TELEDYNE
MONITOR LABS
A Teledyne Technologies Company

DELTA FLOW

DF180 GAS FLOW AND TEMPERATURE MONITOR

Operation and Maintenance Manual

Teledyne Monitor Labs
35 Inverness Drive East
Englewood, CO 80112

TML DOCUMENT 99702200
Revision B

www.teledyne-ml.com

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Sales	**800-422-1499**
Technical Support	**800-846-6062**
Spare Parts	**800-934-2319**

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Specifications

Flow Measurement:	Range:	0-300ft/sec (0-91m/sec)
	Long-Term Repeatability:	+/-0.3ft/sec (+/-0.1 m/sec)
	Relative Accuracy: (vs. EPA Test Method 2)	Site dependent, see Commercial Performance Warranty. Typically <5% above 10 ft/sec
	Response Time:	8 sec
Drift:	+/- 1.5% of span over operating temperature range of instrument panel	
Media Conditions:	Temperature:	-40° to 1000°F (-40° to +538°C)
	Pressure:	-2 to 2 psig (-13.8 to 13.8 kPa)
	Moisture:	Dry to saturated, including condensed water
	Particulate:	</=3000 mg/m^3
Duct Size:	Diameter:	From 1 - 45 Ft. (0.9 – 14m) Dia.
Temperature Measurement:	Accuracy:	+/- 2.7 °F (1.5°C)
	Long-Term Repeatability:	+/- 0.5% of span per year
Power:		100-240 VAC, 50/60Hz, Single Phase, 70 VA Maximum
Environment:	Ambient Temp. Limits:	Probe Assembly: -40°F to +160°F (-40° to 71°C) Instrument Enclosure: +20°F to 104°F (-7°C to +40°C)
	Relative Humidity:	Probe Assembly: 5% to 100% humidity, condensing Instrument Enclosure: 0 to 95% non-condensing
	Instrument Enclosure Ratings:	NEMA 4/IP66 is standard, Ex Py purge protection can be added as an option for Class I Division 2, and Zone 2 applications.
Mounting:	Process Connection:	4" 150# ANSI flange
Sizes & Weights:	Instrument Enclosure	Size: 30H x 24W x 12D (inches) 76H x 61W x 30.5D (cm) Weight: 135 lbs. (61 kg)
	Probe Assembly	Size: Application dependent Weight: 26 lbs. (11.8 kg), typical, application dependent
I/O:	Communication Protocol:	Modbus TCP/IP
	Analog Outputs:	Two Outputs, 4-20mA current, one for differential pressure and one for temperature
	Digital Inputs:	4 Inputs, dry contact Inputs are configurable to initiate blow back, calibrations, Unit On, etc.
	Relay Outputs:	Four configurable Outputs, Form C, (Single Pole Double Throw) Contact Voltage: 120/240VAC Maximum Contact Current: 10 Amps AC

1 System Description

The DeltaFlow 180 is an EPA compliant Pitot tube based flow monitoring system. The three main components of the system are the instrument panel, probe, and sample line. This section describes in detail each of these components.

1.1 Instrument Panel

The Instrument panel is typically mounted in a climate controlled area, and can be provided with or without an enclosure. All the electronics, indicators, and valves for the system are located here.

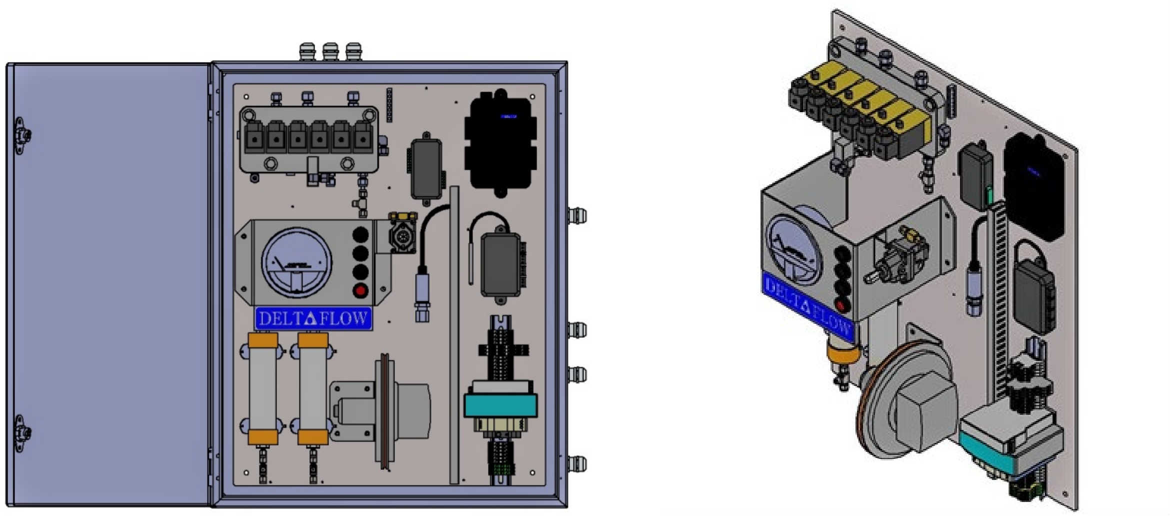


Fig. 1-1 Deltaflow Instrument Panel

1.1.1 Controller

Daily quality assurance checks, signal processing, and monitor configuration are all handled by the controller. The controller module I/O consists of 8 relays and 8 digital inputs. The relays are used to control solenoid valves located on the instrument panel during calibration checks, interference checks, and blowback sequences.   The digital inputs are used to initiate different modes such calibration, interference check, blowback, and maintenance. These modes can be initiated by the buttons located on the instrument panel or by external dry contact signals from a plant distributed control system (DCS) that are wired to the Deltaflow instrument panel terminal blocks.

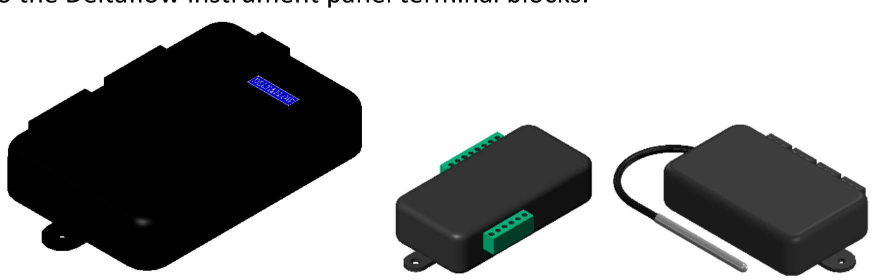


Fig. 1-2 Deltaflow Controller, Analog Module, and Form C Relay Module

The controller has two external modules, the analog module and the form C relay module. The analog module is used to take in 4-20mA signals from the various sensors on the instrument panel, and transmit analog signals out of the instrument panel, such as velocity and temperature. The form C relay module is used to relay status signals, such as fault or sample valid. Terminated on the form C relay module is a temperature sensor that measures the ambient temperature of the instrument panel. Table 1-1 shows a complete I/O list for all the modules.

Table 1-1. Deltaflow Controller I/O list

Main Controller Module	
Channel	**Description**
Relay 1	Solenoid Valve 1 – Impact Line Purge
Relay 2	Solenoid Valve 2 – Static Line Purge
Relay 3	Solenoid Valve 3 – Isolate DP Transmitter Low Side
Relay 4	Solenoid Valve 4 – Isolate DP Transmitter High Side
Relay 5	Solenoid Valve 5 – Span Calibration
Relay 6	Solenoid Valve 6 – Span Calibration (Low Pressure Instrument Air Delivery)
Relay 7	Solenoid Valve 7 – Span Calibration (Isolate DP Pressure Switch)
Relay 8	Not Used
Digital input 1	External Calibration Start
Digital input 2	External Interference Check Start
Digital input 3	External Blowback Start
Digital input 4	Maintenance
Digital input 5	Calibration Start
Digital input 6	Interference Check Start
Digital input 7	Blowback Start
Digital input 8	Not Used
Analog Module	
Input 1	Differential Pressure
Input 2	Stack Temperature
Input 3	Stack Pressure
Input4	User defined
Output 1	Configurable – Differential Pressure, Stack Temperature, Stack Pressure, Velocity, Raw Velocity, Actual Volumetric Flow, Standard Volumetric Flow, any user defined parameter
Output 2	Configurable – Differential Pressure, Stack Temperature, Stack Pressure, Velocity, Raw Velocity, Actual Volumetric Flow, Standard Volumetric Flow, any user define parameter
Form C Relay	
Relay 1	In Calibration Mode
Relay 2	In Sample Mode
Relay 3	Fault (reverse logic, 1 = OK: 0 = Fault)
Relay 4	Value Based Alarm (e.g. based on user defined alarm limits)

1.1.2 Differential Pressure (DP) Transmitter

This device converts the pneumatic differential pressure signal measured by the probe to a 4-20mA signal. It also provides a gauge style display to aid in troubleshooting the electrical signal. The gauge needle can be zeroed and the 4-20mA signal can be calibrated at the display. Various ranges are available; a TML Engineer selects the range based on process parameters of the application. See Appendix A: Spare Parts for a complete list of all available ranges.

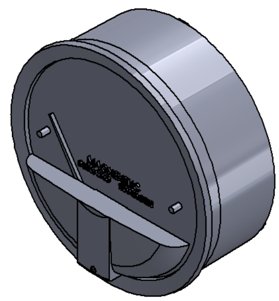


Fig. 1-3 Differential Pressure Transmitter with Display

1.1.3 Push Buttons

These buttons allow the user to start a blowback sequence, calibration check, interference check, or put the Deltaflow into maintenance mode. Once pressed, the blowback sequence will start immediately. Calibration and interference checks will start at the top of the next minute according to the controller clock. Once pressed, the maintenance button will illuminate red and will put the Deltaflow into maintenance mode until the button is pressed again. Maintenance mode causes the Deltaflow controller to flag its' data as invalid.

1.1.4 Valve Manifold Assembly

This assembly consists of 7 solenoid valves installed on a custom designed manifold. Static pressure, impact pressure, and instrument air are directed through the manifold by the valves.

During normal sampling mode none of the valves are actuated; impact pressure and static pressure are directed to the high and low sides of the differential pressure transducer, respectively. During a blowback sequence or interference check, SV1 and SV2 send high pressure instrument air up the sample line, while SV3 and SV4 isolate the differential pressure transmitter from the high pressure instrument air.

The calibration check consists of a zero and span check. First, the DP transmitter high and low sides are exposed to ambient pressure using SV3 and SV4. This provides a zero check. For the span check SV5, SV6, and SV7 are activated. This allows low pressure instrument air to start pressurizing the DP transmitter as well as the DP span set point switch. Once the DP span set point switch senses the correct upscale pressure has been reached, it trips and shuts off SV6. This provides a stable upscale calibration check. See the Plumbing & Instrumentation Diagram and the Timing Diagram in Appendix B for further detail.

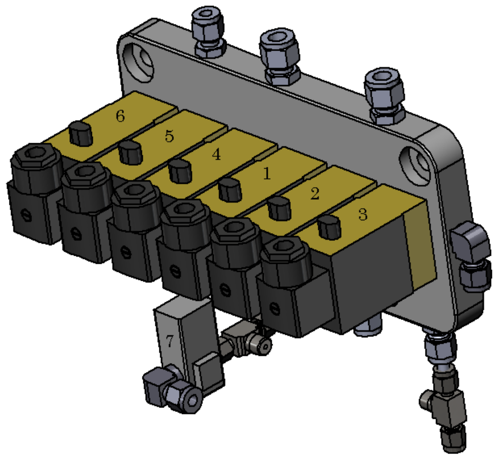


Fig. 1-4 Solenoid Valve Manifold

1.1.5 Absolute Pressure Transmitter

Absolute stack pressure is needed to calculated velocity and standard volumetric flow. The DP transmitter cannot continually measure stack pressure on its own. For this reason, the Deltaflow comes standard with a 0-30 psia (61.1 inHg, 1551 mmHg) pressure transmitter. The transmitter is plumbed to the static pressure line, and wired to input 3 of the analog module.

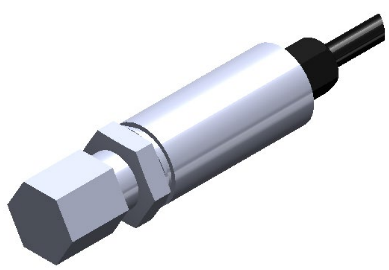


Fig. 1-5 Absolute Pressure Transmitter

1.1.6 Temperature Transmitter

Stack temperature is needed to calculated stack velocity and standard volumetric flow. The probe is equipped with a type K thermocouple to accurately measure stack temperature. The thermocouple signal is carried down to the instrument panel via thermocouple messenger cable in the sample line where it is terminated on a DIN rail mounted transmitter. This device converts the thermocouple signal to a 4-20mA signal that is wired to input 2 of the analog module.

The 4-20mA output range, and input type (RTD, TC, etc.) of the transmitter is adjustable using ProSense XT-SOFT software and a USB adapter cable (TML P/N 55000048-2).

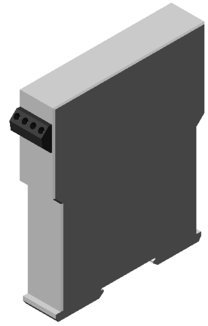


Fig. 1-6 Stack Temperature Transmitter

1.1.7 Precision Differential Pressure Switch

In order to provide a repeatable upscale differential pressure for daily calibration checks, a precision DP switch is tied into the high side of the DP transmitter plumbing. During the beginning of a span check this DP switch will shut off SV6 when it senses the correct pressure has been achieved on the high side of the DP transmitter. This provides a repeatable and stable differential pressure to check the pneumatic and electrical drift of the DP transmitter. The DP switch set point is adjustable via a screw at the left end of the switch spring housing. These switches come in various ranges, see Appendix B: Spare Parts for a complete list of all the available ranges.

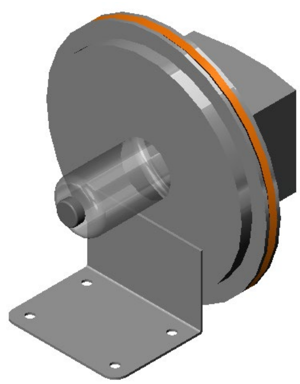


Fig. 1-7 Precision Differential Pressure Switch

1.1.8 Sample Filters

The differential pressure transmitter used in the Deltaflow is meant to only come in contact with clean non- corrosive air. The Deltaflow purges the sample lines at a minimum of every 6 hours to ensure they stay filled with clean instrument air. As added protection, each side of the DP transmitter has sample filters that contain 13X molecular sieve, soda lime, and indicating Drierite®.

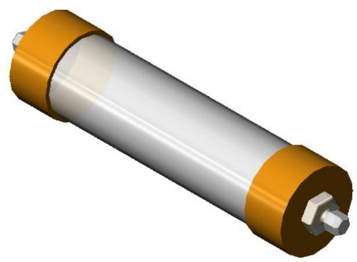


Fig. 1-7 Sample Filter

1.1.9 Power Supplies

Two power supplies are used. A 120W 24VDC power supply powers all the onboard Deltaflow electronics, valves, and switches. A 10W 12 VDC power supply is used as loop power for the analog outputs. Both power supplies' inputs are rated 100-240VAC, 50/60Hz and are automatically adapting. Both power supplies have "DC Voltage OK" indicating LEDs to aid in troubleshooting. The 24 VDC power supply has a DC voltage output adjustment potentiometer.

1.1.10 Precision Regulator

In order to minimize the drift of the upscale differential pressure used during the daily cal checks, a precision regulator is used that drops the instrument air supplied by the user from 50 psi down to 1.5 psi. This low pressure instrument air is bled into the high side plumbing of the DP transmitter by SV6 at the beginning the of the daily upscale cal check.

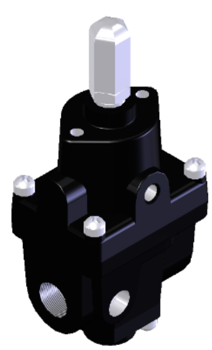


Fig 1-8 Precision Regulator

1.2 Probe

The Deltaflow Pitot tube probe assembly consists of an S type Pitot tube, a K type thermocouple, and a 4" mounting flange. All wetted components are constructed of Stainless steel. The Pitot tube comes in various lengths, and the insertion depth is adjustable for easy installation. Once the desired insertion depth is determined the Pitot tube is secured in place using a large compression fitting. The impact and static sample lines are easily terminated on the probe using 3/8" compression fittings. The K type thermocouple comes in various lengths and has a fixed insertion depth. The thermocouple wires from the sample line are easily terminate in the head of the thermocouple assembly.

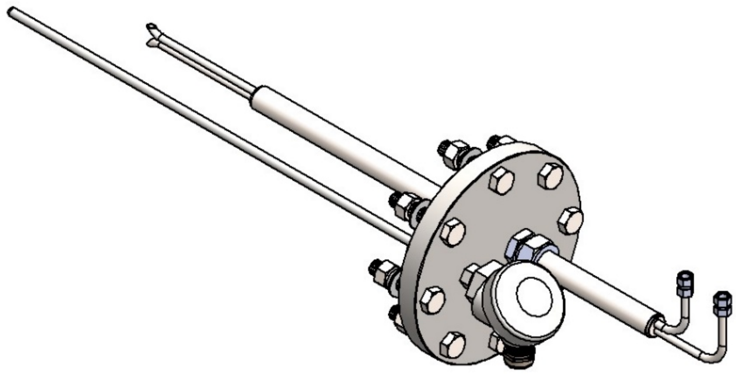


Figure 1-8 Deltaflow Probe

1.3 Sample Line

The Deltaflow sample line consists of a two 3/8" PFA Teflon sample lines, a K type thermocouple messenger cable, a small amount of insulation, and a PVC jacket. The maximum recommended length for the standard sample line is 430 feet. Line longer that this will require custom design. Custom sample lines can be ordered with options such as stainless steel tubes, heaters, larger wires, or extra wires.

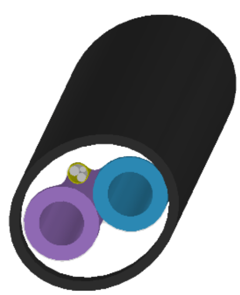


Fig. 1-9 Sample Line Cut Away

2 Theory of Operation

The DeltaFlow 180 is a Pitot tube based gas flow and temperature monitoring system. Like all Pitot tube flow measurements, the Deltaflow uses equations derived from the Bernoulli Principle. The Bernoulli Principle states that for certain flow conditions the total energy of a streamline is constant between two points even if pressure, velocity or elevation changes. A change in one of these parameters will results in an equal and opposite change in the others. Utilizing this concept, a Pitot tube converts all the kinetic energy (velocity energy) of a flow streamline to potential energy (pressure energy). To achieve this, a gas streamline travels into the impact opening of the Pitot tube for a short distance for before it stagnates in the tube, creating an elevated pressure at point B, see Figure 2-1. This is referred to as the impact pressure. Static pressure is the stack or duct pressure not resulting from any velocity energy conversion. The pressure at points A, C, and D are all equal, and can all be thought of as the static pressure (also known as the absolute pressure, or just pressure). A differential pressure transducer is connected to the Pitot tube to measure the difference between the impact pressure and static pressure (this is referred to as the velocity head, delta P, DP, or ΔP).

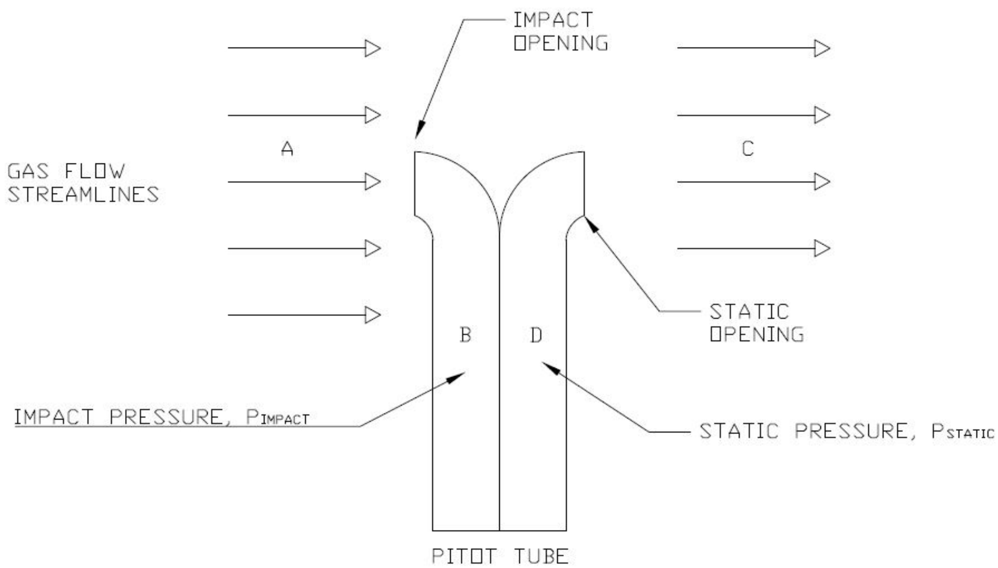


Figure 2-1 Pitot Tube In Gas Stream

The governing equations used by the DeltaFlow for velocity is Equation 2.1 for calculations done in Metric Units, and Equation 2.2 for calculations done in Imperial units. These equations are derived from the Bernoulli Principle, and the Ideal Gas Law.

Eq 2.1 Metric: $$V_s = 11.17(C_p)(\sqrt{\Delta P})\left(\sqrt{\frac{(T_S+273)}{(M_S)(P_S)}}\right)$$

Eq 2.2 English: $$V_s = 85.49(C_p)(\sqrt{\Delta P})\left(\sqrt{\frac{(T_S+460)}{(M_S)(P_S)}}\right)$$

Where:
V_s = stack gas velocity, m/sec (ft/sec).
C_p = Type S pitot tube coefficient, dimensionless, Default 0.84.
ΔP = Velocity head measured by the Pitot tube, Pa (in. H_2O.)
T_s = Stack temperature, °C (°F).
P_s = Absolute stack pressure, mm Hg (in. Hg)
M_s = Molecular weight of stack gas, wet basis, g/g-mole (lb/lb-mole).

Molecular weight is calculated based on Equation 2.3

Eq 2.3
$$M_s = 44\ x\ \frac{\%CO2}{100} + 32\ x\ \frac{\%O2}{100} + 18\ x\ \frac{\%W}{100} + 28\ x\ \frac{(100 - \%CO2 - \%O2 - \%W)}{100}$$

Where:
%W = Percent by volume of water vapor in the gas stream, %
$\%O_2$ = Percent by volume of oxygen in the gas stream, %
$\%CO_2$ = Percent by volume of carbon dioxide in the gas stream, %

After velocity has been calculated, volumetric flow rate can be calculated based on Equation 2.4.

Eq 2.4
$$Q_s = V_s\ x\ A_s\ x\ 3600$$

Where:
A = Cross-sectional area of stack, m^2 (ft^2).
Q_{Act}= Volumetric stack gas flow rate, m^3/hr (ft^3/hr).

To adjust the stack volumetric flow to a standard temperature and pressure, use Equation 2.5.

Eq 2.5
$$Q_{std} = Q_s \left(\frac{T_{std}}{T_s}\right)\left(\frac{P_s}{P_{std}}\right)$$

Q_{std} = Volumetric stack gas flow rate corrected to standard conditions, scm/hr (scf/hr).
P_{std} = Standard absolute pressure, default 760 mm Hg (29.92 in. Hg).
T_{std} = Standard absolute temperature, default 20 °C (68 °F).

3 Installation

Below are general descriptions of several areas of consideration for installation of the Deltaflow 180 system. Please see the installation drawings provided in Appendix B for further detail.

3.1 Pre-Installation Planning and Preparation

The engineering that precedes installation of the Deltaflow is vital to successful operation of the instrument and should be performed in consultation with responsible Teledyne Monitor Labs representatives. Key factors that must be considered include:

Location of the probe, and instrument panel. Items such as vibration, heat range, stream turbulence, installation and maintenance access, and protection from environmental and mechanical hazards must be considered.

Sample line run (distance, routing, proximity to electrical equipment and heat sources).

Accessibility to a continuous supply of clean oil free instrument air at approximately 50 psig (345 kPa). Each blowback sequence consumes about 3 standard cubic feet (0.085 standard cubic meters) of air.

The Deltaflow installation checklist contains a number of questions that must be answered by the user before assembly and calibration of the system may begin at the Teledyne Monitor Labs factory. This is provided at the time of purchase or it can be downloaded off the Teledyne Monitor Labs website.

3.2 Site Selection

Without question, the single most important factor affecting overall performance of any continuous monitoring device is that of site selection. If this decision is not made prudently, then monitor accuracy and reliability will suffer.

3.2.1 Representative Sampling Location

Complex flow patterns in the vicinity of bends or obstructions may potentially cause the monitor's sample point to be unrepresentative of the total flow velocity and volume. Teledyne Monitor Labs recommends a minimum of 6 duct diameters of straight undisturbed duct length upstream of the monitor and 2 downstream. However, due to the complexity of the fluid dynamics of these types of gas streams and their dependence on individual site geometry, the burden of responsibility for testing to determine the flow characteristics at the site location is solely that of the user.

3.2.2 Access to Sampling Location

Ease of access to the stack mounted equipment is a factor that is nearly always underrated when deciding on an installation site. If the monitor location is only accessible via vertical ladders with extensive climbing involved or in exposed outside areas where maintenance personnel are subject to extremes of wind, precipitation, or temperature, then monitor maintenance will suffer adversely in the long term. Without proper maintenance, reliability decreases and the access problems extend monitor outage during repair.

3.2.3 Environmental Conditions at Instrument Panel Location

The other important factor involved in site selection is to consider the potential conditions of the area where the Instrument Panel will be located. Ambient conditions at this location must not exceed the temperature range specified in the Teledyne Monitor Labs specifications. This will void the Teledyne Monitor Labs warranty. The presence of potentially corrosive or toxic gases in the ambient air in the vicinity of the instrument panel may deteriorate the condition of electrical connections.

4 Web Interface

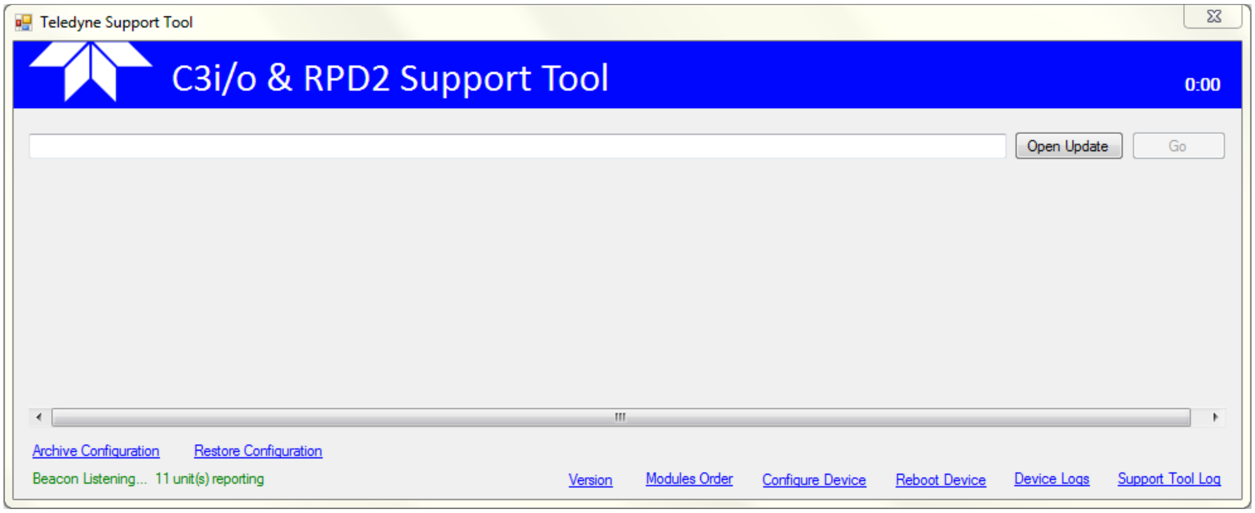
The DeltaFlow web interface is required to configure the monitor. Depending on what the user specifies at the time of order, the Deltaflow controller may ship with a static IP address or a dynamic IP address that will require a DHCP server to assign it one. If it ships with a static IP address, specified by the user, it will have a label on the controller with the IP address, subnet mask, and default gateway.

To connect to the web interface, enter the IP address/delta/ (example: 172.16.254.1/delta/) into the address bar of any web browser. NOTE: "/" at end of address is required. You will be prompted with the below prompt window. Click the **Connect with DF180** button. The web interface is configured at the Teledyne Monitor Labs Factory so you do not need to click **Create New Configuration** the first time you access. You should only need to create a new configuration if you find that the engineering units (British Imperial or Metric) of the configuration are incorrect. When creating a new configuration, you will need to configure all the screens in the Configure menu, see section 4.3.

If the Deltaflow shipped configured for DHCP the *Teledyne Support Tool* software will need to be used to detect the DeltaFlow and what IP address it has been assigned on the network. This can be downloaded from http://www.teledyne-ml.com/downloads.asp you will need to call Teledyne Monitor Labs Technical Support (1-800-846-6062) for a username and password. When started, the program detects all devices present on the network (see lower left hand corner in the image below).

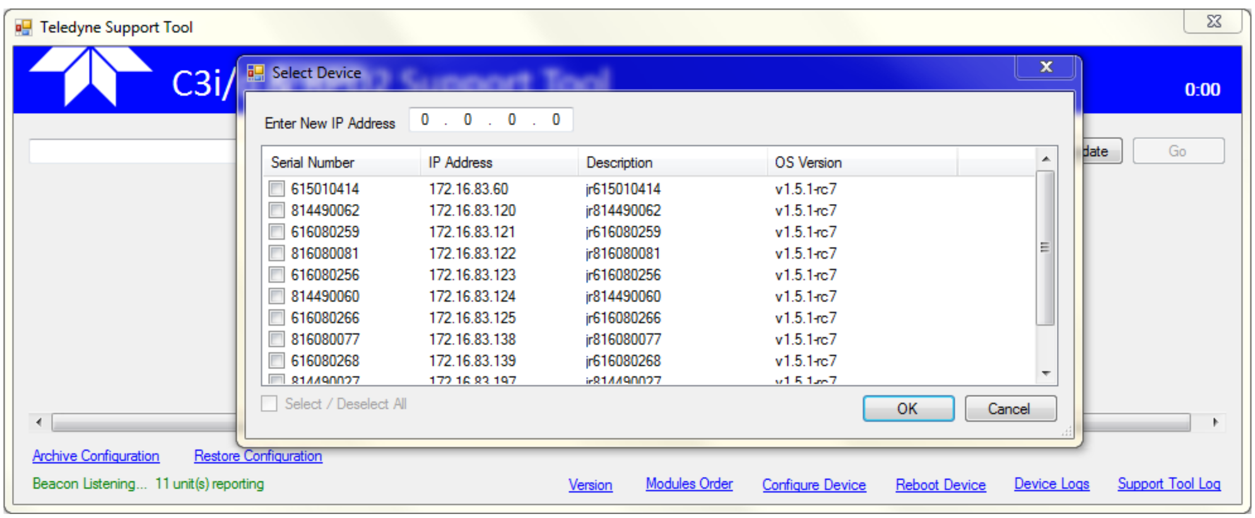
Note: Administrator password may be required to install *Teledyne Support Tool* on a computer.

Note: If you are not able to detect, you may need to be on the same subnet as the DF180, C3i/o, or RPD2 you are attempting to detect. If possible the computer should be plugged into the same network switch as the DF180, C3i/o, or RPD2. Or you may have to open UDP port 4444. Use Administrative Tools->Windows Firewall->Inbound Rules to open this port.

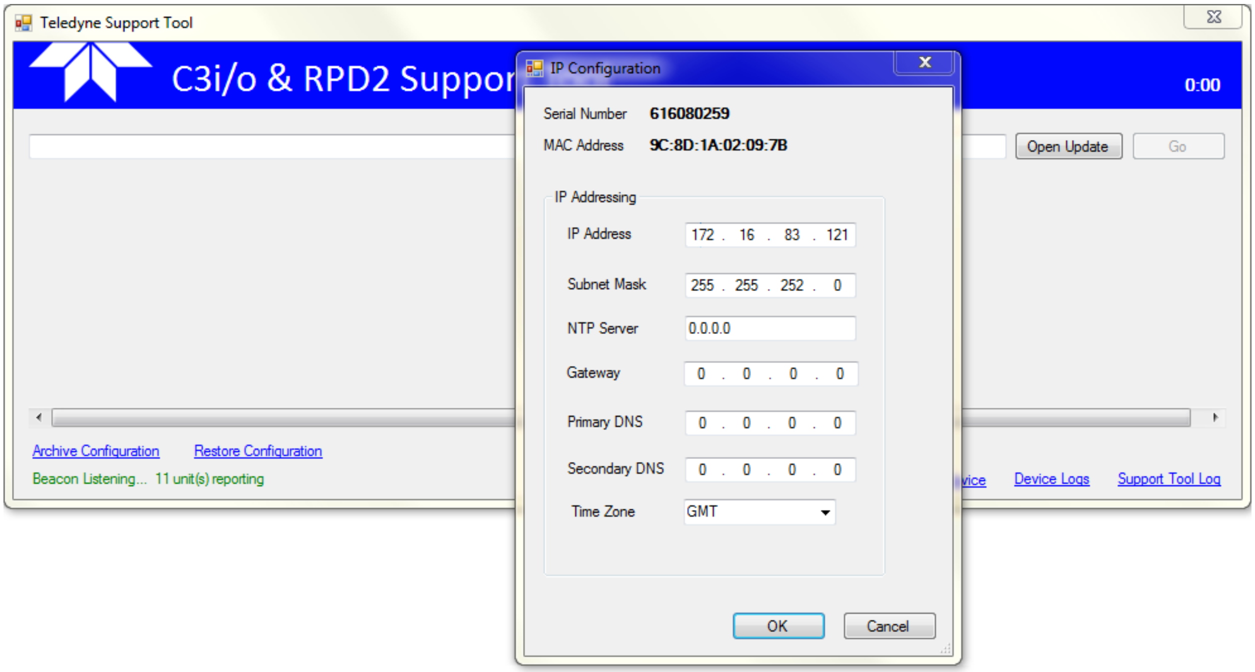


Click the *Configure Device* link to start the configuration process.

A dialog box with all detected devices will be displayed. Using the check box, select the device you want to configure and click OK.



Configure the device's IP Address, Subnet Mask and select Time Zone.



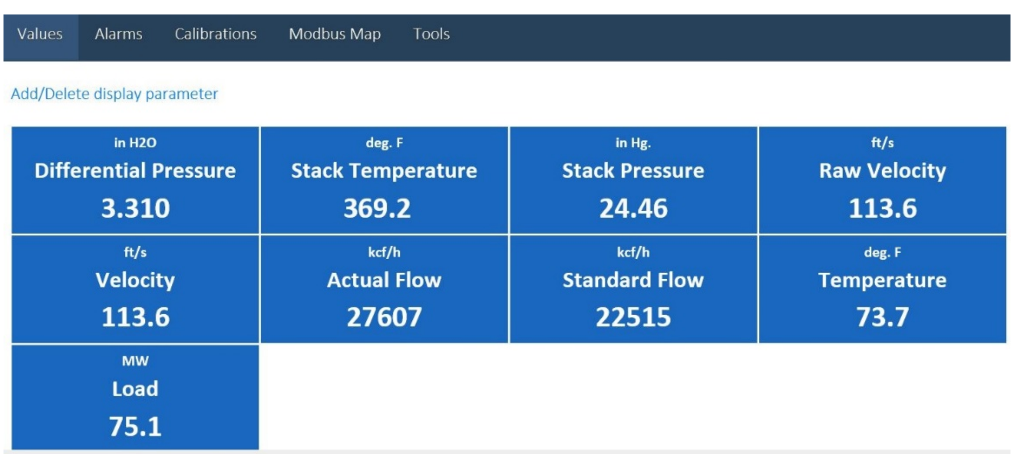
Once configured, enter the IP address/delta/ (example: 172.16.254.1/delta/) into the address bar of any web browser the web interface.

4.1 Data

The Data screen will be the first screen displayed once connected. This section will outline all the data screens and their functionality.

4.1.1 Data: Values

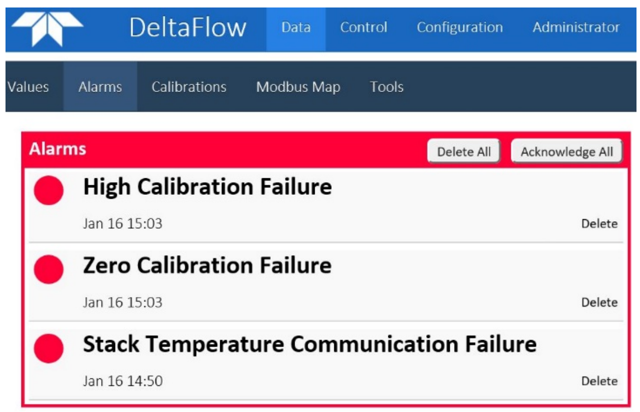
The Values screen displays live data that is updated every five seconds. Each widget can be renamed by clicking on it. A RED border around a widget means that data is invalid due to the value being out of range or a communication failure.



If a parameter is invalid it will also cause any dependent calculated parameters to be invalid. For example invalid Stack Temperature will cause Velocity and Volumetric Flow to be invalid. A YELLOW border means the parameter is in the process of a QA check such as a calibration or interference check, or has failed such check.

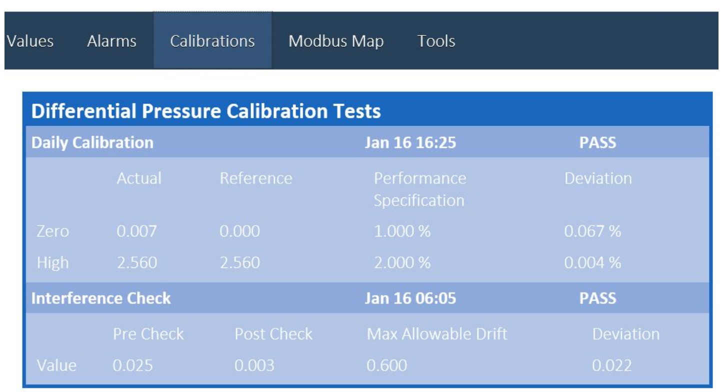
4.1.2 Data: Alarms

This screen keeps a log of the 99 most recent alarms that have occurred. Examples of alarms that will show up here are QA check failures, communication failures, DP/temp/pressure out of range faults, and value alarms. Value alarms are user defined Lo and Hi alarms and can be configured for almost any parameter in the appropriate Configuration: Calibration: Evaluation screen.



4.1.3 Data: Calibrations

This screen will show you the results of the most recent calibration check and interference check. The performance specification is user defined and can be configured in the Configuration screen.



4.1.4 Data: Modbus Map

This screen outlines all the available Modbus addresses.

Values Alarms Calibrations **Modbus Map** Tools

RegPerfect	Address	Content	Instantaneous	1-minute data
		Command Register	496	
		Time-Stamp	497	
Channel	1	Temperature	500	800
Channel	2	Differential Pressure	503	803
Channel	3	Stack Temperature	506	806
Channel	4	Stack Pressure	509	809
Channel	5	Raw Velocity	512	812
Channel	6	Velocity	515	815
Channel	7	Actual Flow	518	818
Channel	8	Standard Flow	521	821
		Instrument State	792	

Daily Calibrations:	Zero	High	Interference Check
	1500	1504	1511

Instantaneous (updated every 5 seconds) and 1-minute values shown above are stored in three 16 bit Modbus registers. The first 2 registers contain a floating point number for the parameter. The 3rd word contains a status word with the individual bits define as follows (bit 0 is the least significant bit):

bit #

15	-	not used
14	-	In interference test
13	-	Interference test failure
12	-	Full scale exceeded
11	-	not used
10	-	In Calibration
9	-	fatal fault
8	-	non-fatal fault
7	-	not used
6	-	In Maintenance
5	-	not used
4	-	Communication Failure
3	-	not used
2	-	Data valid
1	-	In Span Calibration
0	-	In Zero Calibration

Use Command Register (496) to trigger the following actions:

Set the register to 1 to start the Calibration sequence.

Set the register to 2 to start the Interference Check sequence.

Set the register to 3 to start the Blowback sequence.

Instrument State register (792) stores the value defining the current instrument state as follows:

1 – instrument in a Sampling state.

2 - instrument in an Interrupt state which is the same as a Sampling state but in this state any automatic, manual or Modbus requests to start a calibration, interference or blowback will be ignored.

3 – instrument still in a Sampling state but also waiting for the top of the minute to start already requested calibration or interference check.

4 – instrument in a Calibration sequence.

5 – instrument in Maintenance state.

6 – instrument in a Wait state – data is invalid but it is getting ready to enter a Sampling state.

7 through 12 – instrument in an Interference Check state.

13 – instrument in a Blowback state.

14 – instrument in a startup state (will last for just few milliseconds).

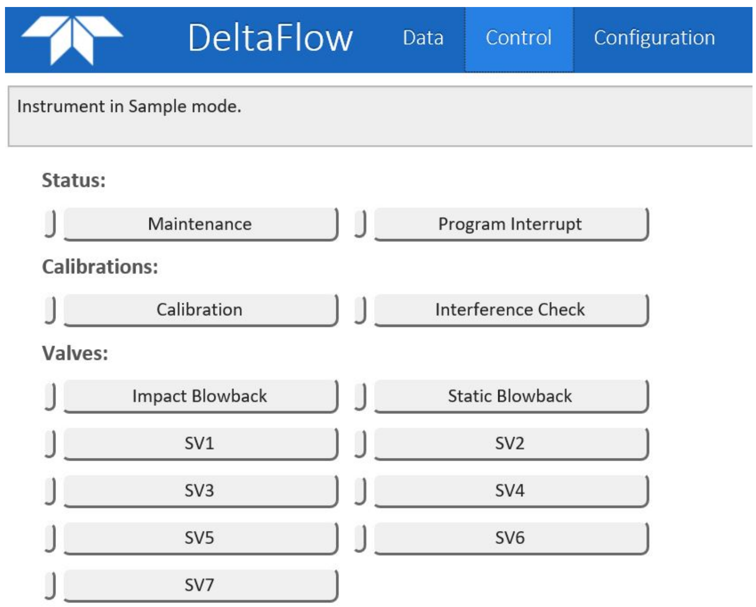
NOTE: When setting Command Register to start calibration, interference or blowback, make sure first that the instrument is in state number 1 (Sampling) otherwise the command will be ignored.

4.1.5 Data: Tools

This screen provides information on firmware version, IP address, and communication status. Occasionally the configuration on the Deltaflow controller and what is shown on the web interface may not match if changes were made and not sent to the controller from the interface, see section 4.4 Administrator. The Read **Configuration from DF180 button** will sync the web interface with the controller. If communication has been lost, it can be restored using the **Restore/Close DF180 communicatio**ns button.

4.2 Control

This screen provides the user with a way to command the DeltaFlow to enter various modes, and perform QA checks. To avoid accidental harm to the instrument, opening individual valves is not possible. The top of the screen shows the current mode of the DeltaFlow.



Next to each button is an indicator that will turn GREEN to show the valve or mode is active. Clicking any of the Blowback buttons will automatically put the DeltaFlow in Maintenance mode until you manually press the button again. When initiating a calibration or interference check, the DeltaFlow will wait for the top of the minute before starting. This is indicated by the button blinking and the message at the top of the screen. Below is a short description of each button's functionality.

Maintenance – Flags all data as invalid.

Program Interrupt – Halts all daily automatic blowbacks, and QA checks such as calibrations and interference checks. This is useful during a Relative Accuracy Test Audit (RATA) where a cal in the middle of a RATA test run will invalidate the run.

Calibration – Starts a calibration sequence.

Interference Check – Starts an interference check sequence.

Impact Blowback – Activates all the valves necessary to continually purge the impact pressure line. This will stay active until the button is pressed again.

Static Blowback – Activates all the valves necessary to continually purge the static pressure line. This will stay active until the button is pressed again.

SV1, 2, 3, 4, 5, 6, 7 – Cannot be manually selected. Their indicators show the state of the valve during various instrument modes.

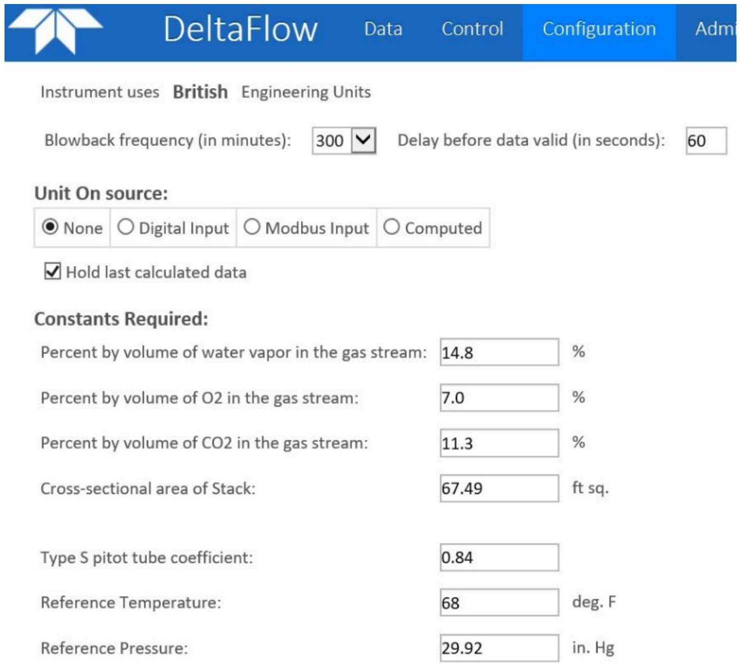
4.3 Configuration

This area of the web interface allows the user to program all the necessary parameters that are application specific. All screens are configured at the factory based on the user completed installation checklist, but can easily be changed by the user in the field.

IMPORTANT: ANY CHANGE TO THE CONFIGURATION MUST BE WRITTEN TO THE CONTROLLER BY GOING TO THE ADMINISTATOR SCREEN AND PRESSING THE **WRITE CONFIGURATION TO DF180** BUTTON.

4.3.1 Configuration: General

See screenshot below for configurable parameters available. If engineering units need to be changed, refresh the webpage then click **Create New Configuration.** All configuration screen will need to be populated in the new engineering units. In order to ensure a long service life, periodic blowbacks are required. The minimum available blowback interval is every 360 minutes. If a “Unit On” signal (e.g. boiler on, flame on, etc.) is to be sent to the controller specify how this will be done by choosing the appropriate option. Unit On status can be displayed on the main Data screen, or passed to the data acquisition system via Modbus. Checking the “Hold last calculated data” box will cause any calculated analog outputs to freeze at the last valid value when a QA check or blowback starts. In other words calibration will not be reflected on the analog output. All other fields are self-explanatory.

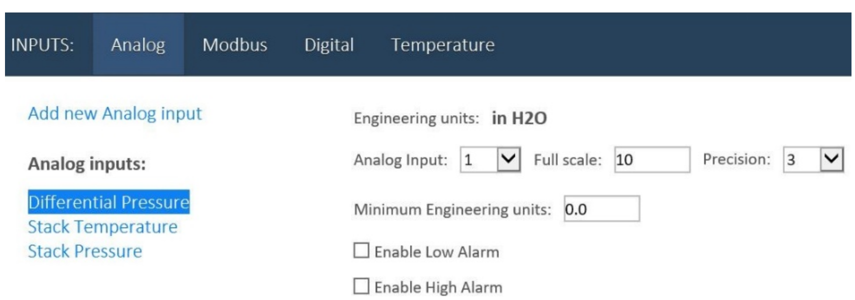


4.3.2 Configuration: Inputs

The Inputs screen is for configuring Analog, Modbus, Digital, and Ambient Temperature signals for the controller.

4.3.2.1 Configuration: Inputs: Analog

Analog inputs 1 through 3 are factory set to match the full scale ranges of the DP transmitter, stack temperature transmitter, and stack pressure transmitters. They will rarely be adjusted, but if needed they can be changed here. Minimum Engineering units is the value that corresponds to 4mA, Full scale corresponds to 20mA. The user can enable low or high value alarms if desired.



Analog input 4 can be used by the user to pass through a signal such as steam load or megawatt load. This is done by providing a 4-20mA signal to terminal block TBAI (see Wiring and Interconnect Diagram). Click “add new Analog input” and follow prompts to specify a name and engineering units. It will then be an available option on the list of Analog inputs; click the link and configure as desired. Once it is configured remember to write the configuration to the controller using the Administrator screen. Once fully configured the parameter can be displayed on the main Data screen, configured as an analog or Modbus output, or used to generate a value alarm. Once the input is configured, the Data: Modbus Map screen will display the address of the user defined parameter, see section 4.1.4.

4.3.2.2 Configuration: Inputs: Modbus

This screen enables the user to configure floating Modbus inputs to the controller that can then be displayed on the main Data screen or configured as analog outputs. Modbus digital inputs can also be configured. If a Modbus Unit On (meaning boiler on, power generating, flame on, etc.) is to be utilized, Bit 0 of a status word sent to address 490 must be used. Once the Modbus input is configured, the Data: Modbus Map screen will display the address of the user defined parameter, see section 4.1.4.

4.3.2.3 Configuration: Inputs: Digital

If a Unit On dry contact closure digital input is to be utilized, Digital input 8 must be used. Once configured, this signal can then be displayed on the main Data screen, or passed through via Modbus (see Modbus Map screen for address) for the data acquisition system to use.

4.3.2.4 Configuration: Inputs: Temperature

This screen is used to configure the instrument panel ambient temperature parameter. Engineering units, and Hi/Lo value alarms can be specified here.

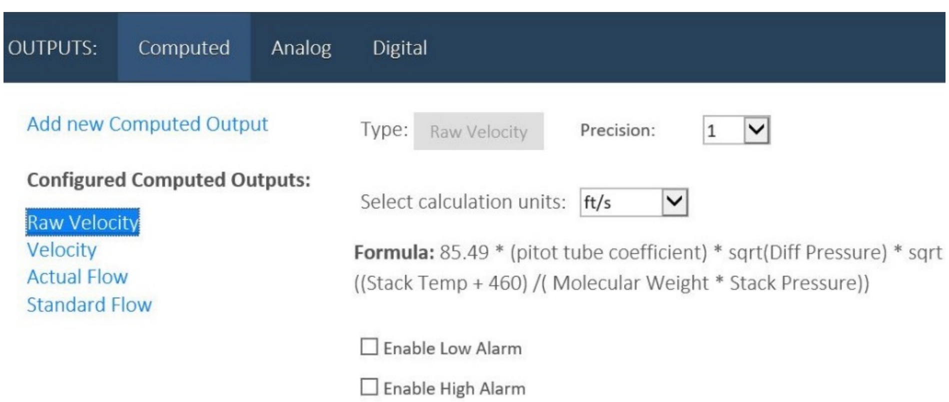
4.3.3 Configuration: Outputs

This section allows the users to configure analog output full scale, engineering units, alarms, precision, etc. as well as some specific aspects of computed analog outputs.

4.3.3.1 Configuration: Outputs: Computed

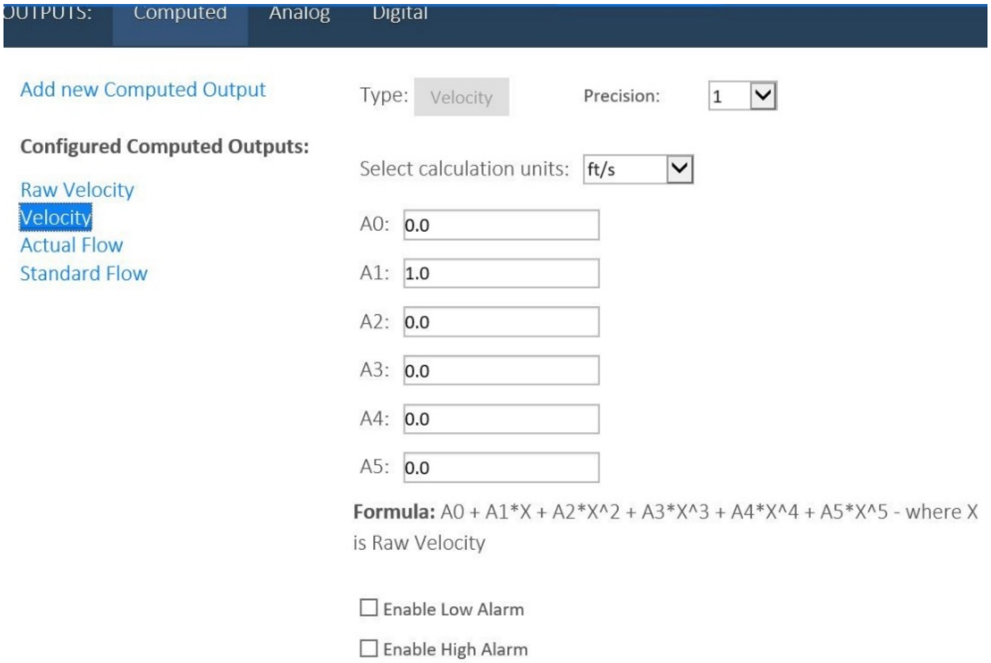
4.3.3.1.1 Configuration: Outputs: Computed: Raw Velocity

Raw velocity is uncorrected. It is the raw calculated velocity based on the measured parameters and the stack composition entered in the ***Configuration: General screen***.



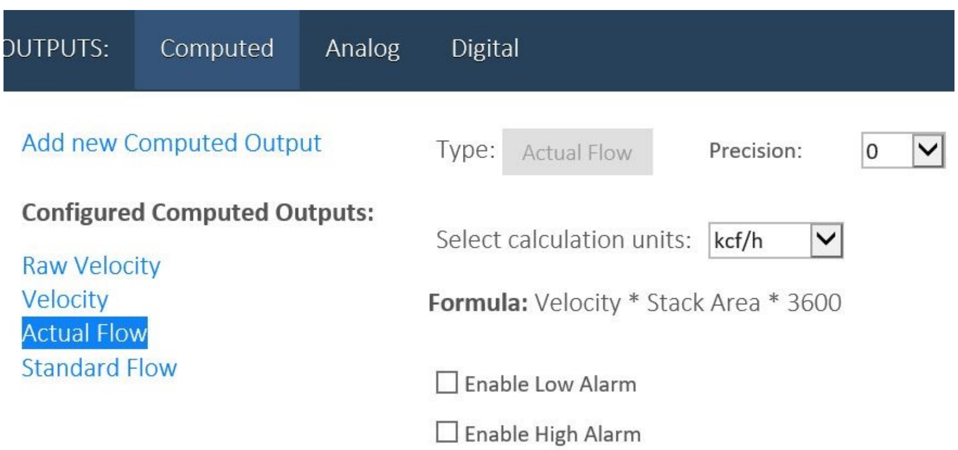
4.3.3.1.2 Configuration: Outputs: Computed: Velocity

Velocity is corrected to match up with reference method results. This is done by plotting DeltaFlow velocity data (x-axis) against stack test results (y-axis) at one or more load conditions using a program like Microsoft Excel. Then by applying a linear or polynomial trend line, a correction curve is obtained. The coefficients from the correction curve can be entered into fields A0 through A5 to obtain a Velocity with very good relative accuracy. See Operation section for more detail. From the factory, Velocity is always the same as Raw Velocity. The constants shown below result in a correction curve of y = x, or Velocity = Raw Velocity.



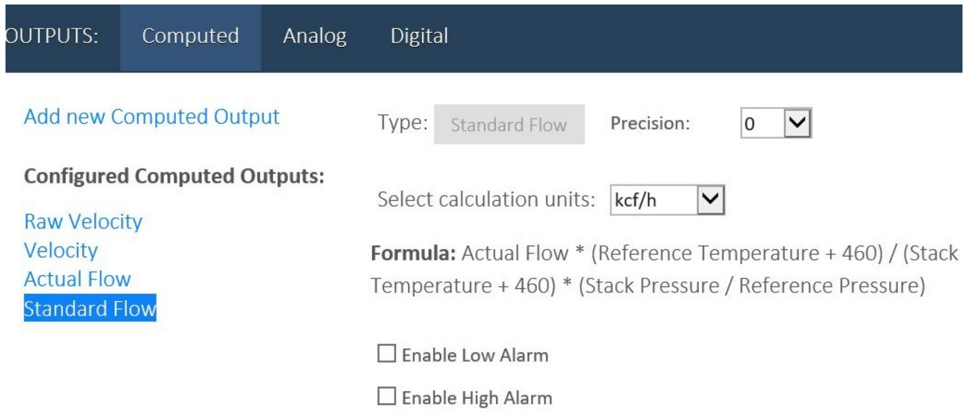
4.3.3.1.3 Configuration: Outputs: Computed: Actual Volumetric Flow

Actual Flow is the volumetric flow rate at stack temperature and pressure.



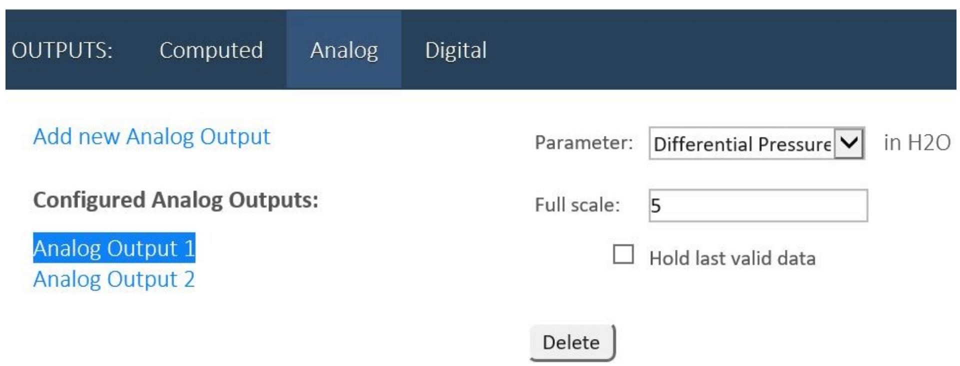
4.3.3.1.4 Configuration: Outputs: Computed: Standard Volumetric Flow

Standard Flow is the volumetric flow rate corrected to the reference temperature and pressure specified in the ***Configuration: General screen***.



4.3.3.2 Configuration: Outputs: Analog

This screen assigns parameters and full scales to the two analog output channels available on the DeltaFlow. Any measured, computed, or user defined analog parameter can be assigned to either channel. See Table 1-1 for all available options.

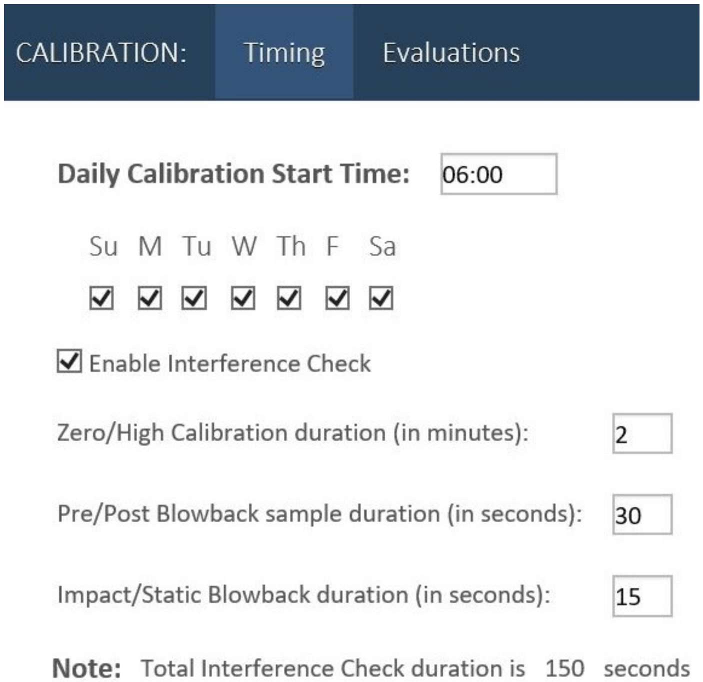


4.3.4 Configuration: Calibrations

These screens are used for detailed configuration of QA checks. These include daily calibrations and interference checks.

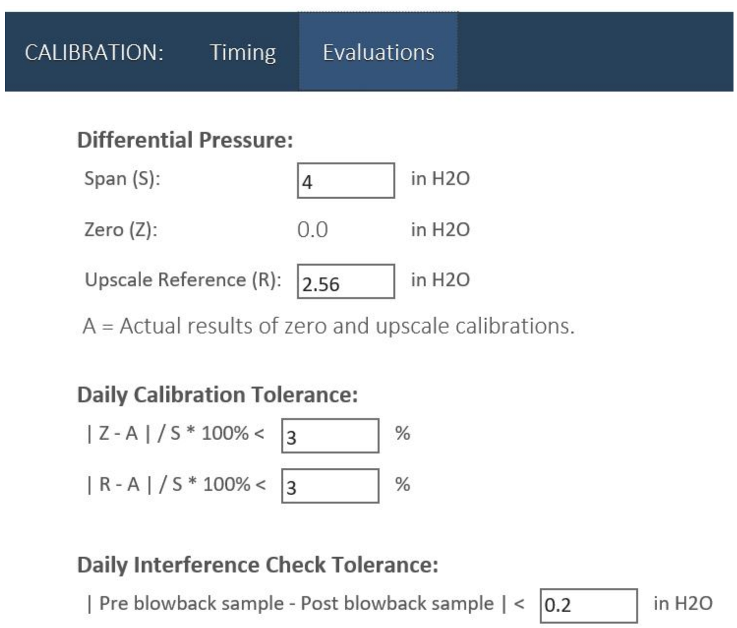
4.3.4.1 Configuration: Calibrations: Timing

This screen defines the timing and frequency of the daily QA checks. A daily calibration check consists of a zero and upscale DP check. The Deltaflow controller can be programmed to automatically perform this check at a certain time on any given day of the week. If the appropriate box is checked, an interference check will also be conducted at that time. An interference check consists of taking an average DP sample over a length of time defined by the user, performing a blowback, then taking another average DP sample. The pre and post blowback samples should agree to some extent depending on how steady the process is. The extent at which they should agree will take some time to determine through trial and error. This is why the sample and blowback durations, as well as the failure tolerance is configurable. If these two samples are significantly different, the Pitot tubes may have been clogged with dirt or water and the interference check blowback cleared out the clog.



4.3.4.2 Configuration: Calibrations: Evaluations

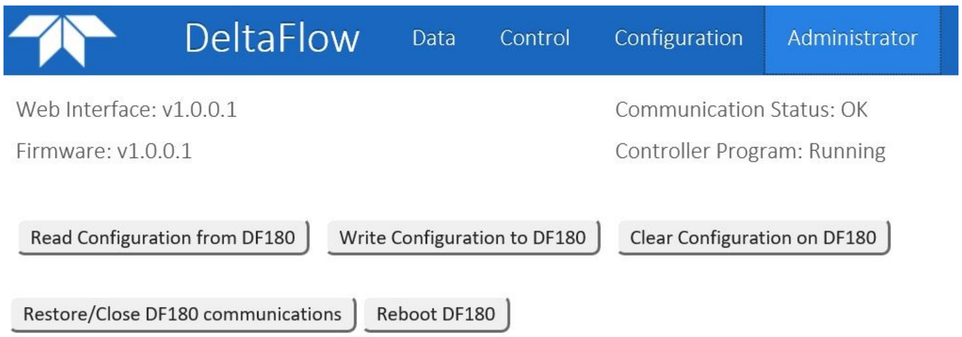
This screen details the pass/fail tolerances, and reference points for the daily QA checks. The span is defined based on the maximum potential flow (MPF). Span is typically 125% of the MPF. The upscale reference set point is typically set to 50-70% of the span.



4.4 Administrator

IMPORTANT: ANY CHANGE TO THE CONFIGURATION MUST BE WRITTEN TO THE CONTROLLER BY GOING TO THE ADMINISTATOR SCREEN AND PRESSING THE **WRITE CONFIGURATION TO DF180** BUTTON.

This screen displays firmware version, communication status, and enables the user to perform several functions involving sending to or receiving information from the DeltaFlow controller.



5 Operation

This section outlines details and procedures associated with startup and daily operation of the Deltaflow. After physical installation is complete the Deltaflow configuration should be examined to ensure it is accurate for the application. This includes reviewing all the screens in the web interface which is the main way of interfacing with the DeltaFlow, see section 4.

5.1 Calibration and Adjustment

Start a calibration check by pressing the “Cal Check” button on the front of the instrument panel. The cal check will not begin until the top of the next minute according to the Deltaflow controller clock. The cal check will take approximately 4 minutes. After it is complete, check the ***Data: Calibrations*** screen in the web interface to verify results are acceptable. New from the factory the zero (4mA) and full scale (20mA) outputs should not need adjustment. Overtime they may drift; if needed they can be adjusted on the front of the DP transmitter via tamper proof knobs. A key for the knobs is provided.

If the upscale reference set point needs adjustment, use a flat head screwdriver to adjust the set screw of the precision DP switch located at the end of the spring housing on the switch. If an adjustment is made, perform three calibrations and enter the average result of the upscale check as the new upscale reference. Tee fittings are located directly under the sample filters to enable the user to hookup an incline water manometer to the Deltaflow to verify absolute accuracy, if desired.

5.2 Interference Check

An interference check attempts to determine if the data collected is inaccurate due to probe or sample line cloggage. An interference check consists of taking an average DP sample over a length of time defined by the user, performing a blowback, then taking another average DP sample. The pre and post blowback samples should agree to some extent depending on how steady the process is. The extent at which they should agree will take some time to determine through trial and error. A good starting point is to conduct three consecutive interference checks with a new probe that is known to be free of cloggage. Determine the average result of these three checks, and multiply it by 1.25. Enter the result into the *Daily Interference Check Tolerance* field in the ***Configuration: Calibrations: Evaluations*** screen. See section 4.3.4.2.

5.3 Creating a Correction Curve

The DeltaFlow can be programmed with a correction curve to achieve better accuracy based on a reference measurement. This is sometimes necessary because the Deltaflow takes only a point measurement. A reference method like EPA Method 2 takes an average of many sample points to get a more accurate measurement of the overall average velocity in the stack. Creating a correction curve is done using the following procedure.

First Deltaflow Raw Velocity data is collected along with a reference method velocity measurement, such as EPA Method 2. It is important to synchronize the Deltaflow and the reference measurements to ensure an accurate correction curve is produced. This can be done by synchronizing the time keeping device used to track the reference measurement start and stop times with the clock of the data acquisition system logging the Deltaflow data. Typically a reference method measurement takes about 10 to 15 minutes to get all the point samples recorded, after which the test personnel will average the points to come up with a single velocity measurement for the 10 to 15 minute period. The DeltaFlow data collected for this period should also be collect and averaged into a single value. If possible parallel Deltaflow and reference measurements should be taken at multiple loads.

Once the data is collected, plot the reference method data (y-axis) verse the Deltaflow Raw Velocity data (x-axis) as shown in figure 5-1.

Start Time	Stop Time	DeltaFlow Raw Velocity (ft/s)	Reference Method Velocity (ft/s)
6:00	6:12	35.2	39.4
8:45	8:57	47.8	55.4
13:03	13:13	60.9	68.2

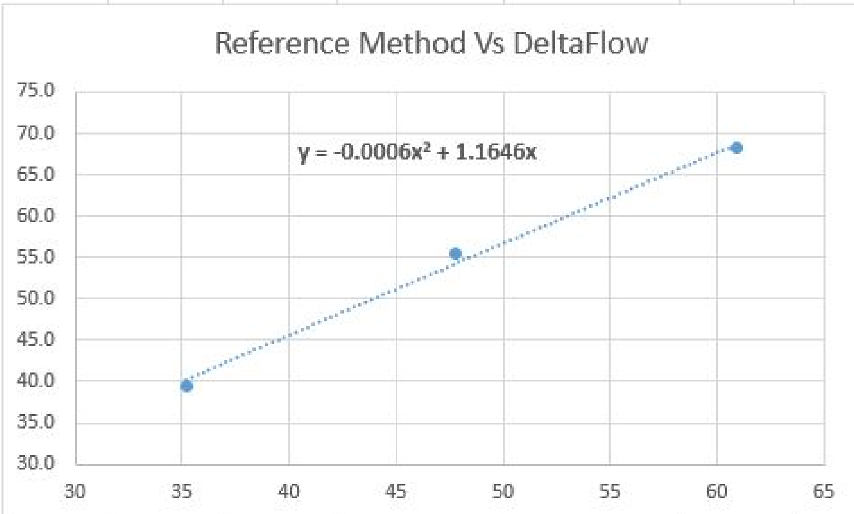


Fig. 5-1 DeltaFlow Correction Curve

Add a linear or up to a 5^{th} order polynomial trend line. The coefficients of each variable can be entered into the A0 through A5 fields of the web interface ***Configuration: Outputs: Computed: Velocity*** screen following the form of $y = A0 + A1*x + A2*x^2 + A3*x^3 + A4*x^4 + A5*x^5$. For the example in Figure 5-1, A0 = 0, A1 = 1.1646, A2 = -0.0006, and A3, A4, A5 = 0. See section 4.3.3.1.2 for a screenshot of the A0 through A5 fields. After the coefficients are entered, write the configuration to the controller. Now the Velocity and Raw Velocity parameters will differ in the Deltaflow as a result of the correction curve. Examining the graph in Figure 5-1, a Raw Velocity of 40 ft/s would result in a Velocity of 45.

5.4 Long-Term Shutdown

If the Deltaflow is to remain out of service for an extended period of time (greater than 24 hours) without power, perform the following steps.

1. Disconnect the impact and static pressure lines from the probe.
2. Cap the probe connections with 3/8" tube caps.
3. Perform a blowback sequence to fill the lines with instrument air.
4. Cap the ends of the impact and static pressure lines.
5. Shutoff power to the Deltaflow instrument panel.

6 Maintenance

6.1 Scheduled Preventative Maintenance Chart

Use the Scheduled Preventative Maintenance Checklists located in Appendix A. Frequency of maintenance will depend on the individual applications.

Description	Monthly	Quarterly	Yearly	Bi-Yearly
Clean Pitot tube		X		
Perform Leak Check on Sample Lines		X		
Replace sample filter media			X	
Clean sample line				X

6.2 Pitot Tube Cleaning Procedure

If the Pitot tube is clogged, it may need to be flushed or blown out. The cleaner used depends on the process and what has accumulated in the sample line. Many lines can be cleaned by flushing with water, Simple Green, or vinegar. In other cases, Acetone may needed. The best way to determine what will work is to start with water, move to Simple Green or Vinegar and finally Acetone.

6.3 Sample Line Cleaning Procedure

If the sample line is clogged, the line may need to be flushed or blown out. The cleaner used depends on the process and what has accumulated in the sample line. Many lines can be cleaned by flushing with water, Simple Green, or vinegar. In other cases, Acetone may needed. The best way to determine what will work is to start with water, move to Simple Green or Vinegar and finally Acetone.

Below is a sample of how to flush a line using Simple Green.

1. Put the Deltaflow into Maintenance mode.
2. Make a dilute solution of Simple Green and Water.
3. Disconnect sample line at solenoid valve manifold. Place this end of the sample line in a bucket to capture cleaning solution. You may want to make a short line to extend the sample line to the floor.
4. Disconnect the sample line at the probe.
5. Flush the line with the cleaning solution.
6. Examine the line the fluid in the bucket.
7. Adjust Simple Green concentration as needed.
8. Repeat as needed until the line is clean.
9. If Simple Green does not work, Acetone may be used.
10. Rinse the line thoroughly.
11. Blow line dry with instrument air.
12. Connect lines at probe.
13. Connect lines at solenoid valve manifold.
14. Perform leak check.

6.4 Filter Media Replacement Procedure

These filters should rarely come in contact with actual stack gas. Since periodic blowback is done every 6 hours at minimum, the sample lines stay filled with instrument air for the most part. Because of this, all the components on the instrument panel should only come in contact with clean dry instrument air 99% of the time. So these filters should last 1 to 2 years. When they do need to be replaced, follow this procedure:

1. Put the DeltaFlow into Maintenance mode.
2. Click the **Impact Blowback** and **Static Blowback** buttons in the ***Control*** screen. This will isolate the filters from the impact and static pressure lines.
3. The filters can then be removed from the plumbing to change out the media.
4. Remove the used media and store in a container for disposal.
5. Refill the canisters with TML P/N 99705000-2. Do not overfill.
6. Click the **Impact Blowback** and **Static Blowback** buttons in the ***Control*** screen.
7. Perform a leak check on the panel, see section 6.5.

6.5 System Leak Test Procedure

CAUTION: Wear gloves when sliding Leak Check Kit tubing onto the tip of the Pitot Tube. The tip of the Pitot tube is sharp!

It is important to ensure the entire pneumatic sampling system is leak free. This includes the probe, sample line, and all the instrument panel plumbing. To check this, use TML P/N 99701100-1 (DF180 Leak Check Kit) and follow the procedure below. Other procedures may be used, such as pressurizing the probe and line with no greater than 50 PSIG compressed air, If a long sample line is installed (>150FT), this may be desirable. But the instrument panel should never be pressurized over 2 PSIG, and should only be checked using the DeltaFlow leak check kit. This procedure requires a person at the probe location and another person at the instrument panel.

1. The probe person disconnects the impact and pressure lines from the Pitot tube.
2. Make sure the syringe is pulled out. Connect the leak check device to the impact line.
3. Slowly inject the syringe plunger while the instrument panel person observes the DP transmitter gauge display.
4. The person at the instrument panel notifies the probe person to shut the leak check kit isolation valve when the DP reading has reach a level approximately 75% of the full scale of the gauge display.
5. Once the leak check valve is closed, observe the DP reading on the gauge display and make sure it remains stable for 30 seconds.
6. Repeat the process for the static side by connecting the leak check kit to the static line, but this time ensure the plunger is pushed in before connecting.
7. The probe person slowly retracts the plunger while the instrument panel person observes the DP gauge. Isolate and check for stability as in steps 4 – 5.

8. Reconnect lines to probe.

This procedure does not check the probe for leaks. Since the probe is made of seamless stainless steel it is unlikely to have leaks. In the event a leak in the probe is suspected, it can be incorporated in the leak check by removing it from the mounting flange and connecting the leak check kit to the ends of the probe using the rubber flexible tubing. Make sure the probe tip is free of debris.

If only a leak check on the instrument panel is require, connect the leak check kit directly to the impact and static connections on the solenoid valve manifold.

7 Troubleshooting

Below is a table of trouble symptoms and checks. Call Teledyne Monitor Labs Technical Support at 1-800-846-6062 if the below checks do not reveal the problem.

Trouble	Check
Suspected inaccurate velocity or flow readings	-Check Probe for debris -Leak check entire system, components prone to leaks are solenoid valves and tube connections -Check variables in *Configuration* screen
Failed calibration	-Leak check instrument panel -Verify upscale reference value in the DeltaFlow matches the value in the data acquisition system - Check that DP transmitter gauge display matches web interface values during zero and upscale calibrations. If not, the DP transmitter 4 to 20mA may have failed or need adjustment.
Unable to reach web interface	-make sure the web address is entered in the format xxx.xxx.xxx.xxx/delta/ -Use Teledyne Support Tool to attempt to verify IP address and presence of the controller on the network -Cycle power on the instrument panel and allow two minutes to reboot before attempting to access again.

Appendix A: Spare Parts

Recommended spare parts for the DeltaFlow 180 are organized into three categories. User can stock the appropriate parts for their level of maintenance. For the highest level of maintenance all three categories should be stocked. The three levels are:

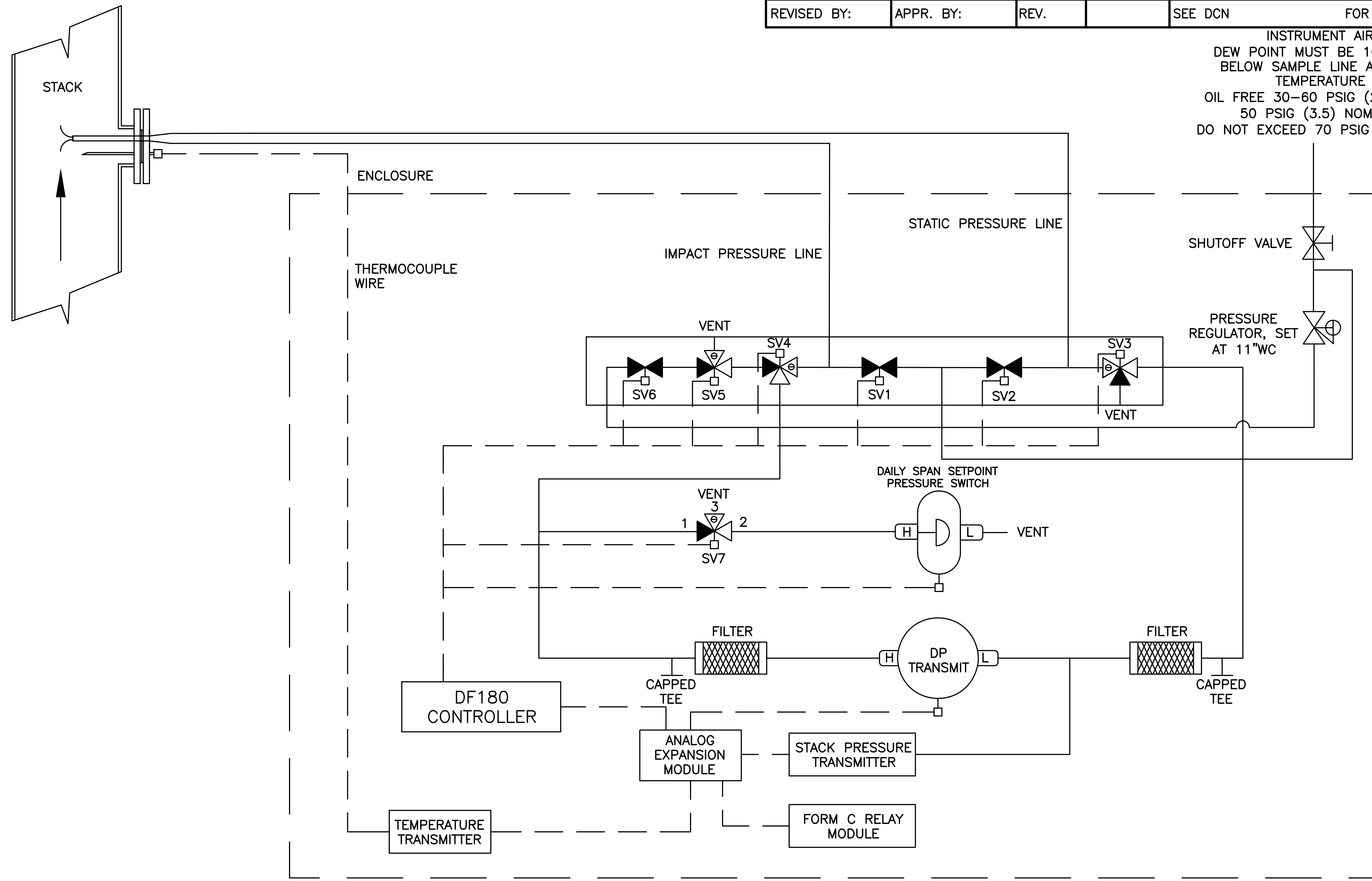
- Startup
  - Parts that may be used during start-up and daily operation.
- Maintenance
  - Parts that may be required as a result of normal wear over time.
- Emergency
  - Parts that will facilitate the fastest possible repair time in failure situations such as power surges, lightning strikes, etc.

DeltaFlow 180 Spare Parts List				
Part Number	Description	Category	Typical on-site stock	Expected Time between replacement
45500007-1	SV1, SV2, and SV6: two way solenoid valve	Maintenance	1	3 years
45500007-2	SV3 and SV4: three way solenoid Valve	Maintenance	1	3 years
45500007-3	SV5: three way solenoid Valve	Maintenance	1	4 years
45500005	SV7: three way solenoid valve	Maintenance	1	4 years
45500007-4	Solenoid valve Plugs w/ diode, 1m cable	Emergency	0	N/A
22000225-1	12VDC PS, 10 W, DIN mount	Emergency	1	N/A
29000241-1	Precision air regulator, 0-2 PSI, Tamper Proof	Emergency	0	N/A
55000046-1	DP Transmitter w/ display, 0-20" H2O	Emergency	1	N/A
55000046-2	DP Transmitter w/ display, 0-10" H2O	Emergency		N/A
55000046-3	DP Transmitter w/ display, 0-6" H2O	Emergency		N/A
55000046-4	DP Transmitter w/ display, 0-3" H2O	Emergency		N/A
55000046-5	DP Transmitter w/ display, 0-0.5" H2O	Emergency		N/A
55000046-6	DP Transmitter w/ display, 0-1500 Pa	Emergency		N/A
55000046-7	DP Transmitter w/ display, 0-500 Pa	Emergency		N/A
55000046-8	DP Transmitter w/ display, 0-125 Pa	Emergency		N/A
55000049-1	Precision Pressure switch, 3-12" H2O	Emergency	1	N/A
55000049-2	Precision Pressure switch, 1-3" H2O	Emergency		N/A
55000049-3	Precision Pressure switch, 0.2-1" H2O	Emergency		N/A
22000222-1	24VDC PS,120 W, DIN mount	Emergency	1	N/A
99705000-1	13X mol sieve soda lime purifier	Emergency	0	N/A
99705000-2	13X mol sieve soda lime refill	Maintenance	1	1 year
99702001-1	S-Type Pitot Tube, 316SS, 24"	Maintenance	1	3 Years
99702001-2	S-Type Pitot Tube, 316SS, 36"	Maintenance		3 Years
99702001-3	S-Type Pitot Tube, 316SS, 48"	Maintenance		3 Years
99702001-XX	Contact TML for Hastelloy, Inconel, special pitot P/Ns	Maintenance		3 Years
99702005-1	Pitot Mounting Fitting (not included w/ pitots)	Maintenance		3 Years
99702003-1	Thermocouple, K-Type, 24", 316SS, 1/2NPT	Maintenance	0	5 Years
99702003-2	Thermocouple, K-Type, 36", 316SS, 1/2NPT	Maintenance		5 Years
99700002-1	Sample Line, 2 x 3/8" Tubes, 1 x K-Type TC	Maintenance	0	10 Years
40000190-1	6A 250VAC Circuit Breaker, DIN Mount	Emergency	0	N/A
55000048-1	TC/RTD Temperature Transmitter, 4-20mA, DIN	Emergency	0	N/A
55000048-2	TC/RTD Transmitter Config Cable	Startup	1	N/A
99703003-1	Deltaflow Controller	Emergency	0	N/A
20250088-5	Analog Module	Emergency	0	N/A
20250088-6	Form C Relay Module	Emergency	0	N/A

Appendix B: Drawings

REVISIONS

REVISED BY:	APPR. BY:	REV.		SEE DCN	FOR CHANGE DESC. REF ECO#



NEXT ASSEMBLY	USED ON

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE INCHES
TOLERANCE ON DECIMALS .X± X1 .XX± .02 .XXX± .010
TOLERANCE ON ANGLES ± 0°30'

DO NOT SCALE DRAWING

MATERIAL

DRAWN BY SEV | DATE 3/22/17

FINISH – BREAK ALL SHARP EDGES 125

THIRD ANGLE PROJECTION

FINISH

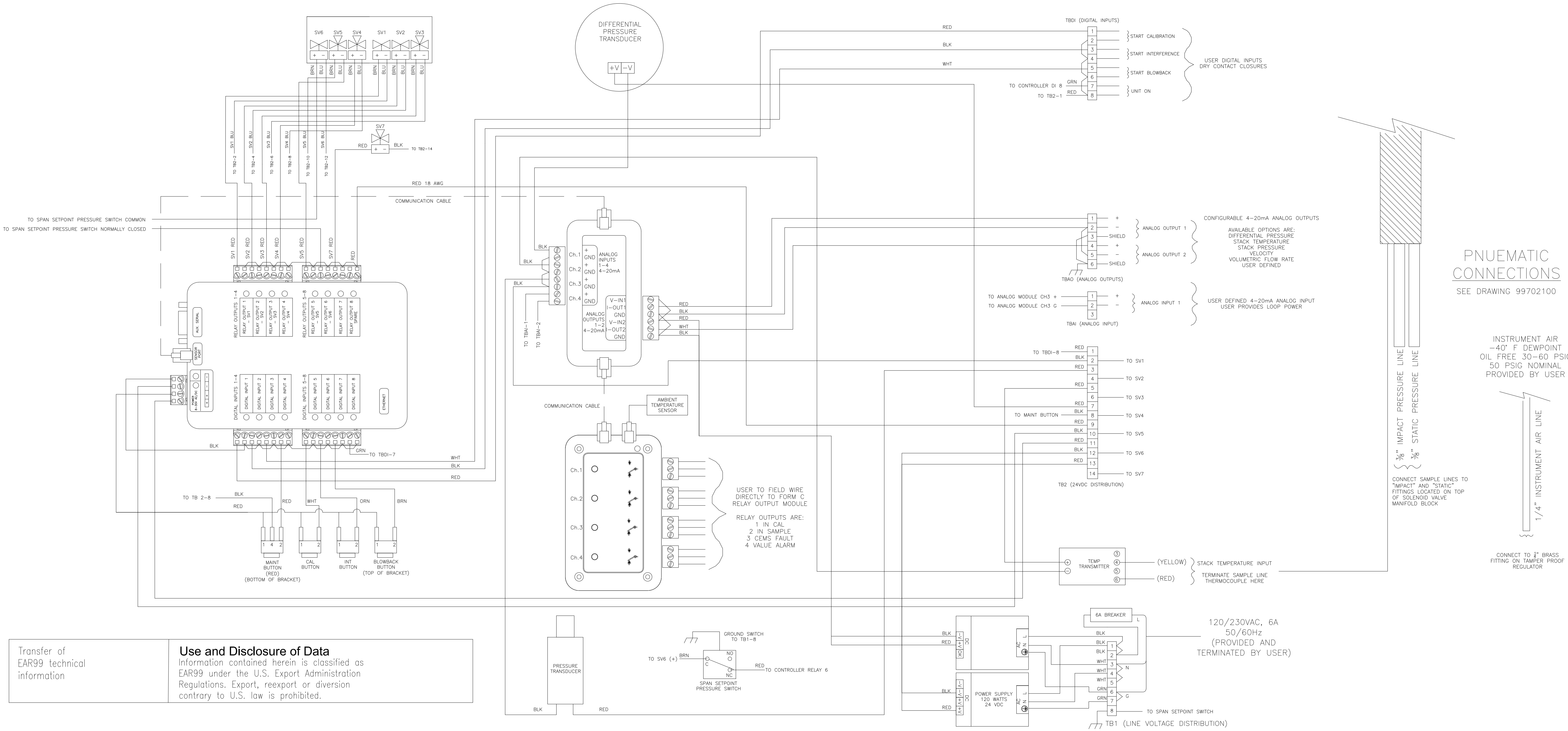
TELEDYNE MONITOR LABS
A Teledyne Technologies Company

DELTAFLOW 180 P&ID

SIZE	CAGE CODE	DWG NO	REV
B		99703100	A

SCALE NTS | SHEET 1 OF 1

REVISIONS



Transfer of EAR99 technical information	**Use and Disclosure of Data** Information contained herein is classified as EAR99 under the U.S. Export Administration Regulations. Export, reexport or diversion contrary to U.S. law is prohibited.

NEXT ASSEMBLY	USED ON

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE INCHES
TOLERANCE ON DECIMALS .X± .1 .XX± .02 .XXX± .010
TOLERANCE ON ANGLES ± 0°30'
DO NOT SCALE DRAWING
MATERIAL

DRAWN BY SEV — DATE 3/22/17
FINISH – BREAK ALL SHARP EDGES 125
THIRD ANGLE PROJECTION
FINISH

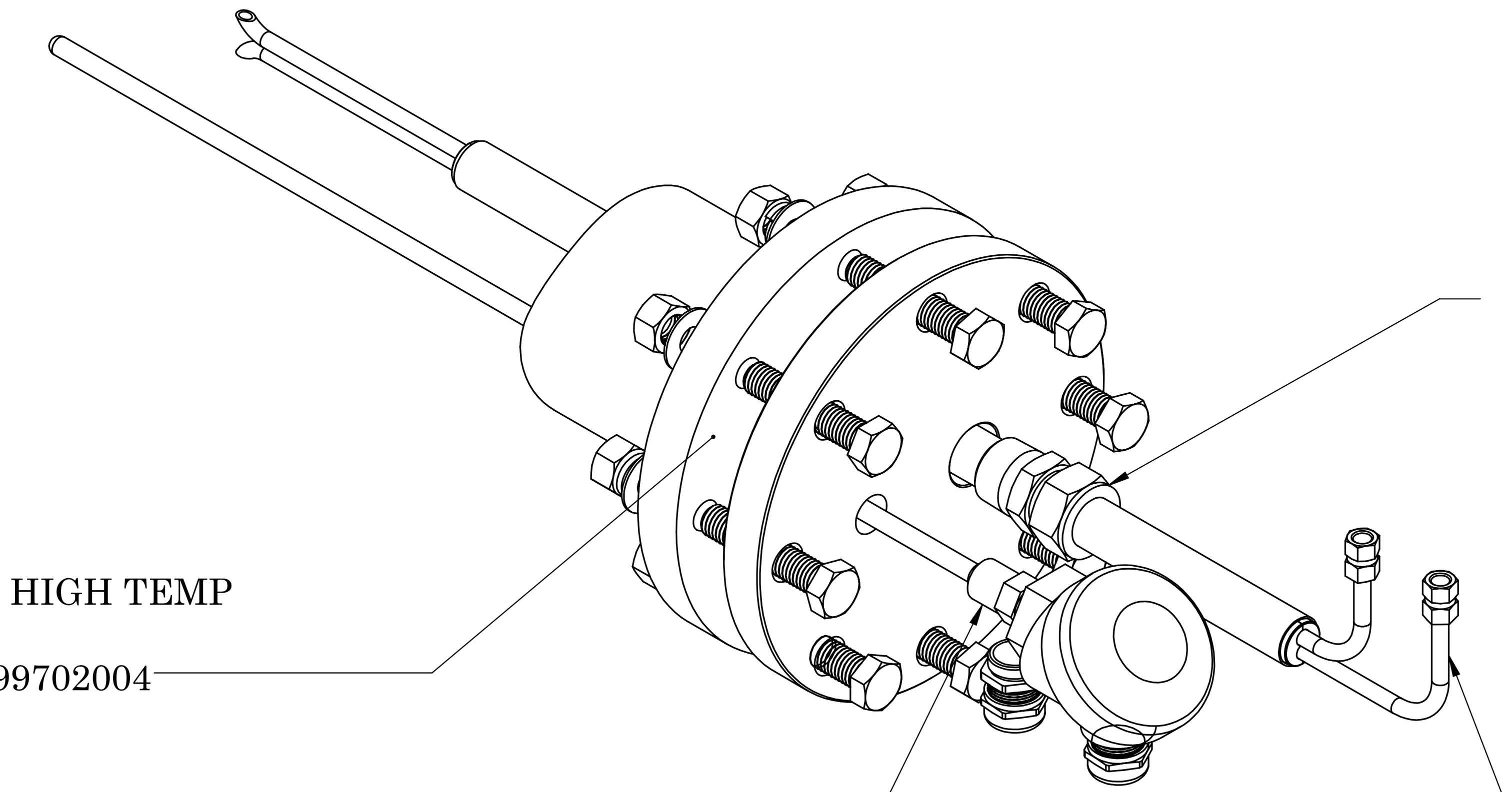
TELEDYNE MONITOR LABS
A Teledyne Technologies Company

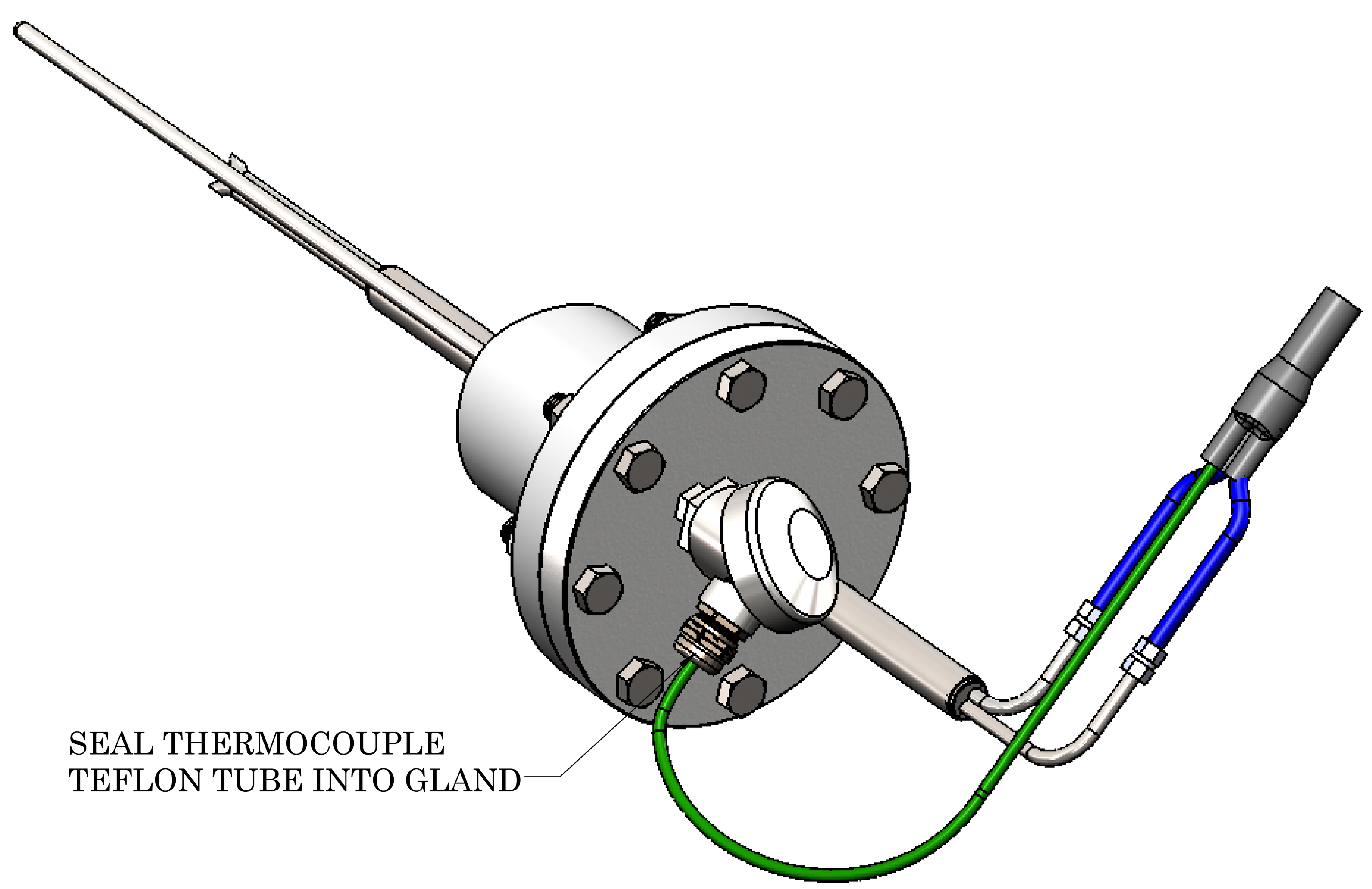
DF180 INSTRUMENT PANEL WIRING AND USER INTERCONNECT

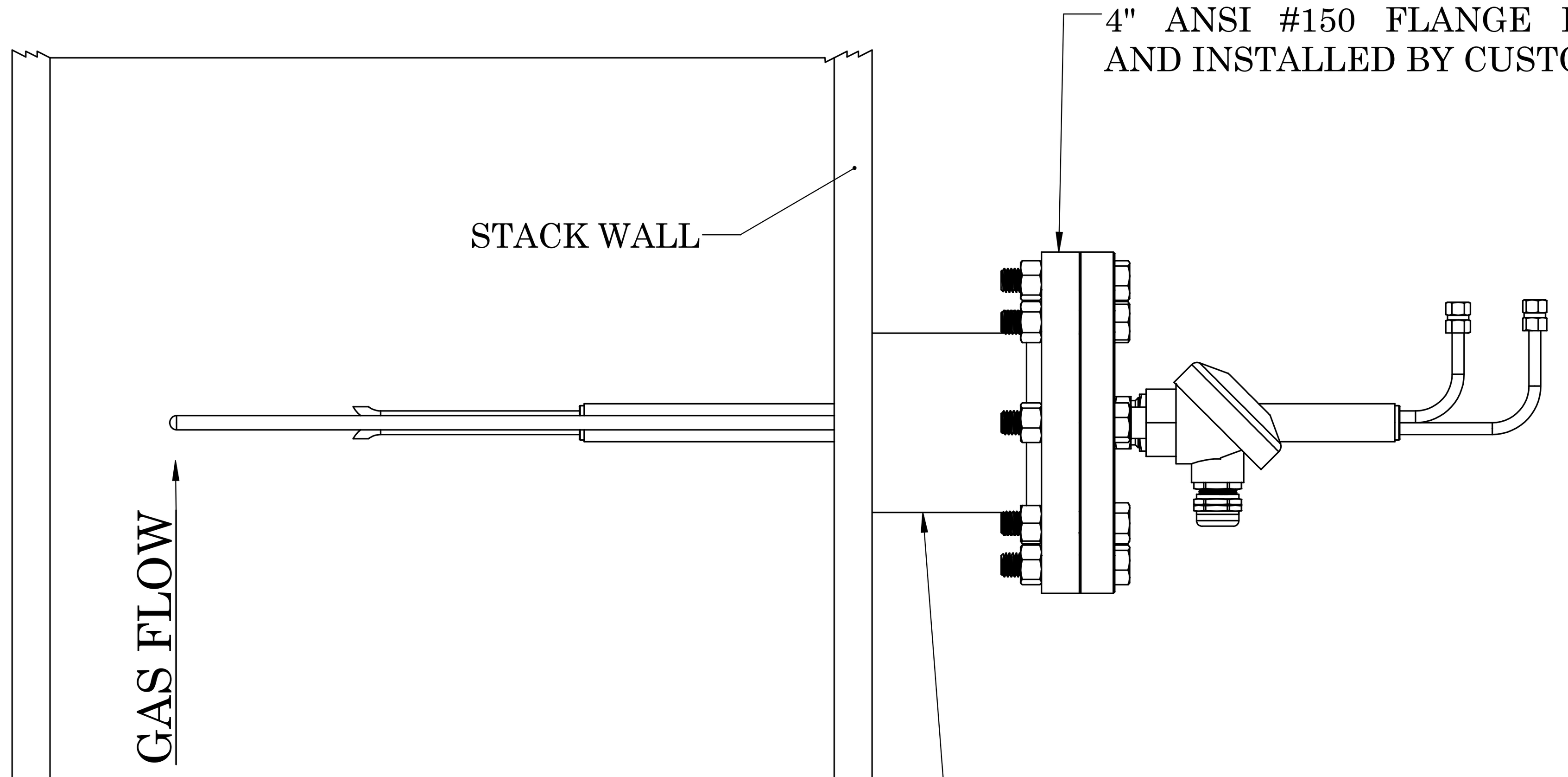
SIZE	CAGE CODE	DWG NO	REV
B		99702101	A

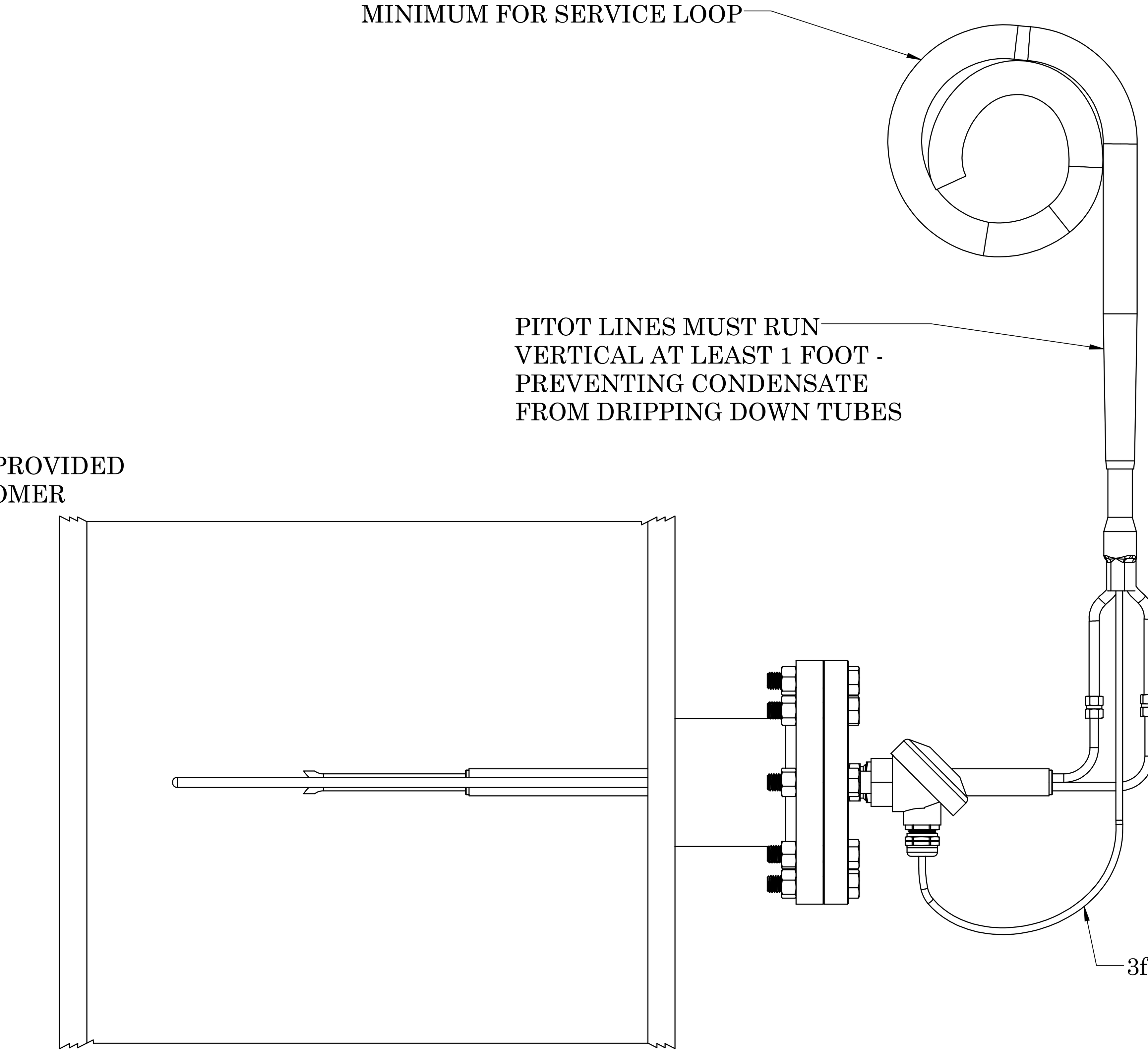
SCALE NTS — SHEET 1 OF 1

REVISIONS			
DATE	APPROVED BY	REV.	DESCRIPTION
8AUG2017		X1	PRELIMINARY INSTALLATION DRAWING & DETAIL
22JAN2018		A	RELEASED PER ECO7228





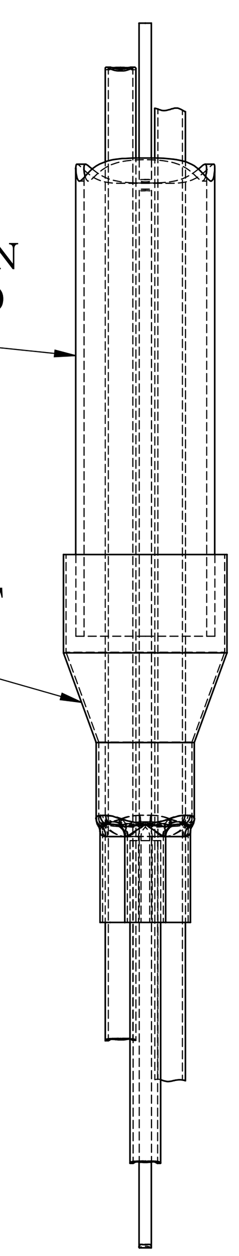


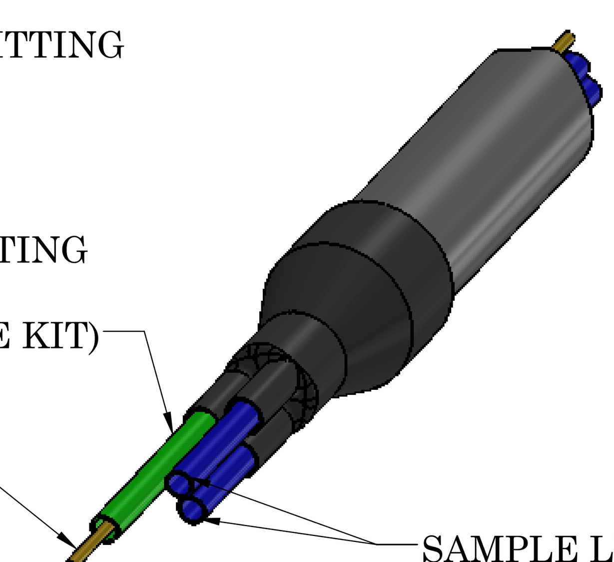


HEATSHRINK BOOT DETAIL

NOTE:

TEFLON TUBING TO BE INSERTED INTO BOOT PRIOR TO APPPLYING HEAT. OBTAINING A PROPER SEAL ON THE THERMOCOUPLE WIRE IS CRITICAL.





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TELEDYNE MONITOR LABS Everywhereyoulook		
TITLE: DF180 PROBE INSTALLATION		
DWG. NO. 99702100	SIZE D	REV A
SCALE: 1:5	SHEET 1 OF 1	

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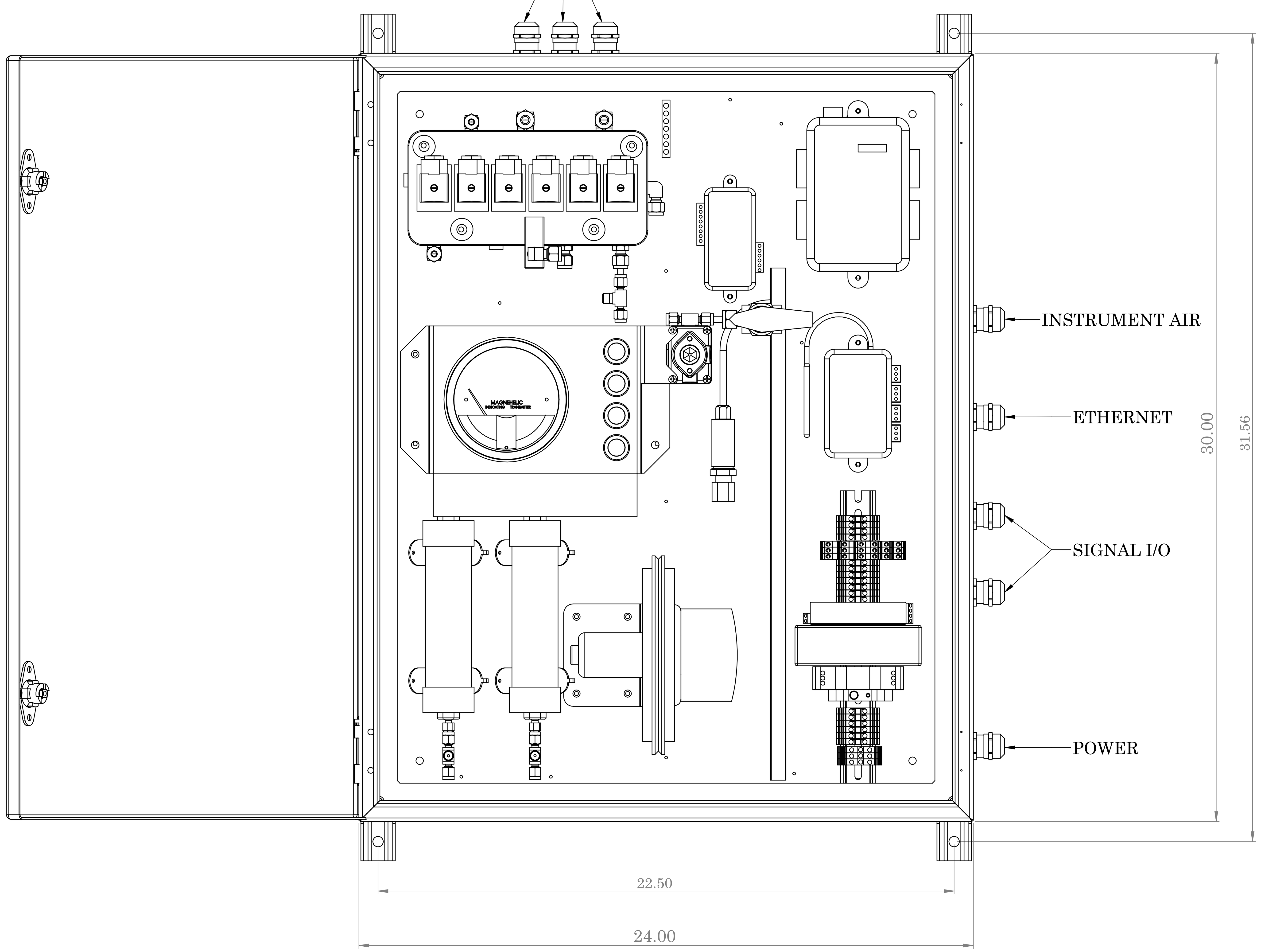
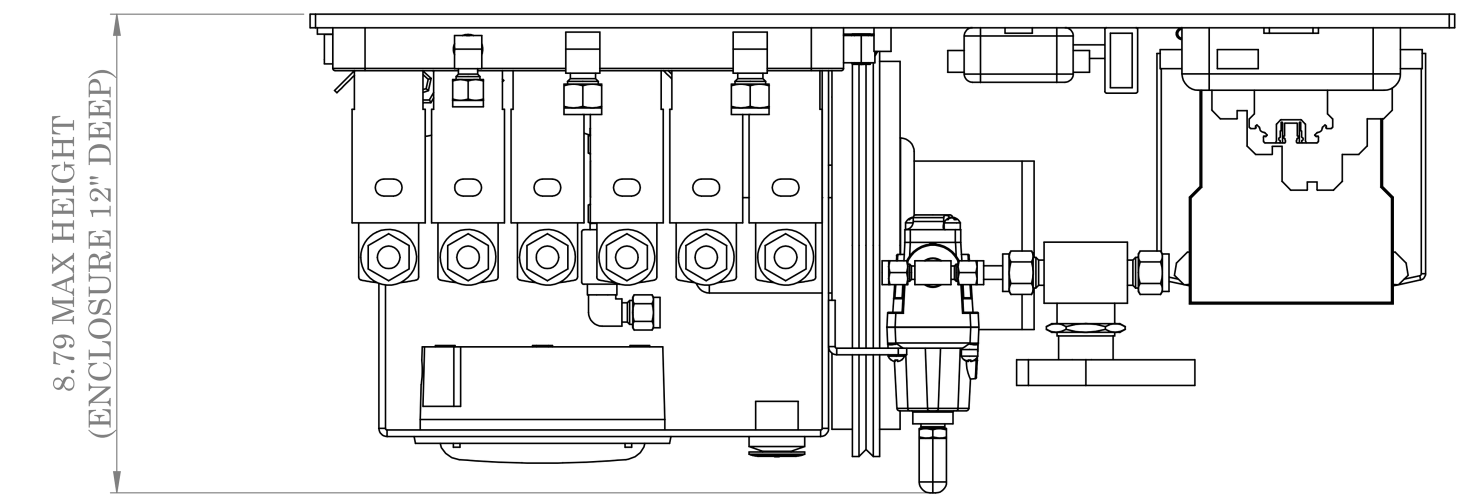
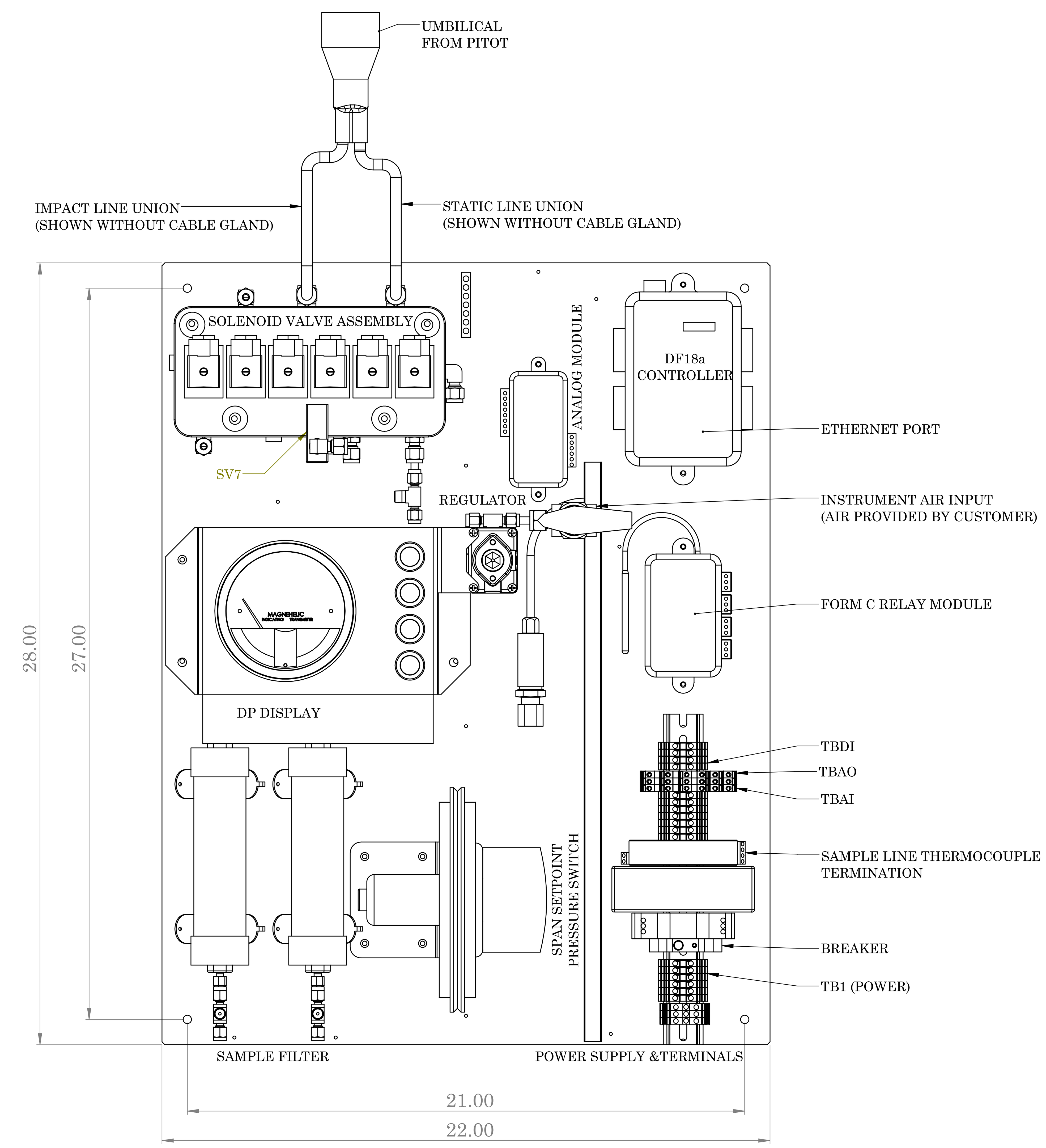
REVISIONS			
DATE	APPROVED BY	REV.	DESCRIPTION
20NOV2017		X1	PRELIMINARY DRAWING
22JAN2018		A	RELEASED PER ECO7228







NOTES:
1. INSTRUMENT PANEL AMBIENT TEMPERATURE LIMITS: 20 TO 104˚F (-7 TO 40˚C)
2. CABLE GLAND CLAMPING RANGE: 6-13mm (0.236 - 0.512 in.)
3. APPROXIMATE WEIGHT: 80lbs, 40lbs WITHOUT ENCLOSURE

TRANSFER OF EAR99 TECHNICAL INFORMATION

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DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES:
0.X±0.1 0.XX±0.02 0.XXX±0.010
ANGULAR: MACH± 0°30'
BEND ±

MATERIAL	N/A
FINISH	N/A
DRAWN BY	D.CONNELLY
DATE	2NOV2017
PART NO.	--

TELEDYNE MONITOR LABS
Everywhereyoulook

TITLE:	DF180 PLATE INSTALLATION		
DWG. NO.	99702102	SIZE D	REV A
	SCALE: 1:5	SHEET 1 OF 1	

2 1

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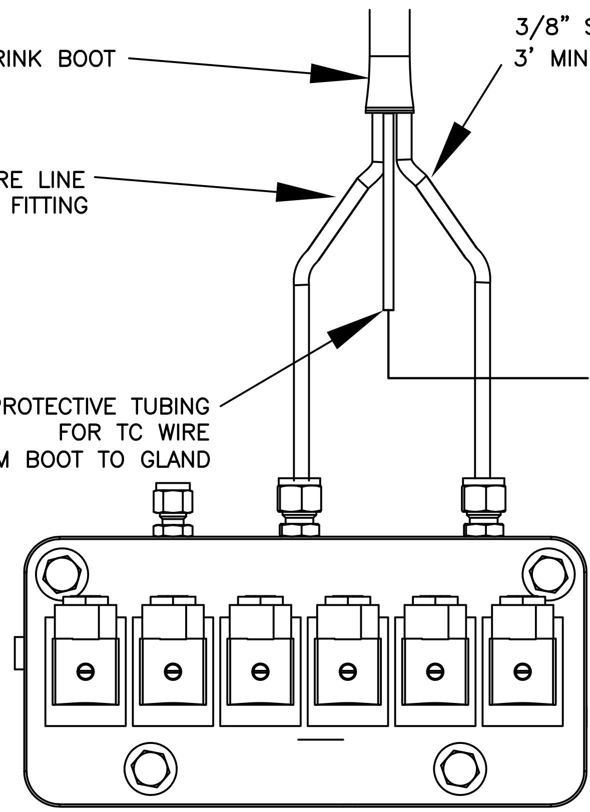
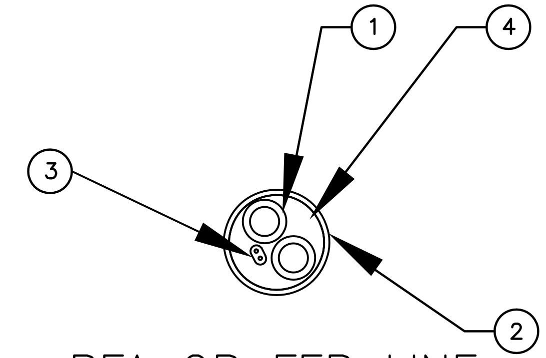
REVISIONS					
REVISED BY:	APPR. BY:	REV.		SEE DCN	FOR CHANGE DESC. REF ECO#

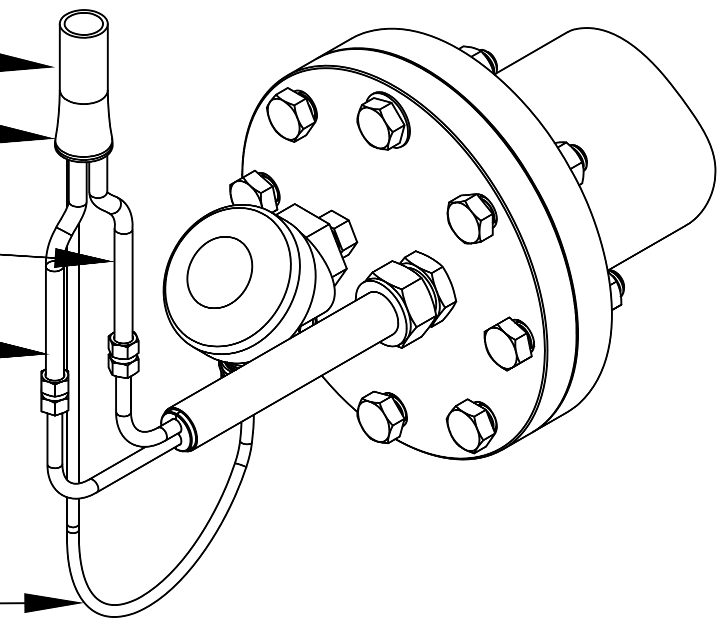


PANEL END TERMINATION OVERVIEW



PFA OR FEP LINE (UNHEATED)

DF180 SAMPLE LINE PARTS LIST		
ITEM	QTY	DESCRIPTION
1	2	3/8" O.D. X .062" PFA OR FEP TEFLON PROCESS TUBE
2	1	BLACK 105°C C ATP OUTER BUNDLE JACKET
3	1	16 AWG TYPE 'K' THERMOCOUPLE MESSENGER WIRES ENTIRE LENGTH, FACTORY INSTALLED.
4	1	MINIMAL FIBERGLASS INSULATION



PROBE END TERMINATION OVERVIEW

B B

SAFETY NOTES:

1. THE FIBERGLASS INSULATION CONTAINED IN THE BUNDLE ASSEMBLY CAN CAUSE SKIN IRRITATION. WEAR EYE PROTECTION, LONG SLEEVES, AND GLOVES WHEN CUTTING INTO THE BUNDLE.

GENERAL NOTES:

1. CABLE ASSEMBLY BEND RADIUS IS 8" MINIMUM.

2. O.D. OF CABLE ASSEMBLY IS 1.1 X 1.2" NOMINAL

3. MAXIMUM RECOMMENDED LENGTH FOR 16 AWG THERMOCOUPLE WIRE IS 434FT. CONSULT TML FOR CUSTOM BUNDLES WITH LARGER GAUGE WIRE.

HEATED SAMPLE LINE INSTALLATION NOTES:

1. SUPPORT EVERY 15' ON VERTICAL DROPS. FLAT CLAMPS MAY ALSO BE USED. TIE WRAPS SHOULD NOT BE USED.

2. SUPPORT EVERY 6' ON HORIZONTAL RUNS.

3. HEATED SAMPLE LINE SHOULD BE ROUTED DOWNWARD FROM PROBE TO INSTRUMENT PANEL WITH NO UPWARD SLOPES.

4. SHORTENING/TRIMMING OF THE BUNDLE ASSEMBLY IS ACCEPTABLE.

5. SEE MANUFACTURER INSTALLATION INSTRUCTIONS PROVIDED WITH BUNDLE FOR FURTHER DETAIL.

6. PROTECTIVE TUBING FOR THERMOCOUPLE WIRE ONLY NEEDED ON PANEL END IF THE INSTRUMENT PANEL IS IN AN ENCLOSURE. TUBING ALLOWS ENCLOSURE CABLE GLAND TO CREATE AIRTIGHT SEAL. PROTECTIVE TUBING PROVIDED IN DF180 HARDWARE KIT.

A A

Transfer of EAR99 technical information

Use and Disclosure of Data

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NEXT ASSEMBLY | USED ON

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE INCHES
TOLERANCE ON DECIMALS .X± .1 .XX± .02 .XXX± .010
TOLERANCE ON ANGLES ± 0°30'

DO NOT SCALE DRAWING

MATERIAL

DRAWN BY S VIGIL | DATE 1/18/18

FINISH – BREAK ALL SHARP EDGES 125

THIRD ANGLE PROJECTION

FINISH

TELEDYNE MONITOR LABS
A Teledyne Technologies Company

DF180
SAMPLE LINE INSTALLATION

SIZE	CAGE CODE	DWG NO	REV
B		99702103	A
SCALE NTS		SHEET 1 OF 1	

2 1

REVISIONS					
REVISED BY:	APPR. BY:	REV.		SEE DCN	FOR CHANGE DESC. REF ECO#

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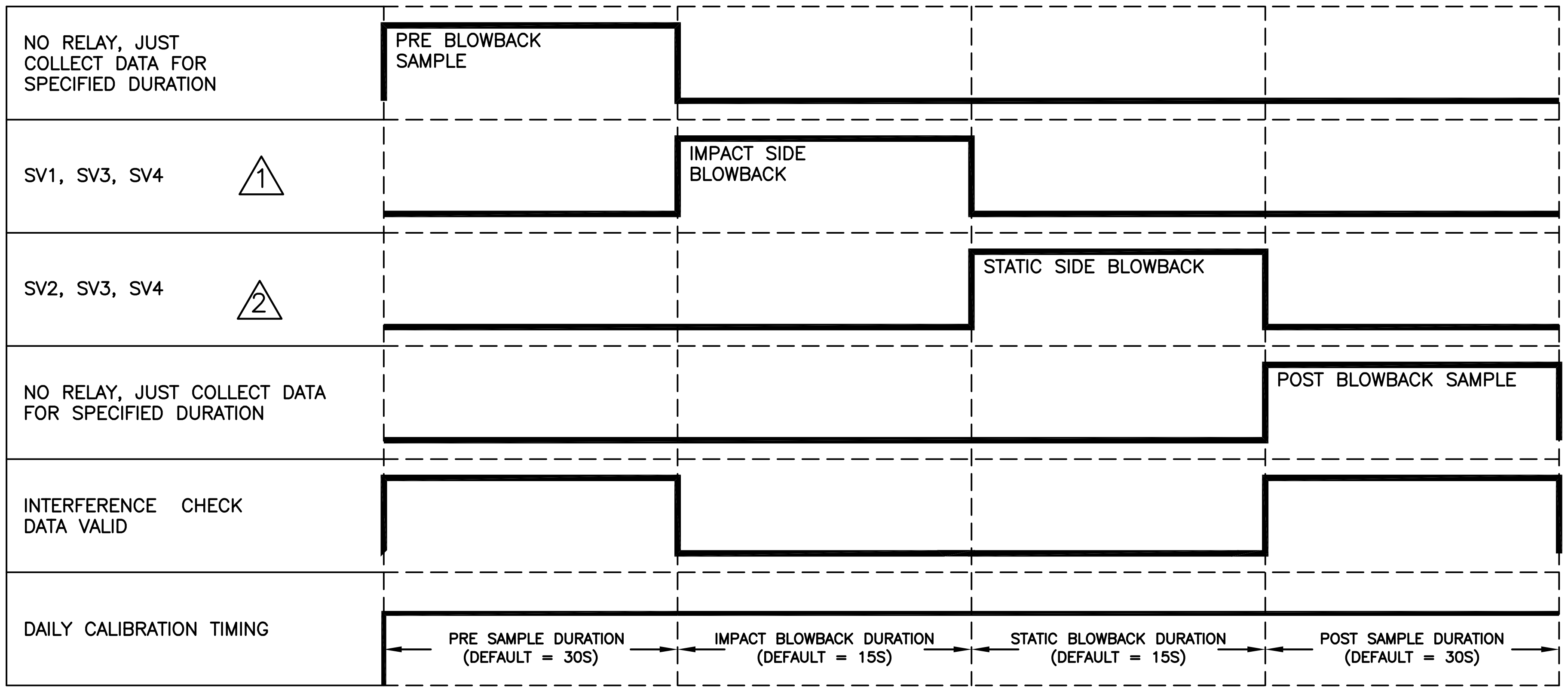
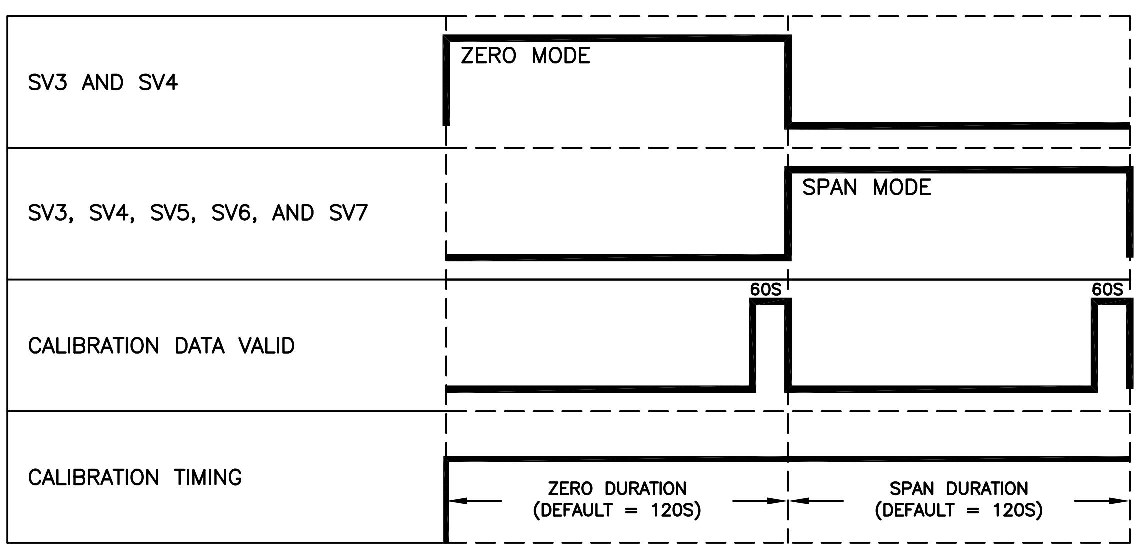
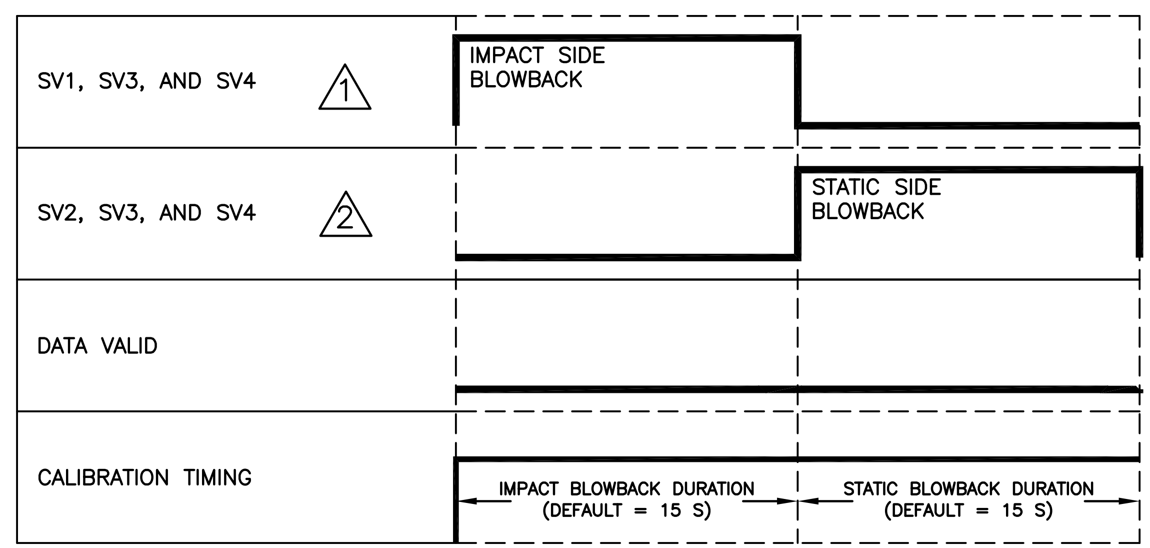
INTERFERENCE CHECK TIMING



CALIBRATION TIMING



BLOWBACK TIMING



1. DURING IMPACT SIDE BLOWBACK PULSE SV1 IN 2 SECOND BURSTS (ON FOR 2 SECONDS OFF FOR 2 SECONDS)

2. DURING STATIC SIDE BLOW BACK PULSE SV2 IN 2 SECOND BURSTS

NEXT ASSEMBLY	USED ON

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE INCHES
TOLERANCE ON DECIMALS .X± .1 .XX± .02 .XXX± .010
TOLERANCE ON ANGLES ± 0°30'

DO NOT SCALE DRAWING

DRAWN BY SEV | DATE 1/24/17

FINISH – BREAK ALL SHARP EDGES 125

THIRD ANGLE PROJECTION

MATERIAL

FINISH

TELEDYNE MONITOR LABS
A Teledyne Technologies Company

TML PITOT TUBE TIMING DIAGRAM

SIZE	CAGE CODE	DWG NO	REV
B		99700003	A

SCALE NTS | SHEET 1 OF 1