CAMERON

Measurement Systems

CALDON® ULTRASONICS

LEFM® 2xxCi Family of Ultrasonic Flowmeters

User Manual

Manual No. IB1215 Rev. 9

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July 2015

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Important Safety Information

Terms Used in this Manual

WARNING

This symbol identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss.

CAUTION

This symbol indicates actions or procedures which if not performed correctly may lead to personal injury or incorrect function of the instrument or connected equipment.

Note – Indicates actions or procedures which may affect instrument operation or may lead to an instrument response which is not planned.

Personal Safety

CAUTION

OPERATORS SHOULD NOT REQUIRE ACCESS TO THE INTERIOR OF THE FLOWMETER. ONLY QUALIFIED PERSONNEL SHOULD SERVICE THE LEFM 2xxCi. DO NOT ATTEMPT TO DISASSEMBLE THE INSTRUMENT OR OTHERWISE SERVICE THE INSTRUMENT UNLESS YOU ARE A TRAINED MAINTENANCE TECHNICIAN.

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment's safety features may be impaired. Cameron is not responsible for damages or injuries sustained as a result of inappropriate use.

Before performing system verification and repair procedures, contact Cameron's Measurement Systems division, Caldon Ultrasonics.

For additional information or assistance on the application, operation or servicing, write or call the Cameron office nearest you or visit www.c-a-m.com.

IEC 61508 Safety

The flowmeter's design has been verified to comply with IEC 61508, Safety Integrity Level 2 (SIL2). The transmitter provides three (3) independent outputs for flow indication. There are two pulse/frequency outputs and one analog current output. For systems that use this flowmeter as part of a safety system, at least two of these outputs should be used for communication verification. The response time of the electronics to a hardware failure has been programmed to be no longer than 6 seconds (3 seconds is typical).

Section 1

Introduction

Equipment Description

The LEFM 2xxCi[1] ultrasonic flowmeter is a highly sophisticated bidirectional[2] flow measurement system that employs ultrasonic transit time to measure fluid velocity and volumetric flow rate. Its advanced signal and data processing circuitry help ensure high accuracy and repeatability. The LEFM 2xxCi can be configured to indicate direction of flow via either a quadrature pulse output or a digital signal.

The LEFM 2xxCi also contains an automatic fault detection system for verifying performance and alerting personnel when abnormal operating conditions are detected. For ease of troubleshooting, the LEFM 2xxCi provides easy-to-interpret diagnostic information via Modbus communications and the local display.

This manual provides detailed instructions on the installation and operation of the flowmeter to include the viewing of flow parameters and interpretation of diagnostic data viewed via the transmitter's display. Users who require a more detailed view of the diagnostic acoustic data can access the data via Cameron's LEFM Link2G software. The operation of this software is outside the scope of this manual (see the LEFM Link2G User Manual for details).

The LEFM 2xxCi flowmeter has two basic components or subsystems:

- a meter body, including up to eight pairs of transducers forming acoustic paths and a temperature sensor.
- a transmitter(s) containing a readout display and acoustic data processing electronics.

Typically, the transmitter is mounted to the meter body at the factory and the assembly is shipped as one instrument, ready for installation. Remote-mount units are available, particularly when there are extreme temperatures at the meter. This manual covers three different models or configurations. These models are described as follows:

> **<u>Models 2xxCi and 2xxCiRN</u>**: For the models 220Ci, 240Ci, 240CiRN, 280Ci and 280CiRN, the transmitter mounted to the meter body (see Section 2 for installation). This model has a factory installed seal between the transmitter and the meter body.

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[1] The term 2xxCi covers all versions of the liquid ultrasonic flowmeters. Specifically, the 220Ci (two path), 240Ci (four path) and 280Ci (8 path) models are covered. Further, different meter body configurations are covered. These include the full bore version and the reduced bore version (RN model).

[2] Meter must be calibrated in the reverse direction to be used in a bidirectional application.

Models 2xxCi-R: The suffix "-R" means that the transmitter is mounted remotely from the meter body (see Section 3 for installation). This model has a factory installed seal between the transmitter and a junction box for terminating cables from the meter body.

Models 2xxCiLT-R: The suffix "-R" again means that the transmitter mounted remotely from the meter body. The suffix "LT" means that the meter body is likely to see extreme temperatures (see Section 3 for installation) and the design has reduced volume electrical compartments. Further, the design uses rigid conduit to put the hazardous location seals in a benign environment.

This model has a factory installed seal between the transmitter and a junction box for terminating cables from the meter body. Additionally, the meter body has factory installed seals.

Models 2xxCi-R and 2xxCiLT-R require that the transmitter be mounted separately from the meter body. In those instances the transmitter(s) and meter body are shipped separately.

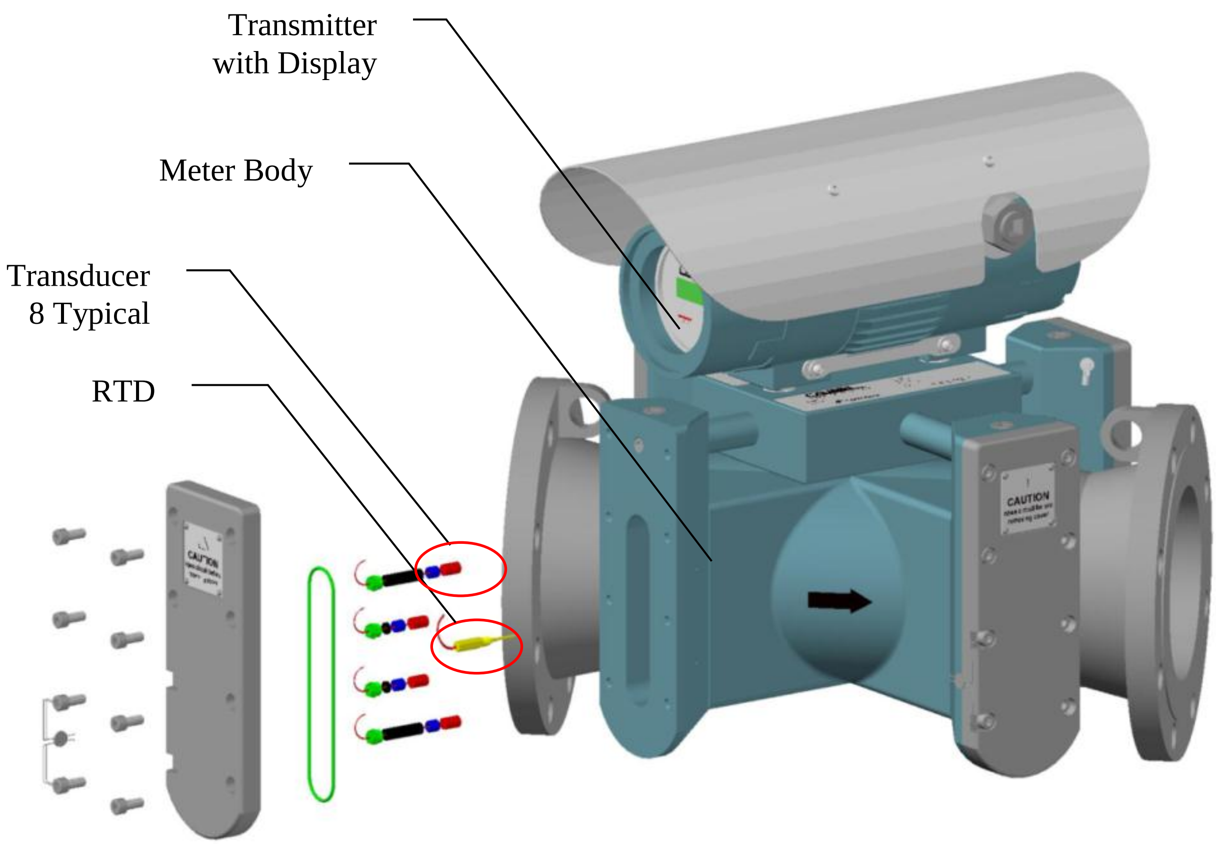


Figure 1.1: LEFM 280Ci Components, Typical of all 2xxCi and 2xxCiRN models

LEFM 2xxCi Meter Body

The meter body, or *metering section* as it is sometimes referenced, contains up to eight pairs of acoustic transducers and a temperature sensor (RTD).

The meter body is a specially designed section of pipe that contains multiple pairs[3] of housings that are positioned to provide acoustic paths at a 45° angle to the flow direction. They are spaced in accordance with the Gaussian Method of flow integration. The transducers are installed inside these housings.

Each transducer transmits and receives ultrasonic pulses (typically 1.0 MHz or 1.6 MHz). The transducer modules contain piezoelectric crystals which transmit and receive acoustic energy. The transducer modules may be removed from their housings for maintenance while the meter body is in the pipeline without affecting the pressure boundary.

The 2xxCiRN meter has a specially designed reducer section in the meter body. This reducer design allows the meter to operate linearly at low Reynolds Numbers (e.g., high viscosities) and to prove better against displacement provers (e.g., ball provers and small volume piston provers).

LEFM 2xxCi Transmitter

The transmitter houses the display that provides a readout of flow data including flow rate, total flow volume, fluid properties, analog input data, alarm indication, fault detection, and acoustic diagnostic information.

Figure 1.2: LEFM 2xxCi Transmitter with Sunshield Shown

[3] 8 paths for the 280Ci, 4 paths for the 240Ci and 2 paths for the 220Ci meters

The transmitter performs all control and timing for the generation and measurement of acoustic pulses. Acoustic processing is performed by specialized proprietary boards that are designed to achieve high sampling rates, provide stable ultrasonic signals, and eliminate zero drift. The circuit boards within the transmitter are programmed to perform the following functions:

- Step through the ultrasonic path cycles and transducer test cycles
- Provide gain control for each ultrasonic path
- Compute flow
- Compute gross to net flow conversions
- Generate pulse outputs and analog outputs

The transmitter offers the following inputs/outputs:

- Standard volume pulse output
    - The K-factors used to configure transmitters at the factory are listed in Table 1.1. The user may configure the K-factor to meet its needs. (Factory defaults are shown in Table 1.1).
- One analog input (optional; choose from 4-20 mA or 0-20 mA). Choose from the following:
    - Product temperature
    - Product pressure
    - Product density
    - Product viscosity
- One analog output (optional; choose from 4-20 mA or 0-20 mA)
    - Flow
    - Any Modbus Register (See Modbus manual)
- Two communication ports
    - 2 RS485 (full and half duplex) – Modbus ASCII
    - 1 RS485 (full and half duplex) – Modbus ASCII and an Ethernet port with Modbus TCPIP

Note: If required, the analog output may be mapped to any variable.

Table 1.1: Standard K-Factors
For 220Ci, 240Ci, and 280Ci Meters

Size		Maximum Flow BPH	K-Factor (P/bbl)	Maximum Flow m^3/h	K-Factor (P/m^3)
Inches	DN				
4	100	2,050	2,000	325	12,600
6	150	4,650	1,000	740	6,300
8	200	8,150	500	1,290	3,150
10	250	12,800	350	2,030	2,200
12	300	19,300	250	3,070	1,570
14	350	23,600	200	3,750	1,000
16	400	28,700	150	4,560	940
18	450	41,000	100	6,500	630
20	500	50,000	85	7,900	530
24	600	72,000	60	11,500	380
26	650	87,000	45	13,900	280
28	700	100,000	40	16,200	240
30	750	115,000	35	18,700	220
32	800	130,000	30	21,300	185
34	850	150,000	25	24,200	165
36	900	165,000	25	27,200	145
40	1,000	205,000	20	32,600	125

For 240CiRN and 280CiRN Meters

Size		Maximum Flow BPH	K-Factor (P/bbl)	Maximum Flow m^3/h	K-Factor (P/m^3)
Inches	DN				
6	150	3,210	2,000	510	12,600
8	200	5,660	1,000	900	12,600
10	250	8,870	1,000	1,410	6,300
12	300	12,710	500	2.020	3,150
14	350	15,100	350	2,400	2,200
16	400	19,900	350	3,165	2,200
18	450	25,540	250	4,060	1,570
20	500	31,075	200	4,940	1,000
24	600	45,230	150	7,190	940
26	650	54,665	100	8,690	630
28	700	63,690	100	10,125	630
30	750	73,540	85	11,690	530
32	800	83,760	85	13,315	530
34	850	95,145	60	15,125	380
36	900	106,940	60	17,000	380

Meter Body Model Number - 2xxCi and 2xxCiRN Models Only

The model number defines construction and features. From the model number, a user can identify and verify the component type, meter size, piping thickness, construction material, flange rating/style, and enclosure type.

MODEL NUMBER CODE: LEFM2BC-D-E-F-G-H-J-K-L-M-N-P-Q-R

B = 20 FOR 2 PATH METERS
B = 40 FOR 4 PATH METERS
B = 80 FOR 8 PATH METERS

C = Ci FOR INTEGRAL ELECTRONICS
C = Ci-R FOR REMOTE ELECTRONICS AND 1 J-BOX PER MANIFOLD
C = CiRN FOR INTEGRAL ELECTRONICS WITH REDUCED BORE
C = CiRN-R FOR REMOTE ELECTRONICS WITH REDUCED BORE AND 1 J-BOX PER MANIFOLD

D = NOMINAL PIPE SIZE (e.g., 04 = 4 INCH, 16 = 16 INCH ....)

E = PIPE SCHEDULE (SCHEDULE 30 THRU 160 AND XXS)

F = CF FOR FORGED CARBON STEEL
F = CC FOR CAST CARBON STEEL
F = SF FOR FORGED STAINLESS STEEL
F = SC FOR CAST STAINLESS STEEL
F = DF FOR FORGED DUPLEX STEEL
F = DC FOR CAST DUPLEX STEEL
F = LF FOR FORGED LOW TEMPERATURE CARBON STEEL
F = LC FOR CAST LOW TEMPERATURE CARBON STEEL
F = HF FOR HASTELLOY FORGED
F = IF FOR INCONEL FORGED

G = ASME FLANGE RATING (CLASS 150, 300, 600, 900, OR 1500)

H = A FOR WELDED MANIFOLDS
H = B FOR MANIFOLDS INTEGRAL WITH METER BODY

J = W FOR WELD NECK RAISED FACE FLANGES
J = R FOR WELD NECK RTJ FACE FLANGES
J = O FOR OTHER FLANGE VARIETY
J = S FOR SLIP-ON FLANGES

K = C FOR CHICO POTTING MATERIAL
K = L FOR LOCTITE E40 EXP POTTING MATERIAL

L = A FOR WELDED TRANSDUCER HOUSING TO METER BODY SEAL
L = B FOR O-RING SEAL IN ACCORDANCE WITH ISA 12.27.01 - CANADIAN APPLICATIONS
L = C FOR O-RING SEAL DESIGN

M = N FOR NO PRESSURE PORT OPTION
M = P FOR PRESSURE PORT OPTION

N = A FOR ALUMINUM MANIFOLDS COVERS
N = S FOR STAINLESS STEEL MANIFOLDS COVERS

P = 1 FOR ONE TRANSMITTER
P = 2 FOR TWO TRANSMITTERS

Q = L FOR LIQUID TRANSDUCER HOUSINGS
Q = G FOR GAS TRANSDUCER HOUSINGS

R = "BLANK" FOR NO CUSTOM OPTION
R = C FOR CUSTOM OPTION

Example for a carbon steel 280Ci meter with Schedule 40, 150# flanges with raised faces:
LEFM280Ci-04-40-CF-150-A-W-L-A-N-A-1-L

Meter Body Model Number - 2xxCi Extreme Temperatures Models Only

The model number for the low temperature application is different, but it still includes information that defines construction and features. From the model number, a user can identify and verify the component type, meter size, piping thickness, construction material, ANSI rating, and enclosure type.

MODEL NUMBER CODE: 2XXKK-LT-SCH-N-H**-WYZ-M-P

XX = 20 FOR 2 PATH METERS
XX = 40 FOR 4 PATH METERS
XX = 80 FOR 8 PATH METERS

KK = C FOR THE ELECTRONICS COVERED UNDER APPROVAL TRL04ATEX11056X
KK = Ci FOR THE ELECTRONICS COVERED UNDER APPROVAL SIRA11ATEX1279X
KK = Ci-R FOR REMOTE ELECTRONICS AND 1 J-BOX PER MANIFOLD

SCH = PIPE SCHEDULE (SCHEDULE 30 THRU 160 AND XXS)

N = ASME FLANGE RATING (CLASS 150, 300, 600, 900, OR 1500)

H** = NOMINAL PIPE SIZE

H01 = 6 INCH	H02 = 8 INCH	H03 = 10 INCH	H04 = 12 INCH
H05 = 14 INCH	H06 = 16 INCH	H07 = 18 INCH	H08 = 20 INCH
H09 = 24 INCH	H10 = 26 INCH	H11 = 28 INCH	H12 = 30 INCH
H13 = 32 INCH	H14 = 34 INCH	H15 = 36 INCH	

W = BRAND OF HAZ LOC SEAL
- W = D FOR BARTEC GLAND
- W = E FOR HAWKE GLAND
- W = F FOR CMP GLAND
- W = G FOR PEPPERS GLAND

Y = R IF 90º ELBOW IS USED IN THE CONDUIT
Y = S IF NO 90º ELBOW IS USED IN THE CONDUIT

Z = T IF A TEE IS USED IN THE CONDUIT
Z = N IF NO TEE IS USED IN THE CONDUIT

M = C FOR CARBON STEEL
M = S FOR STAINLESS STEEL
M = D FOR DUPLEX STEEL

P = 2 FOR TWO TRANSDUCER PORTS PER MANIFOLD
P = 4 FOR FOUR TRANSDUCER PORTS PER MANIFOLD

The example below for a 12 inch stainless steel 280Ci meter using Bartec seals, elbows and no tee in the conduit, that is built as a Schedule 40 meter with 150# flanges:

280Ci-LT-30-150-H04-DRN-S-4

Transmitter Model Number

The model number for the transmitter includes information that defines construction and features.

MODEL NUMBER CODE: CIMFFFFNCCPXYZ

MATERIAL
- M = A, ALUMINUM
- M = S, STAINLESS

FREQUENCY
- FFFF = 0020 FOR 200KHZ
- FFFF = 0100 FOR 1 MHZ
- FFFF = 0160 FOR 1.6 MHZ
- FFFF = BRBD FOR A BROADBAND DESIGN

MAX NUMBER PATHS
- N = 2 FOR 2 PATH METERS
- N = 4 FOR 4 PATH METERS
- N = 8 FOR 8 PATH METERS

COMMUNICATIONS
- CC = S1 FOR TWO SERIAL PORTS AND 1 ANALOG INPUT/OUTPUT
- CC = E1 FOR ONE SERIAL PORT, ONE ETHERNET PORT AND 2 ANALOG INPUTS/OUTPUTS

POWER SUPPLY
- P = O FOR WITHOUT OP-AMP
- W = W FOR WITH OP-AMP

APPROVALS
- X = 0 FOR NO CSA APPROVAL
- X = C FOR CSA APPROVAL
- Y = 0 FOR NO ATEX APPROVAL
- Y = B FOR ATEX EXD IIB APPROVAL
- Y = C FOR ATEM EXD IIC APPROVAL
- Z = 0 FOR NO IEC APPROVAL
- Z = B FOR IECEX EXD IIB APPROVALS
- Z = C FOR IECEX EXD IIC APPROVALS

Flowmeter Specifications

Table 1.2: LEFM 2xxCi Transmitter Specifications

Material	
Standard	Aluminum
Custom	Stainless Steel
Weight (if delivered separate from the meter body)	
Net Weight	13.5 lb. (6.1 kg) Aluminum – Transmitter only Note: when attached to an aluminum junction box, the total maybe over 135 lbs (61 kg) depending on the style of junction box. 35 lb. (15.9 kg) Stainless Steel – Transmitter only Note: when attached to a stainless steel junction box, the total maybe over 350 lbs (159 kg) depending on the style of junction box.
Power Requirements	
Voltage Req'd	24 VDC (18 VDC to 30 VDC)
Current Draw	24 VDC at 0.5A
Power Consumption	12 W
Pulse Outputs/Communications	
Pulse Output	0-5 V or 0-12 V
Alarm Status	5V (for 0-5V output) = normal operation
	12V (for 0-12V output) = normal operation
	0V = alarm condition
Communications	
Standard	Two RS 485 (Modbus RTU-slave) ports
Custom	One RS 485 (Modbus RTU-slave) and one Ethernet port (Modbus TCPIP or web browser)
Modbus	See Modbus specifications
Analog Output	
	4-20 mA or 0-20 mA (max load 650 Ohms)
Analog Input	
	4-20 mA or 0-20 mA
	Meter body RTD is standard

Table 1.2: LEFM 2xxCi Transmitter Specifications (Continued)

Temperature Range	
Storage Temperature	-58°F (-50°C) to 185°F (85°C)
Operating Temperature	-58°F (-50°C) to 158°F (70°C) Check Safe Operation Manual for Operation Within Electrical Certification.
Ultrasonic Information	Frequency Range 0.2 MHz up to 5 MHz Transmitter source impedance 100 ohms (nominal) Transducer load impedance greater than 15 ohms

Table 1.3: LEFM 2xxCi, 2xxCi-R and 2xxCiLT-R Meter Body Specifications

Material	
Standard	Stainless steel or carbon steel
Weight (if delivered separate from the transmitter)	
Net Weight	See Tables 1.5 through 1.9 and subtract transmitter weight
Operating Temperature	Note: For storage temperature, the meter body limits have been set by the limiting ambient rating of any seal/gland or J-box that could be used with the flow meter. Check Safe Operation Manual for Operation Within Electrical Certification.
Operating Pressure	Maximum working pressure is listed on the meter nameplate (surge pressures in excess of the flange maximum working pressure rating must be evaluated.)

Table 1.4: LEFM 2xxCi, 2xxCi-R and 2xxCiLT-R Hazardous Area Approval

2XXCi - with Integral Manifold

Electrical Safety Approvals

Meter Body Approvals	Zone / CE / IEC Approvals	CSA Class / Division Approvals
Using Integral Aluminum Transmitter	II 2 G, Ex d IIB T6 Gb Ta = -40° F to 158° F (-40° C to 70° C)	Class 1, Div. 1 & 2, Grps C & D, T6, Temp -40° F to 158° F (-40° C to 70° C)
Using Integral Stainless Steel Transmitter	II 2 G, Ex d IIB + H_2 T6 Gb Ta = -58° F to 158° F (-50° C to 70° C)	Class 1, Div. 1 & 2, Grps C & D, T6, Temp -40° F to 158° F (-40° C to 70° C)
Remotely Mounted Transmitter	II 2 G, Ex d IIB + H_2 T3 Gb Ta = -58° F to 257° F (-50° C to 125° C)	Class 1, Div. 1 & 2, Grps B, C & D, T3C, Temp -58° F to 257° F (-50° C to 125° C)

Transmitter Approvals	Zone / CE / IEC Approvals	CSA Class / Division Approvals
Remote Mount Transmitter	II 2 G, Ex d IIB T6 Gb Ta = -40° F to 140° F (-40° C to 60° C)	Class 1, Div. 1 & 2, Grps C & D, T6, Temp -40° F to 158° F (-40° C to 70° C)

2XXCi - with Welded Manifold

Electrical Safety Approvals

Meter Body Approvals	Zone / CE / IEC Approvals	CSA Class / Division Approvals
Using Integral Aluminum Transmitter	II 2 G, Ex d IIB T6 Gb Ta = -40° F to 158° F (-40° C to 70° C)	Class 1, Div. 1 & 2, Grps C & D, T6, Temp -40° F to 158° F (-40° C to 70° C)
Using Integral Stainless Steel Transmitter	II 2 G, Ex d IIC T6 Gb Ta = -58° F to 158° F (-50° C to 70° C)	Class 1, Div. 1 & 2, Grps C & D, T6, Temp -40° F to 158° F (-40° C to 70° C)
Remotely Mounted Transmitter	II 2 G, Ex d IIC T3 Gb Ta = -58° F to 257° F (-50° C to 125° C)	Class 1, Div. 1 & 2, Grps B, C & D, T3C, Temp -40° F to 284° F (-40° C to 140° C)

Transmitter Approvals	Zone / CE / IEC Approvals	CSA Class / Division Approvals
Remote Mount Transmitter	II 2 G, Ex d IIB T6 Gb Ta = -40° F to 140° F (-40° C to 60° C)	Class 1, Div. 1 & 2, Grps C & D, T6, Temp -40° F to 158° F (-40° C to 70° C)

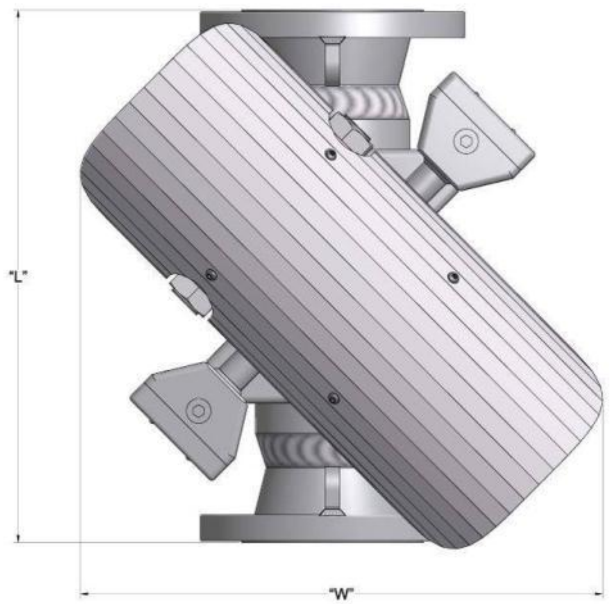
2xxCi Low Temperature

Electrical Safety Approvals

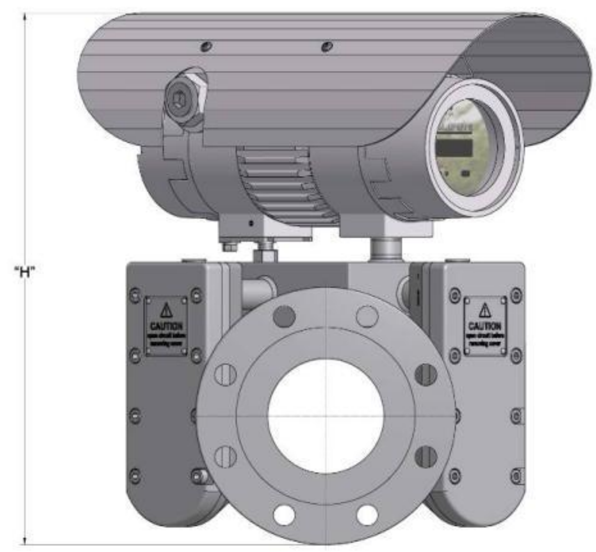
Meter Body Approvals	CE Approvals
Remotely Mounted Transmitter	II 2 G, Ex d IIB T3 Gb Ta = -274° F to 266° F (-170° C to 130° C)
Transmitter Approvals	**CE Approvals**
Remote Mount Transmitter	II 2 G, Ex d IIB T6 Gb Ta = -40° F to 140° F (-40° C to 60° C)

Meter Dimensions

2xxCi and 2xxCiRN Meter Body Dimensions



Top View



End View

Figure 1.6: LEFM 280Ci Dimensions, typical of all 2xxCi models
(Single Electronics)

Table 1.5: Dimensions and Weights for LEFM 280Ci Meter Body, Typical of all 2xxCi Models

Pipe Size Inches [DN]	Flange	Height "H"		Max Width "W" (including manifolds and sunshield)		Overall Length "OAL"		Assembled Meter Weight - with Transmitter	
		Inches	[mm]	Inches	[mm]	Inches	[mm]	lbs	[kg]
4 [100]	150	19.2	[487]	17.7	[450]	21.00	[533.4]	332	[151]
6 [150]	150	20.2	[513]	17.7	[450]	24.00	[609.6]	494	[224]
8 [200]	150	21.4	[545]	17.7	[450]	26.75	[679.5]	733	[332]
10 [250]	150	22.7	[576]	17.7	[450]	28.75	[730.3]	1010	[458]
12 [300]	150	24.2	[614]	19.6	[497]	31.75	[806.5]	1382	[627]
14 [350]	150	25.2	[640]	21.0	[533]	34.00	[863.6]	1669	[757]
16 [400]	150	26.4	[672]	23.5	[597]	35.75	[908.1]	2165	[982]
18 [450]	150	27.2	[691]	25.0	[635]	38.75	[984.3]	2659	[1206]
20 [500]	150	28.4	[722]	27.5	[699]	41.13	[1044.6]	3247	[1473]
24 [600]	150	32.0	[813]	32.0	[813]	45.75	[1162.1]	4586	[2080]
4 [100]	300	19.7	[500]	17.7	[450]	21.75	[552.5]	352	[160]
6 [150]	300	20.9	[532]	17.7	[450]	24.75	[628.7]	535	[243]
8 [200]	300	22.2	[564]	17.7	[450]	27.50	[698.5]	793	[360]
10 [250]	300	23.4	[595]	17.7	[450]	30.00	[762.0]	1104	[501]
12 [300]	300	24.9	[633]	20.5	[521]	33.00	[838.2]	1509	[684]
14 [350]	300	26.2	[665]	23.0	[584]	35.25	[895.4]	1858	[843]
16 [400]	300	27.4	[697]	25.5	[648]	37.25	[946.2]	2400	[1088]
18 [450]	300	28.7	[729]	28.0	[711]	40.25	[1022.4]	2969	[1347]
20 [500]	300	30.5	[775]	30.5	[775]	42.50	[1079.5]	3607	[1636]
24 [600]	300	36.0	[914]	36.0	[914]	47.00	[1193.8]	5159	[2340]
4 [100]	600	20.1	[510]	17.7	[450]	23.50	[596.9]	385	[174]
6 [150]	600	21.7	[551]	17.7	[450]	26.75	[679.5]	624	[283]
8 [200]	600	22.9	[583]	17.7	[450]	29.75	[755.7]	929	[421]
10 [250]	600	24.7	[627]	20.0	[508]	33.25	[844.6]	1364	[619]
12 [300]	600	25.7	[652]	22.0	[559]	35.50	[901.7]	1812	[822]
14 [350]	600	26.6	[675]	23.8	[603]	37.50	[952.5]	2180	[989]
16 [400]	600	28.2	[716]	27.0	[686]	40.25	[1022.4]	2932	[1330]
18 [450]	600	29.3	[745]	29.3	[743]	42.75	[1085.9]	3654	[1657]
20 [500]	600	32.0	[813]	32.0	[813]	45.25	[1149.4]	4554	[2066]
24 [600]	600	37.0	[940]	37.0	[940]	50.25	[1276.4]	6617	[3001]

Pipe Size Inches [DN]	Flange	Height "H"		Max Width "W" (including manifolds and sunshield)		Overall Length "OAL"		Assembled Meter Weight - with Transmitter	
		Inches	[mm]	Inches	[mm]	Inches	[mm]	lbs	[kg]
4 [100]	900	20.4	[519]	17.7	[450]	24.50	[622.3]	419	[190]
6 [150]	900	22.2	[564]	17.7	[450]	28.50	[723.9]	705	[320]
8 [200]	900	23.9	[608]	18.5	[470]	32.00	[812.8]	1112	[504]
10 [250]	900	25.4	[646]	21.5	[546]	35.75	[908.1]	1596	[724]
12 [300]	900	26.7	[678]	24.0	[610]	39.00	[990.6]	2194	[995]
14 [350]	900	27.3	[694]	25.3	[641]	41.25	[1047.8]	2619	[1188]
16 [400]	900	28.6	[725]	27.8	[705]	43.25	[1098.6]	3373	[1530]
18 [450]	900	31.0	[787]	31.0	[787]	46.25	[1174.8]	4405	[1998]
20 [500]	900	33.8	[857]	33.8	[857]	49.75	[1263.7]	5479	[2485]
24 [600]	900	41.0	[1041]	41.0	[1041]	57.25	[1454.2]	8877	[4027]
4 [100]	1500	20.8	[529]	17.7	[450]	25.25	[641.4]	464	[211]
6 [150]	1500	22.4	[570]	17.7	[450]	31.00	[787.4]	839	[381]
8 [200]	1500	24.2	[614]	19.0	[483]	36.00	[914.4]	1334	[605]
10 [250]	1500	26.2	[665]	23.0	[584]	41.25	[1047.8]	2090	[948]
12 [300]	1500	27.9	[710]	26.5	[673]	45.50	[1155.7]	3067	[1391]
14 [350]	1500	29.5	[749]	29.5	[749]	48.00	[1219.2]	3889	[1764]
16 [400]	1500	32.5	[826]	32.5	[826]	50.75	[1289.1]	5104	[2315]
18 [450]	1500	36.0	[914]	36.0	[914]	54.00	[1371.6]	6593	[2990]
20 [500]	1500	38.8	[984]	38.8	[984]	58.25	[1479.6]	8208	[3723]
24 [600]	1500	46.0	[1168]	46.0	[1168]	66.25	[1682.8]	12695	[5758]

Note: All lengths and weights are typical. Refer to site specific product literature and/or site drawings. Specifications for dimensions and weights are subject to change without notification.

Table 1.6: Dimensions and Weights for LEFM 280CiRN Meter Body, Typical of all 2xxCiRN Models

Pipe Size Inches [DN]	Flange	Height "H"		Max Width "W" (including manifolds and sunshield)		Overall Length "OAL"		Assembled Meter Weight - with Transmitter	
		Inches	[mm]	Inches	[mm]	Inches	[mm]	lbs	[kg]
6 [150]	150	20.2	[513]	17.7	[450]	29.52	[749.8]	382	[173]
8 [200]	150	22.3	[567]	17.7	[450]	35.92	[912.3]	587	[266]
10 [250]	150	23.6	[598]	17.7	[450]	40.28	[1023.1]	659	[299]
12 [300]	150	26.3	[668]	17.7	[450]	46.11	[1171.2]	997	[452]
14 [350]	150	28.2	[716]	19.0	[483]	50.21	[1275.4]	1363	[618]
16 [400]	150	29.4	[748]	21.0	[533]	55.37	[1406.5]	1521	[690]
18 [450]	150	31.4	[799]	23.5	[597]	61.63	[1565.4]	1993	[904]
20 [500]	150	33.4	[849]	25.0	[635]	65.93	[1674.7]	2416	[1096]
24 [600]	150	36.9	[938]	27.5	[699]	77.11	[1958.6]	3357	[1523]
6 [150]	300	20.9	[532]	17.7	[450]	29.52	[749.8]	433	[196]
8 [200]	300	23.1	[586]	17.7	[450]	35.92	[912.3]	665	[301]
10 [250]	300	24.3	[618]	17.7	[450]	40.28	[1023.1]	781	[354]
12 [300]	300	27.1	[687]	17.7	[450]	46.11	[1171.2]	1150	[521]
14 [350]	300	29.2	[741]	20.5	[521]	50.21	[1275.4]	1628	[738]
16 [400]	300	30.4	[773]	23.0	[584]	55.37	[1406.5]	1855	[841]
18 [450]	300	32.9	[837]	25.5	[648]	61.63	[1565.4]	2451	[1112]
20 [500]	300	34.9	[887]	28.0	[711]	65.93	[1674.7]	2953	[1340]
24 [600]	300	38.9	[989]	30.5	[775]	77.11	[1958.6]	4274	[1939]
6 [150]	600	21.7	[551]	17.7	[450]	29.52	[749.8]	523	[237]
8 [200]	600	23.8	[605]	17.7	[450]	35.92	[912.3]	813	[369]
10 [250]	600	25.6	[649]	17.7	[450]	40.28	[1023.1]	1053	[478]
12 [300]	600	27.8	[706]	20.0	[508]	46.11	[1171.2]	1488	[675]
14 [350]	600	29.6	[751]	22.0	[559]	50.21	[1275.4]	1959	[888]
16 [400]	600	31.2	[792]	23.8	[603]	55.37	[1406.5]	2388	[1083]
18 [450]	600	33.6	[852]	27.0	[686]	61.63	[1565.4]	3184	[1444]
20 [500]	600	35.7	[906]	29.3	[743]	65.93	[1674.7]	4018	[1822]
24 [600]	600	36.9	[938]	32.0	[813]	77.11	[1958.6]	4986	[2262]
6 [150]	900	22.2	[564]	17.7	[450]	30.12	[765.1]	606	[275]
8 [200]	900	24.8	[630]	17.7	[450]	36.40	[924.7]	1005	[456]
10 [250]	900	26.3	[668]	18.5	[470]	41.19	[1046.1]	1290	[585]
12 [300]	900	28.8	[732]	21.5	[546]	47.07	[1195.7]	1882	[854]
14 [350]	900	30.3	[770]	24.0	[610]	51.23	[1301.1]	2433	[1104]
16 [400]	900	31.6	[802]	25.3	[641]	57.05	[1449.1]	2867	[1301]
18 [450]	900	34.4	[875]	27.8	[705]	62.98	[1599.8]	4034	[1830]
20 [500]	900	36.6	[929]	31.0	[787]	67.70	[1719.5]	5017	[2276]
24 [600]	900	37.8	[960]	33.8	[857]	78.88	[2003.6]	6127	[2779]

Pipe Size Inches [DN]	Flange	Height "H"		Max Width "W" (including manifolds and sunshield)		Overall Length "OAL"		Assembled Meter Weight - with Transmitter	
		Inches	[mm]	Inches	[mm]	Inches	[mm]	lbs	[kg]
6 [150]	1500	22.4	[570]	17.7	[450]	29.64	[752.9]	727	[330]
8 [200]	1500	25.1	[637]	17.7	[450]	34.98	[888.5]	1193	[541]
10 [250]	1500	27.1	[687]	19.0	[483]	39.87	[1012.6]	1713	[777]
12 [300]	1500	30.1	[764]	23.0	[584]	45.21	[1148.5]	2687	[1219]
14 [350]	1500	32.4	[824]	26.5	[673]	50.59	[1285.0]	3724	[1689]
16 [400]	1500	33.9	[862]	29.5	[749]	54.10	[1374.0]	4539	[2059]
18 [450]	1500	36.9	[938]	32.5	[826]	60.12	[1526.9]	6145	[2787]
20 [500]	1500	39.1	[992]	36.0	[914]	63.98	[1625.1]	7546	[3423]
24 [600]	1500	40.3	[1024]	38.8	[984]	74.42	[1890.2]	8757	[3972]

Note: All lengths and weights are typical. Refer to site specific product literature and/or site drawings. Specifications for dimensions and weights are subject to change without notification.

2xxCi-R or 2xxCiLT-R (with J-Boxes) Meter Body Dimensions

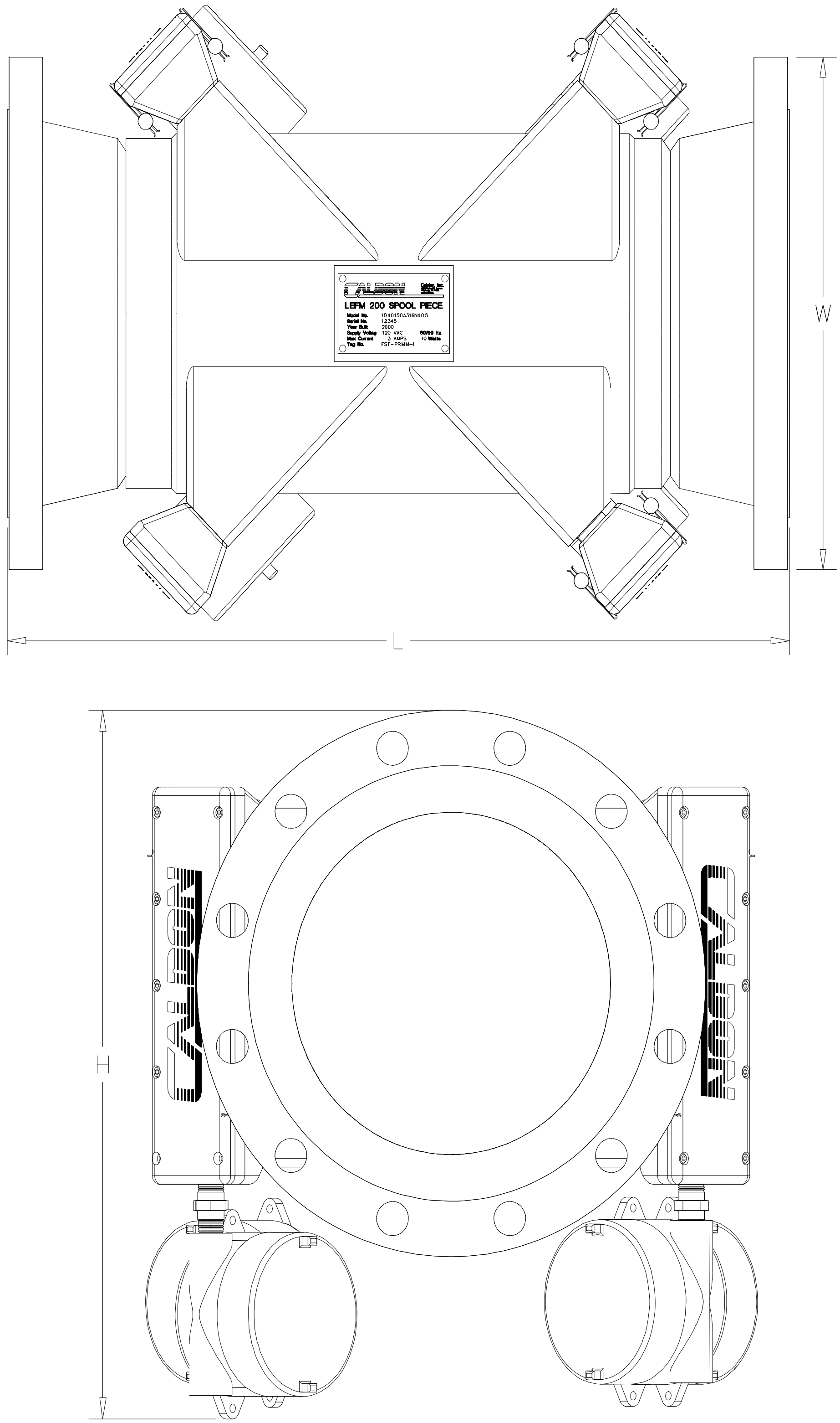


Figure 1.7: LEFM 2xxCi-R and 2xxCiLT-R Dimensions

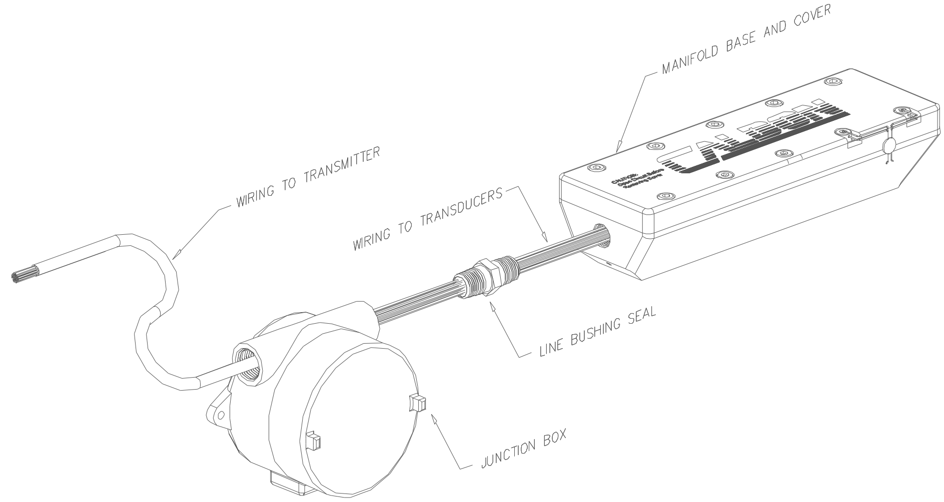


Figure 1.8: 2xxCi-R and 2xxCiLT-R
ATEX Only - Construction of Manifold to Junction Box Connection

Note: The specific ATEX approved cable gland, as specified on ATEX Certificate, must be used.

Table 1.7: Dimensions and Weights for LEFM 280Ci-R and the 280CiLT Extreme Temperatures Meter Body Remote Mount Electronics, Typical of all 2xxCi Models

Pipe Size Inches [DN]	Flange	Height "H"		Max Width "W" (including manifolds)		Overall Length "OAL"		Assembled Meter Weight not including Transmitter	
		Inches	[mm]	Inches	[mm]	Inches	[mm]	lbs	[kg]
4 [100]	150	17.2	[437]	11.9	[302]	21.00	[533.4]	317	[144]
6 [150]	150	18.2	[462]	13.9	[353]	24.00	[609.6]	479	[217]
8 [200]	150	19.4	[494]	15.7	[399]	26.75	[679.5]	718	[326]
10 [250]	150	20.7	[525]	17.7	[449]	28.75	[730.3]	995	[451]
12 [300]	150	22.2	[564]	19.6	[497]	31.75	[806.5]	1367	[620]
14 [350]	150	23.2	[589]	20.8	[527]	34.00	[863.6]	1654	[750]
16 [400]	150	24.4	[621]	22.8	[579]	35.75	[908.1]	2150	[975]
18 [450]	150	25.2	[640]	24.8	[630]	38.75	[984.3]	2644	[1199]
20 [500]	150	27.5	[699]	26.8	[681]	41.13	[1044.6]	3232	[1466]
24 [600]	150	32.0	[813]	30.8	[782]	45.75	[1162.1]	4571	[2073]
4 [100]	300	17.7	[449]	11.9	[302]	21.75	[552.5]	337	[153]
6 [150]	300	18.9	[481]	13.9	[353]	24.75	[628.7]	520	[236]
8 [200]	300	20.2	[513]	15.7	[399]	27.50	[698.5]	778	[353]
10 [250]	300	21.4	[545]	17.7	[449]	30.00	[762.0]	1089	[494]
12 [300]	300	22.9	[583]	19.6	[497]	33.00	[838.2]	1494	[678]
14 [350]	300	24.2	[614]	20.8	[527]	35.25	[895.4]	1843	[836]
16 [400]	300	25.5	[648]	22.8	[579]	37.25	[946.2]	2385	[1082]
18 [450]	300	28.0	[711]	24.8	[630]	40.25	[1022.4]	2954	[1340]
20 [500]	300	30.5	[775]	26.8	[681]	42.50	[1079.5]	3592	[1629]
24 [600]	300	36.0	[914]	30.8	[782]	47.00	[1193.8]	5144	[2333]
4 [100]	600	18.1	[459]	11.9	[302]	23.50	[596.9]	370	[168]
6 [150]	600	19.7	[500]	13.9	[353]	26.75	[679.5]	609	[276]
8 [200]	600	20.9	[532]	15.7	[399]	29.75	[755.7]	914	[415]
10 [250]	600	22.7	[576]	17.7	[449]	33.25	[844.6]	1349	[612]
12 [300]	600	23.7	[602]	19.6	[497]	35.50	[901.7]	1797	[815]
14 [350]	600	24.6	[624]	20.8	[527]	37.50	[952.5]	2165	[982]
16 [400]	600	27.0	[686]	22.8	[579]	40.25	[1022.4]	2917	[1323]
18 [450]	600	29.3	[743]	24.8	[630]	42.75	[1085.9]	3639	[1650]
20 [500]	600	32.0	[813]	26.8	[681]	45.25	[1149.4]	4539	[2059]
24 [600]	600	37.0	[940]	30.8	[782]	50.25	[1276.4]	6602	[2995]

Pipe Size Inches [DN]	Flange	Height "H"		Max Width "W" (including manifolds)		Overall Length "OAL"		Assembled Meter Weight not including Transmitter	
		Inches	[mm]	Inches	[mm]	Inches	[mm]	lbs	[kg]
4 [100]	900	18.4	[468]	11.9	[302]	24.50	[622.3]	404	[183]
6 [150]	900	20.2	[513]	13.9	[353]	28.50	[723.9]	690	[313]
8 [200]	900	21.9	[557]	15.7	[399]	32.00	[812.8]	1097	[498]
10 [250]	900	23.4	[595]	17.7	[449]	35.75	[908.1]	1581	[717]
12 [300]	900	24.7	[627]	19.6	[497]	39.00	[990.6]	2179	[988]
14 [350]	900	25.3	[643]	20.8	[527]	41.25	[1047.8]	2604	[1181]
16 [400]	900	27.8	[705]	22.8	[579]	43.25	[1098.6]	3358	[1523]
18 [450]	900	31.0	[787]	24.8	[630]	46.25	[1174.8]	4390	[1991]
20 [500]	900	33.8	[857]	26.8	[681]	49.75	[1263.7]	5464	[2478]
24 [600]	900	41.0	[1041]	30.8	[782]	57.25	[1454.2]	8862	[4020]
4 [100]	1500	18.8	[478]	12.3	[311]	25.25	[641.4]	449	[204]
6 [150]	1500	20.4	[519]	13.9	[353]	31.00	[787.4]	824	[374]
8 [200]	1500	22.2	[564]	15.7	[399]	36.00	[914.4]	1319	[598]
10 [250]	1500	24.2	[614]	17.7	[449]	41.25	[1047.8]	2075	[941]
12 [300]	1500	26.5	[673]	19.6	[497]	45.50	[1155.7]	3052	[1384]
14 [350]	1500	29.5	[749]	20.8	[527]	48.00	[1219.2]	3874	[1757]
16 [400]	1500	32.5	[826]	22.8	[579]	50.75	[1289.1]	5089	[2308]
18 [450]	1500	36.0	[914]	24.8	[630]	54.00	[1371.6]	6578	[2984]
20 [500]	1500	38.8	[984]	26.8	[681]	58.25	[1479.6]	8193	[3716]
24 [600]	1500	46.0	[1168]	30.8	[782]	66.25	[1682.8]	12680	[5752]

Note: All lengths and weights are typical. Refer to site specific product literature and/or site drawings. Specifications for dimensions and weights are subject to change without notification.

Table 1.8: Dimensions and Weights for LEFM 280CiRN-R Meter Body with Remote Mount Electronics, Typical of all 2xxCiRN-R Models

Pipe Size Inches [DN]	Flange	Height "H"		Max Width "W" (including manifolds and sunshield)		Overall Length "OAL"		Assembled Meter Weight not including Transmitter	
		Inches	[mm]	Inches	[mm]	Inches	[mm]	lbs	[kg]
6 [150]	150	18.2	[462]	11.9	[302]	29.52	[749.8]	367	[166]
8 [200]	150	20.3	[516]	13.9	[353]	35.92	[912.3]	572	[260]
10 [250]	150	21.6	[548]	13.9	[353]	40.28	[1023.1]	644	[292]
12 [300]	150	24.3	[618]	16.0	[406]	46.11	[1171.2]	982	[446]
14 [350]	150	26.2	[665]	19.0	[483]	50.21	[1275.4]	1348	[612]
16 [400]	150	27.4	[697]	21.0	[533]	55.37	[1406.5]	1506	[683]
18 [450]	150	29.4	[748]	23.5	[597]	61.63	[1565.4]	1978	[897]
20 [500]	150	31.4	[799]	25.0	[635]	65.93	[1674.7]	2401	[1089]
24 [600]	150	34.9	[887]	27.5	[699]	77.11	[1958.6]	3342	[1516]
6 [150]	300	18.9	[481]	11.9	[302]	29.52	[749.8]	418	[189]
8 [200]	300	21.1	[535]	13.9	[353]	35.92	[912.3]	650	[295]
10 [250]	300	22.3	[567]	15.0	[381]	40.28	[1023.1]	766	[347]
12 [300]	300	25.1	[637]	17.5	[445]	46.11	[1171.2]	1135	[515]
14 [350]	300	27.2	[691]	20.5	[521]	50.21	[1275.4]	1613	[732]
16 [400]	300	28.4	[722]	23.0	[584]	55.37	[1406.5]	1840	[835]
18 [450]	300	30.9	[786]	25.5	[648]	61.63	[1565.4]	2436	[1105]
20 [500]	300	32.9	[837]	28.0	[711]	65.93	[1674.7]	2938	[1333]
24 [600]	300	36.9	[938]	30.5	[775]	77.11	[1958.6]	4259	[1932]
6 [150]	600	19.7	[500]	11.9	[302]	29.52	[749.8]	508	[231]
8 [200]	600	21.8	[554]	14.0	[356]	35.92	[912.3]	798	[362]
10 [250]	600	23.6	[598]	16.5	[419]	40.28	[1023.1]	1038	[471]
12 [300]	600	25.8	[656]	20.0	[508]	46.11	[1171.2]	1473	[668]
14 [350]	600	27.6	[700]	22.0	[559]	50.21	[1275.4]	1944	[882]
16 [400]	600	29.2	[741]	23.8	[603]	55.37	[1406.5]	2373	[1076]
18 [450]	600	31.6	[802]	27.0	[686]	61.63	[1565.4]	3169	[1437]
20 [500]	600	33.7	[856]	29.3	[743]	65.93	[1674.7]	4003	[1816]
24 [600]	600	34.9	[887]	32.0	[813]	77.11	[1958.6]	4971	[2255]
6 [150]	900	20.2	[513]	11.9	[302]	30.12	[765.1]	591	[268]
8 [200]	900	22.8	[579]	15.0	[381]	36.40	[924.7]	990	[449]
10 [250]	900	24.3	[618]	18.5	[470]	41.19	[1046.1]	1275	[578]
12 [300]	900	26.8	[681]	21.5	[546]	47.07	[1195.7]	1867	[847]
14 [350]	900	28.3	[719]	24.0	[610]	51.23	[1301.1]	2418	[1097]
16 [400]	900	29.6	[751]	25.3	[641]	57.05	[1449.1]	2852	[1294]
18 [450]	900	32.4	[824]	27.8	[705]	62.98	[1599.8]	4019	[1823]
20 [500]	900	34.6	[878]	31.0	[787]	67.70	[1719.5]	5002	[2269]
24 [600]	900	35.8	[910]	33.8	[857]	78.88	[2003.6]	6112	[2772]

Pipe Size Inches [DN]	Flange	Height "H"		Max Width "W" (including manifolds and sunshield)		Overall Length "OAL"		Assembled Meter Weight not including Transmitter	
		Inches	[mm]	Inches	[mm]	Inches	[mm]	lbs	[kg]
6 [150]	1500	20.4	[519]	12.3	[311]	29.64	[752.9]	712	[323]
8 [200]	1500	23.1	[586]	15.5	[394]	34.98	[888.5]	1178	[534]
10 [250]	1500	25.1	[637]	19.0	[483]	39.87	[1012.6]	1698	[770]
12 [300]	1500	28.1	[713]	23.0	[584]	45.21	[1148.5]	2672	[1212]
14 [350]	1500	30.4	[773]	26.5	[673]	50.59	[1285.0]	3709	[1682]
16 [400]	1500	32.5	[826]	29.5	[749]	54.10	[1374.0]	4524	[2052]
18 [450]	1500	36.0	[914]	32.5	[826]	60.12	[1526.9]	6130	[2781]
20 [500]	1500	38.8	[984]	36.0	[914]	63.98	[1625.1]	7531	[3416]
24 [600]	1500	38.8	[984]	38.8	[984]	74.42	[1890.2]	8742	[3965]

Note: All lengths and weights are typical. Refer to site specific product literature and/or site drawings. Specifications for dimensions and weights are subject to change without notification.

2xxCiLT-R Meter Body (without J-Boxes) Dimensions

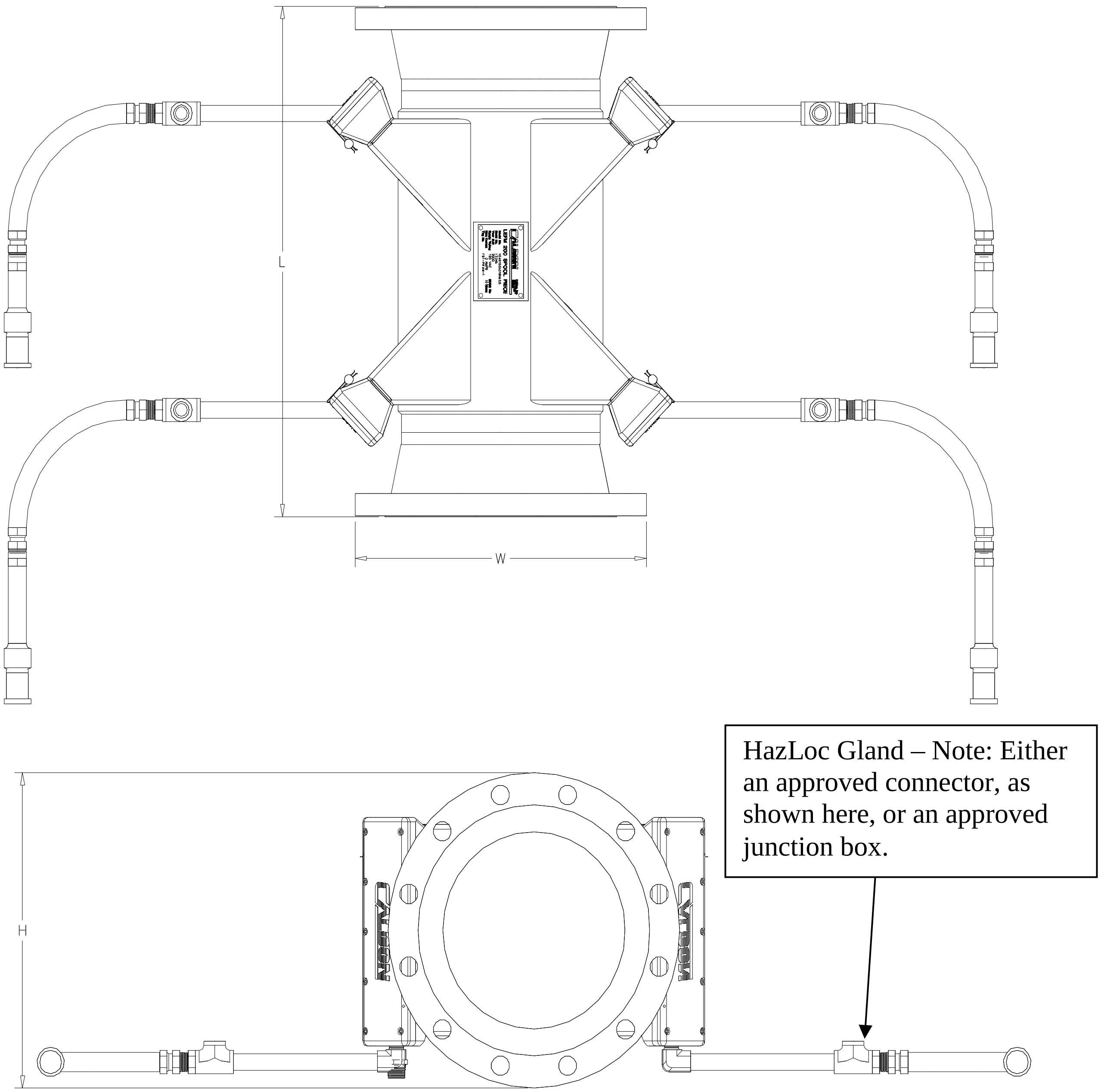


Figure 1.9: LEFM 280CiLT Dimensions

Note: Approved seal at the end of the tee/fitting is required. The specific ATEX approved cable gland, as specified on the ATEX certificate, must be used.

Meter Body Installation

The LEFM 2xxCi flowmeters are designed for use with a broad range of process and environmental conditions. Durable construction permits conventional installation practices. The flowmeter body is typically fabricated of stainless steel, carbon steel, or duplex steel, depending on customer requirements. The flowmeter is designed to be as strong as or stronger than pipe and flanges of the same schedule, pressure class and material. For site stress analyses, the meter can be conservatively treated as equivalent pipe.

Installation procedures vary, depending on whether the transmitter is attached directly to the meter body, or mounted remotely from the meter body. This section describes the installation procedure for the typical case where the transmitter is mounted to the meter body (Model 2xxCi). Section 3 addresses the case where the transmitter is mounted at separate location, typically due to extreme environmental reasons (for example, high or low pipe temperatures). Remote mounting of the electronics is for Models 2xxCi-R, 2xxCiRN-R and 2xxCiLT.

Flow Meter Body Installation - Best Practices

CAUTION

The weights of the flow meter body are listed in Tables 1.5 through 1.8. Never use the transmitter, conduit or junction boxes for lifting or maneuvering the meter body. These components are not designed for the forces required to move the meter body and could be damaged.

CAUTION

If the equipment is likely to come into contact with aggressive substances, then it is the responsibility of the user to take suitable precautions that prevent it from being adversely affected, thus ensuring that the type of protection is not compromised.

No external supports or special mounting pads are required or recommended for the LEFM meter body; however, the piping immediately upstream and downstream of the flowmeter should be well supported in accordance with good piping practices and site seismic requirements (see Section 1 for LEFM weight and size information).

Install the flowmeter so that:

- The acoustic paths are horizontal (with the transmitter and nameplate on top) to decrease the likelihood of debris or air (gas) accumulating in the sensor wells.
- The word “UP” is stamped on the upstream flange to indicate the direction of flow.
- An arrow is on each flowmeter to indicate direction.

- The amount of entrained gas that reaches the meter is to be kept to a minimum (2% or less, as a rule of thumb). Although ultrasonic meters can provide accurate measurement when a small volume of entrained gas exists in the flow stream, performance is improved by eliminating entrained gas. Certain operations can introduce air into the flow stream. Various types of leaks in a liquid handling system can draw air into the flow stream. Also, pressure loss through a system can allow gas to break out (flash). By being aware of these conditions/operations, an operator can help prevent the accumulation of gas in the flow stream. Slugs of gas in the flow stream do not damage the meter. Continuous presence of gas will give a fault indication. In the worst case, all the sensors will stop indicating and no measurements will be made.

- All wiring to the transmitter is routed in shielded conduit/armored cable that meets site environment specifications.

- In order to limit uncertainty caused by hydraulic effects, it is recommended that the installation of the LEFM2xxCi models use the following guidelines:

<u>LEFM 280Ci(-R), 280CiRN-(R) and 280CiLT</u>

- o The adjoining straight pipe should be of the same schedule as the meter. Temperature elements and pressure connections should be located downstream of the meter. The LEFM 280Ci, 280Ci-R, and 280CiLT does not normally require the use of a flow conditioning element. An uninterrupted upstream pipe 5 pipe diameters in length is adequate in most applications. In situations where there is a constriction upstream of the meter that is smaller than the diameter of the meter run piping (such as a reduced bore valve), it is recommended that this be separated from the meter by a pipe at least 15 pipe diameters in length. Downstream of the meter there should be an uninterrupted pipe at least 3 pipe diameters in length. For application specific recommendations or more detailed installation guidance, please consult Cameron.

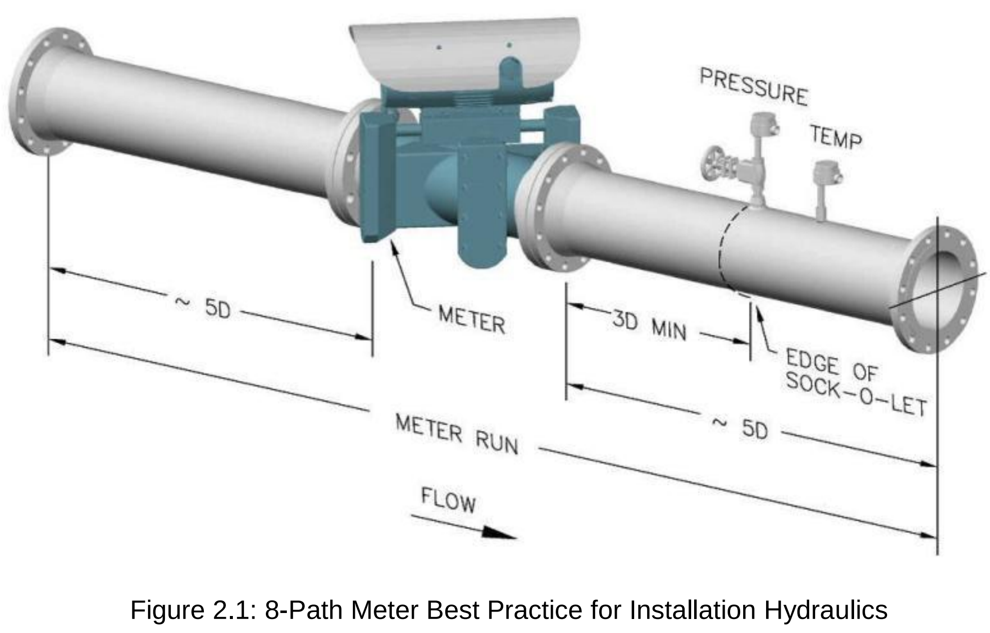


Figure 2.1: 8-Path Meter Best Practice for Installation Hydraulics

LEFM 240Ci(-R), 240CiRN(-R), 240CiLT, 220Ci(-R), and 220CiLT

- The adjoining straight pipe should be of the same pipe schedule as the meter. Temperature elements and pressure connections should be located downstream of the meter. It is recommended that the meter be installed downstream of a 10-diameter pipe section that includes a flow conditioning element at its inlet. For effective flow conditioning, it is generally recommended that there be an additional straight pipe of approximately 5 diameters in length located upstream of the flow conditioner. Downstream of the meter there should be an uninterrupted pipe at least 3 pipe diameters in length. If a flow conditioning element is not used, additional uncertainty can be limited by using a straight pipe upstream at least 20 pipe diameters in length and applying strict rules to avoid the introduction of swirl upstream of that 20 D length. Typically, this will dictate specific requirements for the combination of fittings that can be used for a further 30 diameters upstream. For less demanding uncertainty requirements or when the meter is calibrated in situ, the installation recommendations can be relaxed. For application specific recommendations or more detailed installation guidance, please consult Cameron.

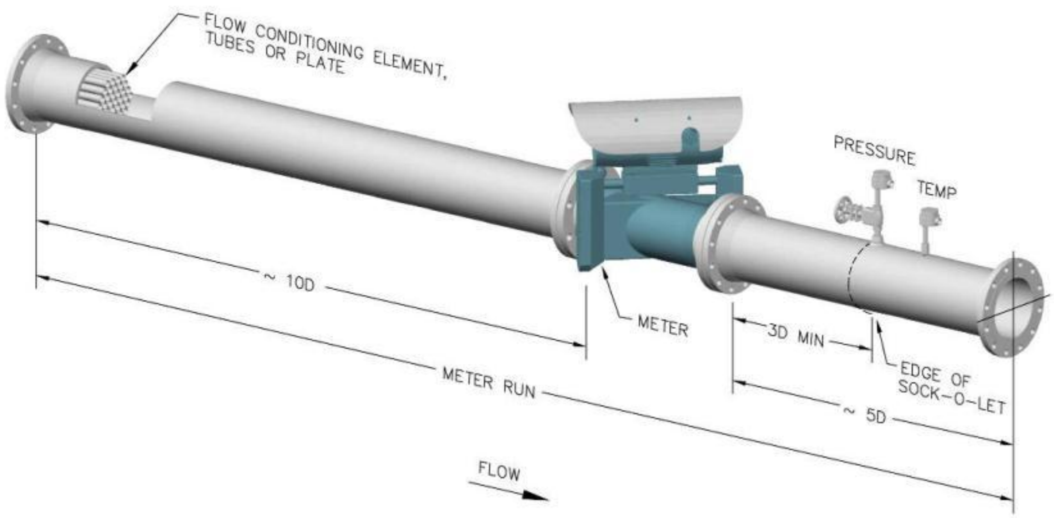


Figure 2-2: 2-Path and 4-Path Meter Best Practice for Installation Hydraulics

<u>Insulation of the LEFM Meter Body and Pipework</u>

- Under normal circumstances it is not necessary to insulate the meter body of adjoining pipework; however, in some circumstances (extreme temperature or laminar flow applications) insulating the meter and pipework may be necessary to avoid incurring additional uncertainty.

- In low Reynolds number applications where the flow may be in laminar or transition regimes, insulation may be effective in preventing the formation of thermal gradients which can lead to additional measurement uncertainty. In order for the insulation to be effective, it should be applied from a point upstream of the meter where the flow is well mixed, down to and including the meter body and manifolds and the straight pipe immediately downstream of the meter.

- If unsure whether insulation is required in your particular application, contact Cameron for guidance.

Section 3

Installing Transmitter Remotely from Meter Body–Only Models 2xxCi-R & 2xxCiLT-R

CAUTION

The physical properties, acoustic properties, and calibration of the meter body are pre-programmed into the transmitter; therefore, the meter body and transmitter are manufactured as a matched set and must be installed as a pair. Failure to install transmitters and meter bodies as matched sets can result in erroneous flow measurements.

Should a customer receive multiple meter bodies and transmitters in one shipment, the installer must verify that each transmitter is installed with the meter body for which it was programmed.

CAUTION

If the equipment is likely to come into contact with aggressive substances, then it is the responsibility of the user to take suitable precautions that prevent it from being adversely affected, thus ensuring that the type of protection is not compromised.

Note - All wiring between the transmitter and the meter body must be routed through grounded metal conduit or equivalent. All wiring to the transmitter is to be routed in shielded conduit that meets site environment specifications.

This section describes the installation procedure for a installing the transmitter separately from the meter body. The following figure illustrates that configuration. The transmitter may be mounted according to this section within 100 meters (~300 feet). For distances further than 100 meters, contact Cameron.

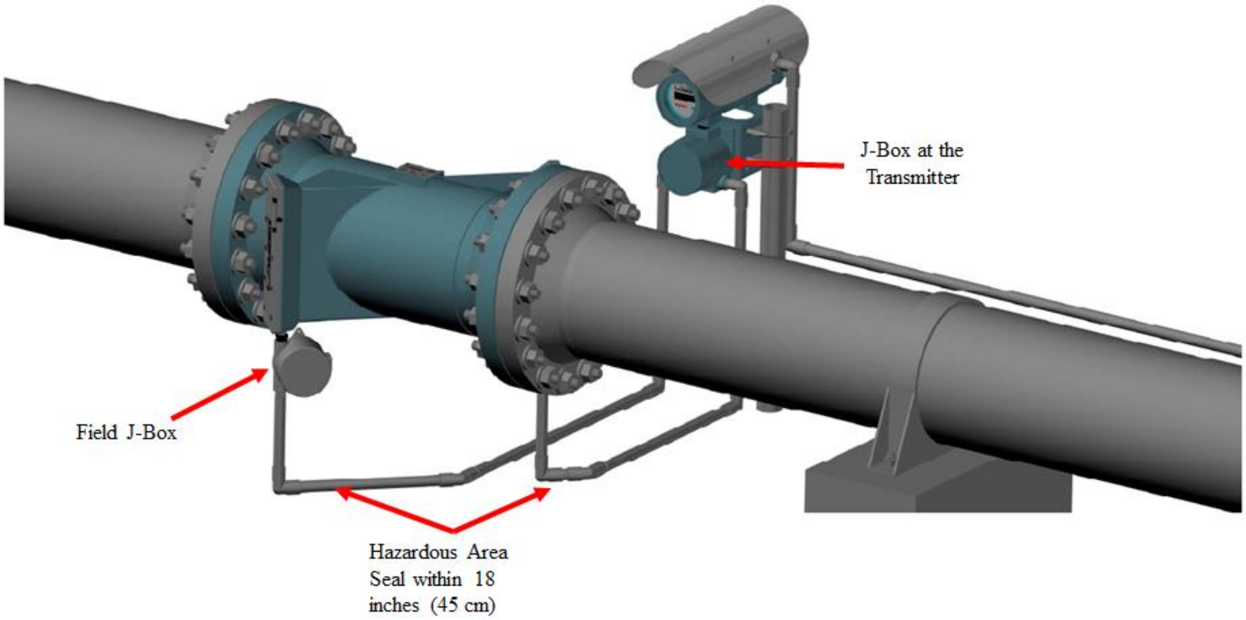


Figure 3.1: Remote Installation of Transmitter from Meter Body

The installation requires field wiring to connect the meter body terminations to the transmitter. Both the meter body and transmitter are installed with junction boxes (J-Box) for the field terminations. The transmitter and its junction box must be mounted according to site seismic rules/guidelines. There is a pole mounting hardware kit as an option for remote mounting the 240Ci-R and 220Ci-R transmitter.

Remote-Mount Terminations Procedure (External Junction Box Only)

The terminations discussed in this section are within the junction boxes associated with the meter body and transmitter. For all other terminations (e.g., power, serial communications etc.), go to Section 4, "Transmitter Installation Procedure".

Meter Body to Transmitter Terminations

WARNING

Before terminating wires, open the power supply circuit breaker. Failure to do so can result in electrical shock and/or explosion.

1. Install hazardous area seals within 18 inches (45 cm) of the meter body junction boxes. (For ATEX see the certificate for the conditions for safe use). Install hazardous area seals at the entry point to transmitter junction box. There is a factory installed hazardous area seal installed between the factory delivered junction box and the transmitter.

WARNING

If ATEX approved glands are to be used, they shall be types that include compound filled seals around individual cores. (Refer to EN 60079-14 clause 10.4.2).

2. Route the transducer and RTD cable(s) from the meter body junction boxes through the hazardous area cable/conduit to the transmitter junction box and make termination connections according to Tables 3.1, 3.2 and 3.3.

Note – The standard interconnect cable provided by Cameron for the LEFM 2xxCi-R meters has a bend radius of 14”.

Note – In the following figures, the location of the hazardous area seals is only nominal. Site geometrics, electrical codes and criteria may change the seal selection and affect the configuration.

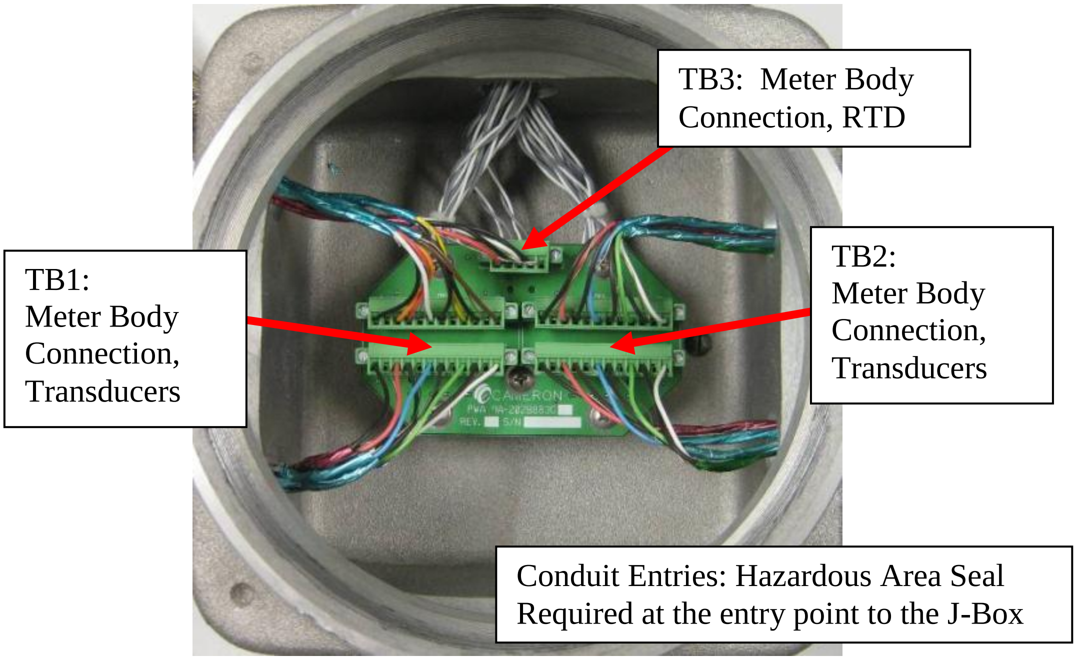


Figure 3.2: 280Ci-R Remote Mount Junction Box Terminations at the Transmitter (Typical)

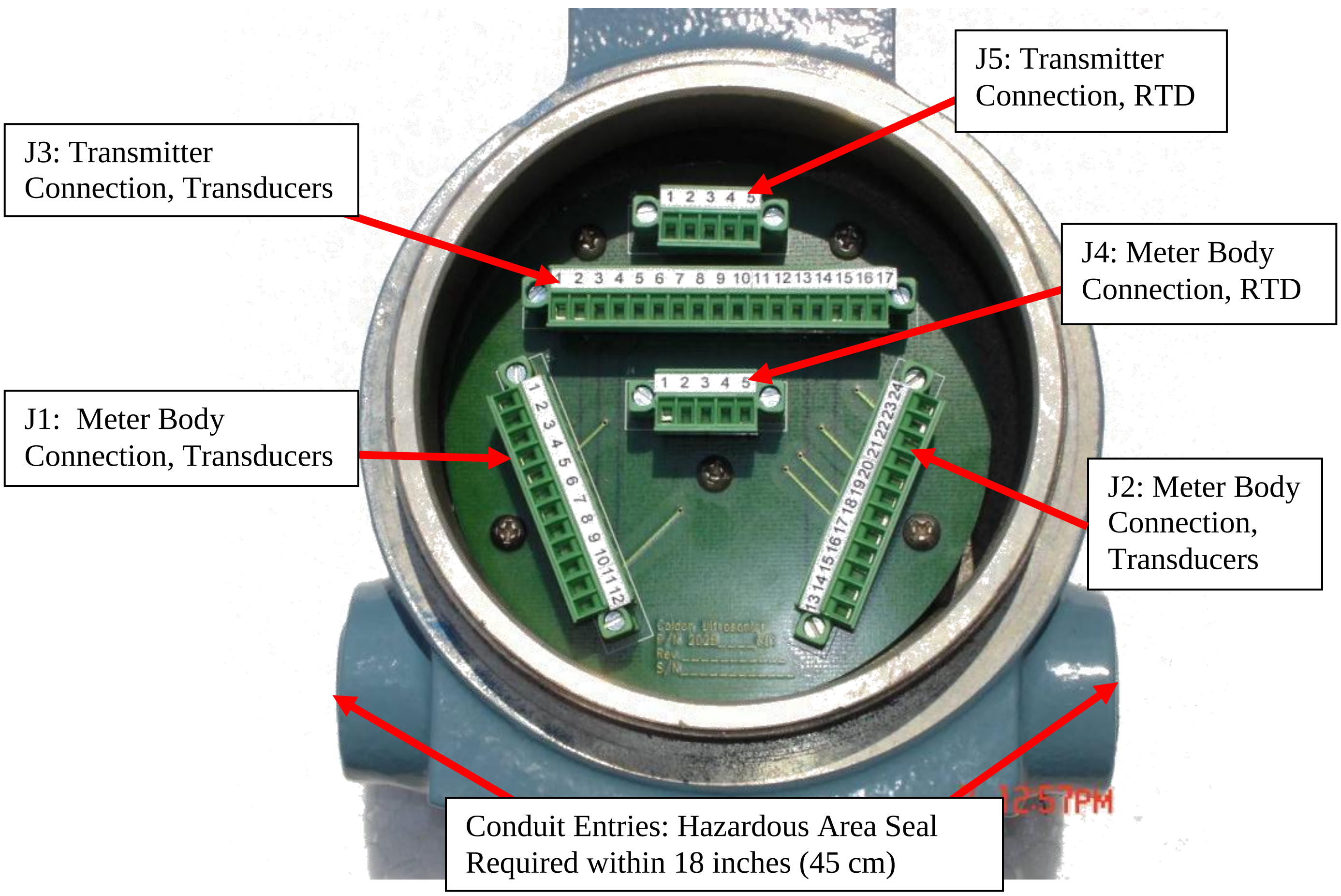


Figure 3.3: 240Ci-R and 220Ci-R - Remote Mount Junction Box Terminations at the Transmitter

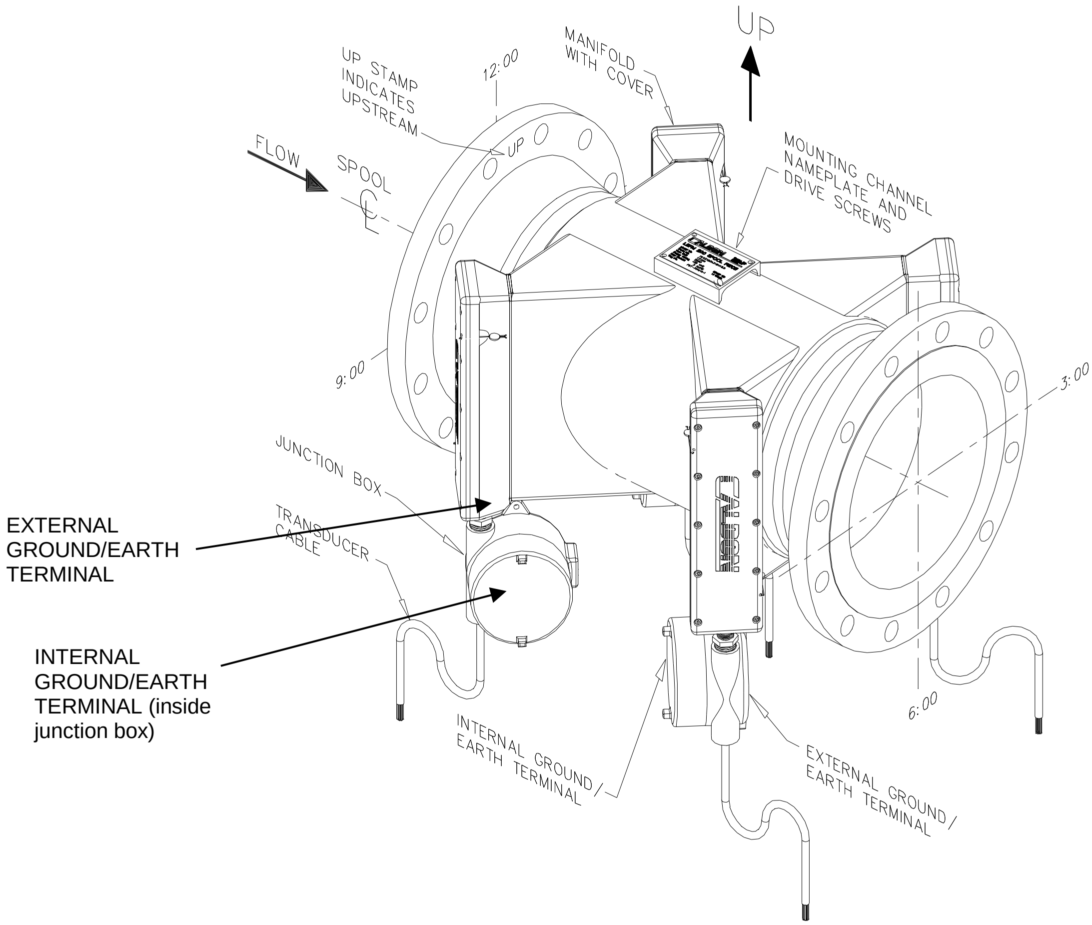


Figure 3.4: LEFM 2xxCi-R or LEFM2xxCiLT Meter Body Junction Box Locations

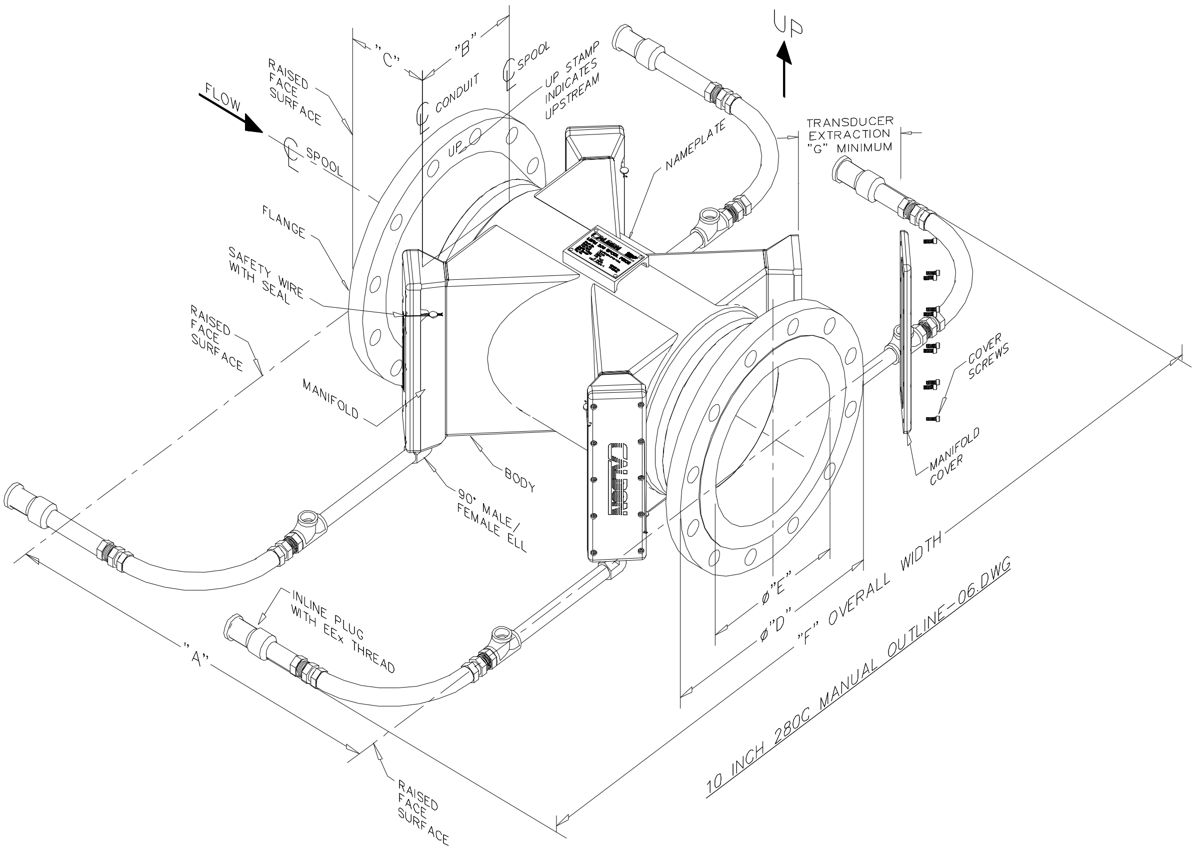


Figure 3.5: LEFM 2xxCiLT: Meter Body Termination Locations with built in connectors.
If Junction box is used – then see Figure 3.4
(Cables and Connectors are pre-made for field connections)

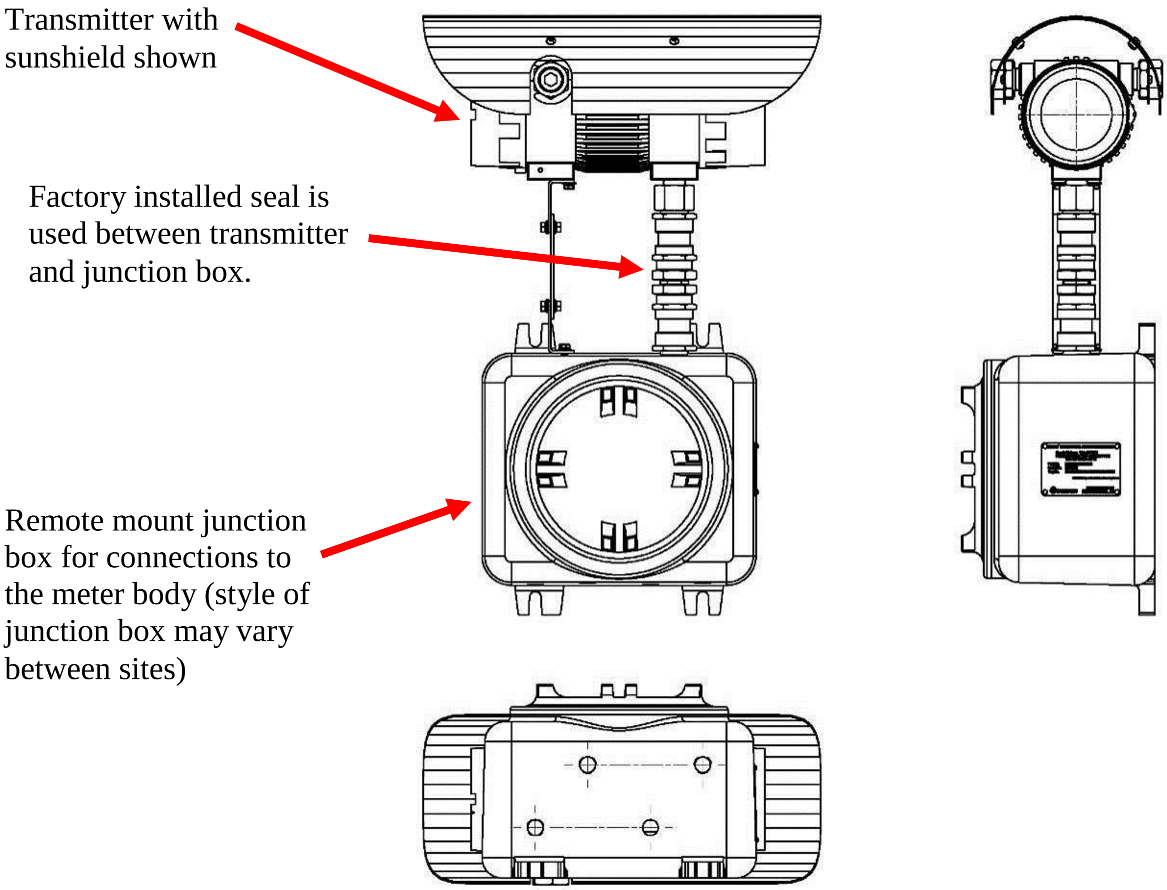


Figure 3.6: 280Ci-R (or 280CiLT-R) Remote Installation of Transmitter/Junction Box

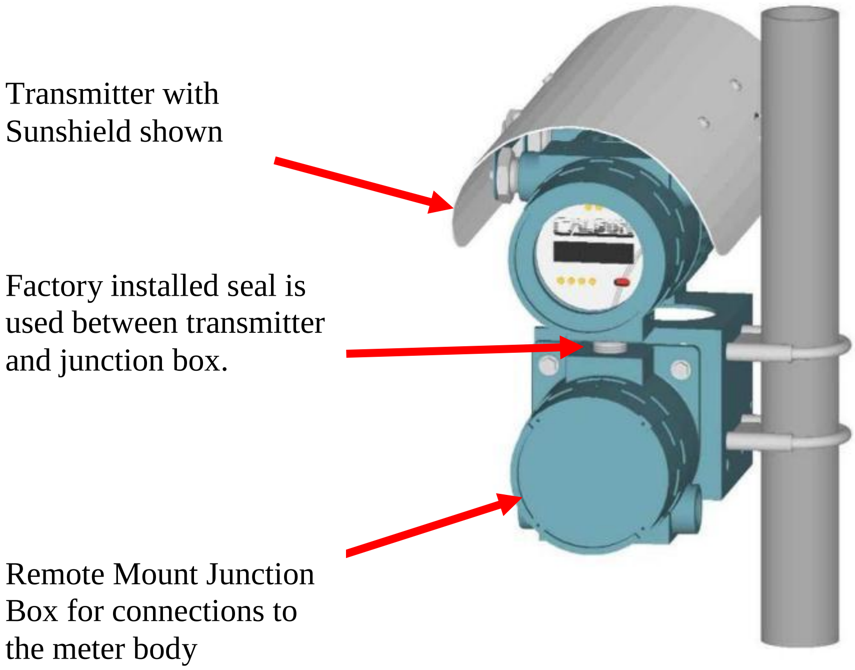


Figure 3.7: 220/240Ci-R Remote Installation of Transmitter/Junction Box

Important	**All equipment should be installed by a licensed electrician in accordance with NEC/CEC or local codes. At a minimum, install a disconnect switch in series with the transmitter power input.**

Table 3.1: LEFM 280Ci(RN)-R Transducer and RTD Terminations
(Note: On the LEFM280CiLT with built in connectors, all terminations are done in the connectors)

Transducer Cable Identification		A-Side J-Box Termination		Meter Body Junction Box	
Wire Name		Device	Pin	Device	Pin
1 UP	+	TB1	1	1A Upstream JBOX-TB1	1
	Shield	TB1	2		—
	-	TB1	3		2
2 UP	+	TB1	4	1A Upstream JBOX-TB1	3
	Shield	TB1	5		—
	-	TB1	6		4
3 UP	+	TB1	7	1A Upstream JBOX-TB1	5
	Shield	TB1	8		—
	-	TB1	9		6
4 UP	+	TB1	10	1A Upstream JBOX-TB1	7
	Shield	TB1	11		—
	-	TB1	12		8
1 DN	+	TB1	13	1B Downstream JBOX-TB1	13
	Shield	TB1	14		—
	-	TB1	15		14
2 DN	+	TB1	16	1B Downstream JBOX-TB1	15
	Shield	TB1	17		—
	-	TB1	18		16
3 DN	+	TB1	19	1B Downstream JBOX-TB1	17
	Shield	TB1	20		—
	-	TB1	21		18
4 DN	+	TB1	22	1B Downstream JBOX-TB1	19
	Shield	TB1	23		—
	-	TB1	24		20
RTD	RTD+	TB3	1	1A Upstream JBOX-TB1	9
	RTD+	TB3	3		10
	Shield	TB3	5		—
	RTD-	TB3	2		11
	RTD-	TB3	4		12
5 UP	+	TB2	1	2A Upstream JBOX-TB1	21
	Shield	TB2	2		—
	-	TB2	3		22
6 UP	+	TB2	4	2A Upstream JBOX-TB1	23
	Shield	TB2	5		—
	-	TB2	6		24
7 UP	+	TB2	7	2A Upstream JBOX-TB1	25
	Shield	TB2	8		—
	-	TB2	9		26
8 UP	+	TB2	10	2A Upstream JBOX-TB1	27
	Shield	TB2	11		—
	-	TB2	12		28
5 DN	+	TB2	13	2B Downstream JBOX-TB1	33
	Shield	TB2	14		—
	-	TB2	15		34

Transducer Cable Identification		A-Side J-Box Termination		Meter Body Junction Box	
Wire Name		Device	Pin	Device	Pin
6 DN	+	TB2	16	2B Downstream JBOX-TB1	35
	Shield	TB2	17		—
	-	TB2	18		36
7 DN	+	TB2	19	2B Downstream JBOX-TB1	37
	Shield	TB2	20		—
	-	TB2	21		38
8 DN	+	TB2	22	2B Downstream JBOX-TB1	39
	Shield	TB2	23		—
	-	TB2	24		40

Table 3.2: LEFM 240Ci(RN)-R Transducer and RTD Terminations
(Note: On the LEFM240CiLT with built in connectors, all terminations are done in the connectors)

Transducer Cable Identification		A-Side J-Box Termination		Meter Body Junction Box	
Wire Name		Device	Pin	Device	Pin
1 UP	+	J1	1	1A Upstream JBOX-TB1	1
	Shield	J1	2		—
	-	J1	3		2
2 UP	+	J1	4	1A Upstream JBOX-TB1	3
	Shield	J1	5		—
	-	J1	6		4
3 UP	+	J1	7	1A Upstream JBOX-TB1	5
	Shield	J1	8		—
	-	J1	9		6
4 UP	+	J1	10	1A Upstream JBOX-TB1	7
	Shield	J1	11		—
	-	J1	12		8
1 DN	+	J2	1	1B Downstream JBOX-TB1	13
	Shield	J2	2		—
	-	J2	3		14
2 DN	+	J2	4	1B Downstream JBOX-TB1	15
	Shield	J2	5		—
	-	J2	6		16
3 DN	+	J2	7	1B Downstream JBOX-TB1	17
	Shield	J2	8		—
	-	J2	9		18
4 DN	+	J2	10	1B Downstream JBOX-TB1	19
	Shield	J2	11		—
	-	J2	12		20
RTD	RTD+	J4	1	1A Upstream JBOX-TB1	9
	RTD+	J4	3		10
	Shield	J4	5		—
	RTD-	J4	2		11
	RTD-	J4	4		12

Table 3.3: LEFM 220Ci-R Transducer and RTD Terminations
(Note: On the LEFM220CiLT with built in connectors, all terminations are done in the connectors)

Transducer Cable Identification		A-Side J-Box Termination		Meter Body Junction Box	
Wire Name		Device	Pin	Device	Pin
1 UP	+	TB1	1	1A Upstream JBOX-TB1	1
	Shield	TB1	2		—
	-	TB1	3		2
2 UP	+	TB1	4	1A Upstream JBOX-TB1	3
	Shield	TB1	5		—
	-	TB1	6		4
1 DN	+	TB2	13	1B Downstream JBOX-TB1	1
	Shield	TB2	14		—
	-	TB2	15		2
2 DN	+	TB2	16	1B Downstream JBOX-TB1	3
	Shield	TB2	17		—
	-	TB2	18		4
RTD	RTD+	TB4	1	1A Upstream JBOX-TB1	9
	RTD+	TB4	3		10
	Shield	TB4	5		—
	RTD-	TB4	2		11
	RTD-	TB4	4		12

To test or validate a meter's installation, perform the procedures in Section 4. For troubleshooting information, see Section 8 of this manual.

Remote-Mount Transmitter Installation Procedure

280Ci Remote Mount Transmitter

It is recommended that the transmitter be mounted at a convenient working height. (The recommended height is the bottom of the transmitter at about 4.5 feet (1.4 meters) from the floor or ground.)

1. Uncrate the transmitter (note the "unpacked weight" of the instrument as listed in Table 1.2).
2. Select bolts/hardware appropriate for the unit's weight and consider site seismic requirements.
3. Determine the orientation that will best accommodate connections to the meter body as well as the transmitter display view angle.
4. Use the indicated mounting points for mounting the units.

   Use properly rated bolts/hardware on all mounting points for the explosion proof transmitter/junction box assembly. Depending on the brand of junction box, the cover bolts may be metric, M12 x 1.75 x 50 mm for the Bartec brand – requiring a 19 mm socket/wrench or for the Adalet brand, the cover bolts are 0.5 inch x 13 x1.5 inches long.

<u>220Ci/240Ci Remote Mount Transmitter</u>

It is recommended that the transmitter be mounted at a convenient working height. (The recommended height is the bottom of the transmitter at about 4.5 feet (1.4 meters) from the floor or ground.)

1. Uncrate the transmitter (note the “unpacked weight” of the instrument as listed in Table 1.2).
2. Consider site seismic requirements.
3. Determine the orientation that will best accommodate connections to the meter body as well as the transmitter display view angle. The mounting bracket design allows the transmitter to be installed on either a horizontal pole or a vertical pole.
4. Connect the mounting bracket to the transmitter and junction box using the four bolts, see Figures 3.8 and 3.9.
5. Position the U-bolts around the pole and through the support bracket.
6. Install and tighten the hardware for the U-bolts such that the support bracket and transmitter/junction box are secure.

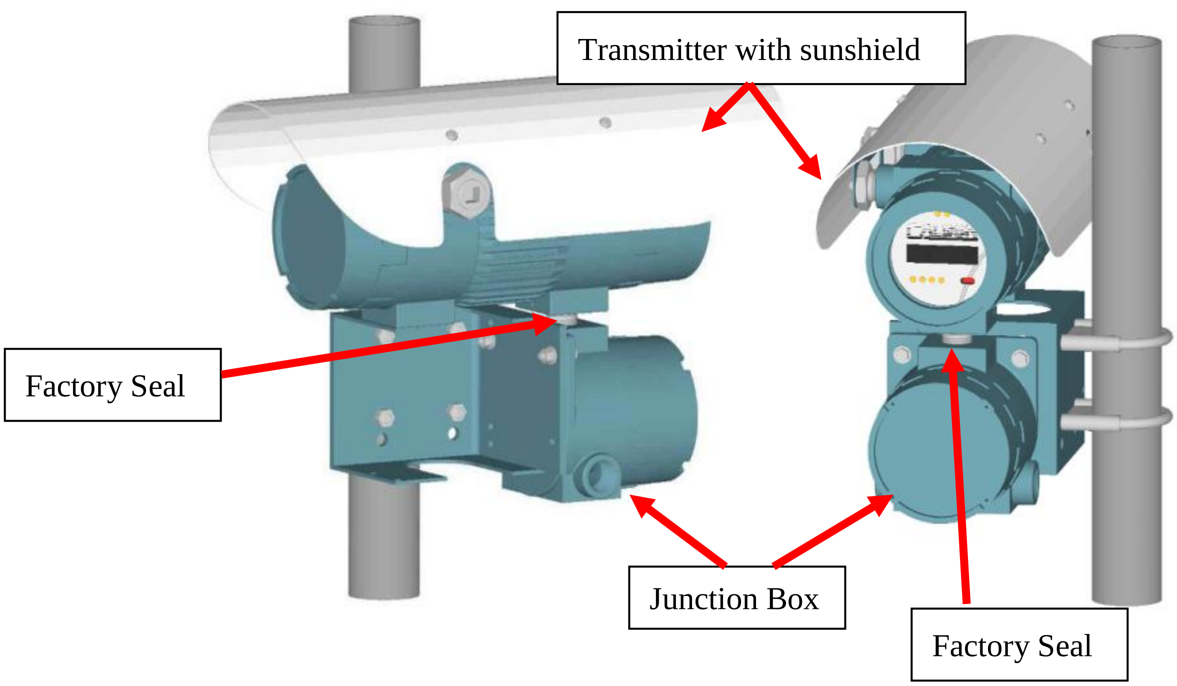


Figure 3.8: Vertical Installation of Transmitter/Junction Box (Sunshield Shown)

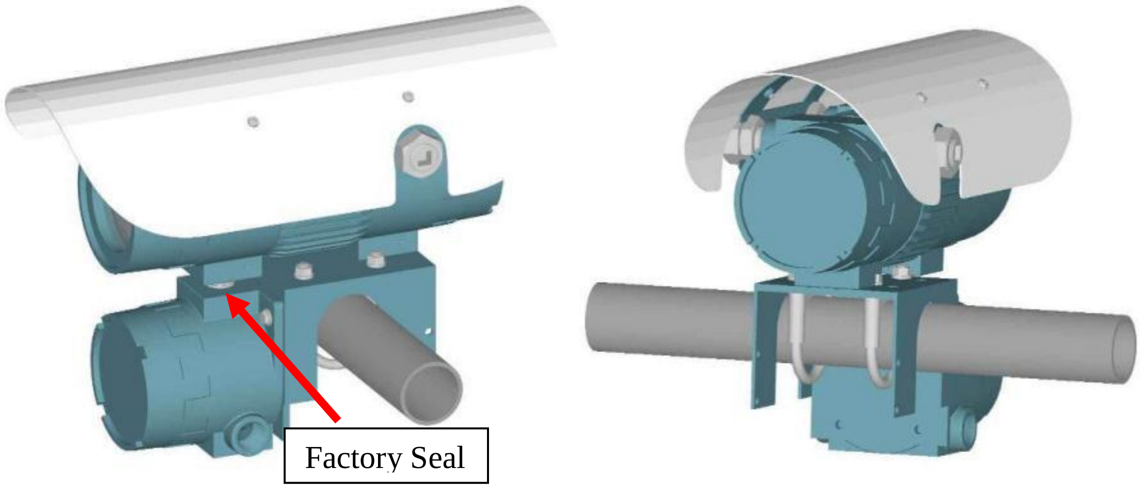


Figure 3.9: Horizontal Installation of Transmitter/Junction Box (Sunshield Shown)

Section 4

Transmitter Connections – All Models

CAUTION

Models 2xxCi-R and 2xxCiLT-R Only: The physical properties, acoustic properties, and calibration of the meter body are pre-programmed into the transmitter; therefore, the meter body and transmitter are manufactured as a matched set and must be installed as a pair. Failure to install transmitters and meter bodies as matched sets can result in erroneous flow measurements.

Transmitter Installation Procedure

Important **All equipment should be installed by a licensed electrician in accordance with NEC/CEC or local codes. At a minimum, install a disconnect switch in series with the transmitter power input.**

NOTES:
1 – All wiring to and from the transmitter must be routed through grounded metal conduit or equal.
2 – All wiring must use wires of 16 to 24 AWG or equal. Larger diameter wires can potentially put damaging stresses onto the transmitter connectors.

Transmitter Terminations

WARNING

Before inspecting components, open the power supply circuit breaker. Failure to do so can result in electrical shock and/or explosion.

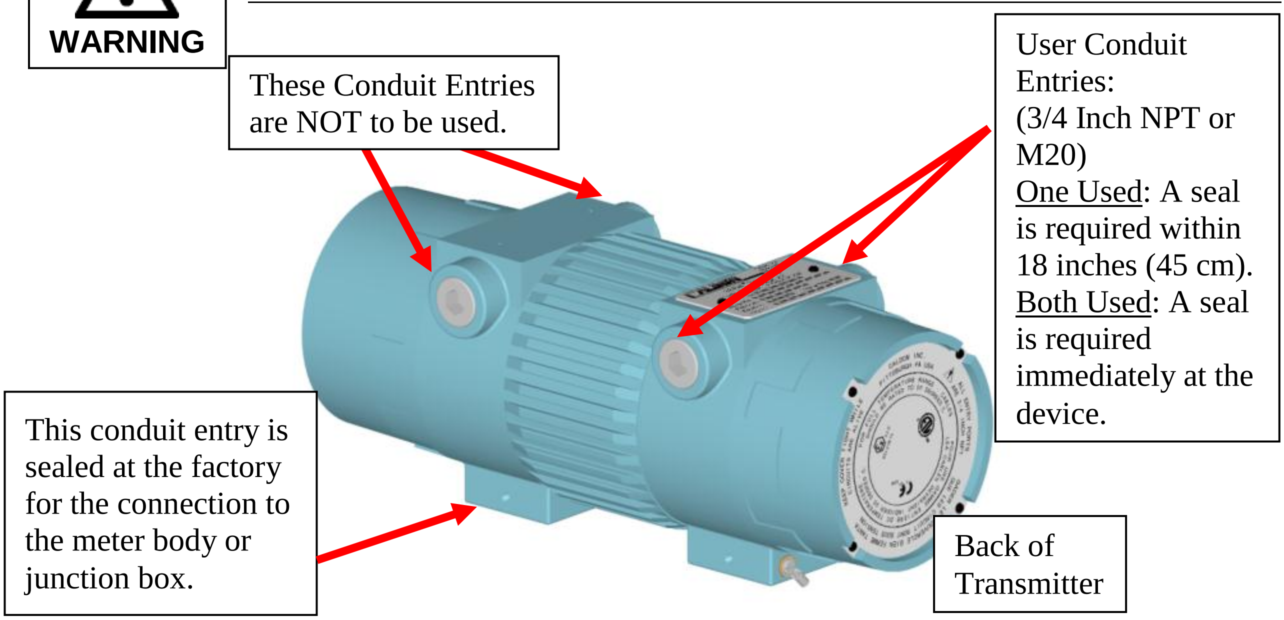


Figure 4.1: Fully Assembled Transmitter – Rear View

The two conduit entries (3/4 inch NPT or M20) at the rear of the transmitter are for user connections. If one entry is used, then a hazardous area conduit seal must be installed within 18 inches (45 cm) of the device. If both entries need to be used, a hazardous area conduit seal is required on both entries immediately at the device.

WARNING

If ATEX approved glands are to be used, they shall be types that include compound filled seals around individual cores. (Refer to EN 60079-14 clause 10.4.2).

The wires should then be routed so that the termination can be made. The terminations are made under the rear cover at the terminal blocks (see Figures 4.2 and 4.3).

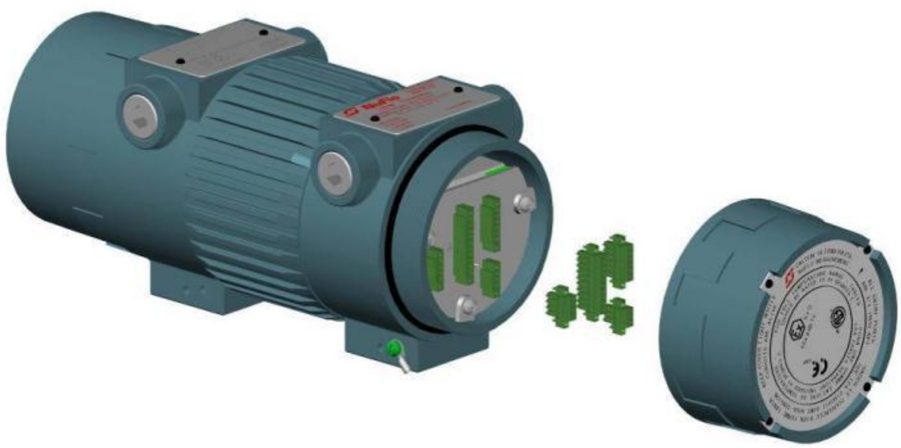


Figure 4.2: Transmitter with Rear Cover Removed
(Communications Option 1 Backplane Shown)

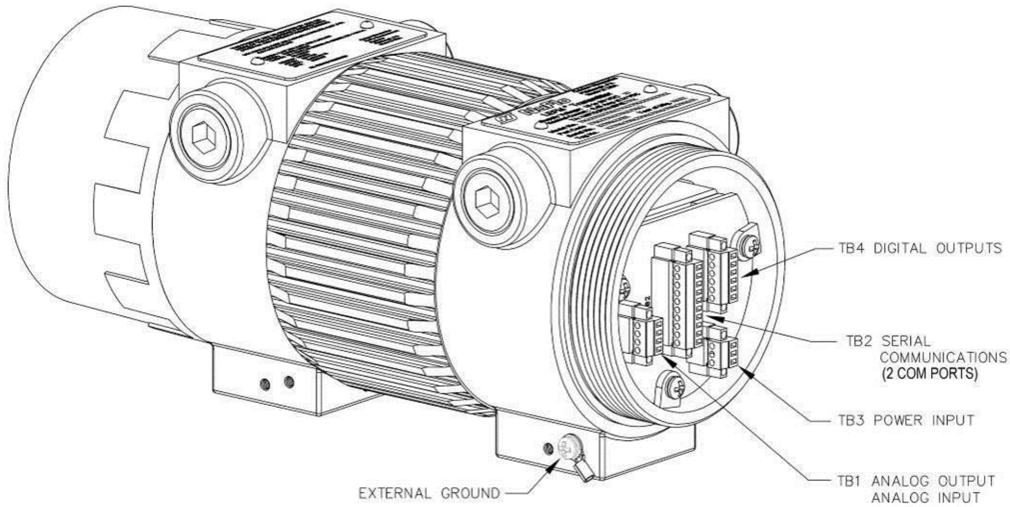


Figure 4.3: User Terminations - Cover Off
(Communications Option 1)

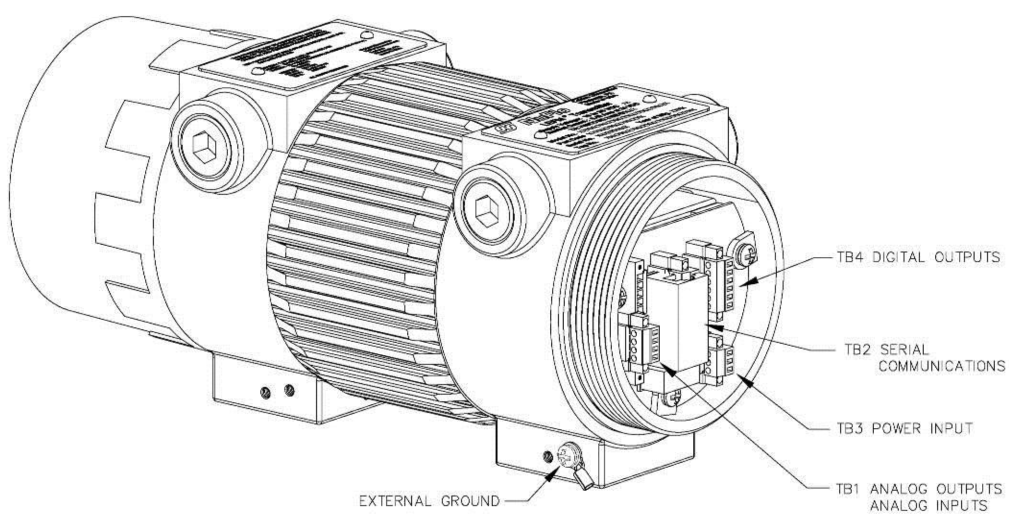


Figure 4.4: User Terminations - Cover Off
(Communications Option 2)

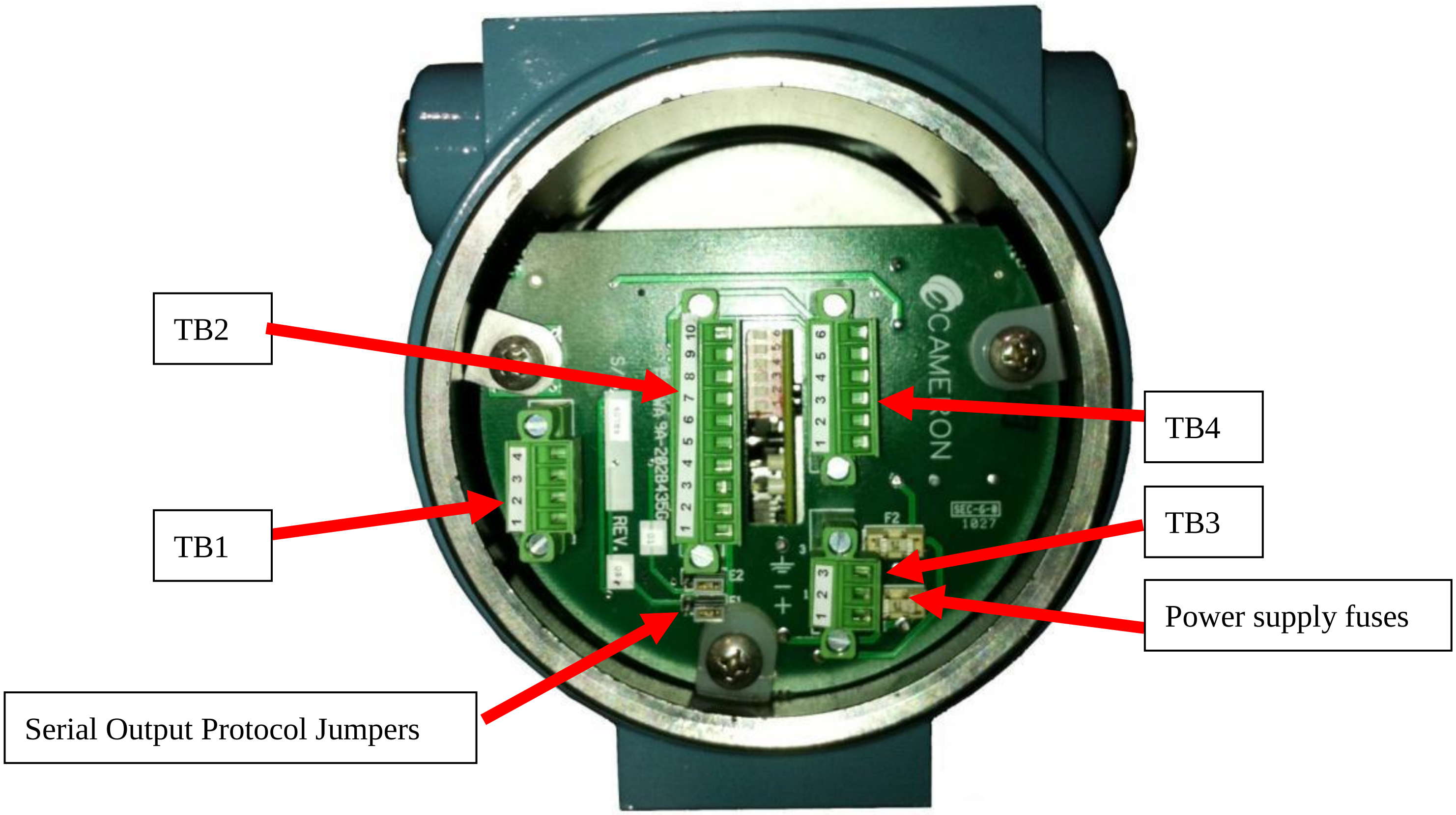


Figure 4.5: User Terminations, Close Up
(Communications Option 1)

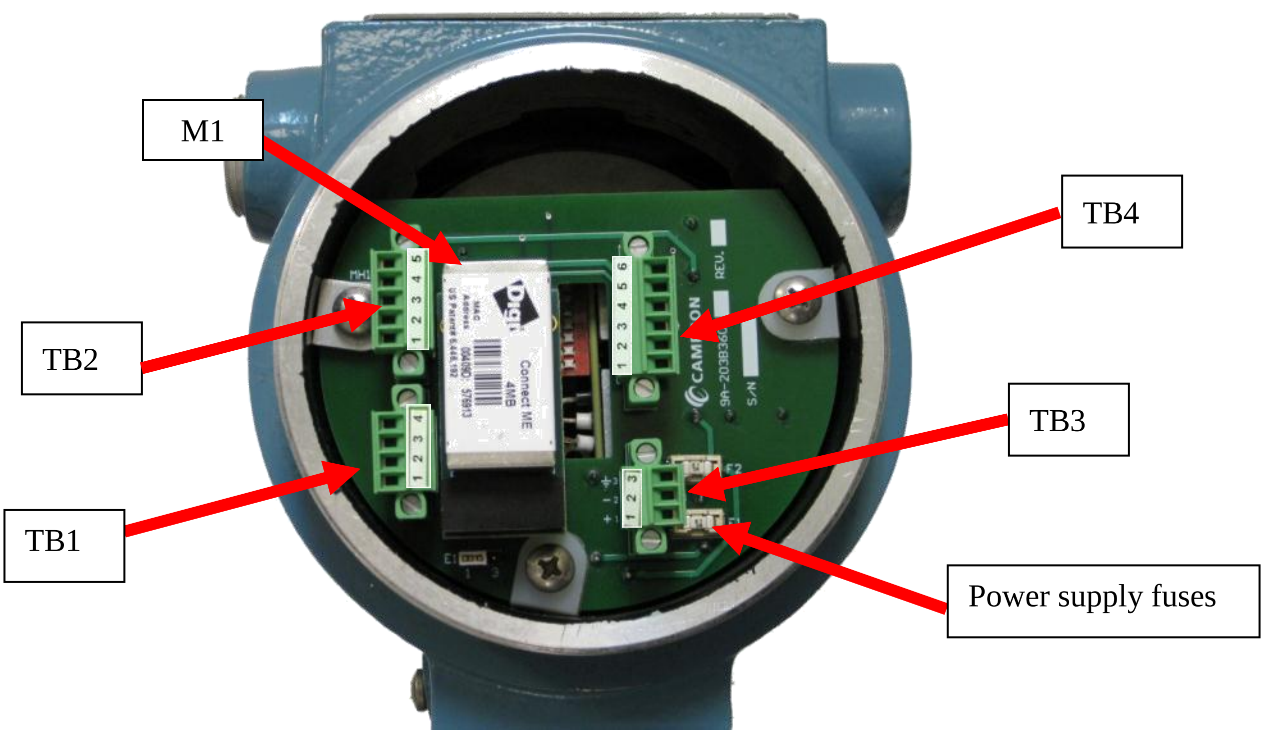


Figure 4.6: User Terminations, Close Up
(Communications Option 2)

Figures 4.3 thru 4.6 show the location of the transmitter terminations for both communication options. Inside the rear cover of the transmitter there is a diagram of the user connections.

A schematic of the terminations is shown below.

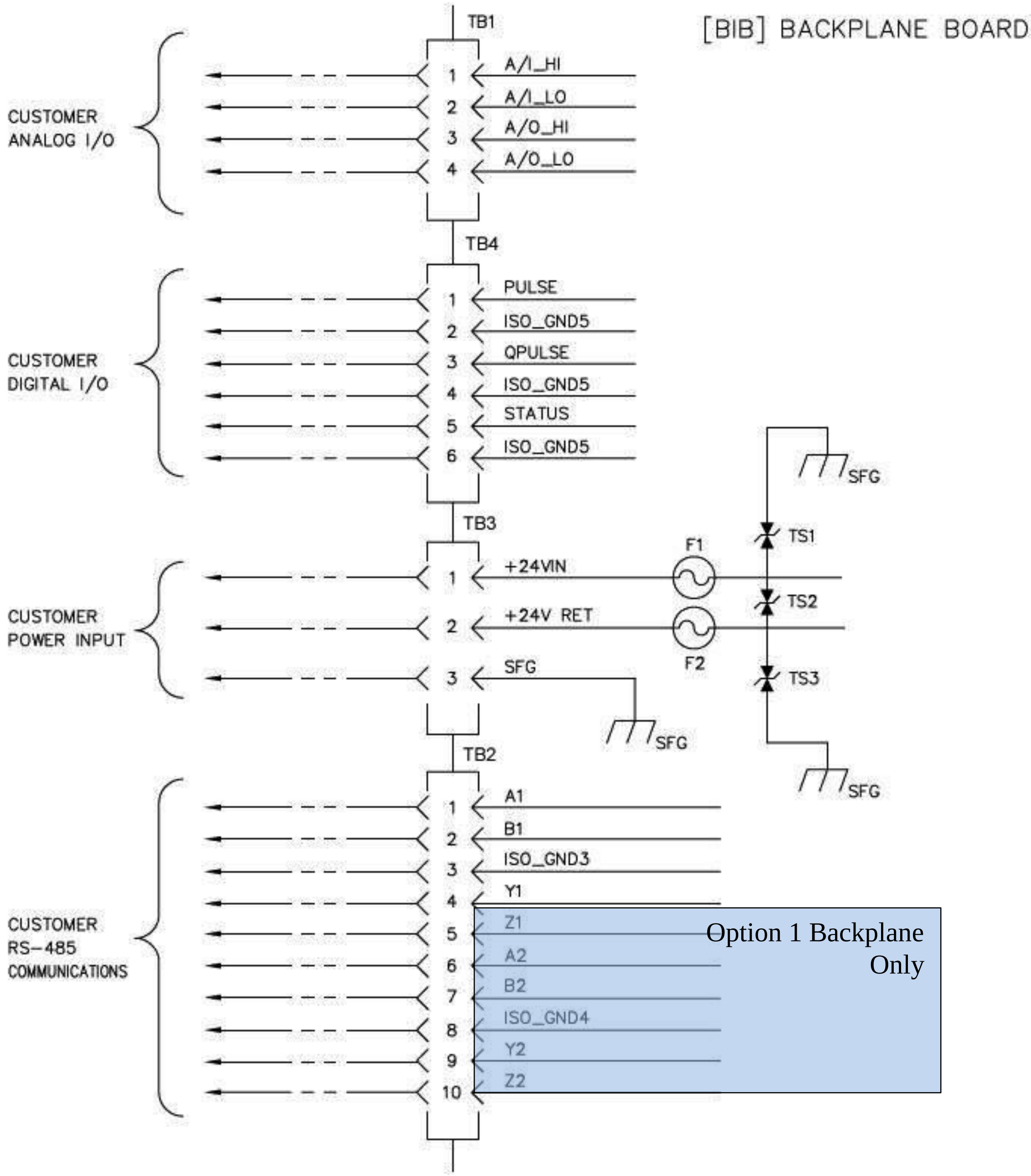


Figure 4.7: User Terminations, Schematic
A/I = Analog Input, A/O = Analog Output
See Serial Communications Section below for RS-485 definitions

Analog Inputs/Outputs (Terminal Block 1)

TB1 contains the transmitter's analog inputs and outputs.

Analog Input

TB1, Pin 1	0 to 20 mA (+)
TB1, Pin 2	0 to 20 mA (-)

Analog Output

TB1, Pin 3	0 to 20 mA (+)
TB1, Pin 4	0 to 20 mA (-)

Digital Outputs (Terminal Block 4)

TB4 contains the transmitter's digital outputs (Table 4.1). The voltage, +V, for the digital signals is factory-programmed to either 5 volts or 12 volts (12 volts is standard). The output impedance is 250 ohms.

Pulse B can be configured to indicate volume or flow direction. The desired function is selected by a Modbus register (HR3234). Refer to either the Modbus manual or the LEFMLink 2G manual for changing parameters.

Table 4.1: LEFM 2xxCi Digital Signals

<table>
<tr><th>Signal</th><th>Pulse Description</th><th>Voltage Description</th><th>Terminal</th></tr>
<tr><td rowspan="2">Pulse A (Volume)</td><td>Pulse A precedes Pulse B by 90 degrees = forward flow</td><td rowspan="2">—</td><td rowspan="2">TB4, Pin 1</td></tr>
<tr><td>Pulse B precedes Pulse A by 90 degrees = reverse flow</td></tr>
<tr><td>Ground</td><td>—</td><td>—</td><td>TB4, Pin 2</td></tr>
<tr><td rowspan="2">Pulse B (Volume)/ Direction</td><td>Pulse B precedes Pulse A by 90 degrees = reverse flow</td><td>0V = forward flow</td><td rowspan="2">TB4, Pin 3</td></tr>
<tr><td>Pulse A precedes Pulse B by 90 degrees = forward flow</td><td>+V = reverse flow</td></tr>
<tr><td>Ground</td><td>—</td><td>—</td><td>TB4, Pin 4</td></tr>
<tr><td rowspan="2">Status</td><td rowspan="2">—</td><td>0V: alarm condition</td><td rowspan="2">TB4, Pin 5</td></tr>
<tr><td>+V: normal operation</td></tr>
<tr><td>Ground</td><td>—</td><td>Ground</td><td>TB5, Pin 6</td></tr>
</table>

Power Terminations (Terminal Block 3)

TB3 contains the power terminations:

TB3, Pin 1	+24 VDC
TB3, Pin 2	-24 VDC (RETURN)
TB3, Pin 3	Earth/ground

There are grounding points on the inside of the junction box at the meter body (if remote mount) and on the outside of the junction box and the manifold. There are grounding points on the inside and outside of the transmitter enclosure. For ATEX applications, both grounding points must be used. Follow all other site guidelines regarding grounding/earthing. See Figures 4.3 and 4.4 for the external ground point on the transmitter body. TB3, Pin 3 is the internal ground connection.

Remote Data Communications

The LEFM transmitter has 2 configuration options that support remote data communications. They are Option 1 (two RS-485 Modbus Slave) and Option 2 (One RS-485 and one Ethernet). The Option 2 is identical to the Option 1 except that the second serial communication port is replaced by an Ethernet port.

Serial Communications (Terminal Block 2)

The serial communications can be configured to be either Full Duplex or Half Duplex (four-wire or two-wire). The COM ports are configured with a jumper on the back interface board (jumpers are located just below TB2). A jumper is provided for each serial port, enabling independent configuration, as shown in Table 4.2. Terminations for serial communications are provided in Table 4.3.

For Ethernet communication on the Option 2 backplane, the RJ45 jack on module M1 can be used.

Table 4.2: Jumper Locations for Serial Communications Protocol

Communication Mode	E1 – COM 1	E2 – COM 2*
Full Duplex	Jumper on Pins 2 and 3	Jumper on Pins 2 and 3
Half Duplex	Jumper on Pins 1 and 2	Jumper on Pins 1 and 2

*COM 2 is not present on Option 2 backplane.

Table 4.3: Terminations for Serial Communications

PORT NAME	Termination	RS-422/485 Full Duplex	RS-485 Half Duplex
COM1	TB2, Pin 1	Noninverting Receive, Rx (+)	—
	TB2, Pin 2	Inverting Receive, Rx (-)	—
	TB2, Pin 3	Ground	Ground
	TB2, Pin 4	Inverting Transmit, Tx (+)	Tx/Rx (+)
	TB2, Pin 5	Noninverting Transmit, Tx (-)	Tx/Rx (-)
COM2*	TB2, Pin 6	Noninverting Receive, Rx (+)	—
	TB2, Pin 7	Inverting Receive, Rx (-)	—
	TB2, Pin 8	Ground	Ground
	TB2, Pin 9	Inverting Transmit, Tx (+)	Tx/Rx (+)
	TB2, Pin 10	Noninverting Transmit, Tx (-)	Tx/Rx (-)

*COM2 is not present on Option 2 backplane.

Meter Installation Check-Out

WARNING

Never open the transmitter when it is energized. Before inspecting components, open the power supply circuit breaker. Failure to do so can result in electrical shock or an explosion.

To test or validate a meter's installation, perform the following procedure. For troubleshooting information, see Section 6 of this manual.

Verify the meter is oriented with the transmitter on top of the meter body, and the upstream hydraulics are adequate. Verify the upstream pipe diameter is concentric with the meter body.

1. Verify all field terminations have proper continuity and isolation from each other and earth. Verify connections are good with respect to insulation.
2. Verify electronics turn on. Only the top two LEDs (LED1 and LED2) should be lit and the display is working.
3. Verify Modbus communications are operational (use LEFMLink 2G software to test Modbus communications via the RS-485 connection).

4. Verify meter operation according to Section 6.
5. If necessary, verify outputs. To simplify this process, use LEFMLink 2G software to force outputs (current and pulses). Verify forced outputs are within 0.1% on current and within 0.01% on pulse frequency. For more information on forced outputs, see Output Test Mode below or consult the LEFMLink 2G software manual.

Note: Always return the meter to normal operation following the use of forced outputs in Output Test mode.

---

6. If the pipe is full of liquid, use LEFMLink 2G software or Modbus communications to verify the following:
   a. Signals have Rejects < 2% and a Signal to Noise Ratio > 40.
   b. Standard deviations of Paths 1 and 4 are less than 6% (for flowing conditions).
   c. Standard deviations of Paths 2 and 3 are less than 4% (for flowing conditions).

Output Test Mode

The Output Test mode is used during field testing or verification checks. In this mode, the analog outputs (pulse and current) are set to a fixed value. By comparing this value to the value being read by a readout device, the user can verify the accuracy of the readout. The words "Forced Outputs" will appear on the display during this test.

Forced Outputs

Section 5

Understanding Flow Calculations

Measuring Flow Velocities

LEFM ultrasonic flowmeters use pairs of ultrasonic transducers to send acoustic pulses to one another along a measurement path. The measurement path is at an angle to the fluid flow. The acoustic pulse's transit time depends upon both the velocity of sound (VOS) in the fluid and the velocity of the fluid along the path. The transit time is shorter for pulses that travel downstream with the flow than for pulses that travel upstream against the flow.

$$T_D = \frac{\ell_P}{C_f + V_P}$$

$$T_U = \frac{\ell_P}{C_f - V_P}$$

where	T_D	= downstream transit time
	T_U	= upstream transit time
	ℓ_p	= path length
	C_f	= velocity of sound in fluid
	V_p	= flow velocity along the ultrasonic path
	V	= flow velocity along the pipe axis

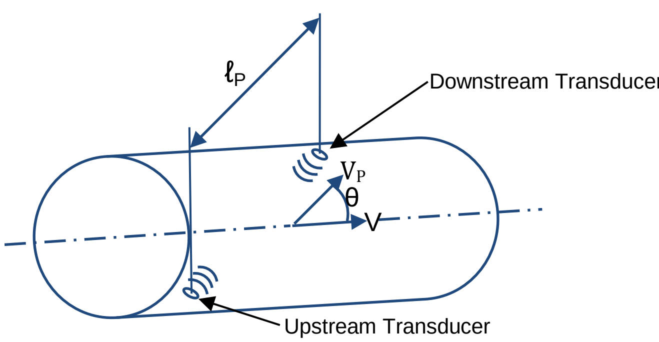


Figure 5.1: Flow Velocities along the Ultrasonic Path and the Pipe Axis

When pulses travel upstream and downstream at the same time, the above equations may be treated as if they are performed simultaneously, and solved for the two unknowns, C_f and V_P.

Solving for V_P and taking into account path angle θ

$$V = \frac{\ell_P}{2\,\mathrm{Cos}\,\theta} \bullet \frac{T_U - T_D}{T_D\ T_U}$$

Using this method, the velocity measurement V is independent of the velocity of sound. Consequently, the velocity measurement is unaffected by variations in flow, temperature, density, chemical composition, etc.

Measuring Flow Rate

LEFM Ultrasonic Flowmeters can measure velocities along multiple acoustical paths arranged across the flow pattern in the pipe. The accuracy and repeatability of the flow measurement increases with the number of paths. The two plane configuration of the 280Ci has the acoustic paths arranged into two planes (orthogonal to each other). The plane is oriented at an angle θ (path angle) with respect to the centerline of the pipe. (See Figure 5.2)

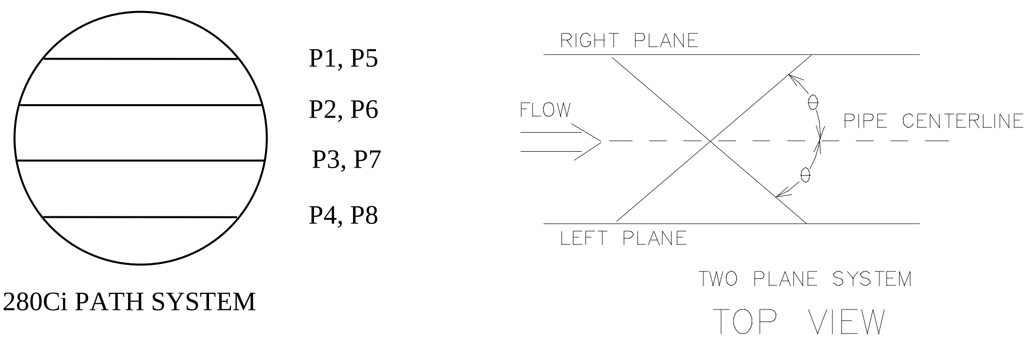


Figure 5.2: Acoustical Path Configurations

The 240Ci uses only paths 1 through 4 built into one plane. The 220Ci uses only 2 paths that are set at mid-radius chord.

During manufacturing, precision measurements of inside diameter (ID), path lengths and path angles are taken and inserted into the equation for volume flow rate.

For maximum accuracy, the LEFM 2xxCi automatically compensates for pipe thermal expansion and contraction.

Likewise, net flow is available when fluid temperature and pressure are continuously monitored. Correction factors that take into account the changes in fluid expansion due to pressure and temperature may be applied to the flow rate equation.

Gross Flow Rate to Net Flow Rate Conversion
Net volumetric flow rate is calculated by correcting gross volumetric flow rate to standard product conditions of 60°F and 0 psig (default, other values can be used).

$$Net\ Flow\ Rate = Gross\ Flow\ Rate \bullet [K_{net,temp} \bullet K_{net,pres}]$$

The LEFM 2xxCi computes a temperature correction factor and pressure correction factor. Typically, these factors are based on the following references

> *API Chapter 11.1, Volume I, November 1984 (API Standard 2540), Table 6A – Generalized Crude Oils and JP-4, Correction of Volume to 60° Against API Gravity at 60°*

> *API Chapter 11.2.1, Manual of Measurement Standards, March 1990, Compressibility Factors for Hydrocarbons: 0-90° API Gravity Range*

Inputs required for gross to net conversions include:

- Gross flow rate
- Product temperature
- Product pressure

The LEFM has only one analog input; therefore, to input all three variables, some values must be sent via Modbus registers. The specific gravity used for the gross to net conversions can be either an analog input entered via Modbus registers, or a value that is automatically computed by the LEFM. The automatic calculation is based on API tables, sound velocity, temperature and pressure.

Section 6

Operations

Definitions

SNR – Signal to Noise Ratio

Gain – Required gain to amplify signal

Rejects – Percentage of Data Rejects due to low SNR

VOS – Velocity of Sound

IOB – Input Output Board

CTC – Control and Timing Card

MXR – Multiplexer, Transmitter and Receiver Card

Normal Operating Conditions

If the LEFM is properly installed, the display will begin working when power is supplied to the unit. Two LED indicators will illuminate, and the display will yield a readout of flow total, flow rate, fluid properties and basic acoustic diagnostic information. If more detailed diagnostic data is needed beyond what is available via the display, consider accessing transmitter diagnostic data via the LEFMLink 2G software.

WARNING

Except when troubleshooting, do not remove the enclosure covers from the transmitter. The diagnostic information is easily read from the display with the covers in place.

Display LEDs

The two green LEDs illuminate to indicate that power is on and that the instrument is operating normally. The other four LEDs illuminate only when an electronic failure is detected.

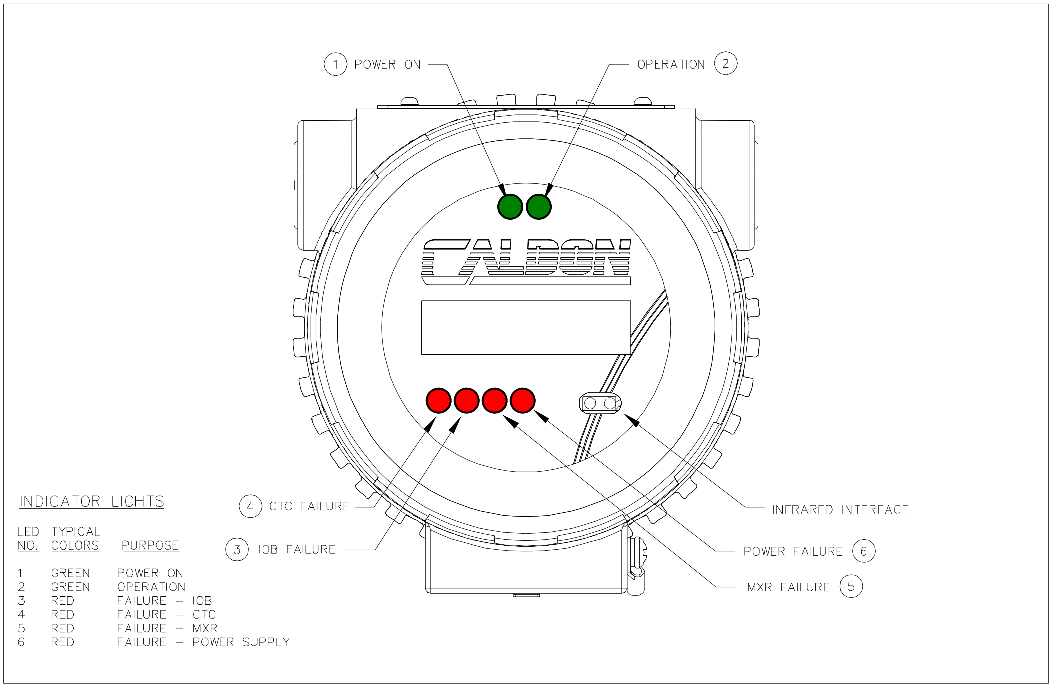


Figure 6.1: LED Diagnostics

The typical statuses of the LEDs are as follows. (See Section 7 for troubleshooting information.)

Table 6.1: LED Diagnostics

LED Number	Color (typical)	Indication	Normal State
1	Green	Power on	On
2	Green	Operation	On
3	Red	Failure - IOB	Off
4	Red	Failure - CTC	Off
5	Red	Failure - MXR	Off
6	Red	Failure – Power Supply	Off

Display

The transmitter has a two-line display (16 characters per line). The display shows the meter's indicated flow, totalized flow, fluid properties, and diagnostics data. The transmitter repeatedly cycles through all display parameters.

The display shows information for each of the meter's eight paths, one path at a time; therefore, the display cycles through the parameter set eight times (path 1, path 2, path 3 and so on up to path 8) in displaying one complete set of data for all eight paths. (Note, in the dual electronics configuration, the number of paths parameter is limited to four.)

At default settings for the display interval, it takes approximately 5 minutes to cycle through all paths.

A typical display cycle is as follows:

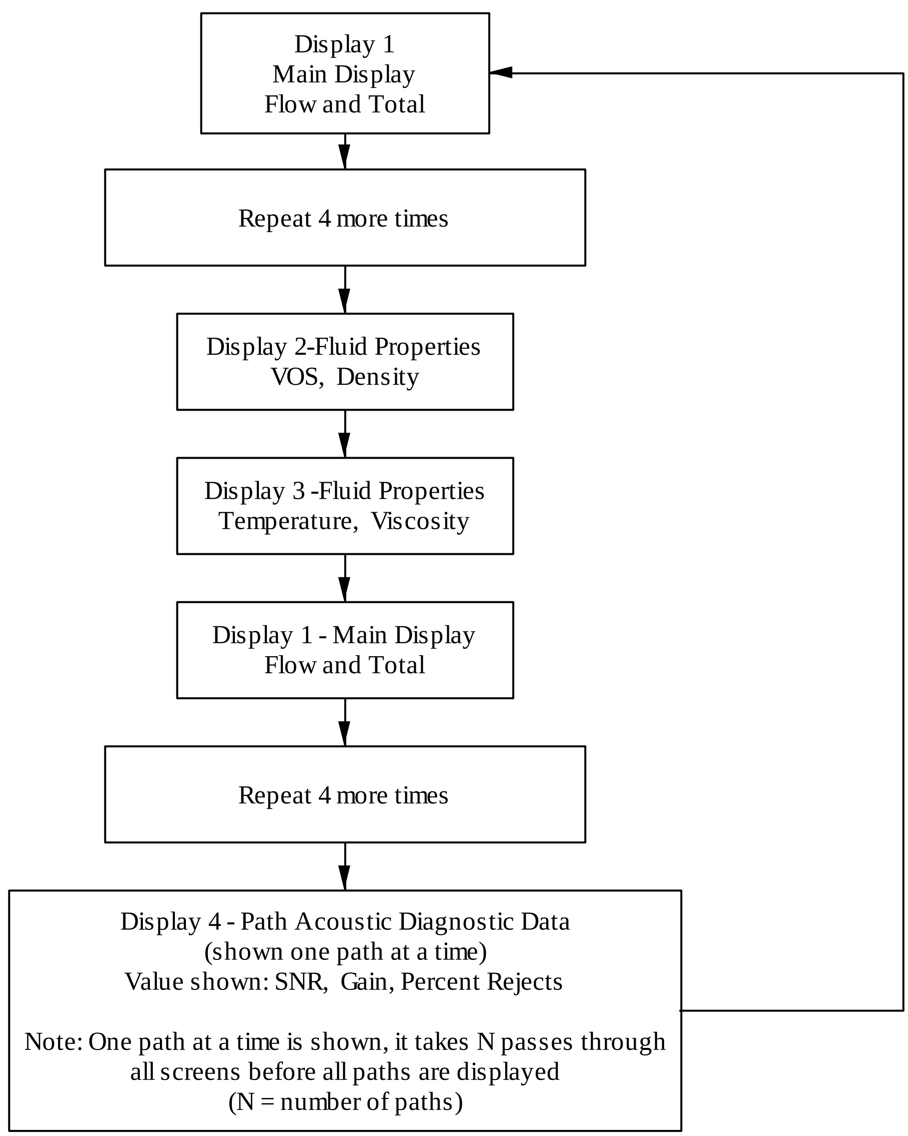
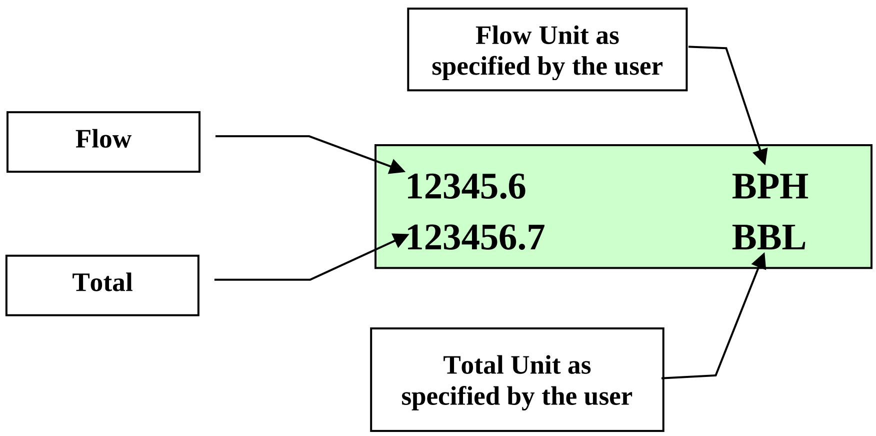


Figure 6.2: Display Sequence During Normal Operation

Display 1—Main Display Data (repeats 5 times by default)

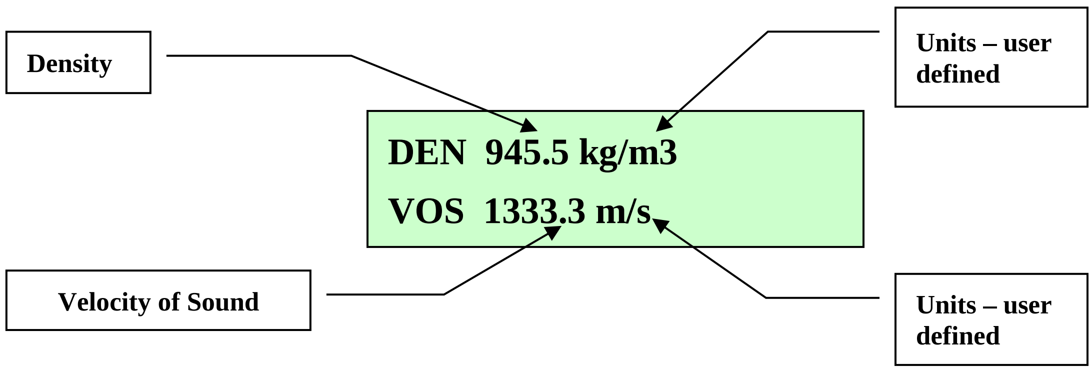
Approximately 1 to 3 seconds after powering on the transmitter, the following screen appears, displaying the total accumulated volume and the current flow rate.

By default, this screen will update five times before the next screen appears.



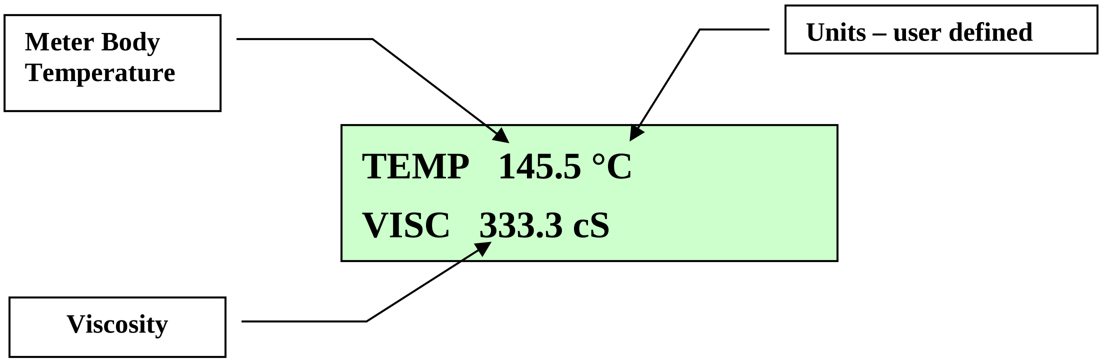
Display 2—Density and Velocity of Sound

The second screen in the display sequence shows the fluid density (DEN) and velocity of sound (VOS).



Display 3—Meter Body Temperature and Viscosity

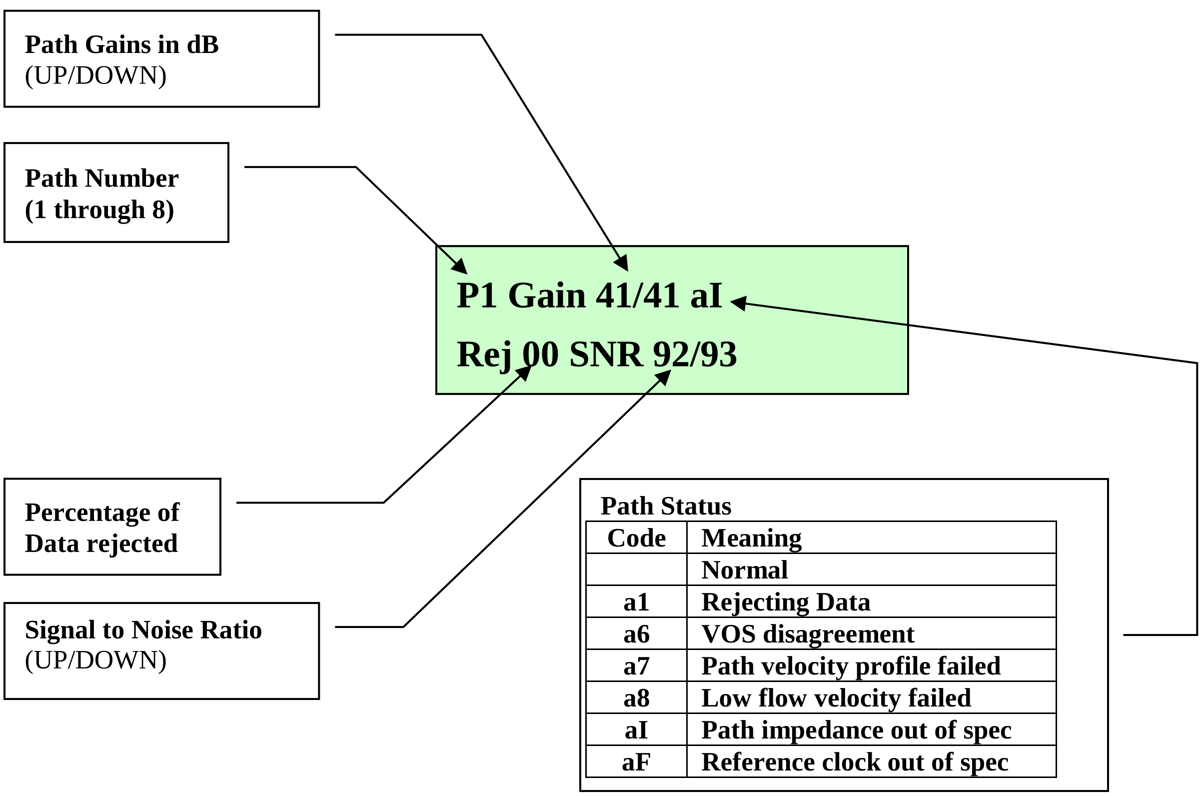
The third screen to appear displays fluid temperature (TEMP) and viscosity (VISC). Unless a separate temperature is provided to the transmitter (either via the 0-20 mA input or a Modbus register), the meter body temperature will be displayed.



Note - Following the display of temperature and viscosity, the Main Display data screen will reappear, and will update five times by default before displaying acoustic path diagnostic data.

Display 4—Acoustic Path Diagnostic Data

The fourth and final screen in the display cycle contains acoustic path diagnostic data.



Path Status

Code	Meaning
	Normal
a1	Rejecting Data
a6	VOS disagreement
a7	Path velocity profile failed
a8	Low flow velocity failed
aI	Path impedance out of spec
aF	Reference clock out of spec

Alarm Conditions

The LEFM 2xxCi's automatic fault detection system is specially designed to verify the performance of the transducers and transmitter electronics and to alert personnel when abnormal operating conditions are detected. It detects faults in three basic steps:

1. The fault detection system checks the data quality for ultrasonic paths and evaluates the data against thresholds. Data evaluation is based on signal to noise ratio (SNR), cross-correlation tests and signal statistics.
2. For each ultrasonic path, the transmitter determines if the path has failed.
3. If an ultrasonic path continues to fail, the meter will alert the operators to a potential problem by generating an "ALARM" status and an error code

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Note - Occasional rejected or bad data will not generate an alarm status; only a repetitious pattern of rejected or bad data will result in an alarm status.

The transmitter outputs the current status via the serial port and the digital output. The displayed status may be any of the following:

NORMAL
ALARM - 1 or more paths failed (flow is computed with a possibility of lesser accuracy)

Note - 1, 2, 3, 4, or 5 path failures lose no accuracy for custody transfer applications when operating conditions do not change significantly.

ALARM - all paths failed (no flow is calculated; flow is set to zero)

The following codes (described in the LEFM Modbus manual) are used to indicate the status of each ultrasonic path:

0 - Path is operating normally

1 - Path is rejecting data due to low signal-to-noise ratio, irregular statistics, or failing cross-correlation tests

6 - Path sound velocities are inconsistent with thresholds (typically, a spread of 2% or less between paths is acceptable)

7 - Path velocity fails a velocity profile test for self-consistency

8 - Path velocity is inconsistent at low flow rates

I - Path fails an impedance self-test

F - Path fails self-test on reference clock

Figure 6.3 illustrates the alarm condition display cycle.

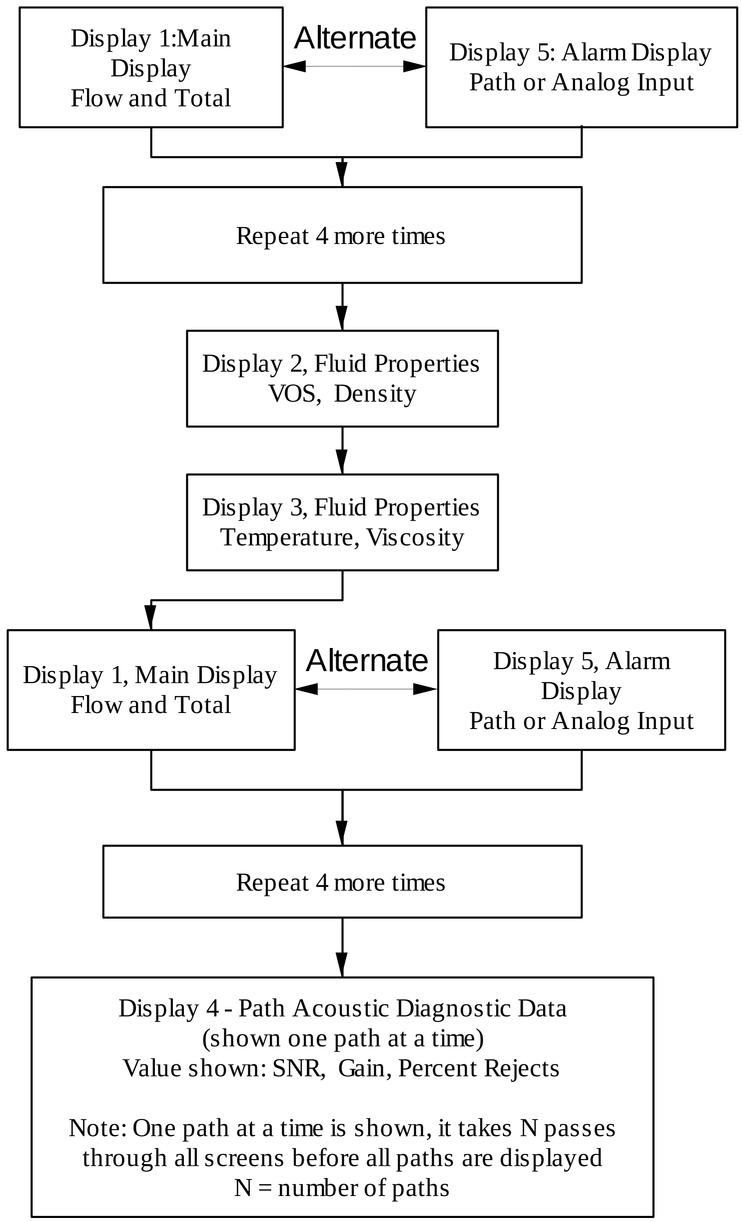

Figure 6.3: Display During an Alarm Condition

Display 5—Alarm Display (switch with Display 1 for a total of 5 times)

Only in an alarm condition, this screen will alternate with Display 1, for a total of five displays (three for Display 1 and two for Display 5). The number of total/flow rate updates allowed before the display progresses to the next set of parameters is configurable through a Modbus holding register (HR3235). For information on changing Modbus registers, see the LEFM Modbus user manual.

12345.6 BPH
00000001 FAIL

Path Status

Code	Meaning
x0000000	Path 1 Failed – see path code
0x000000	Path 2 Failed – see path code
00x00000	Path 3 Failed – see path code
000x0000	Path 4 Failed – see path code
0000x000	Path 5 Failed – see path code
00000x00	Path 6 Failed – see path code
000000x0	Path 7 Failed – see path code
0000000x	Path 8 Failed – see path code
xxxxxxxx	Combination of Paths Failed – see path codes

Note – The number of path codes matches the number of paths in the meter.

Output Test Mode

For test and/or validation purposes, an operator can temporarily override the output of the LEFM 2xxCi and set the output to a fixed value using the Output Test mode. The user places the instrument in the Output Test mode using the LEFMLink 2G software. The words “Forced Outputs” will appear on the display during this test.

Forced Outputs

For more information, see Analog Output and Pulse Output Verification, and the LEFMLink 2G User Manual.

Zeroing the Flow Total

The accumulated flow total can be reset to zero using the LEFMLink 2G software. For more information, see the LEFMLink 2G User Manual.

Safe Start Conditions

Should the instrument's memory become corrupted such that the instrument cannot access its configuration data, the instrument will start in "safe mode." Typically, the configuration data must be reloaded into the instrument to return the instrument to normal operation.

Safe Start

Send Setup

The Safe Start display may appear following the replacement of the CTC board. See Circuit Board Replacement in Section 8 for details.

Section 7

Purge Assembly (Option)

Caldon ultrasonic meters can be supplied with an optional purging arrangement. This arrangement allows the purging fluid to be directed to the tip of the transducer housing to help clear deposits from the cavity in front of the transducer housing.

The purging fluid is introduced to the annular space between the transducer housing and the meter body via a channel that is connected to a valve assembly at the exterior of the meter body. Each transducer housing has its own valve and purging channel. When the valves are closed there is no movement of fluid through the purging channels and therefore no influence of the purging arrangement on the function of the meter.

The tips of the transducer housings are specially adapted to help direct the purging fluid to clear the face of the transducer housing and the cavity itself. Figure 7.1 below shows picture of a demonstration unit of the purging tip, being tested by packing the transducer housing cavity with heavy grease (pink). At the point closest to the internal diameter of the meter (on the left of the housing in the photo), the purging fluid exits from a hole with a deflector that directs the purge across the face of the transducer housing. At the deepest point in the cavity, a second exit hole directs the purge forward away from the face of the transducer housing.

It can be observed in the photograph that in this demonstration the purge has been effective at clearing the grease away from the radiating face of the transducer housing.

Figure 7.1: Result of purging transducer housing and cavity

Under normal operation, the purge channel valves are closed and the meter operates in exactly the same way as a meter that does not have the purging feature.

During operation, if deposition is suspected based on meter factor variations or flow meter diagnostics, the purging feature can be used. How the purging operation is carried out will depend on the process considerations, the nature of the measurement and the implications of a reduction in accuracy during the purging process. For custody transfer applications it is expected that purging would be performed with the meter run offline or in a recirculation mode and not during an actual transfer of product.

Once purging is complete the meter can return to normal operation. If the purging has been effective, the metrological characteristics of the meter will be the same as they were prior to the occurrence of deposition. The effectiveness of the purging exercise can be assessed by means of the flow meter diagnostics, comparing the post-purging data with a foot print taken from the meter when clean.

Purging of Detrimental Materials from the Transducer Housing Face

WARNING

NOTE: The customer is responsible for supplying the purge equipment including the purge connections to the meter. Also, care should be taken while connecting and disconnecting any piping and purge equipment to avoid any chance of cross threading the connections.

NOTE: Failure to perform the following steps in the order given can result in petroleum entering purge lines.

1. Reference Figure 7.2 for a view of the transducer window purge port.
2. Before connecting the purge equipment, make sure that all transducer port valves and that the plane valves (just below the customer connection point) are in the closed position.
3. Remove the ½" plug from the customer connection point.
4. Install purge equipment using the ½" Swagelok nut with ferrule (customer supplied).
5. **Pressurize purge equipment end before opening the plane or transducer ball valve.** Nitrogen gas, compressed air, or diesel fuel can be used to purge the windows.

NOTE: Purge pressure should be at least 500 psi (3.4 MPa) greater that the process pressure so as to not get any back flow from the process line. Do not pressurize to higher than design pressure.

6. Open the plane ball valve.
7. Open transducer ball valve. Do not leave the port ball valve open for more than two minutes.
8. Once purge is complete close the transducer port ball valve.
9. Close the plane ball valve.

   If the purge equipment (customer side) is not permanently attached:

10. Remove the purge equipment (if not permanently installed)
11. Reinstall the ½" plug on the purge assembly from the customer connection point

If petroleum has entered the purge assembly use the following steps:

1. Remove the purge equipment at the customer connection point.
2. Ensure that transducer ball valves are closed.
3. Open the bleed valve by turning the bleed nut ¼ turn, see Figure 7.3. Take care as the purge assembly may be pressurized.
4. Open the plane ball valve.

5. When draining is complete close the plane ball valve and the bleed nut.

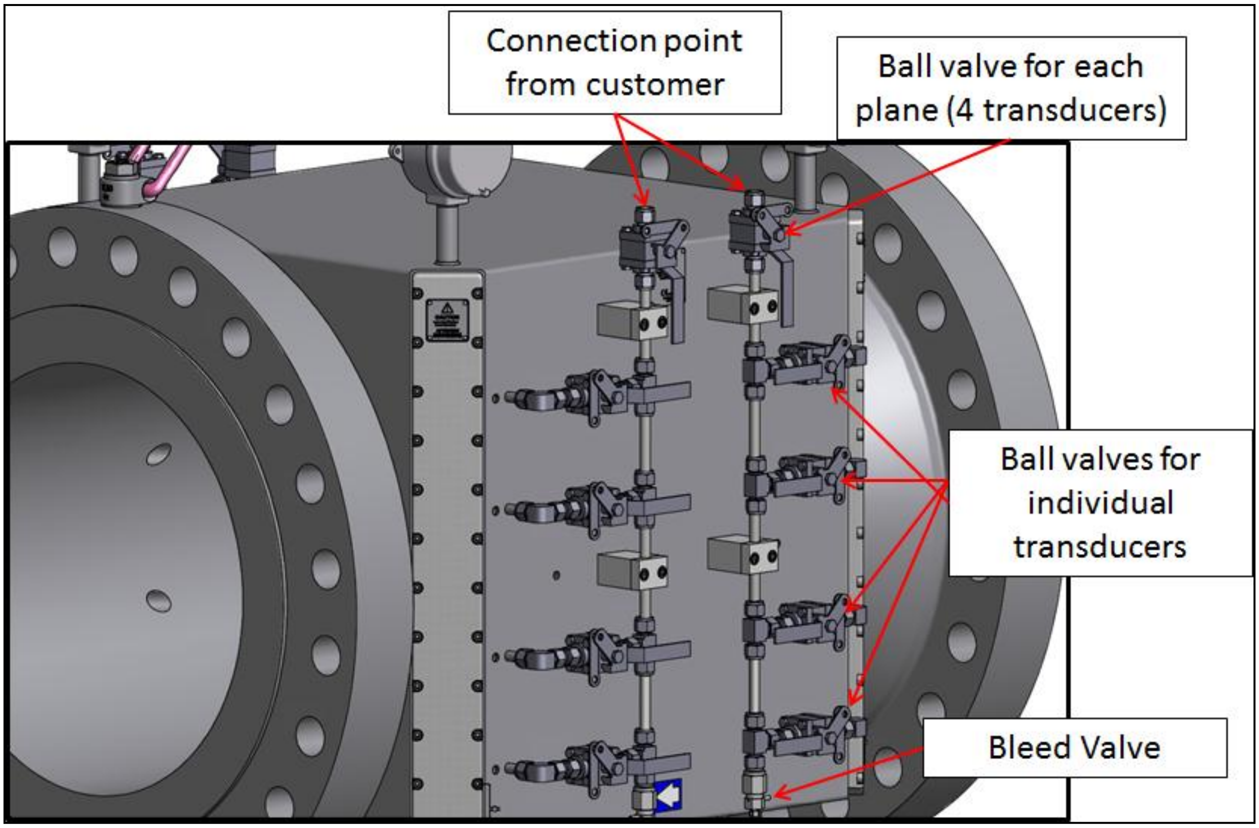

Figure 7.2: Typical Transducer Window Purge Port

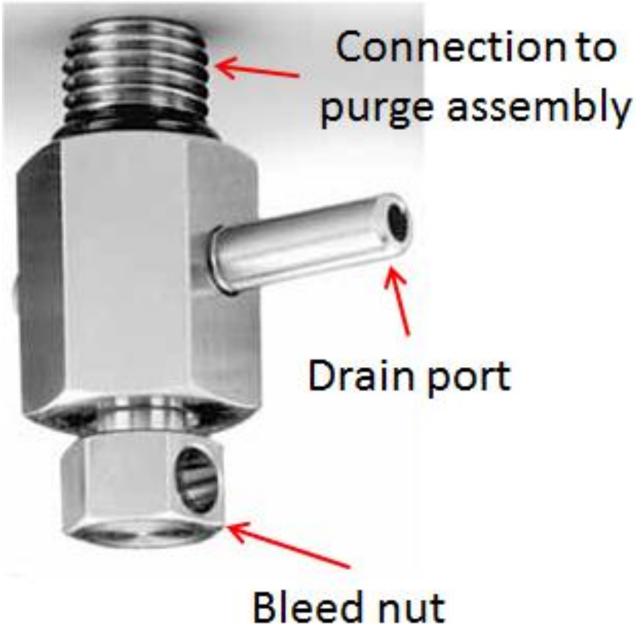

Figure 7.3: Bleed valve on bottom of purge port.

Section 8

Maintenance

WARNING

Service should be performed on the LEFM 2xxCi only by qualified personnel.

Introduction

The troubleshooting and maintenance procedures in this section may be incorporated into the customer's standard maintenance program. The procedures should be performed only by a trained maintenance technician.

General Inspections - Preventative Maintenance Procedures

WARNING

Never open the transmitter or the meter body manifold when the instrument is energized. Before inspecting components, open the power supply circuit breaker. Failure to do so may result in electrical shock and/or an explosion.

CAUTION

Wear an ESD protective wrist strap to avoid damaging any components.

The following procedure covers the inspection of the transmitters, transducers, and metering sections.

Enclosure Inspection

Perform the following inspections on each enclosure:

1. Verify that the transmitter enclosure and the meter body have suffered no structural damage. Report any damage to the proper maintenance supervisor.
2. Remove dust, dirt, and other soiling from the enclosure. Use a damp cloth to clean surfaces.
3. Inspect access cover gaskets.
   a. Clean gaskets and mating surfaces on the enclosure with water if they are dirty.
   b. Remove any corrosion from mating surfaces.
   c. Verify that gaskets compress when the cover is installed.
   d. Lubricate the cover threads with petroleum jelly.

4. Inspect the enclosure mounting.

Internal Electronics Inspection

1. Put on an ESD (Electrostatic Discharge) protective wrist strap. Connect the ESD protective wrist strap to a known ground.
2. Inspect cable entry points to assure that cable insulation is free from damage.
3. Inspect cable connections for tightness. If connections are fouled or corroded, clean with electronic contact cleaning fluid.
4. Inspect all internal connections and terminals for tightness. If connectors and terminals are fouled or corroded, clean with electronic contact cleaning fluid.
5. Inspect the display for damage.
6. Using a damp cloth, clean dust and grime from all accessible surfaces of the enclosure.

Transmitter Troubleshooting

Perform the following inspections on the transmitter to isolate a problem.

WARNING

Never open the transmitter when the instrument is energized. Before inspecting components, open the power supply circuit breaker. Failure to do so may result in electrical shock and/or an explosion.

CAUTION

Wear an ESD protective wrist strap to avoid damaging any components.

1. With the unit energized, verify that power is being supplied to the meter and that the meter is operating (Figure 8.1).

2. When the flowmeter is operating normally, the green LEDs (LED 1 & 2) should be on (illuminated).

If any other LED is on, a component has likely experienced a failure. See Table 8.1 for help in isolating the causes of the failure. Always verify that the “Power On” LED (LED 1) is active before troubleshooting a component.

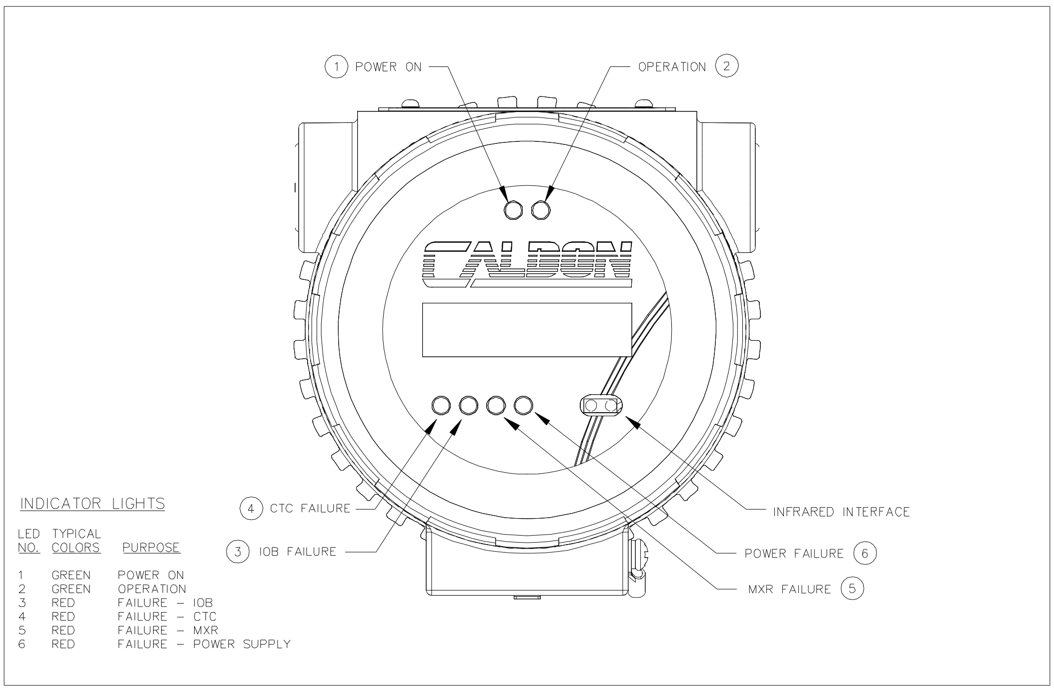

Figure 8.1: LED Indicators

Table 8.1: LED Interpretation

LED Number	Color	Normal State	Error Condition	Meaning
1	Green	On	Off	24-VDC supply is not active
2	Green	On	Off	Transmitter is not operating
3	Red	Off	On	IOB failure
4	Red	Off	On	CTC failure
5	Red	Off	On	MXR failure
6	Red	Off	On	Power supply failure

Troubleshoot an error condition by checking the following lights in the order listed:

1. **If LED1 is out…**
   implies that the 24 VDC power has failed. All the LEDs and the display should be off as well in this instance. Investigate the cause (e.g., loss of power to site). Another possibility is that extreme power surges damaged the protection circuits in the BIB (user panel). Check the BIB for fuses that may be blown; replace as necessary. The BIB also has surge protection circuitry that may be damaged.
2. **If LED2 is out and LED1 is lit…**

   Reset the electronics by removing and returning power. Contact Cameron's Measurement Systems division and possibly replace the CTC board.
3. **If LED6 is on…**
   the power supply may have failed. Replace the power supply (see Power Supply Replacement, page 73.)
4. **If LED3, LED4 or LED5 is on…**
   a board has failed. Replace the suspect board (see IOB, CTC & MXR Replacement, page 81):

   If LED3 is on, replace the IOB board.

   If LED4 is on, replace the CTC board.

   If LED5 is on, replace the MXR board.

Circuit Board Replacement

The transmitter is typically wired to the meter body with factory installed seals for hazardous area environments before the unit leaves the factory. Because of these factory seals on the meter, replacement of a failed circuit board in the transmitter is usually preferable to replacement of the entire assembly (though the entire assembly can be removed).

The transmitter comprises three basic subassemblies:

Power supply and display (front section)
Acoustic processor (middle section)
User interface (rear section)

Table 8.2: Power Supply and Display (Front Section) – Active components only

Power Supply and Display (PSB)	Converts 24 VDC power to internal voltages, which are passed to the FIB to power the electronics. Also contains the two-line display and the Infrared port.

Table 8.3: Acoustic Processor (Middle Section) – Active components only

Input Output Board (IOB)	Provides galvanically isolated digital outputs, analog output and analog input.
Processor Board (CTC)	Performs all flowmeter processing.
Transducer Interface Board (MXR)	Interfaces with acoustic transducers.

Table 8.4: User Interface (Rear Section) – Active components only

Back Interface Board (BIB)	Provides all user terminations

The PSB and the BIB are most accessible, located just inside either end cap of the transmitter. The other three boards are stacked inside the main body of the transmitter parallel to the length of the transmitter; they are accessed only by removing the BIB.

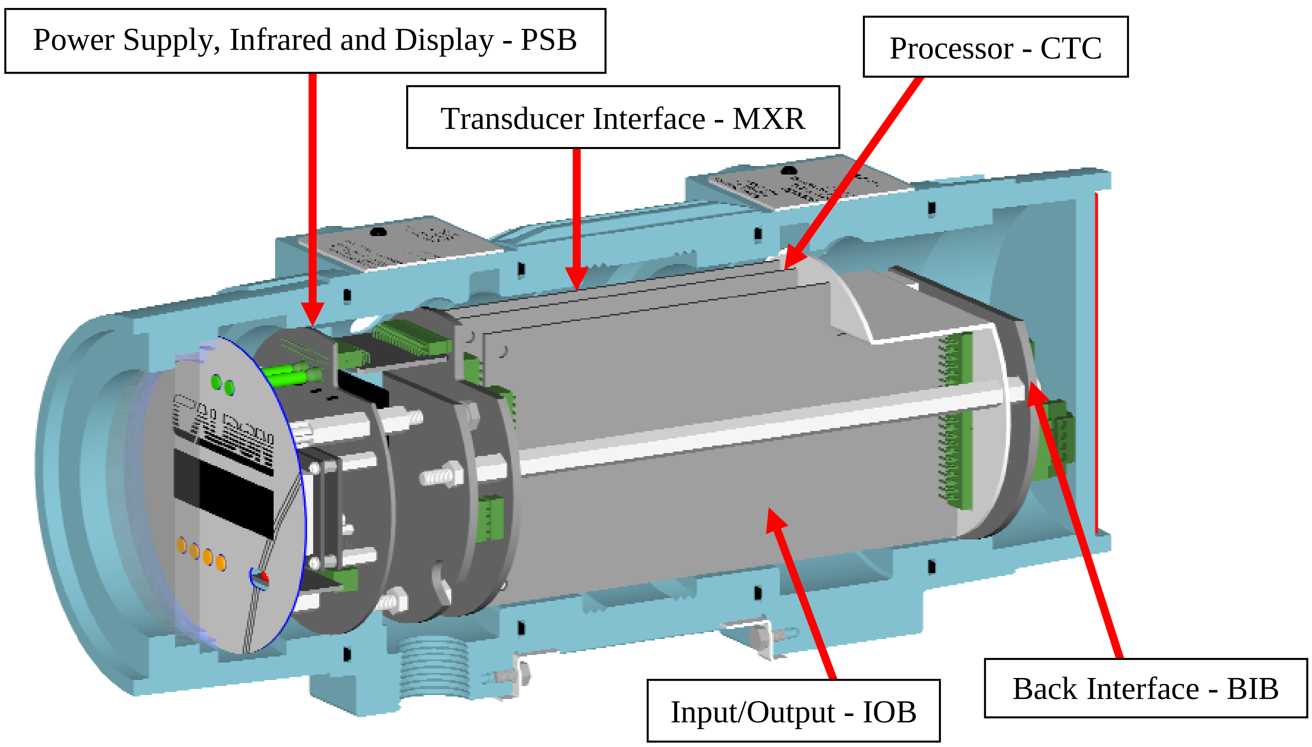

Figure 8.2: Transmitter Active Components

The following identifies passive components in the system that are used to route inter board connections.

Table 8.5: Passive Components Only

Component Name	Section of Electronics
Power Interface Board (PIB)	Front Section
Transducer Interface Board (TIB)	Middle Section
Front Interface Board (FIB)	Middle Section

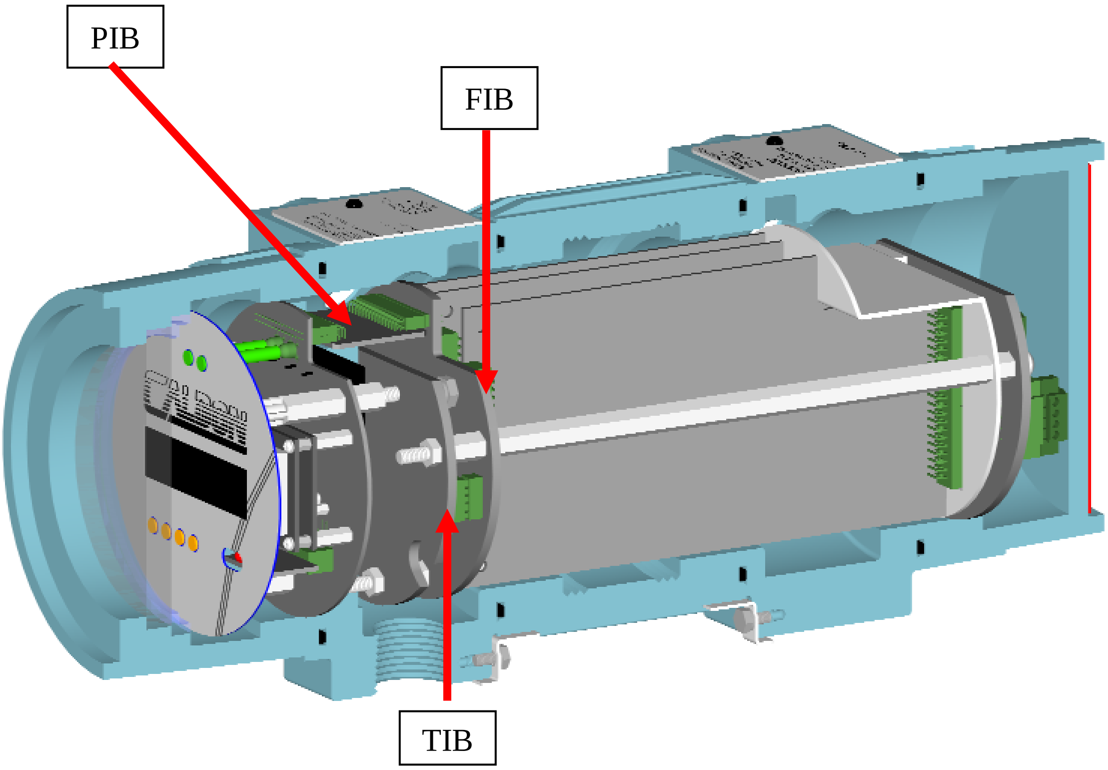

Figure 8.3: Transmitter Passive Components

Power Supply Replacement

WARNING

Never open the transmitter when the instrument is energized. Before inspecting components, open the power supply circuit breaker. Failure to do so may result in electrical shock and/or an explosion if in a hazardous area.

CAUTION

Wear an ESD protective wrist strap to avoid damaging any components.

Though the Power Supply and Display assembly consists of several component boards including the power supply board (PSB), the individual component boards are not designed for individual replacement. If any component on the Power Supply and Display assembly fails, the entire assembly is to be replaced.

To replace the Power Supply and Display assembly, perform the following steps:

1. Loosen the front cover lid set screw (1/16 inch socket) that prevents inadvertent removal of the cover.
2. Unscrew and remove the lid from the display end of the enclosure (Figure 8.4).
3. Grasp the edges of the Display cover and gently pull to lift it from three hex standoffs (Figure 8.5). The Power Supply and Display assembly will be visible.
4. Unscrew the three standoffs to free the Power Supply and Display assembly from the transmitter body, and lift the assembly from the enclosure (Figure 8.6). Unscrew the power regulator as well.
5. Remove the new assembly from its packaging. Connect the new power regulator to the web with the old screw. Align the mounting holes with the standoffs that remain inside the enclosure. Ensure that the connector on the rear of the PSB is aligned with the connector on the PIB.
6. Reinstall the three hex standoffs that were removed in step 3, screwing them into the holes provided in the power supply board (the large board at the back of the assembly).
7. Align the plastic connectors on the back of the display cover with the three hex standoffs and snap the display cover into place.
8. Replace the lid on the enclosure.
9. Re-tighten the cover set screw (1/16 inch socket) preventing inadvertent removal of the cover.

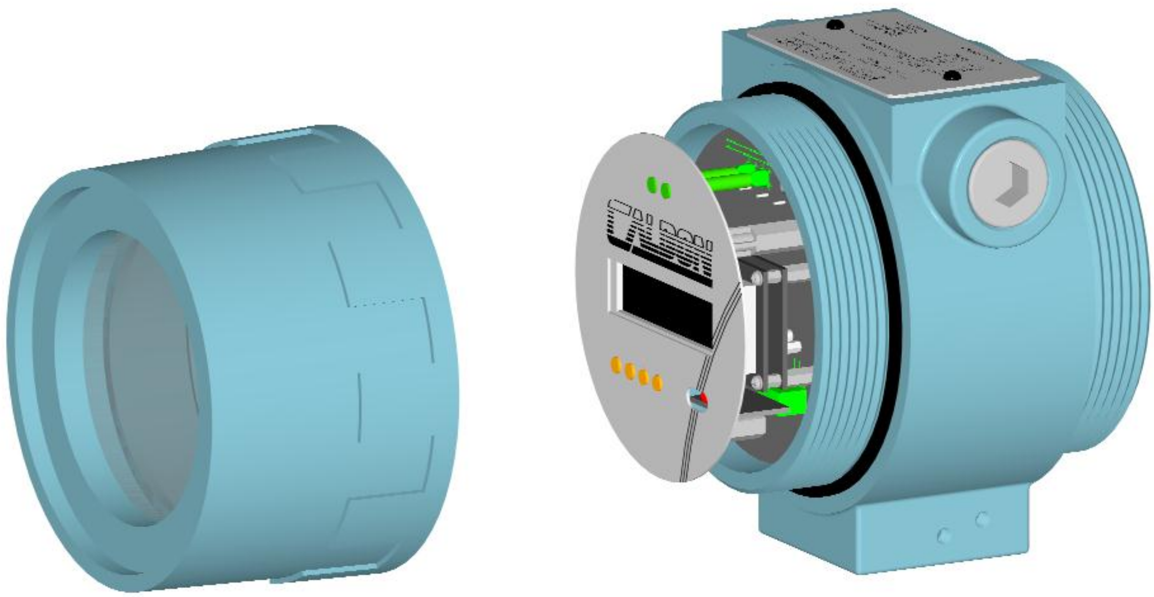

Figure 8.4: Front Cover Removal (Installation)

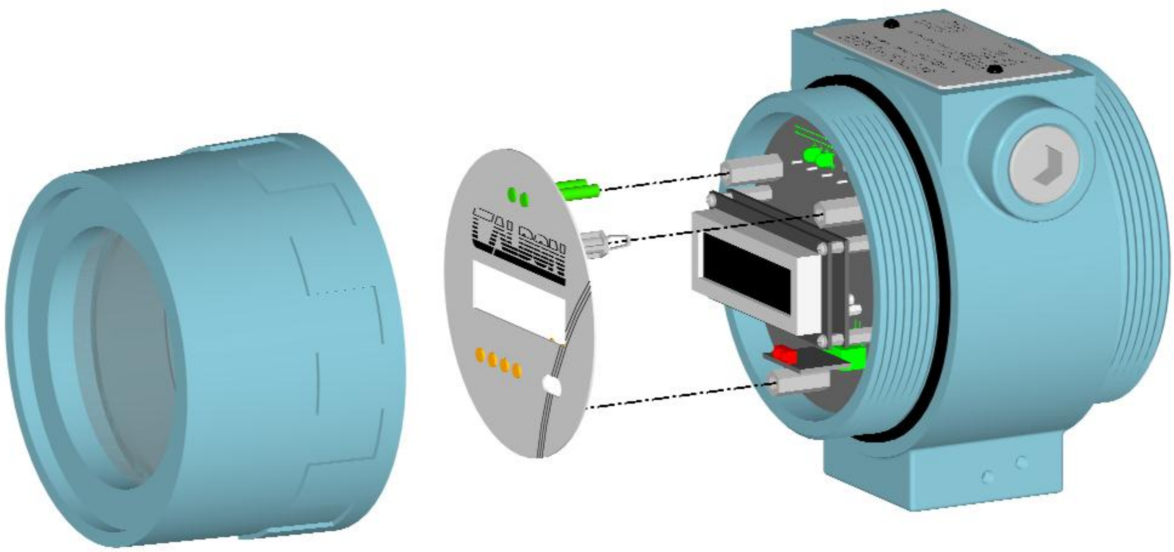

Figure 8.5: Display Cover Removal (Installation)

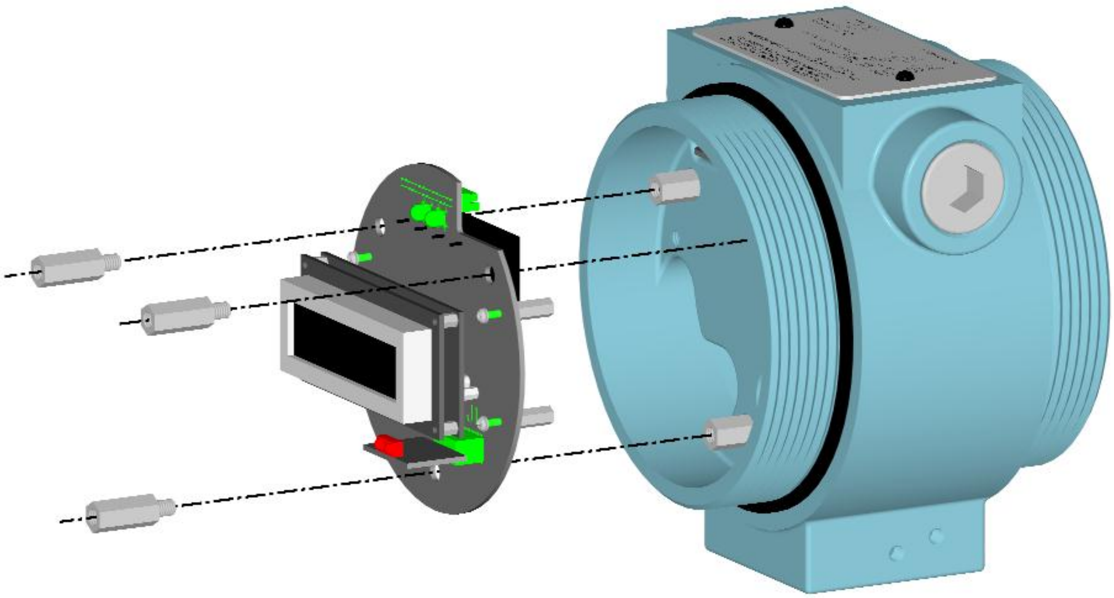

Figure 8.6: Power Supply/Display Removal (Installation)

Backplane Interface Board (BIB) Replacement

WARNING

Never open the transmitter when the instrument is energized. Before inspecting components, open the power supply circuit breaker. Failure to do so may result in electrical shock and/or an explosion if in a hazardous area.

CAUTION

Wear an ESD protective wrist strap to avoid damaging any components.

The Backplane Interface Board (BIB) is located just beneath the rear cover. To replace the BIB, perform the following steps:

1. Loosen the rear cover lid set screw (1/16 inch socket) that prevents inadvertent removal of the cover.
2. Unscrew and remove the rear cover to reveal the BIB and the user terminations (Figure 8.7).
3. Remove the connections to TB1, TB2, TB3 and TB4.
4. Remove the three Phillips head screws connecting the BIB to the rear access panel (Figure 8.8).
5. Carefully lift the BIB board from the enclosure. In doing so, you will detach the connector on the back of the BIB that connects the BIB to the underlying Input/Output board. The IOB is hidden from view by the rear access panel; only the IOB connector that fits through a cutout in the rear access panel is visible when the BIB is removed.
6. Remove the new BIB from its packaging and attach it to the rear access panel with the three screws removed in step 3.
7. Replace the connections to TB1, TB2, TB3 and TB4.
8. Replace the rear cover on the transmitter.
9. Re-tighten the cover set screw (1/16 inch socket) preventing inadvertent removal of the cover.

Figure 8.7: Rear Cover Removal

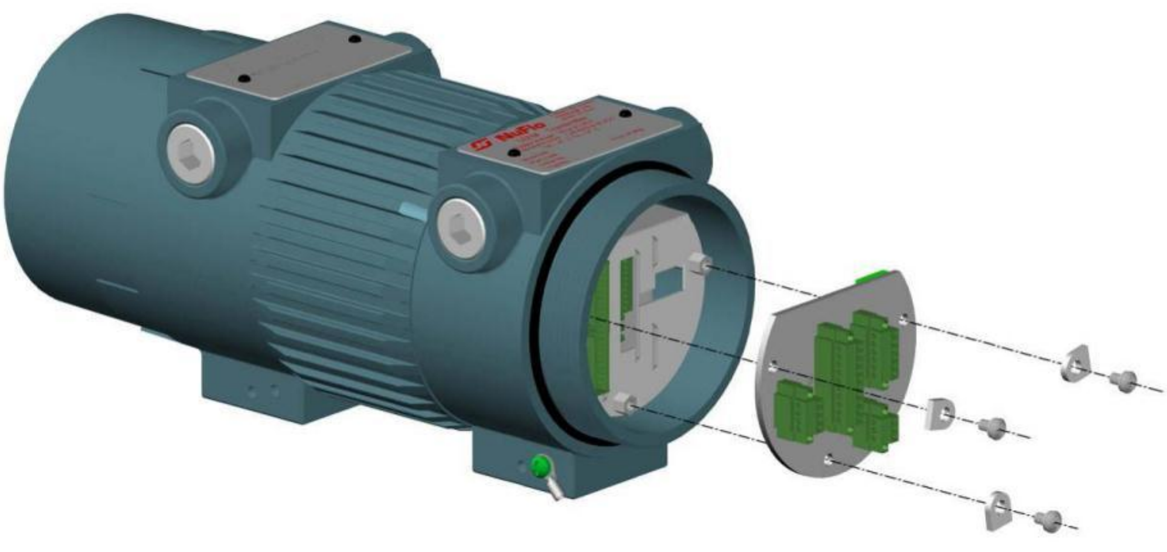

Figure 8.8: Backplane Interface Board (BIB) Removal

Backplane Interface Board (BIB) Fuse Replacement

WARNING

Never open the transmitter when the instrument is energized. Before inspecting components, open the power supply circuit breaker. Failure to do so may result in electrical shock and/or an explosion if in a hazardous area.

CAUTION

Wear an ESD protective wrist strap to avoid damaging any components.

The fuses of the BIB (incoming power) are replaceable. The fuses are designed to fail in the case of an overvoltage situation. These fuses are located in the lower right side of the BIB. To replace the fuse, remove fuse with an IC puller or tweezers. Press replacement fuse into the fuse holder.

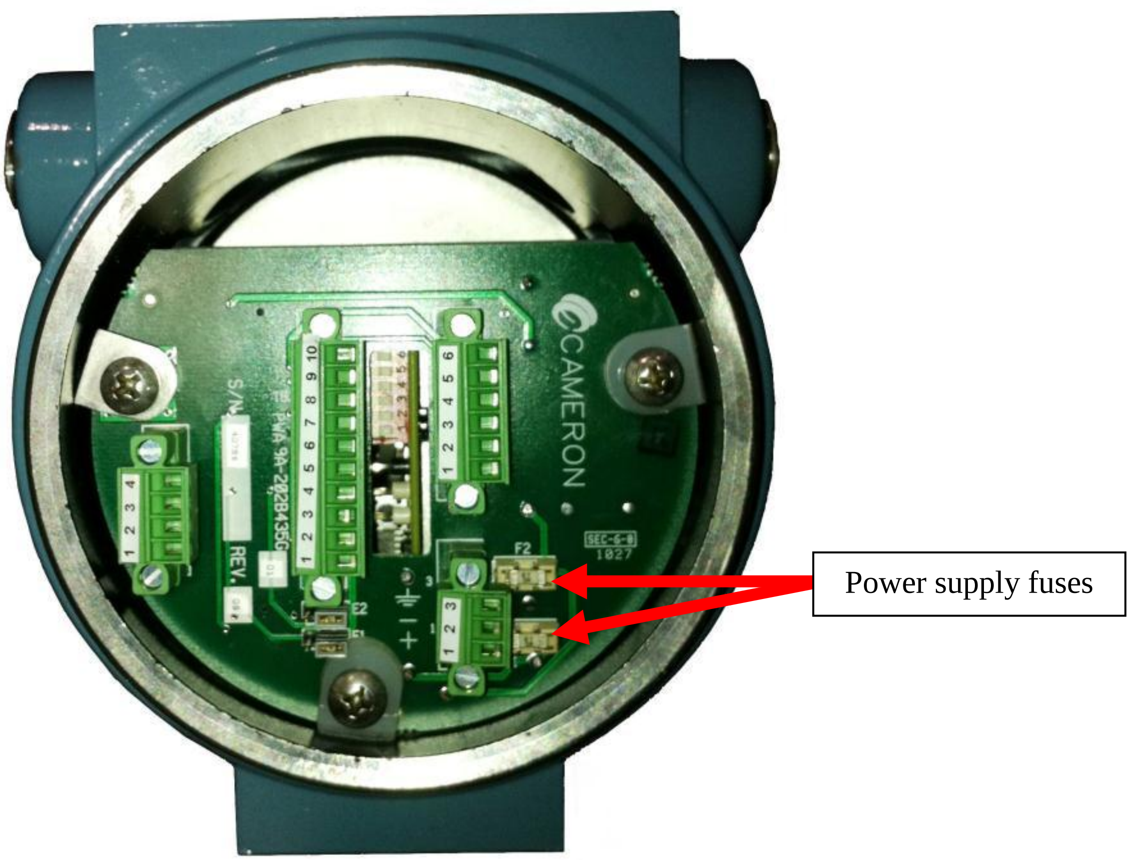

Figure 8.9: Backplane Interface Board (BIB) Fuse Location
(Communication Option 1)

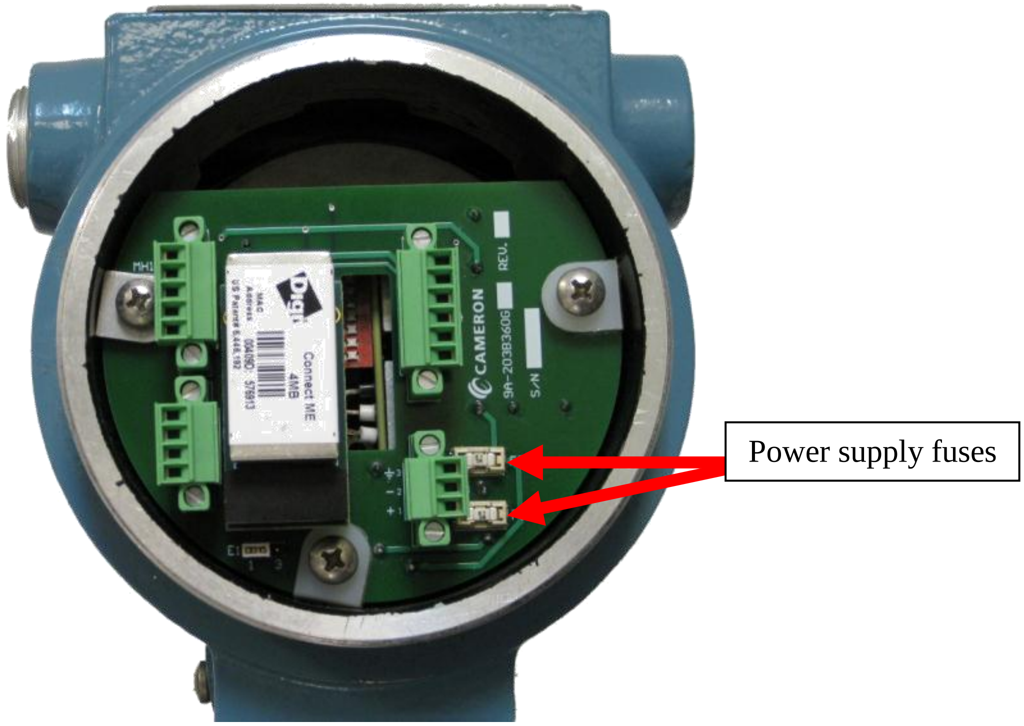

Figure 8.10: Backplane Interface Board (BIB) Fuse Location
(Communication Option 2)

Acoustic Processor Board (IOB, CTC & MXR) Replacement

WARNING

Never open the transmitter when the instrument is energized. Before inspecting components, open the power supply circuit breaker. Failure to do so may result in electrical shock and/or an explosion if in a hazardous area.

WARNING

The transmitter has a real time clock that has battery backup. It is recommended to replace the complete circuit board if the battery ever fails. Do not replace the battery alone. It must be replaced with the identical battery and it must never be changed in a hazardous location area.

CAUTION

Wear an ESD protective wrist strap to avoid damaging any components.

1. Loosen the rear cover lid set screw (1/16 inch socket) that prevents inadvertent removal of the cover.

2. Remove the rear cover from the transmitter and remove the backplane interface board (BIB) according to the procedure above. The BIB has incoming power protection circuits that could possibly be damaged by extreme power excursions.
3. Place the BIB in an ESD resistant jacket/packaging and store it in a safe location.
4. Push site cabling aside as required. (Note: It is assumed that the conduit and site cabling will be installed.) Remove the three hex standoffs holding the rear access panel in place (Figure 8.11) and lift the panel from the enclosure. The three acoustic processing boards (IOB, CTC, and MXR as installed left to right) are now visible.
5. Identify the board requiring replacement. The end of the board farthest from the operator is attached to a connector deep inside the transmitter body. To remove a board, simply grasp the board and gently pull in a back-and-forth motion until it releases from the connector (Figure 8.12).

Note – Pay attention to the orientation of the board removed, as the new board must be inserted in the same position, since the connector is keyed.

---

6. Remove the new board from its packaging, determine the proper orientation for installation, and carefully guide it into the connector inside the transmitter.
7. Repeat steps 4 and 5 if necessary, to install multiple boards.
8. Carefully replace the rear access panel that was removed in step 3, adjusting the position of the interior boards as necessary until the rear access panel fits snugly against them. When the rear access panel is positioned properly, the middle and bottom interior boards (the CTC and MXR boards) will lock into the thin cutouts in the rear access panel.
9. Re-install the three hex standoffs in the rear access panel.
10. Replace the BIB and attach it to the rear access panel with the three screws removed in step 1.
11. Replace the connections to TB1, TB2, TB3 and TB4.
12. Replace the rear cover on the transmitter.
13. Re-tighten the cover set screw (1/16 inch socket) preventing inadvertent removal of the cover.

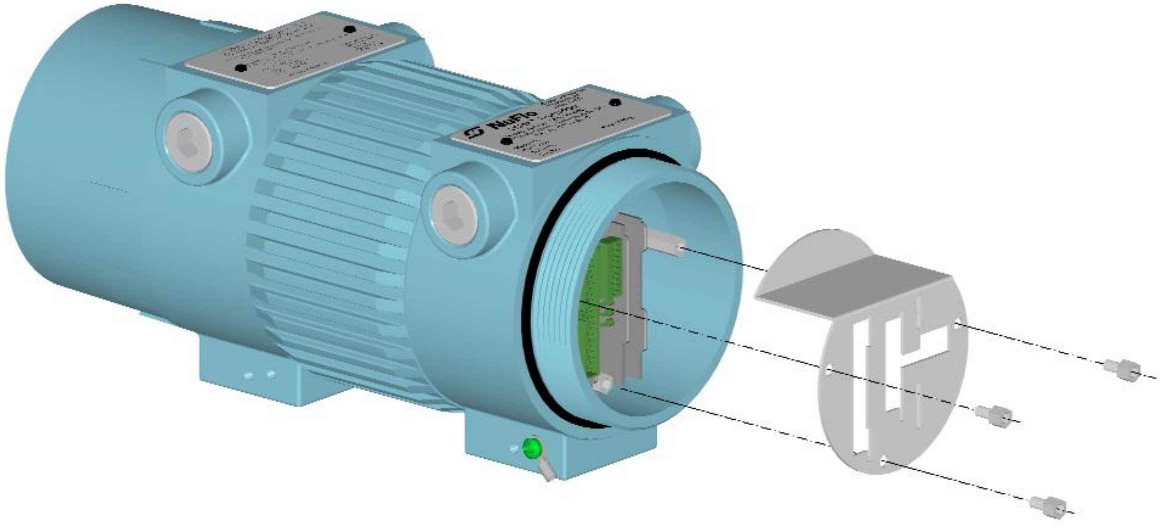

Figure 8.11: Rear Access Panel Removal

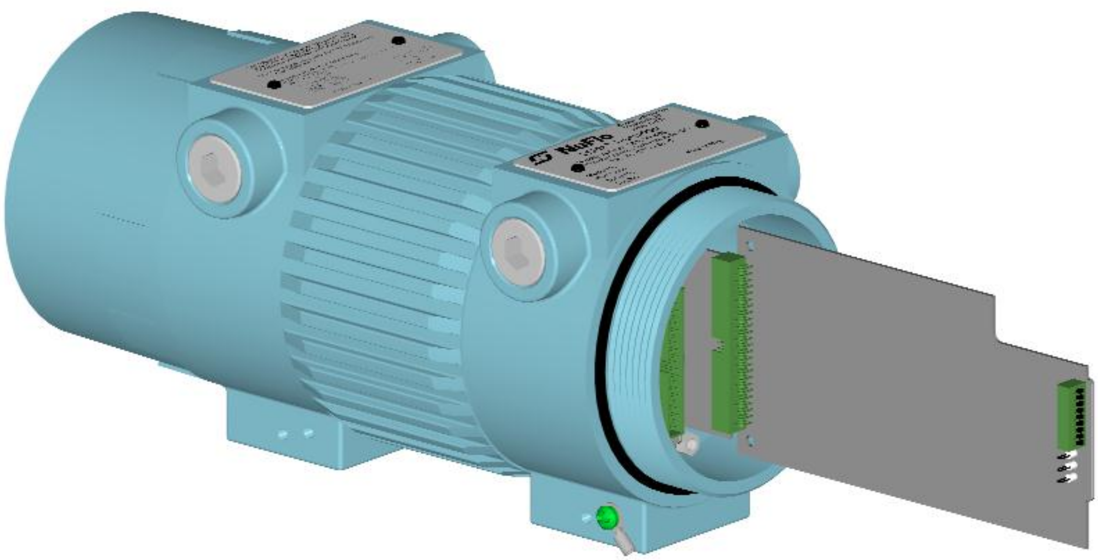

Figure 8.12: IOB, CTC, MXR Board Removal

CAUTION

Following replacement of the CTC board, the "safe mode" readout may appear in the transmitter display. This is an indicator that the configuration data has not been uploaded to the transmitter. See Reprogramming the Transmitter, in the LEFMLink 2G manual, for instruction on downloading the configuration file.

Transducer Installation

WARNING

Never open the manifold when the instrument is energized. Before inspecting components, open the power supply circuit breaker. Failure to do so may result in electrical shock and/or an explosion.

Should a transducer fail, install a replacement using the following procedures:

1. Power down the LEFM.
2. Remove the socket head screws from the manifold cover and remove the manifold cover to reveal the transducer internals. Disconnect the failed transducer from the terminals in the manifold.
3. Remove the transducer internals using an O-ratchet T-socket head (½" socket for the ½" transducer housing and ¾" socket for the 1" transducer housing). Typically 4" to 10" meter bodies contain ½" transducer housings; 12" and larger meter bodies contain 1" housings.
4. Remove the transducer assembly.
5. Use a flashlight to verify that the transducer housing is clean and free from dirt.
6. Re-install the transducer internals as follows:
   a. (0.5 Inch Transducer Housings) Thread the wires of the transducer though the compression spring and the spacer. (1.0 Inch Transducer Housings) Thread the wires of the transducer though the spacer and then through compression spring.
   b. Apply silicone lubricant to the transducer face. Note: For cryogenic applications, Cameron provides a metal foil couplant that must be used.
   c. Insert the transducer and components into the housing until the parts bottom out.
   d. Route the wires though the compression screw and then apply lubricant to the threads (make sure threads are free from grit and dirt).
   e. Screw into the transducer housing and tighten. This will load the compression spring.
7. Connect the new transducer to the terminals.
8. Re-install the manifold.
9. Torque the socket head screws to 30 in-lbs (3.4 nm).

Note - The LEFM 2xxCi system may require that the acoustic performance is verified when a transducer is replaced or re-coupled (See Section 9).

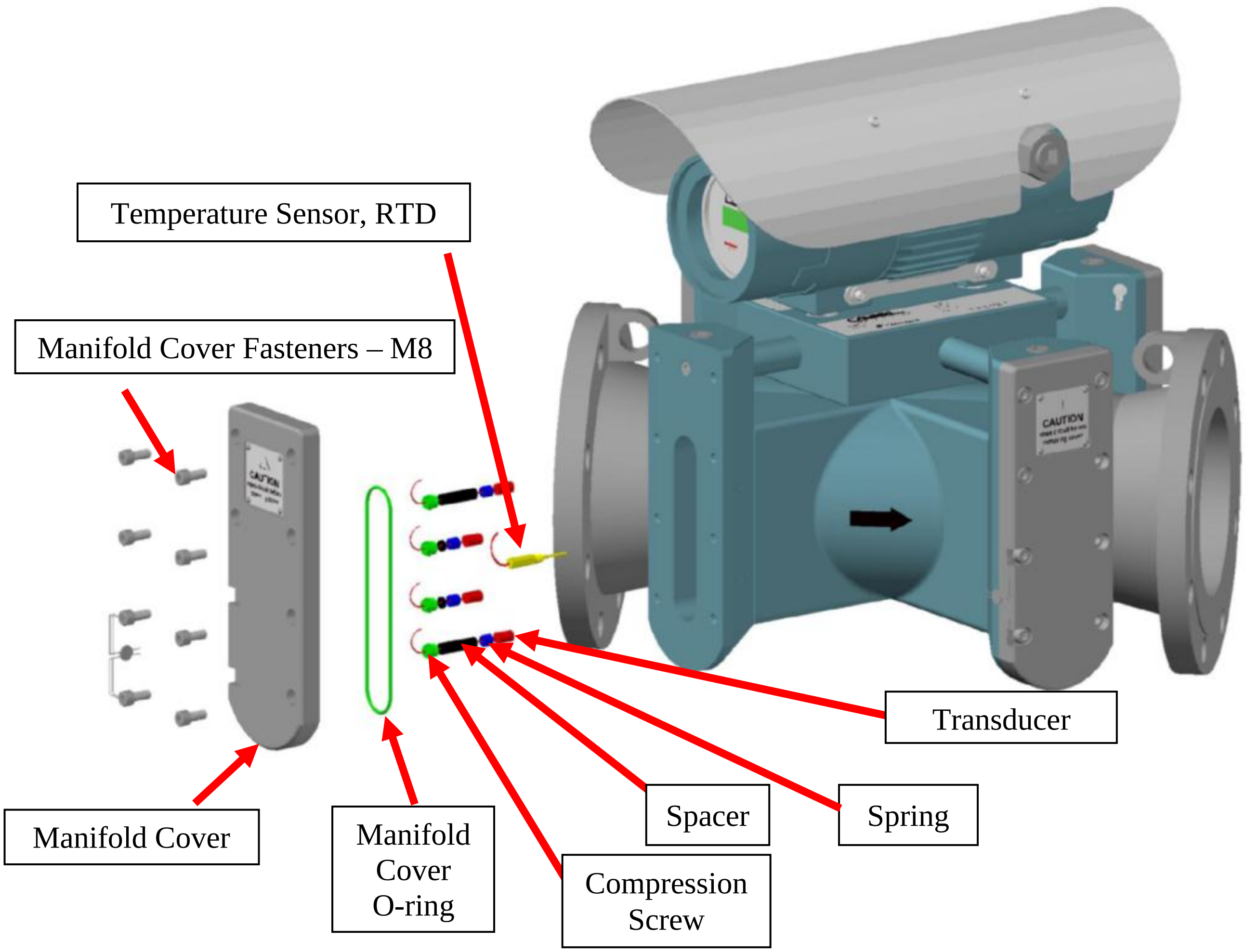

Figure 8.13: Transducer Replacement
(note the order of the spring and spacer are shown for 0.5 inch housings)

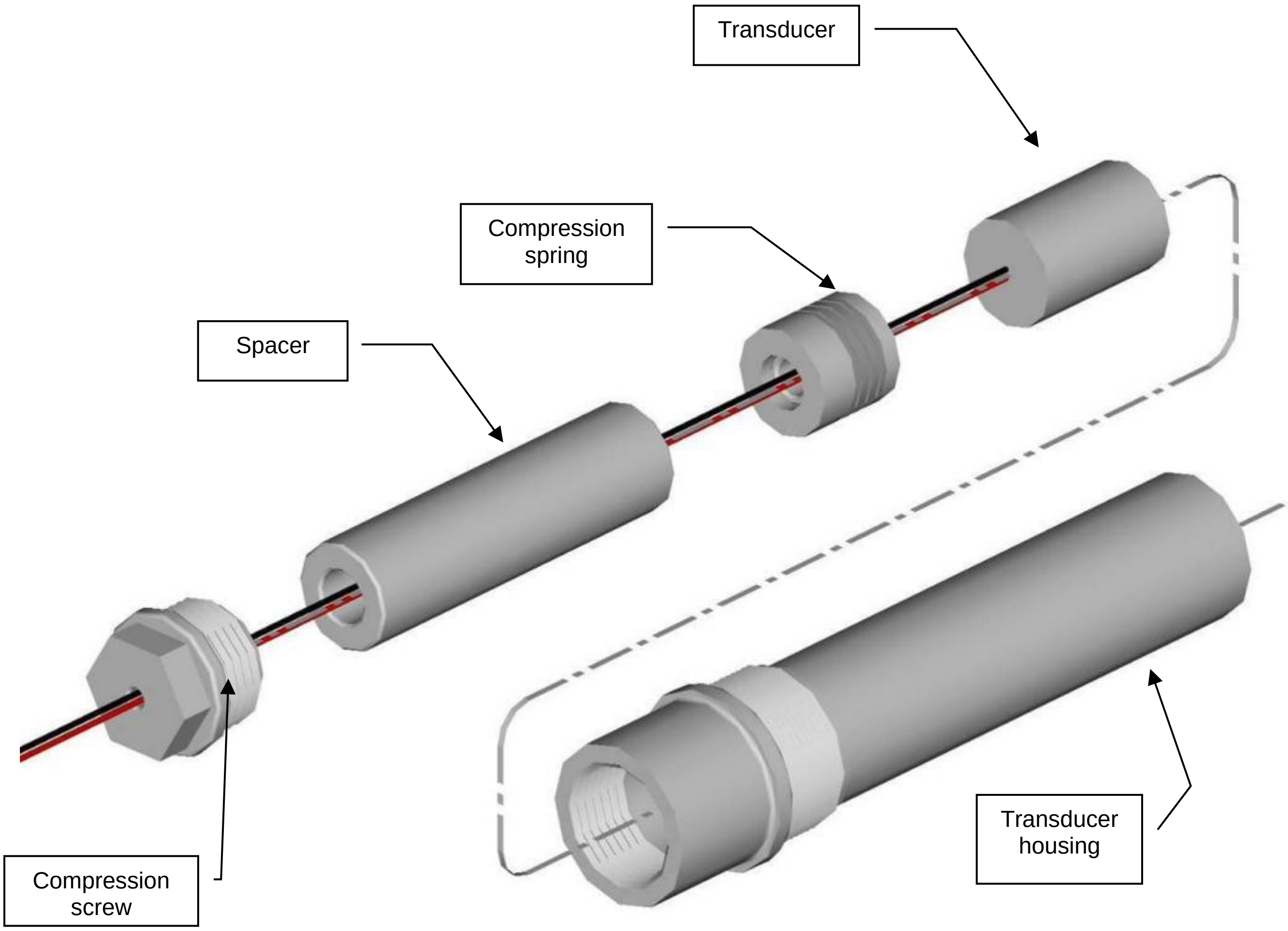

Figure 8.14: Transducer Assembly Construction (half inch housing shown – for the 1 inch housing – the spring and spacer order is reversed).

Analog Input Verification

The LEFM 2xxCi may have an analog input (for example, temperature, pressure, or density). The input signal is conditioned before it is converted to a digital input.

The input is scaled linearly to convert the user input of 4-20 mA (or 0-20 mA) to maximum and minimum values. Analog input ranges can only be adjusted via the LEFMLink 2G software interface (see the LEFMLink 2G manual for instructions).

Failed inputs result in readouts at their lowest range. For example, a 4-20 mA pressure input scaled to 0-1000 psig will go to 0 psig if the input is removed.

Analog Output and Pulse Output Verification

The digital output channels consist of an analog output and a pulse output. The current output channel has a 0-20 mA range. The pulse output has a range of 0 to 5V or 0 to 12V. There are no adjustments to be performed for the analog or pulse outputs. The analog output can be mapped to any Modbus input register for maximum flexibility. By default, the analog output is mapped to read flow.

Force Output (Analog)

The analog output is scaled linearly between its maximum and minimum values. Use the force output function of LEFMLink 2G software to test the scaling of the analog output with input site devices. (See the LEFMLink 2G Manual for detailed instructions).

Force Output (Pulse)

Similar to calibrating the analog outputs, a fixed frequency may be forced out of the transmitter pulse output. To verify the pulse output using a forced output, follow the instructions in the LEFMLink 2G Manual.

Changing Digital Output Voltage

The pulse output and digital output can be configured for either 5 VDC or 12 VDC. This is done by changing jumper E1 on the IOB. See Figure 8.15 to locate jumper E1.

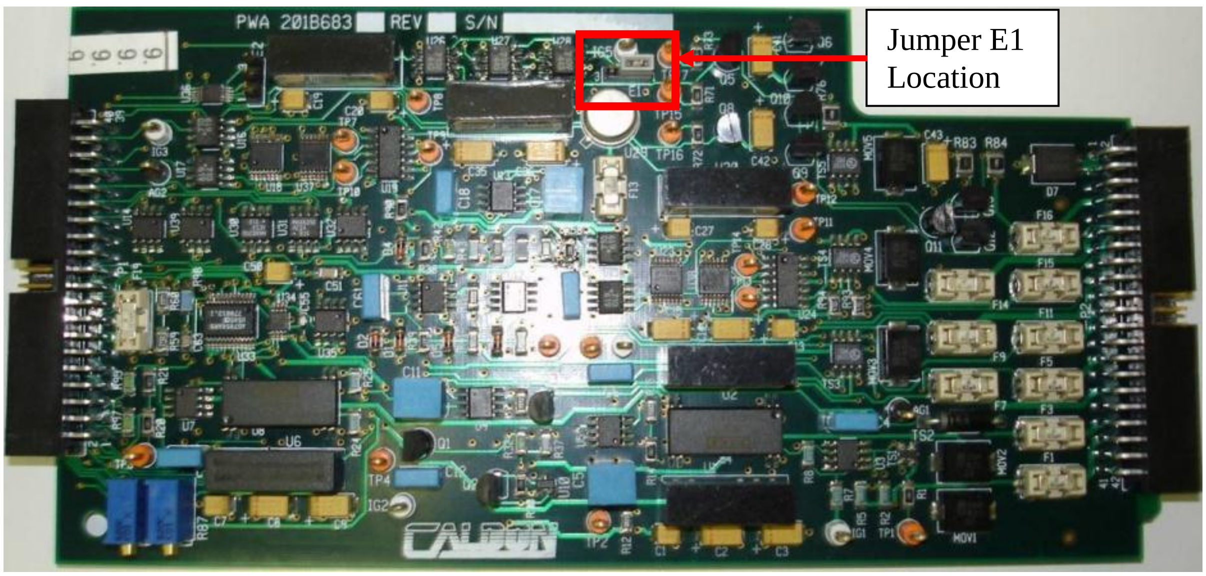

Figure 8.15: Jumper Location to Change Digital Output Voltage

Table 8.6: Digital Output Voltage Jumper Positions

Jumper Position	Voltage
1-2	5V
2-3	12V

Section 9

Troubleshooting and Diagnostics

Diagnostics

The LEFM transmitter display provides basic diagnostic information. Additionally, more detailed diagnostics are available via software download with serial ports or an infrared port. The transmitter's serial and infrared ports use the Modbus protocol. Cameron's LEFMLink 2G software allows the user to interface with the transmitter via Modbus.

Note: Modbus registers can be edited to change the configuration of many LEFM parameters; however, these instructions are outside the scope of this manual. Throughout this section, values such as path SNR (Signal to Noise Ratio), gain etc. are discussed in reference to the LEFMLink 2G Software. Modbus register addresses will not be addressed).

The following screen capture depicts the interface software. The "look" of the LEFMLink 2G software may vary. Please refer to the LEFMLink 2G manual for more information.

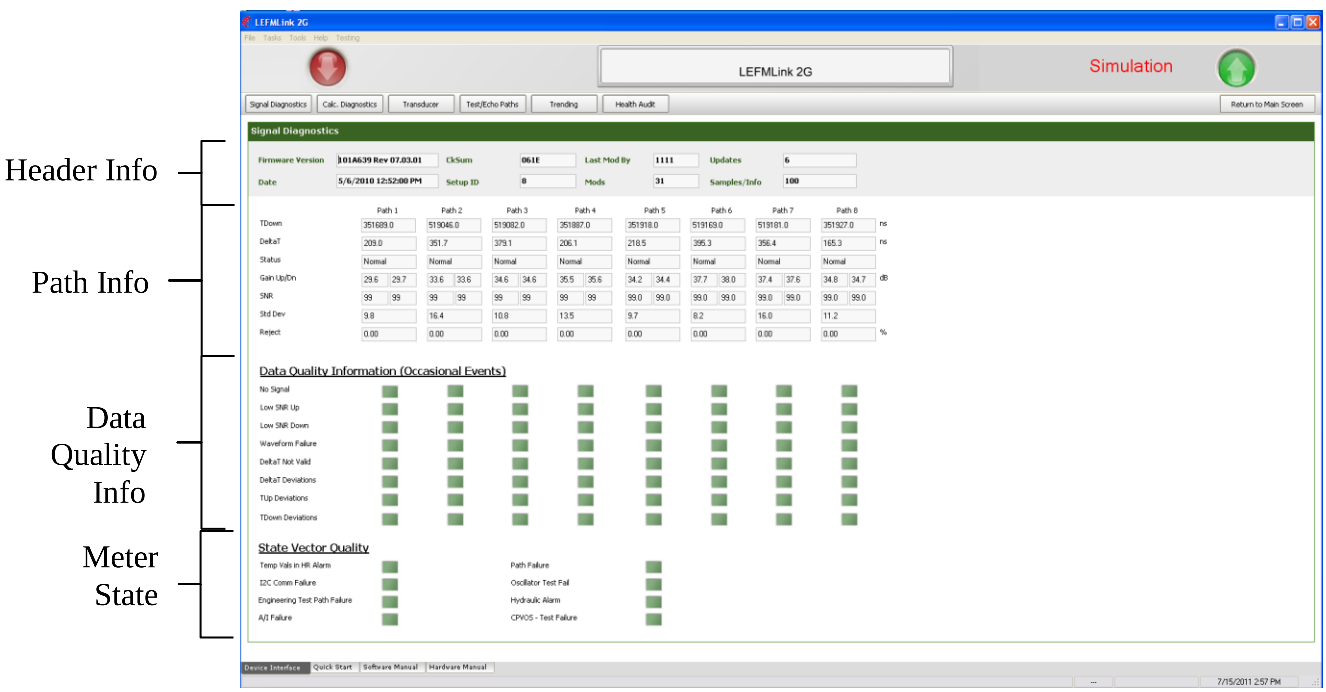

Figure 9.1: PC Diagnostic Screen

For troubleshooting ultrasonic signals, the most frequently used diagnostic parameters are the following:

Table 9.1: Acoustic Signal Diagnostics

Diagnostic Parameter	Range	Typical Values for Normal Operation
Rejects (%)	0 to 100%	0 to 5%
Gain	0 to 88dB	30 to 70dB
SNR	0 to 100	20 to 99

Automatic Fault Detection

The LEFM transmitter continuously checks the data quality of each acoustic path for detecting faults. Each time the signal is sampled, the transmitter tests the signal as follows:

1. The LEFM checks the quality of data collected from the ultrasonic signals and evaluates it against pre-set thresholds. The data is evaluated based on SNR (signal to noise ratio), cross-correlation tests and signal statistics.
   a. The LEFM verifies whether the path's signal to noise ratio (SNR) is higher than its threshold value.
   b. The LEFM correlates the Upstream Signal with the Downstream Signal to test for "cycle skipping." The processor rejects data that does not pass this correlation test.
   c. The LEFM verifies the computed transit time and Delta T are acceptable.

Note - The LEFM will reject data occasionally; however, this will not influence the operation. If an ultrasonic path rejects data continuously, the LEFM will alert the operator with an "ALARM" status and an error code.

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2. The processor outputs the individual path status codes through a digital output and Modbus. LEFMLink 2G software interprets these codes and displays a text message. The individual path status codes are:
   - 0 – Path operating normally
   - 1 or "R" – Path rejecting data due to low SNR, irregular statistics, or failing the correlation test
   - 6 – Path sound velocities are inconsistent with thresholds (typically, up to 2% spread between paths is acceptable).
   - 7 – Path velocity fails profile test
   - 8 – Path velocity inconsistent at low flow rates
   - "I" – Path fails impedance self-test
   - "F" – Internal oscillator test has failed
3. The processor outputs the current meter status through a digital output and Modbus. The meter status is identified as one of the following:
   - "NORMAL" (status bit on TB4 is at 5 volts (12 volts))

- "ALARM" – 1 or more paths failed; flow is computed with a lower accuracy (status bit on TB4 is at 0 volts)
- "ALARM" – All Paths Failed; flow is set to zero (status bit setting is the same as for "NORMAL"). Note: the software can be configured to go to zero flow when only one or two paths function.

Path Reject Status

When the path status indicates that the Reject Test failed, the percentage of data that has been rejected exceeds LEFM thresholds. Use the following troubleshooting sequence to pinpoint the cause.

1. Verify that the meter body is full of liquid. If the pipe is not filled, it may cause the top path to fail.
2. Verify continuity of all cable connections.
3. Check all LED indications. If an LED for a power supply or circuit board is lit on the backplane, a fuse on the board may have blown or a component may have degraded.
4. Check the display. If the display reports "Bad Setup, Send New Setup" the transmitter needs to be reprogrammed or the CTC board requires replacement. See Reprogramming the Transmitter, page 91.
5. Check the acoustic signal. Check path gains via Modbus or LEFMLink 2G Software. If the path gains are high (85dB or higher), the signals may be too weak to be detected. Weak signals can be caused by any of the following (listed from most likely to least likely)
   - The line is not full of liquid.
   - The line pressure is too low for the vapor pressure.
   - The cable/wire from the meter to the transmitter is damaged.
   - The transducer coupling needs to be replaced (with grease couplants only).
   - The transducer has failed.
6. Determine which transducer has failed. The LEFM has a diagnostic capacity for determining which transducer(s), if any, needs attention. The transmitter continuously tests each transducer individually in a pulse-echo mode. A transducer transmits acoustic energy across the liquid, echoes the energy off the opposing transducer, and then receives the energy it has sent. In pulse-echo mode, the transmitter computes the gain for both upstream and downstream transducers. Normally, the gains for the upstream and the downstream pulse-echo tests are equal; however, if a transducer fails due to wiring, coupling, etc., one transducer will have a higher gain. Using the regular acoustic paths and the diagnostic pulse-echo paths, follow these steps to determine which transducer has failed:
   a. Review the SNR (Signal to Noise Ratio) for each path (paths 1 through 8). The SNR should be greater than 40 (or greater than 20 for high viscosities).
   b. Review the gains for each acoustic path (both upstream and downstream). The gains should be between 10dB and 85dB. Upstream and downstream gain should nominally be within 3 dB of each other.

c. Review the percent rejected data for each path. The percent should be between 0 and 5%.
d. Review the gains for each pulse-echo path (both upstream and downstream). The path with the higher gain should be investigated first.

Note - If the pulse-echo paths are both at their maximum gain (~88dB), investigate the cables and transducers of both transducers.

Remember the following troubleshooting tips:

- If all paths fail, the meter has no liquid or an electronics hardware failure has occurred.
- If a path has 100% rejects, the transmitter cannot lock onto a signal. A problem with the cable or transducer should be investigated. (Note: When rejects equal 100% for any given path, the transmitter will always indicate SNR=0).
- If an acoustic signal does not exist, or if SNR has degraded from installation, follow the checklist below:
  1. Verify the pipe is full of liquid.
  2. Check the transducer impedance reported by the transmitter. If the transducer impedance is less than 100 Kilo-ohms, replace the transducer.
  3. Check the continuity of transducer cable in the manifold.
  4. If a signal is present, consider reseating the ultrasonic transducer or replacing the acoustic coupling. See Transducer Installation, page 82.

Reprogramming the Transmitter

Before each transmitter leaves the factory, it is preprogrammed to work with the meter body with which it will be installed. This information is stored within a configuration file that is maintained by Cameron. The file includes the following information:

pipe size

pipe transducer frequency

acoustic path lengths

calibration constant

alarm settings

K-factor

analog input/output scaling

Should the processor in the transmitter fail and require replacement, the transmitter must be reprogrammed with the appropriate configuration file using Caldon's LEFMLink 2G software. The procedure is as follows:

1. Connect the serial interface cable between a COM port on the PC and terminal TB2 on the transmitter's back interface board (BIB). If the COM1 connection is used on TB2, connect the cable to pins 1 through 5; if COM2 is used on TB2, connect the cable to pins 6 through 10.

2. Select the appropriate Modbus ID and baud rate using LEFMLink 2G software. All transmitters are initially programmed with a Modbus ID of 1, and a baud rate of 9600 with RTU Slave Mode.
3. Select the configuration file for the meter.
4. Send the configuration file. The transmitter will be reprogrammed.

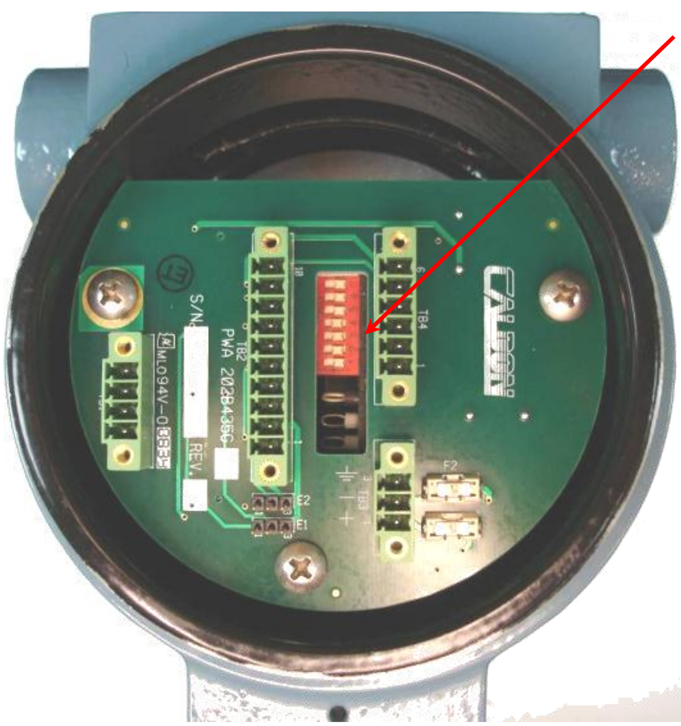
Section 10

LEFM 2xxCi and 2xxCi-R Metrological Seals

CAUTION

The physical properties, acoustic properties, and calibration of the meter body are pre-programmed into the transmitter; therefore, the programming of the transmitter must be controlled. Failure to control transmitter's programming can result in erroneous flow measurements outside the stated accuracy.

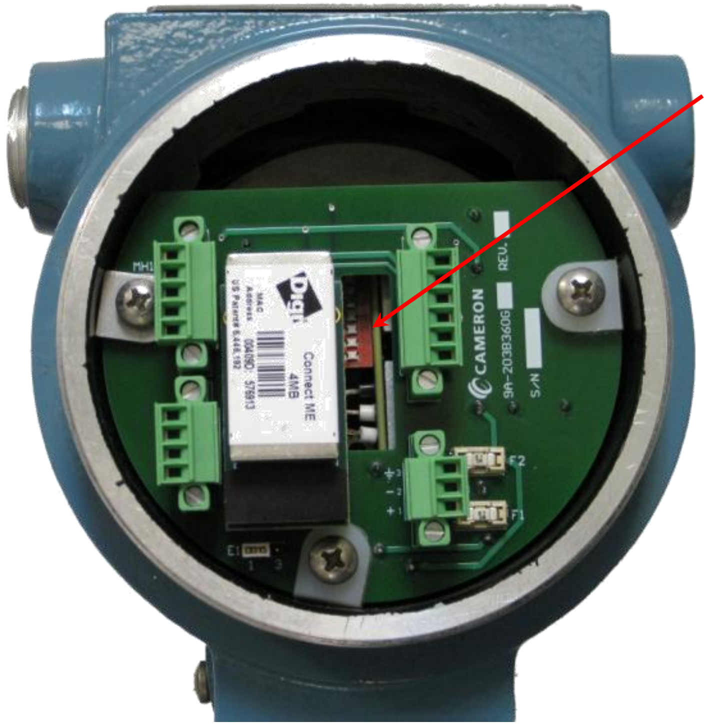
As a precaution, the LEFM 2xxCi design has seals to control how the transmitter gets programmed and any alterations to the meter body. The first step comes in the transmitter itself. The back of the transmitter with the cover removed is shown in Figure 10-1 below. If the electronics switches 1 through 6 are configured to the left (closed) and switches 7 through 9 are configured to the right (open), the electronics cannot be reprogrammed (irrespective of passwords). Using these switches combined with the seal wire on the transmitter enables full metrological control of the system.



Normal Use:
Dipswitches 1 thru 6 inclusive have to be in the "closed" position (to the left), dipswitches 7 thru 9 inclusive have to be in the "open" position (to the right).

Note: Switches 8 and 9 are hidden behind the circuit board.

Figure 10-1
(Communications Option 1)



<u>Normal Use:</u>
Dipswitches 1 thru 6 inclusive have to be in the "open" position (to the left), dipswitches 7 thru 9 inclusive have to be in the "closed" position (to the right).

Note: Switches 8 and 9 are hidden behind the circuit board.

Figure 10-2
(Communications Option 2)

Figure 10-3 shows the seal wire on the transmitter (wire goes from the front cover to the back cover). A properly installed wire seal prevents undetected entry into the transmitter.

Figure 10-3: Depiction of Seal Wire on Transmitter Enclosure

Further, the meter body has a seal wire on the fasteners for the manifold cover. The seal wire allows the meter owner to verify if there has been any tampering with the meter body. (see Figure 10-4).

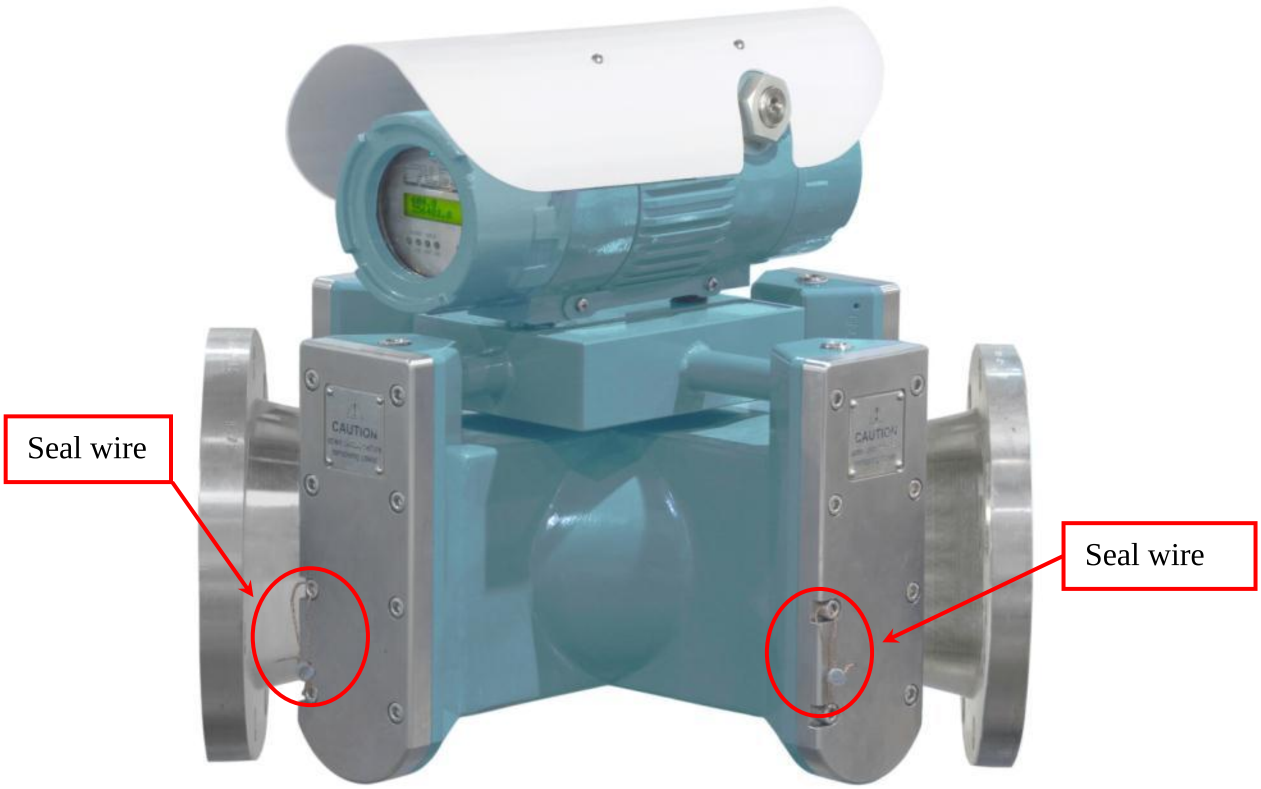


Figure 10-4: Seal Wire on Meter Body

Finally the remote mount configuration, as shown in Figure 10-5, also has seal wires for all the junction boxes used in the system.

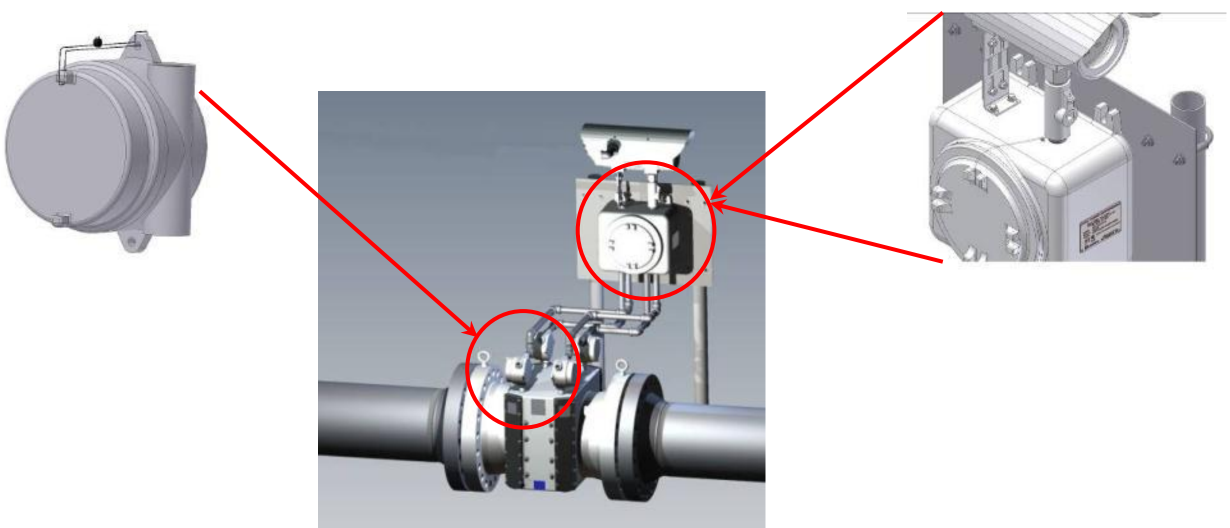


Figure 10-5: Seal Wire for Junction Boxes

Section 11

Recommended Spare Parts

Transducer Equipment

Qty: 1	Transducer (appropriate frequency)
Qty: 1	Transducer Grease (small tube)
Qty: 16	Transducer Cryogenic Couplant (2xxCiLT-R Only)

Electronic Equipment

Qty: 1	Power Supply and Display Board
Qty: 1	CTC Board
Qty: 1	IOB Board
Qty: 1	MXR Board
Qty: 1	BIB Board
Qty: 2	BIB Board Fuses

Note - The printed circuit boards contain electrolytic capacitors. To ensure proper operation of these components, perform a functional test on them at least once every 5 years. Contact Cameron for instructions.

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