

CALDON® ULTRASONICS

LEFM® 380Ci Gas Ultrasonic Flowmeter

User Manual



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Important Safety Information

Terms Used in this Manual



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



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



OPERATORS SHOULD NOT REQUIRE ACCESS TO THE INTERIOR OF THE FLOWMETER. ONLY QUALIFIED PERSONNEL SHOULD SERVICE THE LEFM 380Ci. 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 outputs three (3) independent outputs for flow indication. There are two pulse/frequency 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 typical).

Section 1

Introduction

Equipment Description

The LEFM 380Ci ultrasonic flowmeter is a highly sophisticated bidirectional 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 380Ci can be configured to indicate direction of flow via either a quadrature pulse output or a digital signal. It can also be configured to output positive flow pulses on one channel and negative flow pulses on the other.

The LEFM 380Ci 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 380Ci 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 diagnostic acoustic data can access the data via Cameron's LEFMLink software. The operation of this software is outside the scope of this manual. See the LEFMLink User Manual for details.

The LEFM 380Ci 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

The meter body now has updated features that have been introduced in 2013. These features comply with the requirements of Measurement Canada (PS-G-06), OIML R-137, and ISO 17089-1:2010. They include:

- Removable manifold covers for easy access to the transducer components
- Ability to seal the transmitter and meter body to all changes affecting metrological performance
- Positive indication of the degradation in any primary seal with a secondary seal design that complies with the requirements of ISA 12.27.01

The meter design typically mounts the transmitter 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 itself. This manual covers two different configurations. These are described as follows:

Model 380Ci: 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.

Model 380Ci-R: Transmitter 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.

The Model 380Ci-R requires that the transmitter be mounted separately from the meter body. In those instances the transmitter(s) and meter body are shipped separately.

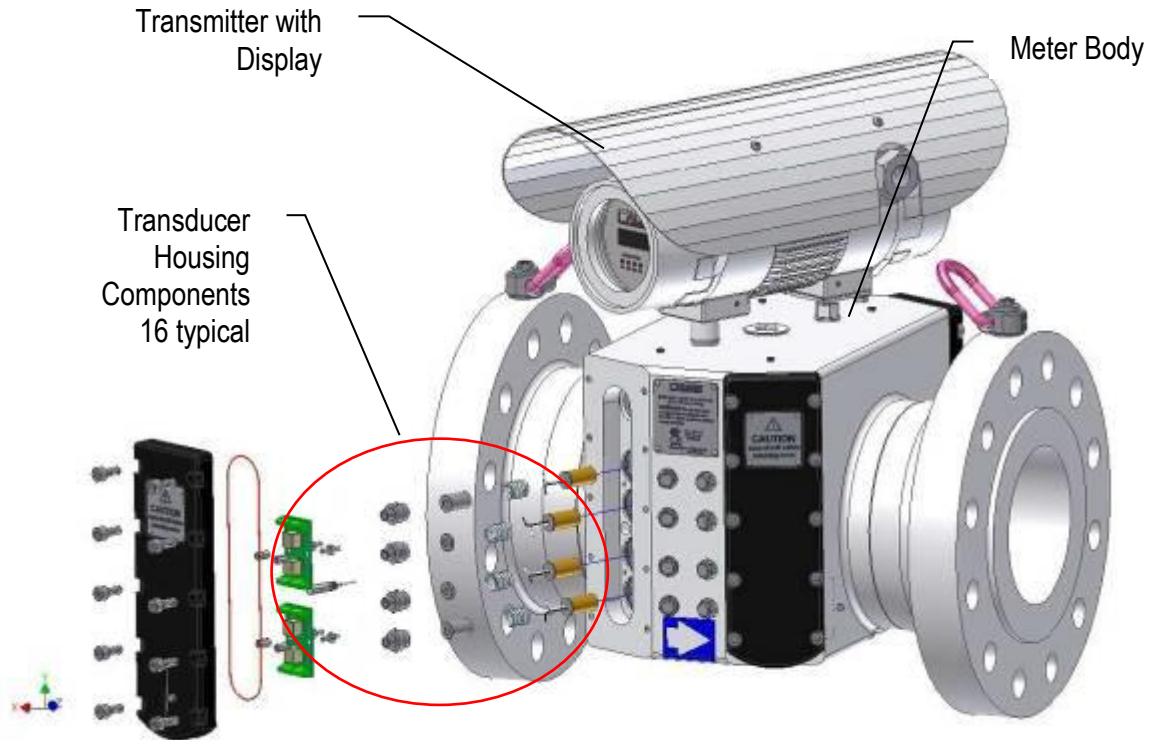


Figure 1.1: LEFM 380Ci Components, Typical

LEFM 380Ci 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 pairs of transducer housings that are positioned to provide acoustic paths at a 65° 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 200 kHz). The transducer modules contain piezoelectric crystals which transmit and receive acoustic energy. A distinguishing design feature is that the transducer modules may be removed from their housings for maintenance while the meter body is in the pipeline without affecting the pressure boundary (i.e. no special extraction tools required).

LEFM 380Ci Transmitter

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



Figure 1.2: LEFM 380Ci Transmitter

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
- Provide gain control for each ultrasonic path
- Compute flow
- 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 as needed.

One analog input (optional; choose from 4-20 mA or 0-20 mA)

Choose from:

Product temperature

Product pressure

One analog output (optional; choose from 4-20 mA or 0-20 mA)

Flow

Any Modbus Input Register (see Modbus manual)

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

Table 1.1: Nominal K-Factors

| Size | | Maximum Flow CFH | K-Factor (P/CF) | Maximum Flow m ³ /h | K-Factor (P/m ³) |
|--------|-----|---------------------|--------------------|-----------------------------------|---------------------------------|
| Inches | DN | | | | |
| 4 | 100 | 29,000 | 240 | 810 | 8900 |
| 6 | 150 | 65,000 | 110 | 1845 | 3900 |
| 8 | 200 | 114,000 | 63 | 3,230 | 2230 |
| 10 | 250 | 180,000 | 40 | 5,090 | 1416 |
| 12 | 300 | 254,000 | 28.3 | 7,200 | 1000 |
| 14 | 350 | 307,000 | 23.5 | 8690 | 829 |
| 16 | 400 | 402,000 | 17.9 | 11,400 | 632 |
| 18 | 450 | 511,000 | 14.1 | 14,500 | 498 |
| 20 | 500 | 632,000 | 11.4 | 17,900 | 402 |
| 24 | 600 | 913,000 | 7.9 | 25,900 | 278 |
| 26 | 650 | 1,203,000 | 6.0 | 34,100 | 210 |
| 28 | 700 | 1,405,000 | 5.1 | 39,800 | 180 |
| 30 | 750 | 1,623,000 | 4.4 | 46,000 | 160 |
| 32 | 800 | 1,857,000 | 3.9 | 52,600 | 140 |
| 34 | 850 | 2,106,000 | 3.4 | 59,600 | 120 |
| 36 | 900 | 2,371,000 | 3.0 | 67,100 | 100 |

Model Number

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, ANSI rating, and enclosure type.

MODEL NUMBER CODE: 380**C-D-E-F-G-B-J-L-L-M-N-1-G-R** (where characters that are **bold** and **red** are configurable)

C = Ci FOR INTEGRAL ELECTRONICS

C = Ci-R FOR REMOTE ELECTRONICS AND 1 J-BOX PER MANIFOLD

C = Ci-RB FOR REMOTE ELECTRONICS AND 1 J-BOX FOR WHOLE METER

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

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

J = W FOR WELD NECK RAISED FACE FLANGES

J = R FOR WELD NECK RTJ FACE FLANGES

J = O FOR OTHER FLANGE VARIETY

L = B FOR SECONDARY SEAL DESIGN COMPLIANT WITH ISA 12.27.01

L = C FOR STANDARD DUAL O-RING 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

R = "BLANK" FOR NO CUSTOM OPTION

R = C FOR CUSTOM OPTION

Example: For a forged carbon steel 380Ci meter that has a head mounted electronics, 6 inch NPS, Schedule 40, 150# weld neck flanges with raised faces, no pressure port, aluminum manifold covers, having the secondary seal design and having no other custom features – the model code will be:

380Ci-06-40-CF-150-B-W-L-B-N-A-1-G

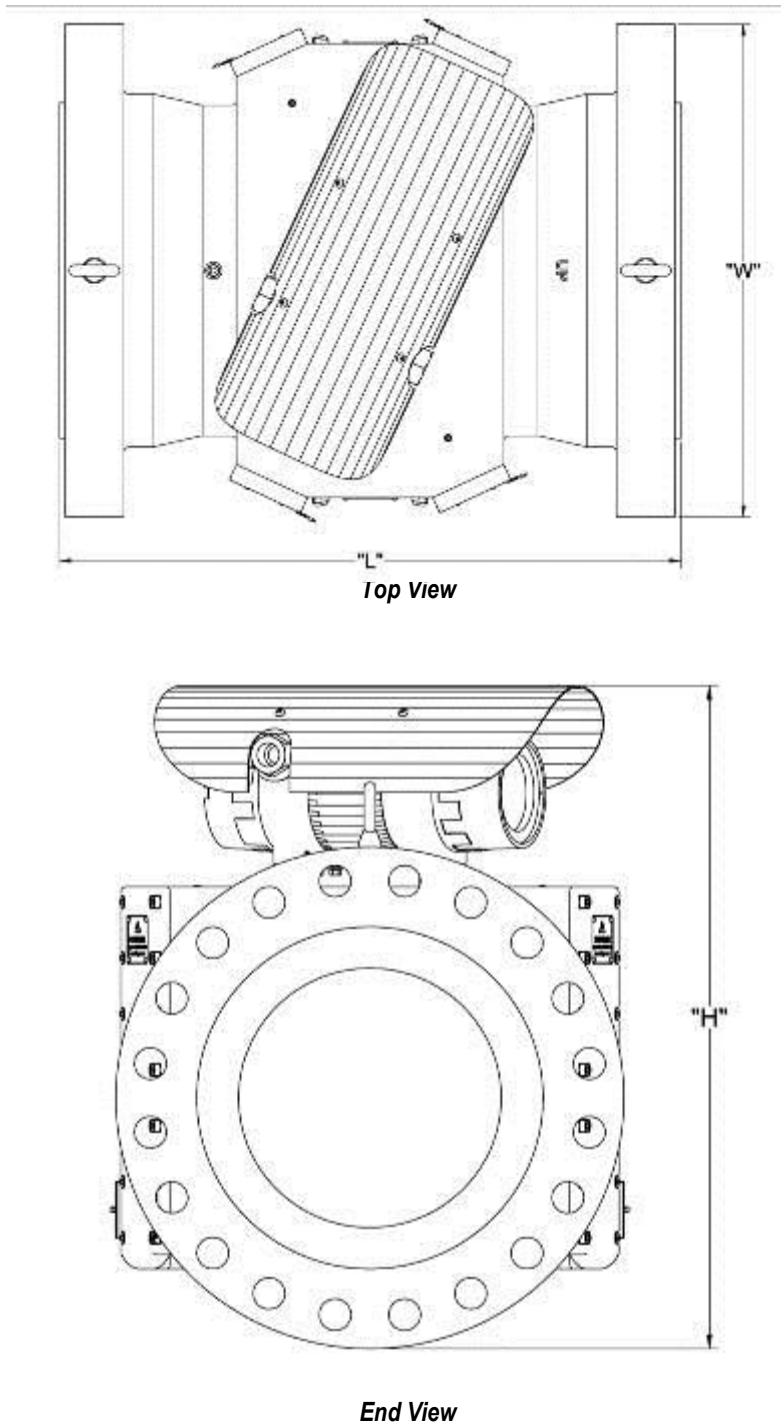
Flowmeter Specifications

Table 1.2: LEFM 380Ci 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 35 lb. (15.9 kg) Stainless Steel |
| Power Requirements | | |
| | Voltage Req'd | 24 VDC (18 VDC to 30 VDC) |
| | Current Draw | 24 VDC at 0.45A |
| | Power Consumption | 13 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 (See Modbus specifications) | | |
| | | Two RS 485 (Modbus RTU-slave) ports |
| Wireless Communications | | |
| | IR Port | Requires IR Computer Link Cable (Actisys Corp. ACT-IR220LN 9.6, or equal) |
| 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 |
| Temperature Range | | |
| | Storage Temperature | -58°F (-50°C) to 257°F (125°C) |
| | Process Temperature | -40°F (-40°C) to 158°F (70°C) – Head Mounted Electronics -58°F (-50°C) to 257°F (125°C) – Remote Mounted Electronics |
| Humidity Range | | |
| | Storage Humidity | 0 to 95% RH |
| | Process Humidity | 0 to 95% RH |

Meter Dimensions

380Ci Meter Body Dimensions



End View
Figure 1.5: LEFM 380Ci Dimensions
(Single Electronics)

Table 1.3: Dimensions and Weights for LEFM 380Ci Meter Body
 Note: Dimensions are subject to change (actual dimensions may be project specific).
 Unless project specific dimensions are given, the tolerances for the following table are ±1.0 inches [25.4 mm] and ±15% in weight. All flanges are based on ASME B16.5 dimensions.

| Pipe Size Inches | Flange | Width "W" | | Height "H" | | Overall Length "OAL" | | Assembled Meter Weight not including Xmtr | | Assembled Meter Weight including Xmtr | |
|------------------|--------|-----------|----------|------------|--------|----------------------|----------|---|--------|---------------------------------------|--------|
| | | Inches | [mm] | Inches | [mm] | Inches | [mm] | lbs | [kg] | lbs | [kg] |
| 4 | 150 | 9.00 | [228.6] | 19.0 | [483] | 16.75 | [425.5] | 264 | [120] | 279 | [126] |
| 6 | 150 | 11.00 | [279.4] | 20.9 | [530] | 18.50 | [469.9] | 386 | [175] | 401 | [182] |
| 8 | 150 | 13.50 | [342.9] | 23.4 | [594] | 20.50 | [520.7] | 560 | [254] | 575 | [261] |
| 10 | 150 | 16.00 | [406.4] | 25.5 | [648] | 21.25 | [539.8] | 748 | [339] | 763 | [346] |
| 12 | 150 | 19.00 | [482.6] | 28.3 | [718] | 23.25 | [590.6] | 992 | [450] | 1007 | [457] |
| 14 | 150 | 21.00 | [533.4] | 30.0 | [762] | 24.75 | [628.7] | 1205 | [546] | 1220 | [553] |
| 16 | 150 | 23.50 | [596.9] | 32.5 | [826] | 25.75 | [654.1] | 1492 | [677] | 1507 | [684] |
| 18 | 150 | 25.00 | [635.0] | 34.2 | [868] | 27.50 | [698.5] | 1795 | [814] | 1810 | [821] |
| 20 | 150 | 27.50 | [698.5] | 36.4 | [926] | 28.88 | [733.4] | 2144 | [972] | 2159 | [979] |
| 24 | 150 | 32.00 | [812.8] | 40.7 | [1033] | 31.25 | [793.8] | 2908 | [1319] | 2923 | [1326] |
| 26 | 150 | 34.25 | [870.0] | 41.8 | [1062] | 33.80 | [858.5] | 1109 | [503] | 1124 | [510] |
| 28 | 150 | 36.50 | [927.1] | 42.9 | [1091] | 36.40 | [924.6] | 1246 | [565] | 1261 | [572] |
| 30 | 150 | 38.75 | [984.3] | 44.1 | [1119] | 39.00 | [990.6] | 1406 | [638] | 1421 | [644] |
| 32 | 150 | 41.75 | [1060.5] | 45.6 | [1157] | 41.60 | [1056.6] | 1669 | [757] | 1684 | [764] |
| 34 | 150 | 43.75 | [1111.3] | 46.6 | [1183] | 44.20 | [1122.7] | 1796 | [815] | 1811 | [821] |
| 36 | 150 | 46.00 | [1168.4] | 47.7 | [1211] | 46.80 | [1188.7] | 2056 | [933] | 2071 | [940] |
| 4 | 300 | 10.00 | [254.0] | 19.5 | [495] | 17.50 | [444.5] | 291 | [132] | 306 | [139] |
| 6 | 300 | 12.50 | [317.5] | 21.6 | [549] | 19.25 | [489.0] | 427 | [194] | 442 | [200] |
| 8 | 300 | 15.00 | [381.0] | 24.1 | [613] | 21.25 | [539.8] | 615 | [279] | 630 | [286] |
| 10 | 300 | 17.50 | [444.5] | 26.3 | [667] | 22.50 | [571.5] | 833 | [378] | 848 | [385] |
| 12 | 300 | 20.50 | [520.7] | 29.0 | [737] | 24.50 | [622.3] | 1112 | [504] | 1127 | [511] |
| 14 | 300 | 23.00 | [584.2] | 31.0 | [787] | 26.00 | [660.4] | 1373 | [623] | 1388 | [630] |
| 16 | 300 | 25.50 | [647.7] | 33.5 | [851] | 27.25 | [692.2] | 1709 | [775] | 1724 | [782] |
| 18 | 300 | 28.00 | [711.2] | 35.7 | [906] | 29.00 | [736.6] | 2081 | [944] | 2096 | [951] |
| 20 | 300 | 30.50 | [774.7] | 37.9 | [964] | 30.25 | [768.4] | 2476 | [1123] | 2491 | [1130] |
| 24 | 300 | 36.00 | [914.4] | 42.7 | [1084] | 32.50 | [825.5] | 3434 | [1558] | 3449 | [1564] |
| 26 | 300 | 38.25 | [971.6] | 43.8 | [1113] | 33.80 | [858.5] | 1719 | [780] | 1734 | [787] |
| 28 | 300 | 40.75 | [1035.1] | 45.1 | [1145] | 36.40 | [924.6] | 2046 | [928] | 2061 | [935] |
| 30 | 300 | 43.00 | [1092.2] | 46.2 | [1173] | 39.00 | [990.6] | 2346 | [1064] | 2361 | [1071] |
| 32 | 300 | 45.25 | [1149.4] | 47.3 | [1202] | 41.60 | [1056.6] | 2669 | [1211] | 2684 | [1217] |
| 34 | 300 | 47.50 | [1206.5] | 48.4 | [1230] | 44.20 | [1122.7] | 3006 | [1364] | 3021 | [1370] |
| 36 | 300 | 50.00 | [1270.0] | 50.0 | [1270] | 46.80 | [1188.7] | 3326 | [1509] | 3341 | [1516] |

| Pipe Size Inches | Flange | Width "W" | | Height "H" | | Overall Length "OAL" | | Assembled Meter Weight not including Xmtr | | Assembled Meter Weight including Xmtr | |
|---------------------|--------|-----------|----------|------------|--------|----------------------|----------|---|--------|--|--------|
| | | Inches | [mm] | Inches | [mm] | Inches | [mm] | lbs | [kg] | lbs | [kg] |
| 4 | 600 | 10.75 | [273.1] | 19.9 | [505] | 19.25 | [489.0] | 328 | [149] | 343 | [156] |
| 6 | 600 | 14.00 | [355.6] | 22.4 | [568] | 21.25 | [539.8] | 508 | [231] | 523 | [237] |
| 8 | 600 | 16.50 | [419.1] | 24.9 | [632] | 23.50 | [596.9] | 741 | [336] | 756 | [343] |
| 10 | 600 | 20.00 | [508.0] | 27.5 | [699] | 25.75 | [654.1] | 1075 | [487] | 1090 | [494] |
| 12 | 600 | 22.00 | [558.8] | 29.8 | [756] | 27.00 | [685.8] | 1379 | [625] | 1394 | [632] |
| 14 | 600 | 23.75 | [603.3] | 31.4 | [797] | 28.25 | [717.6] | 1656 | [751] | 1671 | [758] |
| 16 | 600 | 27.00 | [685.8] | 34.3 | [870] | 30.25 | [768.4] | 2180 | [989] | 2195 | [995] |
| 18 | 600 | 29.25 | [743.0] | 36.3 | [922] | 31.50 | [800.1] | 2663 | [1208] | 2678 | [1215] |
| 20 | 600 | 32.00 | [812.8] | 38.7 | [983] | 33.00 | [838.2] | 3272 | [1484] | 3287 | [1491] |
| 24 | 600 | 37.00 | [939.8] | 43.2 | [1097] | 35.75 | [908.1] | 4634 | [2102] | 4649 | [2109] |
| 26 | 600 | 40.00 | [1016.0] | 44.7 | [1135] | 33.80 | [858.5] | 2432 | [1103] | 2447 | [1110] |
| 28 | 600 | 42.25 | [1073.2] | 45.8 | [1164] | 36.40 | [924.6] | 2726 | [1236] | 2741 | [1243] |
| 30 | 600 | 44.50 | [1130.3] | 46.9 | [1192] | 39.00 | [990.6] | 3083 | [1399] | 3098 | [1405] |
| 32 | 600 | 47.00 | [1193.8] | 48.2 | [1224] | 41.60 | [1056.6] | 3475 | [1576] | 3490 | [1583] |
| 34 | 600 | 49.00 | [1244.6] | 49.2 | [1249] | 44.20 | [1122.7] | 3870 | [1756] | 3885 | [1762] |
| 36 | 600 | 51.75 | [1314.5] | 51.8 | [1314] | 46.80 | [1188.7] | 4270 | [1937] | 4285 | [1944] |
| 4 | 900 | 11.50 | [292.1] | 20.3 | [514] | 20.25 | [514.4] | 362 | [164] | 377 | [171] |
| 6 | 900 | 15.00 | [381.0] | 22.9 | [581] | 23.00 | [584.2] | 586 | [266] | 601 | [272] |
| 8 | 900 | 18.50 | [469.9] | 25.9 | [657] | 25.75 | [654.1] | 913 | [414] | 928 | [421] |
| 10 | 900 | 21.50 | [546.1] | 28.3 | [718] | 28.25 | [717.6] | 1290 | [585] | 1305 | [592] |
| 12 | 900 | 24.00 | [609.6] | 30.8 | [781] | 30.50 | [774.7] | 1740 | [789] | 1755 | [796] |
| 14 | 900 | 25.25 | [641.4] | 32.1 | [816] | 32.00 | [812.8] | 2068 | [938] | 2083 | [945] |
| 16 | 900 | 27.75 | [704.9] | 34.6 | [879] | 33.25 | [844.6] | 2581 | [1171] | 2596 | [1178] |
| 18 | 900 | 31.00 | [787.4] | 37.2 | [945] | 35.00 | [889.0] | 3350 | [1520] | 3365 | [1526] |
| 20 | 900 | 33.75 | [857.3] | 39.6 | [1005] | 37.50 | [952.5] | 4129 | [1873] | 4144 | [1879] |
| 24 | 900 | 41.00 | [1041.4] | 45.2 | [1148] | 42.75 | [1085.9] | 6750 | [3062] | 6765 | [3069] |
| 26 | 900 | 42.75 | [1085.9] | 46.1 | [1170] | 33.80 | [858.5] | 2482 | [1126] | 2497 | [1133] |
| 28 | 900 | 46.00 | [1168.4] | 47.7 | [1211] | 36.40 | [924.6] | 2784 | [1263] | 2799 | [1270] |
| 30 | 900 | 48.50 | [1231.9] | 48.9 | [1243] | 39.00 | [990.6] | 3150 | [1429] | 3165 | [1436] |
| 32 | 900 | 51.75 | [1314.5] | 51.8 | [1314] | 41.60 | [1056.6] | 3551 | [1611] | 3566 | [1617] |
| 34 | 900 | 55.00 | [1397.0] | 55.0 | [1397] | 44.20 | [1122.7] | 3956 | [1794] | 3971 | [1801] |
| 36 | 900 | 57.50 | [1460.5] | 57.5 | [1461] | 46.80 | [1188.7] | 4366 | [1980] | 4381 | [1987] |

| Pipe Size Inches | Flange | Width "W" | | Height "H" | | Overall Length "OAL" | | Assembled Meter Weight not including Xmtr | | Assembled Meter Weight including Xmtr | |
|---------------------|--------|-----------|----------|------------|--------|----------------------|----------|---|--------|--|--------|
| | | Inches | [mm] | Inches | [mm] | Inches | [mm] | lbs | [kg] | lbs | [kg] |
| 4 | 1500 | 12.25 | [311.2] | 20.6 | [524] | 21.00 | [533.4] | 404 | [183] | 419 | [190] |
| 6 | 1500 | 15.50 | [393.7] | 23.1 | [587] | 25.50 | [647.7] | 720 | [326] | 735 | [333] |
| 8 | 1500 | 19.00 | [482.6] | 26.1 | [664] | 29.75 | [755.7] | 1139 | [517] | 1154 | [524] |
| 10 | 1500 | 23.00 | [584.2] | 29.0 | [737] | 33.75 | [857.3] | 1784 | [809] | 1799 | [816] |
| 12 | 1500 | 26.50 | [673.1] | 32.0 | [813] | 37.00 | [939.8] | 2591 | [1175] | 2606 | [1182] |
| 14 | 1500 | 29.50 | [749.3] | 34.3 | [870] | 38.75 | [984.3] | 3302 | [1498] | 3317 | [1505] |
| 16 | 1500 | 32.50 | [825.5] | 37.0 | [940] | 40.75 | [1035.1] | 4263 | [1934] | 4278 | [1940] |
| 18 | 1500 | 36.00 | [914.4] | 39.7 | [1008] | 42.75 | [1085.9] | 5480 | [2486] | 5495 | [2493] |
| 20 | 1500 | 38.75 | [984.3] | 42.1 | [1068] | 46.00 | [1168.4] | 6789 | [3079] | 6804 | [3086] |
| 24 | 1500 | 46.00 | [1168.4] | 47.7 | [1211] | 51.75 | [1314.5] | 10470 | [4749] | 10485 | [4756] |

Table 1.4: Dimensions and Weights for LEFM 380Ci Meter Body – 3 Diameter Long Version Note: Note: Dimensions are subject to change (actual dimensions may be project specific).
 Unless project specific dimensions are given, the tolerances for the following table are ± 1.0 inches [25.4 mm] and $\pm 15\%$ in weight. All flanges are based on ASME B16.5 dimensions.

| Pipe Size Inches | Flange | Width "W" | | Height "H" | | Overall Length "OAL" | | Assembled Meter Weight not including Xmtr | | Assembled Meter Weight including Xmtr | |
|------------------|--------|-----------|----------|------------|--------|----------------------|----------|---|--------|---------------------------------------|--------|
| | | Inches | [mm] | Inches | [mm] | Inches | [mm] | lbs | [kg] | lbs | [kg] |
| 4 | 150 | 10.75 | [273.1] | 18.8 | [476] | 16.75 | [425.5] | 459 | [208] | 474 | [215] |
| 6 | 150 | 11.00 | [279.4] | 20.9 | [530] | 17.72 | [450.0] | 381 | [173] | 396 | [180] |
| 8 | 150 | 13.50 | [342.9] | 23.4 | [594] | 23.62 | [600.0] | 588 | [267] | 603 | [274] |
| 10 | 150 | 16.00 | [406.4] | 25.5 | [648] | 29.53 | [750.0] | 850 | [386] | 865 | [393] |
| 12 | 150 | 19.00 | [482.6] | 28.3 | [718] | 35.43 | [900.0] | 1172 | [531] | 1187 | [538] |
| 14 | 150 | 21.00 | [533.4] | 30.0 | [762] | 41.34 | [1050.0] | 1501 | [681] | 1516 | [688] |
| 16 | 150 | 23.50 | [596.9] | 32.5 | [826] | 47.24 | [1200.0] | 1929 | [875] | 1944 | [882] |
| 18 | 150 | 25.00 | [635.0] | 34.2 | [868] | 53.15 | [1350.0] | 2408 | [1092] | 2423 | [1099] |
| 20 | 150 | 27.50 | [698.5] | 36.4 | [926] | 59.06 | [1500.0] | 2942 | [1334] | 2957 | [1341] |
| 24 | 150 | 44.09 | [812.8] | 46.7 | [1033] | 70.87 | [1800.0] | 4158 | [1886] | 4173 | [1893] |
| 26 | 150 | 34.25 | [870.0] | 41.8 | [1062] | 76.77 | [1950.0] | 1920 | [871] | 1935 | [877] |
| 28 | 150 | 36.50 | [927.1] | 42.9 | [1091] | 82.68 | [2100.0] | 2187 | [992] | 2202 | [998] |
| 30 | 150 | 38.75 | [984.3] | 44.1 | [1119] | 88.58 | [2250.0] | 2487 | [1128] | 2502 | [1135] |
| 32 | 150 | 41.75 | [1060.5] | 45.6 | [1157] | 94.49 | [2400.0] | 2900 | [1315] | 2915 | [1322] |
| 34 | 150 | 43.75 | [1111.3] | 46.6 | [1183] | 100.39 | [2550.0] | 3187 | [1445] | 3202 | [1452] |
| 36 | 150 | 46.00 | [1168.4] | 47.7 | [1211] | 106.30 | [2700.0] | 3617 | [1640] | 3632 | [1647] |
| 4 | 300 | 10.75 | [273.1] | 19.3 | [489] | 17.50 | [444.5] | 470 | [213] | 485 | [220] |
| 6 | 300 | 12.50 | [317.5] | 21.6 | [549] | 17.72 | [450.0] | 416 | [189] | 431 | [196] |
| 8 | 300 | 15.00 | [381.0] | 24.1 | [613] | 23.62 | [600.0] | 637 | [289] | 652 | [296] |
| 10 | 300 | 17.50 | [444.5] | 26.3 | [667] | 29.53 | [750.0] | 920 | [417] | 935 | [424] |
| 12 | 300 | 20.50 | [520.7] | 29.0 | [737] | 35.43 | [900.0] | 1273 | [578] | 1288 | [584] |
| 14 | 300 | 23.00 | [584.2] | 31.0 | [787] | 41.34 | [1050.0] | 1647 | [747] | 1662 | [754] |
| 16 | 300 | 25.50 | [647.7] | 33.5 | [851] | 47.24 | [1200.0] | 2116 | [960] | 2131 | [966] |
| 18 | 300 | 28.00 | [711.2] | 35.7 | [906] | 53.15 | [1350.0] | 2658 | [1205] | 2673 | [1212] |
| 20 | 300 | 30.50 | [774.7] | 37.9 | [964] | 59.06 | [1500.0] | 3237 | [1468] | 3252 | [1475] |
| 24 | 300 | 36.00 | [914.4] | 42.7 | [1084] | 70.87 | [1800.0] | 4644 | [2107] | 4659 | [2113] |
| 26 | 300 | 38.25 | [971.6] | 43.8 | [1113] | 76.77 | [1950.0] | 2530 | [1147] | 2545 | [1154] |
| 28 | 300 | 40.75 | [1035.1] | 45.1 | [1145] | 82.68 | [2100.0] | 2987 | [1355] | 3002 | [1361] |
| 30 | 300 | 43.00 | [1092.2] | 46.2 | [1173] | 88.58 | [2250.0] | 3427 | [1554] | 3442 | [1561] |
| 32 | 300 | 45.25 | [1149.4] | 47.3 | [1202] | 94.49 | [2400.0] | 3900 | [1769] | 3915 | [1776] |
| 34 | 300 | 47.50 | [1206.5] | 48.4 | [1230] | 100.39 | [2550.0] | 4397 | [1994] | 4412 | [2001] |
| 36 | 300 | 50.00 | [1270.0] | 50.0 | [1270] | 106.30 | [2700.0] | 4887 | [2216] | 4902 | [2223] |

| Pipe Size Inches | Flange | Width "W" | | Height "H" | | Overall Length "OAL" | | Assembled Meter Weight not including Xmtr | | Assembled Meter Weight including Xmtr | |
|------------------|--------|-----------|----------|------------|--------|----------------------|----------|---|--------|---------------------------------------|--------|
| | | Inches | [mm] | Inches | [mm] | Inches | [mm] | lbs | [kg] | lbs | [kg] |
| 4 | 600 | 10.75 | [273.1] | 19.6 | [498] | 19.25 | [489.0] | 488 | [221] | 503 | [228] |
| 6 | 600 | 14.00 | [355.6] | 22.4 | [568] | 17.72 | [450.0] | 481 | [218] | 496 | [225] |
| 8 | 600 | 16.50 | [419.1] | 24.9 | [632] | 23.62 | [600.0] | 743 | [337] | 758 | [344] |
| 10 | 600 | 20.00 | [508.0] | 27.5 | [699] | 29.53 | [750.0] | 1129 | [512] | 1144 | [519] |
| 12 | 600 | 22.00 | [558.8] | 29.8 | [756] | 35.43 | [900.0] | 1530 | [694] | 1545 | [701] |
| 14 | 600 | 23.75 | [603.3] | 31.4 | [797] | 41.34 | [1050.0] | 1946 | [883] | 1961 | [889] |
| 16 | 600 | 27.00 | [685.8] | 34.3 | [870] | 47.24 | [1200.0] | 2630 | [1193] | 2645 | [1200] |
| 18 | 600 | 29.25 | [743.0] | 36.3 | [922] | 53.15 | [1350.0] | 3361 | [1524] | 3376 | [1531] |
| 20 | 600 | 32.00 | [812.8] | 38.7 | [983] | 59.06 | [1500.0] | 4244 | [1925] | 4259 | [1932] |
| 24 | 600 | 37.00 | [939.8] | 43.2 | [1097] | 70.87 | [1800.0] | 6332 | [2872] | 6347 | [2879] |
| 26 | 600 | 40.00 | [1016.0] | 44.7 | [1135] | 76.77 | [1950.0] | 3365 | [1526] | 3380 | [1533] |
| 28 | 600 | 42.25 | [1073.2] | 45.8 | [1164] | 82.68 | [2100.0] | 3808 | [1727] | 3823 | [1734] |
| 30 | 600 | 44.50 | [1130.3] | 46.9 | [1192] | 88.58 | [2250.0] | 4327 | [1962] | 4342 | [1969] |
| 32 | 600 | 47.00 | [1193.8] | 48.2 | [1224] | 94.49 | [2400.0] | 4891 | [2218] | 4906 | [2225] |
| 34 | 600 | 49.00 | [1244.6] | 49.2 | [1249] | 100.39 | [2550.0] | 5470 | [2481] | 5485 | [2488] |
| 36 | 600 | 51.75 | [1314.5] | 51.8 | [1314] | 106.30 | [2700.0] | 6065 | [2750] | 6080 | [2757] |
| 4 | 900 | 11.50 | [292.1] | 20.0 | [508] | 20.25 | [514.4] | 507 | [230] | 522 | [237] |
| 6 | 900 | 15.00 | [381.0] | 22.9 | [581] | 17.72 | [450.0] | 541 | [246] | 556 | [252] |
| 8 | 900 | 18.50 | [469.9] | 25.9 | [657] | 23.62 | [600.0] | 887 | [403] | 902 | [409] |
| 10 | 900 | 21.50 | [546.1] | 28.3 | [718] | 29.53 | [750.0] | 1311 | [595] | 1326 | [602] |
| 12 | 900 | 24.00 | [609.6] | 30.8 | [781] | 35.43 | [900.0] | 1844 | [837] | 1859 | [843] |
| 14 | 900 | 25.25 | [641.4] | 32.1 | [816] | 41.34 | [1050.0] | 2310 | [1048] | 2325 | [1055] |
| 16 | 900 | 27.75 | [704.9] | 34.6 | [879] | 47.24 | [1200.0] | 3017 | [1368] | 3032 | [1375] |
| 18 | 900 | 31.00 | [787.4] | 37.2 | [945] | 53.15 | [1350.0] | 4046 | [1835] | 4061 | [1842] |
| 20 | 900 | 33.75 | [857.3] | 39.6 | [1005] | 59.06 | [1500.0] | 5089 | [2308] | 5104 | [2315] |
| 24 | 900 | 41.00 | [1041.4] | 45.2 | [1148] | 70.87 | [1800.0] | 8421 | [3820] | 8436 | [3827] |
| 26 | 900 | 42.75 | [1085.9] | 46.06 | [1170] | 76.77 | [1950.0] | 3554 | [1612] | 3569 | [1619] |
| 28 | 900 | 46.00 | [1168.4] | 47.69 | [1211] | 82.68 | [2100.0] | 4029 | [1827] | 4044 | [1834] |
| 30 | 900 | 48.50 | [1231.9] | 48.94 | [1243] | 88.58 | [2250.0] | 4580 | [2077] | 4595 | [2084] |
| 32 | 900 | 51.75 | [1314.5] | 51.75 | [1314] | 94.49 | [2400.0] | 5179 | [2349] | 5194 | [2356] |
| 34 | 900 | 55.00 | [1397.0] | 55.00 | [1397] | 100.39 | [2550.0] | 5796 | [2628] | 5811 | [2635] |
| 36 | 900 | 57.50 | [1460.5] | 57.50 | [1461] | 106.30 | [2700.0] | 6430 | [2916] | 6445 | [2923] |

Section 2

Meter Body Installation – Models 380Ci & 380Ci-R

The LEFM 380Ci 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 analysis, 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 380Ci). [Section 3](#) addresses the case where the transmitter is mounted at a separate location, typically due to extreme environmental reasons (for example, high or low pipe temperatures). Remote mounting of the electronics is for Model 380Ci-R.

Flow Meter Body Installation – Best Practices



The weights of the flow meter body are listed in Tables 1.4. 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.



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 accumulating in the sensor wells.
- A flow arrow indicates the flow direction for positive flow.
- All wiring to the transmitter is routed in shielded conduit / armored cable that meets site environment specifications.
- For all sizes greater than 4-inch, upstream of the meter there should be at least 5 diameters of straight pipe of the same nominal diameter as the meter. If a straightening/conditioning element is used 10 diameters of straight pipe between the conditioner and flowmeter are recommended with an additional 5 diameters upstream of the flow conditioner. Downstream of the meter, there should be at least 3 diameters of straight pipe of the same nominal diameter as the meter.
- For all the 4-inch meter size, upstream of the meter it is recommended that there be a straightening/conditioning element with 10 diameters of straight pipe between the conditioner and flowmeter with an additional 5 diameters upstream of the flow conditioner. 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. Downstream of the meter, there should be at least 3 diameters of straight pipe of the same nominal diameter as the meter.
- Process temperature and pressure should be measured within 3 diameters downstream of the meter. The pressure measurement may be made at the downstream spool ahead of the temperature measurement or optionally at the meter body itself.

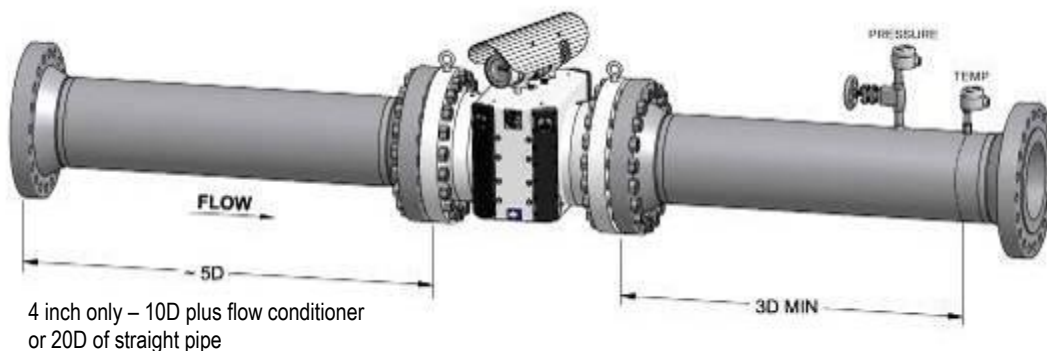


Figure 2.1: Best Practice for Installation Hydraulics

- By following the recommended installation practices detailed below, the LEFM 380Ci has been approved by NMi (certificate number T10504 pipe sizes 6 inches to 32 inches) for the

published flow rates to meet the performance requirements of OIML R137 Class 0.5 and ISO 17089 Class 1.

- The accuracy specifications for the meter following calibration are as follows:

Linearized meter factor less than or equal to +/- 0.1% of measured value relative to calibration facility (between Q_t and Q_{max})

Linearized meter factor less than or equal to +/- 0.2% of measured value relative to calibration facility (between Q_t and Q_{min})

Note that these accuracy statements extend to $Q_{overrange}$ if the meter was calibrated at the higher flow rates.

| Pipe Size Inches | DN | Q_{max} | $Q_{overrange}$ | Q_t | Q_{min} | Q_{max} (m ³ /hr) | $Q_{overrange}$ | Q_t | Q_{min} |
|---------------------|-----|-----------|-----------------|---------|-----------|--------------------------------|----------------------|----------------------|----------------------|
| | | (cfh) | (cfh) | (cfh) | (cfh) | (m ³ /hr) | (m ³ /hr) | (m ³ /hr) | (m ³ /hr) |
| 4 | 100 | 28,700 | 34,440 | 2,870 | 574 | 813 | 975 | 81 | 16 |
| 6 | 150 | 65,200 | 78,240 | 6,520 | 1,304 | 1,850 | 2,216 | 185 | 37 |
| 8 | 200 | 114,000 | 136,800 | 11,400 | 2,280 | 3,230 | 3,874 | 323 | 65 |
| 10 | 250 | 180,000 | 216,000 | 18,000 | 3,600 | 5,100 | 6,116 | 510 | 102 |
| 12 | 300 | 254,000 | 304,800 | 25,400 | 5,080 | 7,190 | 8,631 | 719 | 144 |
| 14 | 350 | 307,000 | 368,400 | 30,700 | 6,140 | 8,690 | 10,432 | 869 | 174 |
| 16 | 400 | 402,000 | 482,400 | 40,200 | 8,040 | 11,400 | 13,660 | 1,138 | 228 |
| 18 | 450 | 510,000 | 612,000 | 51,000 | 10,200 | 14,400 | 17,330 | 1,444 | 289 |
| 20 | 500 | 632,000 | 758,400 | 63,200 | 12,640 | 17,900 | 21,475 | 1,790 | 358 |
| 24 | 600 | 913,000 | 1,095,600 | 91,300 | 18,260 | 25,900 | 31,024 | 2,585 | 517 |
| 26 | 650 | 1,203,000 | 1,443,600 | 120,300 | 24,060 | 34,100 | 40,878 | 3,407 | 681 |
| 28 | 700 | 1,405,000 | 1,686,000 | 140,500 | 28,100 | 39,800 | 47,742 | 3,979 | 796 |
| 30 | 750 | 1,623,000 | 1,947,600 | 162,300 | 32,460 | 46,000 | 55,150 | 4,596 | 919 |
| 32 | 800 | 1,857,000 | 2,228,400 | 185,700 | 37,140 | 52,600 | 63,101 | 5,258 | 1,052 |
| 34 | 850 | 2,106,000 | 2,527,200 | 210,600 | 42,120 | 59,600 | 71,562 | 5,964 | 1,193 |
| 36 | 900 | 2,371,000 | 2,845,200 | 237,100 | 47,420 | 67,100 | 80,567 | 6,714 | 1,343 |

For pipe sizes 6 inches and larger – Upstream Condition Requirements

To meet the requirements of the Measurement Instruments Directive (Directive 2004/22/EC) and OIML R-137 one of the following installation configurations must be used:

Inlet piping configuration No. 1: 5D

Measuring installations using the LEFM 380Ci with 5 diameters or more of straight pipe upstream (without a flow conditioner) and 3 diameters downstream are suitable for accuracy class 0.5 and accuracy class 1.0 in piping arrangements that cause only mild disturbances excluding expanders where the upstream pipe is smaller than the meter diameter. Examples of permitted pipe arrangements upstream of the 5 diameters are bends, tees and reducers, including single bends and out-of-plane combinations.

Inlet piping configuration No. 2: 10D

Measuring installations using the LEFM 380Ci with 10 diameters or more of straight pipe upstream (without a flow conditioner) and 3 diameters downstream are suitable for accuracy class 0.5 and accuracy class 1.0 in piping arrangements that cause only mild disturbances

including expanders where the upstream pipe is smaller than the meter diameter. Examples of permitted pipe arrangements upstream of the 10 diameters are bends, tees, expanders, and reducers, including single bends and out-of-plane combinations.

Inlet piping configuration No. 3: 15D

Measuring installations using the LEFM 380Ci with 15 diameters or more of straight pipe upstream (without a flow conditioner) and 3 diameters downstream are suitable for accuracy class 1.0 in piping arrangements that cause severe disturbances including combinations of out-of-plane bends in combination with partial blockage of the pipe. An example of a severe disturbance would be a 50% open gate valve installed between out-of-plane bends.

Inlet piping configuration No. 4: 15D inclusive of a flow conditioner

Measuring installations using the LEFM 380Ci with 15 diameters or more of straight pipe upstream inclusive of a flow conditioner with its inlet located 10 diameters from the meter, and with 3 diameters downstream are suitable for accuracy class 0.5 and accuracy class 1.0 in piping arrangements that cause severe disturbances including combinations of out-of-plane bends in combination with partial blockage of the pipe. An example of a severe disturbance would be a 50% open gate valve installed between out-of-plane bends.

For all of the above configurations the internal diameter of the pipe sections must be the same as the inlet and outlet diameter of the meter. The pipe sections shall be considered identical if their diameters differ by no more than 3%. For unidirectional flow, the temperature sensor well should be installed downstream of the meter. The distance from the downstream flange face to the temperature sensor well should be between 2 and 5 internal diameters. For bi-directional flow installations, temperature sensor well should be located at between 3 and 5 diameters from the flange of the meter.

Uncalibrated Meters

Some customers may request to have a meter delivered without calibration. In these instances, it is expected that the general performance requirements of AGA 9 and ISO17089 (Class 1) will apply as per the table below:

| Pipe Sizes | Flows between Q_t and Q_{max} | | Flows between Q_{min} and Q_t | |
|---------------|-----------------------------------|------------------------|-----------------------------------|------------------------|
| | Maximum (Permissible) Error | Max Peak to Peak Error | Maximum (Permissible) Error | Max Peak to Peak Error |
| 4 to 10 NPS | +/-1.0% | 1.0% | +/-1.4% | 1.4% |
| 12 and larger | +/-0.7% | 0.7% | +/-1.4% | 1.4% |

Section 3

Installing Transmitter Remote from Meter Body – Model 380Ci-R



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. Each transmitter's serial number should match the meter serial number on its meter body.



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 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) of the meter body. For distances further than 100 meters, contact Cameron.

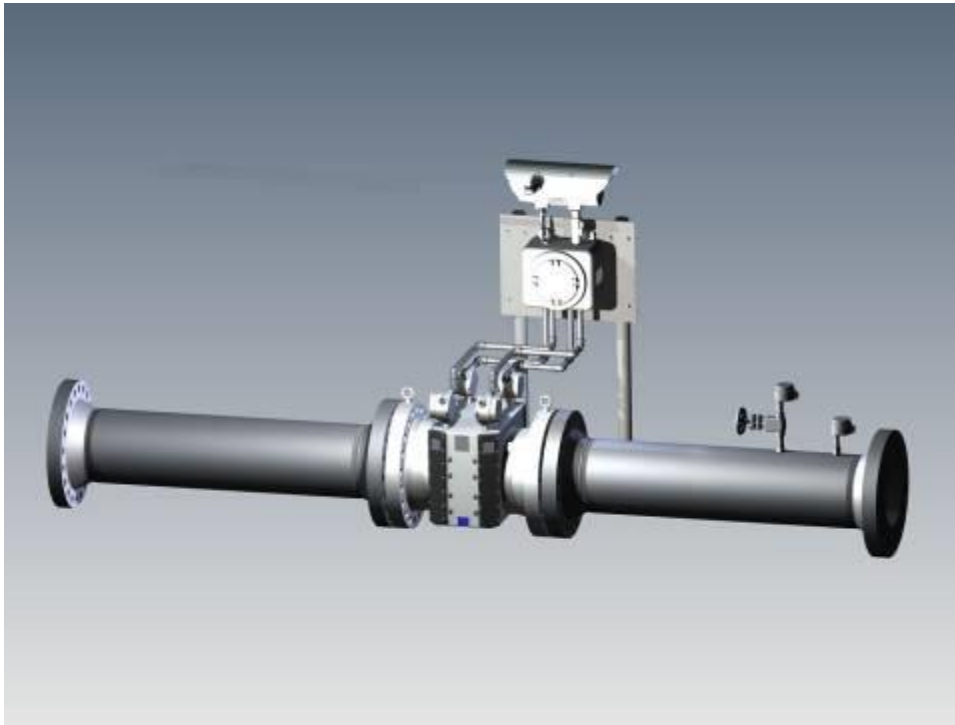


Figure 3.1: Remote Installation of Transmitter from Meter Body

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 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 5](#), "Transmitter Installation Procedure".

Meter Body to Transmitter Terminations



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. 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.
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 Table 3.1.

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.

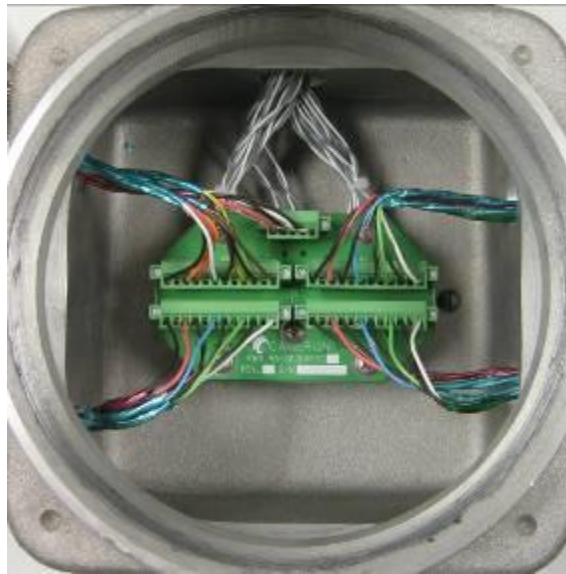


Figure 3.2: Remote Mount Junction Box Terminations at the Transmitter (Typical)

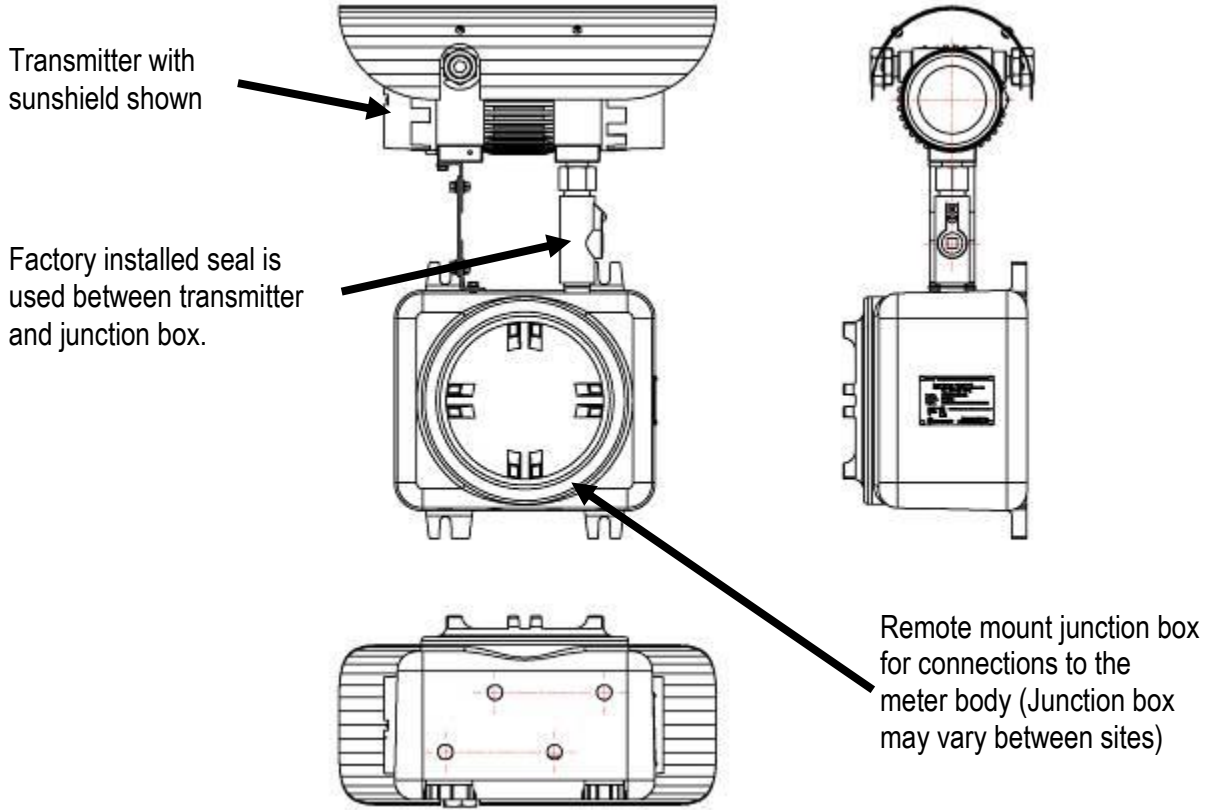


Figure 3.3: Remote Installation of Transmitter/Junction Box

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 380Ci-R Transducer and RTD Terminations
 (Note: On the LEFM380Ci-R 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 | 1 |
| | Shield | TB1 | 14 | | — |
| | - | TB1 | 15 | | 2 |
| 2 DN | + | TB1 | 16 | 1B Downstream JBOX-TB1 | 3 |
| | Shield | TB1 | 17 | | — |
| | - | TB1 | 18 | | 4 |
| 3 DN | + | TB1 | 19 | 1B Downstream JBOX-TB1 | 5 |
| | Shield | TB1 | 20 | | — |
| | - | TB1 | 21 | | 6 |
| 4 DN | + | TB1 | 22 | 1B Downstream JBOX-TB1 | 7 |
| | Shield | TB1 | 23 | | — |
| | - | TB1 | 24 | | 8 |
| RTD | RTD+ | TB3 | 1 | 1B Upstream JBOX-TB3 | 9 |
| | RTD+ | TB3 | 3 | | 10 |
| | Shield | TB3 | 5 | | — |
| | RTD- | TB3 | 2 | | 11 |
| | RTD- | TB3 | 4 | | 12 |
| 5 UP | + | TB2 | 1 | 2A Upstream JBOX-TB1 | 1 |
| | Shield | TB2 | 2 | | — |
| | - | TB2 | 3 | | 2 |
| 6 UP | + | TB2 | 4 | 2A Upstream JBOX-TB1 | 3 |
| | Shield | TB2 | 5 | | — |
| | - | TB2 | 6 | | 4 |
| 7 UP | + | TB2 | 7 | 2A Upstream JBOX-TB1 | 5 |
| | Shield | TB2 | 8 | | — |
| | - | TB2 | 9 | | 6 |
| 8 UP | + | TB2 | 10 | 2A Upstream JBOX-TB1 | 7 |
| | Shield | TB2 | 11 | | — |
| | - | TB2 | 12 | | 8 |
| 5 DN | + | TB2 | 13 | 2B Downstream JBOX-TB1 | 1 |
| | Shield | TB2 | 14 | | — |
| | - | TB2 | 15 | | 2 |

| 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 | 3 |
| | Shield | TB2 | 17 | | — |
| | - | TB2 | 18 | | 4 |
| 7 DN | + | TB2 | 19 | 2B Downstream JBOX-TB1 | 5 |
| | Shield | TB2 | 20 | | — |
| | - | TB2 | 21 | | 6 |
| 8 DN | + | TB2 | 22 | 2B Downstream JBOX-TB1 | 7 |
| | Shield | TB2 | 23 | | — |
| | - | TB2 | 24 | | 8 |

To test or validate a meter's installation, perform the procedures in [Section 5](#). For troubleshooting information, see [Section 9](#) of this manual.

Remote-Mount Transmitter Installation Procedure

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.

For installation, simply uncrate the delivered transmitter (please note the weight of your transmitter in Section 1.0 for proper handling. Use the indicated mounting points for mounting the units. Select bolts/hardware appropriate for the unit's weight. Consider seismic requirements.

- Use ½ inch bolts/hardware (or equal) on all mounting points for the explosion proof (NEMA 7) transmitter. Cover bolts are metric (M12 x 1.75 x 50 mm) (use 19 mm socket/wrench).

Transmitters should be mounted at a convenient working height. (The recommended height is the bottom of the transmitter at about 4 feet (1.2 meters) from the floor.) While an installation in direct sun is acceptable, an installation in the shade will increase the life of all components.

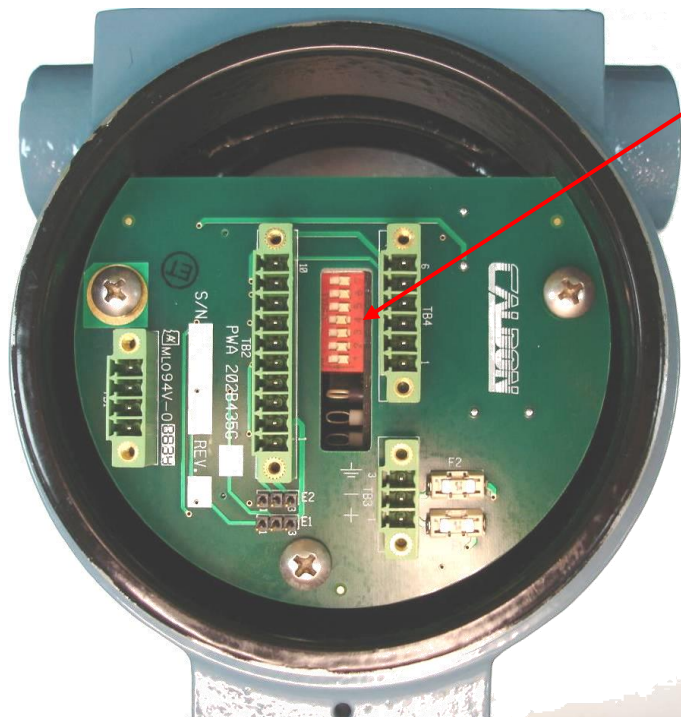
Section 4

LEFM 380Ci and 380Ci-R Metrological Seals



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 380Ci 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 4.1 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 through 6 inclusive have to be in the "closed" position (to the left), dipswitches 7 through 9 inclusive have to be in the "open" position (to the right).

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

Figure 4.1

Figure 4.2 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.

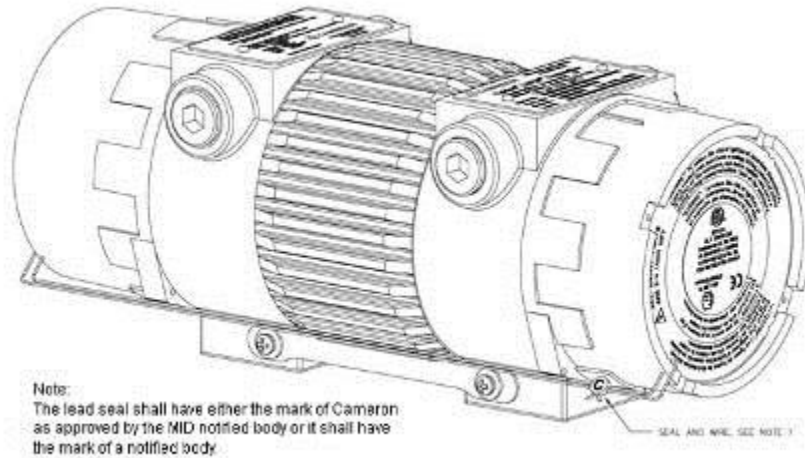


Figure 4.2: Seal Wire on Electronic Unit

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 4.3).

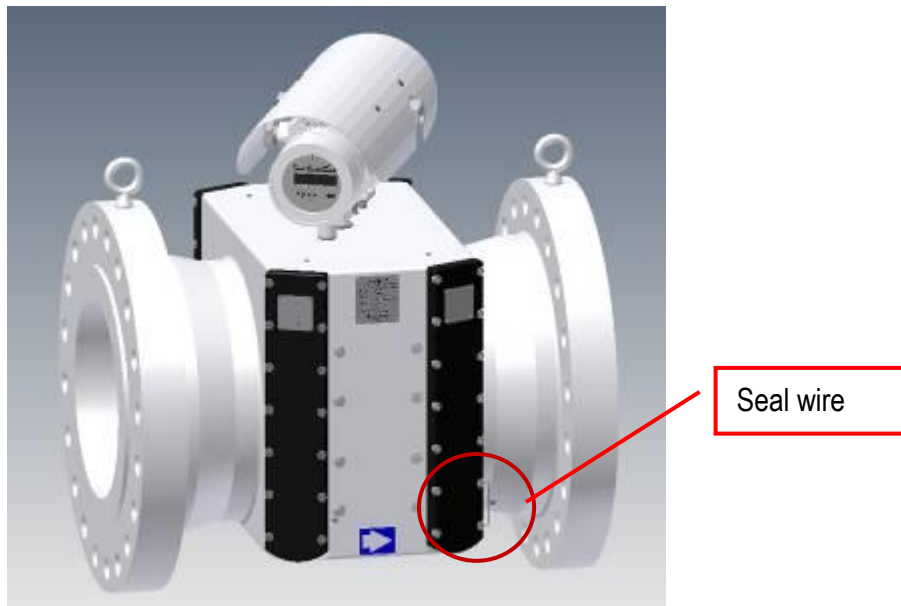


Figure 4.3: Seal Wire on Meter Body

Finally, the remote mount configuration, as shown in Figure 4.4, also has seal wires for all the junction boxes used in the system.

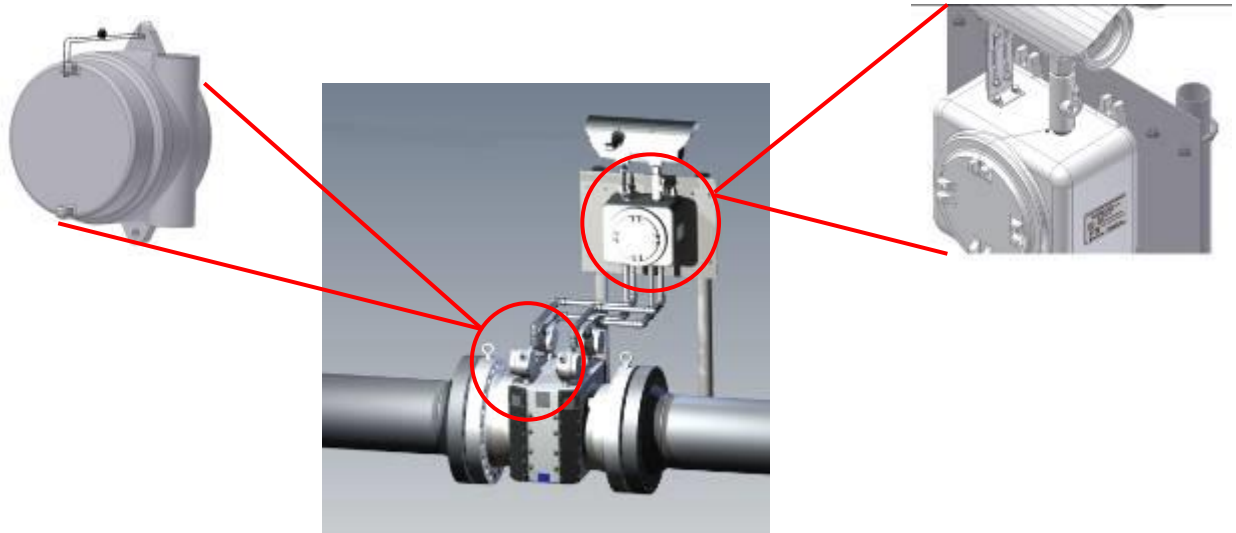


Figure 4.4: Seal Wire on J-Boxes

Section 5

Transmitter Connections – All Models



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.

Note All wiring to and from the transmitter must be routed through grounded metal conduit or equivalent.

Transmitter Location

To ensure that the proper supply voltage reaches the transmitter, the distance between the transmitter and its power source must be less than that given in the below table (based on the wire gage used):

| Wire Gage | Max Distance (Meters) | Max Distance (Feet) |
|-----------|-----------------------|---------------------|
| 12 | 564.6 | 1852.4 |
| 14 | 354.6 | 1163.4 |
| 16 | 223.8 | 734.3 |
| 18 | 140.4 | 460.6 |
| 20 | 88.2 | 289.4 |
| 22 | 55.4 | 181.9 |
| 24 | 34.9 | 114.6 |

Transmitter Terminations

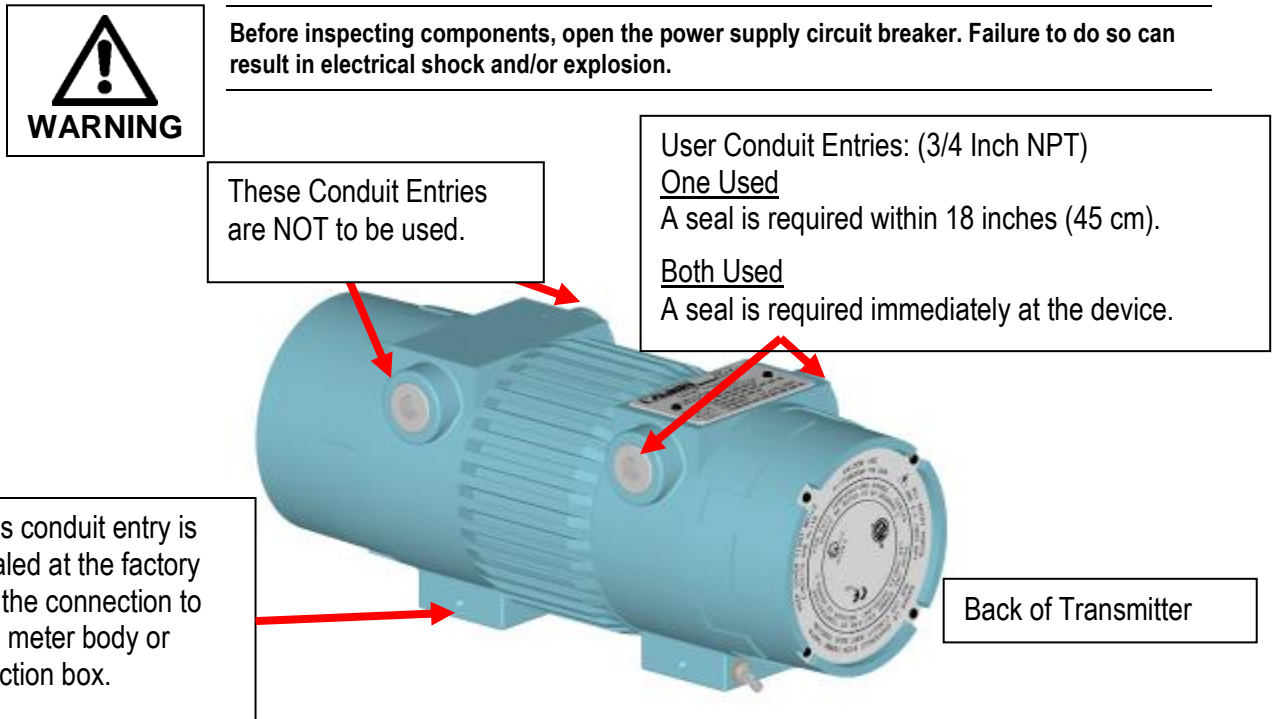


Figure 5.0.1: Fully Assembled Transmitter – Rear View

The two conduit entries (3/4 inch NPT) 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.

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 5.2, and 5.3).

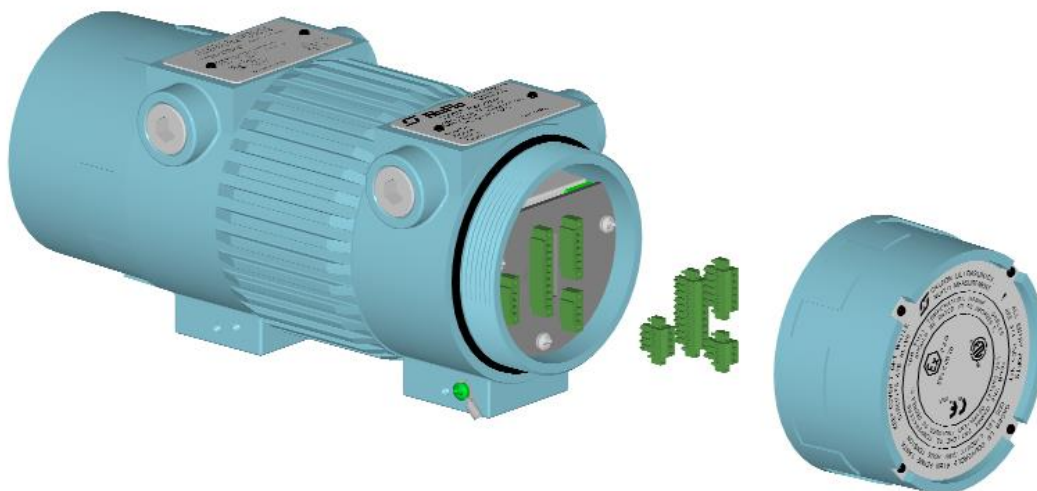


Figure 5.0.2: Transmitter with Rear Cover Removed

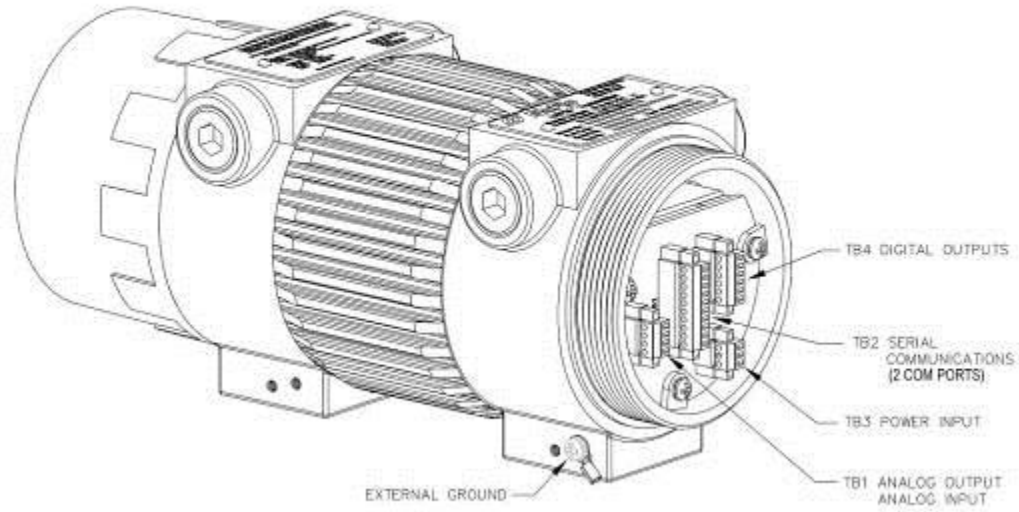


Figure 5.0.3: User Terminations - Cover Off

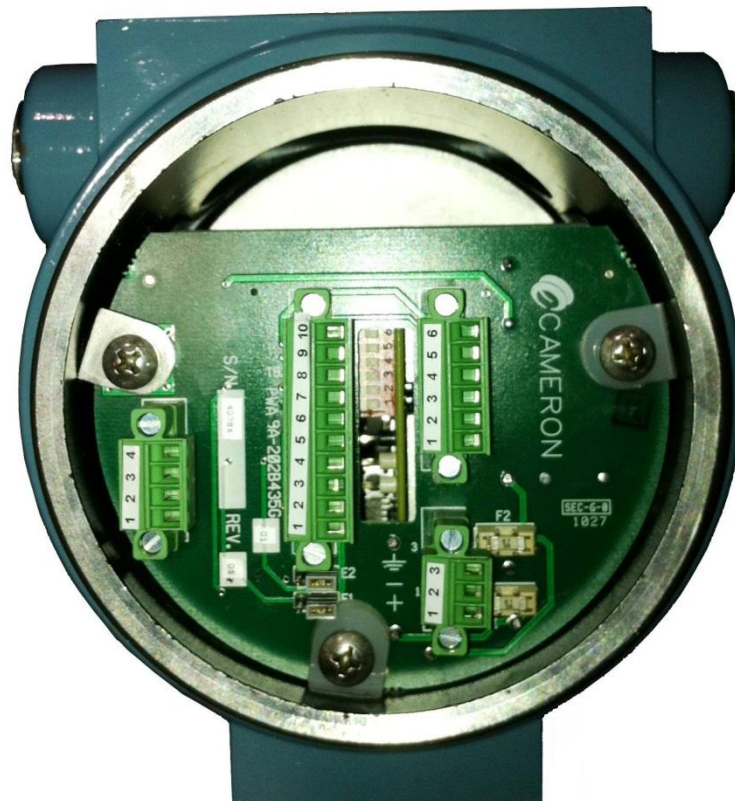


Figure 5.4: User Terminations, Close Up

Figures 5.3 and 5.4 show the location of the transmitter terminations. Inside the rear cover of the transmitter, there is a diagram of the user connections. A schematic of the terminations is shown below.

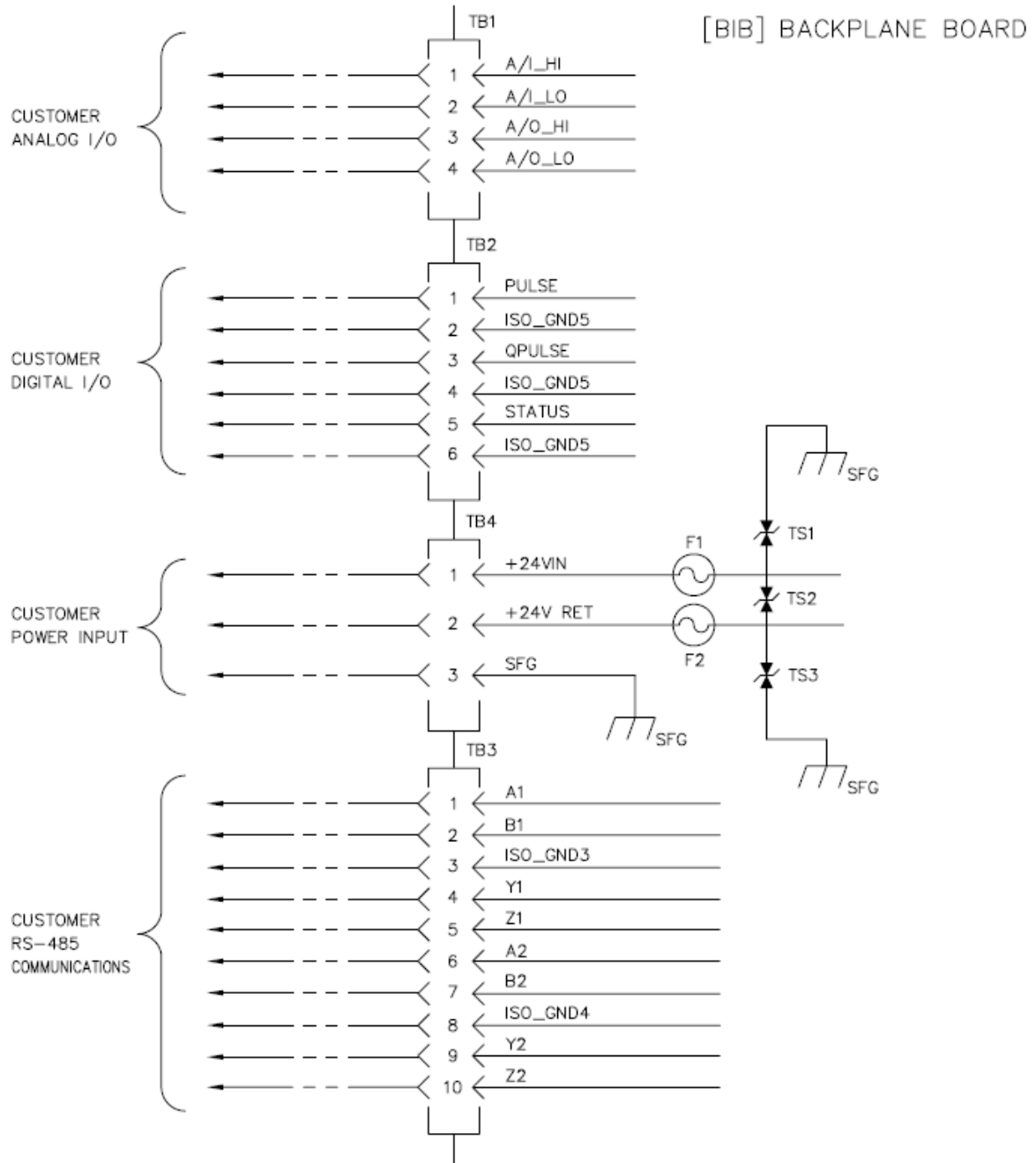


Figure 5.4: User Terminations, Schematic
 A/I = Analog Input, A/O = Analog Output
 See Serial Communications for RS 485 definitions

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 5.1). The voltage, +V, for the digital signals is factory-programmed to either 5 volts or 12 volts. 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 manual for changing parameters.

Table 5.1: LEFM 380Ci Digital Signals

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

Note: By configuration file, the electronics can be configured to have Pulse A for forward flow only and Pulse B for reverse flow only.

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. Follow all other site guidelines regarding grounding/earthing. See Figure 5.3 for the external ground point on the transmitter body. TB3, Pin 3 is the internal ground connection.

Remote Data Communications

The LEFM transmitter has two communication ports and one infrared port using the Modbus protocol. See the LEFM Modbus Manual for details.

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 5.2. Terminations for serial communications are provided in Table 5.3.

Table 5.2: 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 |

Table 5.3: 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 | Noninverting Transmit, Tx (+) | Tx/Rx (+) |
| | TB2, Pin 5 | Inverting 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 | Noninverting Transmit, Tx (+) | Tx/Rx (+) |
| | TB2, Pin 10 | Inverting Transmit, Tx (-) | Tx/Rx (-) |

Meter Installation Check-Out



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 9](#) 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 should be working.
3. Verify Modbus communications are operational. (Use LEFMLink software to test Modbus communications via the IR port or RS-485 connection.)
4. Verify meter operation according to [Section 7](#).
5. If necessary, verify outputs. To simplify this process, use LEFMLink software to force outputs (current and pulses). Verify forced outputs are within 0.1% on current and within 0.01% on pulse

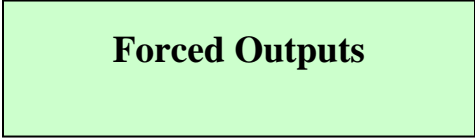
frequency. For more information on forced outputs, see Output Test Mode below or consult the LEFMLink software manual.

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

6. If the pipe is pressurized, use LEFMLink software or Modbus communications to verify the following:
 - a. Signal Rejects and Signal to Noise Ratio are acceptable (values vary with pressure and flow).
 - b. Standard deviations of Paths 1 and 4 are typically less than 6% (for flowing conditions).
 - c. Standard deviations of Paths 2 and 3 are typically 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 6

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 |

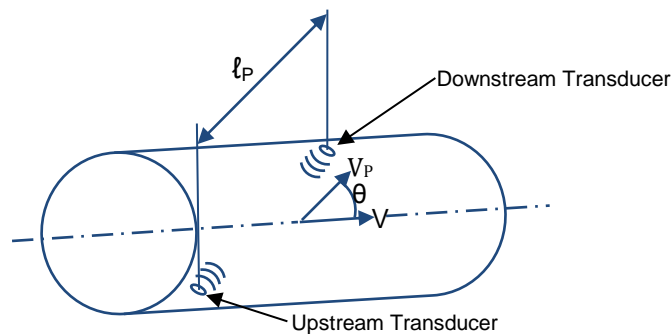


Figure 6.1: Flow Velocities along the Ultrasonic Path and the Pipe Axis

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

$$V = \frac{\ell_p}{2 \cos \theta} \cdot \frac{(T_U - T_D)}{T_D T_U}$$

Using this method, the velocity measurement V is independent of the velocity of sound. Consequently, the velocity measurement is unaffected by variations in 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 380Ci has the acoustic paths arranged into two planes. The plane is oriented at an angle θ (path angle) with respect to the centerline of the pipe. (See Figure 6.2)

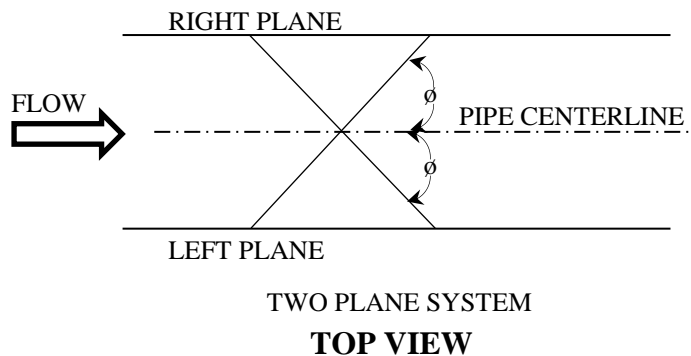


Figure 6.2: Acoustical Path Configurations

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 380Ci automatically compensates for pipe thermal expansion and contraction.

Gross Flow Rate to Net Flow Rate Conversion (Hydrocarbon Gas)

The calculation of volumetric flow rate and total at standard (base) conditions is done externally by a flow computer which meets the current API/AGA/ISO standards for calculation of gas volumes from linear pulse output meters (AGA-7 & AGA-8). The LEFM 380Ci measures and outputs flow rate and volume at “as measured” (actual) conditions. The output from the LEFM must be sent to a suitable flow computer to calculate the volume at “base” conditions; the values upon which custody transfer or allocation transactions are typically based.

The Cameron Scanner family of EFM/RTU flow computers may be used for this function.

Section 7

Operations

Definitions

SNR – Signal to Noise Ratio

Gain – Required gain to amplify signal

Rejects – Percentage of Signal Rejects

Performance – Percentage of Acceptable Signals

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 the transmitter diagnostic data via the LEFMLink software.



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.

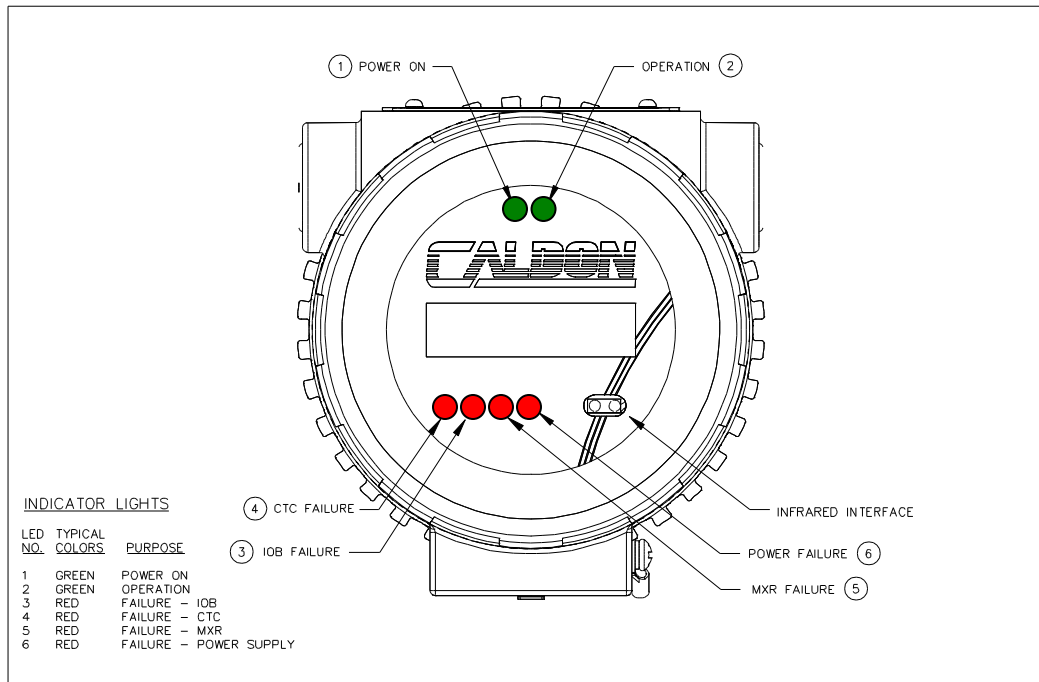


Figure 7.1: LED Diagnostics

The typical statuses of the LEDs are as follows. (See [Section 8](#) for troubleshooting information.)

| 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 |

Infrared Interface

An infrared port is also mounted inside the display window for accessing the LEFM 380Ci via an infrared device operating with a Modbus protocol. LEFMLink software allows the user to interface with the transmitter via Modbus using a PDA or a PC. For details, see the LEFMLink manual.

Display

The transmitter has a two-line display (16 characters per line). On power up, a splash screen shows the firmware part number, revision level, and checksum. An example of which is shown below (of course, part number and revision may be different):

**101A960 – 02.01.01
175A**

After a few seconds, a display test is run. The test turns all display elements on and off. Three cycles are completed, each cycle takes 1 second. If there is a concern about the display, a power cycle will force this test to occur.

After the display test, 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 paths, one path at a time. Therefore, the display cycles through the parameter set multiple times (path 1, path 2, path 3 and so on up to path 8, for example) in displaying one complete set of data for all paths.

At default settings for the display interval, it takes approximately 4 minutes to cycle through all paths.

A typical display cycle is as follows:

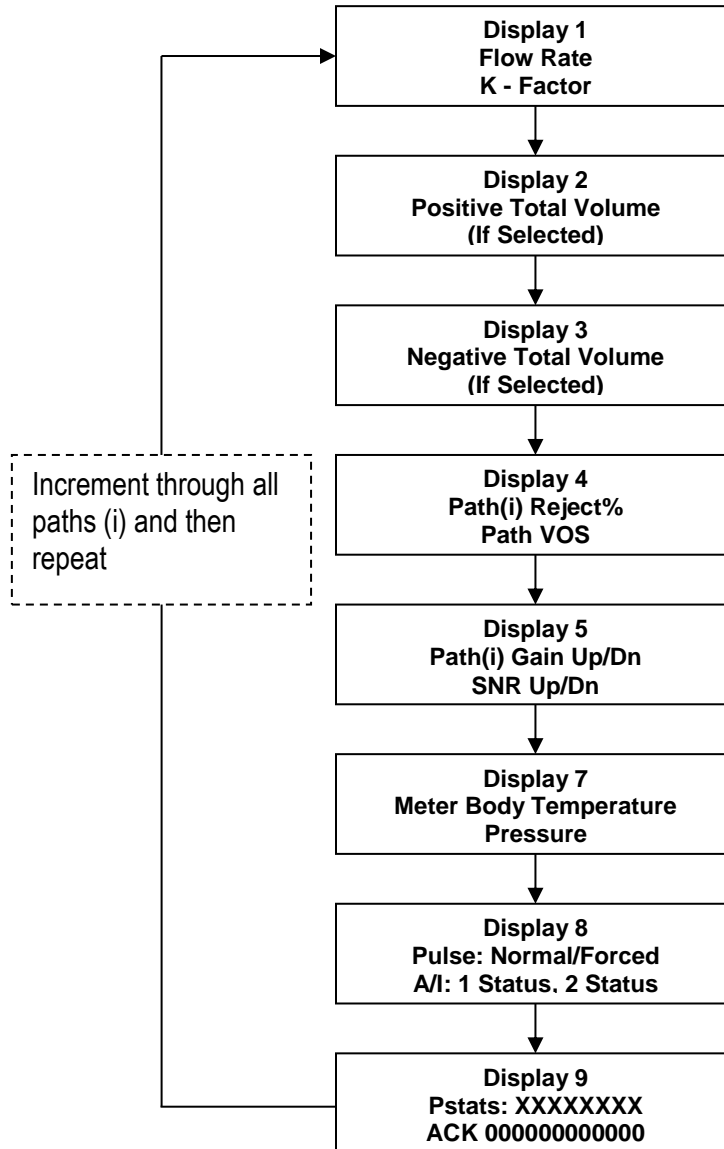


Figure 7.2: Display Sequence

Display 1 – Flow Rate (displayed in user specified units)

| | | |
|-------------------|----------------|------------|
| FLOW | 11245.6 | CMH |
| K – Factor | xxxxxxx | |

Display 2 – Positive Totals: The uncorrected Volume Total in the positive (forward) flow direction is displayed if selected by the user. Units are as specified by the user. The totalizer is capable of displaying 9 digits and is typically configured to wraparound at 1000000000.

| | |
|------------------|-----------|
| TOTVOL+ | CM |
| 123456789 | |

Display 3 – Negative Totals: The uncorrected Volume Total in the negative (reverse) flow direction is displayed if selected by the user. Units are as specified by the user. The totalizer is capable of displaying 9 digits and is typically configured to wraparound at 1000000000.

| | |
|------------------|-----------|
| TOTVOL- | CM |
| 123456789 | |

Display 4 – Path Rejects and Velocity of Sound: Path data is shown for signal reject percent and velocity of sound. Only one path is shown per cycle. In the example, the data is for path 4. It takes multiple cycles through the screens to see all path data for all paths. The units for VOS are specified by the user.

| | |
|-----------------|--------------------|
| P4 Rejs: | 10% |
| VOS | 1346.12 m/s |

Display 5 – Gain and SNR: Path data is shown for gain (up / down) and SNR (up/down). Only one path is shown per cycle. In the example, the data is for path 4. It takes multiple cycles through the screens to see all path data for all paths. Gain is in dB.

| | |
|--------------|----------------|
| P4 Gn | 46/46 |
| SNR | 151/163 |

Display 6 – Average VOS: The average velocity of sound is shown. Units as specified by the user.

| | |
|-----------------|--------------------|
| AVG. VOS | 1500.62 m/s |
|-----------------|--------------------|

Display 7 – Temperature and Pressure: The meter body temperature and fluid pressure are shown. The meter body temperature typically is sensed by a RTD sensor on the meter body. A pressure transmitter must be connected to analog input 1 to see live fluid pressure. Otherwise, a default pressure or a value written to the meter via Modbus is shown. Units as specified by the user.

| | |
|-------------|-------------------|
| TEMP | 143.6 F |
| PR | 1000.5 psi |

Display 8 – I/O Status: I/O status is shown. Outputs may be Normal or Forced. The analog inputs 1 and 2 may be OK, High (Hi), or Low (Lo).

| |
|------------------------|
| Pulse: Normal |
| A/I: 1 OK, 2 LO |

Display 9 – Path Alarm: Path alarm status is shown. Each character represents a path with path 1 on the left and path 8 on the right. In the example given, path 4 has failed. Metrological alarms are also shown on the second line.

| |
|--------------------------|
| Pstat: 00010000 |
| ACK: 000000000000 |

The LEFM 380Ci'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), signal detection 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.

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)

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

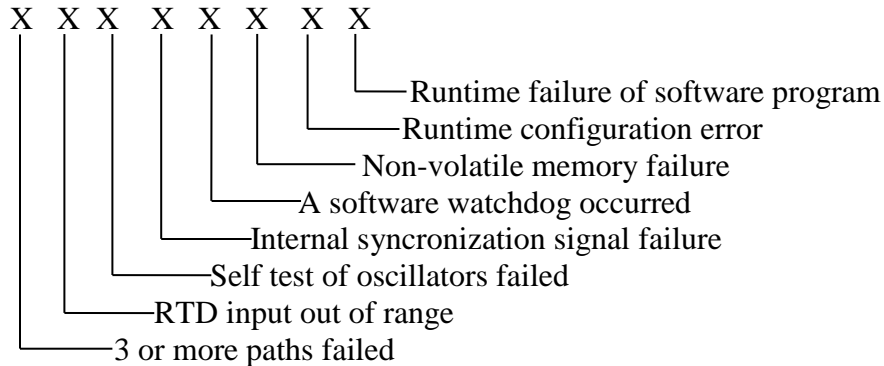
The following codes (described in the LEFM Modbus manual) are used to indicate the status of each ultrasonic path:

- 0 - Path is operating normally
- 1 - Path is rejecting data due to low signal-to-noise ratio, or irregular statistics, or failing signal detection tests
- 6 - Path sound velocities are inconsistent with thresholds (typically, a spread of 1.5 ft/sec or less between paths is acceptable)
- 8 - Path velocity is inconsistent at low flow rates

Metrological Alarms (ACK): Metrologically significant alarms are shown on the second line. These alarms are persistent and require that the condition causing the alarm is no longer present and acknowledgement from the user before the alarm can be cleared.

where 0 = No Alarm
 1 = Alarm

And the following chart explains potential alarms

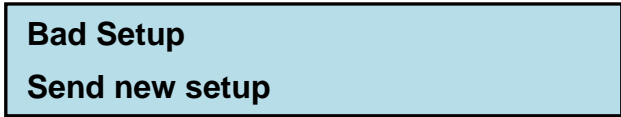


Output Test Mode

For test and/or validation purposes, an operator can temporarily override the output of the LEFM 380Ci 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 software. The words “Forced Outputs” will appear on the display during this test.

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.



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

Section 8

Maintenance



Service should be performed on the LEFM 380Ci 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



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.



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.
 - Clean gaskets and mating surfaces on the enclosure with water if they are dirty.
 - Remove any corrosion from mating surfaces.
 - Verify that gaskets compress when the cover is installed.
 - 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.



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.



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

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

- 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.

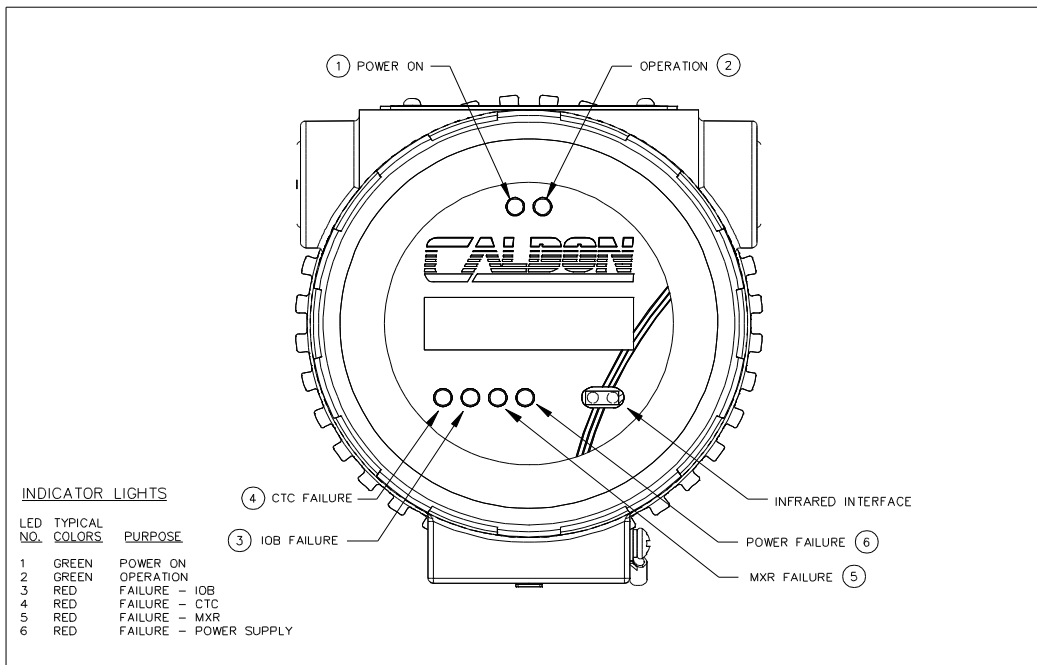


Figure 8.1: LED Indicators

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; possible failure of CTC board |
| 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:

- If LED1 is out...**
 the 24 VDC power has failed. 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). Open circuit breakers and check the BIB for fuses that may be blown; replace as necessary. The BIB also has surge protection circuitry that may be damaged.
- 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.
- If LED2 is out and LED1 is out...**
 Refer to step 1.
- If LED6 is on...**
 the power supply board may have failed. Replace the power supply board (see Power Supply Replacement, page 50.)
- If LED3, LED4 or LED5 is on...**
 a board has failed. Replace the suspect board (see IOB, CTC & MXR Replacement, page 55):
 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)

See Tables 8.2, 8.3 and 8.4 for a description of each subassembly's components.

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 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.

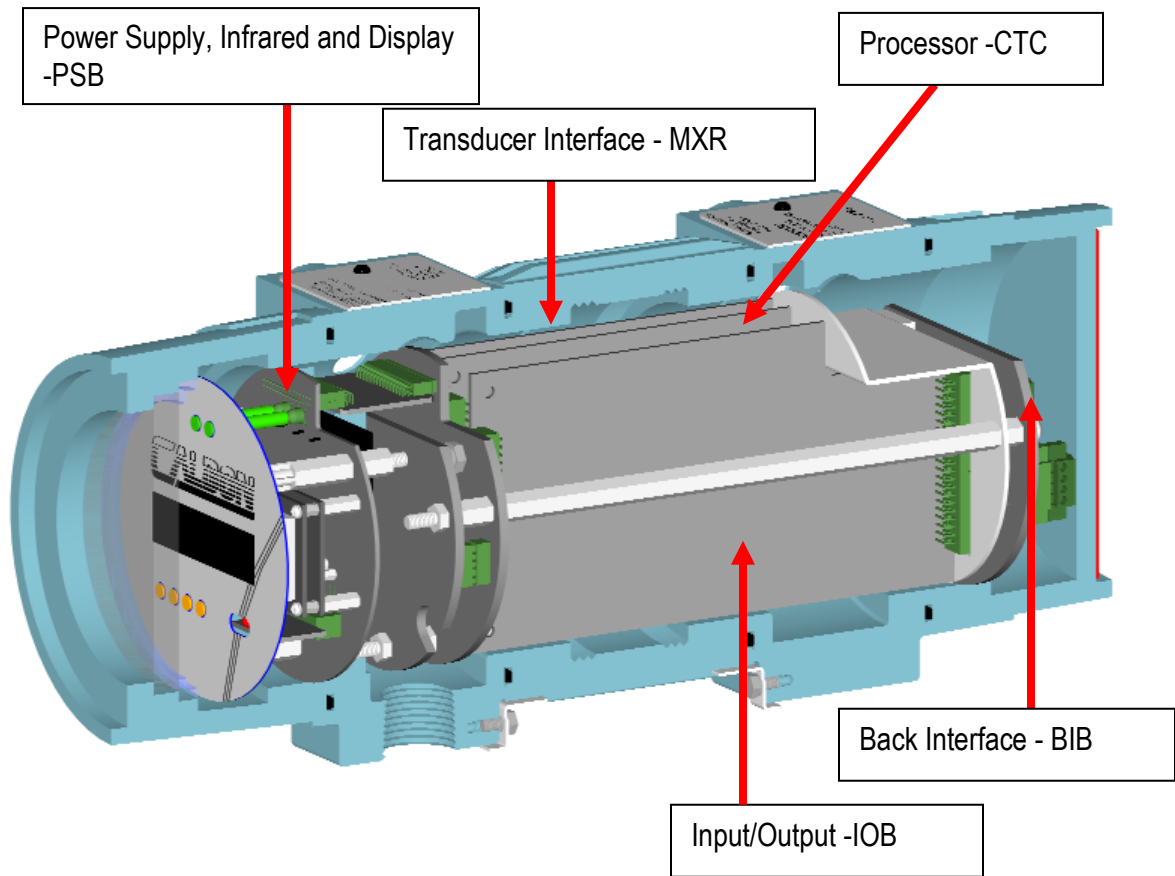


Figure 8.2: Transmitter Active Components

The following identifies passive components in the system that are used to route between 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 |

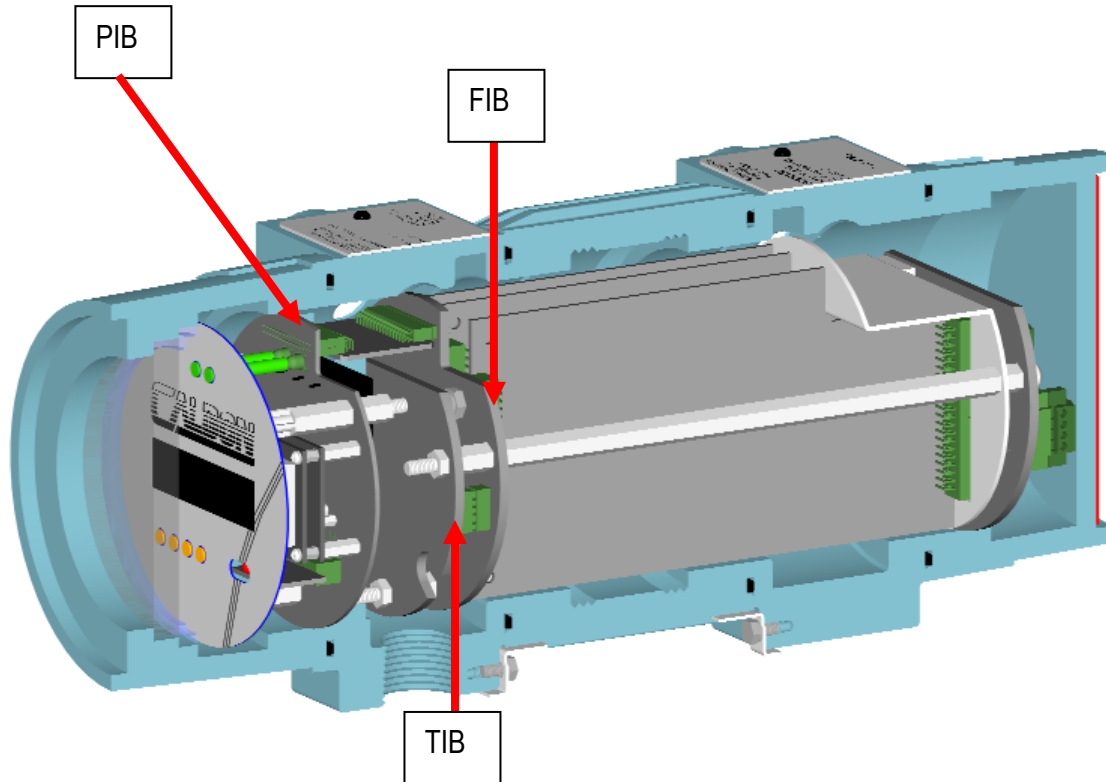


Figure 8.3: Transmitter Passive Components

Power Supply Replacement



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.



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. Rather, 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 (this is attached by wire on the backside of the PSB).
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. Carefully make sure the PSB connector lines up with the connector on the back.
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.

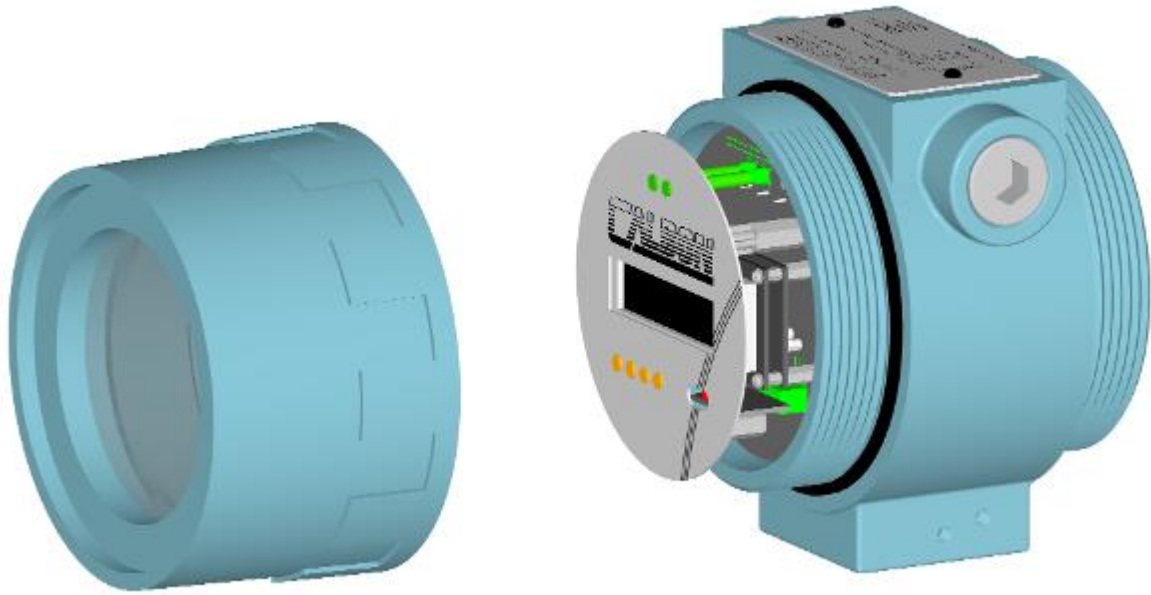


Figure 8.4: Front Cover Removal (Installation)

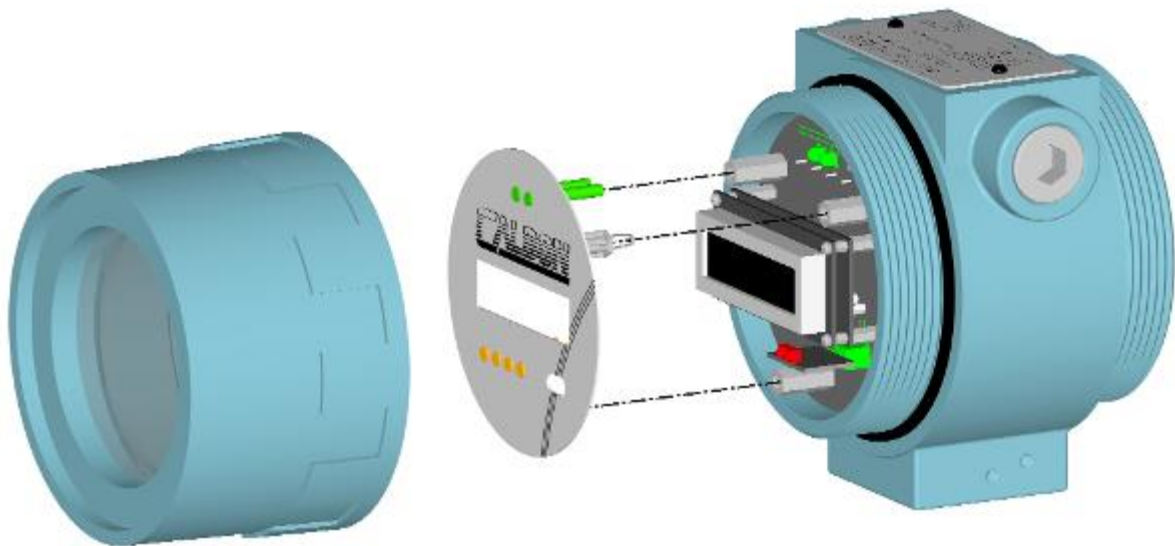


Figure 8.5: Display Cover Removal (Installation)

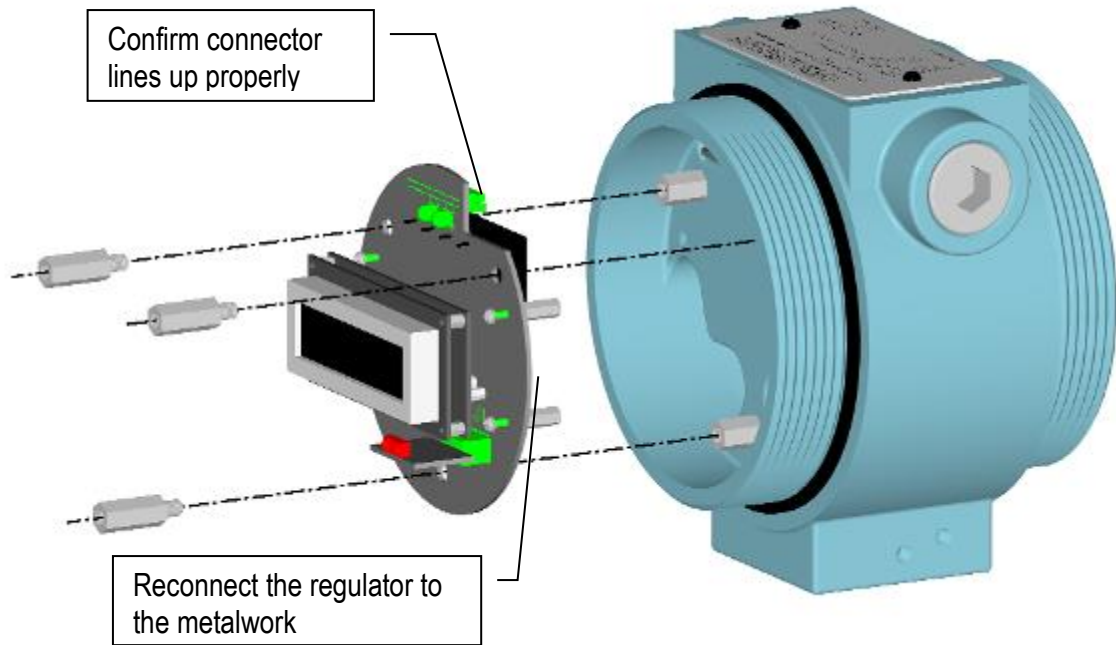


Figure 8.6: Power Supply/Display Removal/Installation

Backplane Interface Board (BIB) Replacement

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.



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.

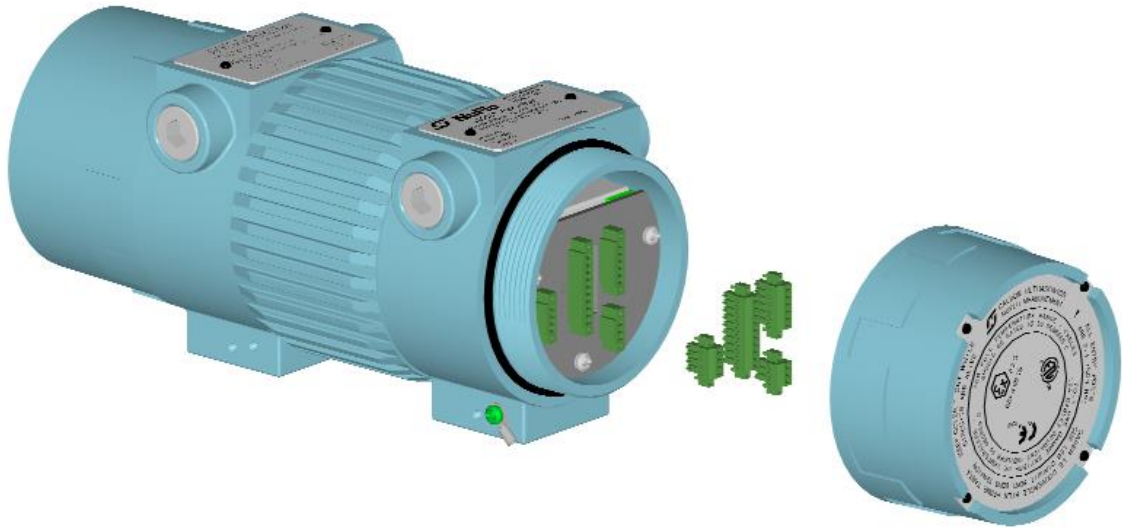


Figure 8.7: Rear Cover Removal

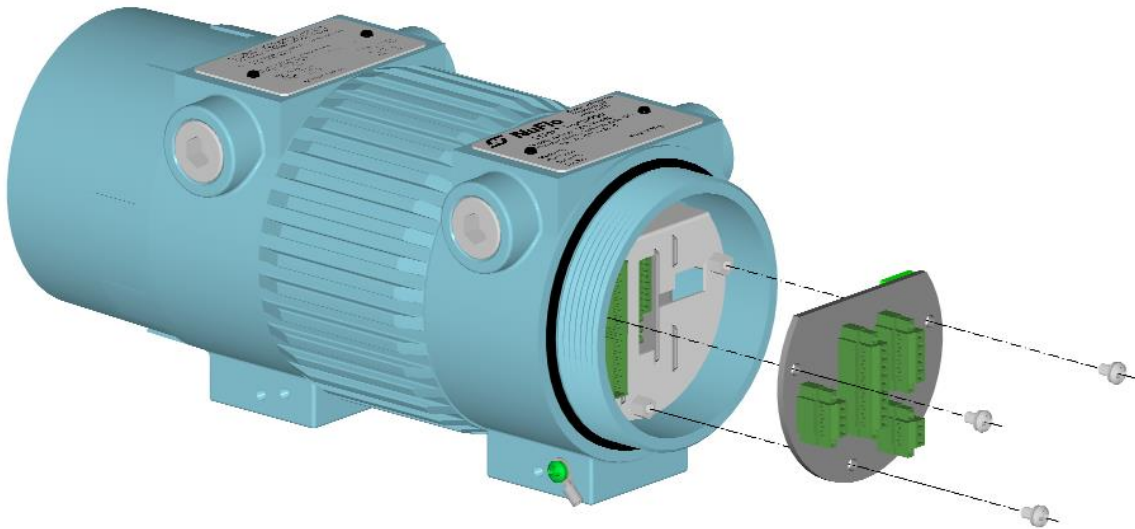


Figure 8.8: Backplane Interface Board (BIB) Removal

Backplane Interface Board (BIB) Fuse Replacement



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.



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 if 120VAC or 230VAC are ever inadvertently put into the input power. 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.

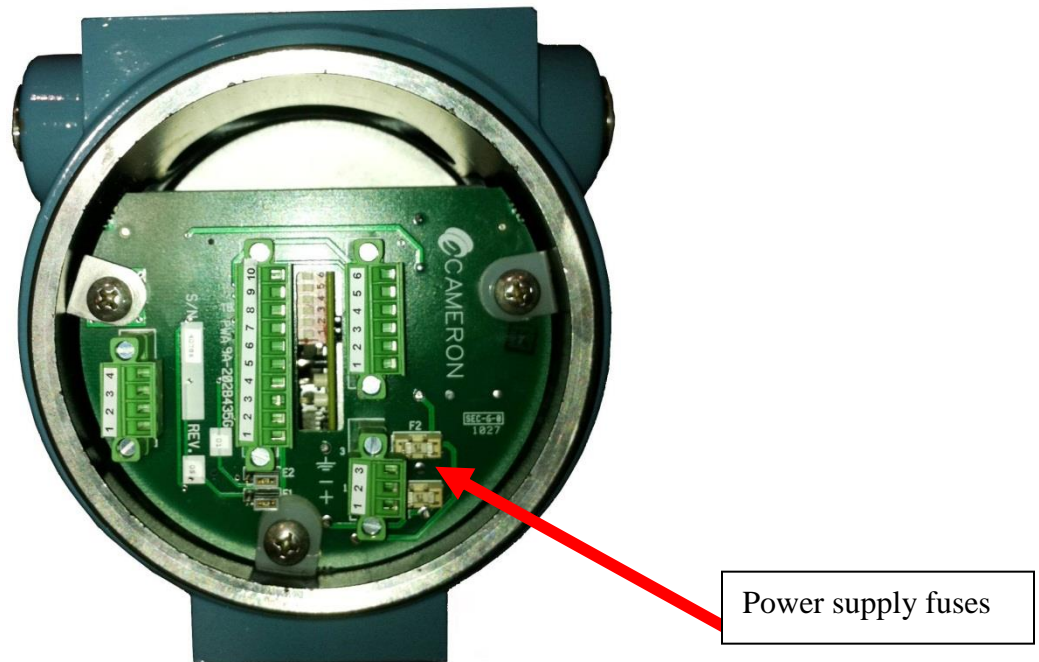


Figure 8.9: Backplane Interface Board (BIB) Fuse Location

Acoustic Processor Board (IOB, CTC & MXR) Replacement



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.



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 (Panasonic CR1632 coin battery) and it must never be changed in a hazardous location area.



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 8.10) 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 8.11).

Note 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.

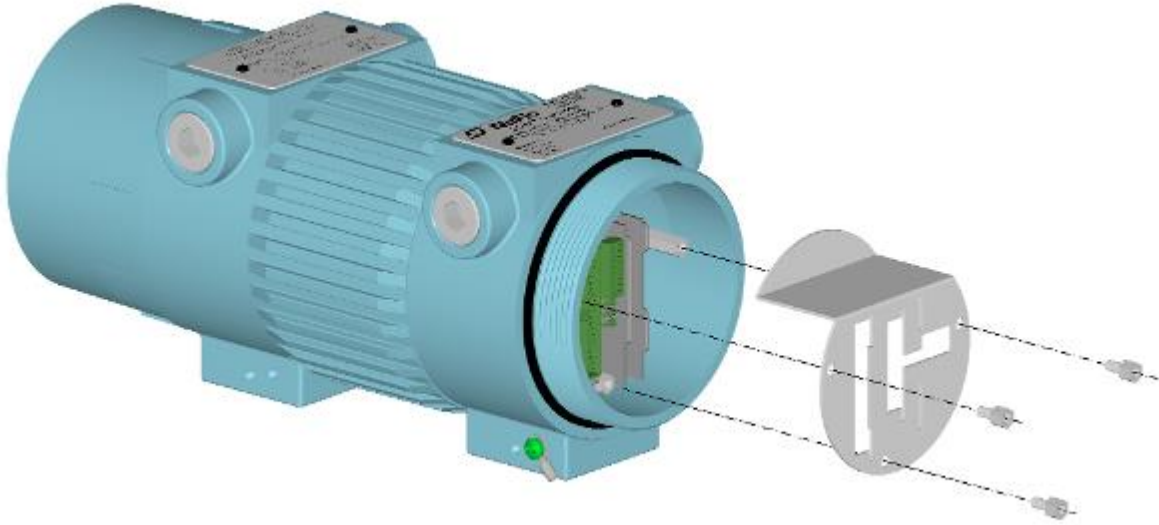


Figure 8.10: Rear Access Panel Removal

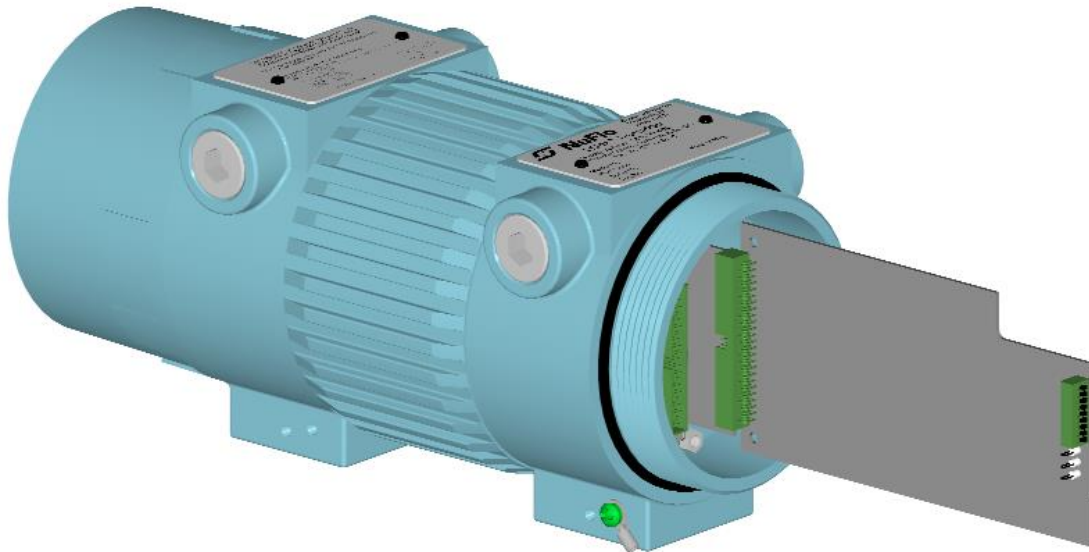


Figure 8.11: IOB, CTC, MXR Board Removal



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 the LEFMLink manual for instruction on downloading the configuration file.

Transducer Installation



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.



The transducer housings use a retaining system of components. If removing a transducer, site personnel should never attempt to remove the retaining rings located around the transducer. This maintenance shall only be done by Cameron trained technicians.

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

1. Power down the LEFM 380Ci.
2. Remove the socket head screws (m5 hex wrench) from the manifold cover and remove the manifold cover to reveal the transducer wiring, transformers, and transducer housings.
3. Disconnect the transducer leads from the transformer terminal block. If necessary, remove the transformer circuit board. Remove the compression plug retaining the transducer (Figure 8.14) Push in and turn clockwise to release.

Note – The transducer housings are pressurized and use two locking rings to keep the housing in place. Specialized tools and trained personnel are required to remove the housing (see Figure 8.12 for details).

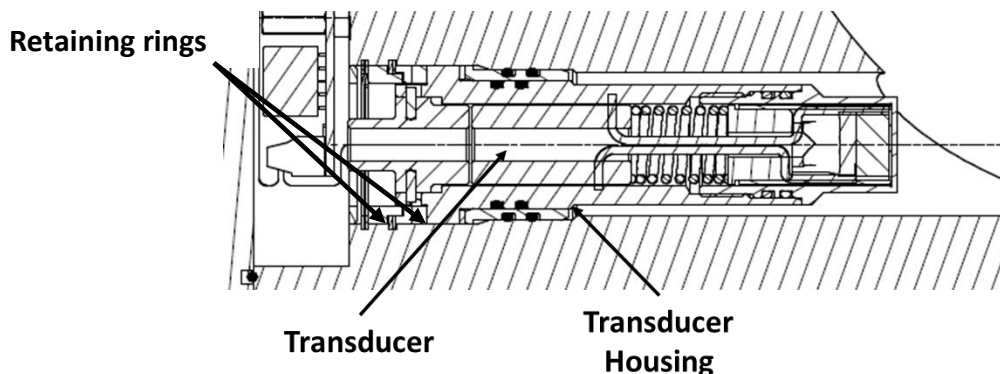


Figure 8.12: Transducer Housings



Do not remove the protective cover over the transducer housing. The mechanical holddowns must not be modified while the meter is under pressure.

4. Remove the transducer internals by a steady pull on the transducer wires.
5. Verify the transducer housing is clean and free from dirt.
6. Re-install the transducer internals as follows.
 - a. Route the wires of the new transducer through the compression spring, the spacer (if used), and the compression plug.
 - b. Apply silicone grease to the transducer face.
 - c. Insert the transducer and components into the housing until the parts bottom out.
 - d. Re-install the compression plug (push and rotate counter clockwise).
7. Connect the new transducer leads to the transformer terminals and reinstall the transformer circuit board if it was removed.
8. Re-install the manifold cover.
9. Torque the socket head screws to 30 in-lbs (3.4 Nm).

Note - The LEFM 380Ci system may require that the acoustic performance be verified when a transducer is replaced or re-coupled (See [Section 9](#)).

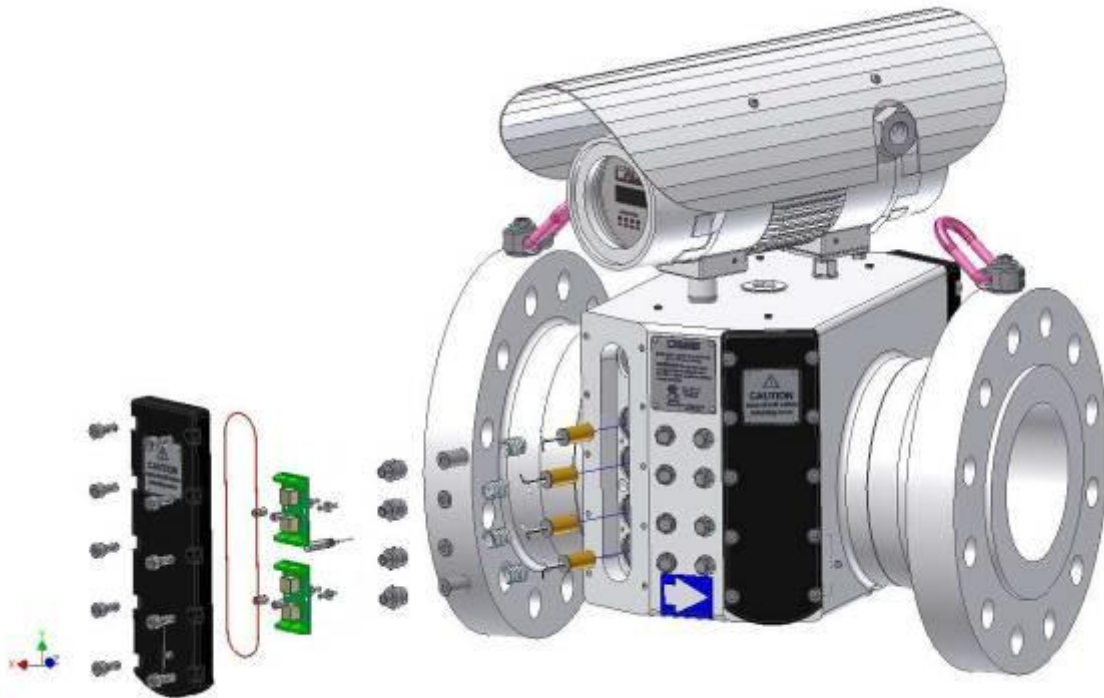


Figure 8.13: Transducer Replacement

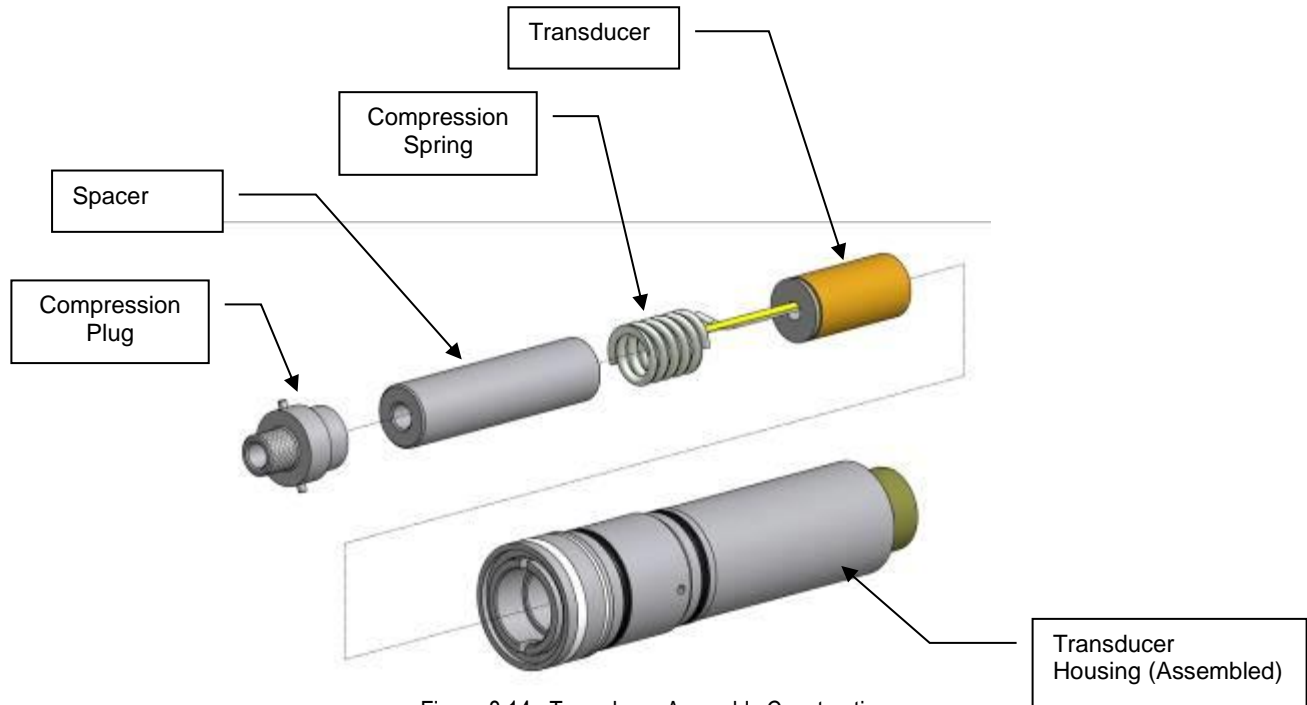


Figure 8.14: Transducer Assembly Construction

Analog Input Verification

The LEFM 380Ci may have an analog input (for example, temperature, or pressure). 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 software interface (see the LEFMLink 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 software to test the scaling of the analog output with input site devices. See the LEFMLink 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 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.

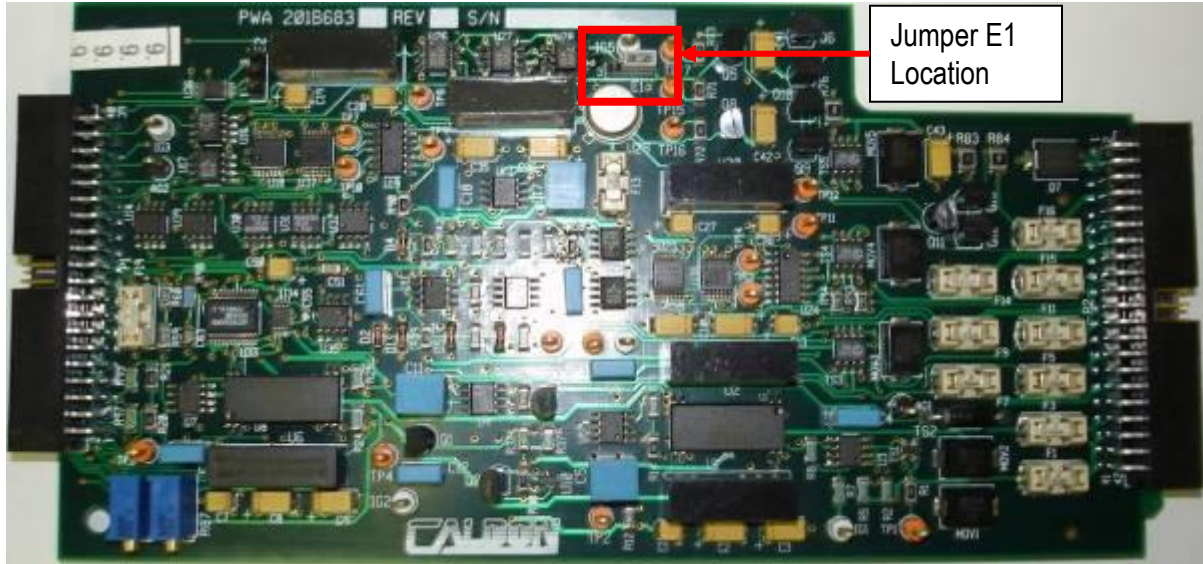


Figure 8.15: Jumper Location to Change Digital Output Voltage

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 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 software. Modbus register addresses will not be addressed.

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

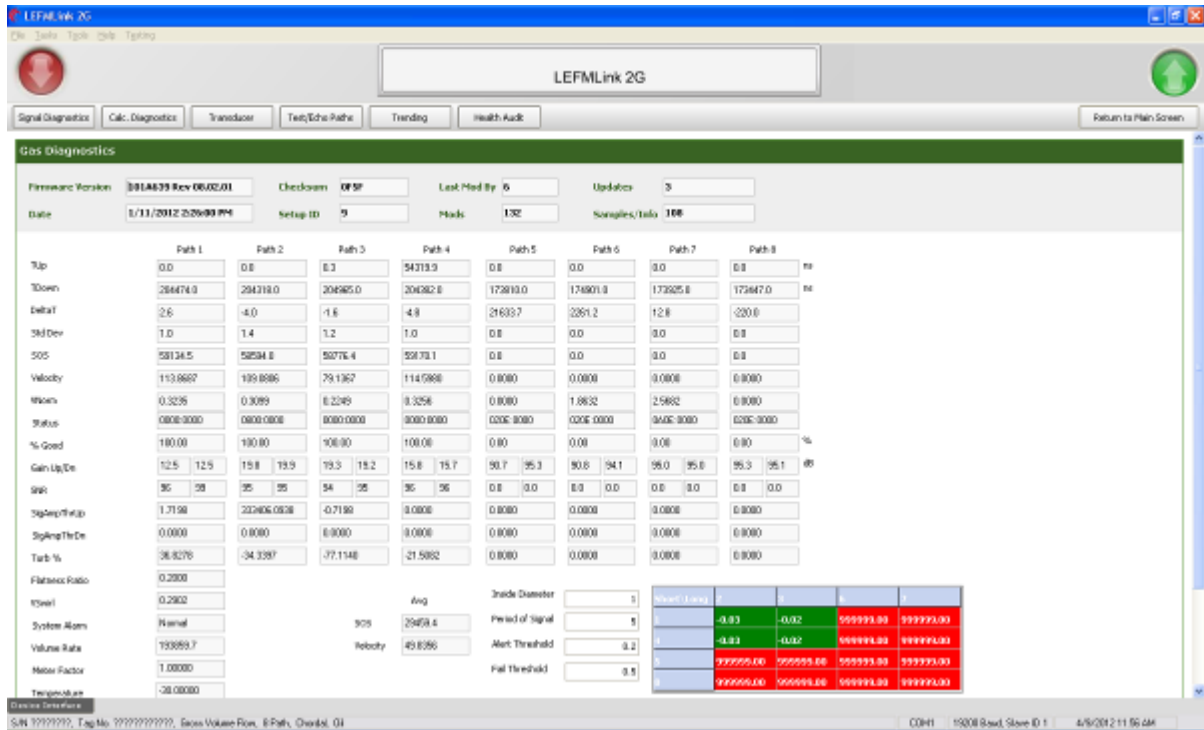


Figure 9.1: PC Diagnostic Screen
(Click the “GasDiagnostics” tab to reach this screen from the main screen)

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 90dB | 20 to 60dB |
| SNR | 0 to 100+ | 10 to 100+ |

Automatic Fault Detection

The LEFM transmitter continuously checks the data quality of each acoustic path for 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), signal detection tests and signal statistics.
 - The LEFM verifies whether the path's SNR is higher than its threshold value.
 - The LEFM validates the Upstream Signal with the Downstream Signal to test for "cycle skipping." The processor rejects data that does not pass the signal detection test.
 - 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.

2. The processor outputs the individual path status codes through a digital output and Modbus. LEFMLink software interprets these codes and displays a text message. The individual path status codes are:
 - 0 - Path operating normally
 - 1 - Path rejecting data due to low SNR, irregular statistics, or failing the signal detection test
 - 6 - Path sound velocities are inconsistent with thresholds (typically, 0.1% spread between paths).
 - 8 - Path velocity inconsistent at low flow rates
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 high (5 or 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 at 0 volts)

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 pressurized. If there are liquids in the line, bottom paths may 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 "Configuration File Needed" or "Flowmeters," the transmitter needs to be reprogrammed or the CTC board requires replacement. See *Reprogramming the Transmitter*, page 65.
5. Check the acoustic signal. Check path gains via Modbus or LEFMLink software. If the path gains are high (85 dB 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 contains liquid.
 - The line pressure is too low.
 - 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. Review the SNR (signal to noise ratio) for each path (paths 1 through 8).
7. Review the gains for each acoustic path (both upstream and downstream). The gains are typically between 20 dB and 70 dB. Gain is dependent on pressure, composition, velocity, and temperature. It will vary as conditions change. Upstream and downstream gain should nominally be within 12 dB of each other.
8. Review the percent rejected data for each path. The percent should be between 0 and 5%.

Remember the following troubleshooting tips:

- If all paths fail, the meter has low pressure, significant 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 contains no liquid.
 2. Check the continuity of transducer cable in the manifold.
 3. If a signal is present, consider reseating the ultrasonic transducer or replacing the acoustic coupling. See Transducer Installation, page 58.

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 software (interface software). The procedure is as follows:

1. Download the LEFMLink User Manual from Cameron's Measurement Systems website for reference.
2. Connect the serial interface cable between a COM port on a PC with RS485 converter and terminal TB2 on the transmitter's back interface board (BIB).
3. Select the appropriate Modbus ID and baud rate using LEFMLink software. All transmitters are initially programmed with a Modbus ID of 1 and a baud rate of 9600 with RTU Slave Mode.
4. Select the configuration file for the meter.
5. Send the configuration file. The transmitter will be reprogrammed.

Section 10

Secondary Seals and Seal Failure Indication

Secondary Seals

Some versions of the 380Ci LEFM flowmeter have been designed to comply with the requirements of ISA standard 12.27.01, "Requirements for Process Sealing between Electrical Systems and Flammable or Combustible Process Fluids", specifically, the meter has an indication when an O-ring fails to meet its specifications.

Each of the transducer housings have been designed and built with 2 sets of seals. The first and primary seal set retains the process gas. If the first seal set were to fail, the secondary seal exists to prevent gas from entering into the electrical compartments and to redirect that gas out through a vent.

The vent has been designed to not only vent the gas – but to provide a visual indication of a seal failure. If a seal were to fail, the vent has a plunger that deploys at the location of the failure (see Figure 10.1).

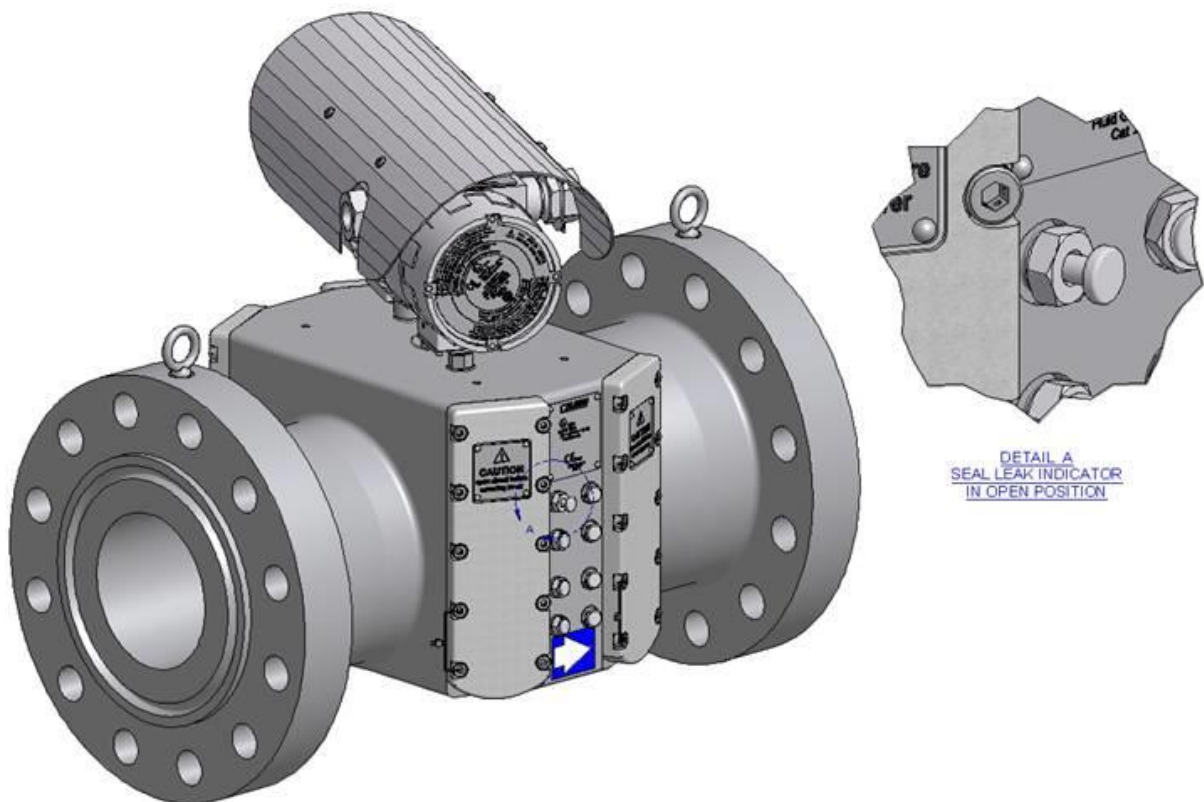


Figure 10.1: Primary Seal Failure Indication

Section 11

Recommended Spare Parts

Transducer Equipment

| | |
|--------|------------------------------------|
| Qty: 2 | Transducer (appropriate frequency) |
| Qty: 1 | Transducer Couplant (small tube) |

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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Caldon[®] Ultrasonics

Customer Service & Technical Support

1000 McClaren Woods Drive
Coraopolis, PA 15108 USA
Tel 724-273-9300



Valves & Measurement

Sales
measurement@c-a-m.com

Service
ms-services@c-a-m.com

HEADQUARTERS +1.281.582.9500
(HOUSTON, TX, USA)

CANADA +1.403.291.4814

LATIN AMERICA +54.11.5070.0266

INDIA +91.9903822044

ASIA PACIFIC +603.7954.0145

MIDDLE EAST & NORTH AFRICA +971.4802.7700

EUROPE, CASPIAN, RUSSIA +44.1892.518000
& SOUTH AFRICA

www.cameron.slb.com

