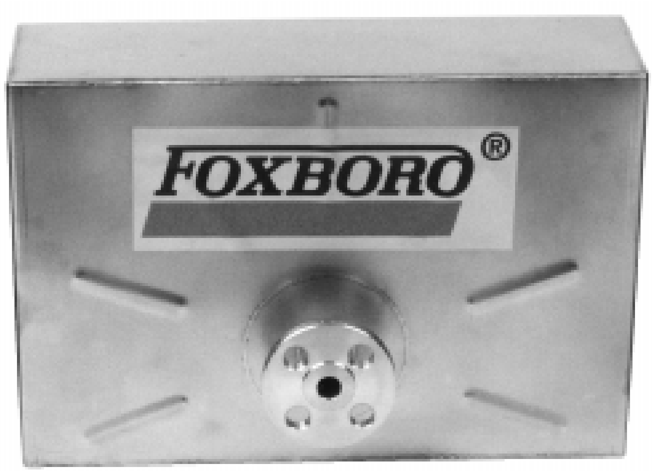
Instruction

MI 019-120
August 1997

I/A Series® Mass Flowmeter
Models CFS10/CFS20 Mass Flowtubes

Installation and Maintenance



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1. Introduction

General Description

Model CFS20 Mass Flowtubes use two *parallel*-connected, large-bore tubes. Fluid entering the flowtube is channeled through a rigid center body via two parallel loops back into the outlet side of the rigid center body.

Model CFS10 Mass Flowtubes use two *serial*-connected, large bore tube loops positioned side by side. Fluid entering the flowtube is channeled first through one loop, through a rigid center body, and then through the second loop.

Electromagnetic drivers bridge both loops at opposite extremities, equidistant from the center. Electromechanical sensors are used for Coriolis force measurement. Each sensor bridges both loops and is positioned adjacent to a driver.

The CFT10/15 Mass Flow Transmitter is wired to the Flowtube and provides an alternating current to each driver. These currents are 180° out of phase so that as the drivers alternately expand and contract, the pairs of tube ends alternately move away from each other and then draw closer to each other. The result is that each tube effectively oscillates about its mid-point.

The movement of the tube acts on the flowing fluid within the tube, so that a Coriolis force is generated normal to the flow path. This Coriolis force acts upon the tubes and consequently the sensors to provide a signal whose amplitude with respect to the drive signal is proportional to the process fluid mass flow rate.

The density of the process fluid can also be measured because the natural driving frequency of the parallel flowtube is dependent upon the density of the fluid in the flowtube.

Temperature measurement is achieved by an internally positioned Resistance Temperature Detector (RTD).

Reference Documents

This instruction covers the installation and maintenance of the CFS10 and CFS20 Mass Flowtubes. Refer to the list below for other supporting documents.

Table 1. Reference Documents

Document Number	Document Description
DP 019-180	CFS10, Style A Flowtube Dimensions (1/4 to 2 inch)
DP 019-181	CFS20, Style A Flowtube Dimensions (1/4 to 2 inch)
DP 019-182	CFS10 Style B Flowtube Dimensions (1/4 through 2 inch)
DP 019-183	CFS20 Style B Flowtube Dimensions (1-1/2 and 3 inch)
DP 019-360	CFT10 Panel-Mounted Transmitter Dimensions
DP 019-361	CFT10 Field-Mounted Transmitter Dimensions
DP 019-365	CFS20 Style B Flowtube Dimensions (1/8 inch)

Table 1. Reference Documents (Continued)

Document Number	Document Description
DP 019-366	CFS10 Style B Flowtube Dimensions (1/8 inch)
MI 019-121	CFT10 Transmitter Installation and Maintenance
MI 019-122	CFT10 Transmitter Configuration and Operation Using Integral Keypad
MI 019-123	CFT10 Transmitter Configuration and Operation Using HHT
MI 019-127	CFT15 Transmitter Installation and Maintenance
MI 019-131	CFT15 Modbus protocol Communication Interface
MI 020-479	PC10 Intelligent Transmitter Configurator, Version 4.0
PL 008-700	CFT10 Panel-Mounted Transmitter Parts List
PL 008-701	CFT10 Field-Mounted Transmitter Parts List
PL 008-702	CFS10 Flowtubes, Sanitary/General, Parts List
PL 008-703	CFS20 Flowtubes, Sanitary/Genera, Parts List
PL 008-733	CFS10 Style B Flowtubes, Sanitary/General, Parts List
PL 008-735	CFS20 Style B Flowtubes, Sanitary/General, Parts List
PL 008-719	CFT15 Field Mounted Transmitter, Parts List
PL 008-731	CFT15 Panel Mounted Transmitter, Parts List

Standard Specifications

(For complete specification information, also refer to PSS 1-2B1 A, PSS 1-2B3 C, and PSS 1-2B4 A.)

Nominal Mass Flow Rate Range

Dependent on flowtube size. Refer to Table 2 for the nominal mass flow rate range for each flowtube size.

Table 2. Mass Flow Rate Range

Flowtube Model	Flowtube Size		Mass Flow Rate Ranges			
			Nominal Mass Flow Rate		Extended Upper Range (a)	
	in	mm	kg/min	lb/min	kg/min	lb/min
CFS10	1/8	3	0.03 to 3.2	0.07 to 7	7	15
	1/4	6	0.09 to 9	0.2 to 20	22	48
	1/2	15	0.4 to 40	0.9 to 90	73	160
	3/4	20	0.9 to 90	2 to 200	119	261
	1	25	1.8 to 180	4 to 400	244	536
	1-1/2	40	4 to 400	9 to 900	607	1335
	2	50	7 to 700	15 to 1500	1023	2250

Table 2. Mass Flow Rate Range (Continued)

Flowtube Model	Flowtube Size		Mass Flow Rate Ranges			
			Nominal Mass Flow Rate		Extended Upper Range (a)	
	in	mm	kg/min	lb/min	kg/min	lb/min
CFS20	1-1/2	40	4 to 400	9 to 900	485	1070
	3	80	18 to 1815	40 to 4000	2040	4500

(a) The extended upper ranges shown above are based on a process fluid specific gravity of 0.8 and a temperature of 212°F (100°C). To find the extended upper range at other specific gravities and temperatures, contact Foxboro.

Process Fluid Density Limits

200 and 3000 kg/m^3 (12.5 and 187 lb/ft^3), or specific gravity limits between 0.2 and 3. Note that a specific gravity of 1 corresponds to a fluid density of 1000 kg/m^3 (62.4 lb/ft^3).

Approximate Mass

Dependent on flowtube size and end connections used. Refer to Table 3.

Table 3. Approximate Flowtube Mass

Flowtube Model	Flowtube Size		With ANSI Class 150 Flanged Ends	With Threaded Ends	With Sanitary Ends
	mm	in			
CFS10	3	1/8	(a)	6.3 kg (13.9 lb)	(a)
	6	1/4	9.6 kg (21 lb)	8.8 kg (19.4 lb)	8.8 kg (19.4 lb)
	15	1/2	11.5 kg (25.5 lb)	10.4 kg (22.9 lb)	10.4 kg (22.9 lb)
	20	3/4	18.5 kg (40.5 lb)	16.7 kg (36.8 lb)	16.7 kg (36.8 lb)
	25	1	22.5 kg (49.5 lb)	(a)	20.3 kg (44.8 lb)
	40	1-1/2	53.4 kg (118 lb)	(a)	49.9 kg (110 lb)
	50	2	77.6 kg (171 lb)	(a)	71.2 kg (157 lb)
CFS20	40	1-1/2	24 kg (53 lb)	(a)	(a)
	80	3	111 kg 244 lb)	(a)	99.3 kg (219 lb)

(a) Not available

Flowtube Internal Fluid Volume

Dependent on flowtube size and end connections used. Refer to Table 4 below.

Table 4. Flowtube Internal Volume

Flowtube Model	Nominal Flowtube Size		Flowtube Internal Fluid Volume			
			With Flanged/Threaded Ends		With Sanitary Ends	
	mm	in	cm^3	in^3	cm^3	in^3
CFS10	3	1/8	18	1.1	(a)	(a)
	6	1/4	67	4	74	5
	15	1/2	321	20	352	21
	20	3/4	1013	62	1111	68
	25	1	1591	97	1630	99
	40	1-1/2	4638	283	4818	294
	50	2	7934	484	8227	502
CFS20	40	1-1/2	2621	160	(a)	(a)
	80	3	10,015	611	9632	588

(a) Not available

Maximum Process Pressure

Dependent on flowtube size, process temperature, and end connections used. The following tables specify the maximum process pressure for either the flowtube size (Table 5) or the type of end connection (Table 6), and a specific process temperature. Interpolation is required for process temperatures between those listed. Use the lesser of the pressures determined from these tables.

Table 5. Maximum Process Pressure in Accordance with Flowtube Size and Process Temperature

Flowtube Size	Process Temperature		Maximum Working Pressure	
	°C	°F	bar	psig
3 and 6 mm (1/8 and 1/4 in)	38	100	207	3000
	100	212	174	2530
	150	302	156	2270
	180	356	148	2144
15, 20, 25, 40, 50 and 80 mm (1/2, 3/4, 1, 1 1/2, 2 and 3 in)	38	100	99	1440
	100	212	84	1215
	150	302	75	1090
	180	356	71	1030

Ambient Temperature Limits

–40 and +85°C (–40 and +185°F)

Process Fluid Temperature Range

See Table 8.

Mechanical Vibration

10 m/s^2 (1 g) at 5 to 40 and 100 to 200 Hz.

Table 6. Maximum Process Pressure in Accordance with Type of End Connection and Process Temperature

Type End Connection	Process Temperature	Maximum Working Pressure	Hastelloy C-22
ANSI Class 150 (AISI Type 316L ss)	100°F 200°F 300°F 356°F	275 psig 240 psig 215 psig 208 psig	290 psig 260 psig 230 psig 217 psig
ANSI Class 300 (AISI Type 316L ss)	100°F 200°F 300°F 356°F	720 psig 620 psig 560 psig 540 psig	750 psig 750 psig 730 psig 719 psig
ANSI Class 600 (AISI Type 316L ss)	100°F 200°F 300°F 356°F	1440 psig 1240 psig 1120 psig 1080 psig	1500 psig 1500 psig 1455 psig 1435 psig
BS 4504 (DN) PN 10/16/25/40 (AISI Type 316L ss)	50°C 100°C 150°C 180°C	40 bar 34.2 bar 30.8 bar 29.3 bar	41.7 37.1 32.9 30.6
Flange to Mate with BS 4504 (1969), PN 100/2	Maximum working pressure is limited by Table 5 or by the User’s End Connection, whichever is less.		
NPT/BS21 R(a)	Maximum working pressure is limited by Table 5.		
Sanitary (Tri-Clamp/ RJT/ISS/DIN)	Maximum working pressure is 10 bar at 25°C (145 psig at 77°F)		

(a) If higher working pressures are required, contact Foxboro Sales.

Electrical Classification

Refer to the Electrical Certification table (see Table 7) for flowtube Electrical Certification. Wiring restrictions required to maintain flowtube Electrical Certification are provided in the

"Wiring" section of this document. Refer to MI 019-121 for transmitter electrical certification information.

Table 7. Electrical Safety Specification

Testing Laboratory, Type of Protection, and Area Classification	Application Conditions	Electrical Safety Design Code
CENELEC intrinsically safe EEx ib for IIB, Zone 1.	Connection to Foxboro Model CFT1.-....EGB/ENB Mass Flow Transmitter. Temperature Class in accordance with process temperature. See Table 8.	EBB
CSA for use in general purpose (ordinary) locations.	Connect to Foxboro Model CFT1.-....CGZ Mass Flow Transmitter.	CGZ
CSA as nonincendive for use in Class I, Division 2, Groups A, B, C, and D, hazardous locations.	Connection to Foxboro Model CFT1.-....CNN Mass Flow Transmitter. Temperature Class T6.	CNN
FM intrinsically safe apparatus for Class I, Division 1, Groups C and D, hazardous locations.	Connection to Foxboro Model CFT1.-....FNS Mass Flow Transmitter. Temperature Class is a function of process temperature. See Table 8.	FBB
FM nonincendive for use in Class I, Division 2, Groups A, B, C, and D locations.	Connection to Foxboro Model CFT1.-....FNN Mass Flow Transmitter. Temperature Class is function of process temperature. See Table 8.	FNN
SAA intrinsically safe Ex ib for Group IIB, Zone 1 explosive atmospheres.	Connection to Foxboro Model CFS1.-....ANS Flow Transmitter. Temperature Class is a function of process temperature. See Table 8.	ABB

NOTE: These flowtubes have been designed to meet the electrical classifications listed in the table above. For detailed information or status of the agency approval, contact Foxboro.

Table 8. Process Medium Temperature Range in Accordance with Flowtube Size and Electrical Certification Code

Flowtube Model	Flowtube Size		Process Medium Temperature Range for Electrical Certification Code	
	mm	in	CGZ, CNN, and FNN	ABB, EBB, and FBB
CFS10	3	1/8	–130 to +180°C (–328 to +356°F)	–130 to +180°C (–328 to +356°F)
	6	1/4	–200 to +180°C (–328 to +356°F)	–150 to +180°C (–238 to +356°F)
	15	1/2	–200 to +180°C (–328 to +356°F)	–200 to +180°C (–328 to +356°F)
	20	3/4	–200 to +180°C (–328 to +356°F)	–200 to +180°C (–328 to +356°F)
	25	1	–200 to +180°C (–328 to +356°F)	–50 to +180°C (–58 to +356°F)
	40	1-1/2	–200 to +180°C (–328 to +356°F)	–50 to +140°C (–58 to +284°F)
	50	2	–200 to +180°C (–328 to +356°F)	–50 to +140°C (–58 to +284°F)
CFS20	40	1-1/2	–200 to +180°C (–328 to +356°F)	–50 to +140°C (–58 to +284°F)
	80	3	–200 to +180°C (-328 to +356°F)	–50 to +140°C (–58 to +284°F)

NOTE: If the flowtube has been ordered for applications below –130 °C (–202 °F), and is now to be used above –130 °C (–202 °F), or vice versa, new Flow C1 and Flow C3 factors may be required to be keyed into the transmitter. Contact Foxboro Sales for assistance.

2. Installation

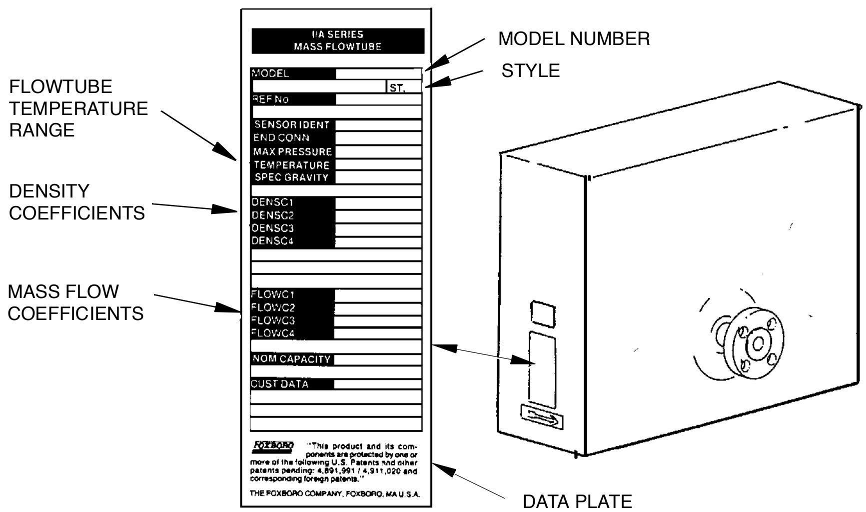

Figure 1. Data Plate Location and Flowtube Identification

NOTE: Before installing flowtube, copy the following information from the flowtube data plate (see Figure 1): Model Number, Sens. ID, Dens C1, Dens C2, Dens C3, Dens C4, Dens C5 (if provided), Dens C6 (if provided), Flow C1, Flow C2, Flow C3, Flow C4, Nom Cap, TP COR S (if provided), and TP COR O (if provided). This information will be required when programming the transmitter.

Moving the Flowtube

Care must be exercised when moving the flowtube to avoid personal injury and prevent damage to the flowtube and integral cable extending from flowtube. Refer to the following recommendations for proper handling and support of the flowtube.

- Before removing flowtube from shipping container, move flowtube as close to the installation location as possible.
- Smaller flowtubes may be removed from the shipping container and installed between the upstream and downstream pipe connections by hand lifting and carrying. However, to avoid personal injury and/or damage to the flowtube, larger flowtubes must be lifted and restrained as shown in Figure 2. Note that in addition to using the upstream and downstream connections, the flowtube must also be restrained at both sides to prevent rotation as the flowtube is lifted.

CAUTION: Do not lift or support by junction box or cable.

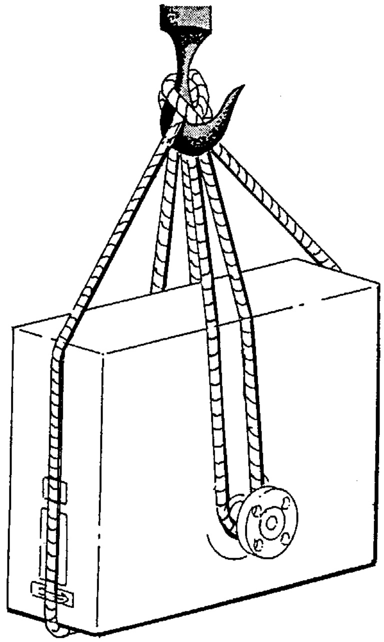

Figure 2. Support Required when Moving a Flowtube

Mounting Considerations

- The flowtube and cable should be mounted no closer than 3 m (10 ft) from any motor, speed controller, large transformer, or power contactor.
- Standard practice is to mount the flowtube on a horizontal pipe as shown in Figures 3, 4, and 6. *For self-draining, or if process fluid contains gas bubbles, the flowtube should be mounted on a vertical pipe as shown in Figures 5 and 6.*

NOTE: Performance and operation are not affected by the orientation of the flowtube, except that when vertical mounting is used, flow must be upward through the flowtube.

- When required by the process application, the flowtube may be heat traced or insulated with a lightweight material.

CAUTION: The flowtube case must not be pierced. The interior is filled with an inert gas pressurized at 70 kPa (10.15 psia).

DANGER: If the process fluid is a gas at ambient conditions, but is in the liquid state due to line pressure, the flowtube must be enclosed in a containment unit. In the event of a break in the flowtube, increasing pressure inside the flowtube case may cause the case to burst. Failure to comply with this warning could result in severe injury or death.

Mounting Procedure

The flowtube may be mounted horizontally or vertically as shown in Figures 3 through 6. When mounted vertically (as in self-draining applications), the direction of flow must be upward to minimize the incidence of trapped air. All of the following steps apply to both horizontal and vertical mounting.

1. Determine the face-to-face distance between the flowtube end connections. Refer to “Reference Documents” on page 1 for Dimensional Prints.
2. Fabricate end connections to pipe.
3. Provide upstream and downstream flowline supports. Supports may extend from floor, ceiling, or wall, as convenient, but should not be firmly secured to the pipeline at this time. Refer to Figure 7 on page 14 for types of recommended pipeline supports. Note that “rest type” supports should not be used for flowtube sanitary connection types L, M, N, and P.

NOTES:

1. Each support must contact flowline as close to the junction of pipe and flowtube enclosure as practically possible. For flowtubes with flanged end connections (Figure 3 and Figure 5), the distance between each support and the junction must not exceed 15 inches.

2. For sanitary flowtube end connections L, M, N, and P, and if flowtube size is 15 mm (1/2 in) or greater, additional supports must be positioned between the flowtube enclosure and the junction of flowtube and pipeline.

3. All supports must provide a minimum of 25 mm (1 in) of axial length of surface contact.

4. A filter is recommended on the smaller line sizes to minimize problems with dirt particles introduced during installation.

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4. Move flowtube into position between flow line end connections. Arrow on flowtube must be pointing in direction of flow.
5. Align flowtube and flowline end connections. Secure flowtube to flowline in accordance with the codes described on page 14 through page 16.

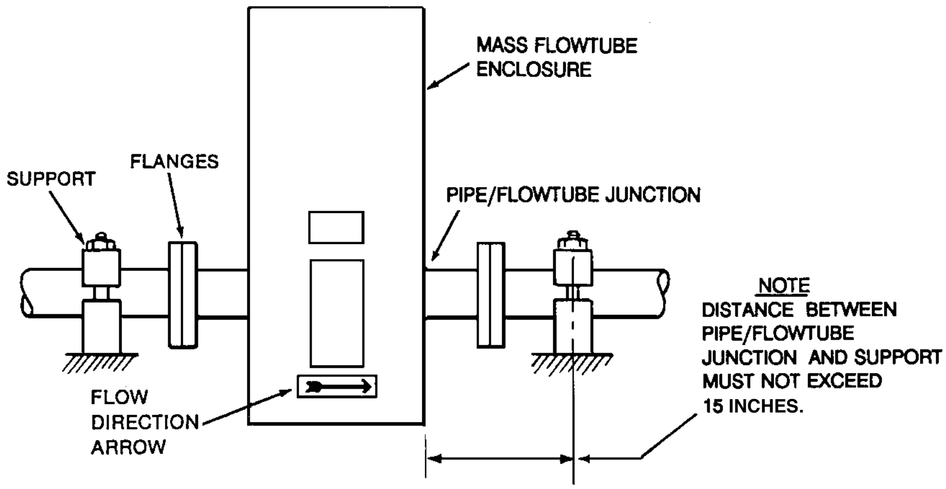


Figure 3. Flowtube Mounting with Flanged End Connections - Horizontal Pipeline

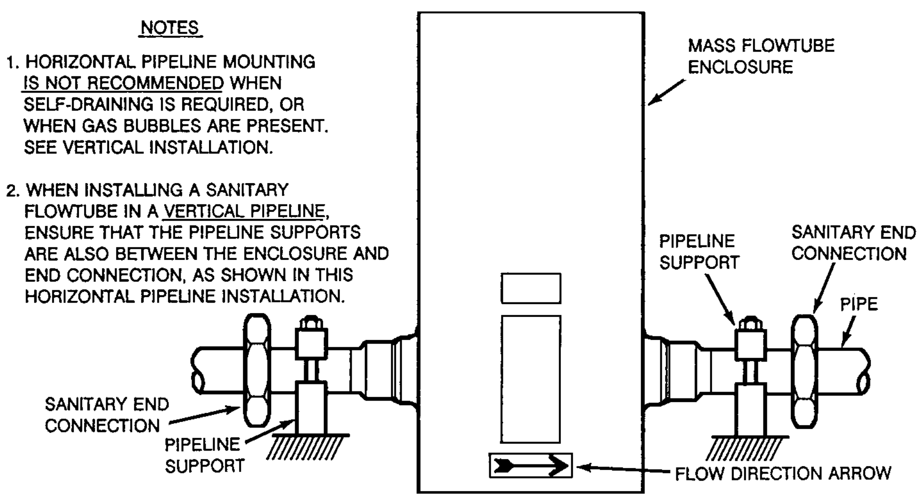


Figure 4. Flowtube Mounting with Threaded or Sanitary End Connections - Horizontal Pipeline

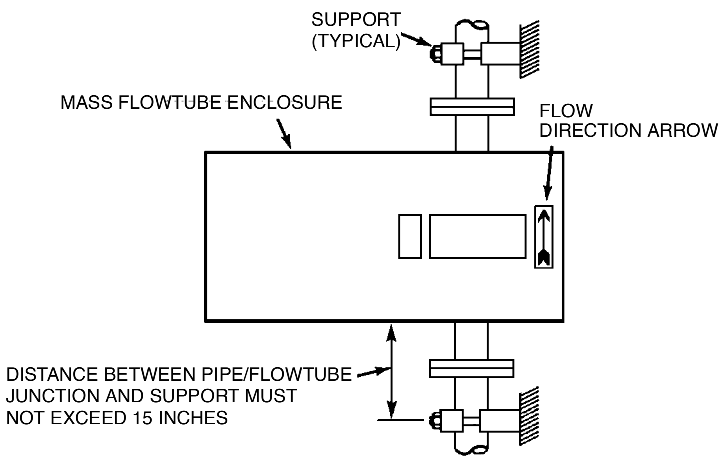


Figure 5. Flowtube Mounting with Flanged End Connections - Vertical Pipeline

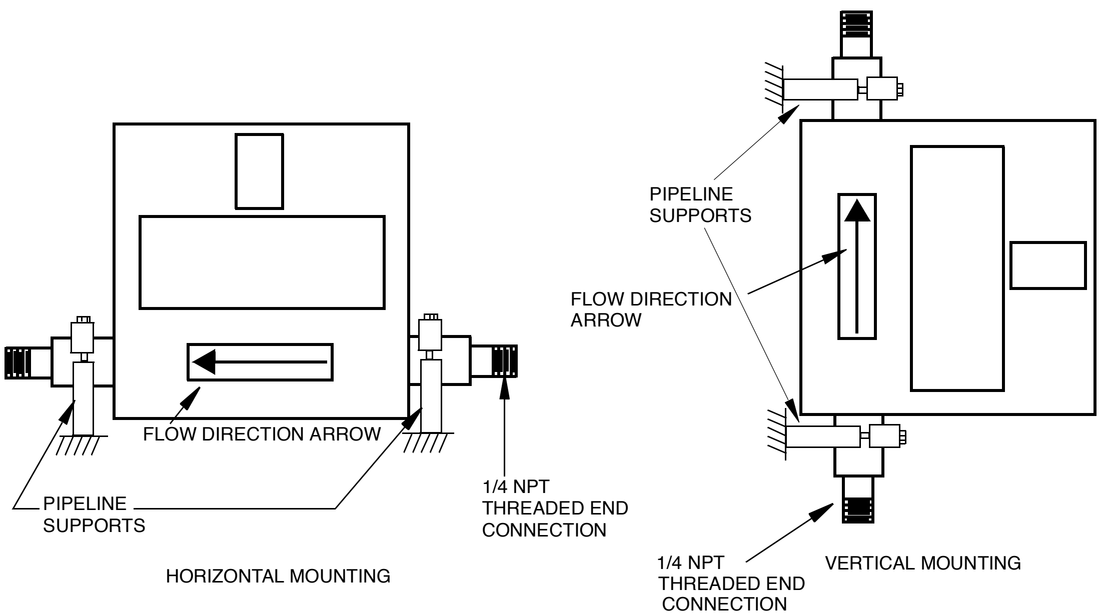


Figure 6. 3 mm (1/8-inch) Flowtube Mounting

CAUTION: Flowtube CFS10-02 (1/8-inch) must be mounted with pipeline supports inside of threaded ends, as shown in Figure 6.

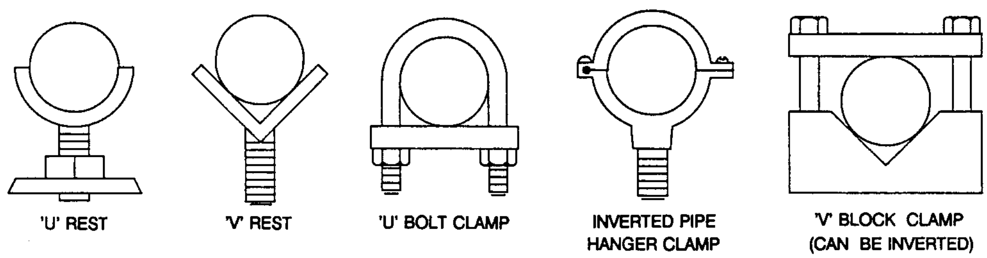


Figure 7. Recommended Pipeline Supports

Code A and B, Threaded End Connections

1. Apply process compatible thread sealant to threaded flowtube end connection.
2. Secure threaded pipe adapter to flowtube threaded end connection.
3. Secure pipeline end of adapter to pipeline.
4. Tighten hardware to secure flowline to supports.

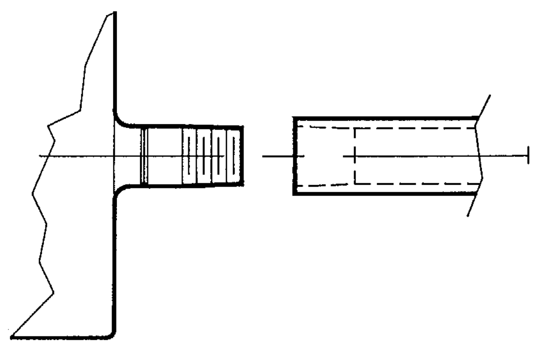


Figure 8. Code A and B, Threaded End Connections

Code C, D, E, F, and J, Flanged End Connections

Refer to current pipe flange and fitting standards for proper gasket dimensions.

1. Insert lower mounting bolts (2 for 4-hole flanges, or 4 for 8-hole flanges).
2. Position gasket between flanges.
3. Insert remaining mounting bolts.
4. Add washers and nuts to all bolts and hand tighten only.
5. Secure meter by tightening nuts in uniform steps, working from nut to opposite nut.
6. Tighten hardware to secure pipeline to supports.

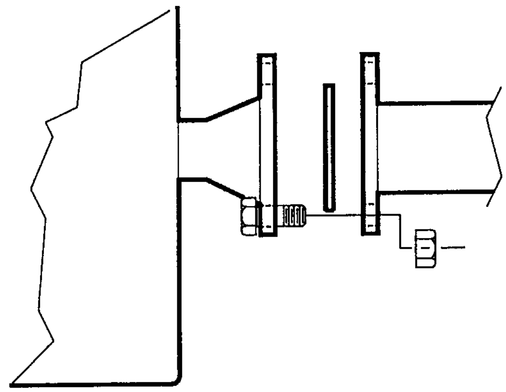


Figure 9. Code C, D, E, F, and J, Flanged End Connections

Code P, Quick Disconnect End Connection

1. Insert seal into each flowtube end connection.
2. Make full face contact between the flowtube end connection and the pipeline end connection.

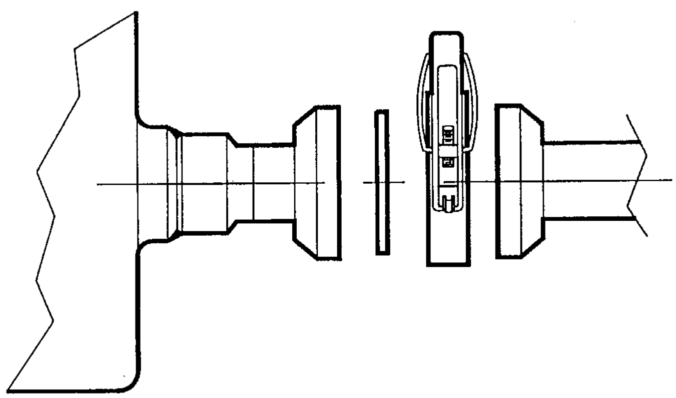


Figure 10. Code P, Quick Disconnect End Connection

3. Position clamp over mating surfaces of flowtube end connection and pipeline end connection and press clamp closed.
4. Tighten hardware to secure flowtube and pipeline to supports.

Code L, RJT Coupling End Connection

1. Insert seal into cavity in each flowtube end connection.
2. Bring pipeline end connection into full contact with flowtube end connection and tighten nut on pipeline end connection securely.
3. Tighten hardware to secure flowtube and flowline to supports.

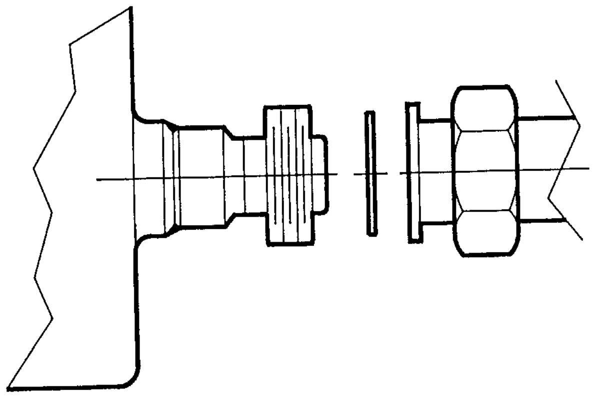


Figure 11. Code L, RJT Coupling End Connection

Code M, ISS/IDF Coupling End Connection

1. Position seal on each flowtube end connection.
2. Bring pipeline end connection into full contact with flowtube end connection and tighten nut on pipeline end connection securely.
3. Tighten hardware to secure flowtube and pipeline to supports.

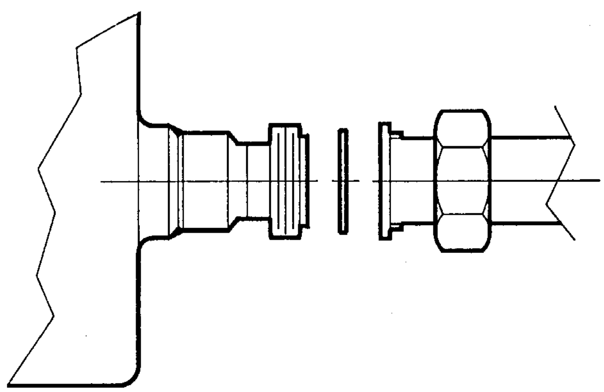


Figure 12. Code M, ISS/IDF Coupling End Connection

Code N, DIN Coupling End Connection

1. Insert seal into groove in each flowtube end connection.
2. Bring pipeline end connection into full contact with flowtube end connection and tighten nut on pipeline end connection securely.
3. Tighten hardware to secure flowtube and flowline to supports.

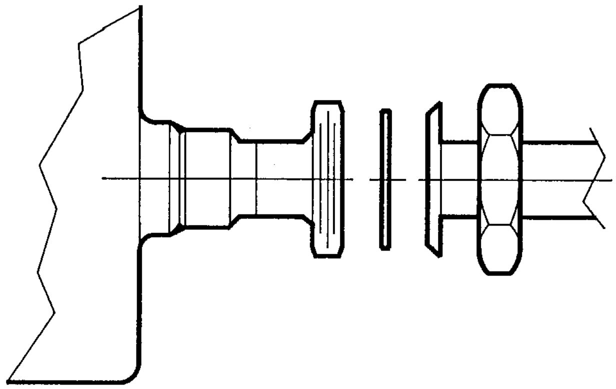


Figure 13. Code N, DIN Coupling End Connection

3. Custody Transfer System

The Custody Transfer System is specified as *Option -T*. (Contact Foxboro Sales for availability.)

Overview

For applications that require accurate measurement of the weight (mass) of liquid products transferred between a supplier and a purchaser, Foxboro offers a custody transfer system (Option -T) that conforms to all applicable NIST Handbook 44 specifications. At present, this system is available only in the United States.

The Foxboro sanitary bulk liquid receiving systems provide each processor with an accurate and reliable means of measuring incoming inventory.

As illustrated in Figure 14, the basic system components are:

1. Tank truck outlet valve
2. Centrifugal pump
3. Air eliminator
4. Air vent tube
5. Flowmeter
6. Check valve

Options available with the system are:

1. Electronic Totalizer
2. Ticket Printer

Related Documents

Related U.S. Government publications are:

Document	Title
NIST Publication 14	National Type Evaluation Program Administrative Procedures, Technical Policy, Checklists, and Test Procedures
NIST Handbook 44	Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices
NIST Special Publication 16	Program and Committee Reports for the National Conference on Weights and Measures
NIST Special Publication 791	State Weights and Measures Laboratories: State Standards Program Description and Directory

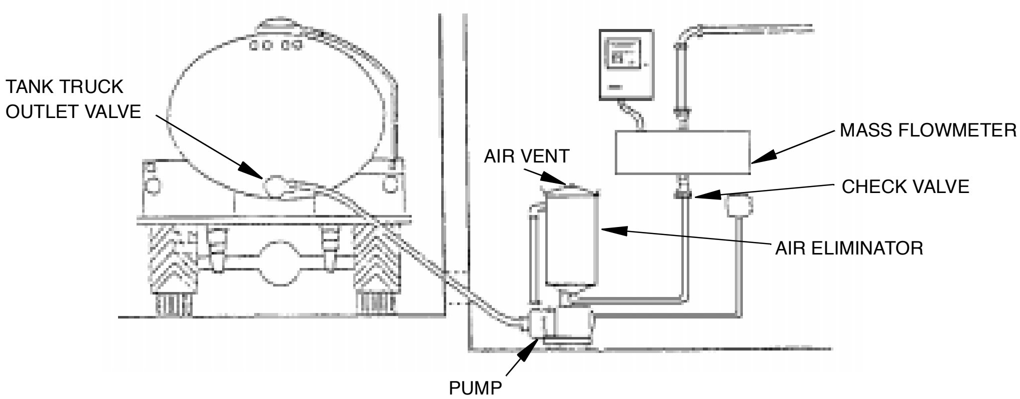


Figure 14. Typical Custody Transfer System

Tank Truck Outlet Valve

This is a quick-disconnect shutoff valve that provides on/off control of flow of liquid from the truck to the custody transfer system.

Pump

This centrifugal pump moves the liquid from truck through the flowmeter to the receiver.

Air Eliminator

The air eliminator, as the name implies, removes entrained air from the liquid. This is most important near the end of an unloading sequence as the truck becomes nearly empty. This unit functions by slowing the flow of the liquid, allowing time for entrained air to rise to the surface and out the float-operated air vent.

Air Vent Tube

This vent, which is part of the air eliminator unit, is float operated — when enough air collects, the float drops, opening the vent valve and allowing the air to escape to atmosphere.

Flowmeter

The flowmeter will be either the CFS10 or CFS20 I/A Series Mass Flowmeter, as described in this document. The meter measures the mass of liquid transferred between Seller and Buyer.

Note that the transmitter can be specified for either pipe or surface mounting.

Check Valve

The function of the check valve is to prevent the backward flow of liquid.

Options

Other options available with the system are:

1. *Electronic Totalizer*
   This instrument provides a continuous remote display of the mass of product transferred and includes a manual reset pushbutton.
2. *Ticket Printer*
   This instrument provides an official printed record of custody transfer in multi-part form.

Installation and Operation Prerequisites

1. The flowtube and transmitter must be calibrated together over a flow range of 1% to 90%.
2. The transmitter door assembly and display window must be sealed by a local department of weights and measures or an NIST official.
3. A NIST approved Certificate of Conformance will be supplied by Foxboro.

4. Wiring

The installation and wiring of the flowtube must conform to local code requirements. If the flowtube is classified intrinsically safe (refer to model number), it also must conform to national standards for installation of intrinsically safe equipment in potentially hazardous areas. Refer to Figure 15 for installation of CSA certified (CNN) Mass Flowmeter Systems in Class I, Division 2 hazardous locations.

DANGER: If the flowtube is classified intrinsically safe, connect the ground (potential equalizing) terminals on the flowtube and the transmitter (see MI 019-121) to the building signal ground reference point with a dedicated wire of 12 AWG or larger. The total resistance of the ground path must not exceed one ohm. Note that this is in addition to the transmitter ac power ground. The intrinsic safety of the flowtube and interconnecting wiring is dependent on making this connection.

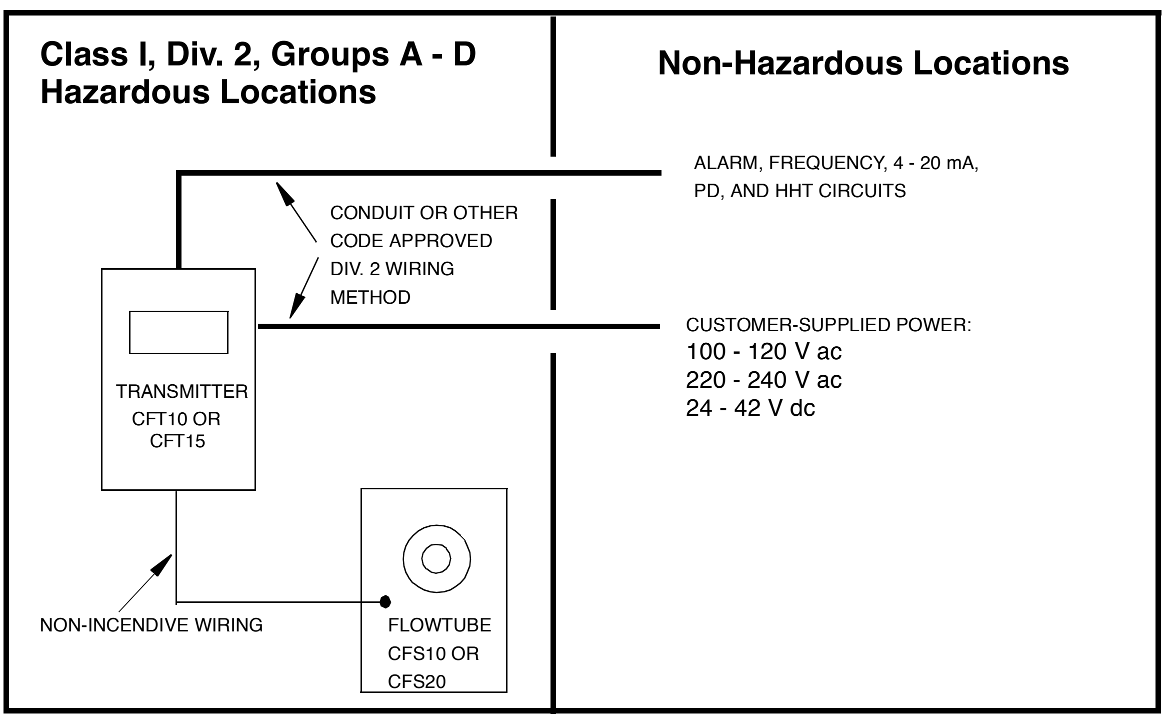


Figure 15. Loop Diagram for CSA Certified (CNN) Systems

General Information

Style A Flowtubes

Permanently attached to each Style A flowtube is a 3/4 NPT female conduit fitting and a wide temperature range FEP insulated and jacketed 5 m (16 ft) pigtail signal cable, prepared for direct connection to the transmitter. The maximum temperature to which this cable may be subjected is 150°C (302°F). If an extension cable is to be connected to a Style A flowtube classified intrinsically safe, a junction box constructed to conform to intrinsically safe requirements, including a separation between conductors of at least 6 mm (0.236 in), must be used. Additionally, for European applications, the junction box must also have a mechanical degree of protection of at least IP54 for outdoor application or IP20 for indoor applications.

Style B Flowtubes

Mounted on each Style B flowtube is an electrical junction box and cover meeting NEMA 4X and IP54 requirements, fitted with a 3/4 NPT female cable entrance. Contained within the junction box are a pair of 6-position feedthrough type screw terminal blocks (properly spaced for intrinsic safety) which are prewired to the flowtube. Signal cable is not supplied with Style B flowtubes, but can be purchased separately (Foxboro Part No. KFS1, KFS2). For flowtube case insulation or steam jacket application, sufficient wire is contained within the junction box to facilitate extension.

Style A and B Flowtubes

Color-coded, single-shielded PVC insulated and double-shielded FEP insulated twisted pair signal cable in specific lengths to 300 m (1000 ft) is available from Foxboro. One end of this cable is prepared for direct connection to the transmitter. The PVC cable can be used for most applications within an ambient temperature range of -20 to 80°C (-4 to 176°F). The FEP cable is suitable for ambient temperatures from -40 to 85°C (-40 to 185°F). If cable other than that supplied by Foxboro is installed, the use of individually shielded 6 twisted pair signal cable of 22 AWG or larger (Belden #8778) is recommended. The total cable length from transmitter to flowtube must not exceed 300 m (1000 ft).

CAUTION: Do not route signal cable close to power cables or equipment that can produce a large magnetic field.

If conduit is to be used, install a watertight conduit connector and drip loop at the junction box (Style B) or cable entrance (Style A) to prevent collection of condensate. If conduit is not used, a watertight cable grip is required. Teflon thread sealant on the connector threads is recommended to reduce the risk of galvanic corrosion.

If rigid conduit is used, the length extending from the conduit fitting must not exceed 0.3 m (12 in). This conduit must not be subjected to additional mechanical loading or attachment. If additional protection is required, flexible armored sheathing is recommended. If the process temperature of a Style A flowtube is below -60°C (-76°F), the cable must be enclosed.

Junction Box Extension (Style B)

The normal clearance between the rear of the junction box and the flowtube case is 0.5 inch (12.7 mm). To accommodate a steam jacket or case insulation, this distance may be increased to 4.00 inches (101.6 mm). A kit for this purpose is available (Foxboro Part No. G0117HZ) consisting of a 3/4 NPT Schedule 40 stainless steel pipe coupling, 2-1/2 inch long nipple and thread sealant (see Figure 16).

CAUTION: Foxboro does not recommend junction box extension without the addition of a steam jacket or case insulation.

To promote heat dissipation at elevated operating temperatures, maintain a space of at least 0.5 inch (12.7 mm) between the rear of the junction box and the case insulation or steam jacket.

Procedure for Installing Junction Box Extension

1. Remove the junction box cover.
2. Loosen the terminal block wiring screws and disconnect the flowtube wiring. Ensure that the wire pairs remain twisted to facilitate identification.
3. Unscrew and remove the junction box from the flowtube using a suitable tool (such as a length of pipe inserted in the conduit entrance). Remove all thread sealant residue.
4. Apply sealant to all male threads.
5. Insert the flowtube wiring through the coupling, nipple, and base of junction box and engage the threads.
6. Tighten the assembly, locating the conduit entrance as desired.
7. Reconnect the flowtube wiring to the appropriate terminals (see Figure 17) and tighten the screws.

CAUTION: No bare wire should be visible at the terminals. Ensure that the wire insulation has not prevented electrical contact.

8. Dress excess flowtube wire within the junction box as necessary.

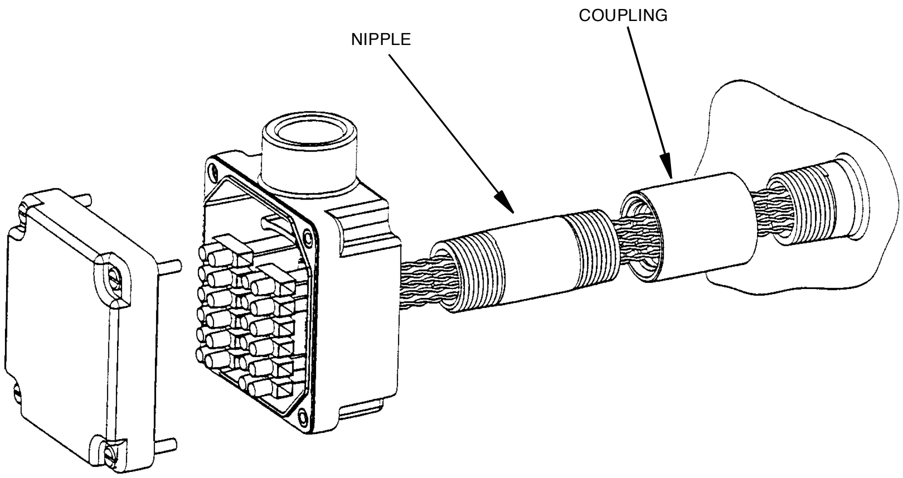


Figure 16. Junction Box Extension (Style B)

Signal Cable Preparation

If conduit is to be used, run the unprepared end of the cable through the conduit from the transmitter.

Flowtube End

1. Cut the flowtube end of the cable to length and strip back the jacket approximately 127 mm (4 in).
2. Separate the twisted pair conductors from their wrappers, shields, and drain wires. The wire pairs should remain twisted for ease of identification.
3. Trim the shields, wrappers, and drain wires back to the jacket interface.
4. Strip the ends of the conductors 6 mm (1/4 in).

Transmitter End (Customer Supplied Cable)

Follow Steps 1, 2, and 4 above. Trim shields and wrappers back to the jacket interface. Tightly twist together (2 to 4 turns) the six individual twisted pair drain wires at a point close to the jacket interface. Trim all but one drain wire close to the twist. Solder the twisted wire area, creating a single drain wire. Appropriately insulate the drain wire and soldered connection to prevent shorting. Refer to MI 019-121 for transmitter wiring instructions.

Extension Cable Wiring (Style A)

The extension cable wiring supplied by Foxboro (and the optional Belden #8778 cable) is color coded for easy pair identification. To facilitate wire identification, ensure that the proper wire pairs remain twisted as the black wires are not common. Carefully match the wire pairs of each cable by color. Connect the two common shield wires. Ensure that all connections provide both electrical and mechanical integrity. Refer to MI 019-121 for transmitter wiring instructions.

Flowtube Wiring (Style B)

1. Remove the junction box cover and insert the prepared cable end through either a cable grip or conduit connector. Route the paired wires to the proper terminal block. To facilitate wire identification, ensure that the proper wire pairs remain twisted as the black wires are not common.
2. Insert the ends of the individual wires into the appropriate terminal block openings, carefully matching the wire color pairs of the cable to the wire color pairs of the flowtube (see Figure 17). Tighten the screws. No bare wire should be visible. Dress the wiring and secure the cover to the junction box. Refer to MI 019-121 for transmitter wiring instructions.

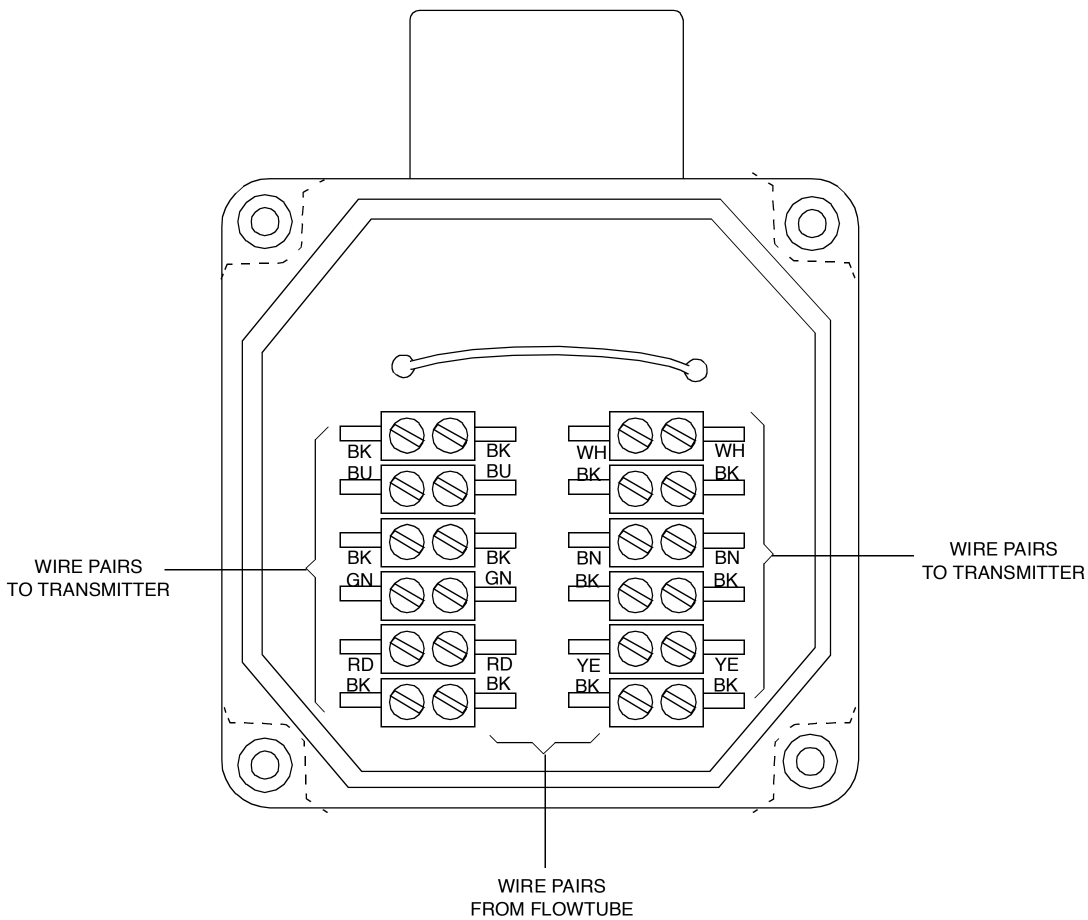


Figure 17. Style B Terminal Box Wiring Color Orientation

5. Startup

Filling the Flowtube

Filling of the flowtube requires a period of continual flushing to remove all air from flowtube. Proceed as follows:

1. Slowly fill the flowtube, avoiding hydraulic shock to flowmeter and associated piping.
2. Flush at highest possible flow rate within operating range for a minimum of five minutes. Flushing rate must be above 2 ft/sec.

Zeroing

1. Close valves to ensure zero flow.
2. Allow 30 seconds minimum for flow to settle at zero.

Flowtube is now ready for zeroing with the Model CFT10/15 Transmitter. If zeroing from the transmitter keypad, refer to MI 019-122. If zeroing from Hand-Held Terminal (HHT), refer to MI 019-123. If zeroing with the PC10 Configurator, refer to MI 020-479. If elapsed time between flushing and zeroing exceeds 10 minutes, the flowtube must be flushed again for five minutes and the zeroing procedure repeated.

NOTE: Flowtube must remain full with process fluid to maintain accurate, repeatable results. In applications where flowtube is frequently emptied or partially emptied and refilled, flowtube must be properly filled, avoiding hydraulic shock. Rezeroing is not generally required.

6. Maintenance

Sanitary End Connection Couplings

For flowtubes using 3A sanitary service, temperature fluctuations within the process can cause couplings and seals to loosen. Process flowtube connections should be routinely checked.

Cleaning the Flowtube

The flowtube must be cleaned at intervals dictated by the properties of the process fluid or industry requirements. If the flowtube is to be removed for cleaning, proceed as follows:

1. Open or close valves as required to isolate flowtube from process.
2. Drain flowtube using appropriate venting procedures.

CAUTION: A significant amount of liquid is retained in a horizontally mounted flowtube. When draining, adequately support the flowtube to compensate for any abrupt weight shift.

3. Disconnect flowtube from pipe.
4. Flush as required.

CAUTION: When cleaning a flowtube, be sure that the flow, pressure, and temperature ratings of flowtube are not exceeded. BE SURE THAT POWER IS DISCONNECTED FROM FLOWTUBE DURING CLEANING PROCESS.

5. Return flowtube to operation.

Flowtube Repair

The flowtube is not field repairable. For troubleshooting and assistance, refer to the flow charts in the appendix.

If problems arise, contact Foxboro TAC (Technical Assistance Center) using the toll free number 1-888-FOXBORO (1-888-369-2676). TAC personnel will assist with troubleshooting issues and determine causes of problems. If the flowtube or transmitter issue cannot be solved via telephone interaction, the instrument will have to be returned to The Foxboro Company for evaluation and repair.

Prior to shipping the instrument, a return authorization number must be issued. The service department representative will assist in providing this information. In addition, it is imperative that the internal structure of the flowtube be thoroughly cleaned and degreased prior to shipping. A letter (signed by a process engineer/manager) stating that cleaning was performed, as well as MSDS sheets stating the plant process fluid used, must accompany the returned flowtube.

Appendix A.

Pressure Calculations

Prior to filling and zeroing the flowtube, the required minimum back pressure and pressure loss across the flowtube must be calculated, using the procedures in the following sections. Refer to Table 9 for the meanings of all symbols appearing in equations. Note that symbols with asterisks denote S.I. units.

NOTE: These equations are valid for Newtonian fluids only. For non-Newtonian fluids, contact Foxboro Sales.

For additional information, refer to *Flow Measurement Engineering Handbook* by R.W. Miller. This handbook is available from Foxboro as Part Number B0150YW.

Table 9. Symbology and Meaning

U.S. Customary		S.I.		Description
Symbol	Units	Symbol	Units	
A	ft^2	A*	m^2	Flowtube inside bore area (see Table 10 on page 40).
d	ft	d*	m	Inside diameter of flowtube (see Table 10 on page 40).
F_L	-	F_L	-	Friction factor, dimensionless ratio used in calculations when Reynolds Number is below 2000 (laminar flow).
F_T	-	F_T	-	Dimensionless ratio used in calculations when R_D is above 2000 (turbulent flow).
g	32 ft/s^2	g*	9.8 m/s^2	Standard acceleration due to gravity.
G_F	-	G_F	-	Specific gravity (relative density) of process fluid.
K_{TUBE}	-	K_{TUBE}	-	Dimensionless factor based on flowtube geometry (refer to Table 10 on page 40).
P_G	psig	P^*_G	kPa	Minimum required back pressure (process pressure at flowtube outflow).
ΔP	psi	ΔP^*	kPa	Pressure Loss (DP) across flowtube.
q_{URV}	lb/m	q^*_{URV}	kg/m	Process fluid mass flow rate upper range value (URV).
R_D	-	R_D	-	Reynolds Number of process fluid.
R_{DW}	-	R_{DW}	-	Reynolds Number of water at velocity corresponding to process fluid mass flow upper range value.
μ_{cP}	centipoise	μ_{cP}	centipoise	Process fluid absolute viscosity.

Table 9. Symbology and Meaning (Continued)

U.S. Customary		S.I.		Description
Symbol	Units	Symbol	Units	
ρ_F	lb/ft^3	$\rho*_F$	kg/m^3	Density of process fluid (for mixture, use highest density of single component in mix).
ρ_W	62.4 lb/ft^3	$\rho*_W$	1000 kg/m^3	Density of water at reference conditions.
V_P	ft/s	$V*_P$	m/s	Process fluid maximum velocity.
P_V	psia	$P*_V$	kPa	Vapor pressure of process fluid (for mixture, use highest vapor pressure of single component in mixture at maximum process temperature).
P_{ATM}	psia	$P*_{ATM}$	kPa	Atmospheric pressure (barometric pressure at flowtube location).

Minimum Back Pressure Calculations

Before putting the flowtube into operation, the minimum back pressure (process pressure at flowtube outflow) that must be maintained by the user must be calculated. This back pressure is required to assure that cavitation will not occur within the system. Cavitation is the boiling of the process fluid when decreased line pressure reaches the vapor pressure of the process fluid. The formation and collapse of vapor cavities can cause severe erosion of the flowtube and downstream piping.

Use the appropriate equation below to determine the minimum back pressure.

S.I. Units:

$$P*_G = (0.3\Delta P*) + P*_V - P*_{ATM}$$

U.S. Customary Units:

$$P_G = (0.3\Delta P) + P_V - P_{ATM}$$

Pressure Loss Calculations

The user must provide sufficient line pressure to maintain the desired flow velocity despite the pressure loss due to flowtube.

The calculations to be used to determine the pressure loss across the flowtube depend on whether the process fluid viscosity is between 0.7 and 1.9 centipoise (cP), or below 0.7 or above 1.9 cP. Refer to the following sections.

Calculating Pressure Drop when Fluid Viscosity is below 0.7 or above 1.9 cP and Reynolds Number is above 2000

Pressure loss is found by dividing the pressure drop determined from Table 18 or Table 19 by the specific gravity (relative density) of the process fluid. Proceed as follows.

1. Refer to the appropriate figure and find the pressure drop corresponding to user's mass flow rate operating point.

   If unknown, the specific gravity (G_F) of the process fluid may be calculated using the appropriate equation below:

S.I. Units:

$$G_F = \frac{\rho^*_F}{\rho^*_W}$$

U.S. Customary Units:

$$G_F = \frac{\rho_F}{\rho_W}$$

2. Apply the pressure drop found in Figure 18 or Figure 19 and the process fluid specific gravity (GF) to the appropriate equation below to find the pressure loss (ΔP) across the flowtube.

S.I. Units:

$$\Delta P^* = \frac{\Delta P^*_{CURVE}}{G_F^*}$$

U.S. Customary Units:

$$\Delta P = \frac{\Delta P_{CURVE}}{G_F}$$

Calculating Pressure Drop when Fluid Viscosity is below 0.7 or above 1.9 cP and Reynolds Number is below 2000

Calculate Reynolds Number (R_D) of the process fluid using the appropriate formula below and referring to Table 9 for definition of symbols.

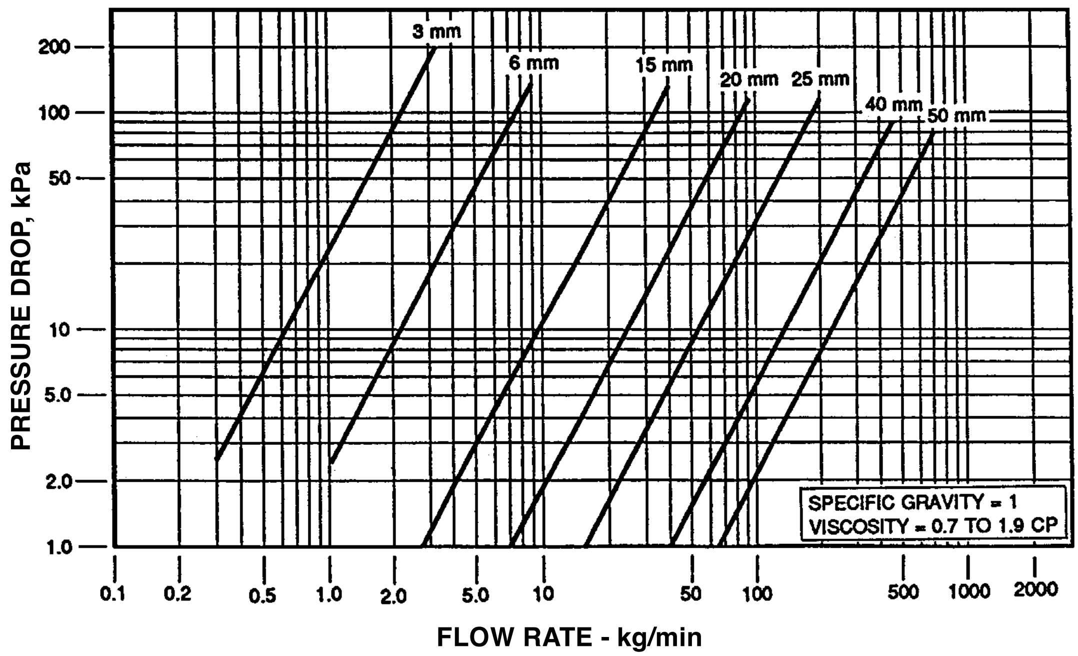
S.I. Units:

$$R_D = \frac{21.3439}{(\mu_{cP})(d^*)} q^*_{URV}$$

U.S. Customary Units:

$$R_D = \frac{31.589}{(\mu_{cP})(d)} q_{URV}$$

Depending on whether the Reynolds number is above or below 2000, refer to appropriate section that follows to calculate pressure loss across flowtube.



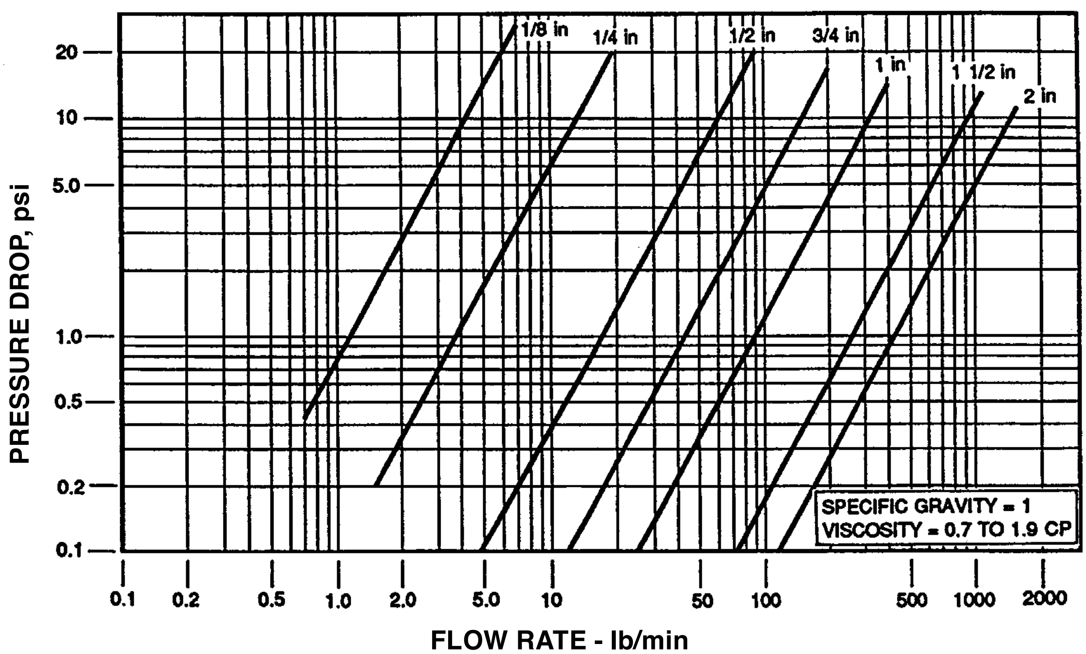
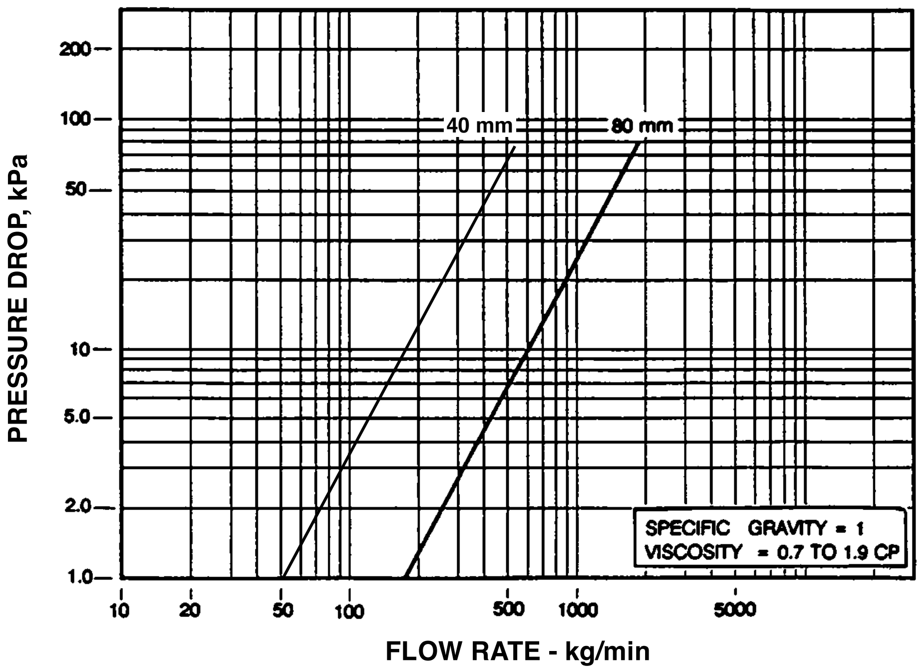


Figure 18. Determination of Pressure Loss - CFS10



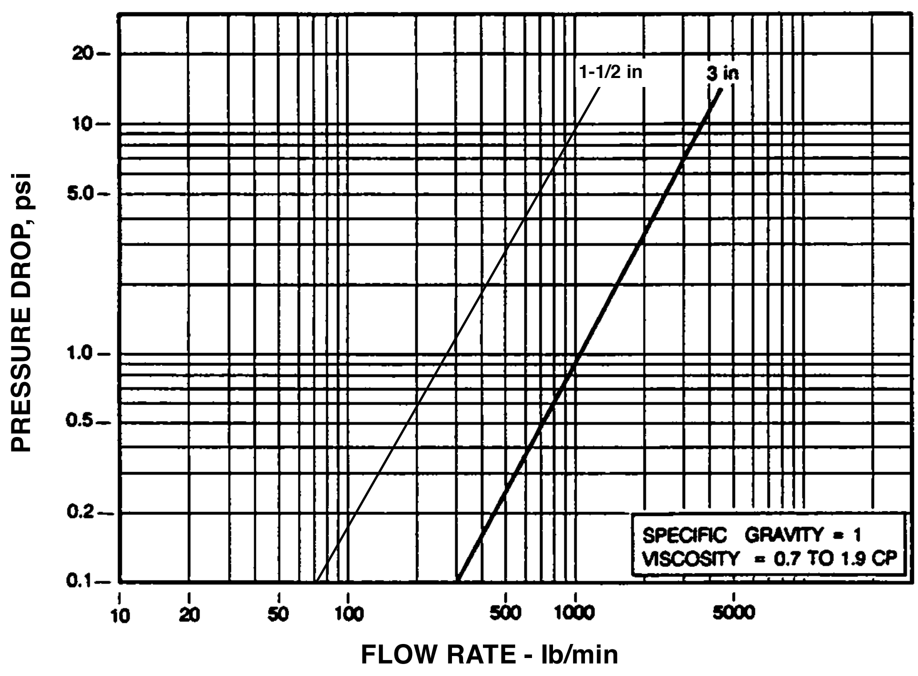


Figure 19. Determination of Pressure Loss - CFS20

Determination of Pressure Loss when Reynolds Number is Calculated to be above 2000

1. Calculate the maximum process fluid velocity (V_P) using the appropriate formula below and parameters from Table 9 and Table 10.

S.I. Units:

$$V*_P = \frac{q*_{URV}}{60\rho*_F A*}$$

U.S. Customary Units:

$$V_P = \frac{q_{URV}}{60\rho_F A}$$

2. Using the maximum process fluid velocity from Step 1, and the flowtube diameter *d* from Table 10, calculate the Reynolds Number for water (R_{DW}) at the same velocity, using the appropriate equation below.

S.I. Units:

$$R_{DW} = 1 \times 10^6 V*_P d*$$

U.S. Customary Units:

$$R_{DW} = (9.2857 \times 10^4) V_P d$$

3. If unknown, calculate the specific gravity (relative density) (G_F) of the process fluid using the appropriate equation below.

S.I. Units:

$$G_F = \frac{\rho*_F}{\rho*_W}$$

U.S. Customary Units:

$$G_F = \frac{\rho_F}{\rho_W}$$

4. Determine the ratio (F_T) of the pressure loss of process fluid relative to water, at the same velocity and over the same distance using the equation below.

$$F_T = \frac{[(1.8)(LnR_{DW}) - (1.64)]^2}{[(1.8)(LnR_D) - (1.64)]^2} G_F$$

5. Refer to Figure 18 or Figure 19 and find the pressure drop (ΔP_{CURVE}) corresponding to user's mass flow rate operating point.
6. Pressure loss across flowtube for user's application is found using the following equation:

S.I. Units:

$$\Delta P* = \frac{F*_T}{(G*_F)^2}\Delta P*_{CURVE}$$

U.S. Customary Units:

$$\Delta P = \frac{F_T}{(G_F)^2}\Delta P_{CURVE}$$

Determination of Pressure Loss when Reynolds Number is Calculated to be below 2000

1. Calculate the maximum process fluid velocity (V_P) using the appropriate formula below and Table 8.

S.I. Units:

$$V*_P = \frac{q*_{URV}}{60\rho*_F A*}$$

U.S. Customary Units:

$$V_P = \frac{q_{URV}}{60\rho_F A}$$

2. Using the Reynolds Number, calculate the friction factor (F_L) of flowtube using the appropriate formula below.

S.I. Units:

$$F_L = \frac{64}{R*_D}$$

U.S. Customary Units:

$$F_L = \frac{64}{R_D}$$

3. Find K_{TUBE} value corresponding to flowtube size from Table 10.
4. Calculate differential pressure (ΔP) using appropriate equation below and Table 10.

S.I. Units:

$$\Delta P^* = 10.386 \times 10^{-4}(F^*_L)(K_{TUBE})(V^*_P)^2(\rho^*_F) = kPa$$

U.S. Customary Units:

$$\Delta P = 2.156 \times 10^{-4}(F_L)(K_{TUBE})(V_P)^2(\rho_F) = psi$$

Table 10. Flowtube Characteristics

Flowtube Model	Flowtube Size		K_{TUBE}	d (ft)	d* (m)	A (ft^2)	A* (m^2)	Wall Thickness	
	mm	in						mm	in
CFS10	3	1/8	372	0.01230	0.003746	0.000151	0.0000110	0.51	0.020
	6	1/4	333	0.02025	0.006172	0.0003222	0.0000299	0.89	0.035
	15	1/2	192	0.03867	0.011786	0.0011736	0.0001090	1.24	0.049
	20	3/4	139	0.06475	0.019736	0.0032910	0.0003058	1.24	0.049
	25	1	126	0.07667	0.023368	0.0046139	0.0004287	1.65	0.065
	40	1/2	105	0.11875	0.036190	0.0110753	0.0010289	2.54	0.100
	50	2	92	0.14533	0.044297	0.0165890	0.0015412	3.25	0.128
CFS20	40	1-1/2	110	0.1083937[a]	0.0330405[a]	0.0092278	0.0008574	1.65	0.065
	80	3	66	0.2058323[a]	0.0626469[a]	0.033178	0.00308233	3.25	0.128

(a) Total effective diameter

Certificate of Conformance

The following is an example of a typical NIST Certificate of Conformance for a Custody Transfer System.

U.S. Department of Commerce
National Institute of Standards and Technology
Gaithersburg, MD 20899

Certificate Number: 93-003
Page 1 of 2

National Type Evaluation Program

Certificate of Conformance
for Weighing and Measuring Devices

For:

Mass Flow Meter
Digital Electronic
Mass Flow Meter Model: CFS10 Series*
Mass Flow Transmitter Model: CFT10 Series*
Flow Rates: See Below

Submitted by:

The Foxboro Company
38 Neponset Avenue
Foxboro, MA 02035
Tele: (508) 549-2958
Fax: (508) 549-2010
Contact: Bruce Wilcox

Standard Features and Options

Model Numbers and Flow Rates: **THE LAST CHARACTER OF THE MODEL NUMBER MUST BE A "T" FOR THE DEVICE TO BE USED IN CUSTODY TRANSFER**

Transmitter Model Number [1]	Flow Meter Model Number [2]	Flow Tube Size (in)	Flow Rates (lb/min)
CFT10-XXXXXXX-T	CFS10-03XXX-XX-T	1/4	0.2 to 20
CFT10-XXXXXXX-T	CFS10-05XXX-XX-T	1/2	0.9 to 90
CFT10-XXXXXXX-T	CFS10-08XXX-XX-T	3/4	2.0 to 200

Alphanumeric display
Automatic temperature compensating
Flow rate indication
Options: Ticket printer (must satisfy Handbook 44 receipt requirements)
Computer interface (must not allow adjustment of metrological parameters)
Sanitary end connections

[1] X's identify transmitter mounting, nominal voltage supply and frequency, front panel, communication, and electrical certification information. **The T must be present for use in custody transfer.**

[2] X's identify flow meter wetted material, end connections, electrical certification and optional selections. **The T must be present for use in custody transfer.**

This device was evaluated under the National Type Evaluation Program (NTEP) and was found to comply with the applicable technical requirements of Handbook 44, "Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices." Evaluation results and device characteristics necessary for inspection and use in commerce are on the following pages.

Effective Date: January 8, 1993

C. S. Brickenkamp
Chief, Office of Weights and Measures
Issue Date: April 16, 1993

Note: The National Institute of Standards and Technology does not "approve", "recommend", or "endorse" any proprietary product or material, either as a single item or as a class or group. Results shall not be used in advertising or sales promotion to indicate explicit or implicit endorsement of the product or material by the Institute. (See NTEP Policy and Procedures).

Certificate Number 93-003
Page 2 of 2

The Foxboro Company
Digital Electronic Mass Flow Meter
Model: Model: CFS10/CFT10 Series

Application: For use in stationary and vehicle-mounted vertical and horizontal installations. The mass flow meter may be used to measure liquids with specific gravities of 0.5 to 2.5. This Certificate does not cover liquids that must be pressurized at ambient temperature to maintain a liquid state, cryogenic liquids, or vaporized products (gases).

Identification: Identification badges are located on the side of the flow meter and the transmitter.

Sealing: The flow meter casing is hermetically sealed with seam welding and provides no internal access. The transmitter front cover and door are sealed with a physical security seal, and no front panel controls are available to affect metrological integrity once seals are in place.

Operation: The principle of Coriolis acceleration is used which allows true mass measurements of fluids to be made directly, without the need for external temperature, pressure, or specific gravity measurements.

In addition to providing both the required driving signals for flow meter operation, and performing the calculations for mass flow, density, and temperature based on the measurement signals received from the flow meter, the Mass Flow Transmitter serves as the primary operator interface. A Level 1 menu structure provides a selection of four parameters: measurement mode, status mode, identify mode, and setup mode.

Measurement mode:	Provides a continuously updated display of the user's choice of fluid mass flow, density, temperature, percent solids, volume flow, or total flow.
Status mode:	Provides information on the transmitter pulse, current, and alarm outputs.
Identify mode:	Allows quick access to the assigned transmitter system module identification, location, description, and tag number.
Setup mode:	Used to enter all initial operational programming relating to process measurement, displayed information and output circuit requirements, and is used to perform calibration.

Test Conditions: The 1/4-inch and 3/4-inch flow meters, models CFS10-03 and CFS10-08 respectively, were interfaced with transmitters (Model CFT10) and tested in a laboratory using water as the test liquid. Each flow meter was tested at flow rates of 100%, 70%, 40%, and 10% for time periods of 1 minute and of 6 seconds. A 1/2-inch flow meter was tested in the field initially and after a throughput of 5 million gallons of "Stoddard" solvent (specific gravity of 0.745). An acceptance tolerance of 0.2%, as specified in the Liquid Measuring Devices Code of National Institute of Standards and Technology Handbook 44, 1993 Edition, was applied.

Results of the evaluation indicate the device complies with the applicable requirements of NIST Handbook 44.

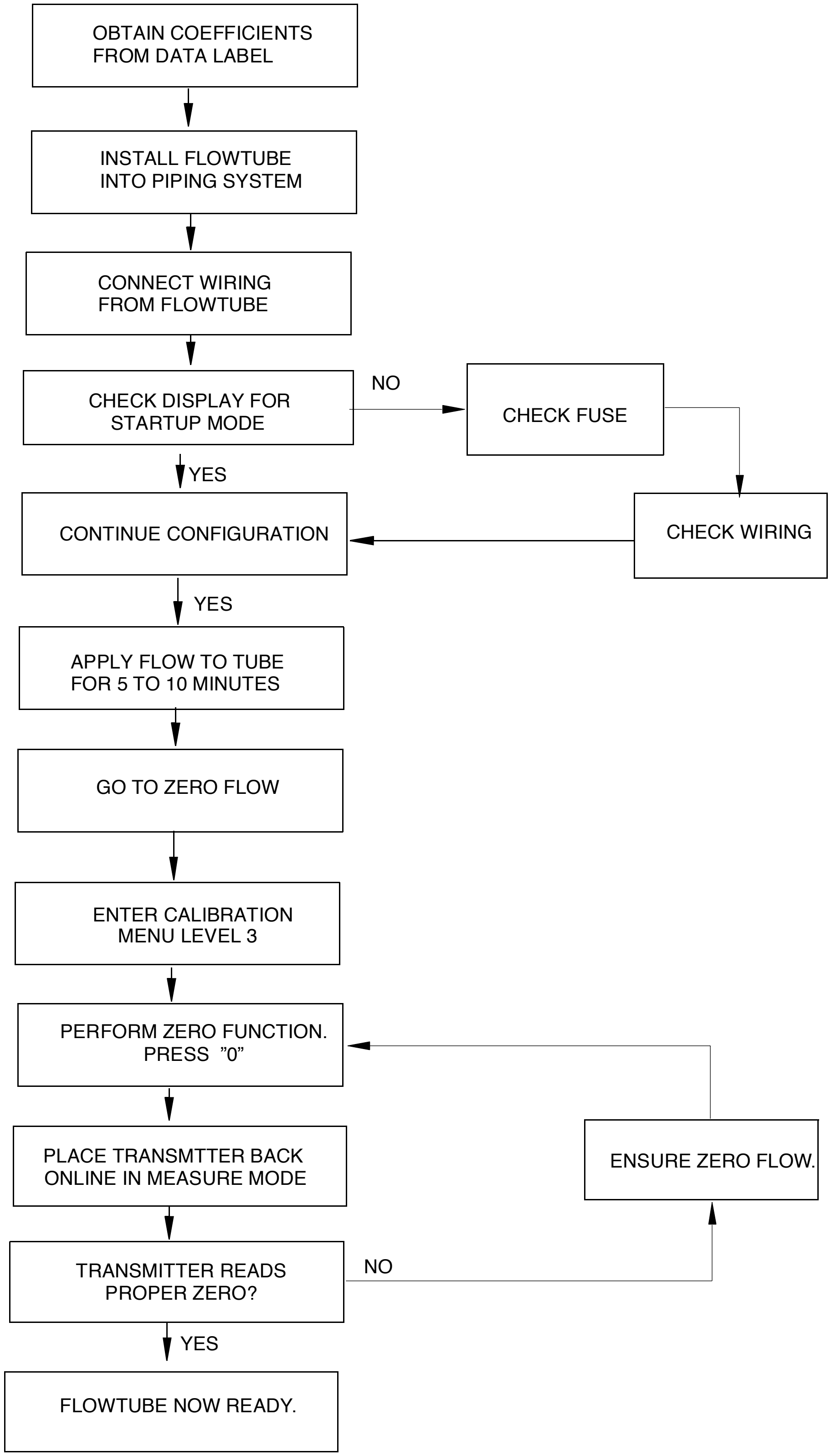
Type Evaluation Criteria Used: NIST Handbook 44, 1993 Edition

Tested By: R. Whipple (NIST)

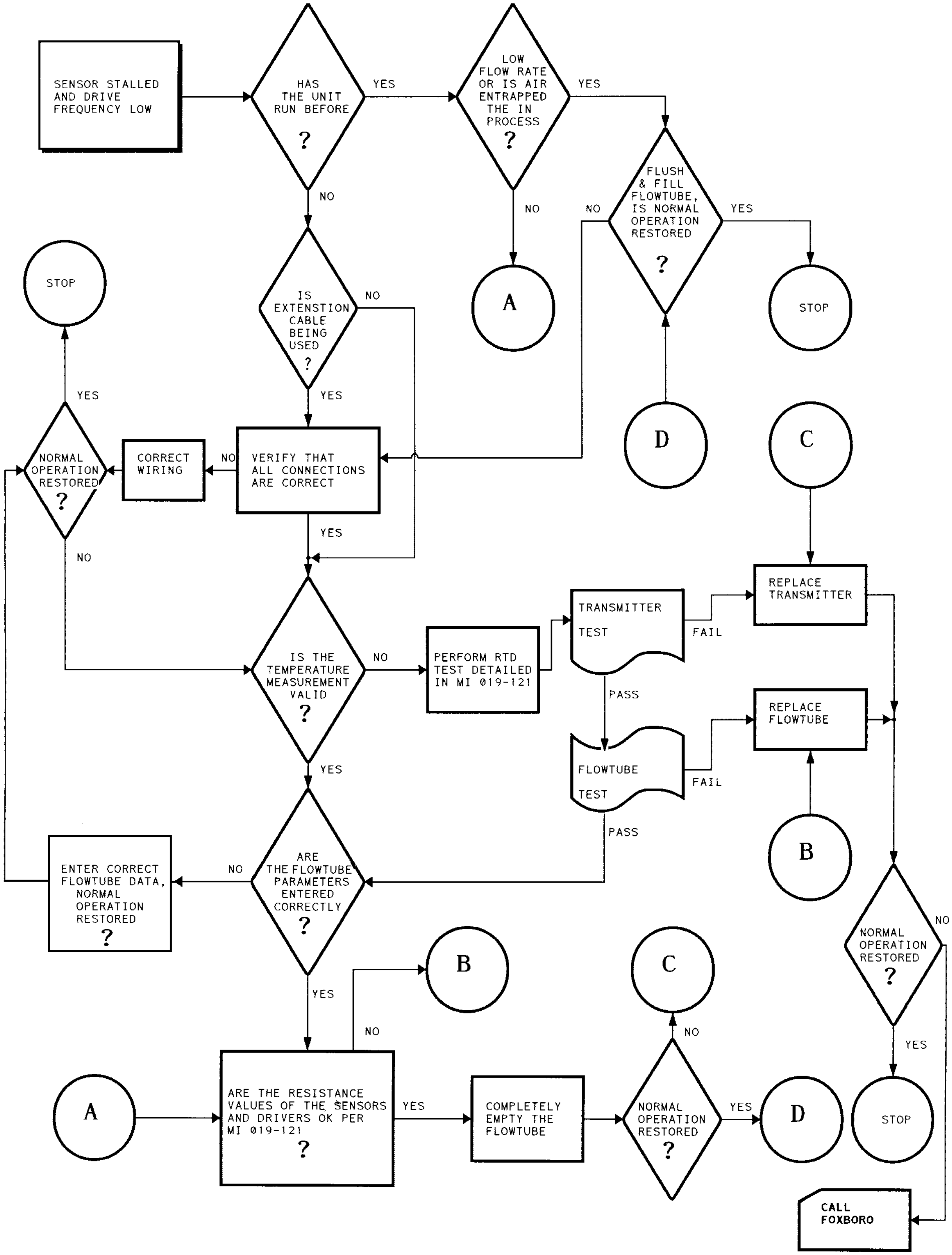
Control Number: 318

Flow Chart 1

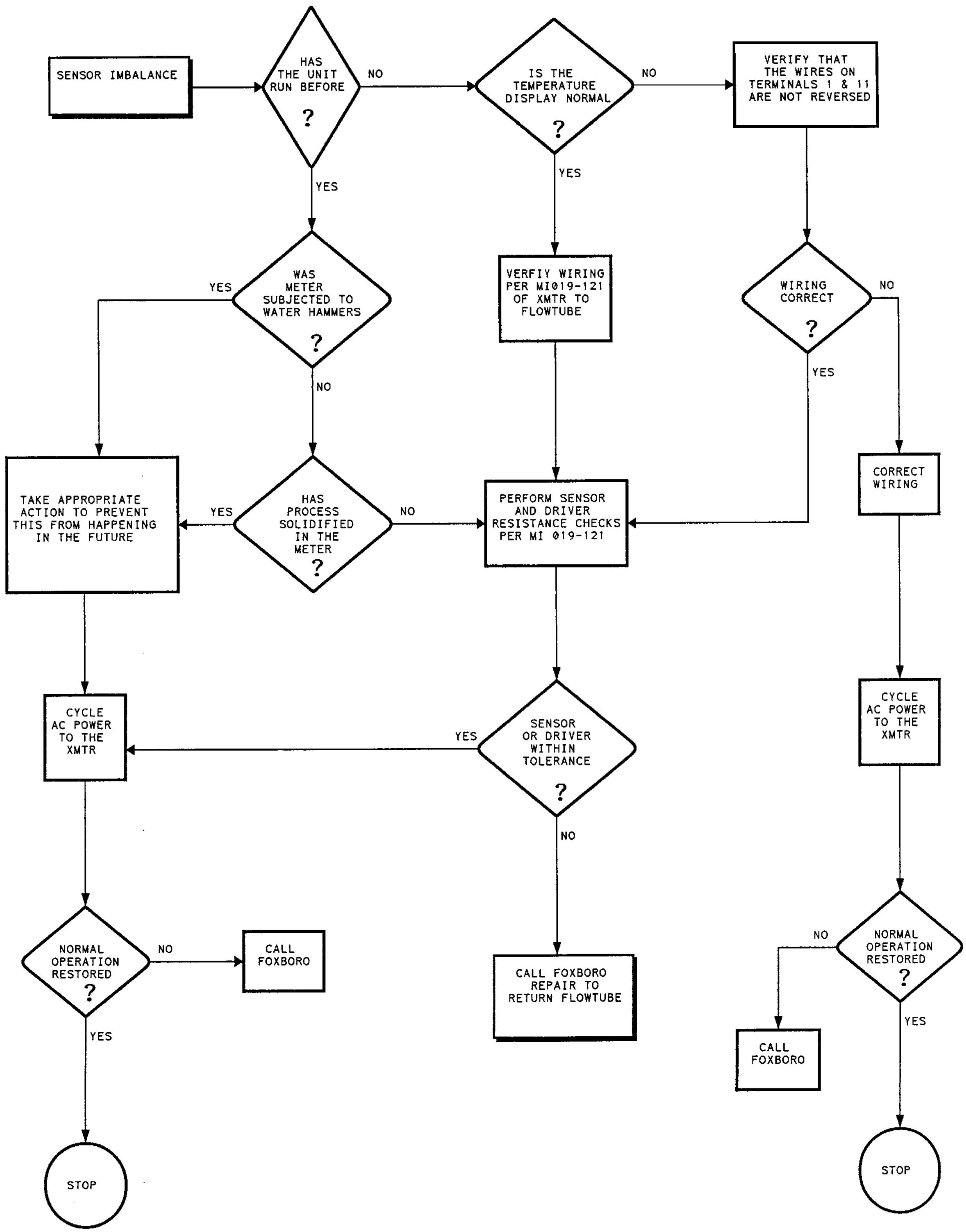
Installation and Startup Guide for CFS10, CFS20, and CFT10



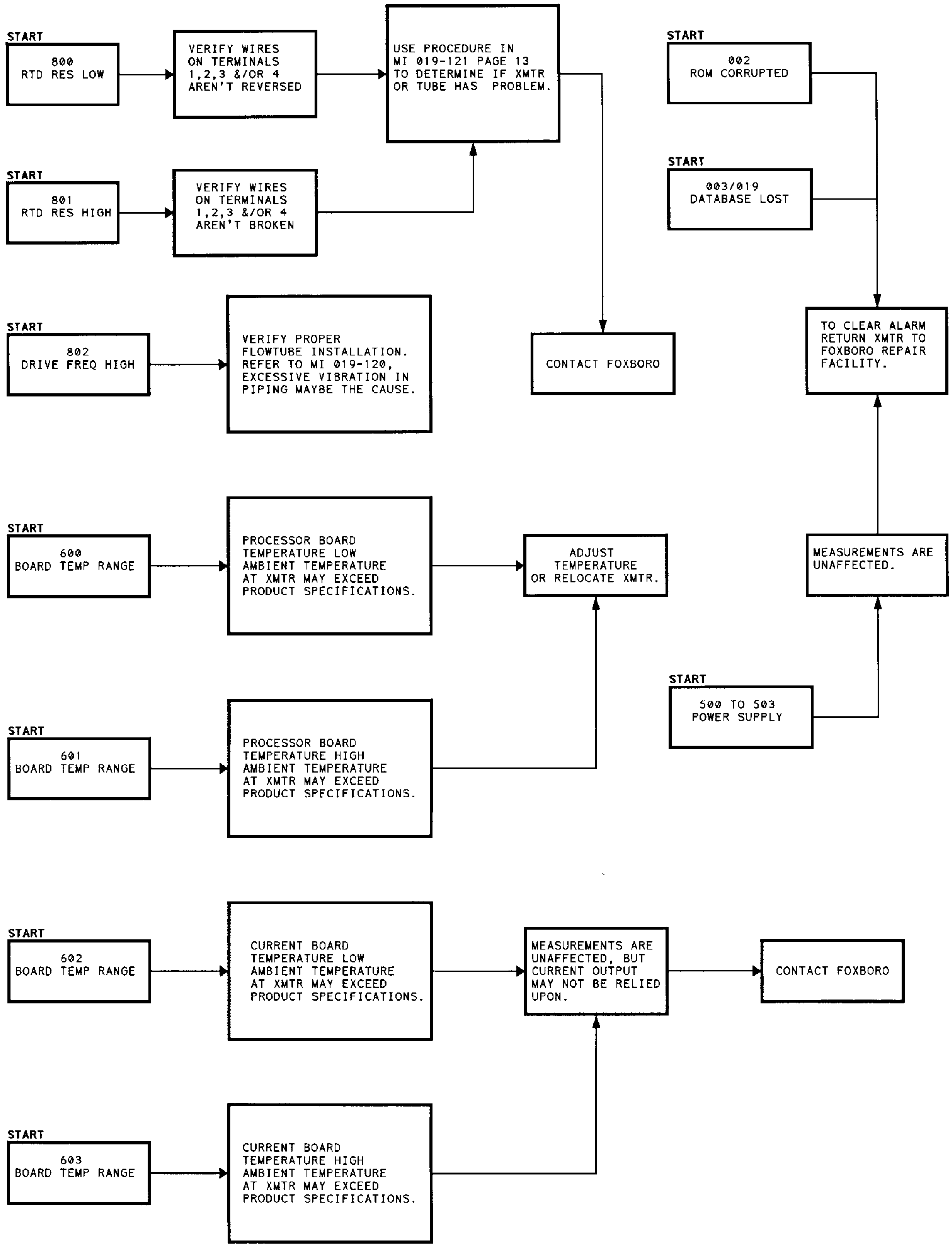
Flow Chart 2


SENSOR STALLED AND DRIVE FREQUENCY LOW
HAS THE UNIT RUN BEFORE ?
YES
NO
LOW FLOW RATE OR IS AIR ENTRAPPED THE IN PROCESS ?
FLUSH & FILL FLOWTUBE, IS NORMAL OPERATION RESTORED ?
STOP
A
B
C
D
IS EXTENSTION CABLE BEING USED ?
VERIFY THAT ALL CONNECTIONS ARE CORRECT
CORRECT WIRING
NORMAL OPERATION RESTORED ?
IS THE TEMPERATURE MEASUREMENT VALID ?
PERFORM RTD TEST DETAILED IN MI 019-121
TRANSMITTER TEST
FAIL
PASS
REPLACE TRANSMITTER
FLOWTUBE TEST
REPLACE FLOWTUBE
ARE THE FLOWTUBE PARAMETERS ENTERED CORRECTLY ?
ENTER CORRECT FLOWTUBE DATA, NORMAL OPERATION RESTORED ?
ARE THE RESISTANCE VALUES OF THE SENSORS AND DRIVERS OK PER MI 019-121 ?
COMPLETELY EMPTY THE FLOWTUBE
CALL FOXBORO

Flow Chart 3


SENSOR IMBALANCE
HAS THE UNIT RUN BEFORE ?
NO
IS THE TEMPERATURE DISPLAY NORMAL ?
NO
VERIFY THAT THE WIRES ON TERMINALS 1 & 11 ARE NOT REVERSED
YES
YES
WAS METER SUBJECTED TO WATER HAMMERS ?
YES
VERFIY WIRING PER MI019-121 OF XMTR TO FLOWTUBE
WIRING CORRECT ?
NO
YES
NO
TAKE APPROPRIATE ACTION TO PREVENT THIS FROM HAPPENING IN THE FUTURE
YES
HAS PROCESS SOLIDIFIED IN THE METER ?
NO
PERFORM SENSOR AND DRIVER RESISTANCE CHECKS PER MI 019-121
CORRECT WIRING
CYCLE AC POWER TO THE XMTR
YES
SENSOR OR DRIVER WITHIN TOLERANCE ?
NO
CYCLE AC POWER TO THE XMTR
NORMAL OPERATION RESTORED ?
NO
CALL FOXBORO
CALL FOXBORO REPAIR TO RETURN FLOWTUBE
NO
NORMAL OPERATION RESTORED ?
YES
CALL FOXBORO
YES
STOP
STOP

Flow Chart 4


START
800
RTD RES LOW
VERIFY WIRES
ON TERMINALS
1,2,3 &/OR 4
AREN'T REVERSED
USE PROCEDURE IN
MI 019-121 PAGE 13
TO DETERMINE IF XMTR
OR TUBE HAS PROBLEM.
START
002
ROM CORRUPTED
START
801
RTD RES HIGH
VERIFY WIRES
ON TERMINALS
1,2,3 &/OR 4
AREN'T BROKEN
START
003/019
DATABASE LOST
START
802
DRIVE FREQ HIGH
VERIFY PROPER
FLOWTUBE INSTALLATION.
REFER TO MI 019-120,
EXCESSIVE VIBRATION IN
PIPING MAYBE THE CAUSE.
CONTACT FOXBORO
TO CLEAR ALARM
RETURN XMTR TO
FOXBORO REPAIR
FACILITY.
START
600
BOARD TEMP RANGE
PROCESSOR BOARD
TEMPERATURE LOW
AMBIENT TEMPERATURE
AT XMTR MAY EXCEED
PRODUCT SPECIFICATIONS.
ADJUST
TEMPERATURE
OR RELOCATE XMTR.
MEASUREMENTS ARE
UNAFFECTED.
START
500 TO 503
POWER SUPPLY
START
601
BOARD TEMP RANGE
PROCESSOR BOARD
TEMPERATURE HIGH
AMBIENT TEMPERATURE
AT XMTR MAY EXCEED
PRODUCT SPECIFICATIONS.
START
602
BOARD TEMP RANGE
CURRENT BOARD
TEMPERATURE LOW
AMBIENT TEMPERATURE
AT XMTR MAY EXCEED
PRODUCT SPECIFICATIONS.
MEASUREMENTS ARE
UNAFFECTED, BUT
CURRENT OUTPUT
MAY NOT BE RELIED
UPON.
CONTACT FOXBORO
START
603
BOARD TEMP RANGE
CURRENT BOARD
TEMPERATURE HIGH
AMBIENT TEMPERATURE
AT XMTR MAY EXCEED
PRODUCT SPECIFICATIONS.

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