Calculation guide

Bi-directional gas flow

AutoSERIES of Thermo Scientific Flow Computers

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Revision History

Revision	**Date**
01	02-01-2023

1. Introduction

The intent of this technical note is to demonstrate to end user, methodology of implementing bi-directional flow through a meter using two distinct methods. Bi-directional is defined by using a single meter run (orifice/USM/turbine/etc), so that measurements/volumes can be calculated both in a forward and reverse manner while maintaining compliance to API 21.1. The two methods elaborated in this document are two of many methods to accomplish bi-directional flow. For example, PLC logic and/or Table 67-Sequencing & Direction can also be used to control directional measurement. For other methods, contact your local regional sales manager or application expert.

2. Typical Application(s): Natural Gas Storage

In natural gas storage, the gas is injected into and stored within a geological formation. The natural gas stored must be measured going into the formation and when removed from the formation. To minimize equipment cost, a bi-directional measurement methodology can be implemented. Bi-directional measurement is a function of performing two distinct measurements (forward and reverse) using a single physical primary device such as an ultra-sonic flow meter, while maintaining compliance to API 21.1. This methodology can be applied to multiple runs utilizing AutoCONFIG software.

2.1 Method One

2.1.1 Math Table (Table-68)

One approach to measurement Bi-direction gas (AGA-3) is to utilize the Math calculation. When flowing in reverse the forward run has negative DP and the reverse run has a positive DP. The math table combined with “DP Cutoff” will allow the user to mutually exclude one run from the other when calculating volumes. This method will create independent flow calculation for forward and reverse operations.

In the example below, we will be measuring both the forward and reverse flow with a single differential meter run. First, user needs to configure both flow runs (i.e. DP Flow #1 and DP Flow #2) to be identical regarding their inputs for static data (DP, Static Pressure, Temp, GC Data, orifice, pipe dia., etc). As well as all other shared static parameters.

Run #1

Process variables for static data will be connected directly to the physical data points (process variable and static parameters) for this run.

Run#2

The shared process variables for Run#2 will be Run#1 Static Pressure and Temperature. The exception to Run #2, will be the DP input. The DP process variable will be the output of the Math Table (Table-68) where we will multiply Run #1 DP*-1 (A*B=C).

For Run#2, or the Reverse Flow meter run, the GQ Data Definition Block will typically need to be changed to reference the same GQ Data Block as Run 1.

Note: The GQ Data Blocks for each bi-directional setup will typically be the same.

Math Table (Table-68) Setup

- **Calculation:** Enable (Math#1 (or next available Function))
- **Function 1:** A*B=C
- **Input A:** Copy “Differential Pressure” from Run #1 Instantaneous tab and paste to Input A.
- **Input B:** Type value of “-1” into field.
- **Output:** Copy and Paste onto “Differential Pressure” of Run#2 Instantaneous tab.

Editing of Audits for Method One: This eliminates duplicate audits within your historical archive**.**

Note: It is recommended that shared parameters between Run#1 and Run#2 are connected so that audits can be logged in Run#1 Audit Archive while simultaneously changing in both runs. Utilizing Method One, the user must disable the Audits for Run #2 by completing the below changes.

- Set Audit Register Offset in Run#2 Historical Archive Settings to “0” (default in program is 8001).

2.1.2 Table 38 Default History Settings

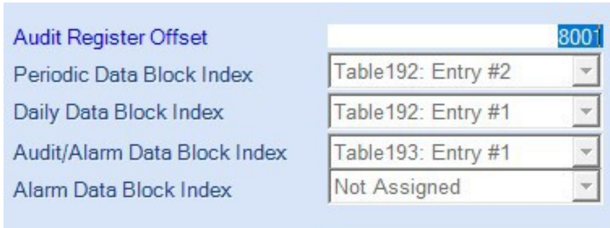

Figure 1. Default Setting

2.1.3 Table 38 Required History Setting for Method One

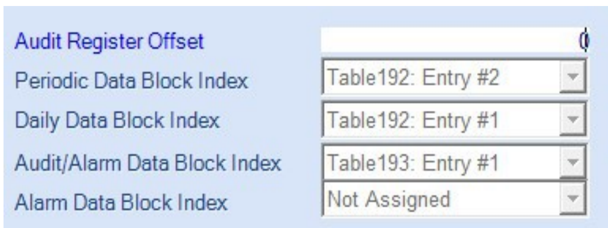

Figure 2. Required Setting for Method One

Once above configuration has been completed and flow has reversed, the DP in Run#1 will read negative. Since the DP will be below the DP cutoff, a no flow state will be active. Run#1 DP will then be multiplied by -1 in the Math Table, producing a positive value in the Output of Function 1. This positive DP will then be displayed and used in Run#2 thereby showing a positive DP and the Flow Status will then switch to “Flowing”.

The images below indicate the positive and negative DP when the reverse Run#2 is flowing. In the forward run is active, you would see positive DP on Run #1 and negative DP on Run #2.

The screen shot below indicates Run#1 negative DP.

Figure 3. Run#1/Forward Negative DP

The screen shot below indicates Run#2 positive DP.

Figure 4. Run#2/Reverse Positive DP

The screen shot below indicates the setup for the Math Table: Math#1 Function 1.

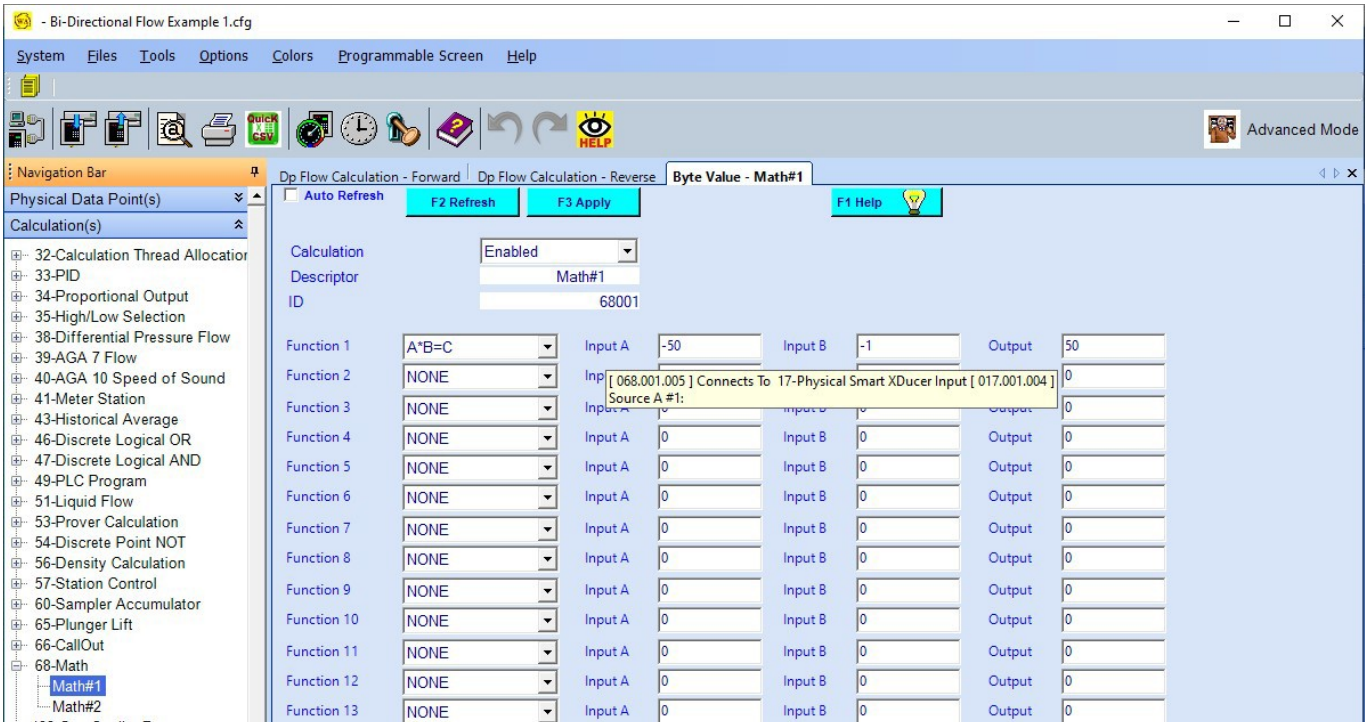

Figure 5. Math#1 Function 1

After completion of the above configuration, Run#1 will be indicative of Forward flow and Run#2 will be Reverse flow.

2.1.4 Calibration Requirement for Method 1

Note: The following assumes a typical orifice meter run.

Users must now calibrate the Differential Pressure, Static Pressure and Temperature. This document will only detail the calibration process for the Differential Pressure, as it differs from the standard method. For details on the standard method of calibration for the Static Pressure and Temperature, refer to the AutoCONFIG Startup Guide, PN 1-0485-068.

We recommend connecting a five-way valve between the pressure transmitter and the orifice meter. The standard five-way valve ports are identified as: High Pressure Block Valve (HPBV), Low Pressure Block Valve (LPBV), High Pressure Equalizing Valve (HPEV), Low Pressure Equalizing Valve (LPEV), and Vent Valve. To calibrate DP, connect a calibrated pressure output device (such as a dead-weight tester or PK-tester) to one of the ¼ inch NPT vents.

1. In AutoCONFIG, click **Tools >Calibrate**. This will activate the calibration wizard.
2. Select the run number and click **Next**.

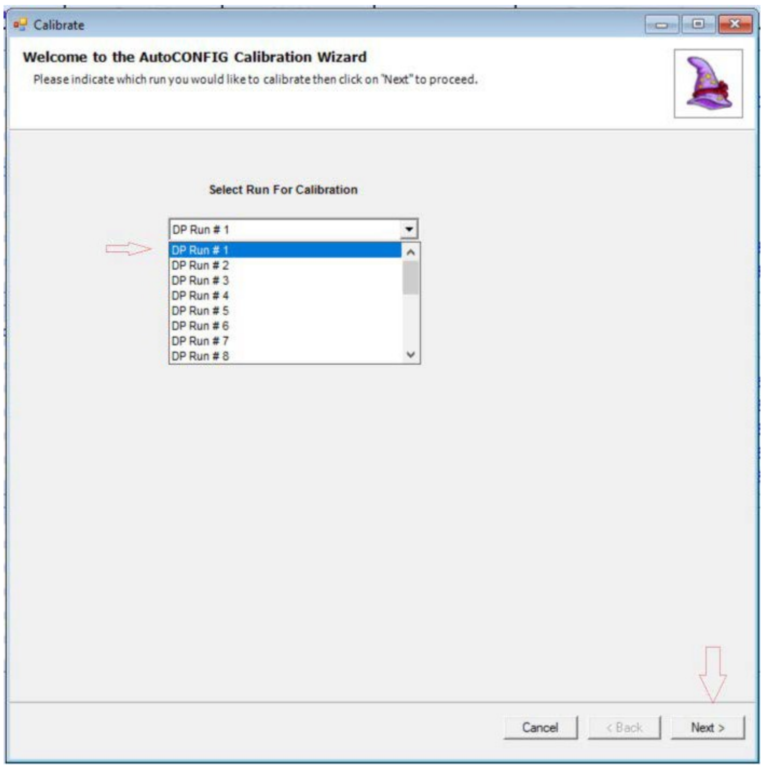

Figure 6. Selecting Run Number

3. Click **Yes** to continue freezing the run and enter calibration mode.

4. Select **Differential Pressure Input** to calibrate and click **Next**.

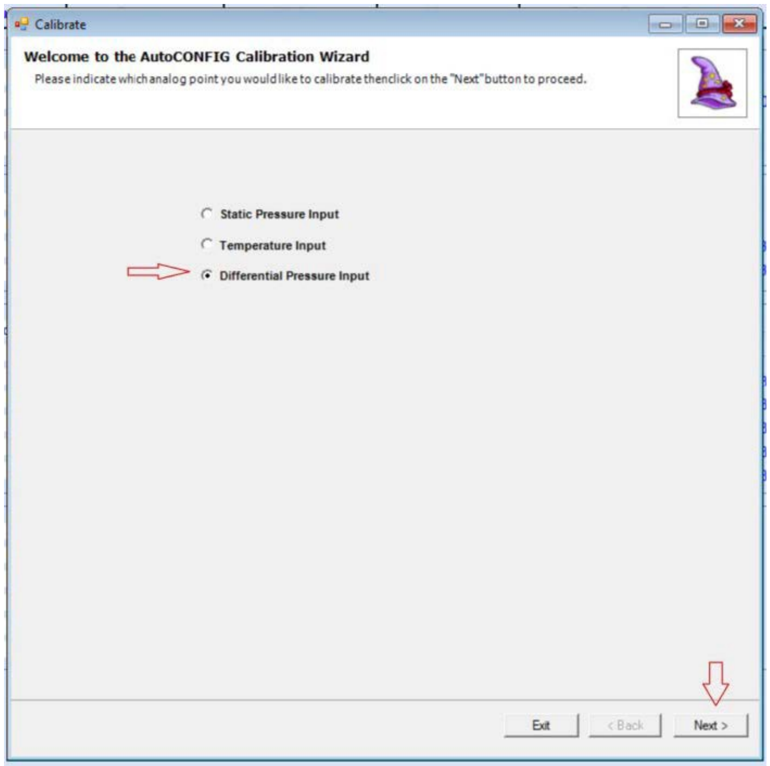

Figure 7. Indicating Analog Point

5. Select **Calibrate Run Input for Selected Run** and click **Next**.

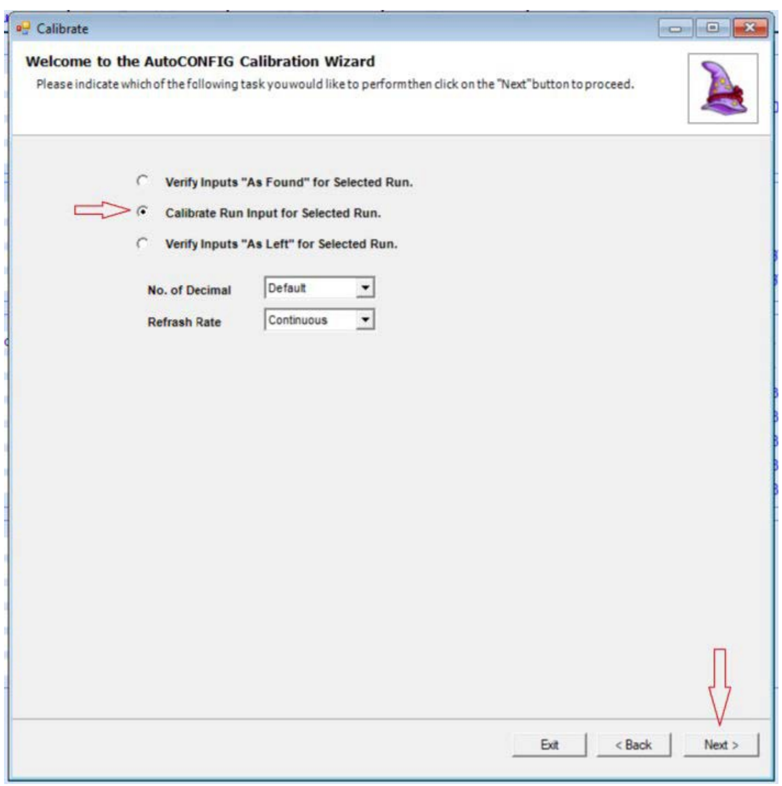

Figure 8. Selecting Calibrate Run Input

6. Select **3-Point Calibration** and click **Next**.

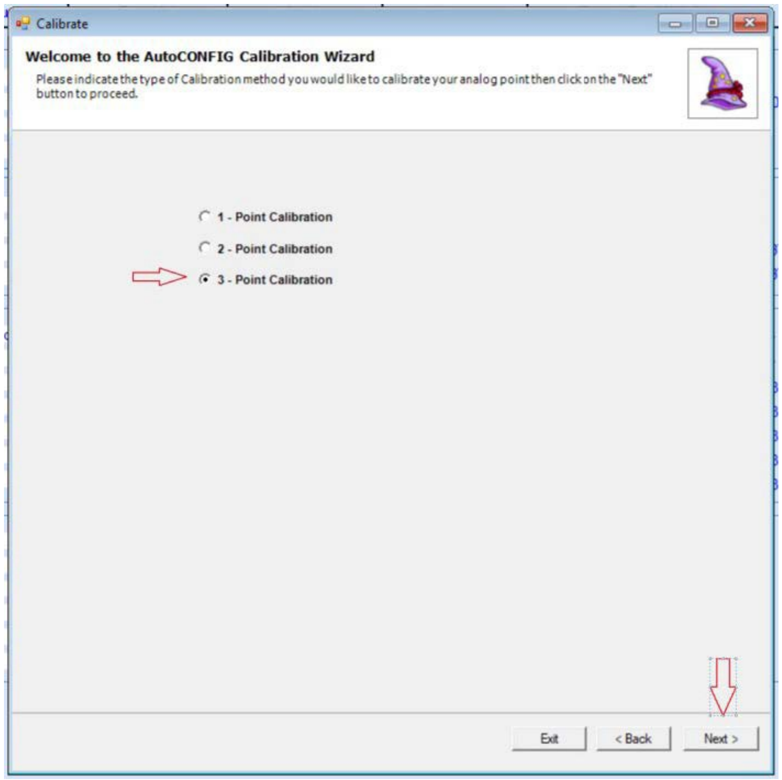

Figure 9. Selecting 3-Point Calibration

7. Connect the calibrated pressure output device to the "Low Pressure" side of the five-way valve via the ¼" NPT vent connection and configure the five-way manifold. Isolate and bleed the manifold. Close the HPBV and LPBV. Close the LPEV and open the HPEV and Vent Valve.

8. The Lo-Diff Pressure will be calibrated to negative 250 inches. Using a dead-weight tester or other calibration device, apply pressure until the Lo Diff Pressure value stabilizes, click on **Click this when steady**, Click **Yes** to use the value and enter the desired input value, (-250) and press Enter.

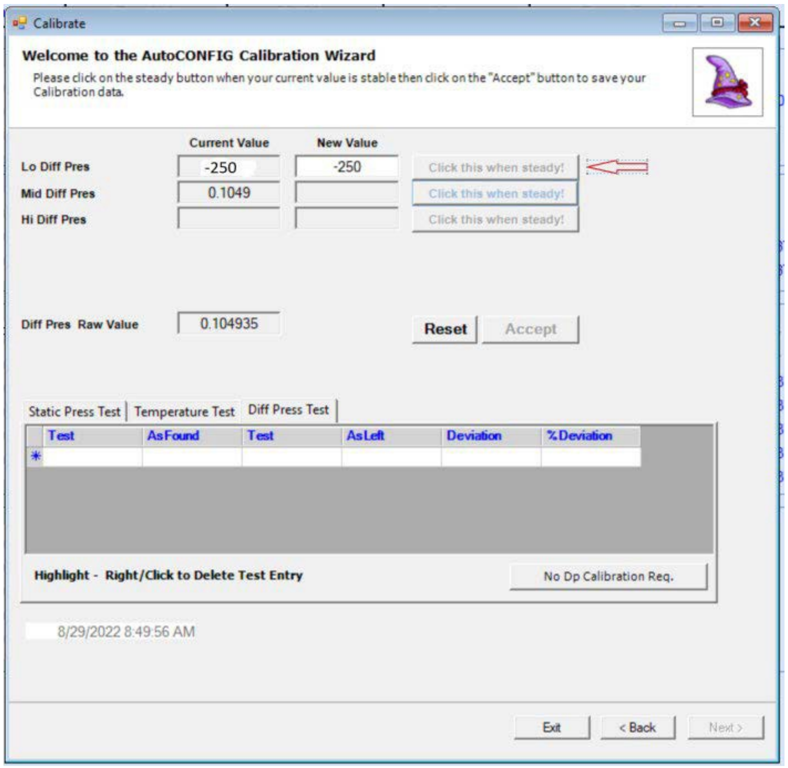

Figure 10. Lo-Diff Pressure Calibration

9. The Mid Diff Pressure will be 0 DP at atmosphere. Open the HPEV, LPEV and Vent to bleed any pressure to atmosphere. When the displayed count of the Mid Diff Pressure value stabilizes, select **Click this when steady**, Click **Yes** to use the value and enter the desired input value, (0) and press Enter.

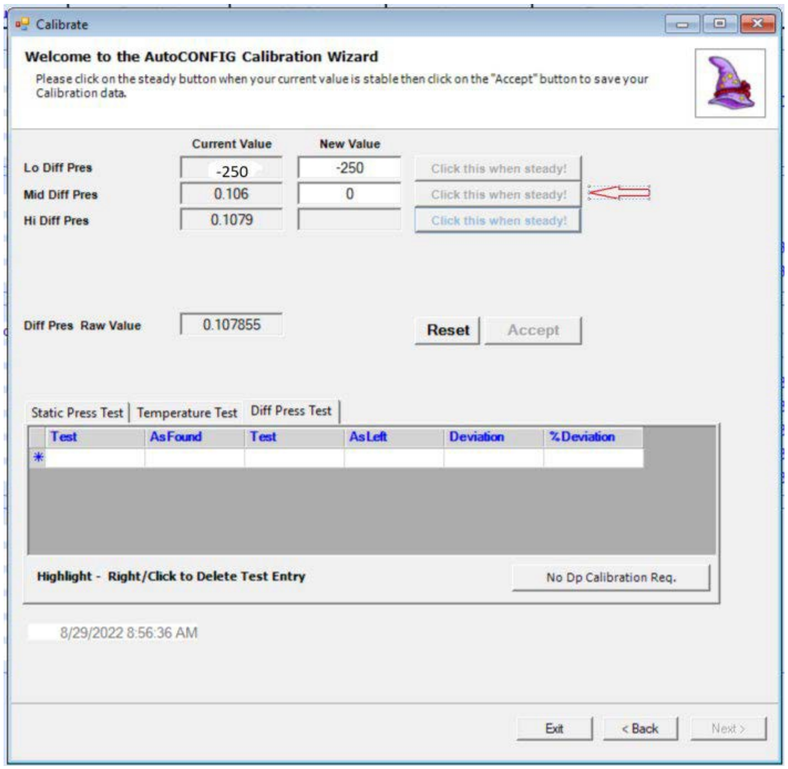

Figure 11. Mid Diff Pressure Calibration

10. The Hi Diff Pressure will be positive 250 inches DP. Connect the calibrated pressure output device to the “High” side of the five-way valve assembly via the ¼" NPT vent port and configure the five-way manifold. Close the HPEV, open the LPEV, and Vent Valve. Using a dead-weight tester or other calibration device, apply pressure until the Hi Diff Pressure value stabilizes, select **Click this when steady**, Click **Yes** to use the value, enter the desired input value, (250) and press Enter.
11. Click **Accept**.

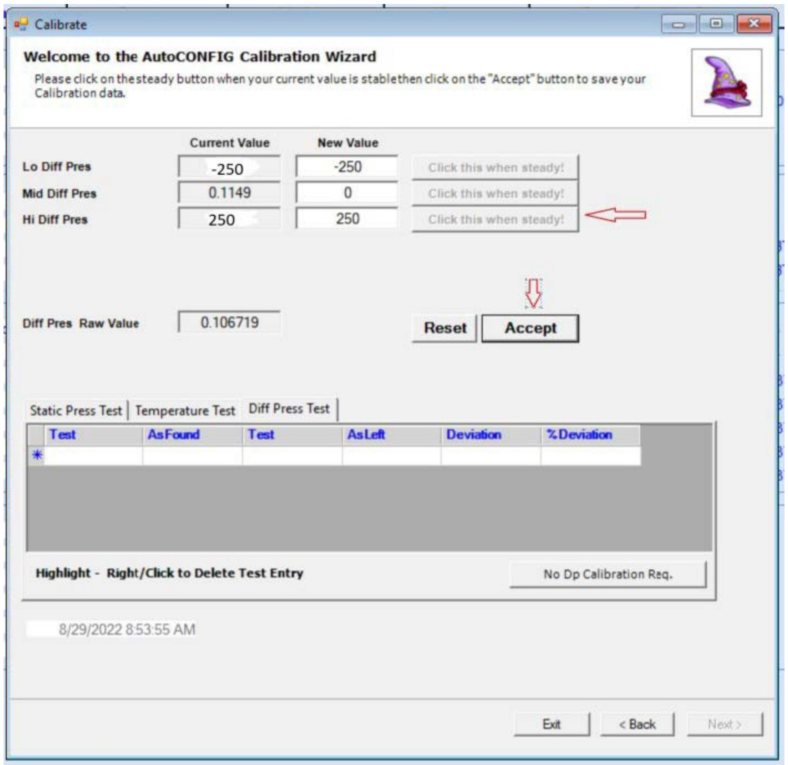

Figure 12. Hi Diff Pressure Calibration

12. Click **Download Diff Press Entries** to save.

Note: Before this step, you can verify the inputs for "As Left" data. Once completed, click the **Download Diff Press Entries** button.

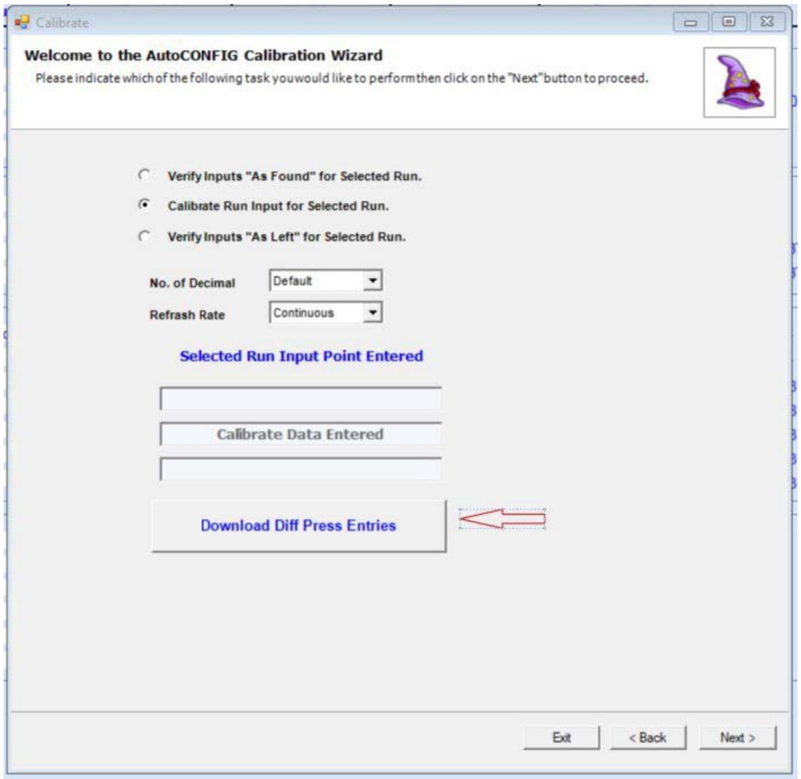

Figure 13. Click Download Diff Press Entries

13. At this point you can reconfigure the manifold to be in service with your process.
14. Click **Exit**.
15. Click **Yes** if you are sure.

16. Decide whether you wish to generate a calibration report or not, in this example we will select **No** to skip the calibration report generation process.

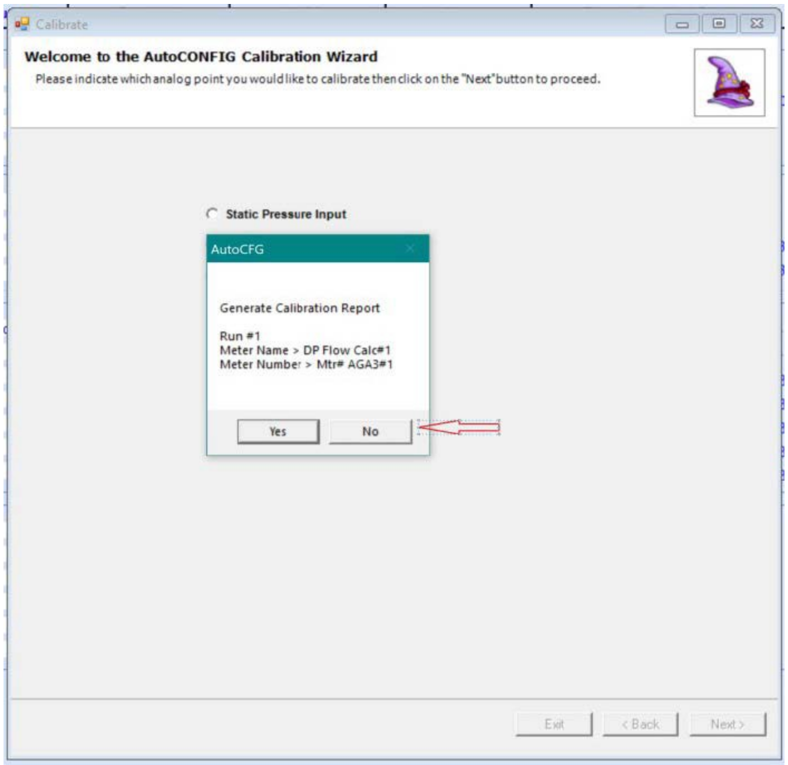

Figure 14. Skipping The Calibration

17. Select **Yes** to continue and exit calibration mode.
18. Yes, again if you are really sure.
19. Once the run is "unfrozen", the DP will be in tolerance no matter if flow is forward or reverse.

2.2 Method Two

2.2.1 Manual Flow Cutoff Using Flow Direction Indicator Input

Application: Typically used with Table 39 (AGA-7: Linear devices).

Note: Can be used with Table 38-Differential Pressure Flow.

Requirements: Directional flow via Discrete Inputs.

The intent of this example is to demonstrate how the directional input discrete input will be utilized to switch between forward and reverse flow runs. This will use the "Manual Flow Cutoff" field.

Note: Actual physical Discrete input may vary for your application. This example assumes the use of DI1 and DI2.

Physical Wiring of Instrument Directional Output (AutoPILOT PRO represented in this example).

- Forward Direction
  - Wire (+) to DI1 (APPRO TB6)
- Reverse Direction (Inverted input/Inverted flow)
  - Wire (+) to DI2 (APPRO TB6)

Common/Typical Wiring Diagram (Below)

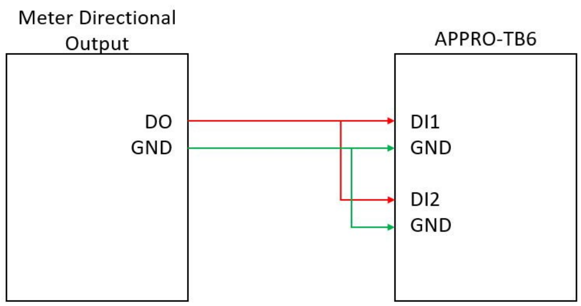

Figure 15. Common/Typical Wiring Diagram

2.2.2 Configuration of Table 39 Run#1 and Run#2

In the example below, we will be measuring both the forward and reverse flow with a single physical meter run. First, user needs to configure two separate AGA7 flow runs (i.e. AGA7 Calc# 1 and AGA7 Calc# 2) to be identical regarding their inputs for static data (Accumulator, Static Pressure, Temp, GC Data, K-Factor, M-Factor, etc).

Run #1 and #2 Configuration

- Copy Table 19 Discrete In#1 field "Current Value" and Paste onto Run#1 "Manual Flow Cutoff" in the Static tab.

Note: Descriptor #1 can be edited to read Forward Flow.

- Copy Table 19 Discrete In#2 field "Current Value" and Paste onto Run#2 "Manual Flow Cutoff" in Static tab.

Note: Descriptor #1 can be edited to read Reverse Flow.

- In Table 19 Entry Discrete In#2 "Invert Input" field and select "Invert Input" from the drop-down menu.

After completion of the above configuration, Run#1 will be indicative of Forward flow and Run#2 will be Reverse flow.

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