suggested that a protective device (i.e., grounding ring) be installed on the upstream end of the flowtube.

6. For flowtubes with polyurethane lining and ac coils, the temperature of the lining can rise above the upper temperature limit if flow is stopped for a period of time and power is left on.

⚠ CAUTION

To avoid possible damage to the polyurethane lining from excessively high temperatures, disconnect (turn off) ac power from the coils whenever flow is stopped for more than about one hour. Note that when a flowtube is **not** filled with liquid, the lining heats faster that when the flowtube is filled with liquid.

Lifting Flowtube for Mounting

Care should be taken in lifting the flowtube into the pipeline position required for horizontal or vertical mounting. To prevent damage to the flowtube lining, housing, or the tube's structural integrity, it is important to reiterate flowtube handling precautions.

1. Never put anything through the flowtube to lift it.
2. Do not use the housing to support or lift the flowtube. Figure 3 and Figure 4 show correct and incorrect methods for lifting the flowtubes. Note that in Figure 3 (horizontal lifting), the suggested approach is to place the lifting rope between the flange and flowtube body. For vertical lifting, shown in Figure 4, the use of eye bolts

in the flange to which the lifting rope is attached is the preferred method. This ensures that the lifting force is applied to the eye bolts as nearly straight upward as possible.

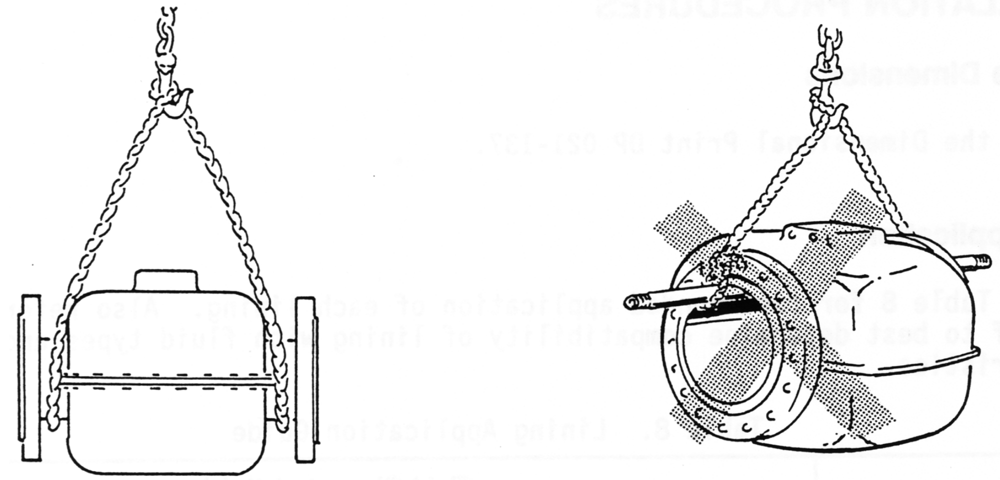

Figure 3. Lifting Flanged Flowtube for Horizontal Mounting

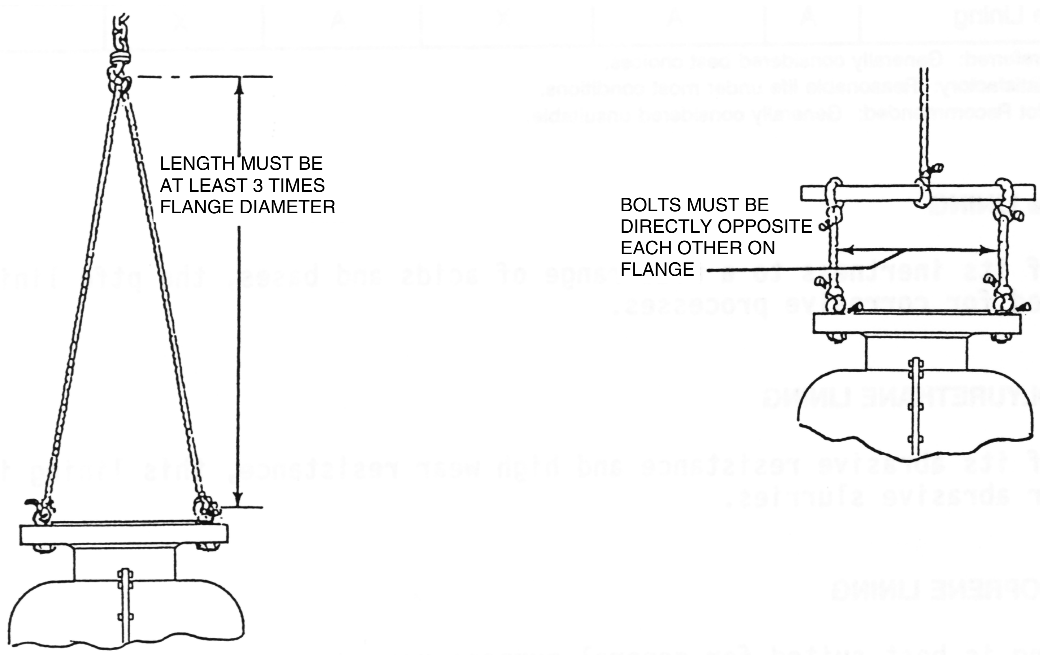

Figure 4. Lifting Flanged Flowtube for Vertical Mounting

Flowtube Sizing

The flowtube operates over a flow velocity range of 0 to 33 ft/s (0 to 10 m/s). Proper flowtube sizing is essential to ensure premium performance and longevity. Refer to Table 10 as a guide to sizing of magnetic flowtubes.

Table 10. Normal Recommended Flow Velocities

Process Liquid	Velocities Corresponding to Normal Flow Should be Between
General Liquids	3 ft/s and 15 ft/s 0.91 m/s and 4.6 m/s
Erosive Slurries	3 ft/s and 6 ft/s 0.91 m/s and 1.8 m/s
Liquids that can Coat Inside Surface of Flowtube	6 ft/s and 15 ft/s 1.8 m/s and 4.6 m/s

If the flow velocity in the pipeline is low, reducers can be used to install a smaller flowtube. Concentric reducers with a taper angle of eight degrees (8°) or less per side are preferred (eccentric reducers with a maximum taper angle of 8° can also be used), and can be connected directly to the flowtube. Refer to Figure 5 for a typical reducer installation. The unrecovered pressure loss caused by using reducers to increase the velocity in the tube to 5 to 10 ft/s (1.5 to 3 m/s) is small, typically less than 1 psi (<27.7 inH_2O, <51.7 mmHg). Equations to calculate the pressure loss can be found in “Fluid Flow through Valves, Fittings, and Pipes,” Technical Paper 410, by the Crane Co.

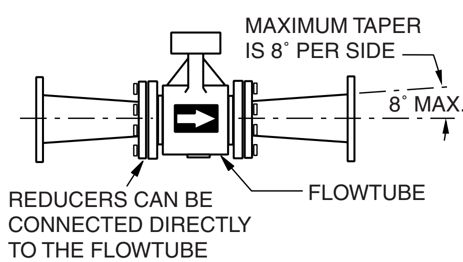

Figure 5. Pipeline Installation Showing a Concentric Reducer and Expander

If normal flow is above the recommended maximum flow velocity, the flowtube liner wear rates become a concern. Generally, expanding a section of the pipeline to install a larger tube is not a good solution, as it creates potential air problems. If you have a high process velocity, consider the following recommendations:

- Use polyurethane liners
- Install the flowtube where there is a long, straight, upstream piping run
- Install a liner protection ring at the upstream end of the flowtube.

Operating the flowmeter outside the recommended normal flow velocity limits may result in performance degradation, maintenance problems, and/or shortened life expectancy. Invensys Process Systems therefore provides its FlowExpertPro™ Sizing Software to facilitate and simplify the flowmeter sizing procedure for any application.

Installation Procedures

Flowtube Dimensions

Refer to DP 021-137.

Flowtube Location and Mounting Position

- The magnetic flowtube must be installed so that it remains full of liquid during operation. An example of good orientation of the flowtube is in a vertical pipeline with flow in an upward direction, as shown in Figure 6.
- The flowtube should have straight, unobstructed piping for a distance of five pipe diameters (5 PDs) upstream and 3 PDs downstream (measured from the center of the flowtube) to ensure optimum performance (see Figure 6). Adjacent process piping should have the same diameter or be slightly larger than the flowtube.
- When installed in a horizontal pipe, the flowtube should be oriented so that the electrodes are not located near the top or bottom of the pipe (see Figure 7). Adjacent piping may be elevated so as to maintain a full flowtube.
- Tube orientation should not trap entrained air, nor cause a build-up of undissolved solids within the flowtube.
- Check valves may be installed to ensure a full flowtube and prevent drainage under static flow conditions.
- Flowmeter performance can be affected if liquids are blended together upstream and are too near the flowtube. There must be enough piping upstream of the meter, between the blending point and the flowtube, to allow for a complete mixing of the liquid streams. This is one of the few cases where you may need to install more than 5 PDs of straight pipe upstream of the flowtube. An in-line static mixer can be installed upstream of the flowtube to insure proper mixing in very tight piping situations.
- Figure 6 also shows a flow direction arrow. However, the tube can be installed in the reverse direction if this orientation provides better wiring access to the connection box (tube performance is the same in both directions). If you do install the tube in the reverse direction, then configure the transmitter flow direction parameter for reverse flow, or reverse the polarity of the electrode wires.

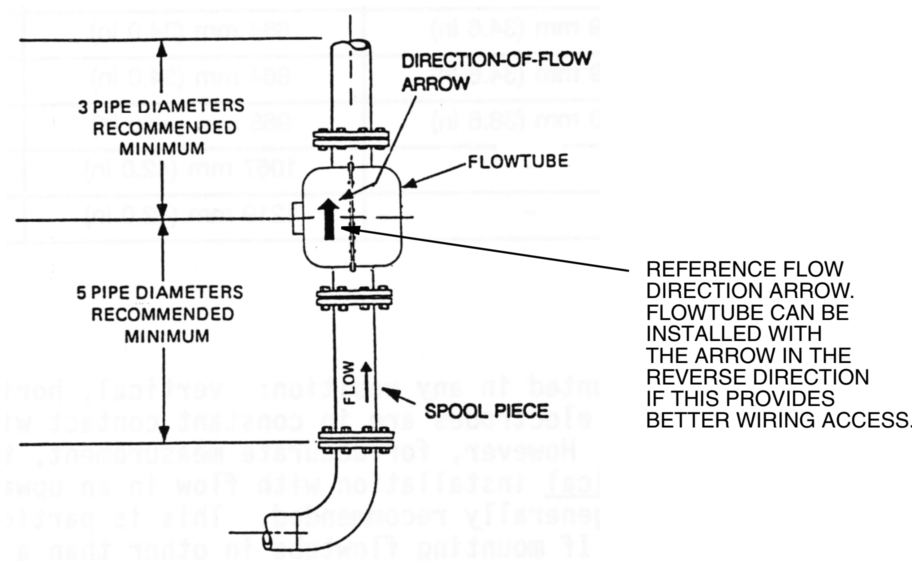

Figure 6. Flanged Body Flowmeter Mounted Vertically

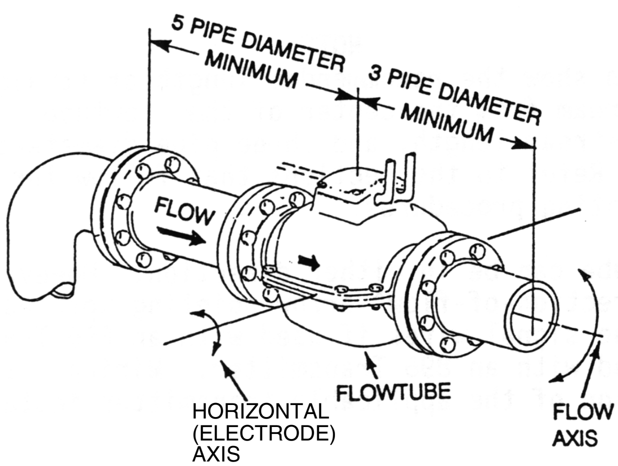

Figure 7. Flanged Body Flowtube Mounted Horizontally

Probably the most common reason for Magnetic Flowmeter errors and erratic performance is air in the flow stream. A Magnetic Flowmeter is a volume flow instrument, and, as such, will show the total volume flow rate of liquid and gas passing through the tube. Therefore, if the fluid is 1% by volume of air, the flow signal will be 1% greater than the amount of liquid flowing. If the entrained air is well mixed, the flow signal will be stable, but high. If the air builds up in the piping until it becomes a sizable bubble and then passes through the pipeline, there will then be disturbances of the flow rate through the tube and the output of the tube will appear to be unstable.

To avoid problems with air in the flow stream:

- Avoid installing the tube in a location that may not be full in all operating conditions.
- Avoid (or correct) upstream conditions that may draw air into the flow stream.

- Avoid (or correct) upstream conditions where any air that is entrained in the flow could collect into a large bubble, and then flow downstream. High spots and places where the flow velocity slows are likely places to create this problem.

Figures 8 to 10 show causes of aeration problems, and preferred installations that can correct these problems.

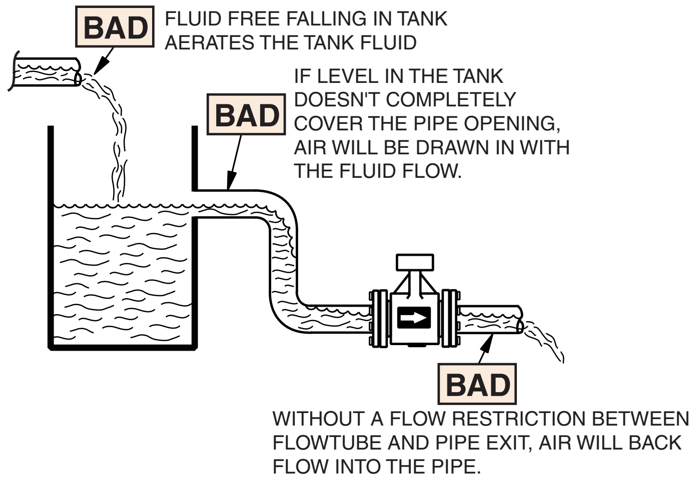

Figure 8. A Bad Installation Showing Causes of Aeration Problem (see Figure 9 for Corrected Installation)

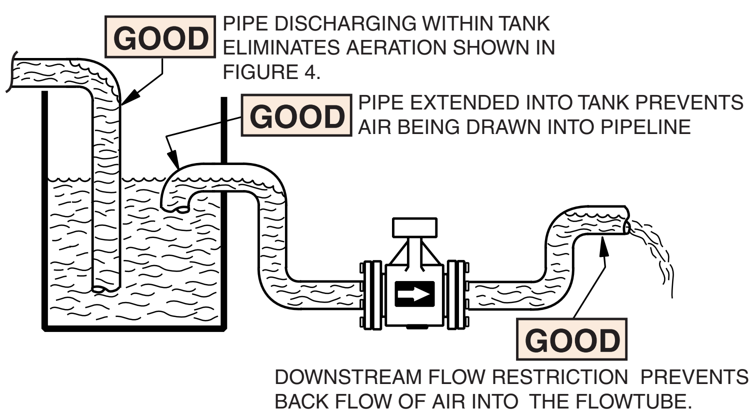

Figure 9. A Preferred Installation to Correct the Aeration Problems Shown in Figure 8

— NOTE —

See Figure 10 for proper flowtube location to avoid air entrapment due to upstream conditions.

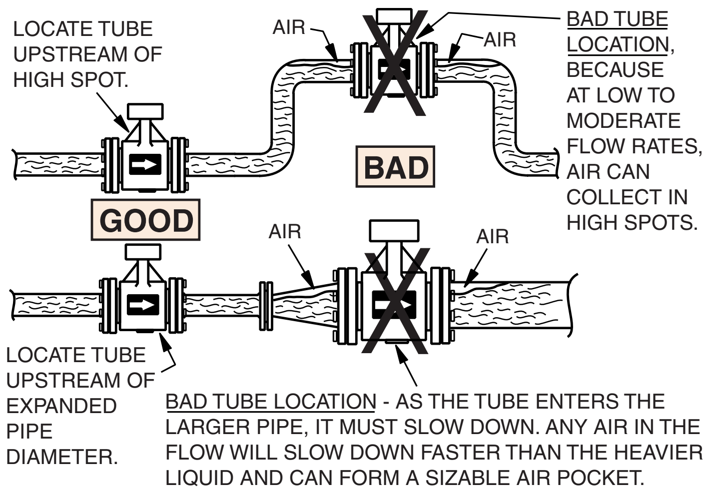

Figure 10. Proper Flowtube Location to Avoid Air Entrainment due to Upstream Conditions

Lining Application

Refer to Table 11 for recommended application of each lining. Also refer to TI 27-71f to best determine compatibility of lining with fluid types and fluid characteristics.

Table 11. Lining Application Guide

Flowtube Construction	Fluid Characteristics(a,b)					
	Clean	Mild Corrosion	Severe Corrosion	Mild Abrasion	Severe Abrasion	Mild Corrosion and Abrasion
ptfe Lining	A	A	A	B	X	B
Polyurethane Lining	A	B	X	A	A	B
Neoprene Lining	A	A	X	A	X	A

(a) A = Preferred: Generally considered best choices.
B = Satisfactory: Reasonable life under most conditions.
X = Not Recommended: Generally considered unsuitable.

(b) This flowtube is PED qualified in EU applications for SEP (Standard Engineering Practice) Category 1 with Group 2 fluids (nonhazardous).

ptfe Lining

Because of its inertness to a wide range of acids and bases, the ptfe lining is best suited for corrosive processes.

Polyurethane Lining

Because of its abrasive resistance and high wear resistance, this lining is best suited for abrasive slurries.

Neoprene Lining

This lining is best suited for general purpose use.

⚠ CAUTION

Do not use hydrocarbon defoamers, such as kerosene or sulfonated oils, with the neoprene lining as they cause neoprene to swell.

Pre-Startup Flow Line Cleaning

If possible, make up a flanged "spool piece" the same length as the flowtube. Insert it in the line before startup. On startup, any foreign objects in the line, such as pieces of wood or metal, should be located and removed before the flowtube is installed. This greatly lessens the possibility of accidental damage to the flowtube. Refer to DP 021-137 for end-to-end dimensions of the different flowtube sizes.

Process Liquid and Metering Tube Continuity

Continuity between flowing liquid and metal metering tube is required to provide a reference for the measurement signal. With **unlined metal pipe** connected to the flowtube flanges, continuity is provided by the pipe, and the flange bolts. Refer to the System Wiring section of the applicable transmitter installation instructions for grounding details between the transmitter, flowtube, and earth.

Installations in which **nonmetal or lined metal** pipe is used require installation of grounding rings on each flowtube flange as shown in Figure 11. To provide continuity, connect one ground strap to each grounding ring. Ground rings can be made from orifice plates. Inside diameters of the grounding rings should be slightly less than the inside diameter of the flowtube liners. The inside diameter provides electrical contact with the process liquid. These rings can also be used to protect the flowtube liner from abrasive wear. Refer to DP 021-120 for the inside diameter of the flowtube liners.

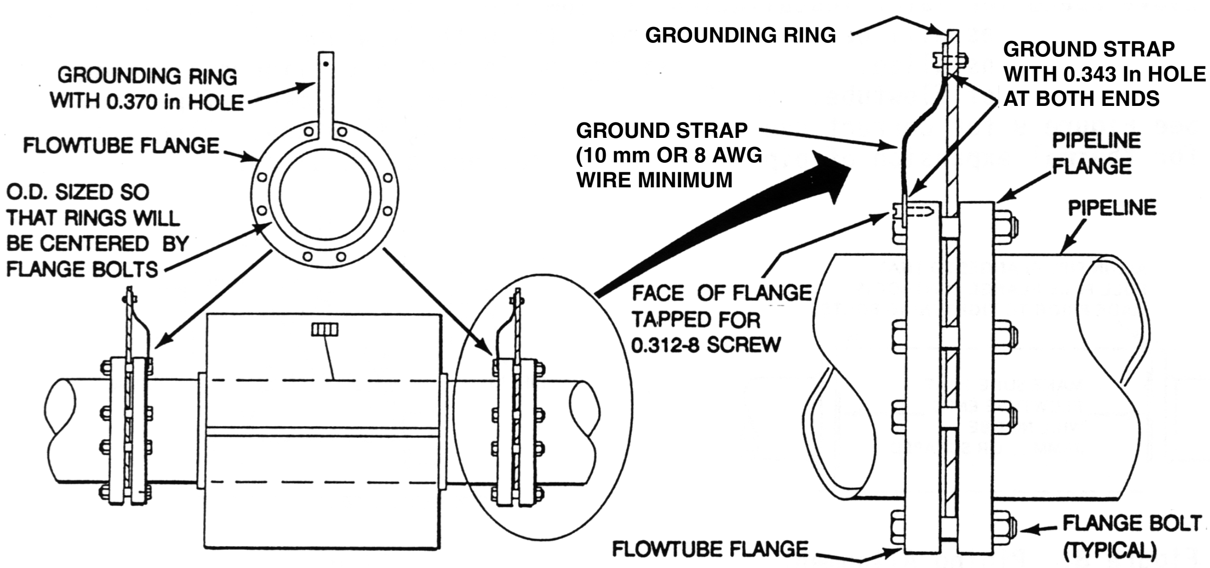

Figure 11. Use of Grounding Rings with Flanged End Flowtubes

Mounting Procedure

⚠ CAUTION

Excessive forces during installation and operation of flowtube can crush extended ends of flowtube lining. Some causes of these forces are excessive bolt torque, weight of vertical pipeline, thermal expansion of pipeline, and misalignment of flanges. To minimize these forces, adhere to the following procedure.

1. Before installing flowtube, install and adequately support the piping. Adjust piping and flanges so that flanges will be aligned and parallel with flowtube flanges when flowtube is installed. Flanges must not be forced into alignment during installation of flowtube. See Figure 12 for correct alignment of piping. See Figure 13 for correct use of hoist in installing flowtube. Also allow for thermal expansion of piping during operation, as required.

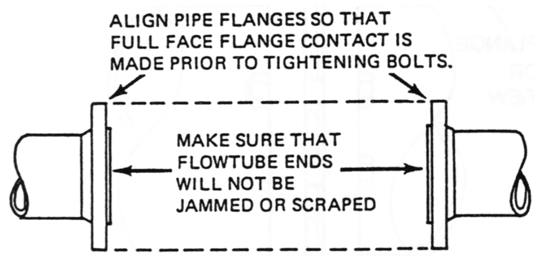

Figure 12. Piping Alignment for Flanged End Flowtube

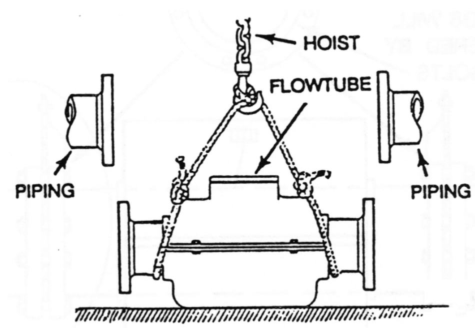

Figure 13. Hoisting Flowtube into Place

⚠ CAUTION

Piping supports must be firm enough so that addition of process fluid will not disrupt alignment of flowtube and adjacent piping.

2. Locate and remove all foreign objects from the piping. If possible, make up and install a section of pipe (spool piece) in the space provided for the flowtube. Start up the process to help locate any foreign objects.
3. To install the flowtube into the pipeline, proceed as follows:
   a. Hoist flowtube into place (see Figure 13).

b. Refer to Figure 14. Spring back piping to allow clearance as necessary to insert flowtube without causing damage to lining.

c. Install gaskets and grounding rings (as applicable) adjacent to flowtube flanges. (For details of grounding rings, "Process Liquid and Metering Tube Continuity" on page 19.

d. Align flanges, install bolts, and position piping into place.

e. Tighten flange bolts alternately and uniformly to torque values given in Table 12.

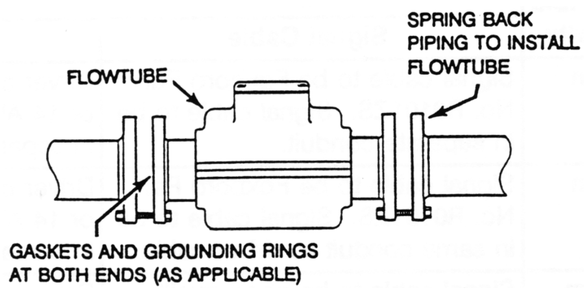

Figure 14. Installing Flowtube into Pipeline

Table 12. Flange-Bolt Torque Values for Flanged-End Flowtubes

Flowtube Size		Number of Bolts in Flange	Flange-Bolt Torque for All Linings	
mm	in		N•m	lb•ft
350	14	12 16	135 110	100 80
400	16	16	135	100
450	18	16 20	170 135	125 100
500	20	20	170	125
600	24	20	200	150
750	30	24 28	200 200	150 150
900	36	28 32	240 240	175 175

Flowtube Field Coil Connections

The flowtube coils may be wired either in series or in parallel as shown in Figure 15.

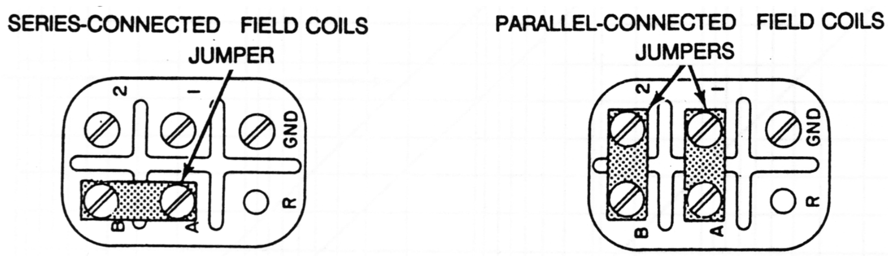

Figure 15. Series- and Parallel-Connected Field Coils Showing Jumper Position

1. With an IMT96 Transmitter, use series coils.
2. With an E96Transmitter, both series and parallel connections are used. Check the data plate.

Transmitter Installation and System Wiring

Transmitter installation and system wiring (flowtube and transmitter) are described in the applicable transmitter installation instructions. Refer to Table 1.

3. Maintenance

If a fault is suspected in the flowtube, first make exterior checks for wire continuity and rusted or corroded flanges, flange bolts, and/or ground straps. Rusted flanges, ground straps, and/or bolts can result in a poor process ground. Use the ultrasonic cleaner or low-voltage cleaning procedure, if the flowtube is so equipped, to clean the electrodes.

If it becomes necessary to clean the flowtube, avoid damaging the tube interior. Do **not** exceed temperature or pressure limits of the flowtube.

System fault location and maintenance information are described in MI 021-404 (if using an IMT96 Transmitter) or MI 021-138 (if using an E96 Transmitter). For flowtube parts, refer to PL 008-544.

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