CAMERON

Measurement Systems

CALDON® ULTRASONICS

LEFM® 220C Ultrasonic Flowmeter

User Manual

Manual No. IB0204, Rev. 17

Manual No. IB0204, Rev. 17
November 2008

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INTRODUCTION

The Caldon® LEFM 220C Ultrasonic Flow Meter is a highly sophisticated flow measurement system. It employs the ultrasonic transit time method to measure fluid velocity and volumetric flowrate. It contains advanced signal and data processing circuitry to achieve high accuracy and repeatability. It also contains an automatic self-checking system to continuously verify that it is performing properly and to initiate warnings and alarms when unsatisfactory conditions are detected. For ease of troubleshooting, it provides via ModBus easy to interpret diagnostic information.

It is recommended that before performing system verification and repair procedures, personnel receive general training from Cameron. Contact Cameron's Measurement Systems division for information on training programs.

A complete range of support services are offered. For additional information or assistance on the application, operation or servicing of the LEFM 220C, write or call, or visit **www.c-a-m.com/flo.**

CAUTION

NO OPERATOR ACCESS IS PERMITTED IN THE UNIT. SERVICE SHOULD ONLY BE PERFORMED BY QUALIFIED PERSONNEL.

IF THE EQUIPMENT IS USED IN A MANNER NOT SPECIFIED BY THE MANUFACTURER, THE PROTECTION PROVIDED BY THE EQUIPMENT MAY BE IMPAIRED.

1.0 EQUIPMENT SPECIFICATION

1.1 LEFM 220C Equipment

LEFM 220C Flow Measurement Systems consist of two types of equipment.

1. LEFM 220C Transmitter
2. LEFM 220C Meter body or Metering Section, including transducers, cables for transducers, temperature transmitters, and pressure transmitters (optional)

1.1.1 LEFM Transmitter

The LEFM 220C transmitter is a wall mount unit with the following special features:

- Standard Outputs of:
  Pulse (0-5 V standard, other amplitudes are optional); the meter K factor is programmable. The standard factory delivered K factors are listed in Table 1-1 below.
- Optional Analog Inputs of:
  Product temperature (RTD, 4-20, or 0-20mA)
  Product pressure (4-20, or 0-20 mA)

Up to Two of the Following:

- Optional Analog Outputs of:
  Flow (4-20, or 0-20 mA)
  Density (4-20, or 0-20 mA)
  Sound Velocity (4-20, or 0-20 mA)
  Temperature (4-20, or 0-20 mA)

Additionally, any internal ModBus input register can be mapped to any analog output.

The LEFM 220C transmitter contains signal processing and digital computing circuitry, and power supply equipment.

Size		Maximum Flow BPH	K Factor (P/bbl)	Maximum Flow m3/h	K Factor (P/m3)
Inches	**DN**				
4	100	2,050	2,000	325	12,600
6	150	4,650	1,000	740	6,300
8	200	8,150	500	1,290	3,150
10	250	12,800	350	2,030	2,200
12	300	19,300	250	3,070	1,570
14	350	23,600	200	3,750	1,000
16	400	28,700	150	4,560	940
18	450	41,000	100	6,500	630
20	500	50,000	85	7,900	530
24	600	72,000	60	11,500	380
26	650	87,000	45	13,900	280
28	700	100,000	40	16,200	240
30	750	115,000	35	18,700	220
32	800	130,000	30	21,300	185
34	850	150,000	25	24,200	165
36	900	165,000	25	27,200	145

Table 1-1: Standard Delivered K Factors

1.1.2 LEFM 220C Meter Body Section

The Meter Body Section or Metering Section, as it is sometimes referenced, contains the acoustic transducers that transmit and receive the ultrasonic pulses that pass through the fluid.

The meter body is a specially designed section of pipe, which contains two pairs of housings into which the ultrasonic transducers are installed. The housings are positioned in a configuration to provide two chordal paths at 45° to the flow direction and are spaced in accordance with the Gaussian Method of flow integration.

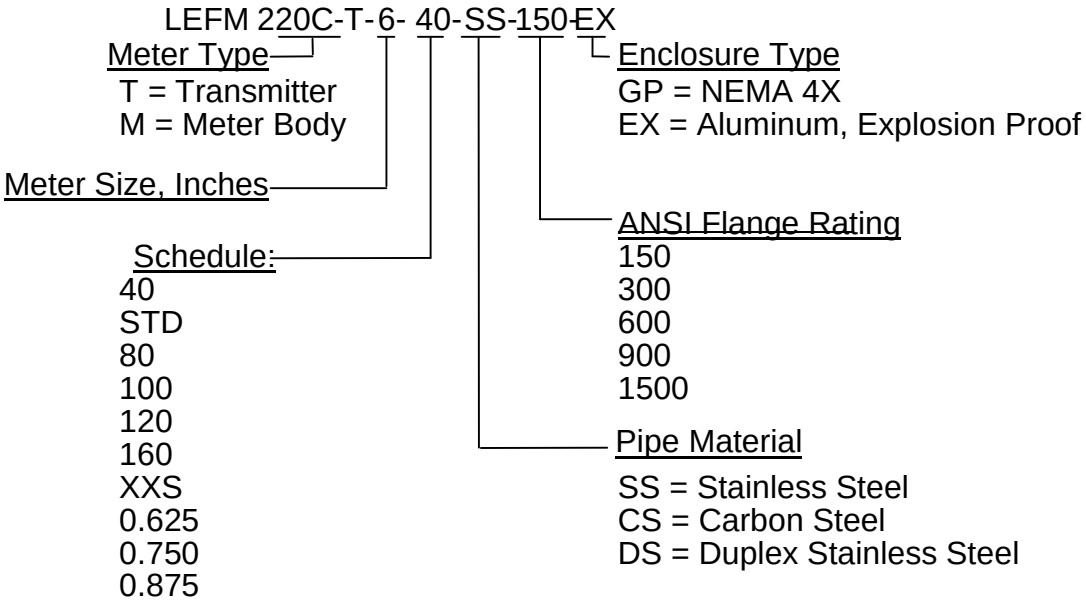
1.1.2.1 Transducers

Each transducer transmits and receives ultrasonic pulses, (typically 0.5MHz, 1.0 MHz or 1.6 MHz). The transducer modules contain piezoelectric crystals and are contained in housings that are designed to permit module removal from their housings for maintenance without affecting the pressure boundary.

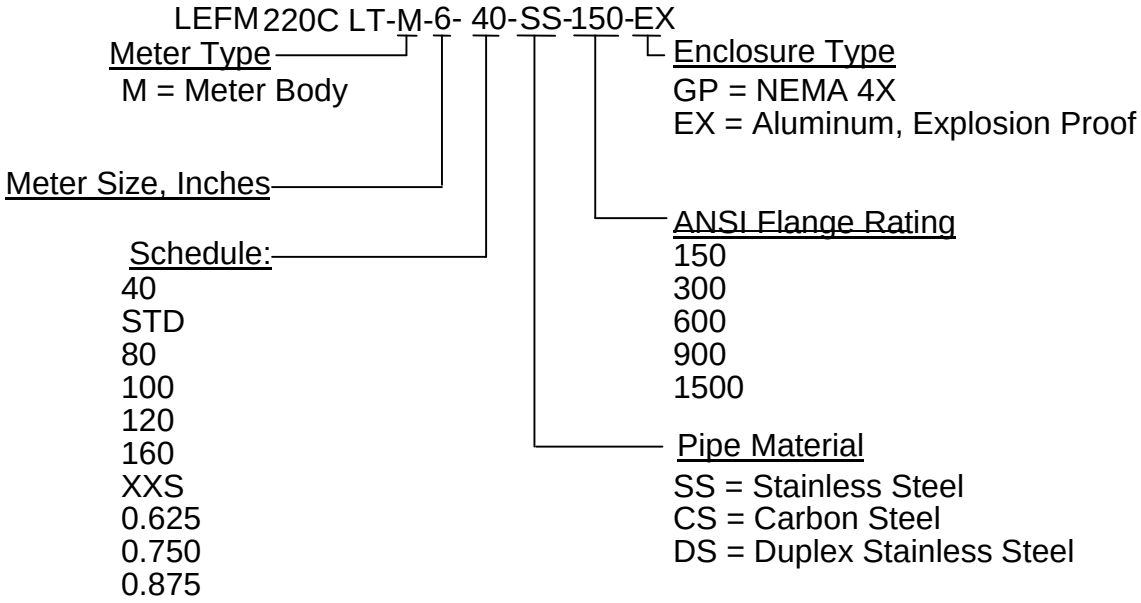
1.2 LEFM 220C Model Number

Each LEFM 220C has a Model Number and part code that completely defines the construction and features of that flow meter. The following subsections define the Model Number and part codes.

1.2.1 LEFM 220C Model Number

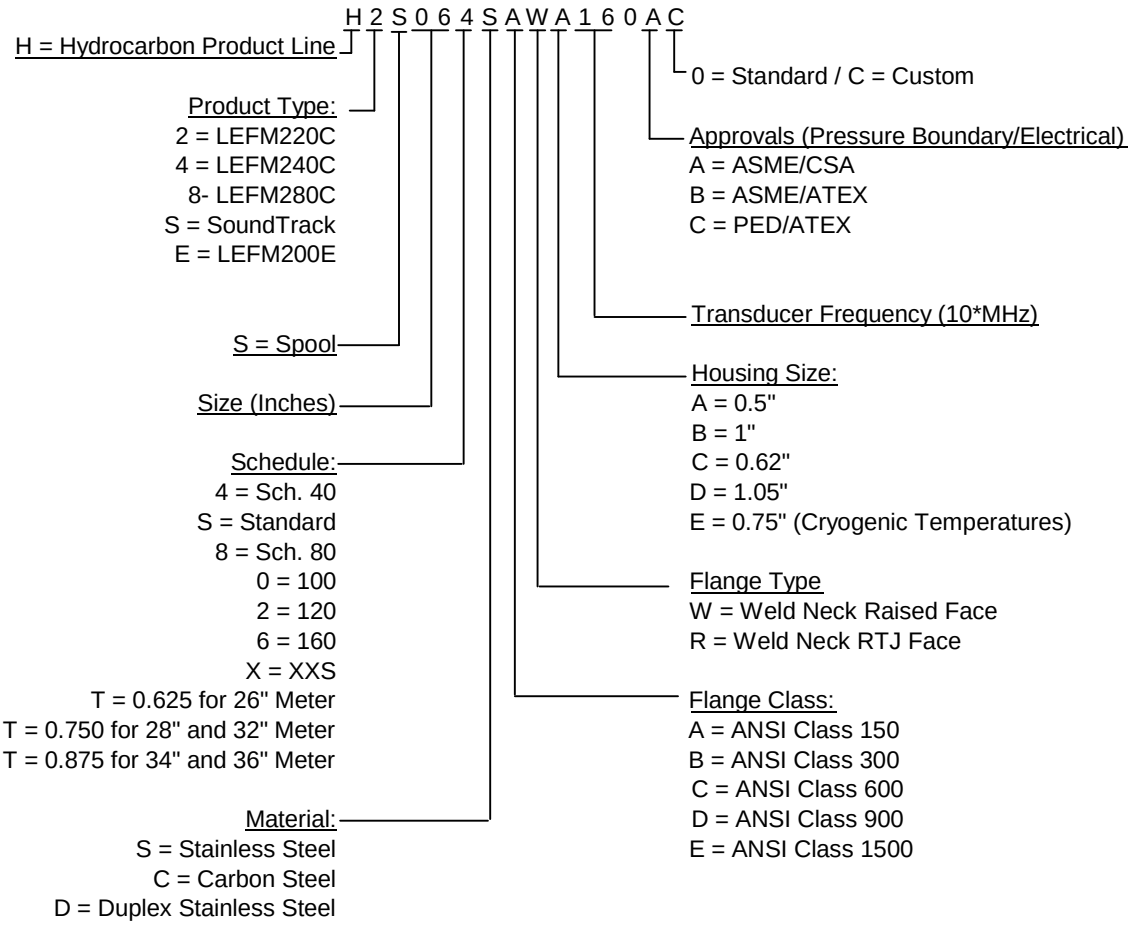


1.2.2 LEFM 220C LT Model Number (Cryogenic)

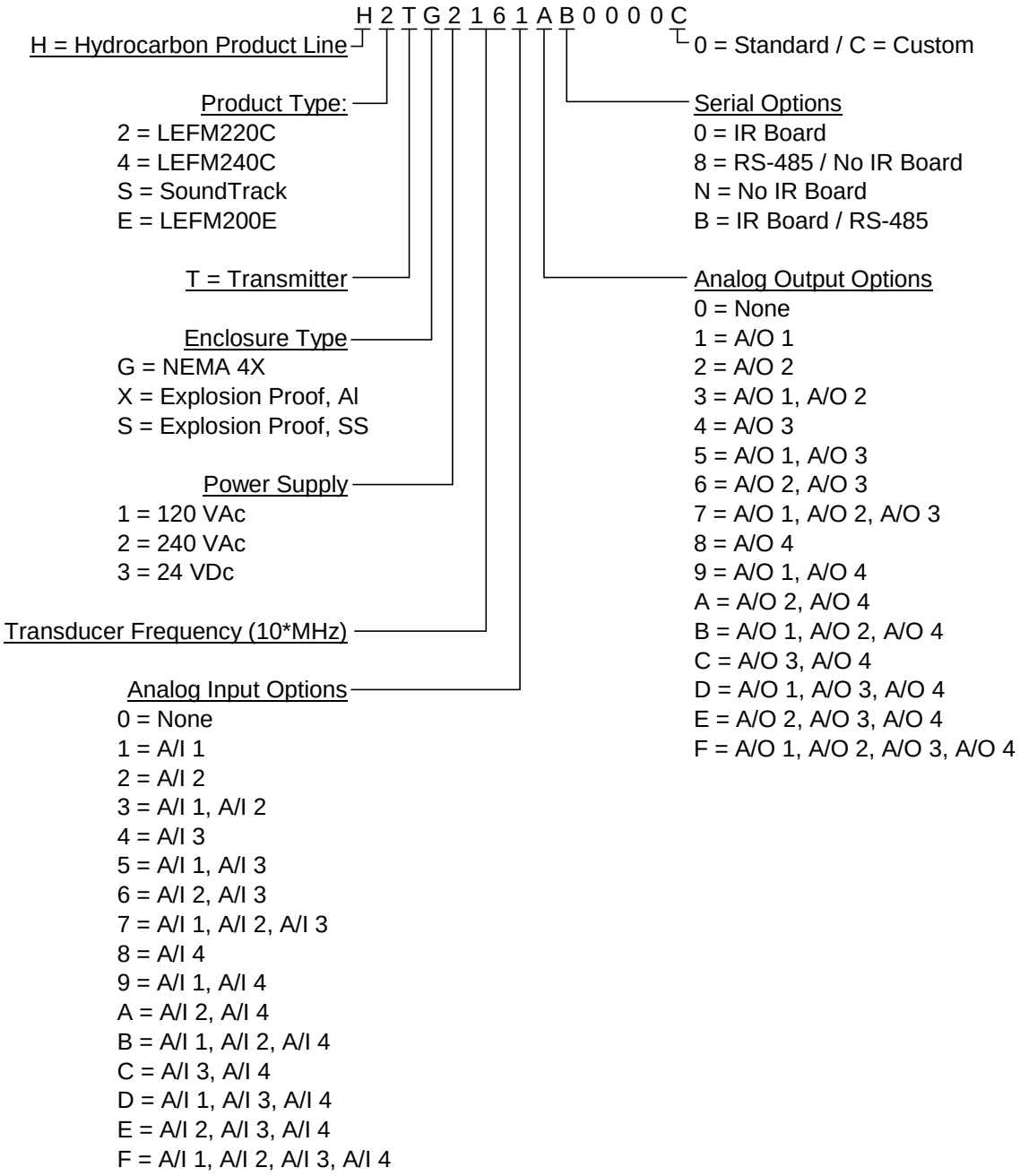


1.2.3 LEFM 220C Part Code

Meter Body Part Code Key



Transmitter Part Code Key



1.3 LEFM 220C Specifications

1.3.1 LEFM 220C Transmitter

Material:

Explosion Proof	Aluminum
NEMA4X	Stainless Steel

Weight

Net Weight:	NEMA 4X - 30 lbs. (13.6 kg) Explosion Proof - 120 lbs. (54.5 kg) (See following figures for dimensions)

Power Requirements

Voltage Supply Required:	24 VDC or, 120 VAC, 50/60 Hz or, 230 VAC, 50/60 Hz
Current Draw:	24 VDC – 3.0 Amps 120 VAC – 0.8 Amps 230 VAC – 0.6 Amps
Power Consumption:	20W (80W with heaters active)

Cable Lengths

Standard:	15 feet (approximately 5 meters); lengths up to 200' (61 meters) can be ordered
Extended Range:	Special cables can be used for runs up to 1000’(300 meters). Contact the Cameron's Measurement Systems division Engineering department to discuss the needs of the application.

Pulse Outputs/Communications

Pulse Output:	0-5 Volts
Alarm Status:	5 Volts (Normal), 0 Volts (Alarm)
Serial Communications:	RS-232 (typical, RS-422 or RS-485 options available) ModBus Protocol, see Caldon ModBus Specifications

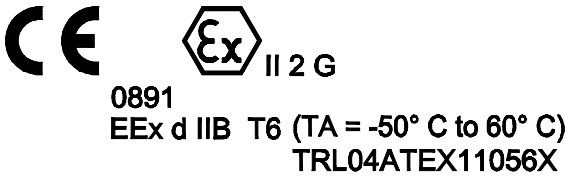
Analog Outputs	4-20mA or 0-20mA (max load 650 Ohms), up to 4 total.
Analog Inputs	4-20mA, 0-20mA, RTD, or Frequency, up to 3 total. Meter Body Temperature RTD is standard.

1.3.2 Approvals – Transmitter, LEFM 220C-T-….-EX

Hazardous Area Approvals: (USA and Canada)

Class I Div I Groups C and D, Conforms to UL Std 1203, Std UL 61010-1, CSA Std 22.2 No. 30, CSA Std 22.2 No. 61010.1

Hazardous Area Approvals: (ATEX)



1.3.3 Approvals – Meter Body, 220C-M and 220C-LT-M

USA and Canada 220C-M Manifold Part Number 202B264HXX

Class I Div I Groups B, C and D, Conforms to CAN/CSA-C22.2 No.0-M91, CSA Std C22.2 No.30-M1986, CAN/CSA-C22.2 No. 94-M91, CSA Std C22.2 No.142-M1987, UL Std No. 50, ANSI/UL Std No.508, UL Std No.1203

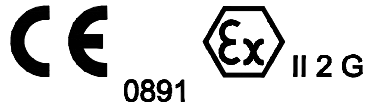
Temperature Range: -40 deg C to 140 deg C

ATEX 220C-M Manifold Part Number 202B264-W-HXX

EEx d II B T5 (TA = See Note Below)
TRL04ATEX11068X

	Explanation of Part Number Code and Temperature Range (ATEX only)
"W"	Defines the different glands/seals that may be used with the device Where: "W" is set to D – the temperature range is: TA = -50°C to 93°C "W" is set to E – the temperature range is: TA = -50°C to 80°C "W" is set to F – the temperature range is: TA = -50°C to 93°C
H"XX"	Defines the different sizes ("XX" can be any value from 01 to 16)

ATEX 220C-LT-M (Wide Range Temperature)
*Manifold Part Number 202B582"WYZ"-H"**"*



EEx d IIB T3 (TA = See Note Below)
TRL04ATEX11068X

	Explanation of Part Number Code
"W"	Defines the different glands/seals that may be used with the device Where: "W" is set to D – the temperature range is: TA = -170°C to 130°C "W" is set to E – the temperature range is: TA = -170°C to 130°C "W" is set to F – the temperature range is: TA = -170°C to 130°C
"Y"	Defines the different whether the device has an elbow in the fittings Where: "Y" is set to R – There is an elbow in the fittings "Y" is set to S – There is no elbow in the fittings
"Z"	Defines the different whether the device has a Tee or an adaptor in the fittings Where: "Z" is set to T – There is a tee in the fittings "Z" is set to F – There is an adaptor used instead of a tee in the fittings
H"**"	Defines the different sizes ("**" can be any value from 01 to 40)

WARNING

Note: The ambient temperature range for the ATEX approved glands is limited to -50°C. The meter body is rated to -170°C and must be under thermal insulation.

The ATEX certificates are located in an appendix of this manual and define the conditions for safe use of the meter manifold and the transmitter. The temperature ranges listed are for the enclosures indicated on the certificate. The temperature limit of the meter assembly is dependent on the temperature limits for the components used to connect the meter to the electronics and may limit the temperature limits for the assembled meter. See the meter nameplate for the temperature limit of the system as assembled.

1.3.4 Environment (Transmitter and Meter body)

Storage Temperature

Transducer Cable: -40°F (-40°C) to 140°F (60°C)

Transmitter: -40°F (-40°C) to 158°F (70°C)

Meter body:

220C (all models) -40°F (-40°C) to 176°F (80°C)

220C LT (Cryogenic) -40°F (-40°C) to 176°F (80°C)

Note: For storage temperature, the meter body limits have been set by the limiting ambient rating of any seal/gland or J-box that could be used with the flow meter. The operating temperatures are defined in the previous section.

Operating Temperatures (See Approvals Section)

Operating Pressures

Meter body: Max working is listed on meter nameplate (surge pressures in excess of flange max working pressure rating, must be evaluated)

1.3.5 LEFM 220C and 220C-LT with J-Boxes Meter Body Specifications

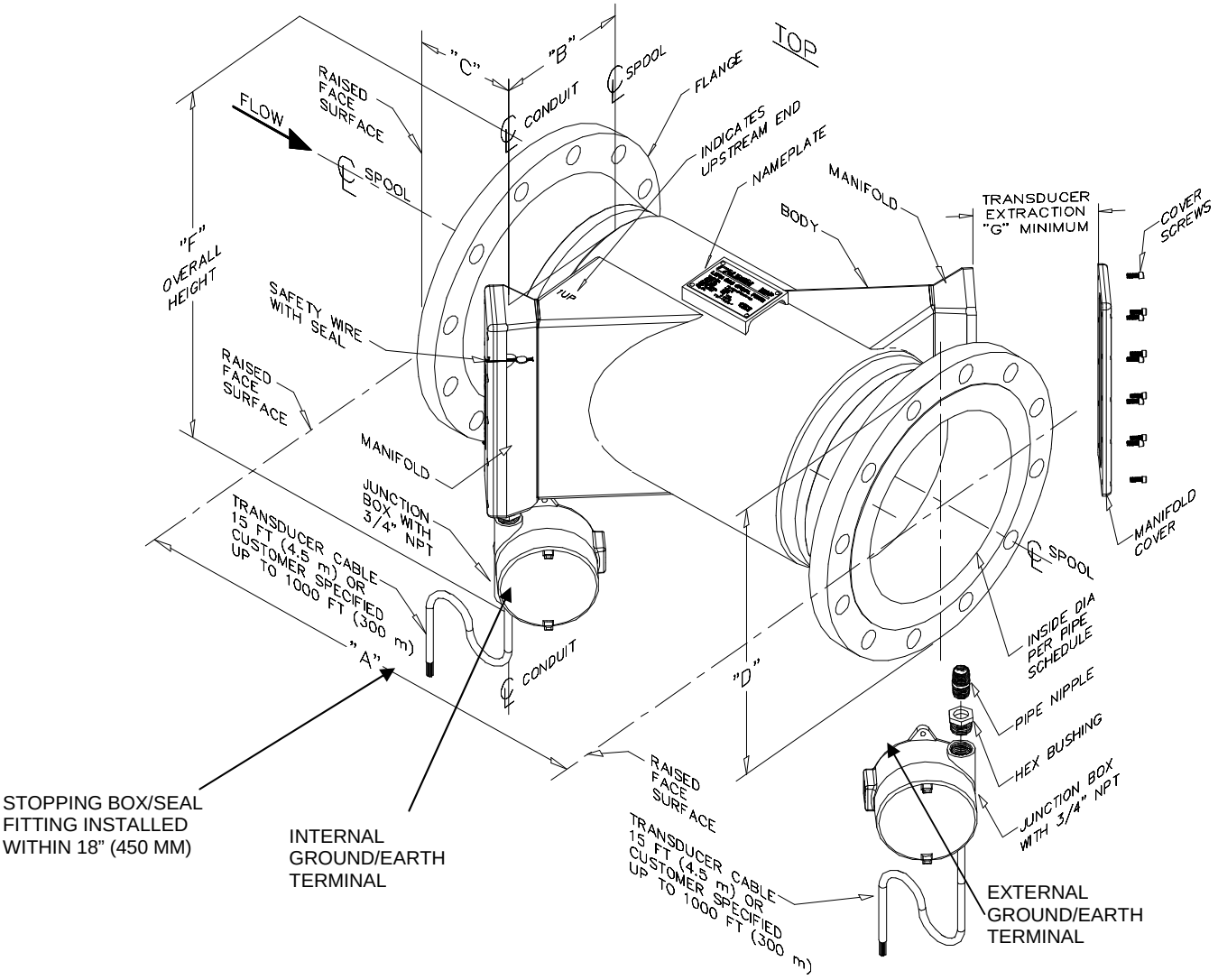


Figure 1-1: Construction Outline Drawing (Dual Junction Boxes)

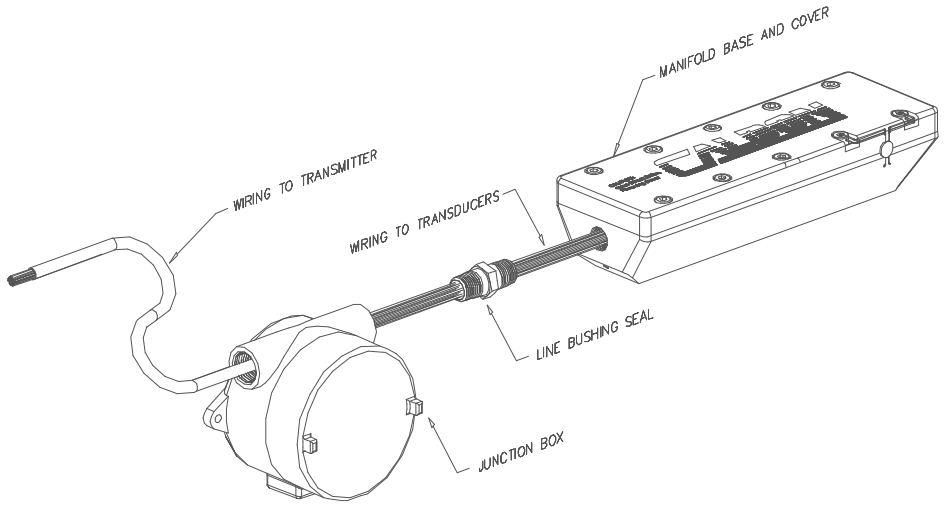


Figure 1-1 (Addendum): ATEX Only - Construction of Manifold to Junction Box Connection

Note: The specific ATEX approved cable gland, as specified on ATEX Certificate, must be used. (See Appendix C of this manual for a copy of the ATEX Certificate).

Dimensions

PIPE SIZE			A		B		C		D		F		G		L		Weight	
Inches	(DN)	* FLANGE	Inches	(mm)	Inches	(mm)	Inches	(mm)	Inches	(mm)	Inches	(mm)	Inches	(mm)	Inches	(mm)	lbs.	(kg)
4	(100)	150	18.0	(457)	4.6	(117)	4.4	(112)	9.0	(229)	13.5	(344)	6.5	(165)	180.0	(4572)	100	45
4	(100)	300	18.8	(477)	4.6	(117)	4.8	(121)	10.0	(254)	14.0	(357)	6.5	(165)	180.0	(4572)	117	53
4	(100)	600	20.5	(521)	4.6	(117)	5.7	(144)	10.8	(273)	14.4	(366)	6.5	(165)	180.0	(4572)	151	68
4	(100)	900	21.5	(546)	4.6	(117)	6.2	(156)	11.5	(292)	14.8	(376)	6.5	(165)	180.0	(4572)	169	77
4	(100)	1500	22.3	(565)	4.6	(117)	6.5	(166)	12.3	(311)	15.2	(385)	6.5	(165)	180.0	(4572)	213	97
6	(150)	150	20.5	(521)	5.4	(137)	4.9	(123)	11.0	(279)	15.4	(390)	6.5	(165)	180.0	(4572)	166	75
6	(150)	300	21.3	(540)	5.4	(137)	5.2	(133)	12.5	(318)	16.1	(409)	6.5	(165)	180.0	(4572)	200	91
6	(150)	600	23.2	(590)	5.4	(137)	6.2	(158)	14.0	(356)	16.9	(428)	6.5	(165)	180.0	(4572)	278	126
6	(150)	900	25.0	(635)	5.4	(137)	7.1	(180)	15.0	(381)	17.4	(441)	6.5	(165)	180.0	(4572)	336	152
6	(150)	1500	27.5	(699)	5.4	(137)	8.4	(212)	15.5	(394)	17.6	(447)	6.5	(165)	180.0	(4572)	446	202
8	(200)	150	24.0	(610)	6.4	(163)	5.6	(142)	13.5	(343)	17.6	(447)	6.5	(165)	180.0	(4572)	308	140
8	(200)	300	24.8	(629)	6.4	(163)	6.0	(152)	15.0	(381)	18.4	(466)	6.5	(165)	180.0	(4572)	364	165
8	(200)	600	27.0	(686)	6.4	(163)	7.1	(180)	16.5	(419)	19.1	(485)	6.5	(165)	180.0	(4572)	470	213
8	(200)	900	29.3	(743)	6.4	(163)	8.2	(209)	18.5	(470)	20.1	(511)	6.5	(165)	180.0	(4572)	580	263
10	(250)	150	26.0	(660)	7.6	(193)	5.4	(137)	16.0	(406)	19.9	(506)	6.5	(165)	180.0	(4572)	481	218
10	(250)	300	27.2	(692)	7.6	(193)	6.0	(153)	17.5	(445)	20.7	(525)	6.5	(165)	180.0	(4572)	559	254
10	(250)	600	30.5	(775)	7.6	(193)	7.7	(194)	20.0	(508)	21.9	(557)	6.5	(165)	180.0	(4572)	757	343
10	(250)	900	33.0	(838)	7.6	(193)	8.9	(226)	21.5	(546)	22.7	(576)	6.5	(165)	180.0	(4572)	897	407
12	(300)	150	29.5	(749)	8.6	(218)	6.2	(156)	19.0	(483)	22.4	(569)	6.5	(165)	180.0	(4572)	687	312
12	(300)	300	30.7	(781)	8.6	(218)	6.8	(172)	20.5	(521)	23.2	(588)	6.5	(165)	180.0	(4572)	807	366
12	(300)	600	33.2	(844)	8.6	(218)	8.0	(204)	22.0	(559)	23.9	(607)	6.5	(165)	180.0	(4572)	977	443
12	(300)	900	36.8	(934)	8.6	(218)	9.8	(248)	24.0	(610)	24.9	(633)	6.5	(165)	180.0	(4572)	1177	534
14	(350)	150	32.0	(813)	9.4	(237)	6.7	(169)	21.0	(533)	24.0	(611)	6.5	(165)	180.0	(4572)	900	408
14	(350)	300	33.2	(844)	9.4	(237)	7.3	(185)	23.0	(584)	25.0	(636)	6.5	(165)	180.0	(4572)	1040	472
14	(350)	600	35.5	(902)	9.4	(237)	8.4	(213)	23.8	(603)	25.4	(646)	6.5	(165)	180.0	(4572)	1240	562
14	(350)	900	39.3	(997)	9.4	(237)	10.3	(261)	25.3	(641)	26.2	(665)	6.5	(165)	180.0	(4572)	1480	671
16	(400)	150	33.5	(851)	10.3	(262)	6.5	(164)	23.5	(597)	26.4	(671)	6.5	(165)	180.0	(4572)	1056	479
16	(400)	300	35.0	(889)	10.3	(262)	7.2	(183)	25.5	(648)	27.4	(696)	6.5	(165)	180.0	(4572)	1276	579
16	(400)	600	38.0	(965)	10.3	(262)	8.7	(221)	27.0	(686)	28.2	(715)	6.5	(165)	180.0	(4572)	1556	706
16	(400)	900	41.5	(1054)	10.3	(262)	10.5	(265)	27.8	(705)	28.5	(725)	6.5	(165)	180.0	(4572)	1766	801

Table 1-2: 4 Inch through 16 Inch Meter Body Dimensions and Weights

PIPE SIZE			A		B		C		D		F		G		L		Weight	
Inches	(DN)	* FLANGE	Inches	(mm)	Inches	(mm)	Inches	(mm)	Inches	(mm)	Inches	(mm)	Inches	(mm)	Inches	(mm)	lbs.	(kg)
18	(450)	150	37.0	(940)	11.4	(290)	7.1	180.2	25.0	(635)	28.2	(716)	6.5	(165)	180.0	(4572)	1170	(531)
18	(450)	300	38.5	(978)	11.4	(290)	7.8	199.3	28.0	(711)	29.7	(754)	7.5	(191)	180.0	(4572)	1510	(685)
18	(450)	600	41.0	(1041)	11.4	(290)	9.1	231.0	29.3	(743)	30.3	(770)	7.5	(191)	180.0	(4572)	1820	(826)
18	(450)	900	44.5	(1130)	11.4	(290)	10.8	(275)	31.0	(787)	31.2	(792)	7.5	(191)	180.0	(4572)	2230	1012
20	(500)	150	39.4	(1000)	12.4	(315)	7.3	185.0	27.5	(699)	29.8	(757)	8.5	(216)	180.0	(4572)	1310	(594)
20	(500)	300	40.8	(1035)	12.4	(315)	8.0	202.6	30.5	(775)	31.3	(795)	8.5	(216)	180.0	(4572)	1750	(794)
20	(500)	600	43.5	(1105)	12.4	(315)	9.3	237.4	32.0	(813)	32.0	(814)	8.5	(216)	180.0	(4572)	2130	(966)
20	(500)	900	48.0	(1219)	12.4	(315)	11.6	(295)	33.8	(857)	32.9	(836)	8.5	(216)	180.0	(4572)	2610	1184
24	(600)	150	44.0	(1118)	14.4	(366)	7.6	192.9	32.0	(813)	34.0	(865)	9.5	(241)	180.0	(4572)	1610	(730)
24	(600)	300	45.2	(1149)	14.4	(366)	8.2	208.7	36.0	(914)	36.0	(915)	9.5	(241)	180.0	(4572)	2250	(1021)
24	(600)	600	48.5	(1232)	14.4	(366)	9.8	250.1	37.0	(940)	36.5	(928)	9.5	(241)	180.0	(4572)	2750	(1247)
24	(600)	900	55.5	(1410)	14.4	(366)	13.3	(339)	41.0	(1041)	38.5	(979)	9.5	(241)	180.0	(4572)	4090	1855
26	(650)	150	43.5	(1105)	15.4	(391)	6.3	161.1	34.3	(870)	36.2	(919)	9	(229)	180.0	(4572)	1790	(812)
26	(650)	300	48.5	(1232)	15.4	(391)	8.8	(225)	38.3	(972)	38.2	(969)	9.0	(229)	180.0	(4572)	2400	1089
28	(700)	150	45.9	(1165)	16.4	(417)	6.5	166.0	36.5	(927)	38.3	(973)	10	(254)	180.0	(4572)	1970	(894)
28	(700)	300	51.5	(1308)	16.4	(417)	9.3	(237)	40.8	(1035)	40.4	(1027)	10.0	(254)	180.0	(4572)	2770	1256
30	(750)	150	48.8	(1239)	17.4	(442)	7.0	177.1	38.8	(984)	39.7	(1007)	10.5	(267)	180.0	(4572)	2160	(980)
30	(750)	300	54.5	(1384)	17.4	(442)	9.8	(250)	43.0	(1092)	41.8	(1061)	10.5	(267)	180.0	(4572)	3100	1406
32	(800)	150	51.4	(1305)	18.4	(468)	7.3	185.0	41.8	(1060)	42.2	(1071)	11.5	(292)	180.0	(4572)	2450	(1111)
32	(800)	300	57.5	(1461)	18.4	(468)	10.3	(263)	45.3	(1149)	43.9	(1115)	11.5	(292)	180.0	(4572)	3450	1565
34	(850)	150	53.8	(1366)	19.4	(493)	7.5	189.8	43.8	(1111)	44.2	(1122)	12.5	(318)	180.0	(4572)	2600	(1179)
34	(850)	300	60.2	(1530)	19.4	(493)	10.7	(272)	47.5	(1207)	46.0	(1169)	12.5	(318)	180.0	(4572)	3810	1728
36	(900)	150	56.4	(1432)	21.4	(544)	6.8	172.3	46.0	(1168)	46.3	(1176)	13	(330)	180.0	(4572)	2880	(1306)
36	(900)	300	63.0	(1600)	21.4	(544)	10.1	256.4	50.0	(1270)	48.3	(1227)	13	(330)	180.0	(4572)	4150	(1882)

Table 1-3: 18 Inch through 36 Inch Meter Body Dimensions and Weights

1.3.6 LEFM 220C LT Meter Body Specifications (Without J-Boxes)

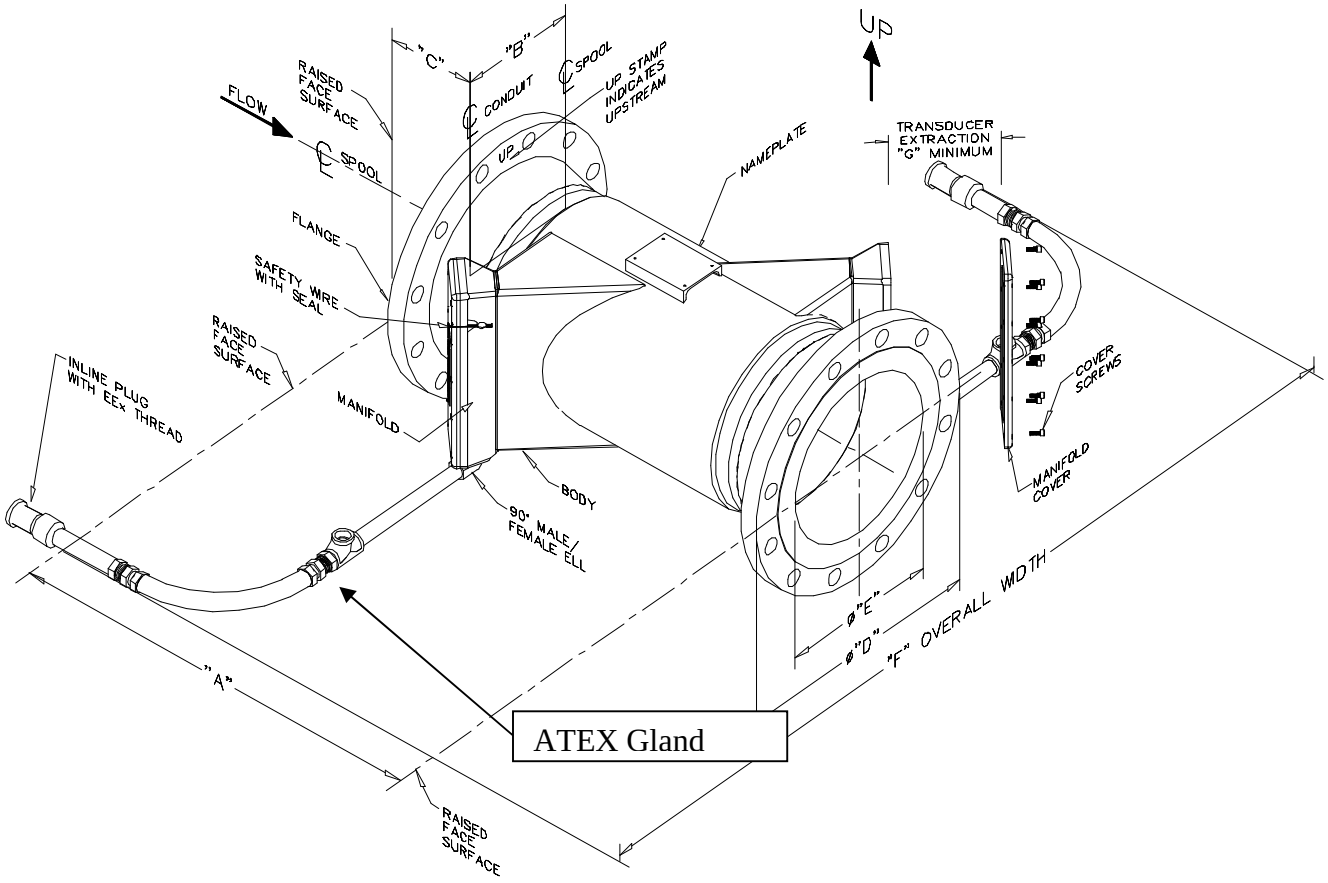


Figure 1-2: Construction Outline Drawing (220C LT Cryogenic Temperatures)

Note: Approved Seal at the End of the Tee/Fitting is required. The specific ATEX approved cable gland, as specified on ATEX Certificate, must be used. (See Appendix C of this manual for a copy of the ATEX Certificate).

PIPE SIZE			A		B		C		D		F		G		L		Weight	
Inches	(DN)	* FLANGE	Inches	(mm)	Inches	(mm)	Inches	(mm)	Inches	(mm)	Inches	(mm)	Inches	(mm)	Inches	(mm)	lbs.	(kg)
4	(100)	150	18.0	(457)	4.6	(117)	4.4	(112)	9.0	(229)	53.2	(1351)	6.5	(165)	180.0	(4572)	100	(45)
4	(100)	300	18.8	(477)	4.6	(117)	4.8	(121)	10.0	(254)	53.2	(1351)	6.5	(165)	180.0	(4572)	117	(53)
4	(100)	600	20.5	(521)	4.6	(117)	5.7	(144)	10.8	(273)	53.2	(1351)	6.5	(165)	180.0	(4572)	151	(68)
4	(100)	900	21.5	(546)	4.6	(117)	6.2	(156)	11.5	(292)	53.2	(1351)	6.5	(165)	180.0	(4572)	169	(77)
4	(100)	1500	22.3	(565)	4.6	(117)	6.5	(166)	12.3	(311)	53.2	(1351)	6.5	(165)	180.0	(4572)	213	(97)
6	(150)	150	20.5	(521)	5.4	(137)	4.9	(123)	11.0	(279)	54.8	(1392)	6.5	(165)	180.0	(4572)	166	(75)
6	(150)	300	21.3	(540)	5.4	(137)	5.2	(133)	12.5	(318)	54.8	(1392)	6.5	(165)	180.0	(4572)	200	(91)
6	(150)	600	23.2	(590)	5.4	(137)	6.2	(158)	14.0	(356)	54.8	(1392)	6.5	(165)	180.0	(4572)	278	(126)
6	(150)	900	25.0	(635)	5.4	(137)	7.1	(180)	15.0	(381)	54.8	(1392)	6.5	(165)	180.0	(4572)	336	(152)
6	(150)	1500	27.5	(699)	5.4	(137)	8.4	(212)	15.5	(394)	54.8	(1392)	6.5	(165)	180.0	(4572)	446	(202)
8	(200)	150	24.0	(610)	6.4	(163)	5.6	(142)	13.5	(343)	56.8	(1443)	6.5	(165)	180.0	(4572)	308	(140)
8	(200)	300	24.8	(629)	6.4	(163)	6.0	(152)	15.0	(381)	56.8	(1443)	6.5	(165)	180.0	(4572)	364	(165)
8	(200)	600	27.0	(686)	6.4	(163)	7.1	(180)	16.5	(419)	56.8	(1443)	6.5	(165)	180.0	(4572)	470	(213)
8	(200)	900	29.3	(743)	6.4	(163)	8.2	(209)	18.5	(470)	56.8	(1443)	6.5	(165)	180.0	(4572)	580	(263)
10	(250)	150	26.0	(660)	7.6	(193)	5.4	(137)	16.0	(406)	59.2	(1504)	6.5	(165)	180.0	(4572)	481	(218)
10	(250)	300	27.2	(692)	7.6	(193)	6.0	(153)	17.5	(445)	59.2	(1504)	6.5	(165)	180.0	(4572)	559	(254)
10	(250)	600	30.5	(775)	7.6	(193)	7.7	(194)	20.0	(508)	59.2	(1504)	6.5	(165)	180.0	(4572)	757	(343)
10	(250)	900	33.0	(838)	7.6	(193)	8.9	(226)	21.5	(546)	59.2	(1504)	6.5	(165)	180.0	(4572)	897	(407)
12	(300)	150	29.5	(749)	8.6	(218)	6.2	(156)	19.0	(483)	61.2	(1554)	6.5	(165)	180.0	(4572)	687	(312)
12	(300)	300	30.7	(781)	8.6	(218)	6.8	(172)	20.5	(521)	61.2	(1554)	6.5	(165)	180.0	(4572)	807	(366)
12	(300)	600	33.2	(844)	8.6	(218)	8.0	(204)	22.0	(559)	61.2	(1554)	6.5	(165)	180.0	(4572)	977	(443)
12	(300)	900	36.8	(934)	8.6	(218)	9.8	(248)	24.0	(610)	61.2	(1554)	6.5	(165)	180.0	(4572)	1177	(534)
14	(350)	150	32.0	(813)	9.4	(237)	6.7	(169)	21.0	(533)	62.7	(1593)	6.5	(165)	180.0	(4572)	900	(408)
14	(350)	300	33.2	(844)	9.4	(237)	7.3	(185)	23.0	(584)	62.7	(1593)	6.5	(165)	180.0	(4572)	1040	(472)
14	(350)	600	35.5	(902)	9.4	(237)	8.4	(213)	23.8	(603)	62.7	(1593)	6.5	(165)	180.0	(4572)	1240	(562)
14	(350)	900	39.3	(997)	9.4	(237)	10.3	(261)	25.3	(641)	62.7	(1593)	6.5	(165)	180.0	(4572)	1480	(671)
16	(400)	150	33.5	(851)	10.3	(262)	6.5	(164)	23.5	(597)	64.6	(1641)	6.5	(165)	180.0	(4572)	1056	(479)
16	(400)	300	35.0	(889)	10.3	(262)	7.2	(183)	25.5	(648)	64.6	(1641)	6.5	(165)	180.0	(4572)	1276	(579)
16	(400)	600	38.0	(965)	10.3	(262)	8.7	(221)	27.0	(686)	64.6	(1641)	6.5	(165)	180.0	(4572)	1556	(706)
16	(400)	900	41.5	(1054)	10.3	(262)	10.5	(265)	27.8	(705)	64.6	(1641)	6.5	(165)	180.0	(4572)	1766	(801)

Table 1-4: 4 Inch through 16 Inch Meter Body Dimensions and Weights 220C LT (Cryogenic Temperatures)

2.0 INSTALLATION

The transmitter and meter body of the LEFM 220C are shipped as a matched set. The exact physical properties, acoustic properties, and calibration of the meter body are pre-programmed into the transmitter. **When installing multiple units ensure that the transmitter and meter body pair remain together.**

220C LT units outfitted for cryogenic temperatures will have short cables with connectors attached to the meter body. The mating cables are attached to the transmitters. The connections in Table 2-1 are only for reference when using cables with connectors.

2.1 Transmitter

WARNING

DO NOT OPEN WHEN ENERGIZED!

BEFORE INSPECTING COMPONENTS
OPEN THE LEFM 220C CIRCUIT BREAKER
TO AVOID ELECTRICAL SHOCK AND/OR EXPLOSION HAZARD.

The LEFM 220C meter is designed to be used under a wide variety of process and environmental conditions. Durable construction permits conventional installation practices. The transmitter should be installed in an environment consistent with the ratings of the enclosure (i.e., NEMA 4X or Explosion Proof). All wiring to and from the transmitter must be put in grounded metal conduit or equivalent. Mounting must use the mounting points indicated in Figure 2-1 and Figure 2-3. No ventilation is required, other than that is necessary to meet the ambient temperature requirements.

2.1.1 Transmitter Mounting

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 site 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).
- Use ¼ inch bolts/hardware (or equal) on at least the 2 top and 2 bottom mounting points for the NEMA 4X transmitter.

The transmitter 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.

2.1.2 Field Terminations

The following installation instructions are for current revision of boards. This revision has blue circuit boards. For older units with green circuit boards, refer to Appendix B of this manual for wiring.

The wiring should be routed to the transmitter in shielded conduit that meets site environment specifications. All terminations should be made according to Table 2-1 through Table 2-5. For full environmental temperature range all wiring (conductors) should be rated for a minimum of 194°F (90°C). All supply wiring must be rated to 300 volts AC (18 AWG). Equipment must be installed by a licensed electrician, in accordance with NEC/CEC or local codes. As a minimum, a disconnect switch should be installed before and near the transmitter power input. The external disconnect device must be an approved device rated for the supply voltages and is rated to 3 Amps (or 15 Amps for the 24 Volts DC) and provide a minimum of 3.0 mm spacing.

Explosion Proof enclosures must be installed with rigid conduit with stopping boxes / seal fittings installed within 3 inches (75 mm) of the enclosure.

The Figure 2-1, Figure 2-2, Figure 2-3, and Figure 2-4 illustrate the conduit connections for the LEFM 220C Transmitter and the transmitter layout.

2.1.3 Terminations - Digital Signals

Terminal block TB5 has all the digital outputs and inputs. These are listed as follows:

TB5-1 Volume pulses (0-5 Volts)
TB5-2 Volume pulses (0-5 Volts)
TB5-3 Volume pulses (Quadrature 0-5 Volts) See Section 2.2.3
TB5-4 Flow direction (5 Volts forward, 0 Volts reverse)
TB5-5 Status (5 Volts normal, 0 Volts alarm)
TB5-7 Ground, return for all signals
TB5-9 External trigger (GSS signal) this is used and is for exceptional site installations. Use of this feature is ONLY done with Cameron input.

2.1.4 Grounding/Earthing (Meter Body and Transmitter)

The meter body and transmitter have grounding/earthing points available. There are grounding points on the inside of the junction box at the meter body and on the outside of the junction box and the manifold. There are grounding points on the inside and outside of the transmitter enclosure. For ATEX applications, both grounding points must be used. Follow all other site guidelines regarding grounding/earthing. See Figure 1-1 and Figure 1-2 for earthing points on the meter body.

2.2 Flow Meter Body

WARNING

DO NOT OPEN WHEN ENERGIZED!

BEFORE INSPECTING COMPONENTS
OPEN THE LEFM 220C CIRCUIT BREAKER
TO AVOID ELECTRICAL SHOCK AND/OR EXPLOSION HAZARD.

No external supports or special mounting pads are specifically required or recommended for the LEFM 220C meter body. However, the piping immediately upstream and downstream of the flow meter should be well supported in accordance with good piping practices and site seismic requirements. See Table 1-2 and Table 1-3 for weights and sizes of the LEFM 220C Flow Meter. The flow meter body can be installed in either horizontal or vertical piping runs. When it is installed in horizontal piping, the acoustic paths should be horizontal to decrease the likelihood of the accumulation of water, gas, or debris in the sensor wells.

The flow meter body is typically fabricated of stainless steel, carbon steel, or duplex steel, depending on customer requirements. The flow meter is designed such that it is as strong as or stronger than pipe and flanges of the same schedule, pressure class and material. Site stress analysis can conservatively treat the meter as equivalent pipe.

2.2.1 Meter Body Terminations

The meter body terminations are defined in Table 2-1. For hazardous environments, the connections from the meter body junction box to the electronics must be through rigid conduit or approved equals with stopping boxes/seal fittings installed within 18 inches (450 mm) of the junction box(es). (For ATEX see the certificate for the conditions for safe use).

2.2.2 Upstream and Downstream Piping

It is recommended that the LEFM 220C meter body be installed downstream of at least 20 diameters of straight pipe of the same nominal diameter as the meter or 10 diameters downstream of a straightening/conditioning element. Downstream there should be at least 3 diameters of straight pipe of the same nominal diameter as the meter. These conditions minimize the possibility of significant flow profile distortions and swirl.

2.2.3 Flow Direction

The LEFM 220C Meter is a bidirectional meter with a quadrature pulse output available to indicate direction of flow (Reference Table 2-4). Pulse output A leading pulse output B by 90° indicates forward flow while pulse output B leading pulse output A by 90° indicates reverse flow with respect to the flow arrow of the nameplate. To ensure that the flow indication is displayed correctly, the fluid should flow in the same direction as the arrow on the meter body nameplate.

2.2.4 Gas (Air) in the Flow Stream

The LEFM 220C Flow Meter should be installed such that minimal entrained gas will reach it (2% or less, as a rule of thumb). Although ultrasonic meters can provide accurate measurement when there is a small volume of entrained gas in the flow stream, better performance can be achieved by eliminating it.

Certain operations can introduce air into the flow stream. Various types of leaks in a liquid handling system can draw air into the flow stream. Also, pressure loss through a system can allow gas to break out (flash). Operators must be aware of these conditions/operations and assure that the amount of gas reaching the sensor is kept to a minimum. Slugs of gas in the flow stream do not damage the meter. Continuous presence of gas in the LEFM 220C will give a fault indication. In the worst case, all the sensors will stop indicating and no measurements will take place.

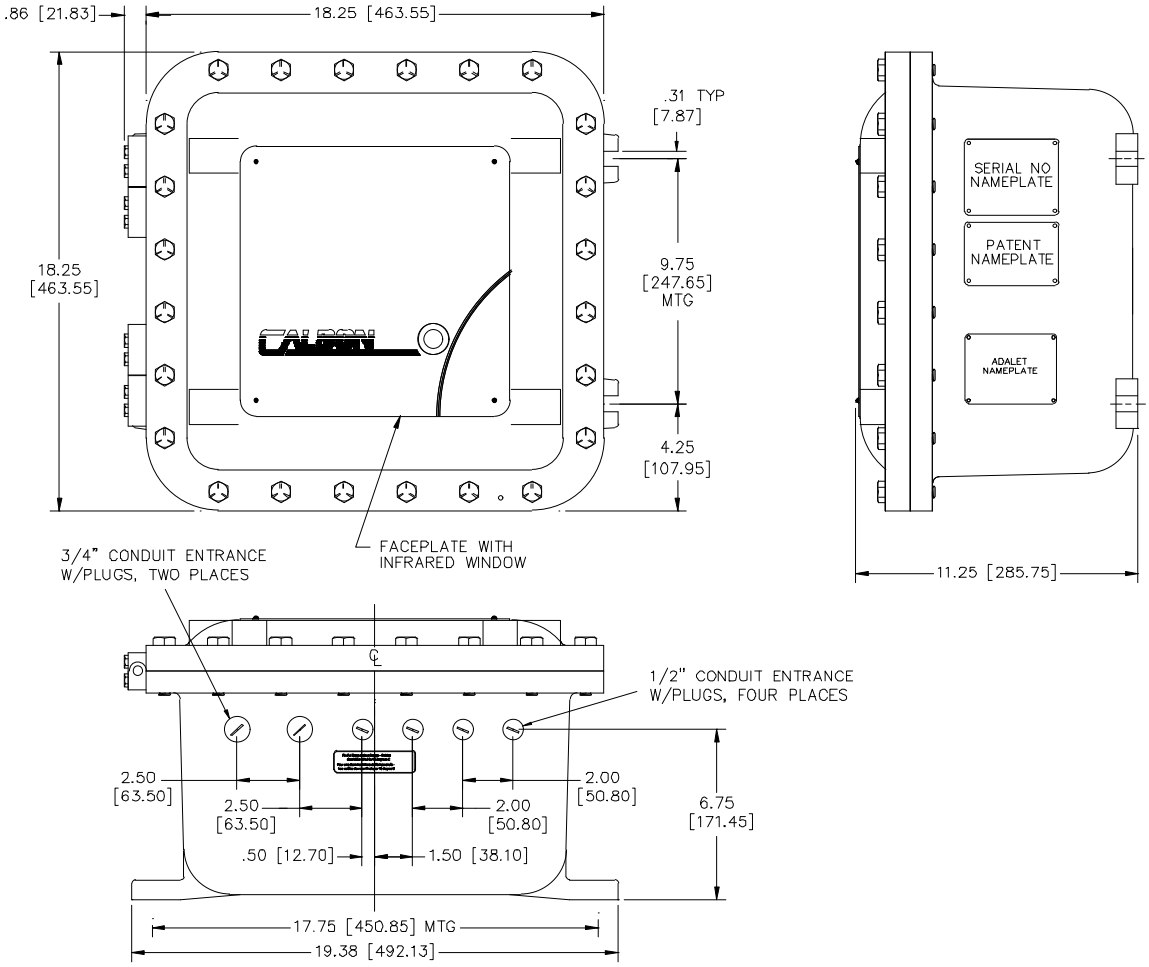


Figure 2-1: Explosion Proof Enclosure (Units in Inches [mm])

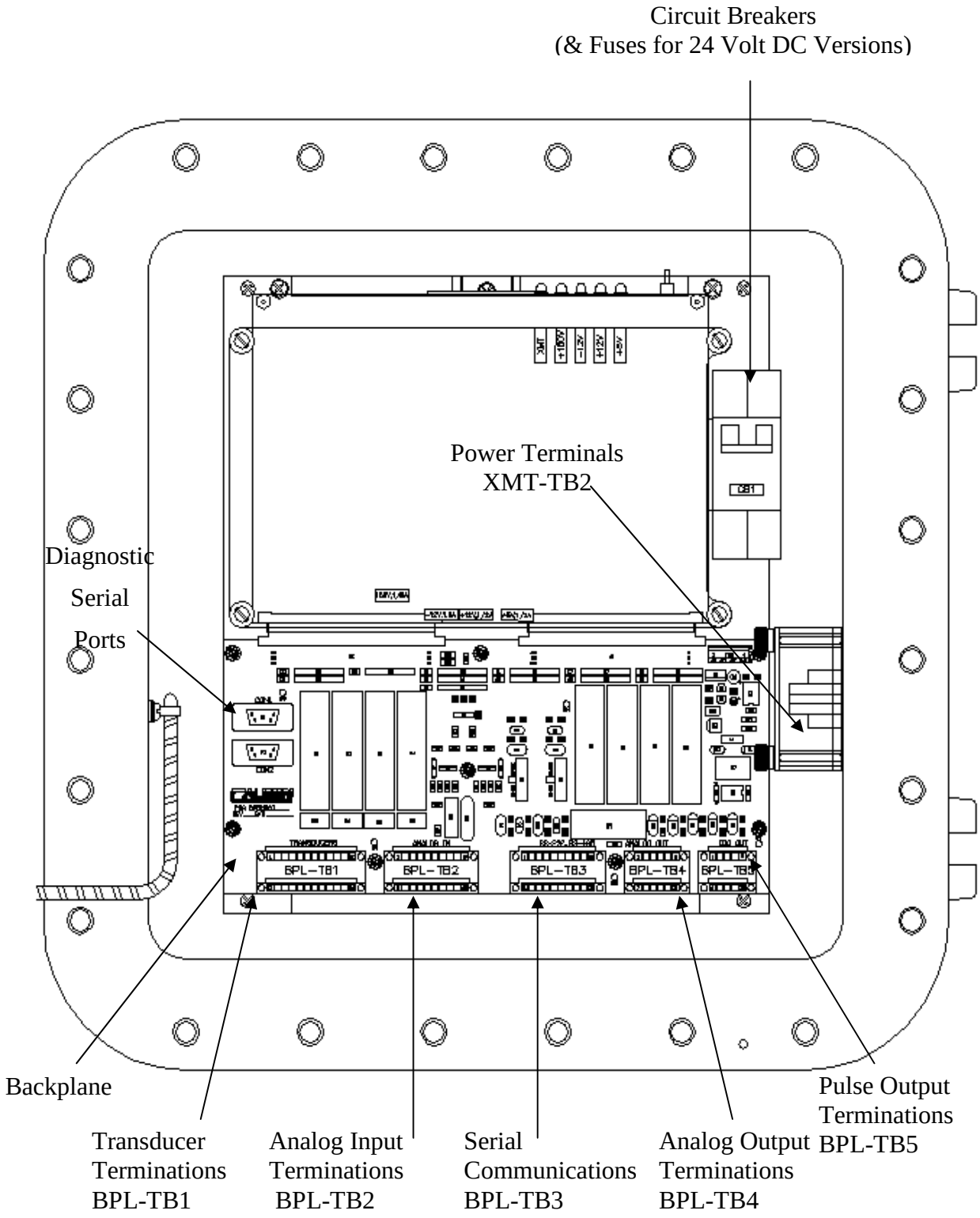


Figure 2-2: Explosion Proof Enclosure with Cover Open

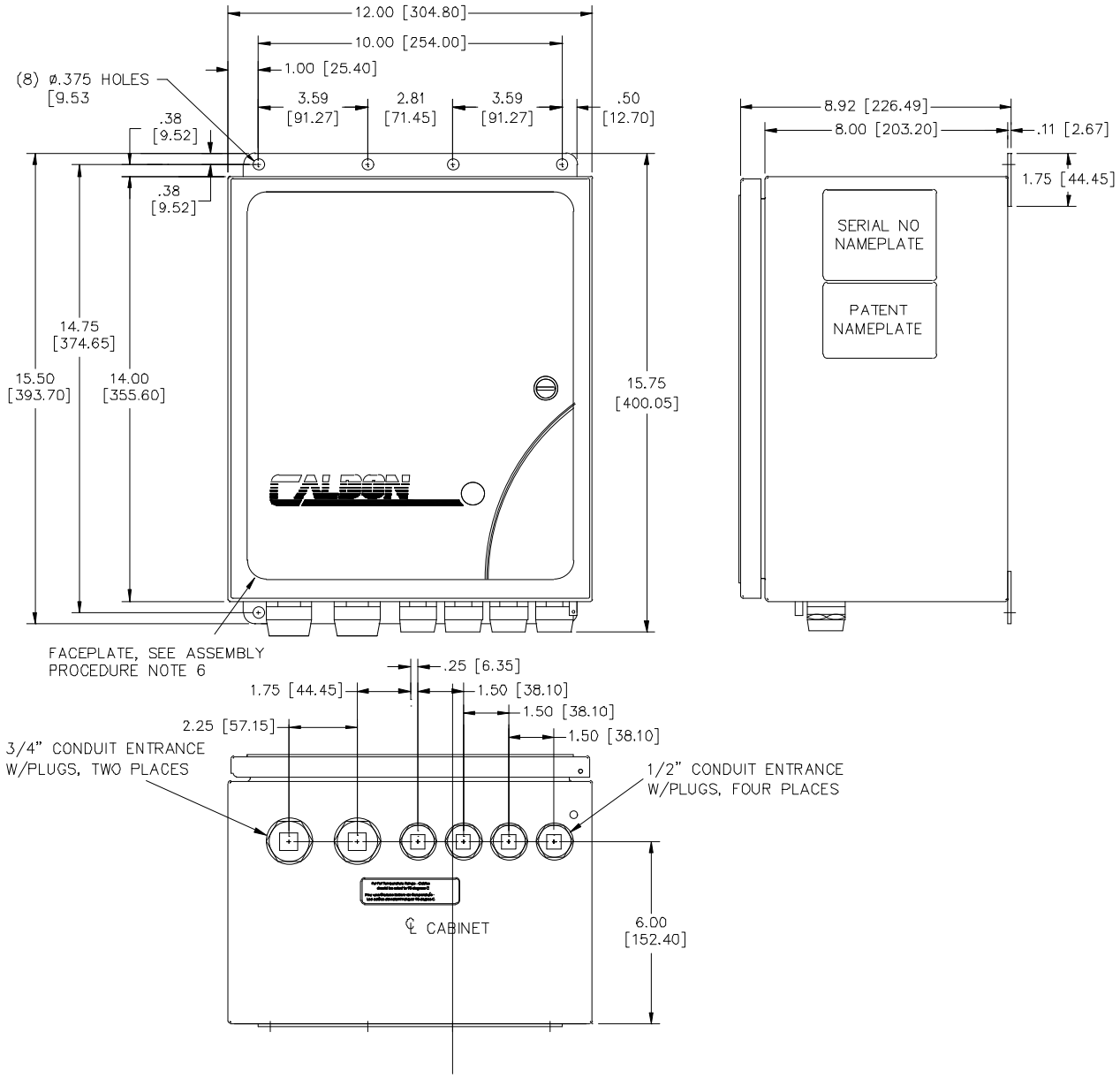


Figure 2-3: NEMA 4X Enclosure (Units in Inches [mm])

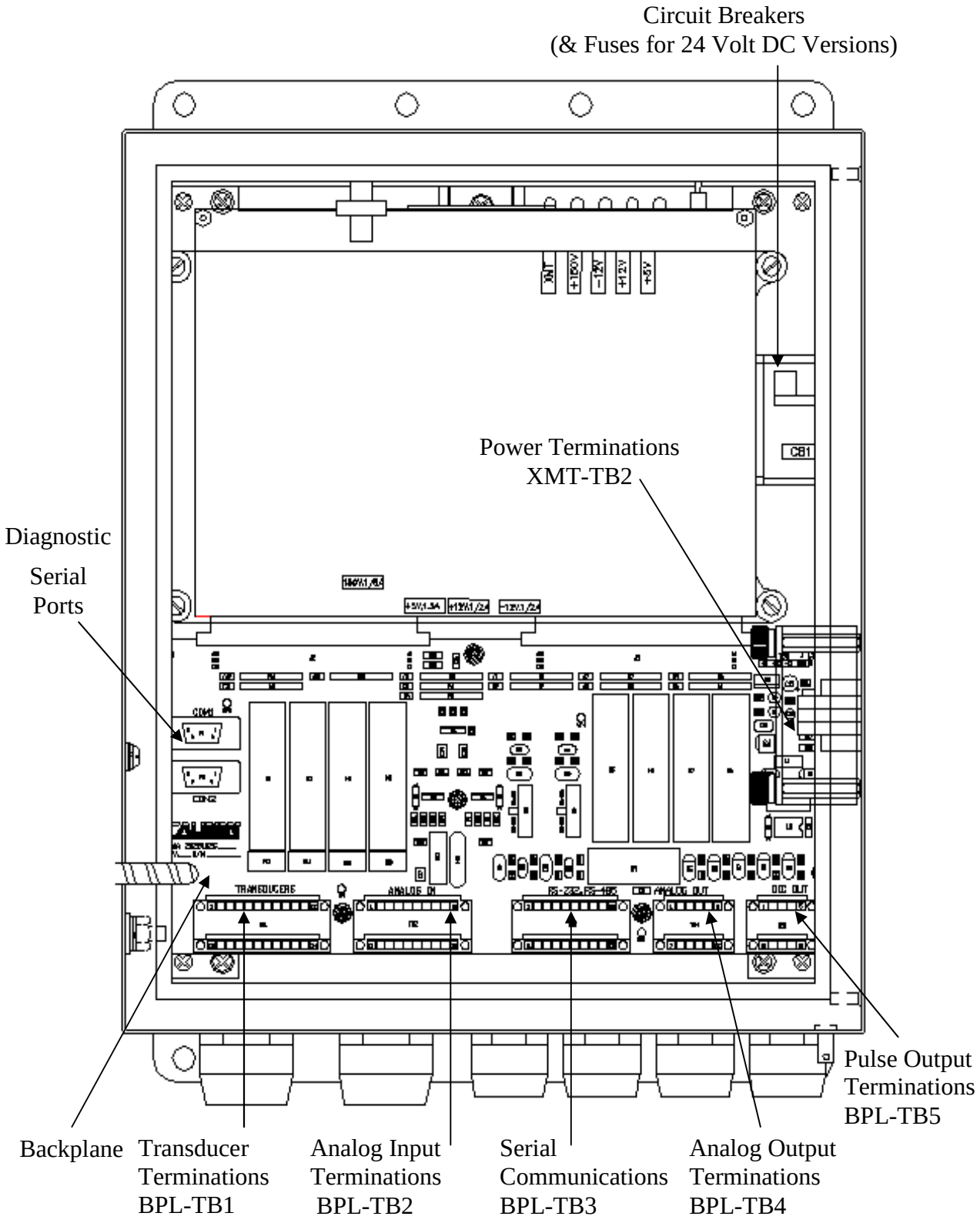


Figure 2-4: NEMA 4X Enclosure with Door Open

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

Table 2-1: LEFM 220C Transducer and RTD Terminations
(2 junction boxes)

Analog Input Source	RTD Connection			0, 4 - 20 mA Connection		
	Description	Terminus	Module Type	Description	Terminus	Module Type
Meter Temperature See Tables 2-1, 2-2, & 2-3	RTD +	TB2-1	100Ω Pt -100°C to 100°C, MB34-01 (Typical, See Table 4-2)			
	RTD +	TB2-2				
	Shield	TB2-3				
	RTD -	TB2-4				
	RTD -	TB2-5				
Pressure				0, 4-20 mA +	TB2-6	4 - 20 mA = MB32-01 0 - 20 mA = MB32-02
				Shield	TB2-8	
				0, 4-20 mA -	TB2-10	
Fluid Temperature	RTD +	TB2-11	100Ω Pt -100°C to 100°C, MB34-01 (Typical, See Table 4-2)	0, 4-20 mA +	TB2-11	
	RTD +	TB2-12				
	Shield	TB2-13		Shield	TB2-13	
	RTD -	TB2-14				
	RTD -	TB2-15		0, 4-20 mA -	TB2-15	
Density				0, 4-20 mA +	TB2-16	
				Shield	TB2-18	
				0, 4-20 mA -	TB2-20	

Table 2-2: Analog Input Customer Connection Locations (Located on Backplane)

Typical Analog Output*	Signal Description	Terminus	Module Location
Flow	4,0-20 mA + (high)	TB4-1	M5
	Shield	TB4-2	
	4,0-20 mA – (low)	TB4-3	
Sound Velocity	4,0-20 mA + (high)	TB4-4	M6
	Shield	TB4-5	
	4,0-20 mA – (low)	TB4-6	
Temperature	4,0-20 mA + (high)	TB4-7	M7
	Shield	TB4-8	
	4,0-20 mA – (low)	TB4-9	
Specific Gravity	4,0-20 mA + (high)	TB4-10	M8
	Shield	TB4-11	
	4,0-20 mA – (low)	TB4-12	

Table 2-3: Analog Output Customer Connection Locations (Located on Backplane)

*Note: Other variables can be mapped to the analog outputs. Contact Cameron's Measurement Systems division for specifics.

Pulse Output	Signal Description	Terminus
A-1	+5 V, A leads B by 90 degrees to indicates forward flow	TB5-1
A-2		TB5-2
B	+5 V, B leads A by 90 degrees to indicate reverse flow	TB5-3
Direction	+5V Forward Flow, 0V Reverse Flow	TB5-4
Status	+0 V, indicates alarm condition meter +5 V, indicates normal operation	TB5-5
Ground	Ground	TB5-7
GSS +	GSS Input Signal	TB5-9
GSS RTN	GSS Return	TB5-10

Table 2-4: Pulse and Digital Output Wiring

Power Connectivity	Description	terminus
120 VAC	LINE	1
	Neutral	2
	Ground/Earth	3
24 VDC	+24 VDC	1
	24 VDC Return	2
	Ground/Earth	3
230 VAC	LINE 1	1
	LINE 2	2
	Ground/Earth	3

Table 2-5: Power Connections

(Only one type of power should be connected)

PORT NAME	Termination	RS-232* BPL-S3, S4 = RS-232	RS-422/485 Full Duplex** BPL-S3, S4 = RS-485 E6, E7 jumpered 2-3	RS-485 Half Duplex** BPL-S3, S4 = RS-485 E6, E7 jumpered 1-2
COM3	BPL-TB3-11	Transmit (Tx)	A, Noninverting Receive (+Rc)	
	BPL-TB3-12	Ground (GND)	B, Inverting Receive (-Rc)	
	BPL-TB3-13	Receive (Rc)	Z, Inverting Transmit (-Tx)	Z, Inverting Transmit/Receive (- Data)
	BPL-TB3-14	+5 Volts	Y, Noninverting Transmit (+Tx)	Y, Noninverting Transmit/Receive (+Data)
	BPL-TB3-15		Ground	
COM4	BPL-TB3-16	Transmit (Tx)	A, Noninverting Receive (+Rc)	
	BPL-TB3-17	Ground (GND)	B, Inverting Receive (-Rc)	
	BPL-TB3-18	Receive (Rc)	Z, Inverting Transmit (-Tx)	Z, Inverting Transmit/Receive (- Data)
	BPL-TB3-19	+5 Volts	Y, Noninverting Transmit (+Tx)	Y, Noninverting Transmit/Receive (+Data)
	BPL-TB3-20		Ground	

Table 2-6: RS-232, 422/485 Serial Communications

*RS-232 selected when S3 (COM3) and S4 (COM4) on the transmitter backplane are positioned toward "RS-232".

**RS-422/485 are selected when S3 (COM3) and S4 (COM4) on the transmitter backplane are positioned toward "RS-485". Jumpering E6 (COM3) and E7 (COM4) on the transmitter backplane to positions 1-2 selects half duplex mode (RS-485). Jumpering E6 (COM3) and E7 (COM4) on the transmitter backplane to positions 2-3 selects full duplex mode RS-422/485).

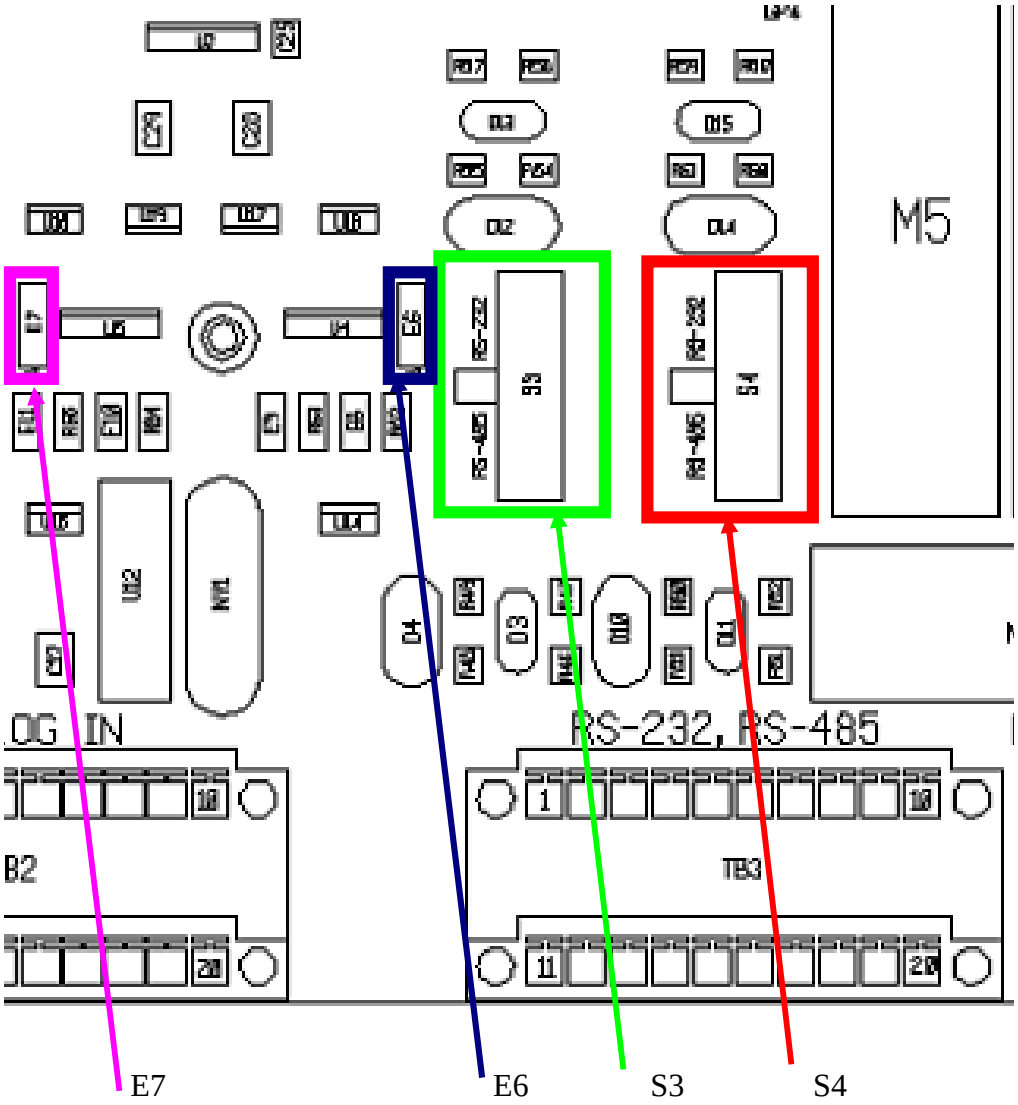


Figure 2-5: RS-485 Switch and Jumper Position

Fuse	Size/Type	Function
F1	3.15 Amp (time delay)	Electronics
F2	5.0 Amp (fast acting)	Heaters for cold ambient applications

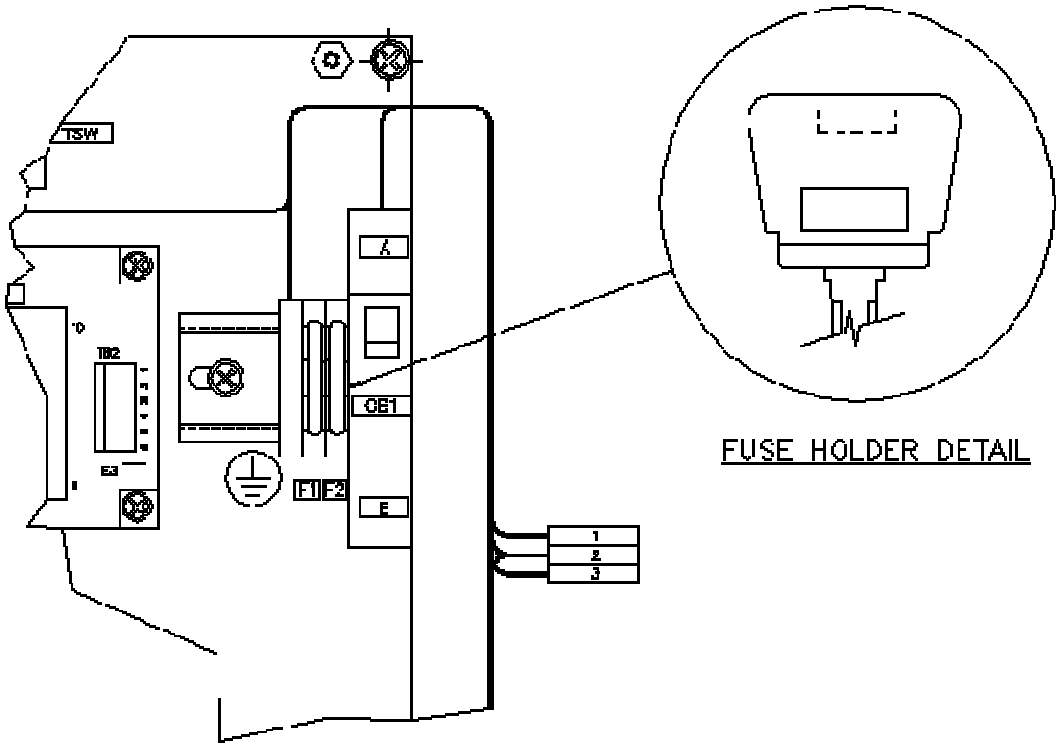


Figure 2-6: 24 Volt DC Fuses

2.3 Meter Installation Check-Out

WARNING

DO NOT OPEN WHEN ENERGIZED!

BEFORE INSPECTING COMPONENTS
OPEN THE LEFM 220C CIRCUIT BREAKER
TO AVOID ELECTRICAL SHOCK AND/OR EXPLOSION HAZARD.

The following steps are recommended to checkout a meter's installation. See Section 5 for Troubleshooting and Caldon EFP-70.

Step 1: Verify meter's installation is hydraulically acceptable (horizontal preferred), and adequate upstream hydraulics. Upstream pipe diameter is concentric with meter body.

Step 2: Verify all field terminations have proper continuity and isolation from each other and earth. Verify connections are good with respect to insulation.

Step 3: Verify electronics turn on (all LEDs lighted).

Step 4: Verify ModBus communications (Use Caldon LEFMLink software or plant computer to communicate). Verify meter operation according to Section 5.

Step 5: Verify Analog Outputs, preferably using LEFMLink to force outputs (current and pulses). Forcing outputs verifies connections to site instruments. Verify observed forced outputs are within 0.1% on current and 0.01% on pulse frequency. Return meter to normal operation.

Step 6: If pipe is full of liquid, verify acoustic signals have Rejects < 2% and SNR (signal to noise ratio) > 40 (or >20 for higher viscosities). Verify standard deviation is less than 4% (at flowing conditions). See Section 5.0

3.0 OPERATION

3.1 Measuring Velocities

LEFM Ultrasonic Flow Meters 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 will be shorter for pulses, which travel downstream with the flow, than for the pulses which 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 pipe axis

θ = angle between path and pipe centerline

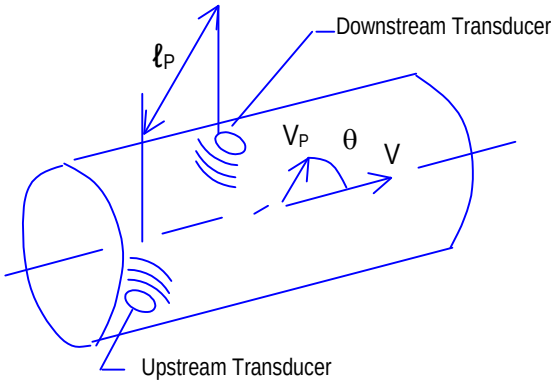


Figure 3-1: Flow Velocities Along the Ultrasonic Path and the Pipe Axis

When pulses travel upstream and downstream during the same time, the above equations may be treated as simultaneous, and solved for the two unknowns, C_f and V_p.

Solving for V_p and taking into account path angle θ

$$V = \frac{\ell_P}{2\cos\theta} \bullet \frac{T_U - T_D}{T_D\ T_U}$$

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

3.2 Measuring Flowrate

LEFM Ultrasonic Flow Meters are capable of measuring velocities along a multiple of acoustical paths arranged across the flow pattern in the pipe. The accuracy and repeatability of the flow measurement increases with the numbers of acoustic paths. A single plane system has all the acoustical paths laid out in a single acoustical plane as shown in Figure 3.2. The plane is oriented at an angle θ (path angle) with respect to the centerline of the pipe.

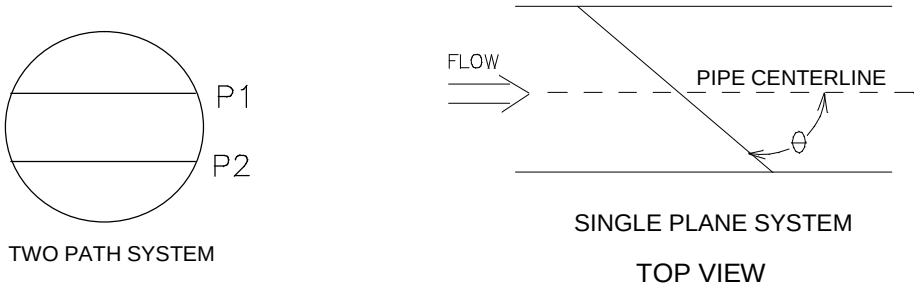


Figure 3-2: Acoustical Path Configurations

During manufacturing, precision measurements of inside diameter, path lengths and path angles are taken and are inserted into the equation for volume flowrate.

For maximum accuracy, the LEFM 220C automatically compensates for pipe thermal expansion and contraction.

Likewise, net flow is available when fluid temperature and pressure are continuously monitored and correction factors maybe applied to the flowrate equation that takes into account the changes in fluid expansion due to pressure and temperature. See Section 3.6.

3.3 LEFM 220C Transmitter

The LEFM 220C transmitter contains three major functional units, the Acoustic Processing Unit (APU), the Backplane, and the power supply. The Acoustic Processing Unit is a specialized board proprietary to Cameron. It is designed to achieve high sampling rates, stable ultrasonic signals, and no zero drift.

The APU board performs all control and timing for the generation and measurement of acoustic pulses. The APU board has a microprocessor programmed to perform the following functions:

- Step through the ultrasonic path cycles and test cycles.
- Provide Gain Control for each ultrasonic path.
- Compute flow.
- Compute gross to net conversions
- Generate pulse and analog outputs.

Setups to the APU are provided by a serial link through the backplane.

3.4 LEFM 220C Fault Detection

The LEFM 220C performs the following automatic fault detection:

- Checks data quality for ultrasonic paths. Evaluates data against thresholds. The data is evaluated based on SNR (signal to noise ratio), cross-correlation tests and signal statistics.
- For each ultrasonic path, the APU determines if the path has failed.
- Occasional rejected or bad data does not influence the operation. However, if an ultrasonic path continues to fail, the meter will alert the operators with the "ALARM" status and an error code.

The APU outputs the current status on the serial port and the digital output. The status may be one of the following:

- "NORMAL" status
- "ALARM" status – 1 path failed - flow computed with a lower accuracy
- "ALARM" status – all paths failed - flow is set to zero (0)

Path status, each ultrasonic path the codes (Reference Caldon ModBus Specifications) are:

- 0 – Path operating normally
- 1 – Path rejecting data due to low SNR, irregular statistics or failing cross-correlation tests
- 6 – Path sound velocities are inconsistent with thresholds (typically up to 2% spread between paths is acceptable)
- 8 - Path velocity inconsistent at low flows
- 10 - Path fails impedance self test
- 11 - Electronics fails clock accuracy test

3.5 Gross to Net Flowrate Conversion

Net volumetric flowrate is calculated by correcting gross volumetric flowrate to standard product conditions of 60° F and 0 psig.

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

The LEFM 220C computes a temperature correction factor and pressure correction factor typically based on the following references

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

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

The required inputs for gross to net calculations include:

- Gross flowrate
- Product temperature
- Product pressure

The specific gravity used for all the gross to net conversions are either hard coded or automatically computed by the LEFM 220C. The automatic calculation is based on API tables, sound velocity, temperature and pressure.

3.6 Remote Data Communications

The LEFM 220C has three communication ports using the ModBus protocol. See the ModBus Manual for more detail. One serial port is dedicated to the IR serial interface. The second and third serial ports can be accessed via direct connection (RS-232, or optional RS-422/RS-485).

4.0 MAINTENANCE

WARNING: NO OPERATOR ACCESS IS PERMITTED IN THE UNIT. SERVICE SHOULD ONLY BE PERFORMED BY QUALIFIED PERSONNEL.

4.1 Introduction

The purpose of this section is to provide procedures for troubleshooting and maintenance tasks which personnel can perform on each LEFM 220C. These procedures may be incorporated into the customer's standard maintenance program.

This section includes procedures for maintaining the LEFM 220C that are designed for a trained maintenance technician to perform. These procedures may require the maintenance person to reference schematics, system connection diagrams, and construction outlines in Section 0.

4.2 General Inspections - Preventative Maintenance Procedures

WARNING

DO NOT OPEN WHEN ENERGIZED!

BEFORE INSPECTING COMPONENTS
OPEN THE LEFM 220C CIRCUIT BREAKER
TO AVOID ELECTRICAL SHOCK AND/OR EXPLOSION HAZARD.

CAUTION

WEAR AN ESD PROTECTIVE
WRIST STRAP TO AVOID
DAMAGING ANY COMPONENTS

This procedure covers the inspection of the electronics unit, transducers, metering sections, and cables.

Enclosure Inspection

Perform the following inspections on each enclosure:

a. Verify electronic unit enclosure has suffered no structural damage. Report any damage to proper maintenance supervisor.

b. Remove dust, dirt, and other soiling from enclosure. If necessary, remove power to the LEFM 220C by opening circuit breaker CB1.

c. Inspect access cover gaskets. Clean gaskets and mating surfaces on enclosure with water if they are dirty; remove any corrosion from mating surfaces. Verify gaskets compress when cover is installed and fastened to enclosure.

d. Inspect door latch mechanism.

e. Lubricate door hinges with lubricant specified on enclosure.

f. Inspect enclosure mounting and fastening hardware.

Internal Electronics Inspection

a. If necessary, remove power to the LEFM 220C by opening circuit breaker CB1.

b. Put on an ESD (Electrostatic Discharge) protective wrist strap. Connect ESD protective wrist strap to a known ground; any part of enclosure structure is an acceptable ground.

c. Inspect cable entry points to assure that cable insulation is undamaged. Inspect cables that cross hinges to assure that cable insulation is undamaged.

d. Inspect cable connections for tightness. Clean connections if fouled or corroded with electronic contact cleaning fluid.

e. Inspect all internal connections and terminals for tightness, clean connectors and terminals if fouled or corroded with electronic contact cleaning fluid.

f. Inspect fuses to assure that they are not damaged or discolored. Replace any damaged or blown fuses.

g. Inspect display panel components (if equipped) and devices for damage. Replace any damaged components. Check all connectors to see that each is properly seated. Check that all devices are securely mounted.

h. Inspect acoustical processing unit (APU) components and devices for damage. Check that the printed circuit boards are properly seated. Check that devices are securely mounted. Clean dust and grime from the surface of all components using compressed air or a PC parts cleaner.

i.  **Caution:** There are heaters located behind the backplane surface may be hot.

j. Clean dust and grime from all surfaces of the enclosure interior walls using compressed air or a PC parts cleaner.

4.3 Power Supply Voltage Troubleshooting and Maintenance

With the unit energized and the system software executing, verify by looking at the top edge of the APU cards that the following indicator lights are on:

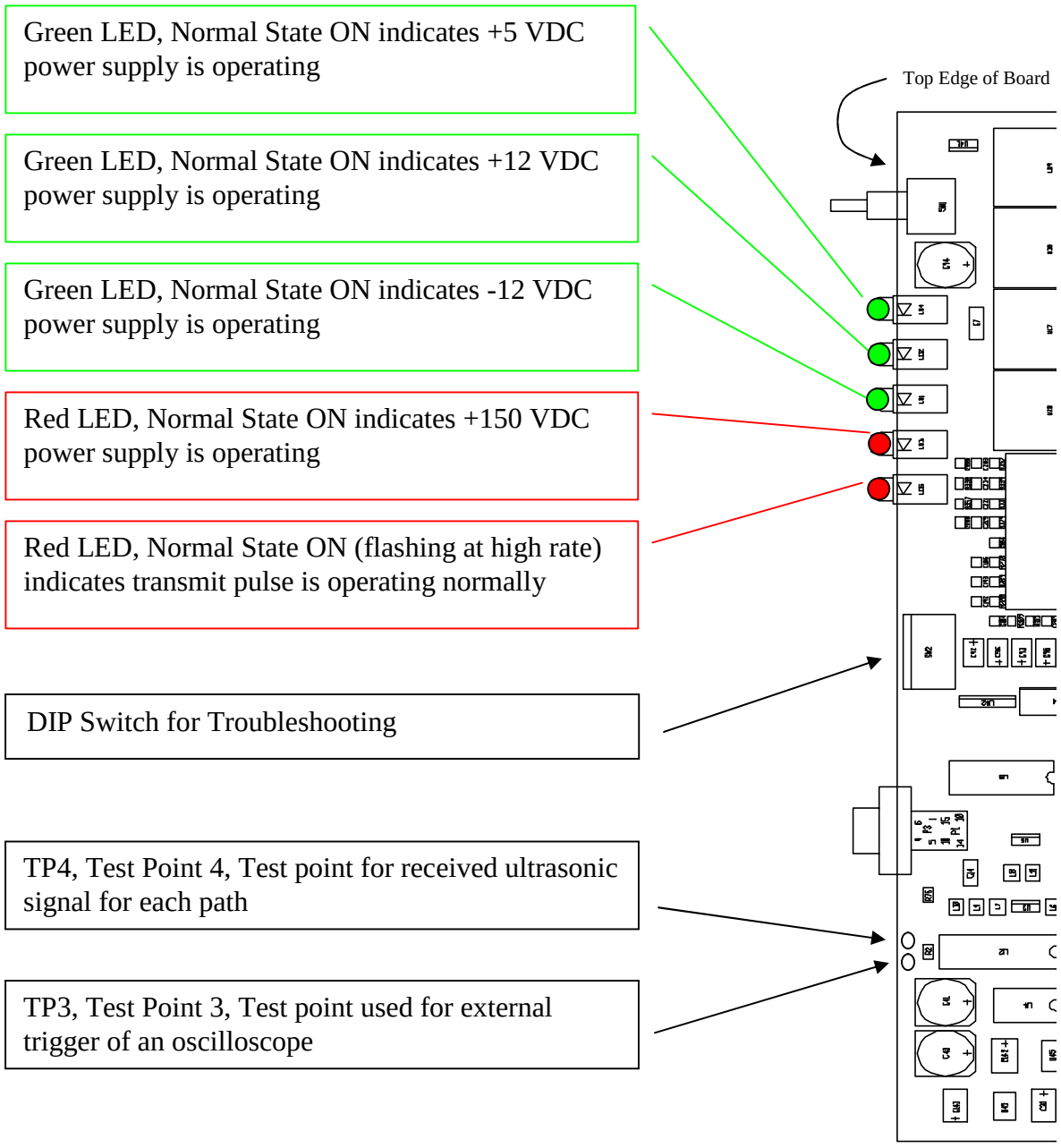


Figure 4-1: APU LED Indicators

If any of the power supply voltage lights are not on, please check the backplane voltage (See terminal block on Figure 4-2, See Table 4-1). If the power supplies are functioning properly, then the APU fuses may need to be replaced. If not, then the power supply should be tested and possibly replaced.

The following table provides the specified backplane voltage.

Table 4-1: Required Backplane Test Voltages

Terminal	Name	Requirement
TB8-1	5 Volts	5 ±0.1 Volts
TB8-2	+12 Volts	+12 ±0.5 Volts
TB8-3	-12 Volts	-12 ±0.5 Volts
TB8-4	Ground	Electrical Ground, 0V

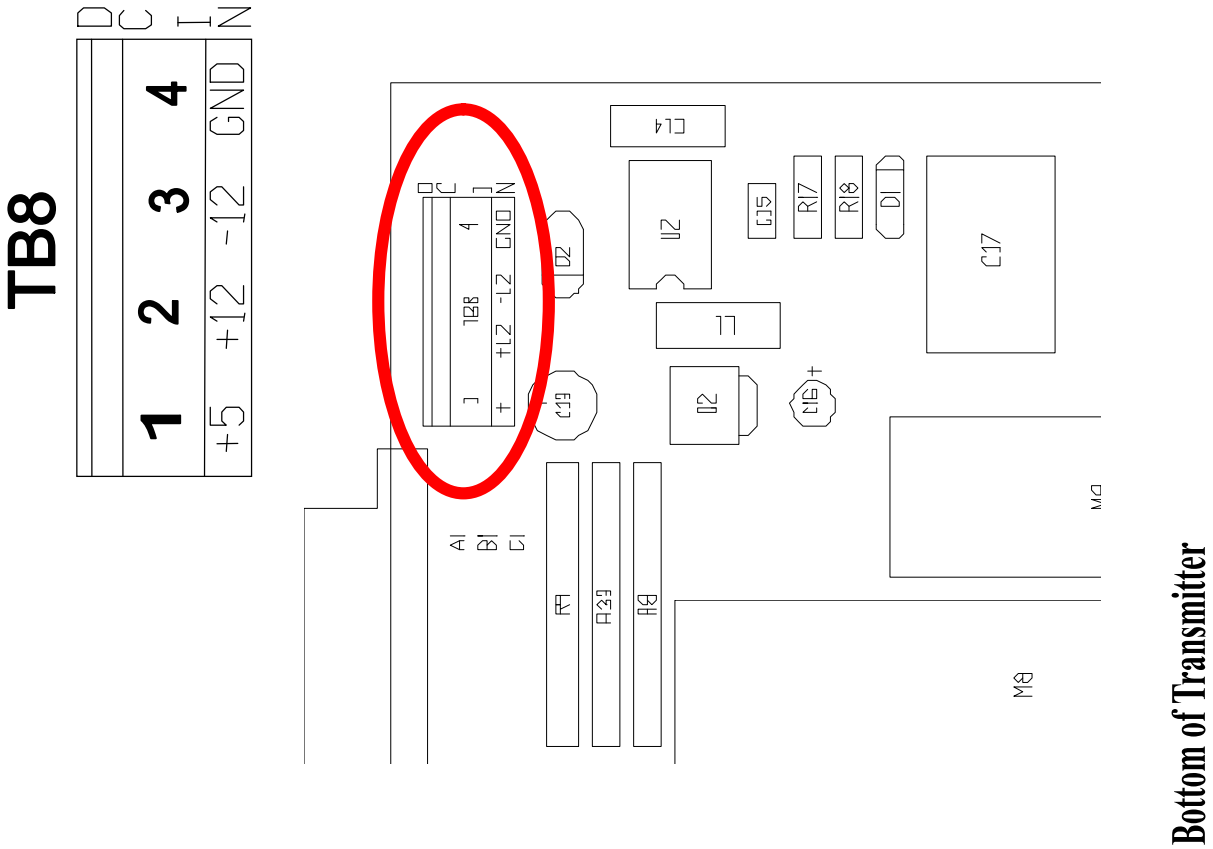


Figure 4-2: APU Backplane Terminal Block to Inspect Voltages

(Note Figure is displayed "sideways")

+5 V (1.5A) F2 – Very Fast Acting (FF)

150 VDC (0.125A) F1 – Very Fast Acting (FF)

+12V (0.5A) F7 – Very fast Acting (FF)

-12V (0.5A) F10 – Very Fast Acting (FF)

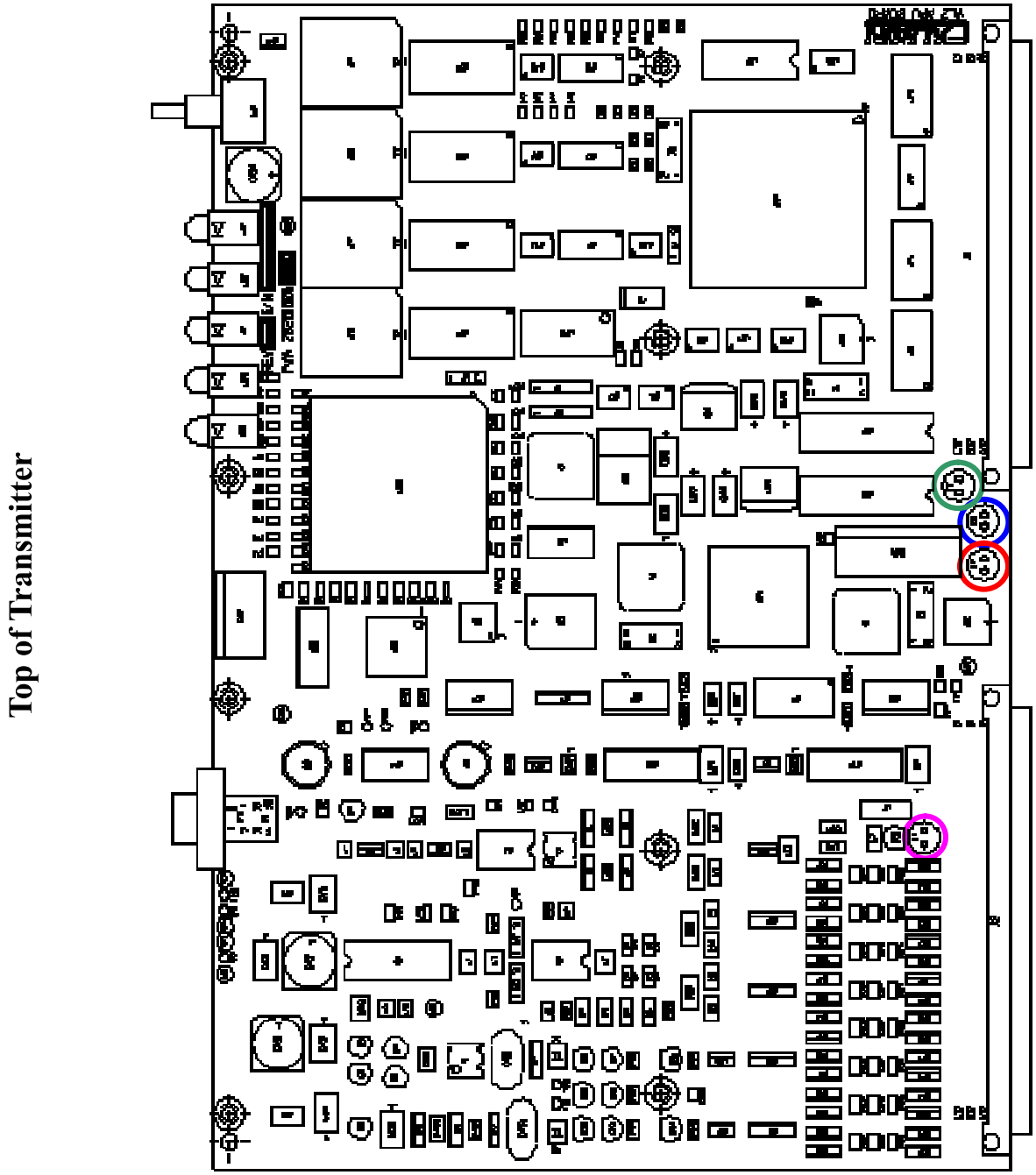


Figure 4-3: APU Fuse Location

(Note Figure is displayed "sideways")

4.4 Metering Section and Transducer Cables

Metering Section Inspection

Perform the following inspection and maintenance tasks:

a. Inspect the meter body. Verify meter body has not suffered any damage.

WARNING

DO NOT OPEN WHEN ENERGIZED!

BEFORE INSPECTING COMPONENTS
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b. Check connectors on transducers cables to verify they are undamaged. Clean connectors with electronic contact cleaner if fouled or corroded. Verify all mounting hardware is secure.

Transducer Cable Inspection

Inspect transducer cables as follows:

WARNING

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BEFORE INSPECTING COMPONENTS
OPEN THE LEFM 220C CIRCUIT BREAKER
TO AVOID ELECTRICAL SHOCK AND/OR EXPLOSION HAZARD.

a. Verify each transducer cable has not suffered any damage. Check connectors on cables at each end to verify each is undamaged. Clean connector with electronic contact cleaner if fouled or corroded. Replace any damaged cable or connector.

b. **Disconnect transducer cables from LEFM 220C.** Check continuity and isolation of cables.

c. Reinstall transducer junction box covers after completing all inspections. Be careful not to cut any wires in junction box while threading on junction box covers.

4.5 Transducer Installation Procedure

Should the unlikely event occur in that a transducer fails, this section defines the procedure for transducer installation . The LEFM 220C system may require verification when a transducer is replaced or recoupled.

The transducer should be installed using the following procedures:

Step 1 Power down the LEFM 220C and disconnect the transducer to be replaced from the terminals in the junction box, (note upstream and downstream junction boxes).

Step 2 Remove manifold cover (remove socket head screws, either M5 or M8 size).

Step 3 Remove transducer internals. Use O-Ratchet socket head (½ inch socket for the ½ inch (12.5 mm) transducer housing and ¾ inch socket for the 1 inch (25 mm) transducer housing). Typically 4 inch to 10 inch meter bodies contain ½ inch transducer housings and 12 inch and larger meter bodies contain 1 inch housings.

Step 4 Replace transducer.

Step 5 Verify the transducer housing is clean and free from dirt.

Step 6 Re-install the transducer internals with fresh lubricant to the transducer face.

Step 6a Thread the wires of the transducer though the compression spring and the spacer.

Step 6b Apply silicone lubricant to the transducer face before inserting into the transducer housing.

Step 6c Insert the transducer and components into the housing until the parts bottom out.

Step 6d Route the wires though the compression screw and then apply lubricant to the threads. Screw into the transducer housing and tighten. This will load the compression spring.

Step 7 Connect the new transducer to the junction box terminals.

Step 8 Re-install the manifold and junction box cover. Torque socket head screws, M5 size screws to 10 in-lbs (1.1 nm) or the M8 size screws to 30 in-lbs (3.4 nm).

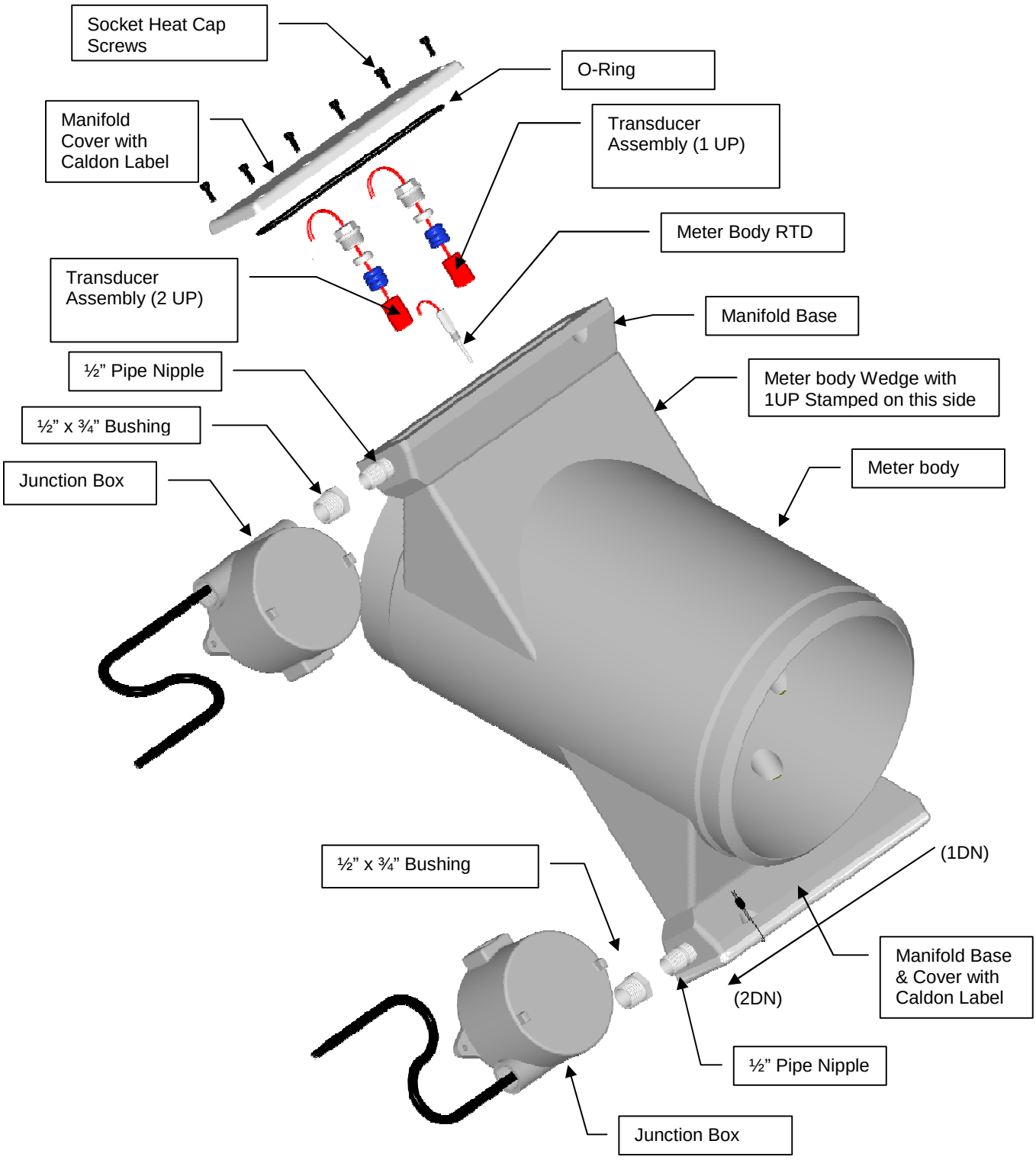


Figure 4-4: Meter Body Assembly Construction Outline

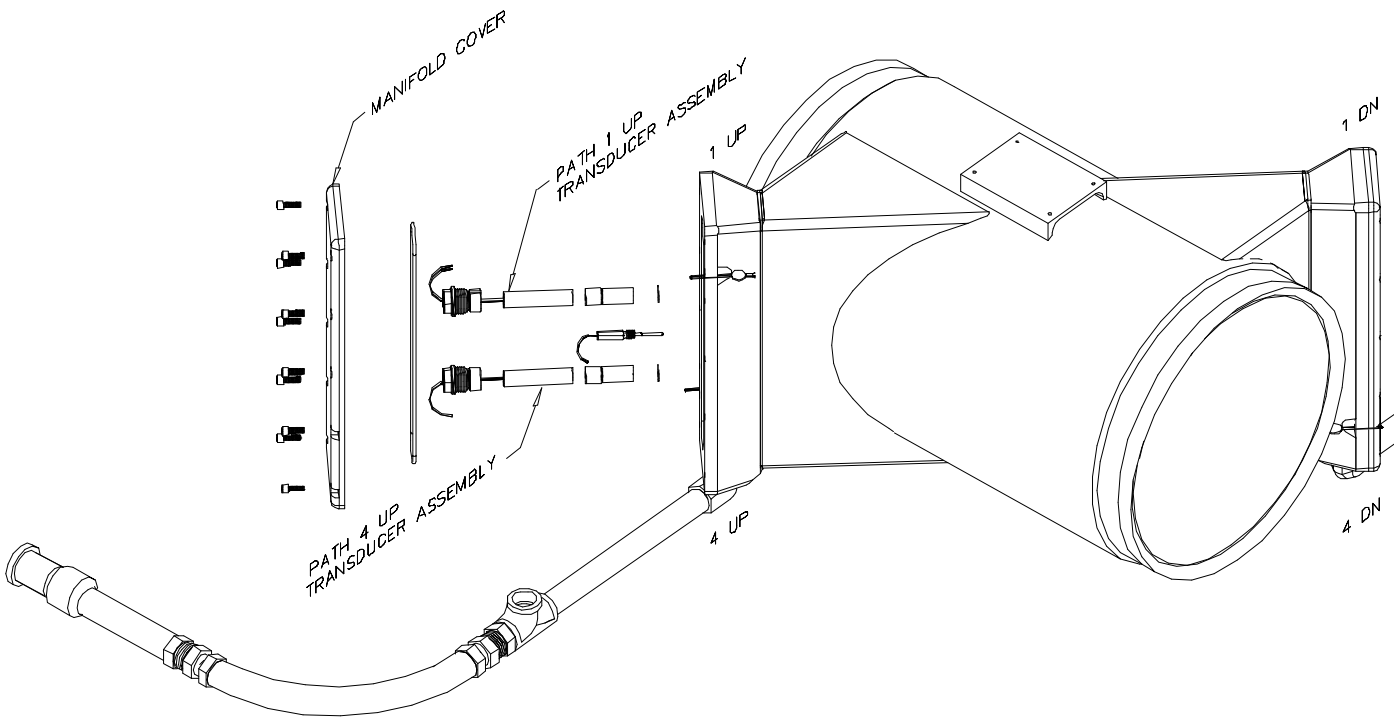


Figure 4-5: Meter Body Assembly Construction Outline (Cryogenic Temperatures)

NOTE: Cryogenic Applications Only: Do not remove Stainless Steel Wool from Conduits. This wool is required for hazardous area approvals.

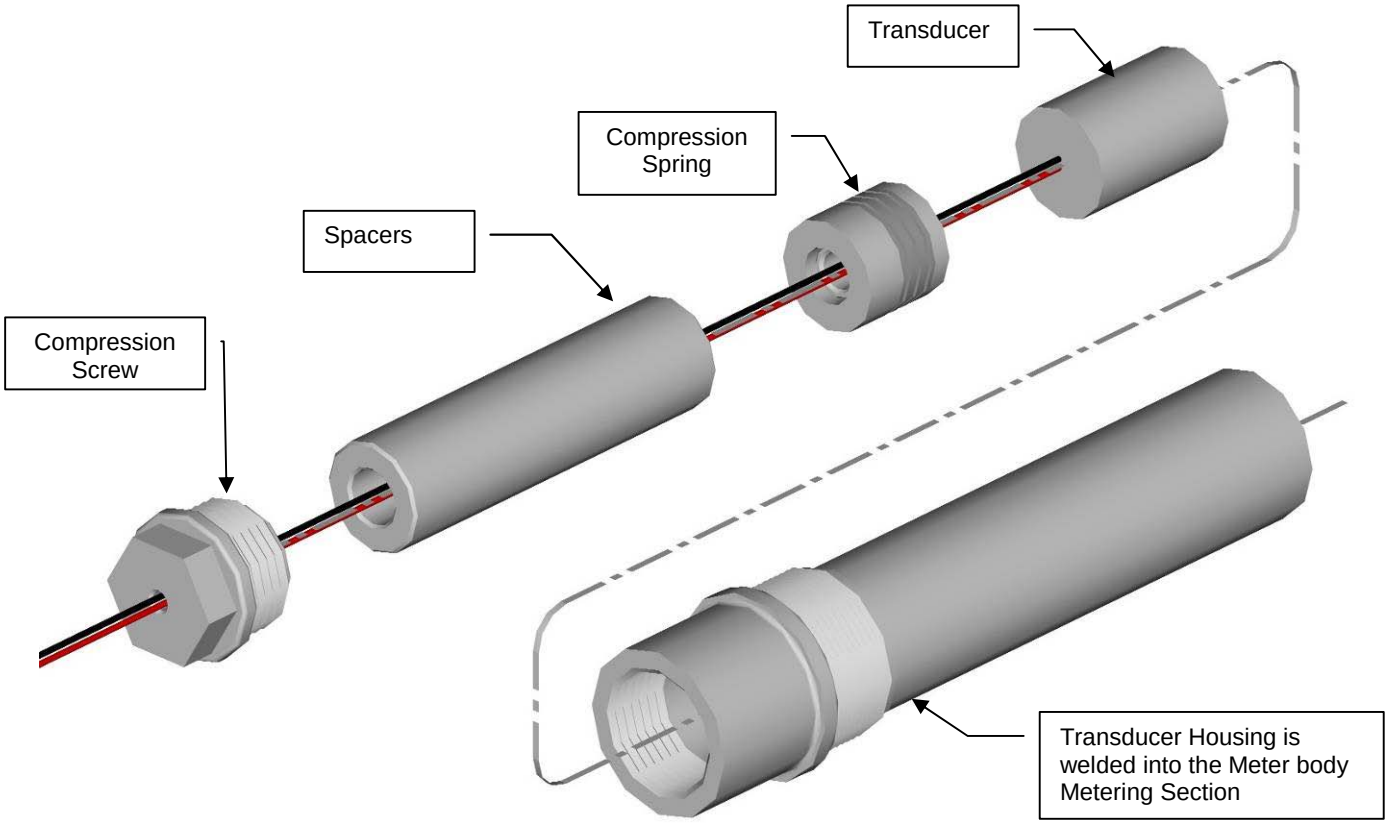


Figure 4-6: Transducer Assembly Construction Outline

ASSEMBLY PROCEDURES

1. Thread the wires of the transducer though the compression spring and the spacer as shown.

2. Apply silicone lubricant to the transducer face before inserting into the transducer housing.

3. Insert the transducer and components into the housing until the parts bottom out.

4. Route the wires though the compression screw and then apply lubricant to the threads. Screw into the transducer housing and tighten. This will load the compression spring.

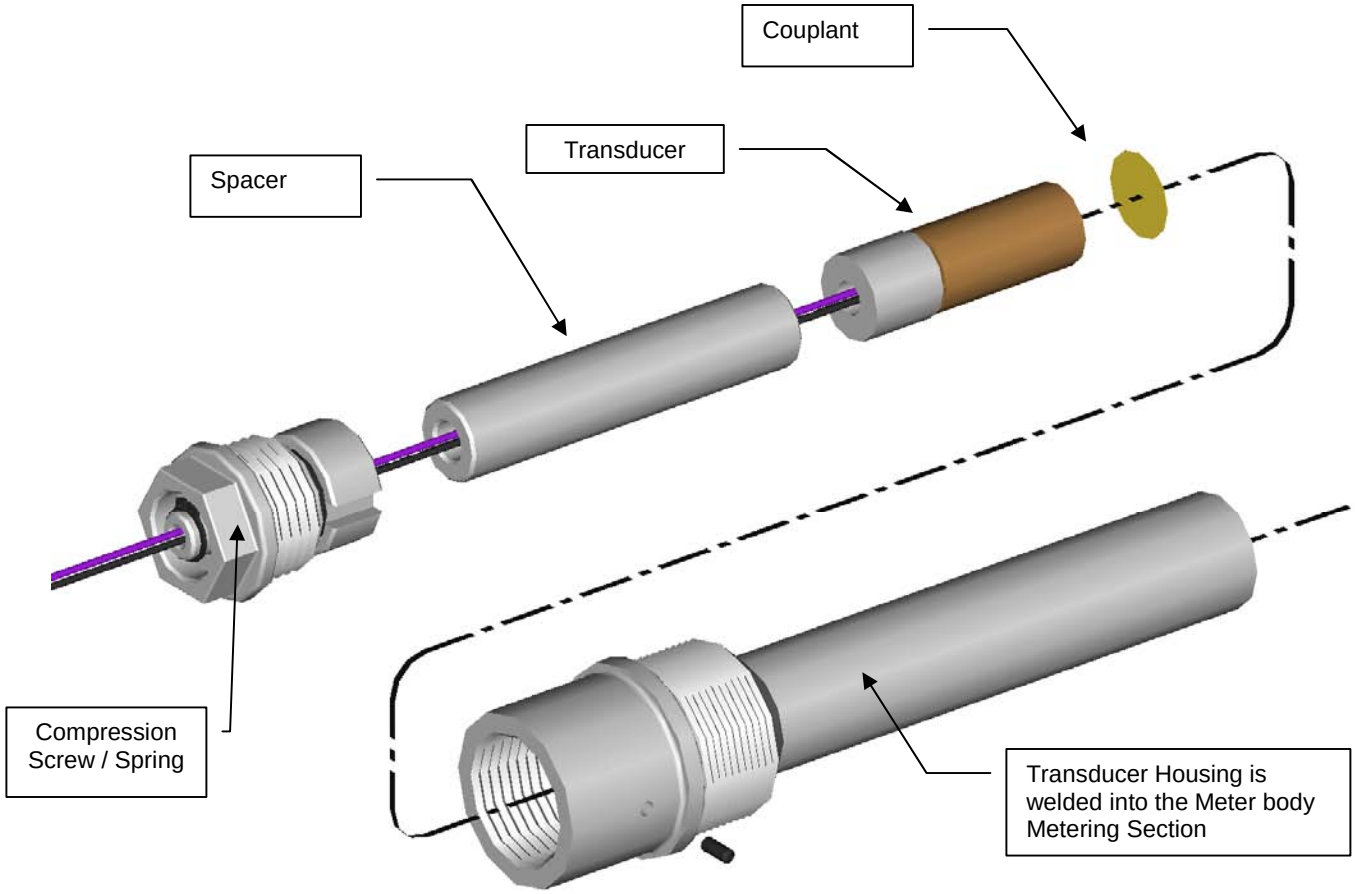


Figure 4-7: Cryogenic Transducer Assembly Construction Outline

ASSEMBLY PROCEDURES

1. Thread the wires of the transducer though the compression screw / spring and the spacer as shown.

2. Apply foil coupling to the transducer face before inserting into the transducer housing.

3. Insert the transducer and components into the housing until the parts bottom out. Be sure to align with the pin as shown.

4. Screw into the transducer housing and tighten. This will load the compression spring.

Transducer Cable Inspection Checks

WARNING

DO NOT OPEN WHEN ENERGIZED!
BEFORE INSPECTING COMPONENTS
OPEN THE LEFM 220C CIRCUIT BREAKER
TO AVOID ELECTRICAL SHOCK AND/OR EXPLOSION HAZARD.

Inspect transducer cables as follows:

- Verify each transducer cable for physical damage. Check connectors on cables at each end to verify each is undamaged. Clean connector with electronic contact cleaner if fouled or corroded. Replace any damaged cable or connector.

- Reinstall transducer housing covers after completing all inspections.

- **Disconnect connectors from Electronics.** Check continuity and isolation of cables (shield, positive, negative, earth ground, and impedance of transducers).

- Verify cable impedance (positive/negative disconnected from transducer and +/shield/- disconnected from electronics) as follows:

• Positive to negative	> 10MΩ
• Positive to shield	> 10MΩ
• Negative to shield	> 10MΩ
• Shield to earth ground	> 10MΩ

NOTE: DO NOT USE a high voltage instrument (like a Meggar) to test cables/transducers.

Reconnect cables when completed.

Transducer Impedance

WARNING

DO NOT OPEN WHEN ENERGIZED!
BEFORE INSPECTING COMPONENTS
OPEN THE LEFM 220C CIRCUIT BREAKER
TO AVOID ELECTRICAL SHOCK AND/OR EXPLOSION HAZARD.

- **Disconnect connectors from Electronics.** Check continuity and isolation of cables (shield, positive, negative, earth ground, and impedance of transducers).

- Verify cable impedance (positive/negative disconnected from transducer and (+), (-), (shield) disconnected from electronics) as follows:
  - Positive to negative > 10MΩ
  - Positive to shield > 10MΩ
  - Negative to shield > 10MΩ
  - Shield to earth ground > 10MΩ

NOTE: DO NOT USE a high voltage instrument (like a Meggar) to test cables/transducers.

Reinstall cables when completed.

4.6 Analog Input Alignment and Verification Procedure

The LEFM 220C may have up to three analog inputs and an RTD input for meter body temperature. Each input signal is conditioned before it is converted to a digital input. There are several input modules available for the temperature (Table 4-2). The input options for pressure are MB32-01, 4-20 mA input and MB32-02, 0-20 mA input.

Table 4-2: Temperature Input Modules Available

Part #	Input Type
MB32-01	4-20 mA
MB32-02	0-20 mA
MB34-01	100Ω Pt -100°C to 100°C
MB34-02	100Ω Pt 0°C to 100°C
MB34-03	100Ω Pt 0°C to 200°C
MB34-04	100Ω Pt 0°C to 400°C
MB34-C-01	10Ω Cu (@0°C) 0°C to 100°C
MB34-C-02	10Ω Cu (@25°C) 0°C to 100°C
MB34-N-01	10Ω Ni 0°C to 300°C
5B35-Custom	100Ω Pt -200°C to 100°C

The inputs are scaled to linearly convert either (4-20mA) or (RTD inputs) between the maximum and minimum ranges. Adjustments to the analog input ranges can only be changed through the software interface (See the LEFMLink manual for instruction on configuring this range).

Failed inputs will typically go to 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. However, if the LEFM 220C does not respond to calibrated inputs, then the following should be checked:

- Connection to the backplane (see Section 0)
- Analog Input Interface Module
  - Meter Body Temperature (Location M1)
  - Pressure (Location M2)
  - Fluid Temperature (Location M3)

4.7 Analog Output Verification

When provided, the LEFM 220C may have up to four Analog Output Channels. Each analog channel has a 0-20 mA (Part MB39-03), or 4-20 mA (part MB39-01) range, depending on the isolation module requested. The pulse output has a range of 0-5V. There are no adjustments to be performed for the analog or pulse outputs. Analog outputs M5 – M8 can be mapped to any ModBus input register for maximum flexibility. By default the analog outputs are mapped as follows:

M5 Flow
M6 Velocity of Sound
M7 Temperature
M8 Density
M9 Pulse Output

4.7.1 Analog Scaling

The analog outputs are scaled linearly anywhere between their maximum and minimum values. Use the force outputs function of LEFMLink to test the scaling of the analog outputs with input site devices (See the LEFMLink Manual).

4.7.2 Pulse Verification Tests

Similar to calibrating the Analog Outputs, a fixed frequency may be forced out of the transmitter pulse output. The ModBus Register for Frequency Output (Reference ModBus Manual), may be set to any frequency. Writing a value to this register and commanding the transmitter to use it, will force the pulse output to a fixed frequency. Returning the Frequency Output Register to 0 or normal, will return the transmitter to normal operation.

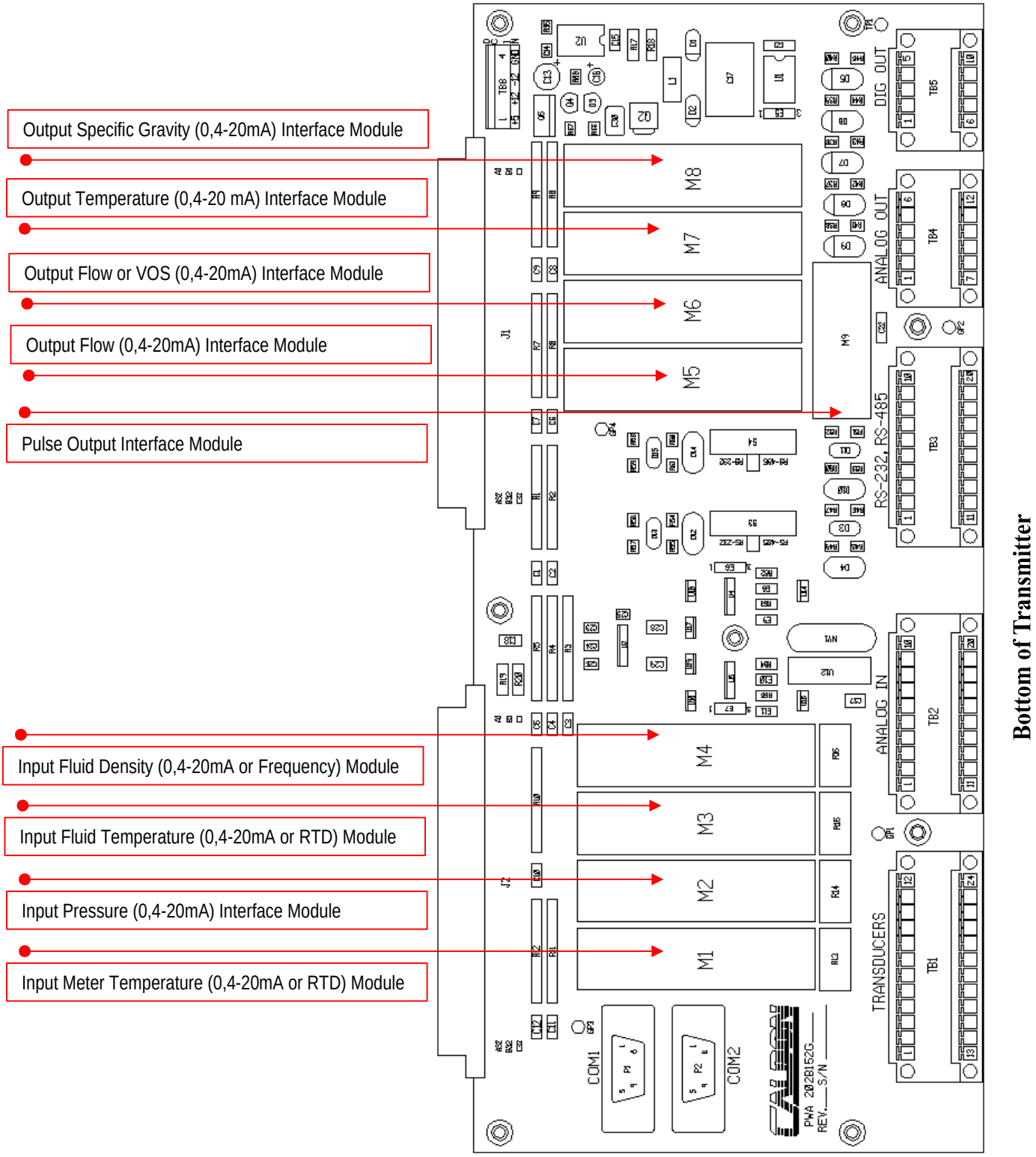


Figure 4-8: APU Backplane: Interface Module Location (Typical)

5.0 TROUBLESHOOTING AND DIAGNOSTICS FOR THE ULTRASONICS

5.1 Diagnostics

The LEFM 220C Transmitter interfaces via a serial port or infrared port to external devices. The 220C uses the MODBUS protocol. Cameron provides PC (laptop) software LEFMLink or PDA software to interface with the 220C via MODBUS. Alternatively, the Caldon MODBUS manual can be used to select the appropriate registers.

> Note: Throughout, the remainder of this manual, values such as path SNR (Signal to Noise Ratio), gain etc. are discussed as if the reader is using the Cameron provided LEFMLink software, (MODBUS register addresses will not be mentioned).

For detailed information on using LEFMLink see the LEFMLink User's Manual.

The following figure is an example of the Caldon interface software.
In this figure the following items are highlighted.

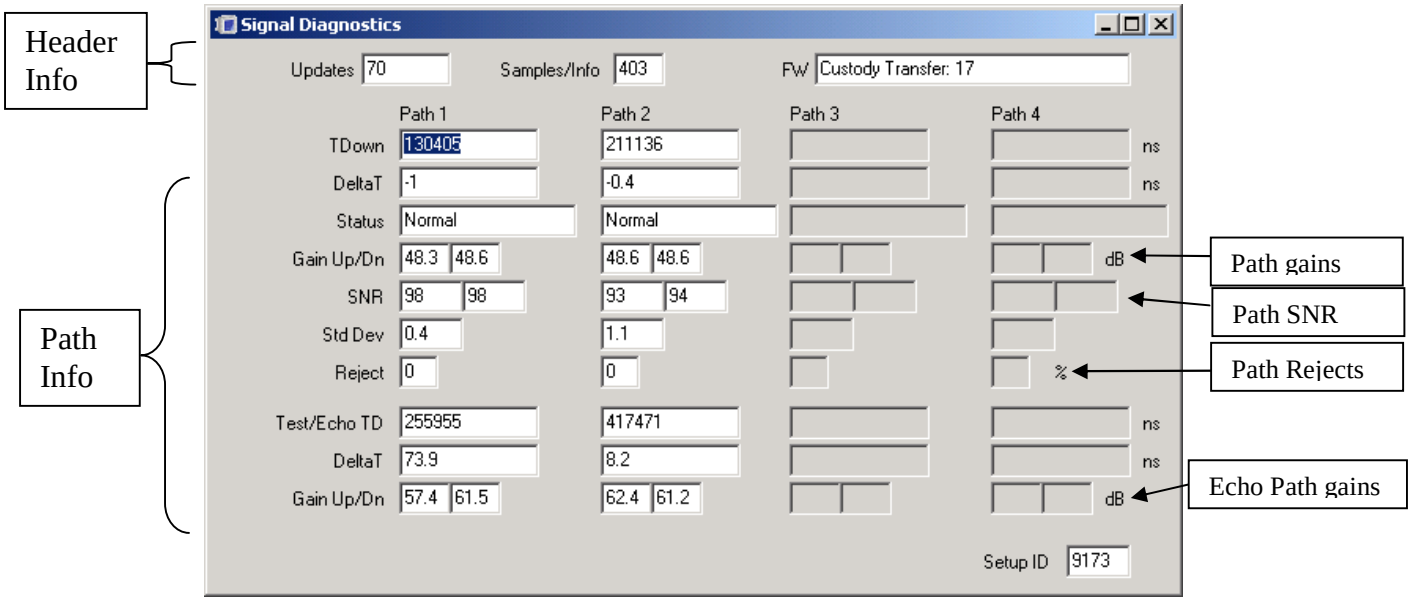


Figure 5-1: PC Diagnostic Software

For the ultrasonic signals, the most frequently used diagnostic information will be the following:

- Rejects (%) Range 0 – 100%, normal operation, 0 – 5%
- Gain (up/down) Range 0 – 88dB, normal operation, 40dB – 80dB
- SNR Range 0 - 100

The LEFM 220C performs the following automatic fault detection:

- The APU checks data quality of the ultrasonic signals and evaluates data against pre-set thresholds. The data is evaluated based on SNR (signal to noise ratio), cross-correlation tests and signal statistics.

- Occasionally data will be rejected; however, this will not influence the operation. If an ultrasonic path continues to reject data, the meter will alert the operator with an "ALARM" status and an error code.

- The APU will output the current status through a digital output and MODBUS.

The meter status includes:

- "NORMAL" status (status bit on Terminal Block, TB5-5, is at 5 volts)

- "ALARM" status – 1 path failed - flow computed with a lower accuracy (status bit on TB5-5 is at 0 volts)

- "ALARM" status – all paths failed - flow is set to zero (0) – (status bit same as normal status)

The individual path status codes are:

- 0 – Path operating normally

- 1 – Path rejecting data due to low SNR, irregular statistics, or failing the correlation test.

- 6 –Path sound velocities are inconsistent with thresholds (typically up to 1% spread between paths is acceptable).

- 8 - Path velocity inconsistent at low flows

- 10 - Path fails impedance self test

- 11 - Electronics fails clock accuracy test

NOTE: Caldon interface software interprets these codes and displays a text message.

5.2 Path Troubleshooting

The LEFM 220C System continuously checks the data quality of each acoustic path. Each time the signal is sampled, the APU tests the signal as follows:

- Verifies path's signal to noise ratio (SNR) is higher than its threshold value.
- Correlates the Upstream Signal with the Downstream Signal to test for "cycle skipping". The APU rejects data that does not pass this correlation test.
- Verifies the statistics of the computed transit time and Delta T are acceptable.

5.2.1 Path Reject Status

When the path status indicates that the Reject Test failed, it indicates that the percentage of data that has been rejected has exceeded the LEFM 220C System thresholds. The following troubleshooting sequence can be followed to pinpoint the root cause.

Step 1) Verify that the meter body is full of liquid. For example, if the top path is failing, then the pipe may not be filled.

Step 2) Verify continuity for all cables.

Step 3) Check all APU power supply voltages.

If the LED for any power supply is not lit on the front of the APU card, then the fuse may be blown, or the power supply has failed. (See Section 4.3).

Step 4) Check Transmit LED on APU board.

If transmit pulse on the APU is not lit, then the APU may need a configuration file, otherwise replace current APU board with a new APU board. (See Section 5.3)

Step 5) Check the Acoustic Signal

Check path gains (via MODBUS or Caldon Interface Software). If the path gains are high (85db and higher), then the signals may be too weak to operate. Weak signals can be caused by any of the following (listed from most likely to least likely)

- Line is not full of liquid.
- Line pressure is too low for the vapor pressure
- Cable/wire from the meter to the transmitter is damaged
- Transducer coupling needs to be replaced (with grease couplants only)

- Transducer has failed

Step 6) Determine Which Transducer Has Failed

Except for the earliest versions of the products, the LEFM 220C has a diagnostic feature for determining which transducer(s), if any, needs attention. The transmitter continuously tests each transducer individually in a pulse–echo mode. Pulse-echo means that a transducer transmits acoustic energy across the liquid, echoes the energy off the opposing transducer, and then receives the energy it has sent. In pulse-echo mode, the transmitter then computes the gain for both upstream and downstream transducers. Normally, the gains for the upstream and the downstream pulse-echo tests are equal. However, if there is a failed transducer due to wiring, coupling, etc., then one transducer will have a higher gain. Using the regular acoustic paths and the diagnostic pulse-echo paths, follow these steps to determine which transducer to evaluate:

1) Review the SNR (Signal to Noise Ratio) for each path (paths 1 and 2). The SNR should be greater than 40 (or greater than 20 for high viscosities).

2) Review the gains for each acoustic path (both upstream and downstream). The gains should be between 40dB and 80dB. Upstream and downstream gain should nominally be within 3 dB of each other.

3) Review the percent rejected data for each path. The percent should be between 0 and 5%.

4) Review the gains for each pulse-echo path (both upstream and downstream). The path with the higher gain should be investigated first.

Note: There will be situations where the pulse-echo paths are both at their maximum (~88dB). If this is the case, investigate the cables and the transducers of both transducers.

Remember the following troubleshooting tips:

- If all paths are in fail, not just one, then either the meter has no liquid or an electronics hardware failure has occurred.

- If a path has 100 % rejects it means the APU cannot lock onto a signal. It is possibly a cable or transducer problem. (Note: When rejects equal 100% then the APU will always indicate SNR=0 for the path).

If an acoustic signal does not exist, or if SNR has degraded from installation, then follow checklist below:

- Verify the pipe is full of liquid.
- Check the transducer impedance. If the transducer impedance is less than 10 Megohms, then replace transducer.

NOTE: DO NOT USE a high voltage instrument (like a Meggar) to test cables/transducers.

- Check the impedance of the transducer cable. If cable impedance is less than 10 Megohms, then replace/repair cable.
- Check continuity of transducer cable. If transducer cable continuity impedance is infinite, then repair/replace cable.
- If a signal is present, the ultrasonic transducer may need to be reseated, or the acoustic coupling may need to be replaced. See Section 4.5.

5.3 Reprogramming the Transmitter

While it is not likely, there may be a time that the transmitter may need to be reprogrammed.

This would typically occur when an:

- APU Board has been replaced with an inventory item, not specifically assigned to a given meter body. It is Cameron's policy to provide a configuration file for each spool. This configuration file includes:
  - Pipe Size
  - Pipe Transducer Frequency
  - Acoustic Path Lengths
  - Calibration Constant
  - Alarm Settings
  - K-Factor
  - Analog Input/Output Scaling

Cameron maintains records and configuration files for all of its delivered meters. The simplest way to reprogram a transmitter is to use Caldon's PC or PDA interface software. The procedure is as follows:

1) Select appropriate ModBus ID and Baud Rate (See Section 5.3.1)
2) Select the configuration file for the meter body
3) Send the Configuration File

Once these steps are complete, the transmitter is reprogrammed.

The transmitter may also be reprogrammed through ModBus using the site interface, however, it is not recommended to do the reprogramming this way. Given that there are many registers to load, the process will be tedious and prone to errors.

5.3.1 ModBus ID and Baud Rate

All Caldon transmitters are programmed with ModBus ID set to 1, Baud Rate at 9600 and in RTU Slave Mode. If the transmitter has been reprogrammed with a different setting and this setting is not known, simply set DIP Switch Number 2 to up (TRUE) and toggle the reset switch. Resetting the transmitter in this mode forces the transmitter to operate with its default settings. In this mode the transmitter will wait for a new setup before restarting:

NOTES:

1. **MAKE SURE YOU HAVE THE CORRECT SETUP FILE FIRST!**
2. MAKE SURE YOU PUSH DOWN DIP SWITCH NUMBER 2 WHEN FINISHED!

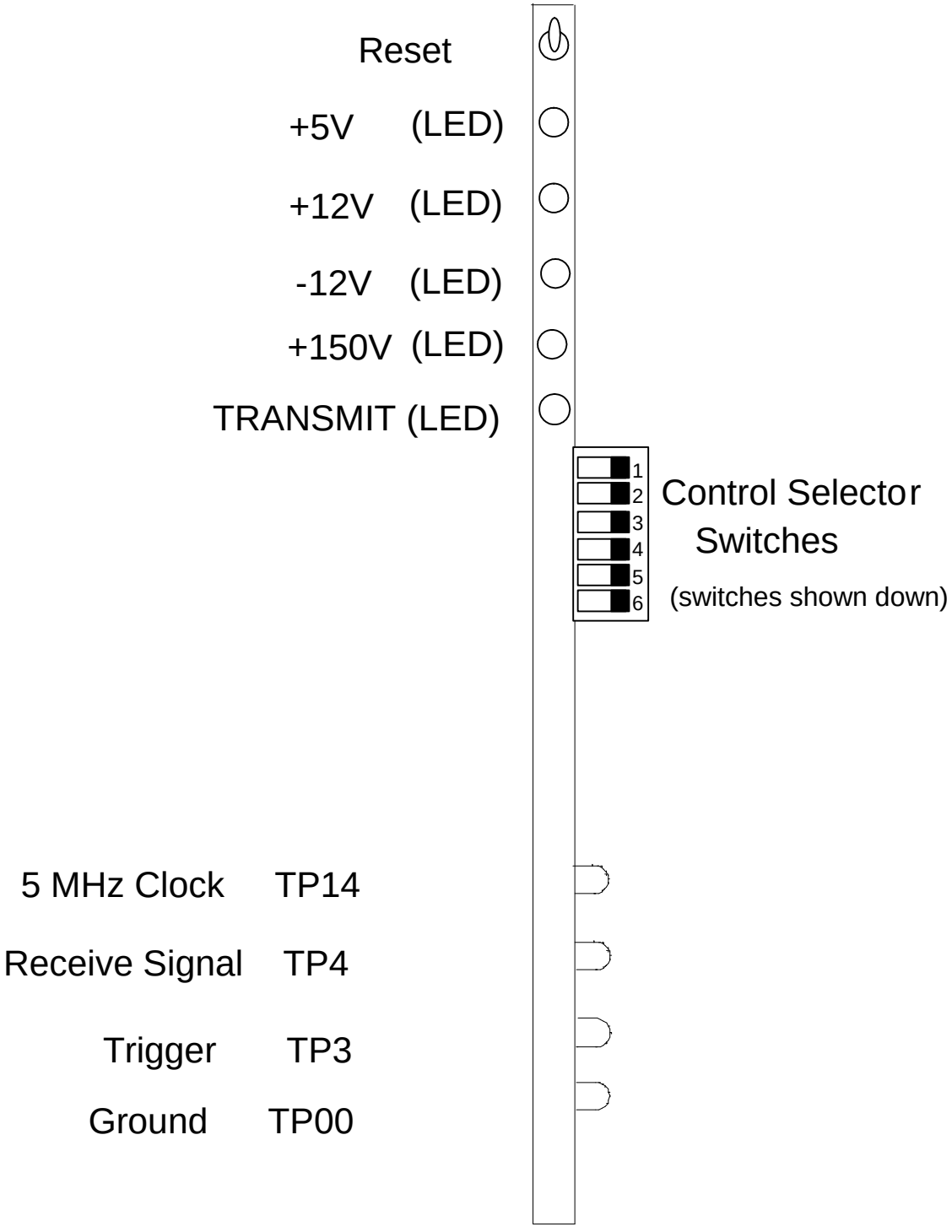


Figure 5-2: Top Edge of APU Board (Side View)

6.0 RECOMMENDED SPARE PARTS

6.1 Domestic (US and Canada)

Qty: 1 F1 - Littelfuse 274.125 – 125mA radial lead fuse very fast acting (FF)
Qty: 1 F2 - Littelfuse 27201.5 – 1500mA radial lead fuse very fast acting (FF)
Qty: 2 F7/F10 - Littelfuse 274.5 – 500mA radial lead fuse very fast acting (FF)
Qty: 1 Transducer (appropriate frequency)
Qty: 1 Transducer Grease (small tube)
Qty: 16 Transducer Cryogenic Couplant (220C-LT Only)
Qty: 2 Pulse Output Interface Module, P/N AD261BND-0
Qty: 1 4-20 mA Interface Module (Input – See Table 4-2, Section 4.6)
Qty: 1 4-20 mA Interface Module (Output – See Section 4.7)
Qty: 1 Serial Communications Kit (Includes LEFMLink Software)

6.2 International

Same as above, except includes:

Qty: 1 APU Board

Note: The APU Board contains electrolytic capacitors. In order to maintain proper operation of these components they must have a functional test at least once every five (5) years. Contact Cameron's Measurement Systems division for the specifics of the functional test.

7.0 Appendix A: Optional Display Configuration

An optional 4 – 20 mA display is available to display the flow and totalized flow locally. The analog output for flow is used to power this display. The display should be used as an indicator of flow. High accuracy data should be taken from the pulse output or the ModBus serial link.

7.1 Installation

The display should be installed on shielded conduit that meets site environment specifications near either the meter body or the transmitter. Using 2 conductor instrument wires connect per Table 7-1.

Type	Transmitter Term.	Display Term.	Type
4,0-20 mA + (high)	TB3-1	2	Input +
Shield	TB3-2		
4,0-20 mA – (low)	TB3-3	1	Input -

Table 7-1: Display Connections

The range of the output is scaled using the LEFMLink PC Software or the ModBus interface. See the respective manual for instructions.

7.2 Programming the Display

See the flow chart in Figure 7-1.

- Press the **M** key to enter the programming menu.
- If the panel lock is on, you must enter the 4 digit lock code to gain access to the menu.
- Press the ↑ key to increment each individual digit of the code.
- Press the ← key to advance to the next digit.
- Press the **E** key to enter the displayed code.
- If the code is correct, display advances to "clr tot", if not, display returns to run mode

- Press the **E** key to clear the totalizer and return to the Run Mode
- Press the **M** key to skip and go to next menu item.

- Press the ↑ key to step to the desired number of digits for the rate display.
- Press the E key to enter the displayed choice.
- Press the M key to skip and keep the existing choice.

- Press the ← key to step the decimal to the next digit.
- Press the E key to enter the displayed decimal location.
- Press the M key to skip and keep the existing decimal location.

- Press the ← key to step the decimal to the next digit.
- Press the E key to enter the displayed decimal location.
- Press the M key to skip and keep the existing decimal location.

- Press the ↑ key to step to the desired totalizer descriptor.
- Press the **E** key to enter the displayed descriptor.
- Press the **M** key to skip and keep the existing descriptor.

- Press the ↑ key to step to the desired rate descriptor.
- Press the **E** key to enter the displayed descriptor.
- Press the **M** key to skip and keep the existing descriptor.
  (Choose the descriptor which reflects the time base used for rate high)

- Press the ↑ key to step to the desired input type.
- Press the **E** key to enter the displayed choice.
- Press the **M** key to skip and keep the existing input type.

- Press the ↑ key to increment each individual digit of the rate low setting.
- Press the ← key to advance to the next digit.
- Press the **E** key to enter the displayed value.
- Press the **M** key to skip and keep the existing value.

- Press the ↑ key to increment each individual digit of the rate high setting.
- Press the ← key to advance to the next digit.
- Press the **E** key to enter the displayed value.
- Press the **M** key to skip and keep the existing value.

- Press the↑ key to increment each individual digit of the low cutoff setting.
- Press the ← key to advance to the next digit.
- Press the **E** key to enter the displayed value.
- Press the **M** key to skip and keep the existing value.

- Press the ↑ key to step to the desired divider for the pulse output.
- Press the **E** key to enter the displayed divider.
- Press the **M** key to skip and keep the existing divider.

- Press the ↑ key to step to cal YES or cal NO.
- Press the **E** key to enter the displayed choice.
- Press the **M** key to skip and proceed to lock code.

- Press the **E** key when 4mA is supplied to the input.
- Press the **M** key to skip and proceed to cal hi.

- Done will appear to signal that the cal lo was successful.
- Press the **M** key to advance to cal hi.

- Press the **E** key when 20mA is supplied to the input.
- Press the **M** key to skip and proceed to loc code.

- Done will appear to signal that the cal hi was successful.
- Press the **M** key to advance to loc code.

- Press the ↑ key to increment each individual digit of the lock code.
- Press the ← key to advance to the next digit.
- Press the **E** key to enter the displayed code.
- Press the **M** key to skip and keep the existing code.

- Press the ↑ key to step to the desired lock setting.
- Press the **E** key to enter the displayed lock setting.
- Press the **M** key to skip and keep the existing setting.

(Setup Instructions provided are from the display manufacturer (KEP) document 99327)

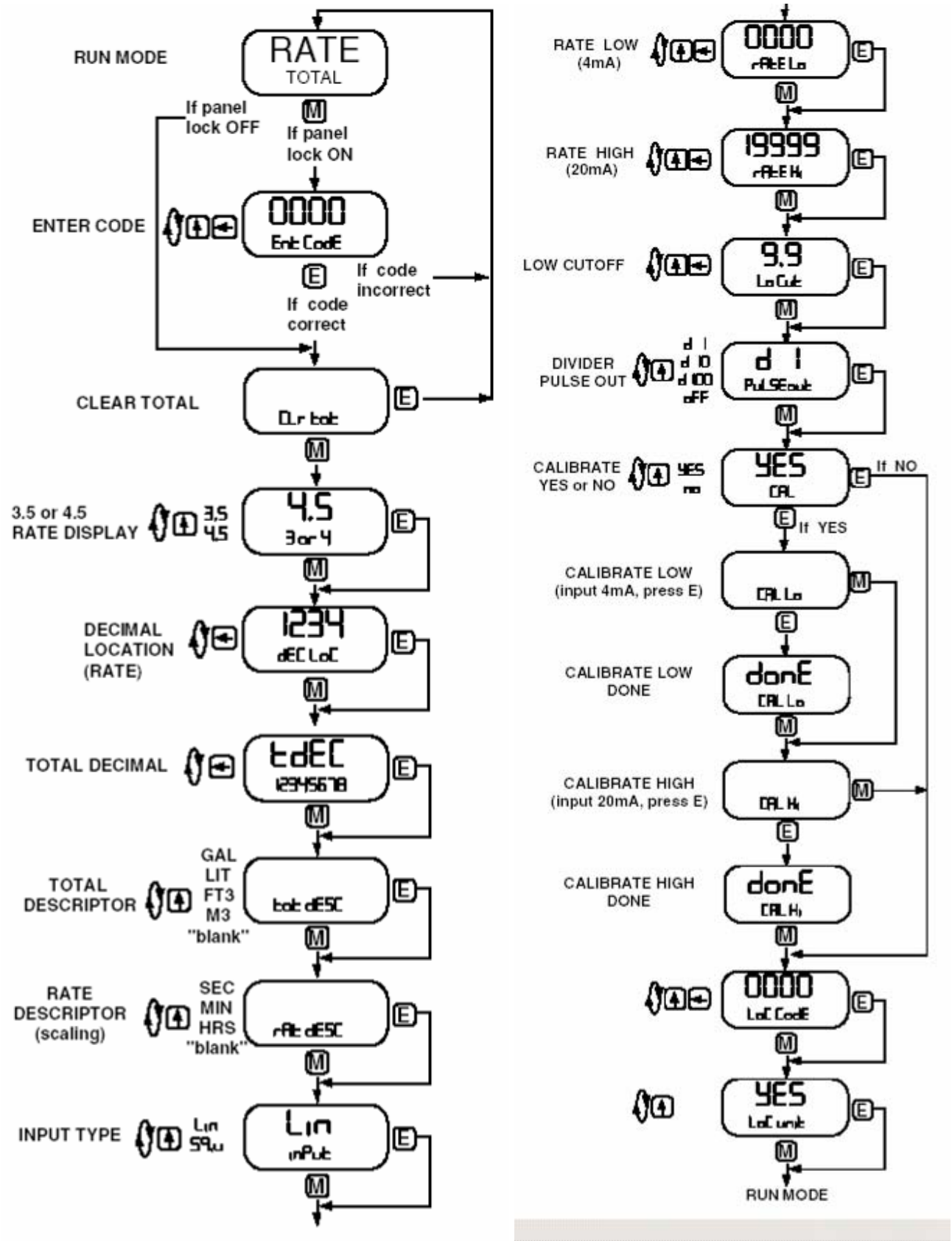


Figure 7-1: Programming Flow Chart

8.0 APPENDIX B

8.1 Legacy System Installation

8.1.1 Field Terminations

The following installation instructions are for the legacy systems which have a green circuit board. For new units with blue circuit boards refer to Section 0.

The wiring should be routed to the transmitter in shielded conduit that meets site environment specifications. All terminations should be made according to Table 8-1 through Table 8-7. For full environmental temperature range all wiring (conductors) should be rated for a minimum of 194°F (90°C). All supply wiring must be rated to 300 volts AC (18 AWG). Equipment must be installed by a licensed electrician, in accordance with NEC/CEC and local codes. As a minimum a disconnect switch should be installed before and near the transmitter. The external disconnect device must be an approved device rated for the supply voltages and is rated to 3 Amps (or 15 Amps for the 24 Volts DC) and provide a minimum of 3.0 mm spacing.

Explosion Proof enclosures must be installed with rigid conduit with stopping boxes / seal fittings installed within 3 inches (75 mm) of the enclosure.

Figure 8-1, Figure 8-2, Figure 8-3, and Figure 8-4 illustrate the conduit connections for the LEFM 220C Transmitter and the transmitter layout.

8.1.1.1 Infrared Interface

The IR interface is an infrared wire extension interface. It will not work with the built in IR port on most laptops. A serial to IR adapter is available to make this connection on the laptop. The IR port in most Palm Pilot handheld devices and pocket PCs is supported though.

8.1.1.2 RS-232 to RS-485 Converter

An optional RS-232 to RS-485 converter is available. Figure 8-6 shows the setup and configuration of the RS-485 module. Figure 8-7 shows the location of the module in the transmitter. The module should be wired into the transmitter per Table 8-7.

8.1.2 Grounding/Earthing

The meter body and transmitter have grounding/earthing points available. Site guidelines are to be followed regarding grounding/earthing. See Figure 1-1and **Error! Reference source not found.** for earthing points on the meter body.

8.1.3 Meter Body Terminations

The meter body terminations are defined in Table 8-1 and Table 8-2. For Class I Div I or Div II environments, the connections to the meter body or junction box must be through rigid conduit or approved equals with stopping boxes/seal fittings installed within 18 inches (450 mm) of the junction box(es).

8.1.4 Flow Direction

The LEFM 220C Meter is a bidirectional meter with a quadrature pulse output available to indicate direction of flow (Reference Table 8-5). Pulse output A leading pulse output B by 90° indicates forward flow while pulse output B leading pulse output A by 90° indicates reverse flow with respect to the flow arrow of the nameplate. To ensure that the flow indication is displayed correctly, the fluid should flow in the same direction as the arrow on the meter body nameplate.

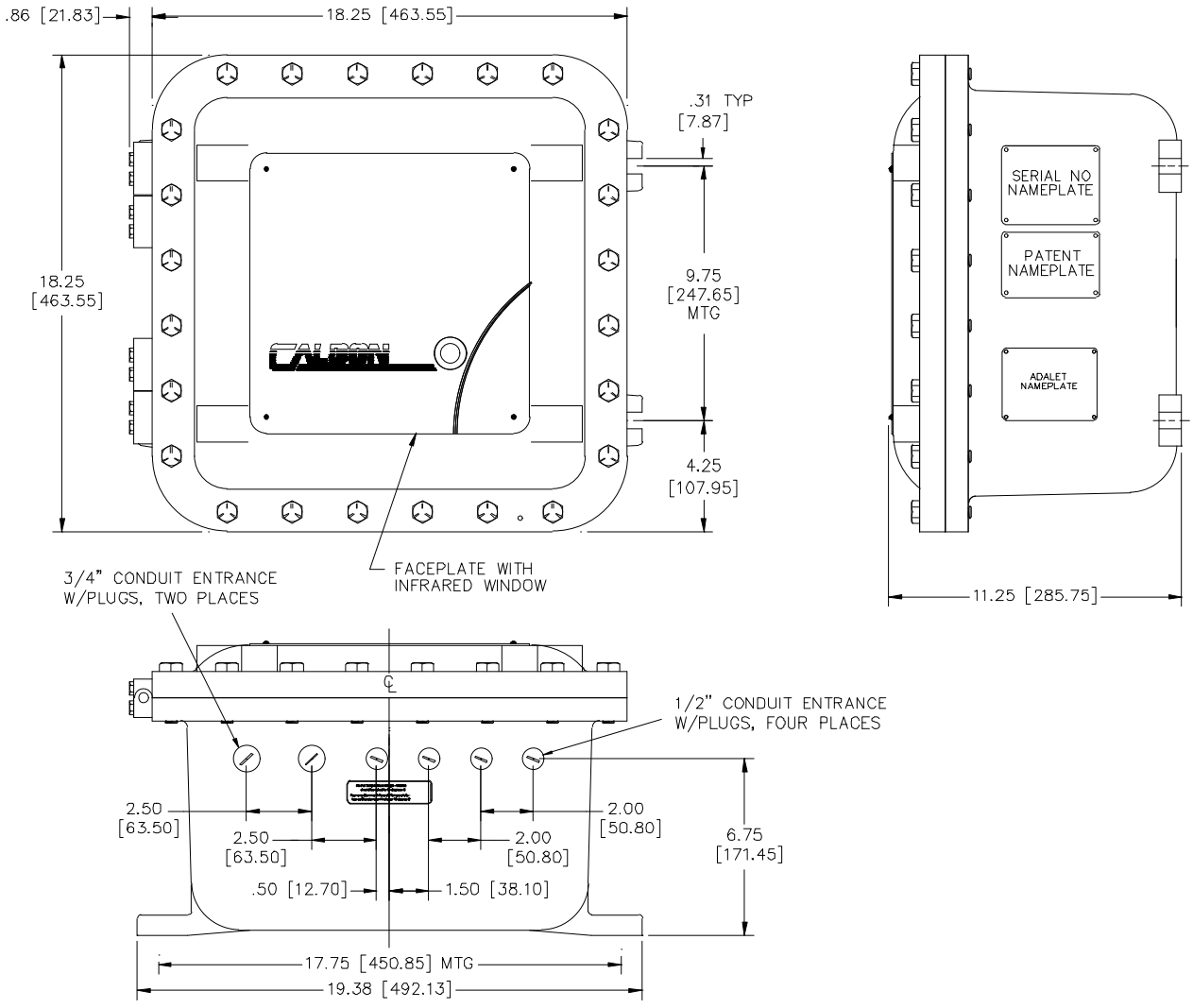


Figure 8-1: Explosion Proof Enclosure (Units in Inches [mm])

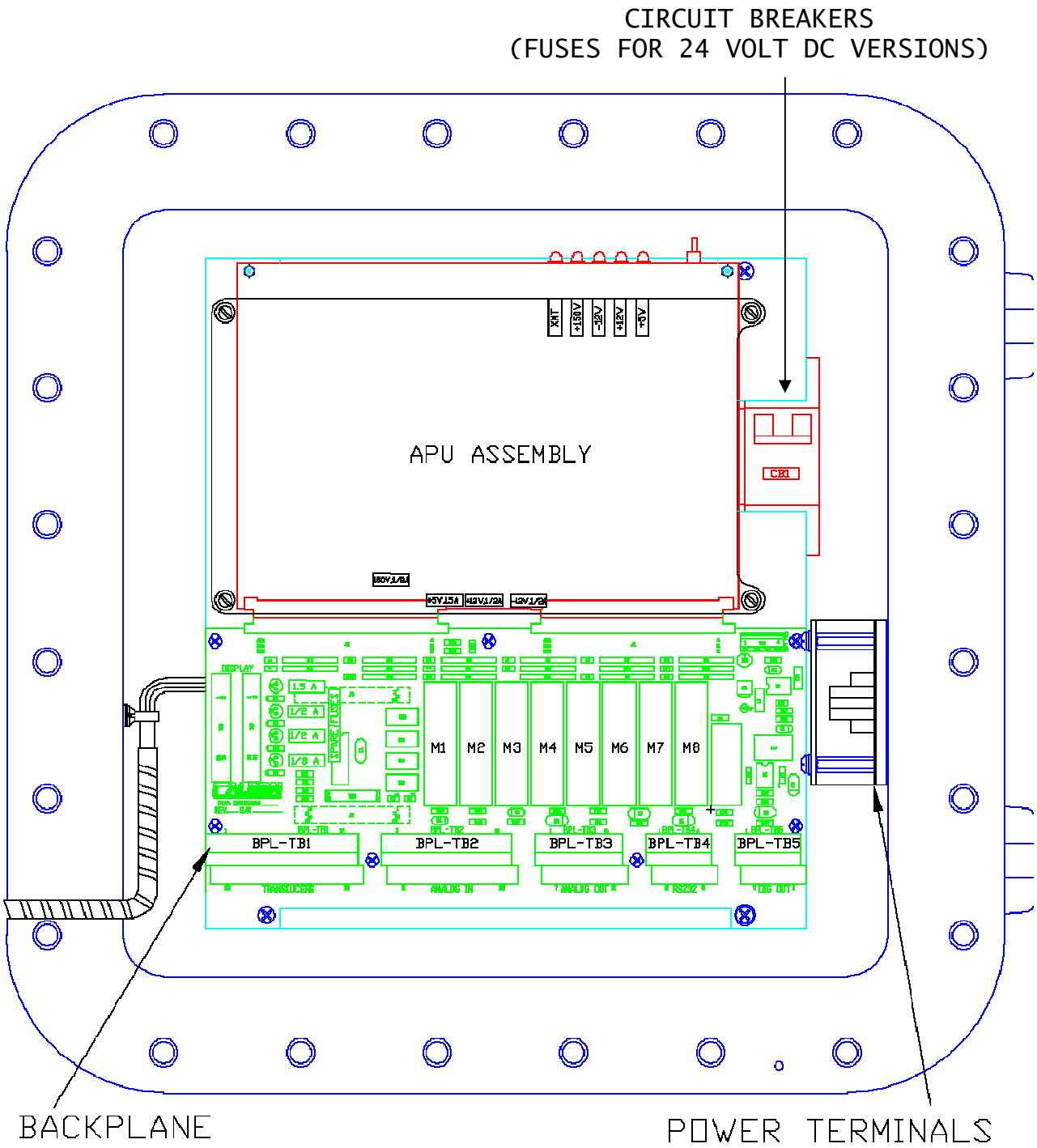


Figure 8-2: Explosion Proof Enclosure with Cover Open

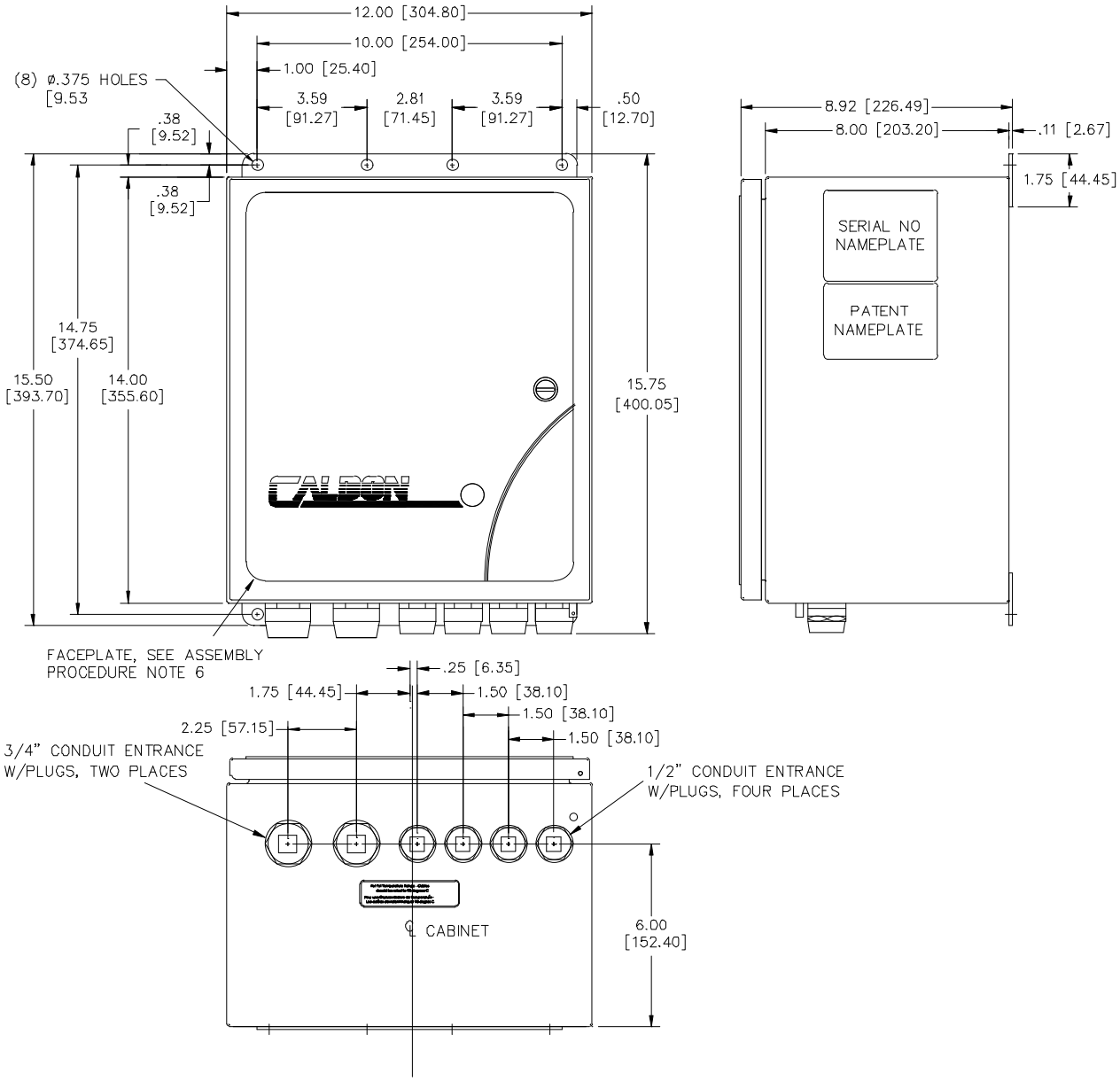


Figure 8-3: NEMA 4X Enclosure (Units in Inches [mm])

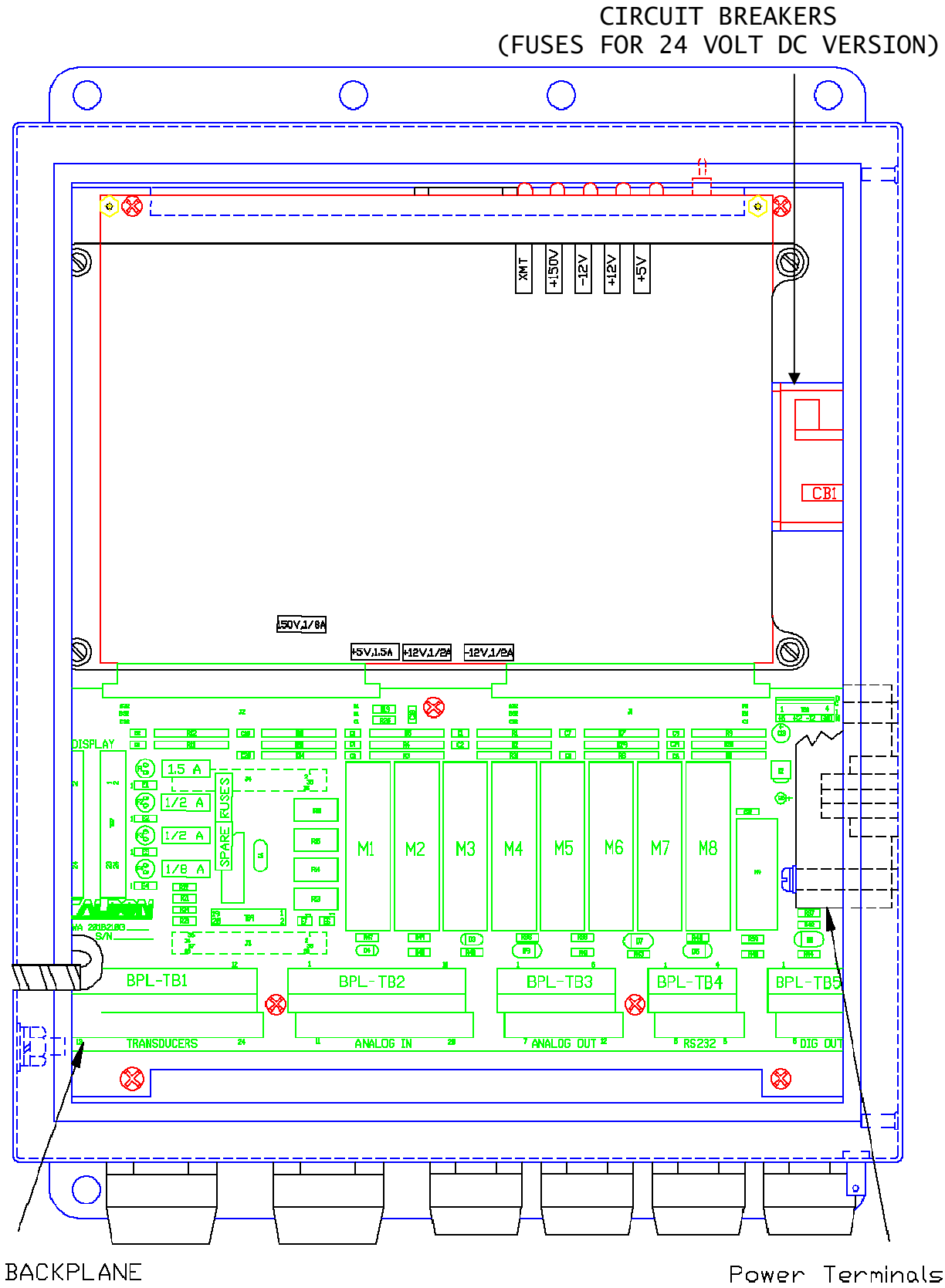


Figure 8-4: NEMA 4X Enclosure with Door Open

Transducer Cable Identification		Transmitter Termination		Meter Body Junction Box	
Wire Name		Device	Terminal	Device	Terminal
1 UP	+	TB1	1	Upstream JBOX-TB1	1
	Shield	TB1	2		-
	-	TB1	3		2
1 DN	+	TB1	4	Downstream JBOX-TB1	13
	Shield	TB1	5		-
	-	TB1	6		14
2 UP	+	TB1	7	Upstream JBOX-TB1	3
	Shield	TB1	8		-
	-	TB1	9		4
2 DN	+	TB1	10	Downstream JBOX-TB1	15
	Shield	TB1	11		-
	-	TB1	12		16
RTD	RTD+	TB2	1	Upstream JBOX-TB1	9
	RTD+	TB2	2		10
	Shield	TB2	3		-
	RTD-	TB2	4		11
	RTD-	TB2	5		12

Table 8-1: LEFM 220C Transducer and RTD Terminations (2 junction boxes)

Transducer Cable Identification		Transmitter Termination		Meter Body Junction Box	
Wire Name		Device	Terminal	Device	Terminal
1 UP	+	XMT-BPL-TB1	1	JBOX-TB1	1
	Shield	XMT-BPL-TB1	2		-
	-	XMT-BPL-TB1	3	JBOX-TB1	2
1 DN	+	XMT-BPL-TB1	4	JBOX-TB1	3
	Shield	XMT-BPL-TB1	5		-
	-	XMT-BPL-TB1	6	JBOX-TB1	4
2 UP	+	XMT-BPL-TB1	7	JBOX-TB1	5
	Shield	XMT-BPL-TB1	8		-
	-	XMT-BPL-TB1	9	JBOX-TB1	6
2 DN	+	XMT-BPL-TB1	10	JBOX-TB1	7
	Shield	XMT-BPL-TB1	11		-
	-	XMT-BPL-TB1	12	JBOX-TB1	8
RTD	RTD+	TB2	1	JBOX-TB1	9
	RTD+	TB2	2		10
	Shield	TB2	3		-
	RTD-	TB2	4		11
	RTD-	TB2	5		12

Table 8-2: LEFM 220C Transducer and RTD Terminations (1 junction box)

Analog Input Source	RTD Connection			0, 4 - 20 mA Connection		
	Description	Terminus	Module Type	Description	Terminus	Module Type
Meter Temperature See Tables 2-1, 2-2, & 2-3	RTD +	TB2-1	100Ω Pt -100°C to 100°C, MB34-01 (Typical, See Table 4-2)			
	RTD +	TB2-2				
	Shield	TB2-3				
	RTD -	TB2-4				
	RTD -	TB2-5				
Pressure				0, 4-20 mA +	TB2-6	4 - 20 mA = MB32-01 0 - 20 mA = MB32-02
				Shield	TB2-8	
				0, 4-20 mA -	TB2-10	
Fluid Temperature	RTD +	TB2-11	100Ω Pt -100°C to 100°C, MB34-01 (Typical, See Table 4-2)	0, 4-20 mA +	TB2-11	
	RTD +	TB2-12				
	Shield	TB2-13		Shield	TB2-13	
	RTD -	TB2-14				
	RTD -	TB2-15		0, 4-20 mA -	TB2-15	
Density				0, 4-20 mA +	TB2-16	
				Shield	TB2-18	
				0, 4-20 mA -	TB2-20	

Table 8-3: Analog Input Customer Connection Locations (Located on Backplane)

Typical Analog Output*	Signal Description	Terminus	Module Location
Flow	4,0-20 mA + (high)	TB3-1	M5
	Shield	TB3-2	
	4,0-20 mA – (low)	TB3-3	
Sound Velocity	4,0-20 mA + (high)	TB3-4	M6
	Shield	TB3-5	
	4,0-20 mA – (low)	TB3-6	
Temperature	4,0-20 mA + (high)	TB3-7	M7
	Shield	TB3-8	
	4,0-20 mA – (low)	TB3-9	
Specific Gravity	4,0-20 mA + (high)	TB3-10	M8
	Shield	TB3-11	
	4,0-20 mA – (low)	TB3-12	

Table 8-4: Analog Output Customer Connection Locations (Located on Backplane)

*Note: Other variables can be mapped to the analog outputs. Contact Cameron's Measurement Systems division for specifics.

Pulse Output	Signal Description	Terminus
A-1	+5 V, A leads B by 90 degrees to indicates forward flow	TB5-1
A-2		TB5-2
B	+5 V, B leads A by 90 degrees to indicate reverse flow	TB5-3
Status	+0 V, indicates alarm condition meter +5 V, indicates normal operation	TB5-5
Ground	Ground	TB5-7

Table 8-5: Pulse and Digital Output Wiring

Description			Terminus	DB9
TX	-	Transmit	TB4-1	2
GND	-	GND/Shield	TB4-2	5
RX	-	Receive	TB4-3	3
5V	-	+5V DC	TB4-4	-

Table 8-6: RS-232 Output

Power Connectivity	Description	terminus
120 VAC	LINE	1
	Neutral	2
	Ground/Earth	3
24 VDC	+24 VDC	1
	24 VDC Return	2
	Ground/Earth	3
230 VAC	LINE 1	1
	LINE 2	2
	Ground/Earth	3

Table 8-7: Power Connections

(Only one type of power should be connected)

Fuse	Size/Type	Function
F1	3.15 Amp (time delay)	Electronics
F2	5.0 Amp (fast acting)	Heaters for cold ambient applications

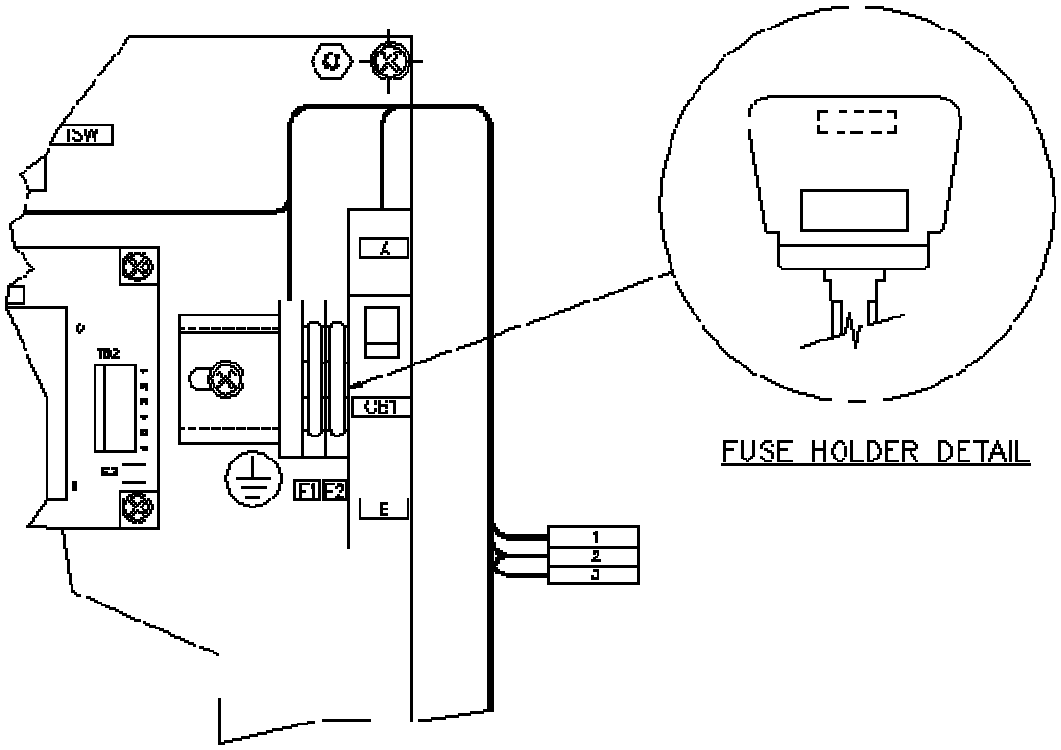


Figure 8-5: 24 Volt DC Fuses

Table 1. Typical Communication Setups

	Switch 1 TX Enable	Switch 2 RX Enable	Switch 3 2/4 Wire	Switch 4 2/4 Wire
RS-485 2-Wire Mode (half duplex)	ON	ON	ON	ON
RS-485 4-Wire Mode (full duplex)	ON	OFF	OFF	OFF
RS-422 Mode (full duplex)	OFF	OFF	OFF	OFF

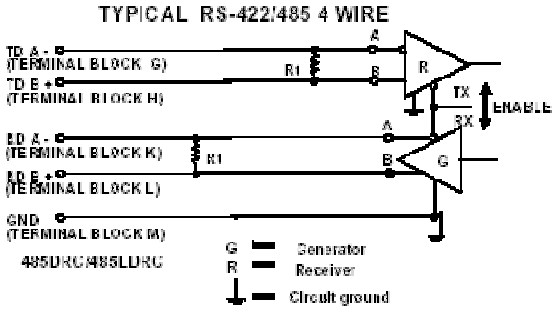
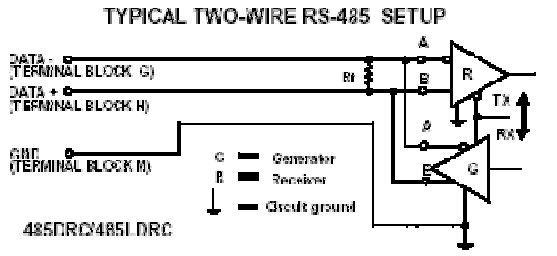


Table 2. Baud Rate Selection

	Switch 6	Switch 7	Switch 8	R11	Time (ms)
1200	OFF	OFF	OFF	820kΩ	8.33
2400	OFF	OFF	ON	Not Used	4.16
4800	OFF	ON	OFF	Not Used	2.08
9600	ON	OFF	OFF	Not Used	1.04
19200	ON	ON	ON	Not Used	.500
38400	OFF	OFF	OFF	27kΩ	.200
57600	OFF	OFF	OFF	16kΩ	.176
115200	OFF	OFF	OFF	8.2kΩ	.0868



In a two-wire setup, switches 3 & 4 should be "ON", making terminal block (G) the Data (–) line and terminal block (H) the Data (+) line.

Terminal Block Configuration

RS-232

(D)	TD (input)
(A)	RD (output)
(B)	SIG. GND
(F)	+10 to 30VDC
(C)	PWR. GND

RS-422/485

TDA	(G) Tx inverted or (-) (output)
RDA	(K) Rx inverted or (-) input)
TDB	(H) Tx non-inverted or (+) (output)
RDB	(L) Rx non-inverted or (+) (input)
ISO.GND	(M) Isolated RS-422/485 Signal Ground/Common

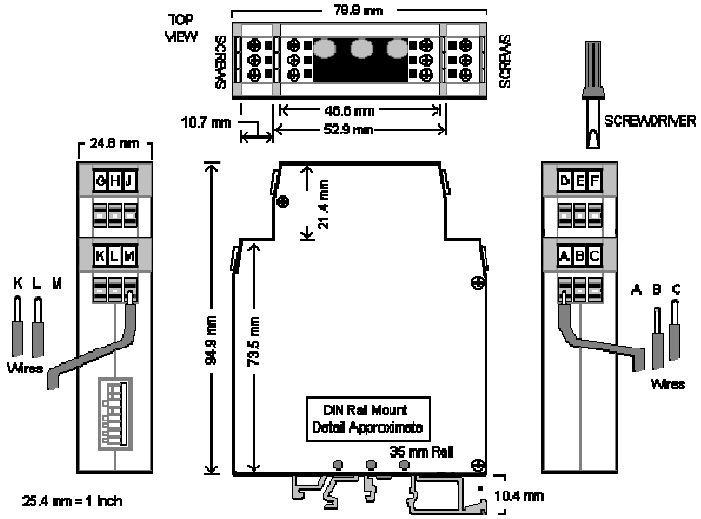


Figure 8-6: RS-485 Setup and Configuration

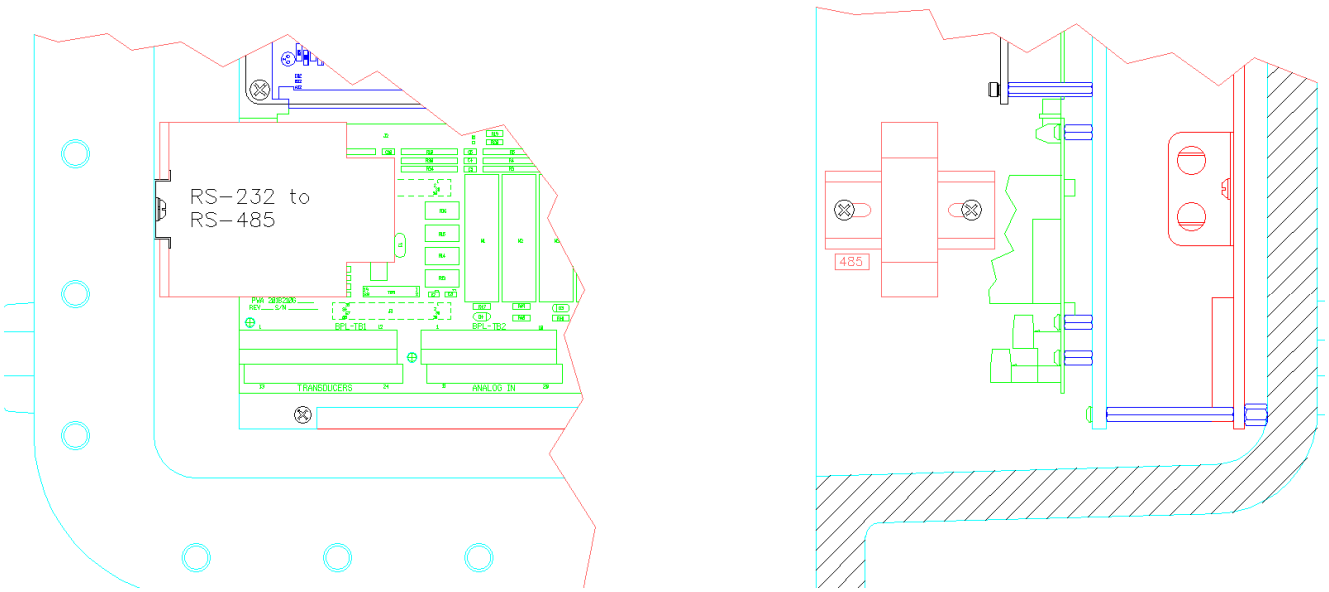


Figure 8-7: RS-485 Converter Location

RS-485 Module	Wire Color	Transmitter	Reference
485-D	Orange	BPL-TB4-1	TD (input)
485-A	Yellow	BPL-TB4-3	RD (output)
485-B	Black	BPL-TB4-2	SIG. GND
485-F	Red	BPL-TB8-2	+12 VDC
485-C	Blue	BPL-TB8-4	PWR. GND

Table 8-7: RS-232 to RS-485 Wiring Instructions

9.0 APPENDIX C

9.1 ATEX Certifications (Document IB0613)

See the following ATEX certifications for conditions of safe use for the meter manifold and the transmitter. The temperature ranges listed are for the enclosures indicated on the certificate. The temperature limit of the meter assembly is dependent on the temperature limits for the components used to connect the meter to the electronics and may limit the temperature limits for the assembled meter. See the meter nameplate for the temperature limit of the system as assembled.

WARRANTY - LIMITATION OF LIABILITY: Seller warrants only title to the products, software, supplies and materials and that, except as to software, the same are free from defects in workmanship and materials for a period of one (1) year from the date of delivery. Seller does not warranty that software is free from error or that software will run in an uninterrupted fashion. Seller provides all software "as is". THERE ARE NO WARRANTIES, EXPRESS OR IMPLIED, OF MERCHANTABILITY, FITNESS OR OTHERWISE WHICH EXTEND BEYOND THOSE STATED IN THE IMMEDIATELY PRECEDING SENTENCE. Seller's liability and Buyer's exclusive remedy in any case of action (whether in contract, tort, breach of warranty or otherwise) arising out of the sale or use of any products, software, supplies, or materials is expressly limited to the replacement of such products, software, supplies, or materials on their return to Seller or, at Seller's option, to the allowance to the customer of credit for the cost of such items. In no event shall Seller be liable for special, incidental, indirect, punitive or consequential damages. Seller does not warrant in any way products, software, supplies and materials not manufactured by Seller, and such will be sold only with the warranties that are given by the manufacturer thereof. Seller will pass only through to its purchaser of such items the warranty granted to it by the manufacturer.

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