

2800 Series Flanged Magnetic Flowtubes ptfe, pfa, or Polyurethane Lined, 2.5 to 300 mm (1/10 to 12 in) Sizes

<u>Models</u>	<u>Sizes</u>	<u>Style</u>
2891 and 2893	2.5 and 6 mm (1/10 and 1/4 in)	A
280H to 281H	15 to 40 mm (1/2 to 1-1/2 in)	B
2802 to 2812	50 to 300 mm (2 to 12 in)	C



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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. Selections of High Humidity/Condensate, General Purpose NEMA 4X, and Submergence Housings are offered.

The stainless steel flowtube is lined with a choice of pfa, ptfe, or polyurethane lining, depending on the flowtube size. 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 the applicable parts list in Table 1 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 voltage 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 021-120	Dimensional Print - 2800 Series Flanged Flowtubes, 1/10 to 12 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

Table 1. Reference Documents

Document	Description
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 008-541	Parts List - 2800 Series Flanged Flowtubes, 1/2 to 12 in Sizes
PL 008-543	Parts List - 2891 and 2893 Series Flowtubes, 1/10 and 1/4 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 V_o induced in a conductor of length D_e 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 the E96T Transmitter is integrally mounted to the flowtube, the maximum temperature is 38°C (100°F).

Electrodes

Models 2891 and 2893: Hastelloy C or platinum-10% iridium

Model 280H: Hastelloy C, tantalum-tungsten, 316L ss, platinum-10% iridium, or titanium.

Models 2801 - 2812 (with ptfе lining): Hastelloy C, tantalum-tungsten, 316L ss, platinum-10% iridium, or titanium. 316L ss and Hastelloy C electrodes are also available in conical shaped configurations.

Models 2802 - 2812 (with polyurethane lining): 316L ss.

Refer to TI 27-71f for a process-wetted materials selection guide.

Metering Tube

Models 2891, 2893, and 280H: stainless steel, investment casting

All other models: AISI Type 304 Stainless steel, Schedule 10.

Process Fluid Conductivity

The minimum process fluid conductivity required is 2 $\mu\text{S}/\text{cm}$ for Models 280H through 2812 and 5 $\mu\text{S}/\text{cm}$ for Models 2891 and 2893.

Maximum Cable Length

With an 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 $\mu\text{S}/\text{cm}$, the system accuracy is affected.

Table 2. Process Fluid Conductivity and Cabling

Fluid Conductivity	Cable Length	Signal and Coil Drive Cables
>20 $\mu\text{S}/\text{cm}$	<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 $\mu\text{S/cm}$	<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 $\mu\text{S/cm}$; for example, for a conductivity of 12 $\mu\text{S/cm}$ the additional error would be 0.3%. 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 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 $\mu\text{S/cm}$; for example, for a conductivity of 12 $\mu\text{S/cm}$ 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 B407TE 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 an 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.

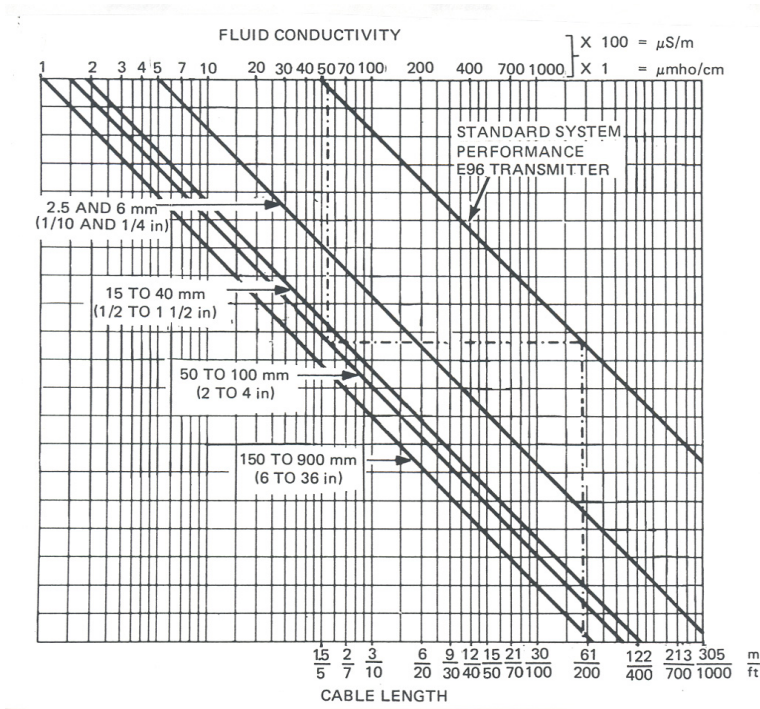


Figure 1. Maximum Signal Cable Length

— 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 $\mu\text{S}/\text{cm}$.

1. Draw a vertical line at the fluid conductivity of 55 $\mu\text{S}/\text{cm}$ 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 tube sizes, transmitter models, and linings.

**Table 3. Flowtube Selection for Use with IMT96 Transmitters
Based on Measurement Range and Liner Material**

Flowtube Size		Power from IMT96 See IMT96 MI 021-402 for wire type & gauge	Liner	Nominal Cal Fact Calibration Factor in $\mu\text{V/A/gpm}$	Flow Measurement Range Limits			
mm	in				Minimum		Maximum ^(a)	
					L/min 0 to:	U.S. gpm 0 to:	L/min 0 to:	U.S. gpm 0 to:
15	1/2	70 VA Maximum	ptfe	185	4.2	1.1	75	20
25	1		ptfe	84	15	4	290	76
40	1-1/2		ptfe	37.6	37.5	10	740	195
50	2		ptfe	25	60	16	1260	335
			poly	37.5	42	11	600	160
80	3		ptfe	11.3	135	35	2900	770
			poly	12.9	114	30	1930	510
100	4		ptfe	6.21	245	65	5100	1350
			poly	7.78	192	50	3240	855
150	6		ptfe	1.75	570	150	11400	3000
			poly	2.02	480	130	8800	2300
200	8		ptfe	0.817	985	260	19500	5150
			poly	0.902	900	240	16400	4300
250	10		ptfe	0.712	1500	400	31000	8200
			poly	0.771	1440	375	27000	7150
300	12		ptfe	0.417	2270	600	44200	11700
		poly	0.441	2100	550	39600	10450	

(a) (Maximum flow rates are based on a velocity of 10 m/s (33 ft/s). Higher flow rates are permissible, but may accelerate liner wear. This rate is the maximum recommended for non-abrasive fluids. Lower maximum flow rates are recommended for abrasive fluids.)

**Table 4. Flowtube Selection for Use with E96 Transmitters
Based on Measurement Range and Liner Material**

Nominal Line Size		Power to Flowtube			Flow Measurement Range ^(b)				Liner Mat'l (c)	Nominal Calibration Factor in mV/gpm
mm (d)	in (d)	Supply Voltage and Coil Connection (a)(b)	Watts	VA	Min. L/min	Max. L/min	Min. U.S.gpm	Max. U.S.gpm		
2.5	1/10	(A, D, or E)[s]	48	525	0 to 0.3	0 to 3	0 to 0.08	0 to 0.8	pfa	12.2
		B [s]; C [p]	48	525	0 to 0.3		0 to 0.08			
6	1/4	(A, C, D, or E)[s]	13	180	0 to 1.92	0 to 19	0 to 0.50	0 to 5	pfa	2.00 4.00
		B [s]; (A, C, or D)[p]	62	720	0 to 0.96		0 to 0.25			
15	1/2	(A, C, D, or E)[s]	17	275	0 to 8.4	0 to 75	0 to 2.2	0 to 20	ptfe	0.450 0.900
		B [s]; (A, C, or D)[p]	95	1220	0 to 4.2		0 to 1.1			
25	1	(A, C, D, or E)[s]	13	195	0 to 30	0 to 290	0 to 8	0 to 76	ptfe	0.125 0.250
		B [s]; (A, C, or D)[p]	60	775	0 to 15		0 to 4			
40	1 1/2	(A, C, D, or E) [s]	14	175	0 to 75	0 to 740	0 to 20	0 to 195	ptfe	0.050 0.100
		B [s]; (A, C, or D)[p]	67	690	0 to 37.5		0 to 10			
50	2	(A, C, D, or E)[s]	13	160	0 to 120	0 to 1260	0 to 32	0 to 335	ptfe	0.030 0.060
		B [s]; (A, C, or D)[p]	62	625	0 to 60		0 to 16			

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

Nominal Line Size		Power to Flowtube			Flow Measurement Range ^(b)				Liner Mat'l (c)	Nominal Calibration Factor in mV/gpm
mm (d)	in (d)	Supply Voltage and Coil Connection (a)(b)	Watts	VA	Min. L/min	Max. L/min	Min. U.S.gpm	Max. U.S.gpm		
50	2	(A, C, D, or E)[s]	13	160	0 to 84	0 to 600	0 to 22	0 to 160	poly	0.045
		B [s]; (A, C, or D)[p]	62	625	0 to 42		0 to 11			
80	3	(A, C, D, or E)[s]	19	160	0 to 270	0 to 2900	0 to 70	0 to 770	ptfe	0.014
		B [s]; (A, C, or D)[p]	91	625	0 to 135		0 to 35			
80	3	(A, C, D, or E)[s]	19	160	0 to 228	0 to 1930	0 to 60	0 to 510	poly	0.016
		B [s]; (A, C, or D)[p]	91	625	0 to 114		0 to 30			
100	4	(A, C, D, or E)[s]	21	150	0 to 490	0 to 5100	0 to 130	0 to 1350	ptfe	0.0075
		B [s]; (A, C, or D)[p]	100	595	0 to 245		0 to 65			
100	4	(A, C, D, or E)[s]	21	150	0 to 384	0 to 3240	0 to 100	0 to 855	poly	0.0094
		B [s]; (A, C, or D)[p]	100	595	0 to 192		0 to 50			
150	6	(A, C, D, or E)[s]	36	240	0 to 1140	0 to 11400	0 to 300	0 to 3000	ptfe	0.0033
		B [s]; (A, C, or D)[p]	169	950	0 to 570		0 to 150			
150	6	(A, C, D, or E)[s]	36	240	0 to 960	0 to 8800	0 to 260	0 to 2300	poly	0.0038
		B [s]; (A, C, or D)[p]	169	950	0 to 480		0 to 130			
200	8	(A, C, D, or E)[s]	50	285	0 to 2040	0 to 19500	0 to 520	0 to 5150	ptfe	0.0019
		B [s]; (A, C, or D)[p]	232	1140	0 to 1020		0 to 260			
200	8	(A, C, D, or E)[s]	50	285	0 to 1800	0 to 16400	0 to 480	0 to 4300	poly	0.0021
		B [s]; (A, C, or D)[p]	232	1140	0 to 900		0 to 240			
250	10	(B,C, D, or E)[s]	83	450	0 to 3000	0 to 31000	0 to 800	0 to 8200	ptfe	0.0012
		(A)[p]	83	450	0 to 3000		0 to 800			
		(B, C, or D)[p]	345	1880	0 to 1500		0 to 400			
250	10	(B,C, D, or E)[s]	83	450	0 to 2880	0 to 27000	0 to 750	0 to 7150	poly	0.0013
		(A)[p]	83	450	0 to 2880		0 to 750			
		(B, C, or D)[p]	345	1880	0 to 1440		0 to 375			
300	12	(B,C, D, or E)[s]	91	465	0 to 4500	0 to 44200	0 to 1200	0 to 11700	ptfe	0.00085
		(A)[p]	91	465	0 to 4500		0 to 1200			
		(B, C, or D)[p]	375	2040	0 to 2250		0 to 600			
300	12	(B,C, D, or E)[s]	91	465	0 to 4200	0 to 39600	0 to 1100	0 to 10450	poly	0.00090
		(A)[p]	91	465	0 to 4200		0 to 1100			
		(B, C, or D)[p]	375	2040	0 to 2100		0 to 550			

(a) A = 120 V ac, 60 Hz; B = 240 V ac, 60 Hz; C = 120 V ac, 50 Hz; D = 220 V ac, 50 Hz; E = 240 V ac, 50 Hz; and [s] = Series connection of the flowtube coils; and [p] = Parallel connection of the flowtube coils.

(b) (Maximum flow rates are based on a velocity of 10 m/s (33 ft/s). Higher flow rates are permissible, but may accelerate liner wear. This rate is the maximum recommended for non-abrasive fluids. Lower maximum flow rates are recommended for abrasive fluids.

(c) pfa = perfluoroalkoxy; ptfe = polytetrafluoroethylene (Teflon); poly = polyurethane.

(e) Sizes from 50 mm (2 in) and above are shown twice, first with a ptfe liner and then with a polyurethane liner. Note the higher flow measurement ranges when the ptfe liner is used.

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.

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 12.

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 and Total Submergence (Code -N): Enclosure is sealed for accidental or continuous operation under water up to 9 m (30 ft) deep. This selection is supplied with a kit for sealing the power and signal connections during installation.

Enclosure Finish

High-build epoxy paint.

Electrical Connections

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

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 in the pipeline, review “Flowtube Location and Mounting Position” on page 19.

End Connections

ANSI Class 150 and 300 and Metric PN 10, 16, 25, and 40 flanges, depending on the flowtube specified.

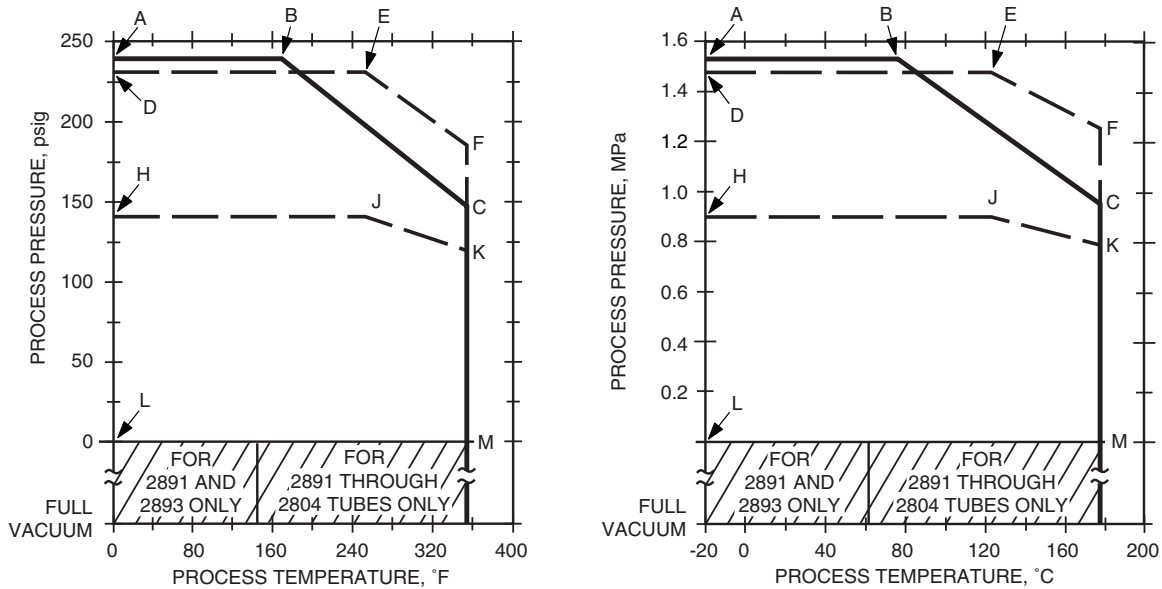
Approximate Mass

Table 5. Approximate Flowtube Mass

Line Size		Approximate Mass		Line Size		Approximate Mass	
mm	in	kg	lb	mm	in	kg	lb
2.5	1/10	13	35	80	3	27	60
6	1/4	13	35	100	4	34	76
15	1/2	21	46	150	6	55	122
25	1	18	40	200	8	85	188
40	1-1/2	20	45	250	10	91	200
50	2	21	47	300	12	125	275

Process Pressure and Temperature Limits

See Figure 2 and Table 6.



NOTES

- Process pressure and temperature must be within the following regions:
 - Region bounded by curve LABCM for flowtubes with ANSI Class 150 or 300 flanges
 - Region bounded by curve LHJKM for flowtubes with PN 10 flanges
 - Region bounded by curve LDEFM for flowtubes with PN 16, 25, or 40 flanges
- Refer to Invensys Process Systems for applications involving elevated pressure.

Figure 2. Process Temperature and Pressure Limits for Flowtubes with pfa or ptfe Lining

Table 6. Process Temperature and Pressure Limits for Polyurethane Lining

Flange	Model Code Series	Pressure Limits		Lower Limit	Temperature Limits	
		Upper Limits			Lower Limit	Upper Limit
		MPa	psi			
ANSI Class 150	2802 to 2812	1.7	240	Full Vacuum	-18°C (0°F)	+71°C (+160°F)
ANSI Class 300	2802 to 2804	4.8	700			
	2806 and 2808	1.7	240			
PN10	2802 to 2812	1.0	145			
PN 16	2802 to 2812	1.6	232			
PN 25	2802 to 2804	2.5	362			
	2806 to 2812	1.7	240			
PN 40	2802 to 2804	4.0	580			
	2806 to 2812	1.7	240			

Product Safety Specifications

— NOTE —

The flowtube has been designed to meet the electrical safety descriptions listed in Tables 7 and 8. For detailed information or status of testing laboratory approvals or certifications, contact Invensys Process Systems.

Table 7. 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.		CS-E/CN-A
CSA certified for Type Y Purging for Class I, Groups A, B, C, and D, Division 1.		CS-E/CP-A
FM certified for use in Class I, Groups A, B, C, and D, Division 2 hazardous locations.		CS-E/FN-A
FM certified for Type Y Purging intrinsically safe connection for Class I, Groups A, B, C, and D, Division 1. ^(a)		CS-E/FP-A

Product Safety Specifications

— **NOTE** —

The flowtube has been designed to meet the electrical safety descriptions listed in Tables 7 and 8. For detailed information or status of testing laboratory approvals or certifications, contact Invensys Process Systems.

Table 7. Electrical Classifications

Testing Laboratory, Types of Protection and Area Classification	Conditions of Certification	Electrical Safety Design Code
PTB certified EEx e (ib) for IIC, Zone1 (CENELEC)	Model 280H through 2808. 220 V, 50 Hz coils only. Coils can be factory wired in series or parallel but cannot be changed in the field. Use only with PTB certified E96 Transmitter. Temperature Class per Table 8.	CS-E/PS-E

(a) Refer to Invensys Process Systems for use with ultrasonic electrode cleaning, submersible construction, or increased corrosion resistant construction.

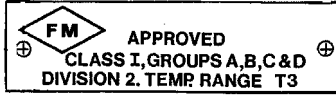
**Table 8. Temperature Classification for PTB Certified Flowtubes in ac Systems
(E96 Transmitter)**

Nominal Line Size		Series Connected Coils, 220 V, 50 Hz Only Process Temperature Classification				Parallel Connected Coils, 220 V, 50 Hz Only Process Temperature Classification			
mm	in	T3	T4	T5	T6	T3	T4	T5	T6
15	1/2	155°C	110°C	–	80°C	155°C	–	–	–
25	1	155°C	110°C	–	80°C	155°C	110°C	70°C	–
40	1 1/2	155°C	110°C	–	80°C	155°C	–	–	–
50	2	155°C	110°C	–	80°C	155°C	–	–	–
80	3	155°C	110°C	–	80°C	155°C	110°C	70°C	–
100	4	155°C	110°C	–	80°C	155°C	–	100°C	–
150	6	155°C	110°C	–	80°C	155°C	–	70°C	–
200	8	155°C	110°C	–	70°C	155°C	–	–	–

Flowtube Identification

The flowtube can be identified by data plates located on the housing surface of the flowtube. Typical data plates are shown in Figure 3. For an interpretation of the model code, refer to the applicable parts list. Refer to the applicable transmitter instruction for information regarding transmitter data plates. References to parts lists and transmitter instructions are given in Table 1.

2800 SERIES MAGNETIC FLOWTUBE			
MODEL	ST		
CERT SPEC			
REF NO.			
ORIGIN			
POWER	IMT96	AC	896
SUPPLY VOLTS			
FREQ. Hz			
AMPS MAX.			
PHASE BAND			
COILS			
IMT96 CAL FACT.	IMT96		
CAL FACTOR	AC		
mV/	896		
ELECTRODES			
CUST. DATA			
invensys® FOXBORO FOXBORO MASS U.S.A.			



CAUTION			
FLANGE RATING MAY EXCEED INSTRUMENT PRESSURE LIMITS			
MWP	PSI @	°F	
	MPa @	°C	
MWP	PSI @	°F	
	MPa @	°C	
CAUTION			
COIL DRIVE EXCITATION PWR VARIES. CHECK COMPATABILITY OF TRANSMITTER WITH FLOWTUBE. OTHERWISE DAMAGE MAY OCCUR.			

2800 SERIES MAGNETIC FLOWTUBE				
MODEL	ST			CAUTION
CERT SPEC				
REF NO.				
ORIGIN				
POWER	IMT96	AC	896	MWP
SUPPLY VOLTS				
FREQ. Hz				PSI @ °F
AMPS MAX.				MPa @ °C
PHASE BAND				MWP
COILS				
IMT96 CAL FACT.	IMT96			CAUTION
CAL FACTOR	AC			
mV/	896			
ELECTRODES				
CUST. DATA				COIL DRIVE EXCITATION PWR VARIES. CHECK COMPATABILITY OF TRANSMITTER WITH FLOWTUBE. OTHERWISE DAMAGE MAY OCCUR.
invensys® FOXBORO FOXBORO MA. U.S.A.				

FM	WARNING	M/	FOXBORO
TYPE Y PURGED ENCLOSURE FOR CLASS I, DIV. 1 TEMP RANGE T3. ENCLOSURE SHALL NOT BE OPENED UNLESS AREA IS NONHAZARDOUS OR POWER TO THE INTERNAL DEVICES HAS BEEN DISCONNECTED.		DO NOT ENERGIZE UNTIL PURGED AT _____ FOR _____ MINUTES. DURING NORMAL OPERATION MAINTAIN FLOW OF _____	

Figure 3. Sample Flowtube Data Plates

2. Installation

Unpacking and Handling Considerations

The 2800 Series 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, or other appropriate equipment, as shown in the “Flowtube Handling” sections that follow. The lifting technique may vary depending on the mass of the flowtube (see “Approximate Mass” on page 9). 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 the 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 results 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. “Maximum Cable Length” on page 3.
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. Note that on small size flowtubes, the recommended straight runs of pipe are included in the overall length of the flowtube. Refer to Figure 7.

To avoid excessive lining wear (especially with ptfе), 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 than 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. In order to prevent damage to the flowtube lining, housing, or structural integrity, pay close attention to the following:

1. Never put anything through the flowtube to lift it.
2. Do not use the housing to support or lift the flowtube. Figure 4 and Figure 5 show correct and incorrect methods for lifting the flowtubes. Note that in Figure 4 (horizontal lifting), the suggested approach is to place the lifting rope or strap (or equivalent) between the flange and flowtube body. For vertical lifting, shown in Figure 5, 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.

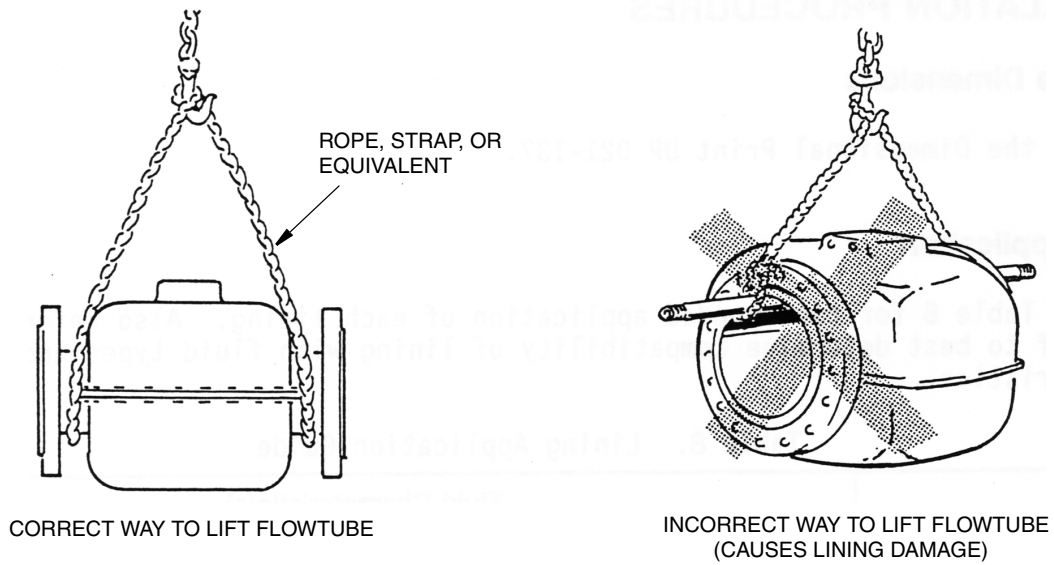


Figure 4. Lifting Flanged Flowtube for Horizontal Mounting (14 to 36 in Size Shown)

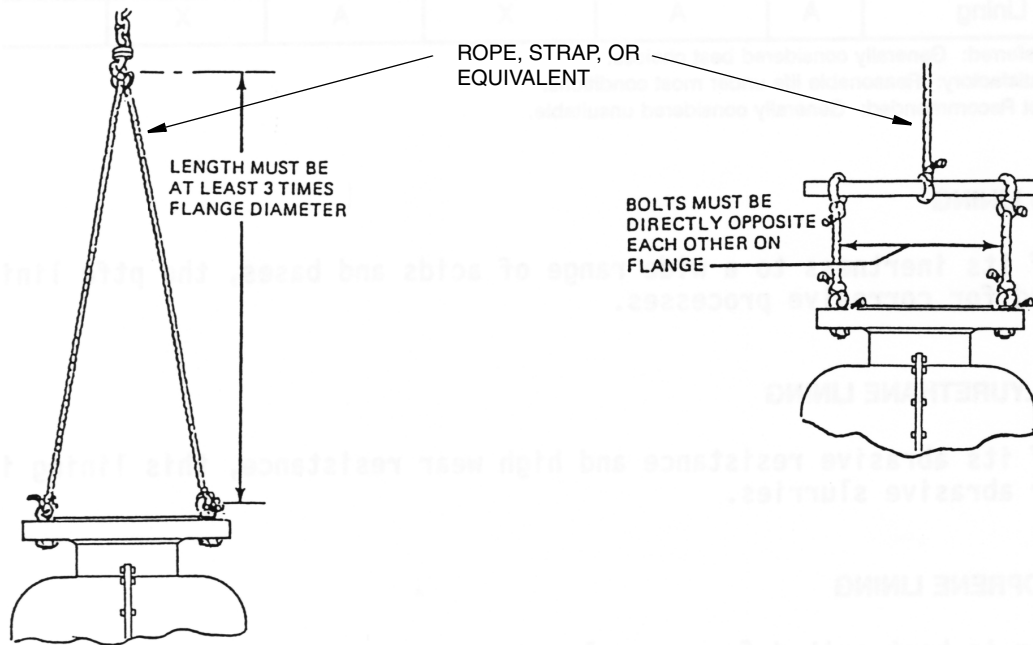


Figure 5. Lifting Flanged Flowtube for Vertical Mounting

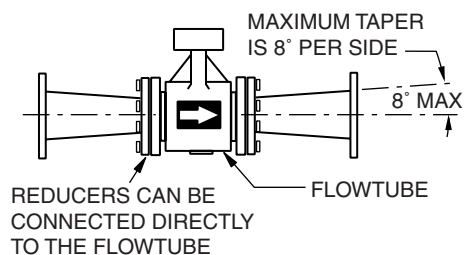
Magnetic Flowtube Sizing

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 9 as a guide to sizing of magnetic flowtubes.

Table 9. 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 the 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 6 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 inH₂O, <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 6. 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 Foxboro therefore provides its FlowExpertPro™ Sizing Software to facilitate and simplify the flowmeter sizing procedure for any application.

Installation Procedures

Flowtube Dimensions

Refer to DP 021-120.

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 7.
- ◆ 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 7). 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 8). Adjacent piping can 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 can 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 7 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.

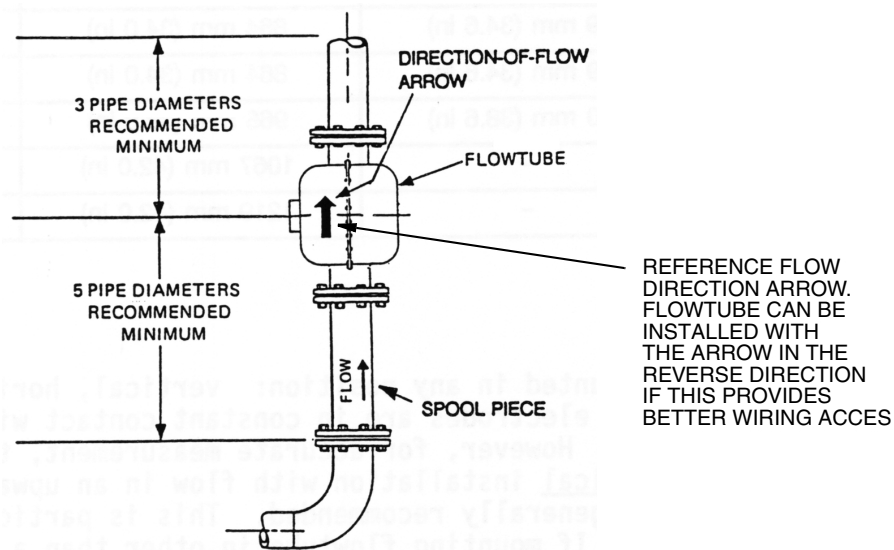


Figure 7. Flanged Body Flowmeter Mounted Vertically

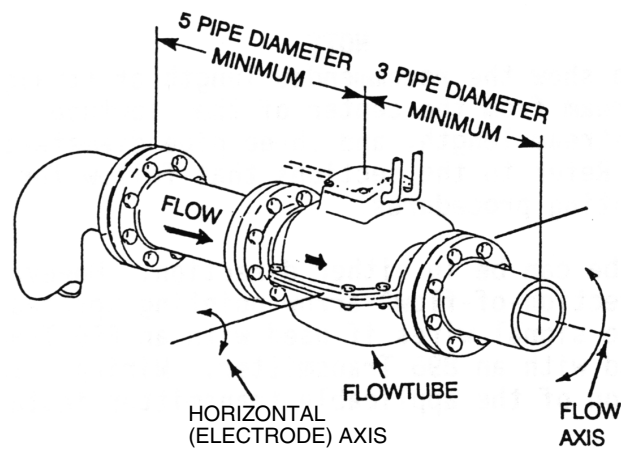


Figure 8. Flanged Body Flowmeter Mounted Horizontally

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 9 to 11 show causes of aeration problems, and preferred installations that can correct these problems.

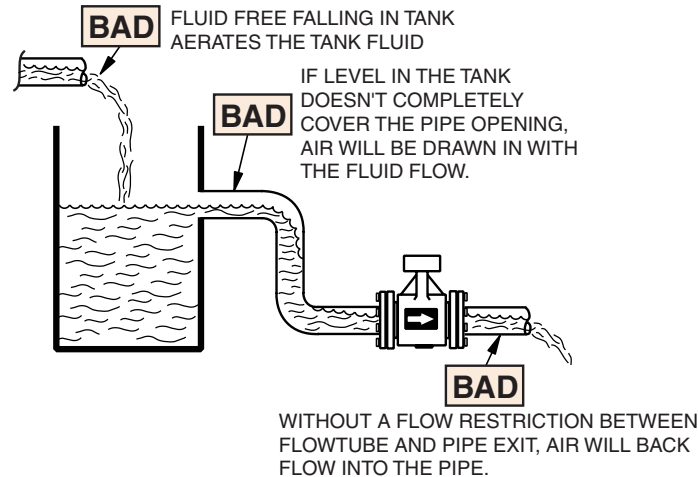


Figure 9. A Bad Installation Showing Causes of Aeration Problem (see Figure 10 for Corrected Installation)

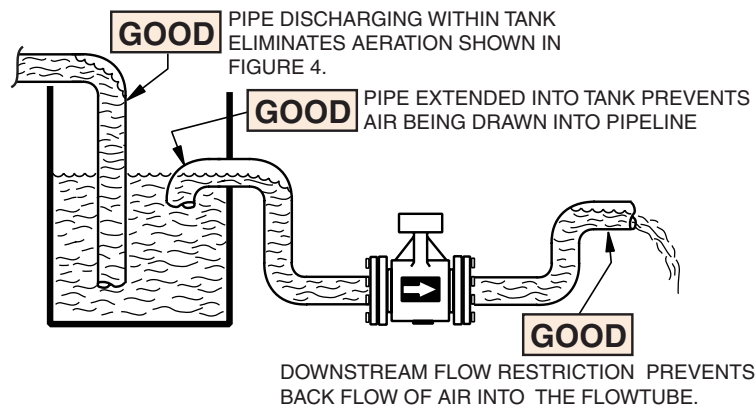


Figure 10. A Preferred Installation to Correct the Aeration Problems Shown in Figure 9

— **NOTE** —

See Figure 11 for proper flowtube location to avoid air entrapment due to upstream conditions.

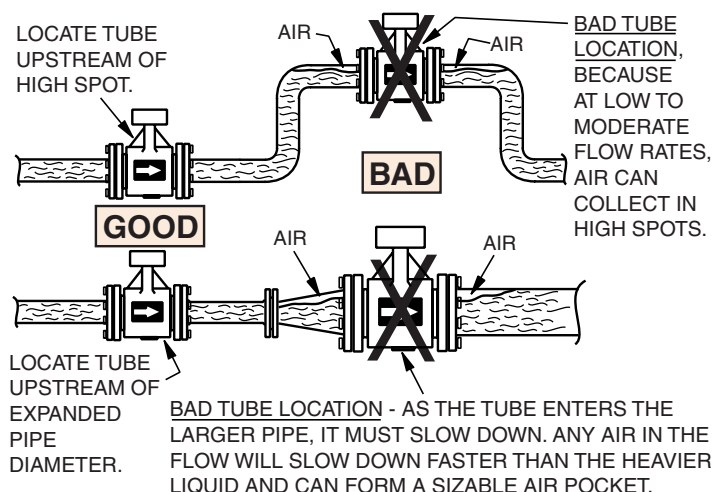


Figure 11. Proper Flowtube Location to Avoid Air Entrainment due to Upstream Conditions

Lining Application

Refer to Table 10 for recommended application of each lining. Also refer to TI 27-71f to best determine compatibility of each lining with various specific fluids.

Table 10. Lining Application Guide

Flowtube Construction	Fluid Characteristic ^{(a)(b)}					
	Clean	Mild Corrosion	Severe Corrosion	Mild Abrasion	Severe Abrasion	Mild Corrosion and Abrasion
ptfe or pfa Lining	A	A	A	B	X	B
Polyurethane Lining	A	B	X	A	A	B

- (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).

Use of ptfe and pfa Linings

Because of their inertness to a wide range of acids and bases, the ptfe and pfa linings are best suited for corrosive processes.

Use of Polyurethane Lining

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

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 021-120 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 12. 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.

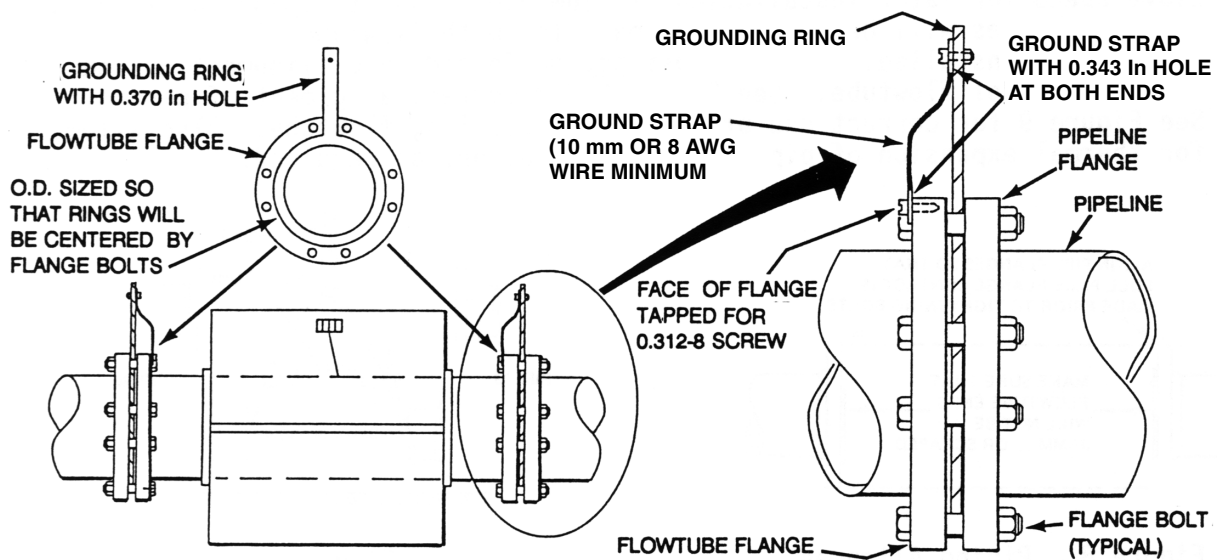


Figure 12. Use of Grounding Rings with Flanged End Flowtubes

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 the flowtube, install and adequately support the piping. Adjust the piping and flanges so that the flanges are aligned and parallel with the flowtube flanges when the flowtube is installed. Flanges must **not** be forced into alignment during installation of the flowtube. See Figure 13 for correct alignment of piping. See Figure 14 for correct use of a hoist in installing the flowtube. Also allow for thermal expansion of piping during the operation, as required.

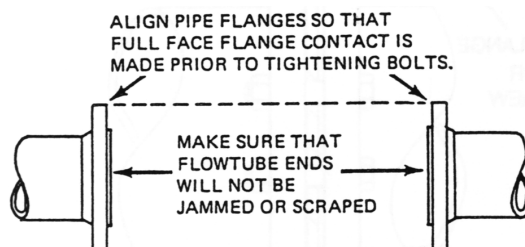


Figure 13. Piping Alignment for Flanged End Flowtube

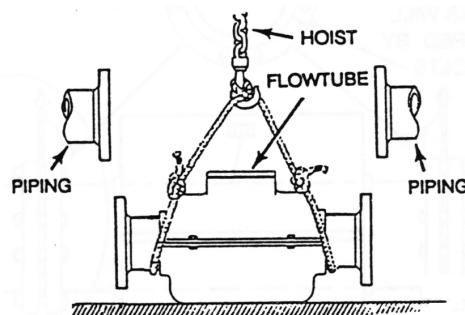


Figure 14. Hoisting Flowtube into Place

—! CAUTION —

Piping supports must be firm enough so that addition of process fluid does not disrupt alignment of the flowtube and adjacent piping. When mounting a 2.5 or 6 mm (1/10 or 1/4 in) flowtube to a pipe that has less than 15 mm (1/2 in) I.D., use mounting holes on bottom of the flowtube housing for additional support. These holes can either be used with self-tapping bolts or can be tapped for MBx20 mm or 5/16-18 x 3/4 in bolt.

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 the flowtube into place (see Figure 14).
 - b. Refer to Figure 15. Spring back the piping to allow clearance as necessary to insert the flowtube without causing damage to its lining.
 - c. Install gaskets and grounding rings (as applicable) adjacent to the flowtube flanges. (For details of installing grounding rings, see “Process Liquid and Metering Tube Continuity” on page 23.
 - d. Align flanges, install bolts, and position piping into place.
 - e. Tighten flange bolts alternately and uniformly to torque values given in Table 11.

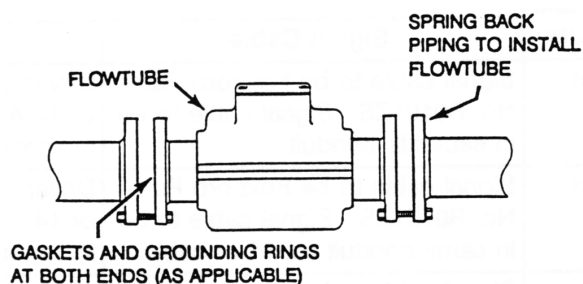


Figure 15. Installing Flowtube into Pipeline

Table 11. Flange-Bolt Torque Values

Flowtube Size		Number of Bolts in Flange	Flange-Bolt Torque			
			ptfe or pfa Lining		Polyurethane Lining	
mm	in		N•m	lb•ft	N•m	lb•ft
2.5	1/10	4	7	5	-	-
6	1/4	4	7	5	-	-
15	1/2	4	7	5	-	-
25	1	4	15	10	-	-
40	1-1/2	4	20	15	-	-
		8	15	10	-	-
50	2	4	35	25	55	43
		8	20	15	30	20
80	3	4	55	40	80	60
		8	35	25	55	40
100	4	8	40	30	60	45
150	6	8	80	60	120	90
		12	60	45	95	70
200	8	8	100	75	150	120
		12	80	60	120	90
250	10	12	95	70	120	110
		16	80	60	120	90
300	12	12	110	80	160	120
		16	95	70	140	110

Flowtube Coil Connections

The flowtube coils can be connected either in series or in parallel as shown in Figure 16.

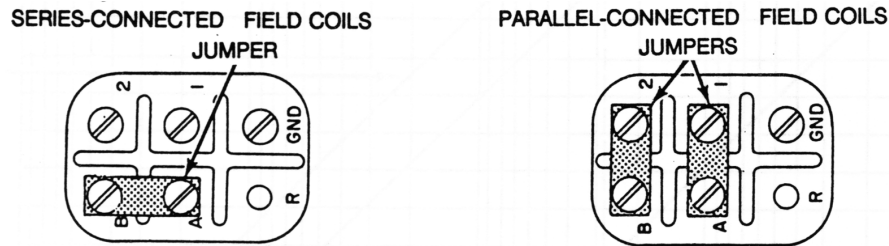


Figure 16. Series- and Parallel-Connected Field Coils Showing Jumper Position

1. With an IMT96 Transmitter, use series coils (except for 1/2- through 8-in flowtubes dual calibrated for 220/240 V 50 Hz E96).
2. With an E96 Transmitter, both series and parallel connections are used. Check the data plate.

NOTE
120 V parallel and 220/240 V series configurations are interchangeable.

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 for the applicable transmitter document.

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 the applicable flowtube parts list in Table 1.

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