Fermilab

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Installation of Coriolis Flowmeters

Mike White

Oct. 14, 2015

Overview

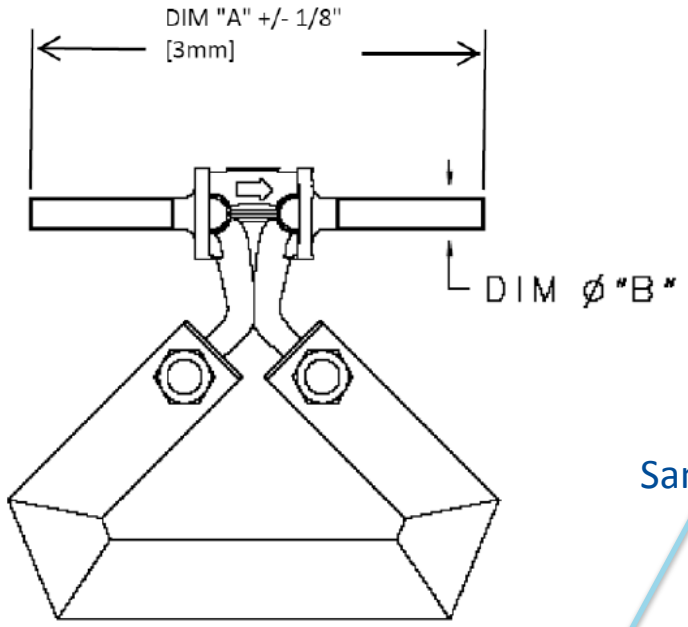
- Dimensions of Sensor
- Electrical Junction Box Options
- Wiring Options to Vacuum Vessel
- Installation at Cryotherm
- Pin diagrams and resistances
- Installation at FNAL
- Description of Micro Motion start up assistance
- First weekend of data

Coriolis Sensor Quotation Dwg

2. CUSTOMER SPECIAL PROCESS CONNECTION:

   PIPE EXTENSION: ½" SCHEDULE 10S
   MECHANICAL PROPERTIES: 316 STAINLESS STEEL
   CHEMICAL PROPERTIES: 316L STAINLESS STEEL

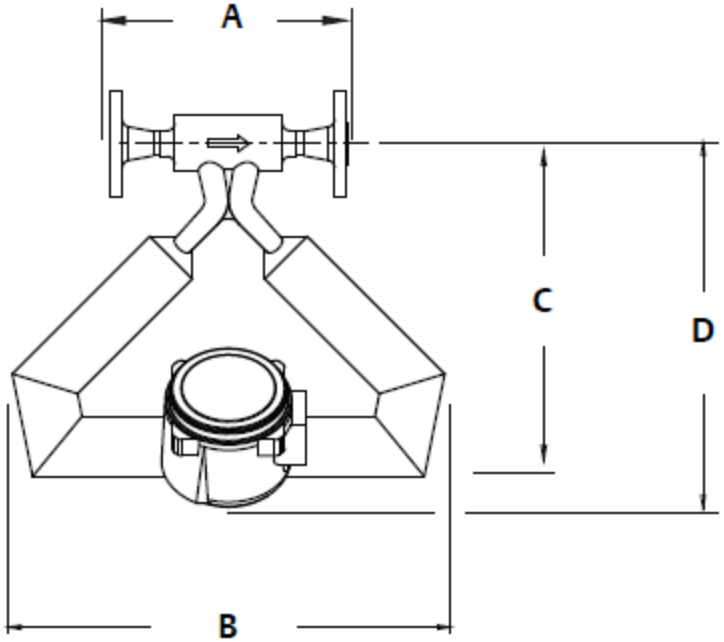
3. DIMENSIONS ARE IN INCHES [MM]. METRIC UNITS ARE FOR REFERENCE; DO NOT CONVERT.

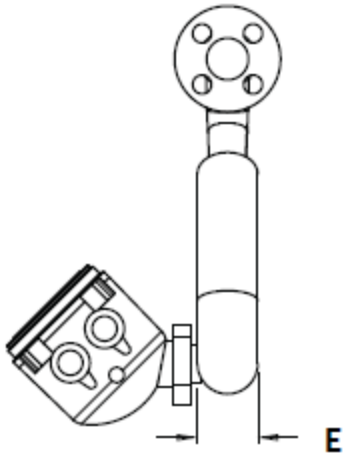


Same as delivered

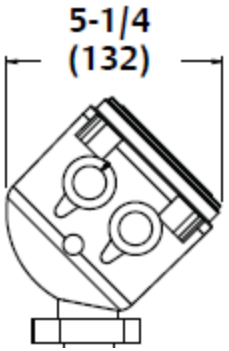
Sensor Model	ETO Process Connection Ref. #	Dim. "A"	Dim. "B"
CMF025M	19868	9.33" [237]	.84"[21]

Std Catalog Dimensions





Model	Dim. A		Dim. B		Dim. C		Dim. D		Dim. E	
	Inch	mm	Inch	mm	Inch	mm	Inch	mm	Inch	mm
CMF025	6-3/4	171	10	254	8-1/4	210	9-7/16	238	1-5/8	42

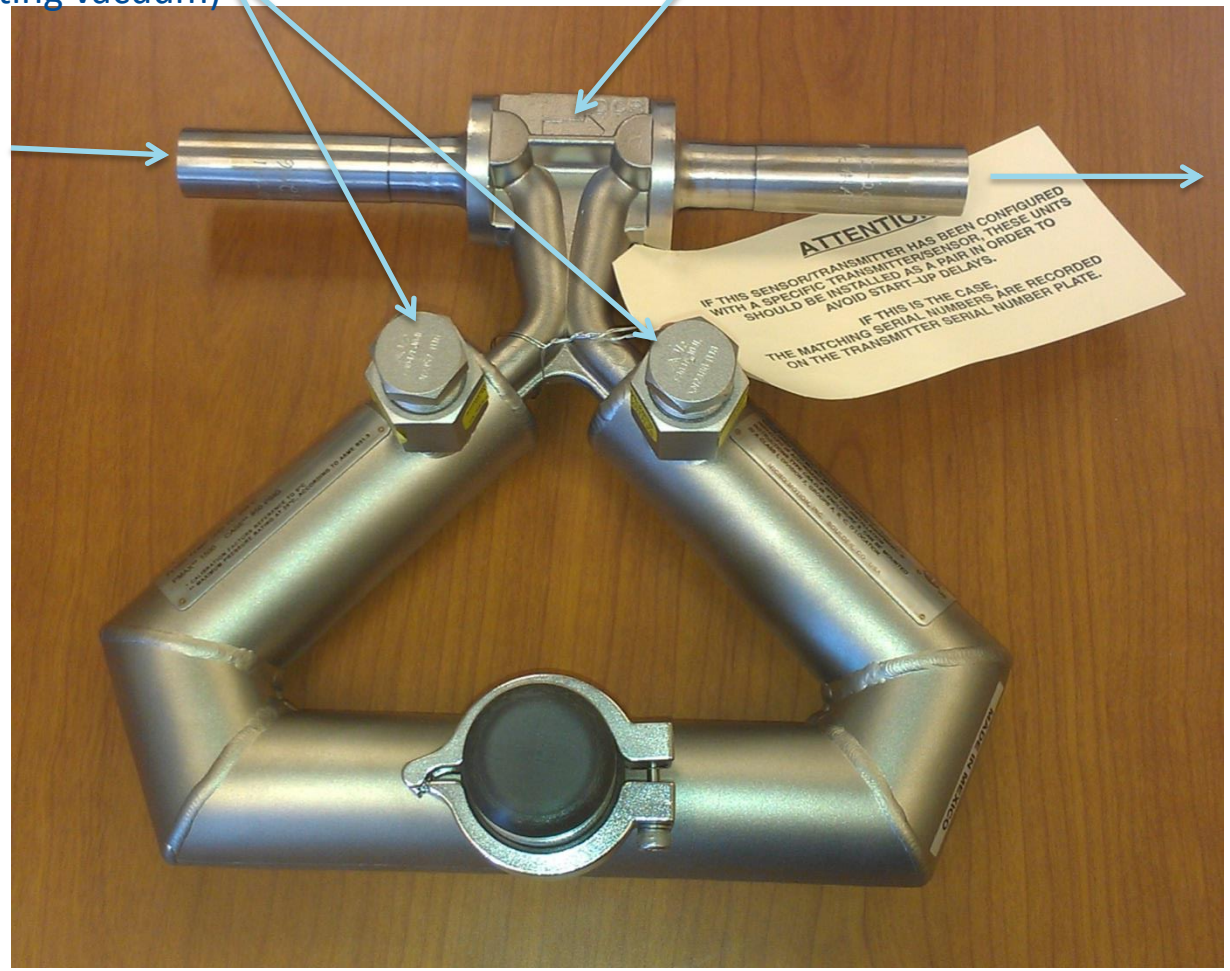


Coriolis Sensor as Delivered

Plugs removed prior to installation (secondary containment is common with insulating vacuum)

Flow direction label

Inlet
½” (DN15) Sch 10



Outlet
½” (DN15) Sch 10

There are no requirements for straight runs of pipe upstream or downstream of sensor

Sensor can be installed in any orientation since only gas phase fluid passes through sensor

Coriolis Pressure Rating

ELITE Series Coriolis Flow and Density Meters December 2014

Process pressure ratings

Sensor maximum working pressure reflects the highest possible pressure rating for a given sensor. Process connection type and environmental and process fluid temperatures may reduce the maximum rating. See Temperature and Pressure De-Ratings on page 9 for common sensor and fitting combinations.

All sensors comply with ASME B31.3 process piping code and Council Directive 97/23/EC of 29 May 1997 on pressure equipment. Some sensor models also comply with the ASME B31.1 power piping design code as indicated with a pressure rating in the table. Sensors with JIS process connections do not comply with ASME B31.1 power piping code.

Sensor maximum working pressure for stainless steel models: 304L (L) and 316L (M/A)

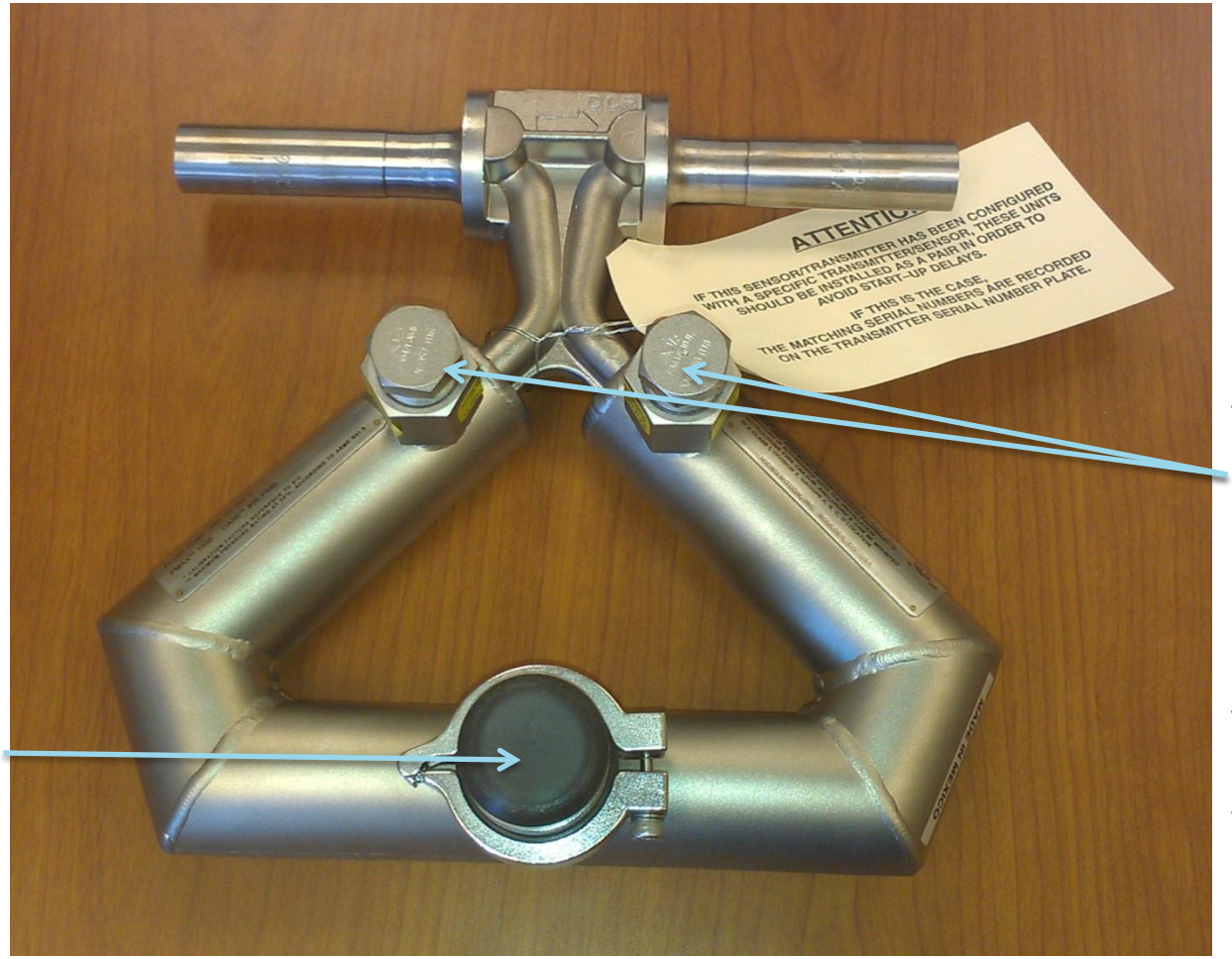
	ASME B31.3 compliance		ASME B31.1 compliance	
Model	psig	barg	psig	barg
CMFS007M, CMFS010M, CMFS015M	1,812	125	n/a	n/a
CMFS025M, CMFS040M, CMFS050M, CMFS075M, CMFS100M, CMFS150M	1,500	103	1,500	103
CMF010M/L	1,812	125	1,812	125
CMF025M/L, CMF050M/L	1,500	103	1,500	103
CMF100M/L	1,450	100	1,450	100
CMF200M/L/A	1,580	109	1,580	109
CMF300M/L/A	1,730	119	1,730	119
CMF350M/A	1,480	102	1,480	102
CMF400M/A	1,500	103	1,500	103
CMFHC2M/A	1,480	102	1470	101
CMFHC3M/A	1,480	102	1460	101
CMFHC4M	1,480	102	n/a	n/a

Coriolis Sensor as Delivered

ITEM	MODEL NUMBER	DESCRIPTION
1	CMF025MB67PHBAEZZX_19868	**Micro Motion Coriolis ELITE Sensor** • 1/4", 316LSS Construction • ETO Flange Process Connections • Purge fittings (two 1/2-inch NPT female • 9-Wire exteded Mount polyurethane-painted aluminum J-box • 1/2" NPT Conduit Connections, No Gland • CSA Approval: Class I, Div II, Groups C and D • English Installation Manual • 0.10% Mass Flow and 0.0005 G/CC Density Calibrations • No Measurement Application Software • ETO Product • ETO Description: Pipe Ext, ½" Sched 10S X 3" 316L Bevel Cut and Cryo Temp Cycling Modeifications For A CMF025M • ***** This sensor application process conditions are outside Micro Motion's published specification. Therefore, the warranty return and repair coverage shall not apply. *****

No Bevel on Weld Stub as Requested. Cryotherm beveled edges during valve box installation

Coriolis Sensor as Delivered



Cover to protect electrical connector during shipment/storage

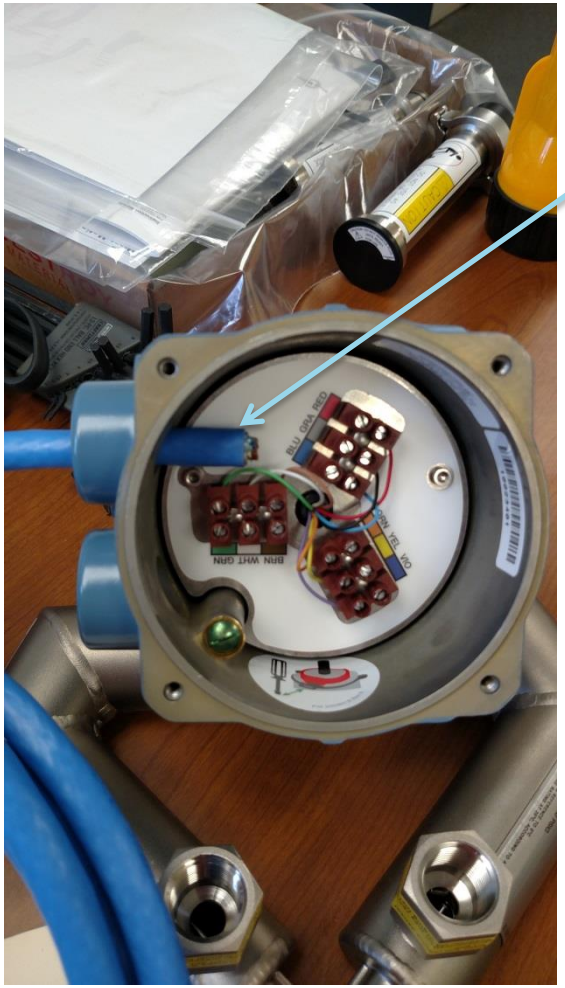
In many applications the sensor case is filled with dry nitrogen. For FNAL the male ½" NPT plugs will be removed prior to installation so that the sensor case is at full vacuum during normal operation

Electrical Connection of Coriolis Sensor

Junction Box Mounting

- Options include:
  - Std Junction Box Mounting
  - Extended Junction Box Mounting
  - Removing small electrical connector from junction box
  - Using a circuit board

Std Junction Box Mounting



Standard installation method is to strip MicroMotion supplied cable and connect to screw terminals inside junction box

Extended Mount Junction Box

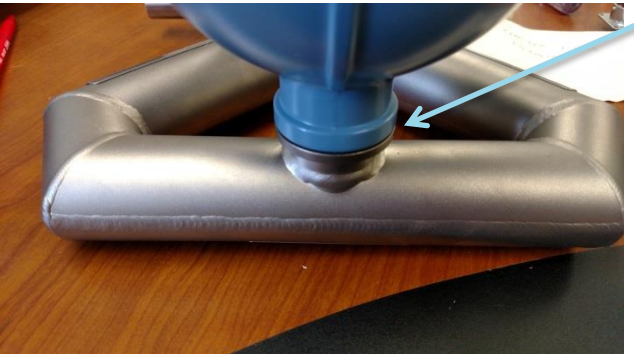
Junction box assy that is almost as large as the meter!

Wiring insulation is Teflon per email communication with Micro Motion

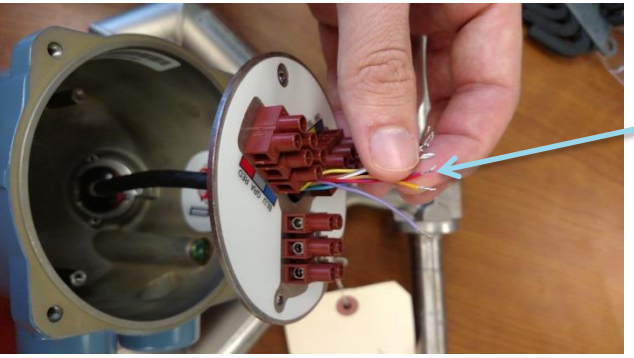
Extended mount is optional, used to move junction box further from sensor (which could be hot or cold). In some cases a core processer is built into junction box, but for CMTS the core processor is built into transmitter (processor not intended for cryo temp or vacuum, wire length to transmitter not an issue)

Detoronics flange mount electrical connector with solder cup pins to be mounted on vacuum vessel wall. Simple to solder one end of Micro Motion cable here.

Removing small electrical connector from junction box

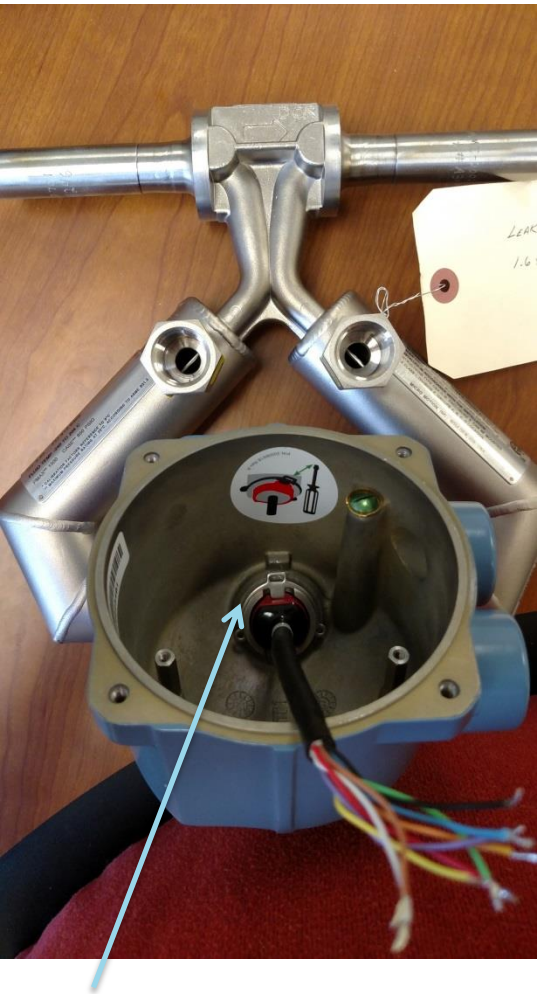


Remove Clamp



Disconnect leads from screw terminal

Removing small electrical connector from junction box



Remove clip

Due to o-ring, connector requires some force to pull out

Use clip to secure connector to sensor

PCB Board

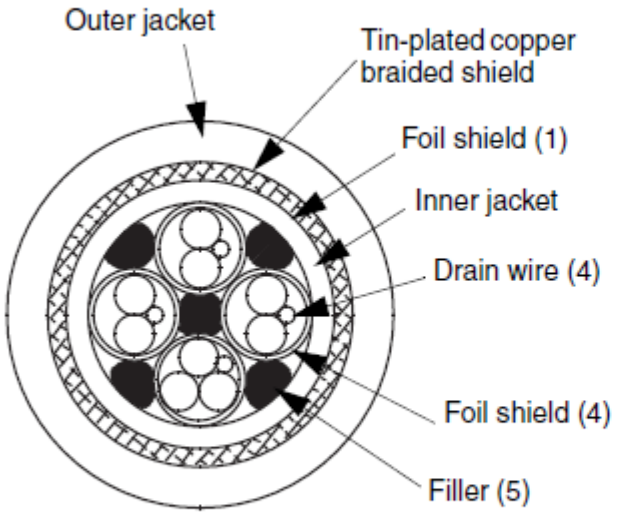
- It’s also possible to custom fabricate PCB boards (photo courtesy of Luigi Serio, CERN) as the electrical connector

Wiring to Vacuum Vessel

- Options
  - Use cable supplied by MicroMotion
    - Quite stiff
    - Has outgassing
    - Color coded for easy installation
    - Always used at DESY, sometimes at CERN (calibration station)
  - Use user selected & supplied wire
    - Wire can be more flexible
    - Outgassing less of an issue
    - Difficult to match color coding
    - Sometimes used at CERN (in tunnel due to fire/radiation concerns)

Micro Motion Supplied Cable

Figure 2-2 **Shielded cable**



Jacket material	Outside diameter *inches (mm)*	Minimum bend radii: Static (no load) condition *inches (mm)*	Minimum bend radii: Under dynamic load *inches (mm)*
PVC	0.525 (14)	4 1/4 (108)	8 1/2 (216)
Teflon FEP	0.425 (11)	3 1/4 (83)	6 3/8 (162)

Drive wires are 18 AWG and all other wires 22 AWG per email communication with MicroMotion

Micro Motion Supplied Cable

Table 1-1: Maximum lengths for Micro Motion cable

Cable type	To transmitter	Maximum length
Micro Motion 9-wire	9739 MVD transmitter	1000 ft (300 m)
	All other MVD transmitters	60 ft (20 m)
Micro Motion 4-wire	All 4-wire MVD transmitters	1000 ft (300 m)

Table 1-2: Maximum lengths for user-supplied 4-wire cable

Wire function	Wire size	Maximum length
Power (VDC)	22 AWG (0,35 mm^2)	300 ft (90 m)
	20 AWG (0,5 mm^2)	500 ft (150 m)
	18 AWG (0,8 mm^2)	1000 ft (300 m)
Signal (RS-485)	22 AWG (0,35 mm^2) or larger	1000 ft (300 m)

Micro Motion Supplied Cable

A.2 Cable wire colors and functions

Micro Motion 9-wire cable is color coded. Table A-1 lists the wire colors and functions for all 9-wire cable types.

Table A-1 **9-wire cable wire colors and functions**

Wire Color	Function
Brown	Drive +
Red	Drive –
Orange	• T-Series sensors (straight tube): Composite RTD • All other sensors (curved tube): Lead length compensator (LLC)
Yellow	Temperature return
Green	Left pickoff +
Blue	Right pickoff +
Violet	Tube RTD
Gray	Right pickoff –
White	Left pickoff –
Black	Drain

9-Wire Flowmeter Cable Preparation and Installation 25

Micro Motion Supplied Cable

- Concern is that filler material in Coriolis cable will trap air and lead to outgassing
  - This is tolerable for CMTS since valve box has separate vacuum volume from cryomodule
- Test with Bell Jar
  - Pumped using helium leak detector
  - No leak detected on hose or base of bell jar
  - 9:00 am, Start of active pumping, quickly reaches 0 micron
  - 3:00 pm, Vacuum pump shut off, 0 micron
  - 3:15 pm, 3 micron
  - 4:00 pm, 16 micron
  - 9 am next morning: 288 micron

Micro Motion Supplied Cable

User Selected & Supplied wire

- Requirements per Micro Motion Email Communication
  - Use twisted pairs
  - Each pair should be shielded
  - Internal RTD has tendency to break at LHe temperatures, so RTD wires don't need to be connected. Instead, connect RTD wires on transmitter to a 100 ohm resistor (this causes meter to think it's at 0 deg C)

User Selected & Supplied wire

- Recommendations from Luigi Serio (CERN)
  - 22 AWG tinned copper
  - 2 conductors twisted L.H.L., 30 +/- 5 twists/meter nominal
  - The number of twists per meter is not so critical, but each of the three pairs must have the same number of twists
  - Foil free edged aluminum/polyimide tape wrap, 25% minimum overlap; aluminum side in
  - May need parallel resistance across the drive terminal to avoid oscillations when cooling at low temperatures.
  - Used 3 m length inside vacuum jacket

User Selected & Supplied Wire External to Vacuum Vessel

Consolidated
ELECTRONIC WIRE & CABLE

Part # 5353-CL, 18 AWG 3 Pair Individually My/AL Foil Shielded Multi-Pair Consolidated Cable (UL) CM/CMG or CMG UL 2919

Product Construction
Conductor:

- 18 AWG annealed stranded tinned copper wire per ASTM B-33

Insulation:

- (PE) Polyethylene insulation

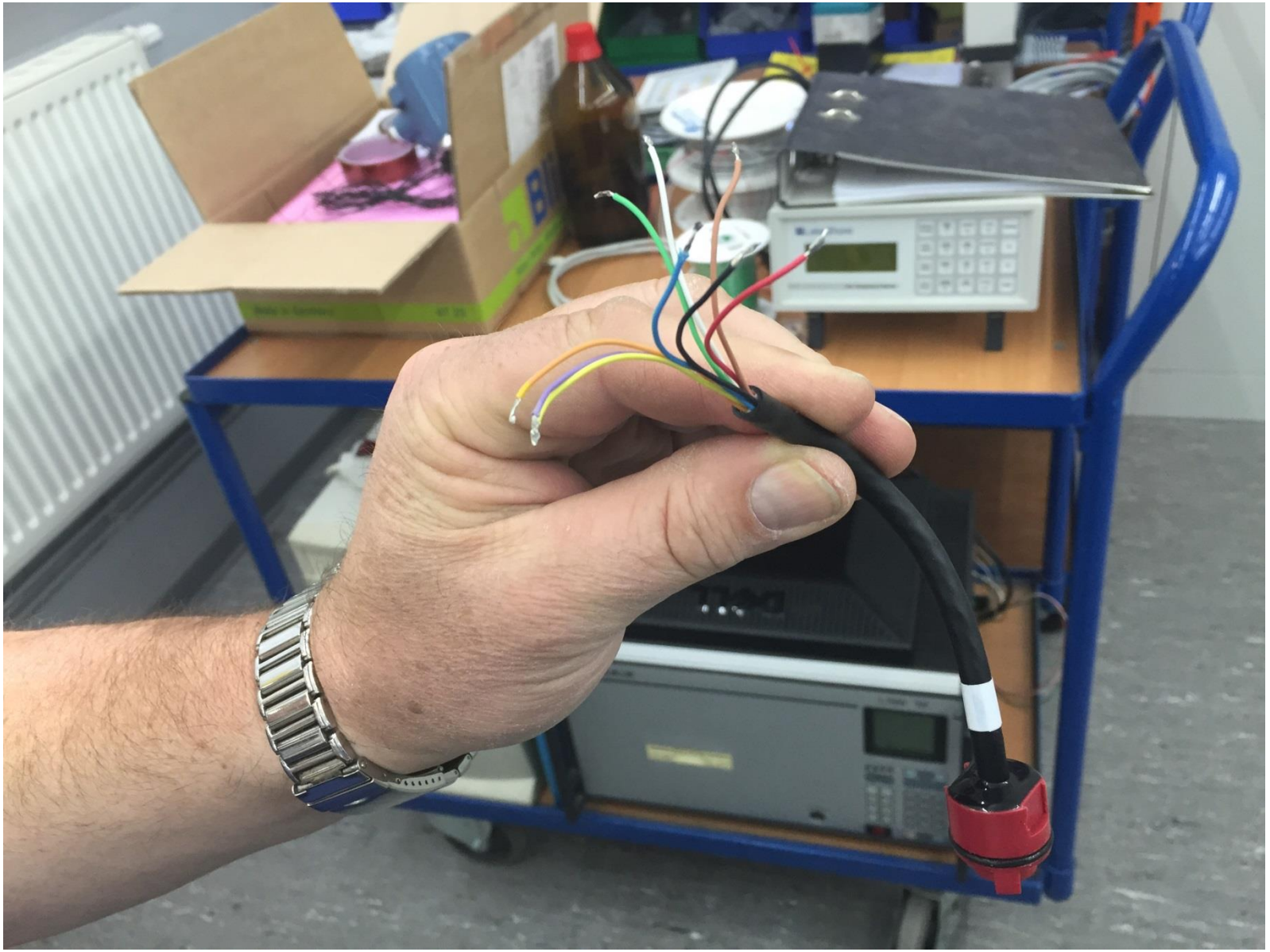
Shield:

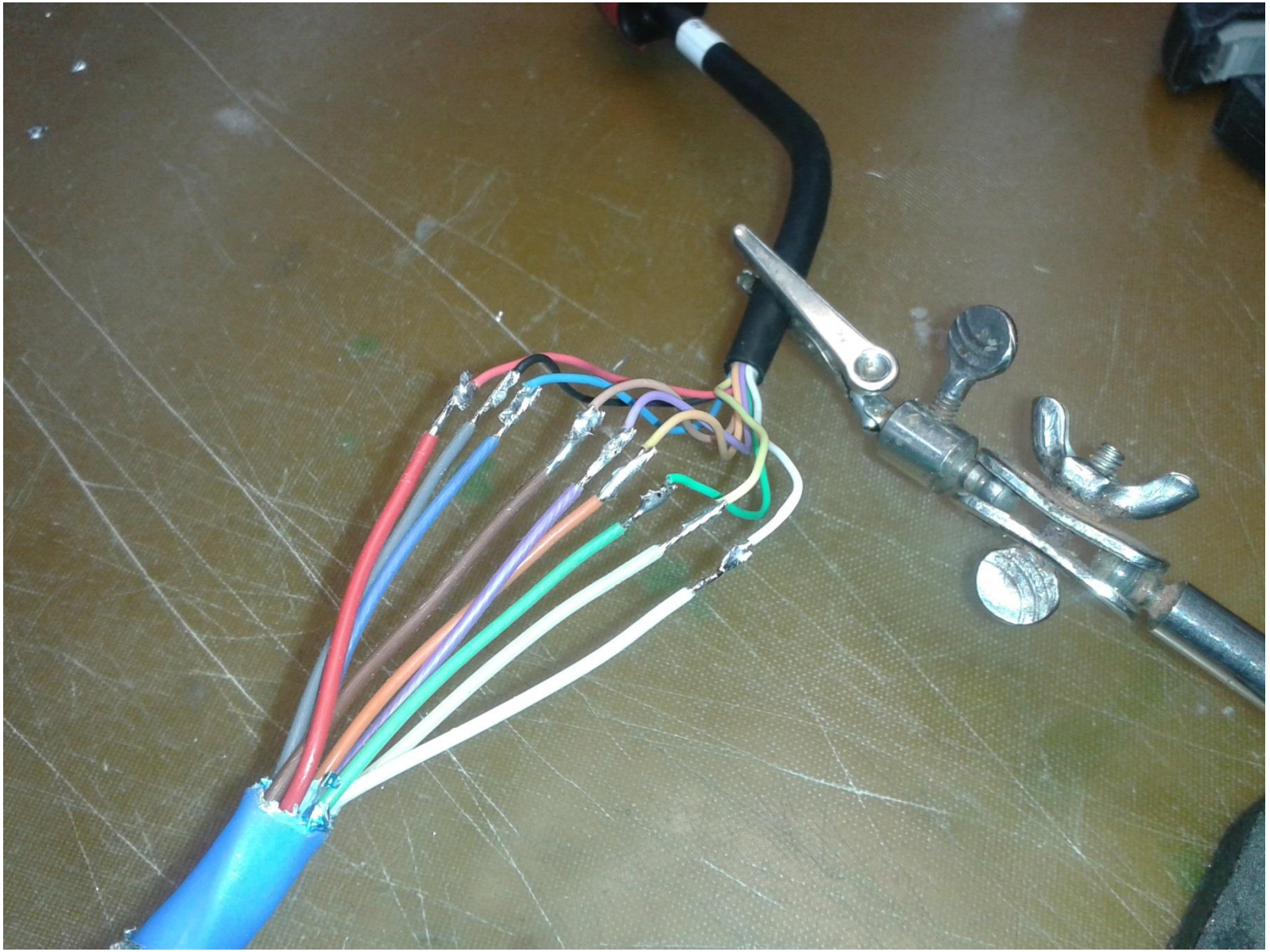
- Individually shielded pairs
- 100% Mylar/aluminum foil shield 25% overlap
- Stranded tinned copper drain wire each pair

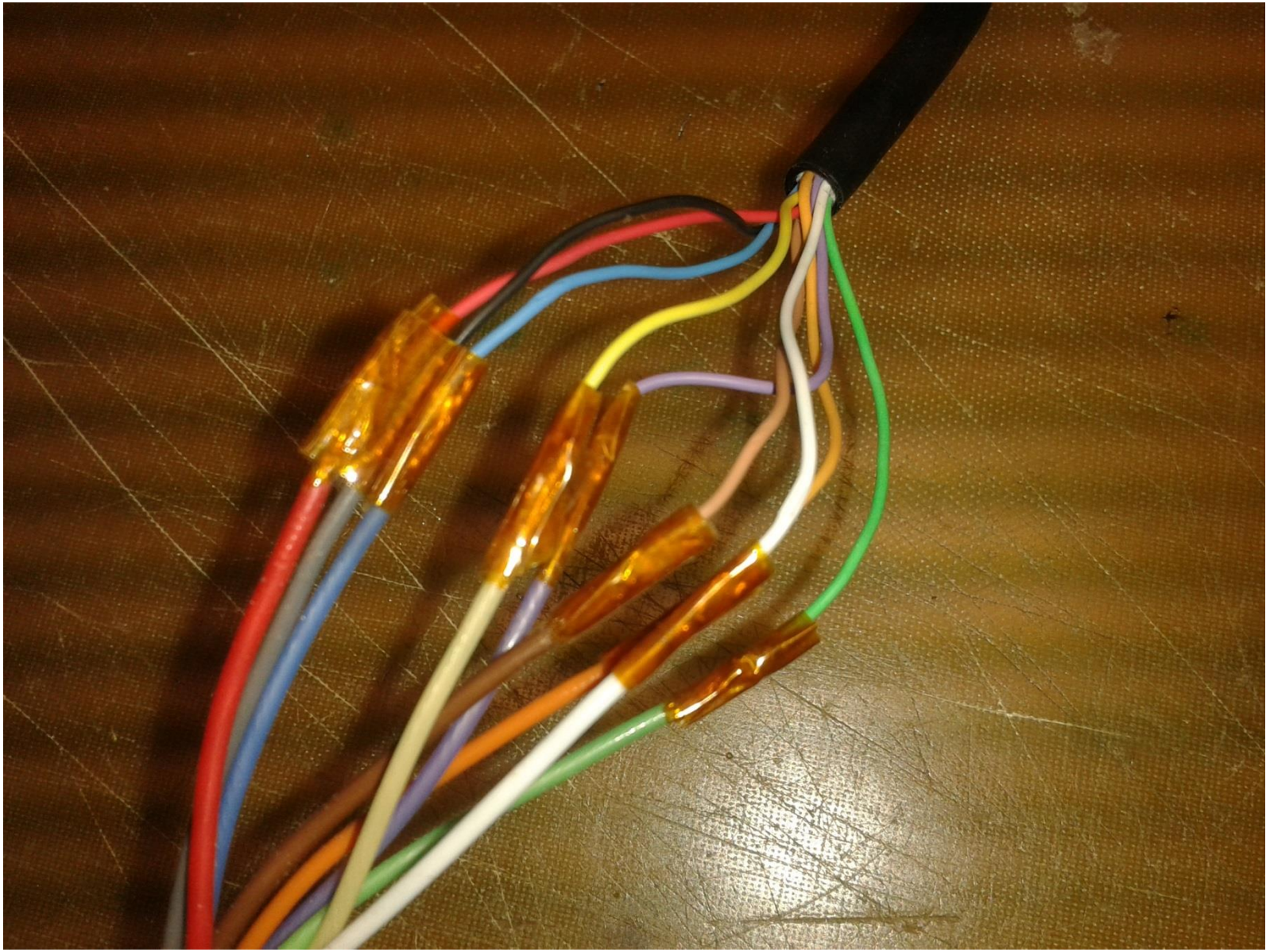
Jacket:

- Chrome gray PVC
- Temperature: -20°C to +75°C CM/CMG
- Temperature: -20°C to +80°C UL 2919
- Voltage: 300 volts CM/CMG
- Voltage: 30 volts UL 2919

Wiring Installation at Cryotherm





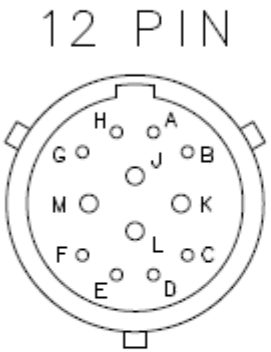



ZARGES

Pin Diagrams

Pin Diagram (Vacuum Vessel Connector)

Detoronics DTO2H-14-12PN Connector mounted on Vacuum Vessel



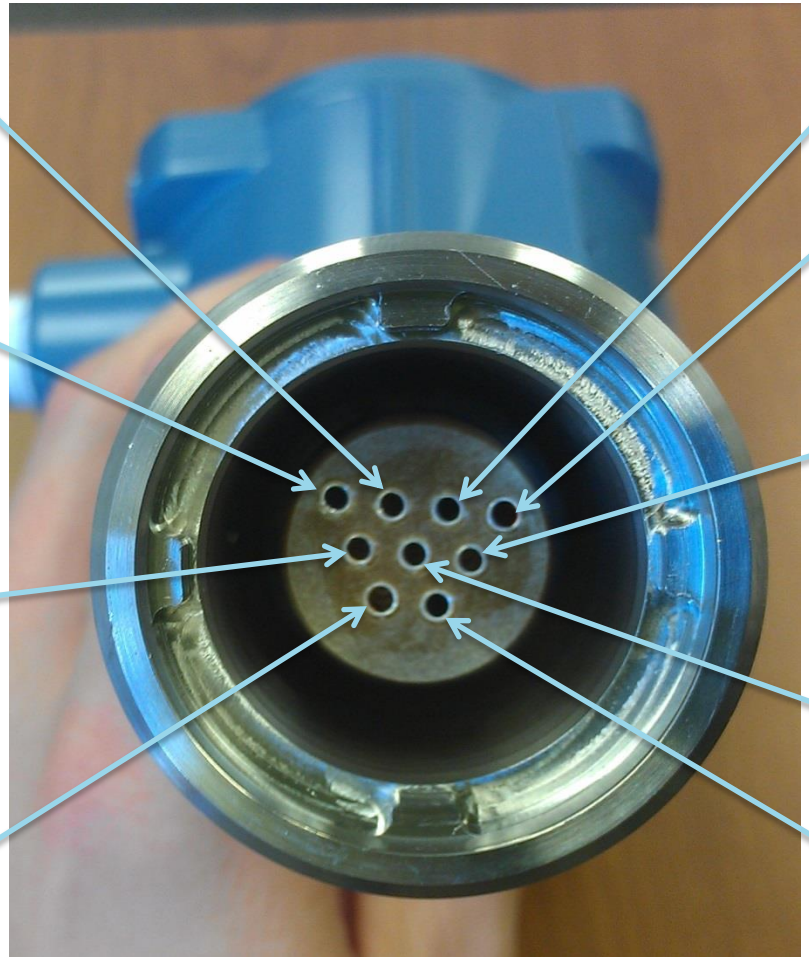
A	←	Brown
B	←	Red
C	←	Orange
D	←	Yellow
E	←	Green
F	←	Blue
G	←	Violet
H	←	Gray
J	←	White
K	<	-
L	<	-
M	<	-

CURRENT RATING

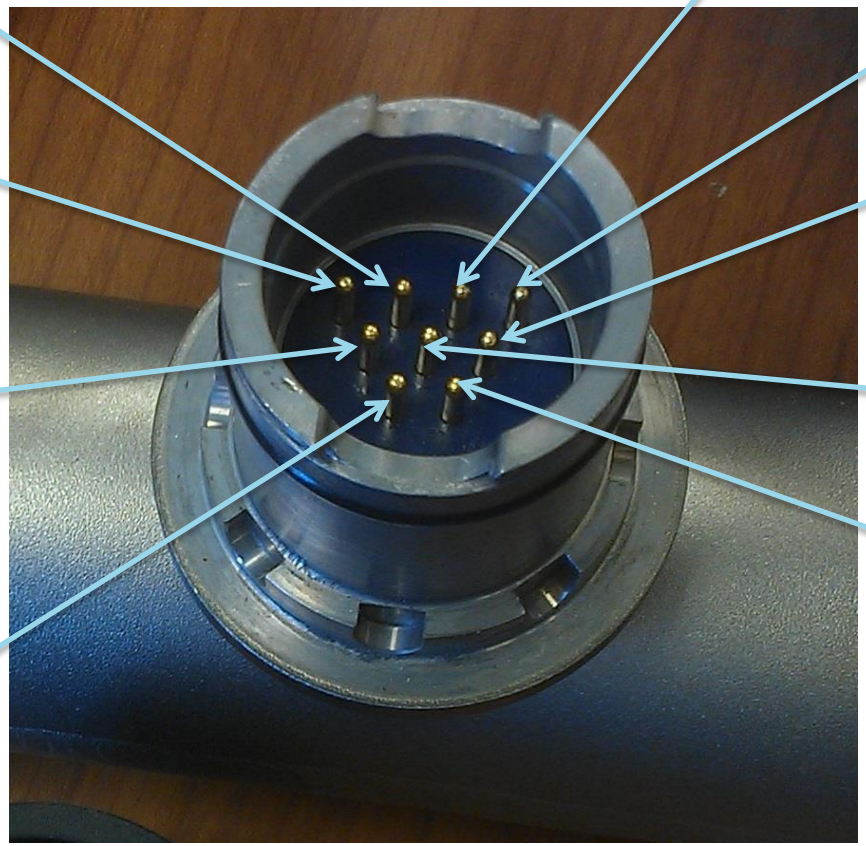
Size 20: 5 AMPS
Size 16: 10 AMPS

Figure 7.14.2. Flow meter wiring diagram

Pin Diagram (Junction Box)



Pin Diagram (Coriolis Sensor)



Expected Sensor Resistances

- Use for comparison during electrical checkout at Cryotherm and acceptance test of valve box at FNAL
- All combinations of pin-to-pin resistances not shown in table below should be infinite (open circuit)
- No pins are electrically connected to the sensor body
- The table below is for sensor S/N14462034

Function	Pin 1	Pin 2	Measured Resistance [ohm]
Right Pickoff	Gray	Blue	115.8
Left Pickoff	Green	White	115.8
Drive	Red	Brown	296.2
Temperature	Yellow	Violet	109.1
RTD/Lead length	Yellow	Orange	0.5
RTD/Lead length	Violet	Orange	109.1

Expected Sensor Resistances

- Use for comparison during electrical checkout at Cryotherm and acceptance test of valve box at FNAL
- All combinations of pin-to-pin resistances not shown in table below should be infinite (open circuit)
- No pins are electrically connected to the sensor body
- The table below is for sensor S/N14462033

Function	Pin 1	Pin 2	Measured Resistance [ohm]
Right Pickoff	Gray	Blue	113.7
Left Pickoff	Green	White	114.1
Drive	Red	Brown	292.5
Temperature	Yellow	Violet	107.8
RTD/Lead length	Yellow	Orange	0.3
RTD/Lead length	Violet	Orange	107.8

Expected Sensor Resistances

- Use for comparison during electrical checkout at Cryotherm and acceptance test of valve box at FNAL
- All combinations of pin-to-pin resistances not shown in table below should be infinite (open circuit)
- No pins are electrically connected to the sensor body
- The table below is for sensor S/N14462035

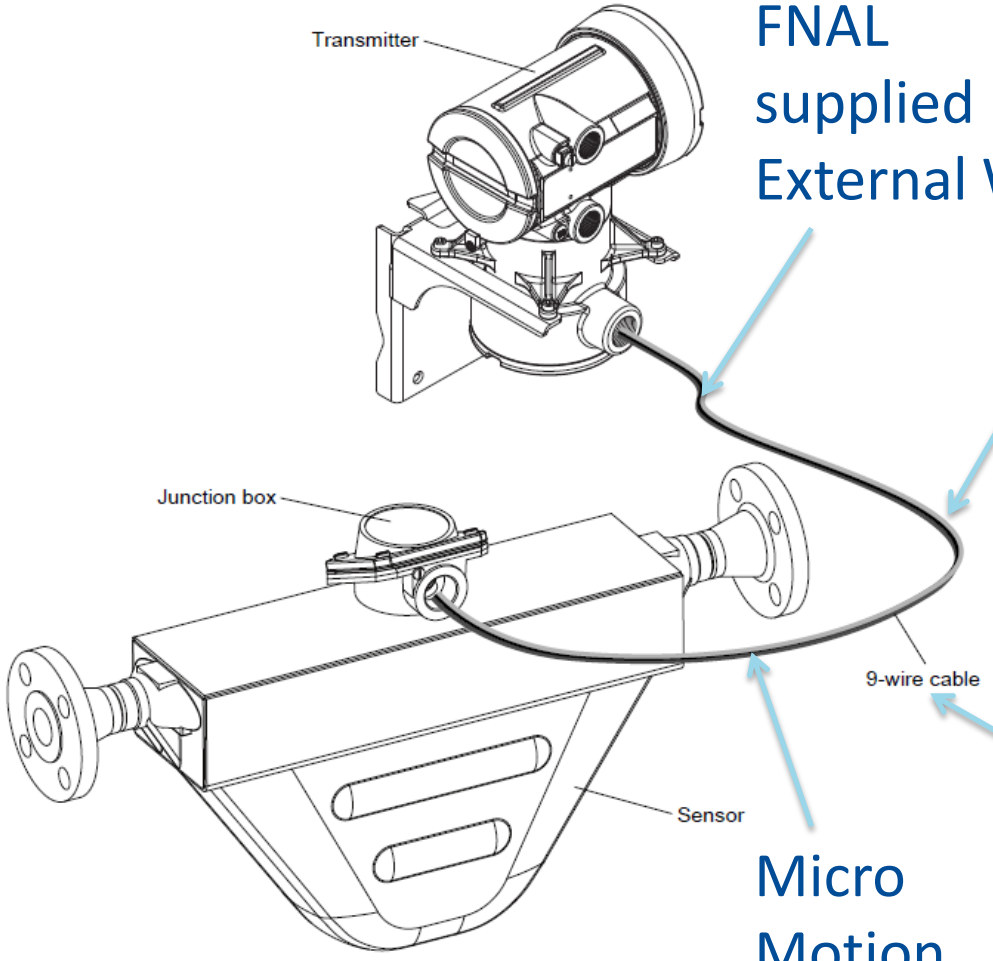
Function	Pin 1	Pin 2	Measured Resistance [ohm]
Right Pickoff	Gray	Blue	115.2
Left Pickoff	Green	White	116.0
Drive	Red	Brown	295.2
Temperature	Yellow	Violet	109.0
RTD/Lead length	Yellow	Orange	0.3
RTD/Lead length	Violet	Orange	109.0

Installation at FNAL

- Read the 2700 Transmitter Install manual for full details
- Key details repeated in next few slides

Connection to Transmitter

Figure 1-6: 9-wire remote installation type



FNAL supplied External Wire

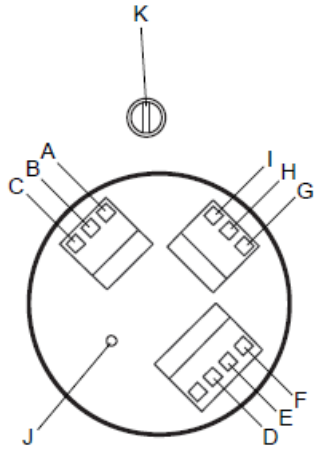
We have an electrical connector on the vacuum vessel in the middle of the cable

For LHe applications only 6 wires required (3 wires for temp sensor not used)

Micro Motion Wire

Connection to Transmitter

Figure 4-10: transmitter terminals



A. Brown
B. Violet
C. Yellow
D. Orange
E. Gray
F. Blue
G. White
H. Green
I. Red
J. Mounting screw
K. Ground screw (black)

Yellow, orange, and violet are connected to 100 ohm dummy resistor (not using Coriolis temp sensor)

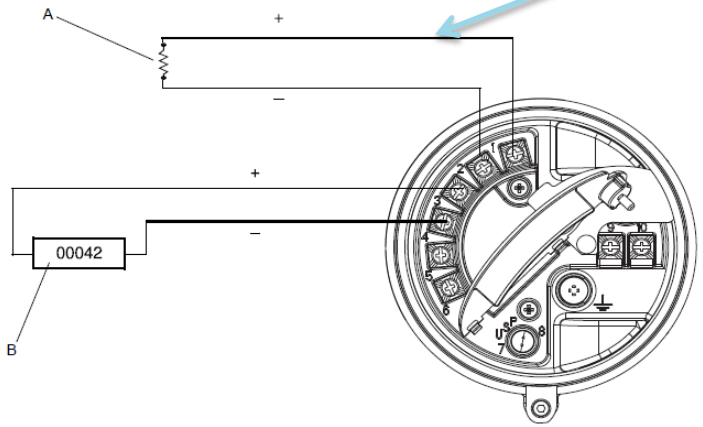
All other colors are connected to pins on vacuum vessel

Connection to Transmitter

Output Signal

7.1 Basic analog wiring

Figure 7-1: Basic analog wiring



A. mA output loop (820 Ω maximum loop resistance)
B. Frequency receiving device (output voltage level is +24 VDC ± 3%, with a 2.2 kΩ pull-up resistor)

We only care about Channel A (mass flow). We aren't outputting density or temperature, so other channels not required

Output Signal

Power Supply

1.5 Power requirements

Note

For DC power:

- Power requirements assume a single transmitter per cable.
- At startup, the power source must provide a minimum of 1.5 amps of short-term current per transmitter.
- Length and conductor diameter of the power cable must be sized to provide 18 VDC minimum at the power terminals, at a load current of 0.5 amps.

Power Supply

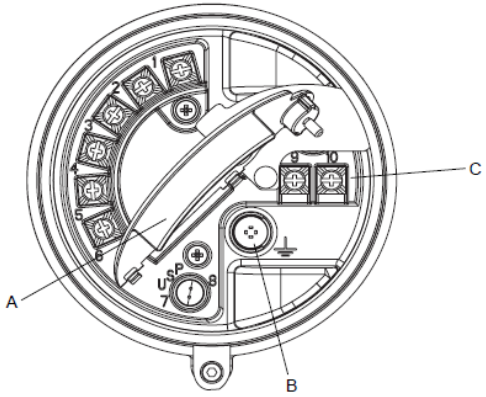
6.1 Wire the power supply

A user-supplied switch may be installed in the power supply line. For compliance with low-voltage directive 2006/95/EC (European installations), a switch in close proximity to the transmitter is required.

1. Remove the transmitter housing cover.
2. Open the warning flap.
3. Connect the power supply wires to terminals 9 and 10.

   Terminate the positive (line) wire on terminal 10 and the return (neutral) wire on terminal 9.

Figure 6-1: Power supply wiring terminals



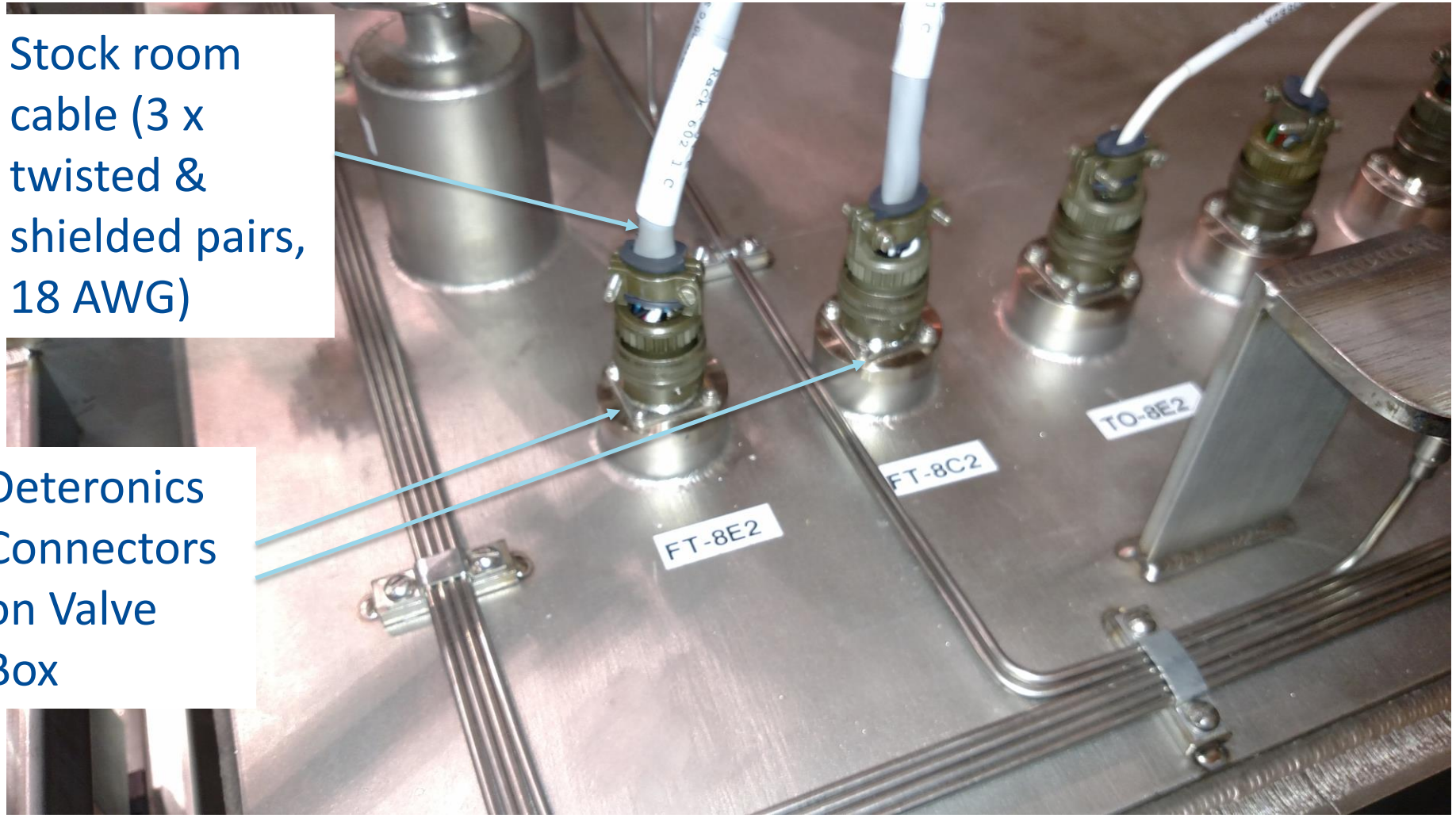
A. Warning flap
B. Equipment ground
C. Power supply wiring terminals (9 and 10)

4. Ground the power supply using the equipment ground, also under the warning flap.

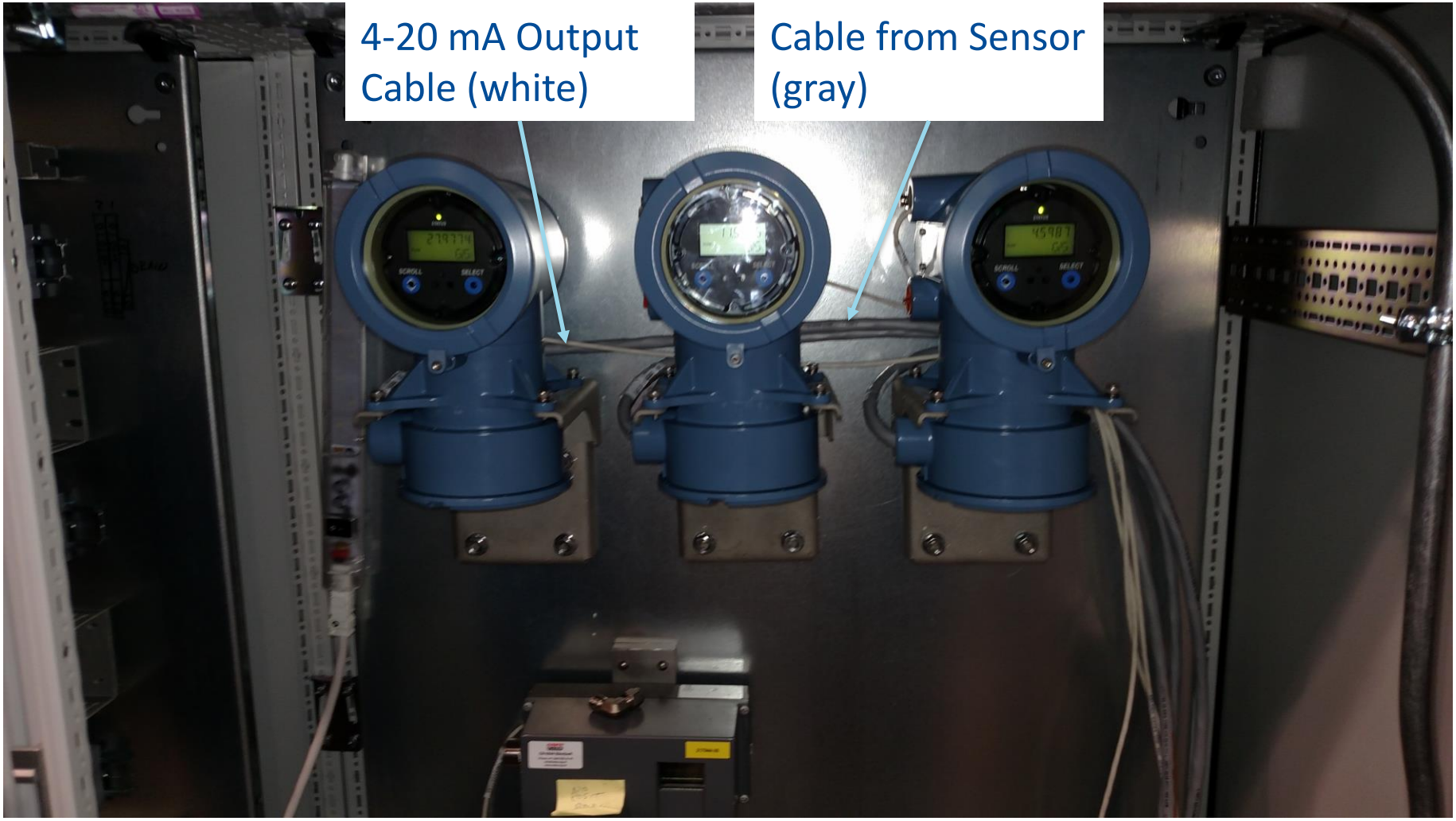
Micro Motion Referenced Documents

- ELITE Coriolis Flow and Density Sensors Installation Manual 20002158 Rev D1
- Model 1700 & 2700 Installation Manual, 20001700 Rev CD

Transmitter/Processer Installation at FNAL

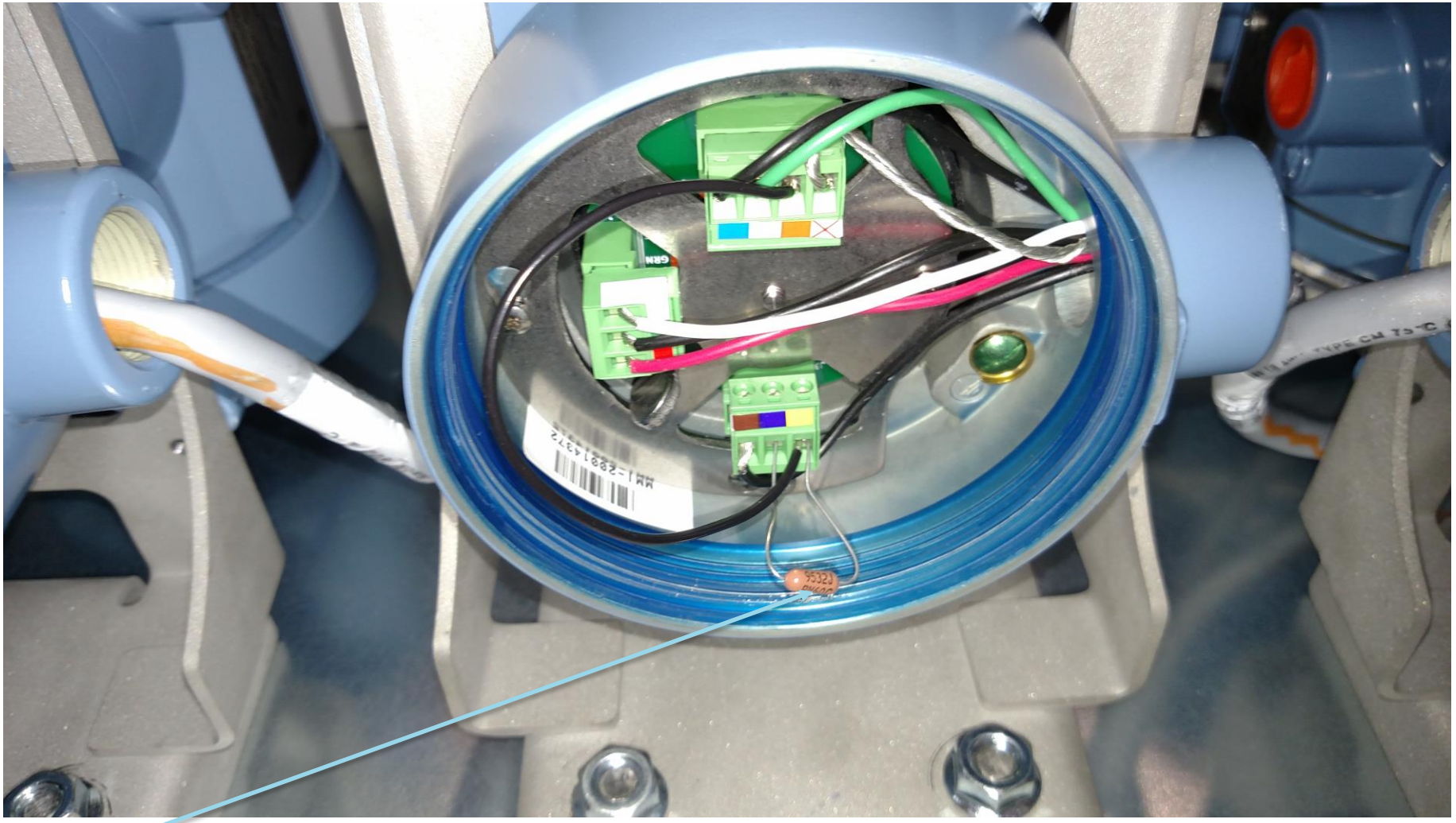


Transmitter/Processer Installation at FNAL



Transmitter/processor units display readings locally

Transmitter/Processer Installation at FNAL



100 ohm resistor, one end to purple and one end to yellow & orange

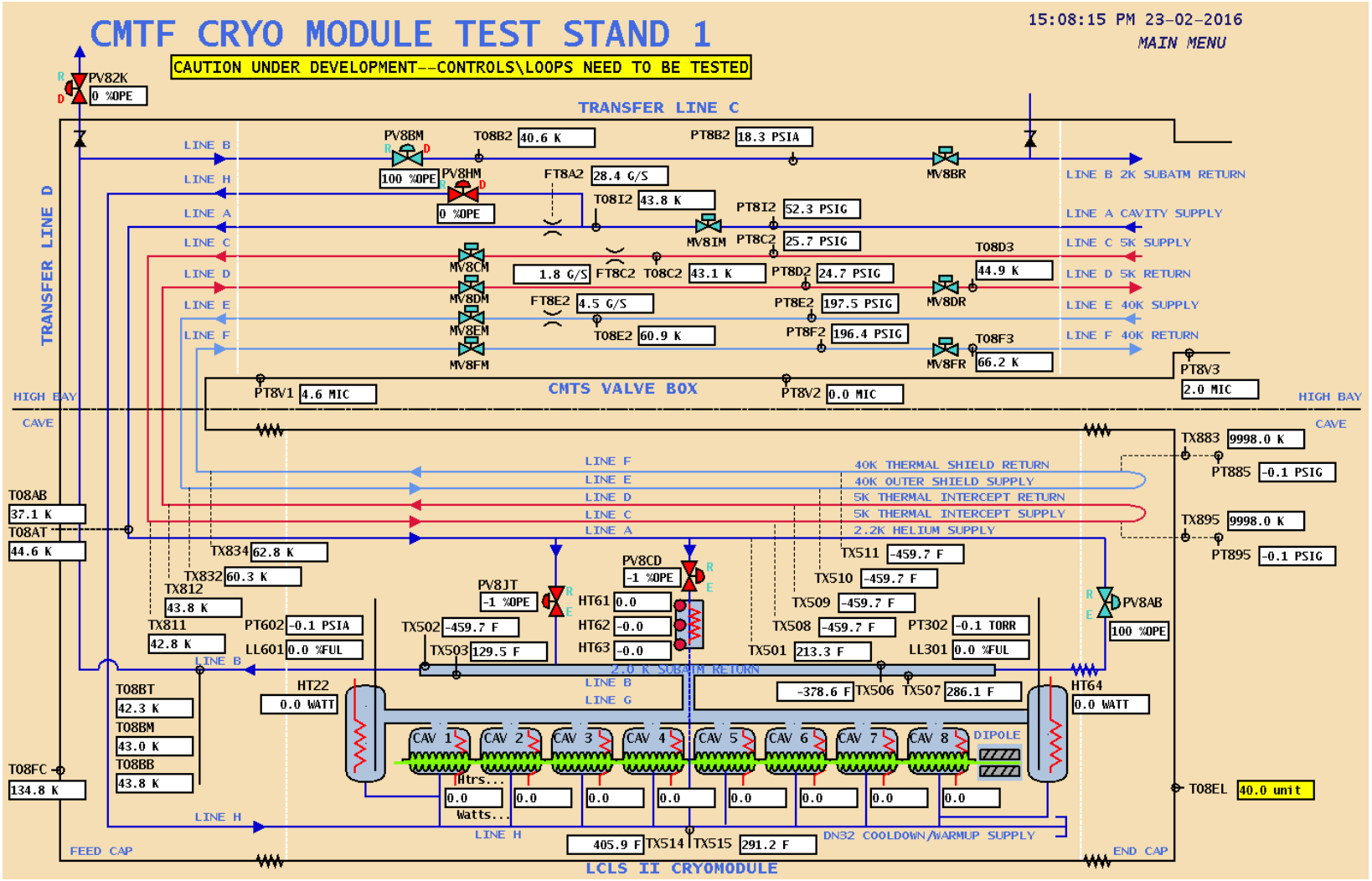
Micro Motion Start Up Assistance

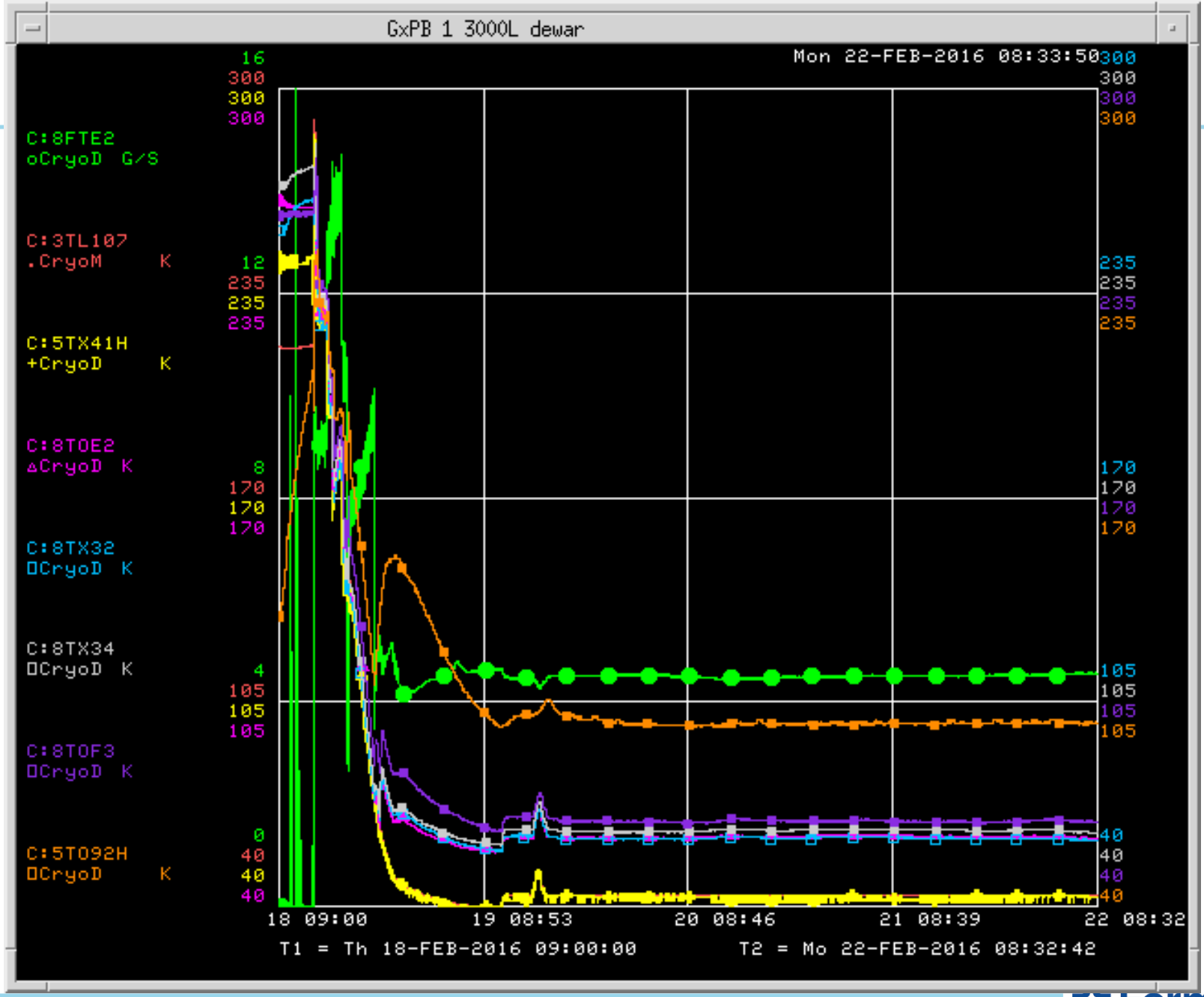
- Visual check out of wiring
- Verification of configuration details
  - Configuration reports attached as datasets in Teamcenter
- Set span and units of transmitter output
  - Determined by user (FNAL), but set by Micro Motion via portable laptop
  - In this case, 4-20 mA corresponds to 0 to 40 g/s
  - At low flow rates the error increases rapidly
    - For this size meter, the default lower value is 0.86 g/s. Below this value the unit will simply transmit 0 g/s
    - FNAL accepted the default lower value for use at CMTS

Micro Motion Start Up Assistance

- Check of zero point and max flow point
  - Micro Motion uses laptop to force the transmitter to send out a zero flow signal (0 g/s) and a maximum flow signal (40 g/s)
  - This is useful for verifying that the users (FNAL) data monitoring and logging system is functioning correctly
- Troubleshooting
  - One of the units was occasionally giving out random signals of flow even though the sensor was in between two fully closed valves
  - Micro Motion technician helped trace the source of noise to a crack in the insulation on one of the Deteronics connector wires

First Weekend Of Data

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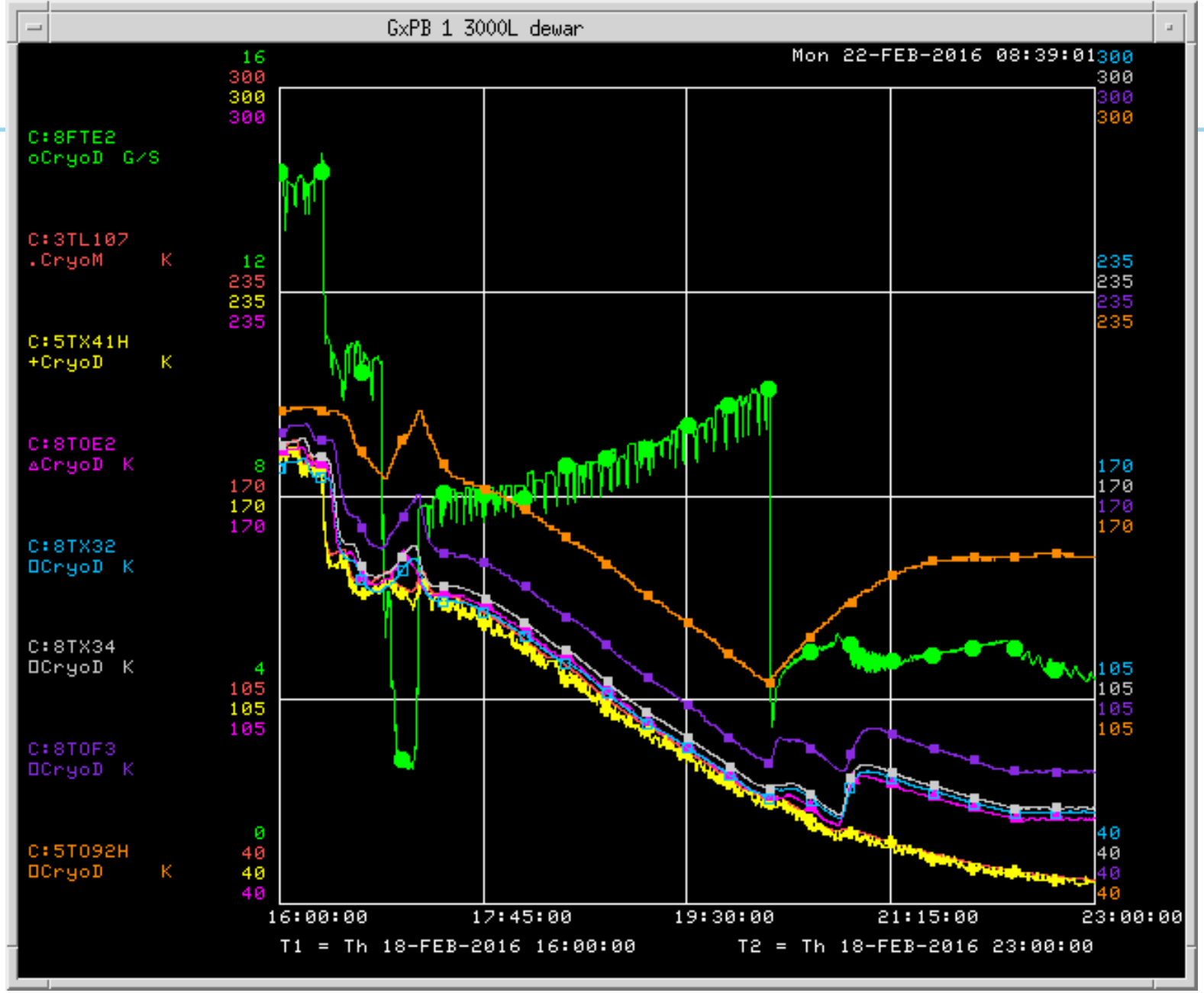
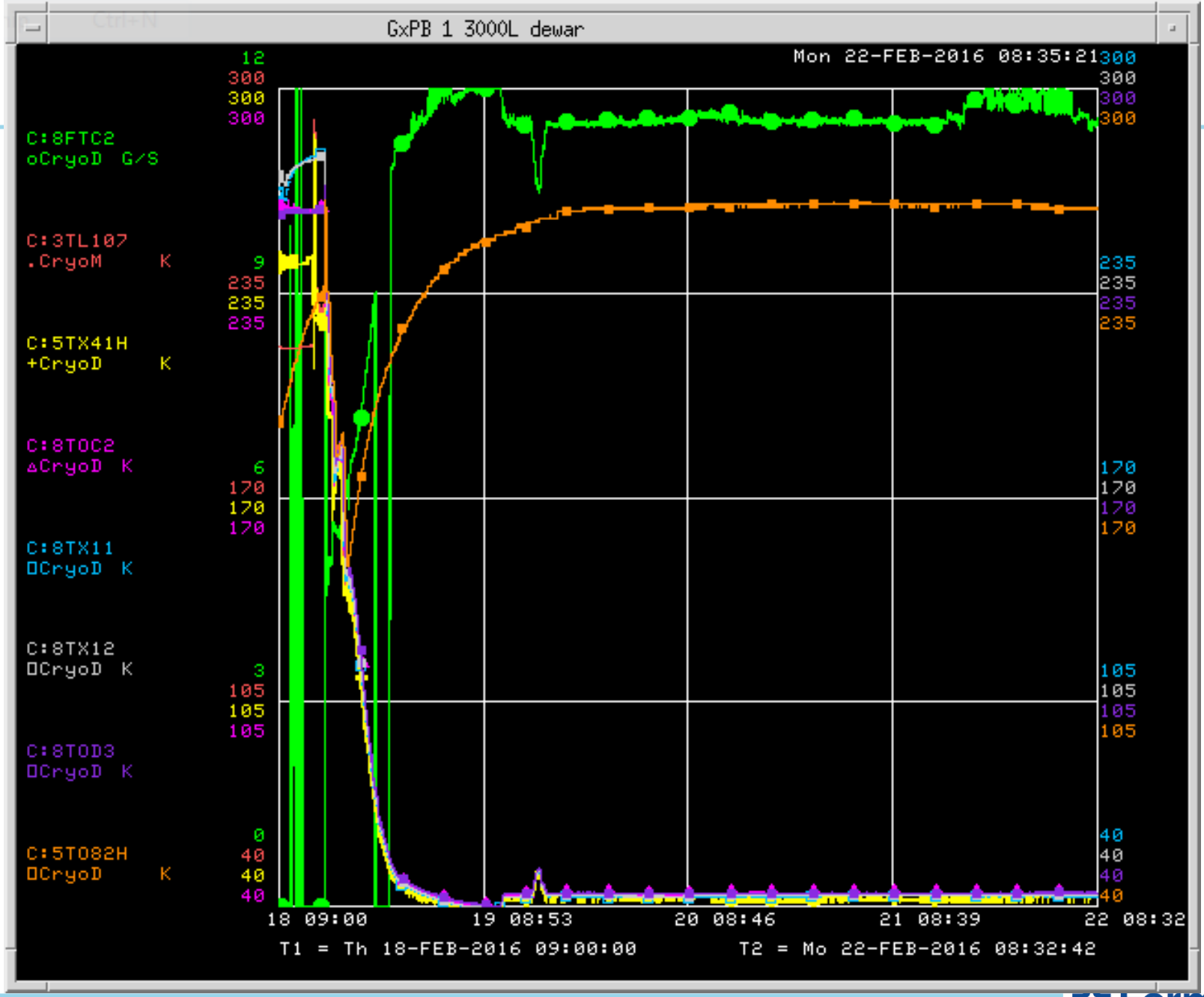
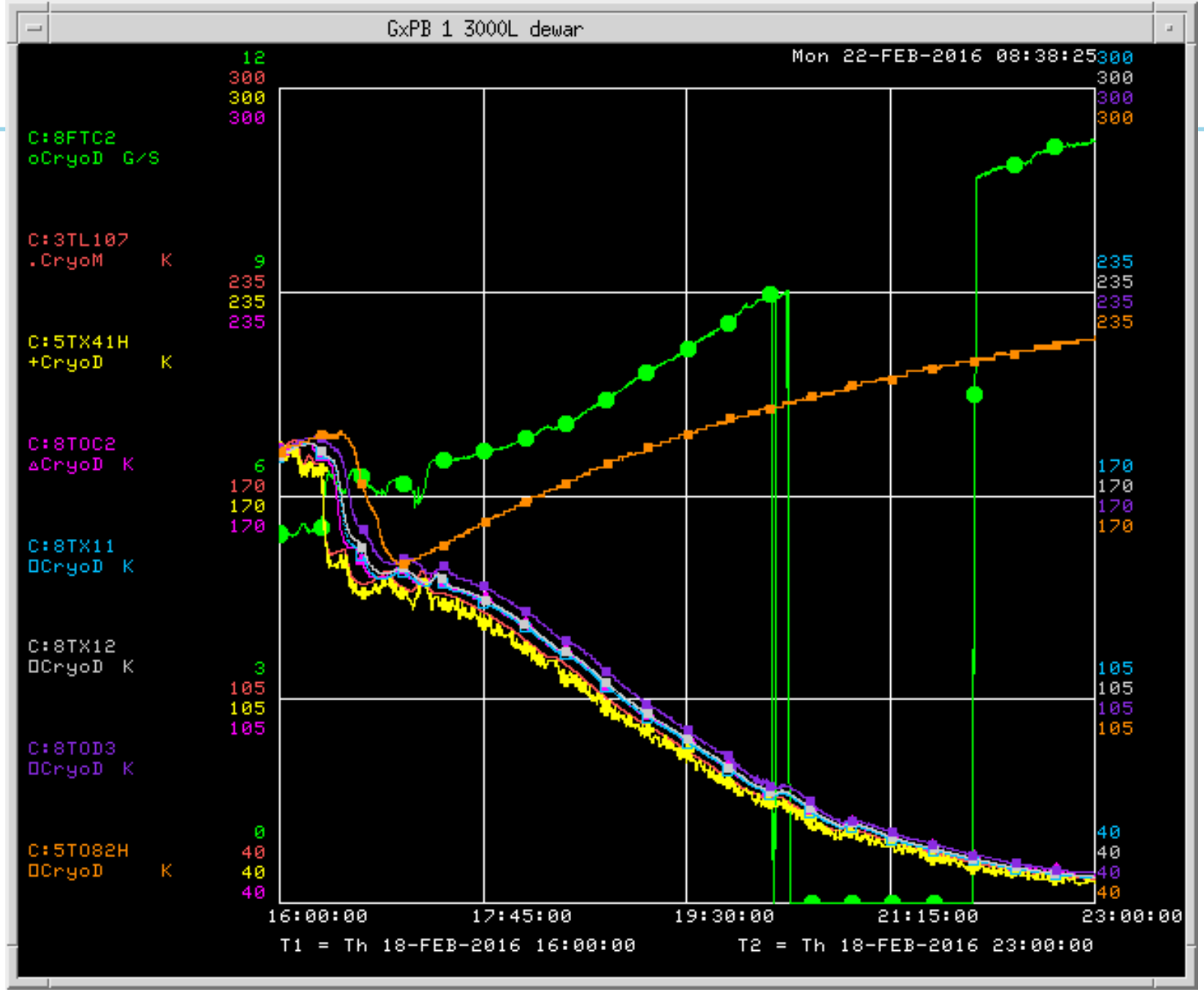
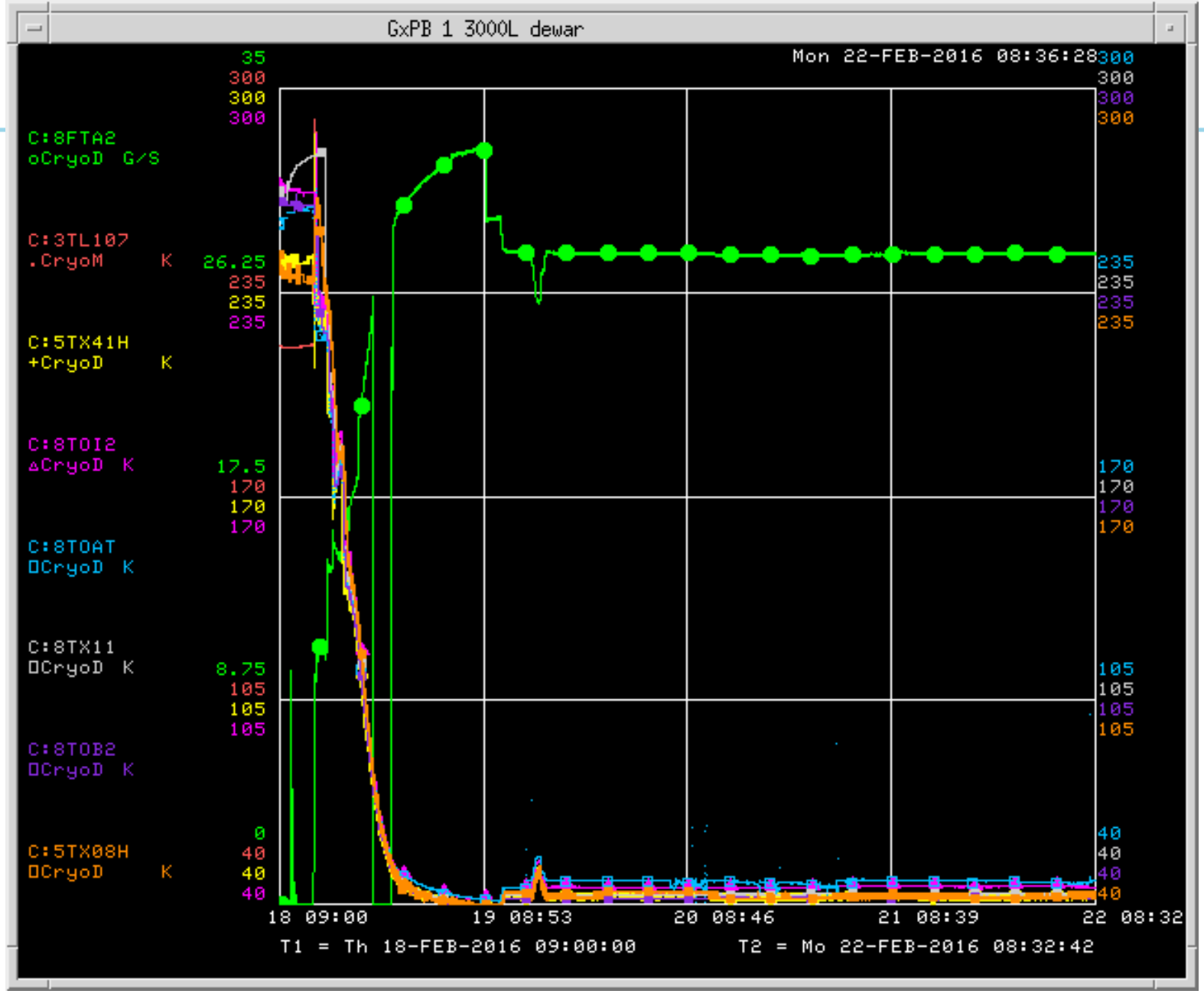
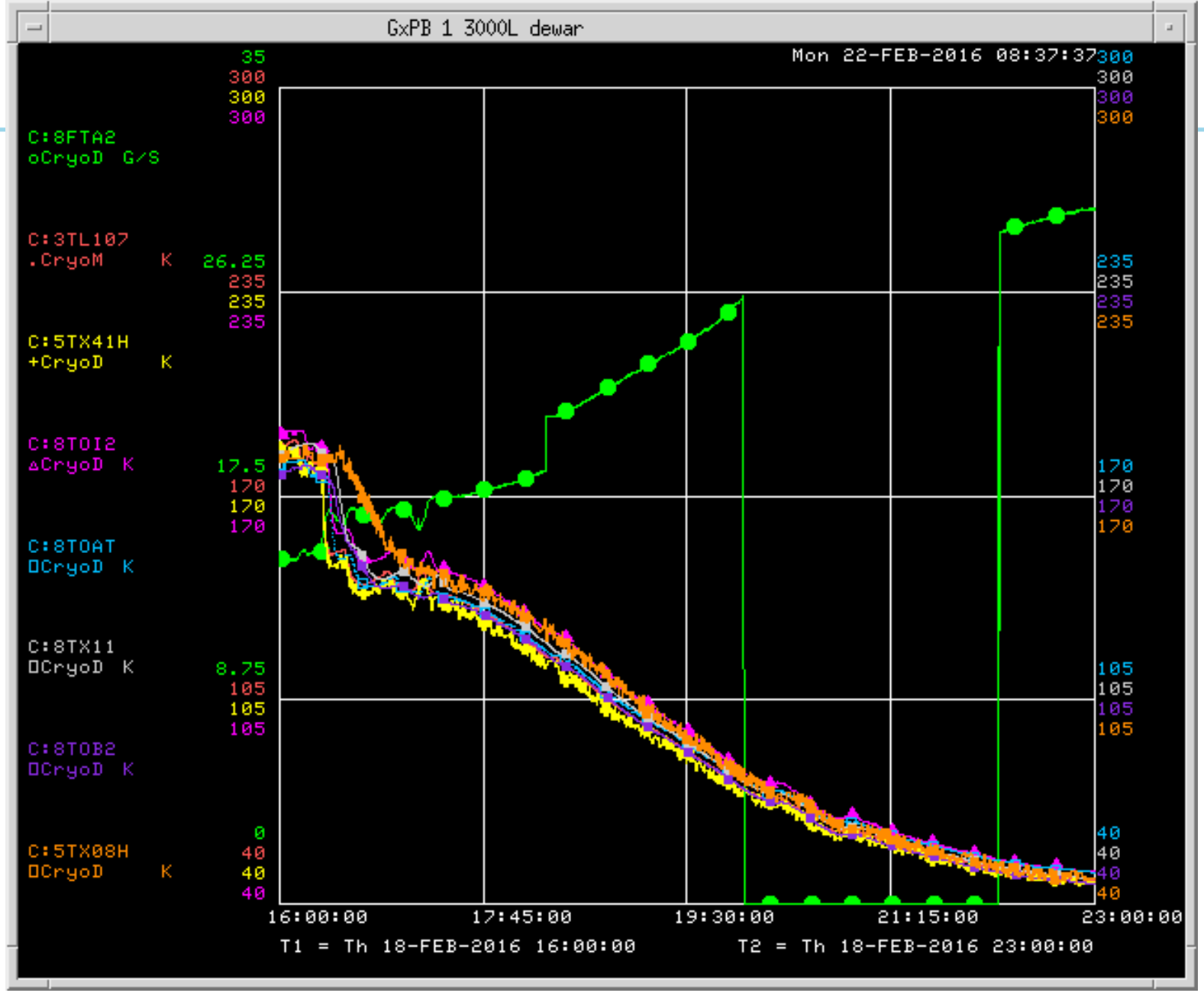
Mon 22-FEB-2016 08:33:50
C:8FTE2
oCryoD G/S
C:3TL107
.CryoM K
C:5TX41H
+CryoD K
C:8TOE2
ΔCryoD K
C:8TX32
□CryoD K
C:8TX34
□CryoD K
C:8TOF3
□CryoD K
C:5TO92H
□CryoD K
16
300
300
300
12
235
235
235
8
170
170
170
4
105
105
105
0
40
40
40
18 09:00
19 08:53
20 08:46
21 08:39
22 08:32
T1 = Th 18-FEB-2016 09:00:00
T2 = Mo 22-FEB-2016 08:32:42


GxPB 1 3000L dewar
Mon 22-FEB-2016 08:39:01
C:8FTE2
oCryoD G/S
C:3TL107
.CryoM K
C:5TX41H
+CryoD K
C:8TOE2
ΔCryoD K
C:8TX32
□CryoD K
C:8TX34
□CryoD K
C:8TOF3
□CryoD K
C:5TO92H
□CryoD K
16
300
300
300
12
235
235
235
8
170
170
170
4
105
105
105
0
40
40
40
300
300
300
300
235
235
235
235
170
170
170
170
105
105
105
105
40
40
40
40
16:00:00
17:45:00
19:30:00
21:15:00
23:00:00
T1 = Th 18-FEB-2016 16:00:00
T2 = Th 18-FEB-2016 23:00:00

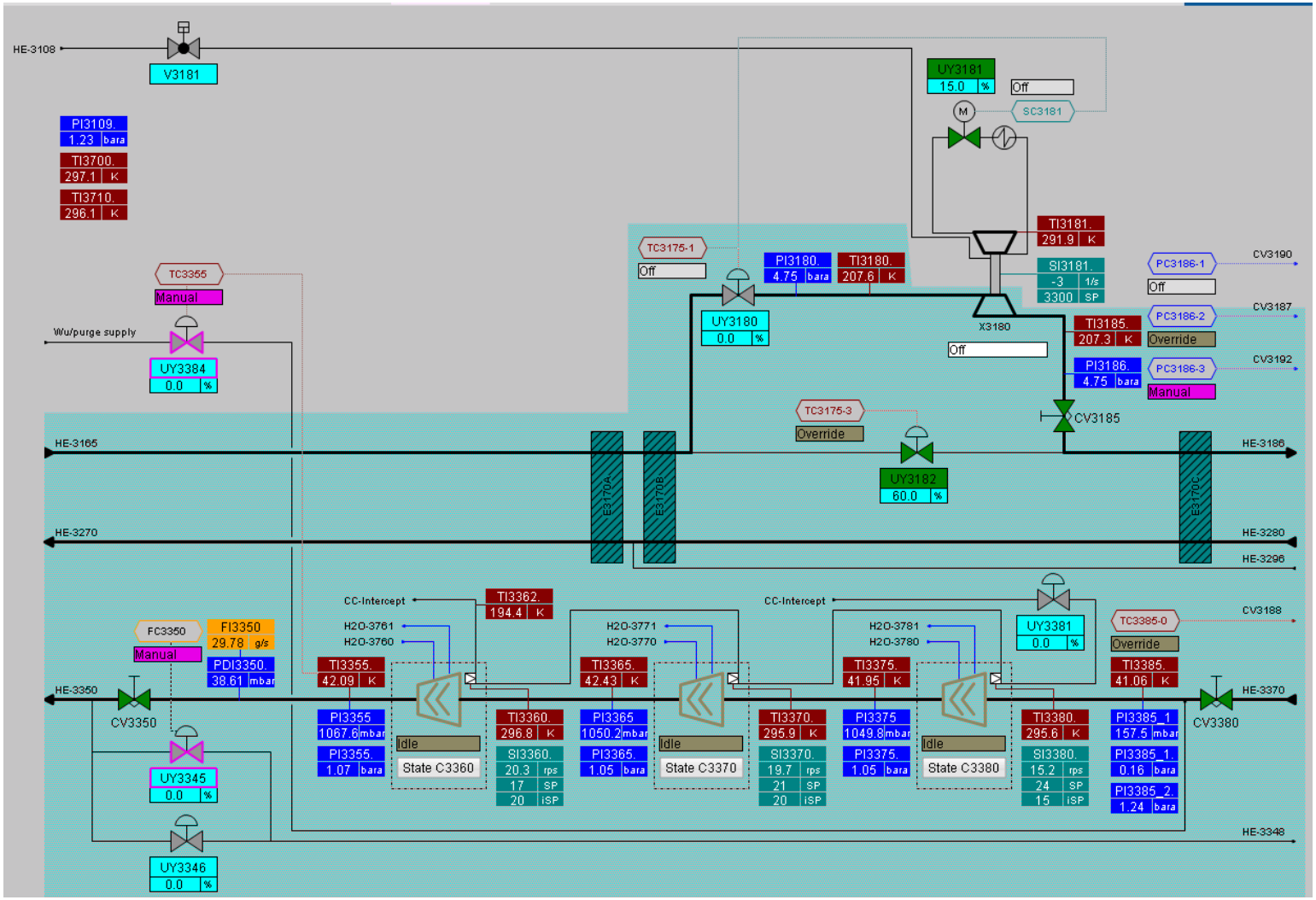

GxPB 1 3000L dewar
Mon 22-FEB-2016 08:35:21
C:8FTC2
oCryoD G/S
C:3TL107
.CryoM K
C:5TX41H
+CryoD K
C:8TOC2
ΔCryoD K
C:8TX11
□CryoD K
C:8TX12
□CryoD K
C:8TOD3
□CryoD K
C:5TO82H
□CryoD K
12 300 300 300
9 235 235 235
6 170 170 170
3 105 105 105
0 40 40 40
300 300 300 300
235 235 235 235
170 170 170 170
105 105 105 105
40 40 40 40
18 09:00
19 08:53
20 08:46
21 08:39
22 08:32
T1 = Th 18-FEB-2016 09:00:00
T2 = Mo 22-FEB-2016 08:32:42


GxPB 1 3000L dewar
Mon 22-FEB-2016 08:38:25
C:8FTC2
oCryoD G/S
C:3TL107
.CryoM K
C:5TX41H
+CryoD K
C:8TOC2
ΔCryoD K
C:8TX11
□CryoD K
C:8TX12
□CryoD K
C:8TOD3
□CryoD K
C:5TO82H
□CryoD K
12
300
300
300
9
235
235
235
6
170
170
170
3
105
105
105
0
40
40
40
16:00:00
17:45:00
19:30:00
21:15:00
23:00:00
T1 = Th 18-FEB-2016 16:00:00
T2 = Th 18-FEB-2016 23:00:00


GxPB 1 3000L dewar
Mon 22-FEB-2016 08:36:28
C:8FTA2
oCryoD G/S
C:3TL107
.CryoM K
C:5TX41H
+CryoD K
C:8TOI2
ΔCryoD K
C:8TOAT
□CryoD K
C:8TX11
□CryoD K
C:8TOB2
□CryoD K
C:5TX08H
□CryoD K
35
300
300
300
26.25
235
235
235
17.5
170
170
170
8.75
105
105
105
0
40
40
40
18 09:00
19 08:53
20 08:46
21 08:39
22 08:32
T1 = Th 18-FEB-2016 09:00:00
T2 = Mo 22-FEB-2016 08:32:42


GxPB 1 3000L dewar
Mon 22-FEB-2016 08:37:37
C:8FTA2
oCryoD G/S
C:3TL107
.CryoM K
C:5TX41H
+CryoD K
C:8TOI2
ΔCryoD K
C:8TOAT
□CryoD K
C:8TX11
□CryoD K
C:8TOB2
□CryoD K
C:5TX08H
□CryoD K
35
300
300
300
26.25
235
235
235
17.5
170
170
170
8.75
105
105
105
0
40
40
40
16:00:00
17:45:00
19:30:00
21:15:00
23:00:00
T1 = Th 18-FEB-2016 16:00:00
T2 = Th 18-FEB-2016 23:00:00

The plant Venturi was reading 29.8 g/s and the valve box Coriolis read 29.4 g/s, a difference of 1.3%



The plant Venturi was reading 29.8 g/s and the valve box Coriolis read 29.4 g/s, a difference of 1.3%