Manual Level Mode Correction for Vented Sensors

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Overview

In-Situ® pressure transducers can output level data in three modes based on pressure. These modes include Depth, Level Surface Elevation, and Level Depth to Water. Level Surface Elevation and Level Depth to Water modes calculate level using a reference point that is either set at the time the transducer is programmed or at the time the transducer begins to log data. The reference that is set records a value, called Pressure Head at Reference, and all readings are relative to this pressure.

Frequently, the user programming the transducer inadvertently sets an incorrect reference because the user does not realize the transducer must be placed in its location when the reference is programmed. Typically, a user mistakenly sets a "bad" reference by taking the Pressure Head at Reference in air. Then the transducer takes erroneous data when placed in water. This technical note explains how to set a reference correctly, and shows how to manually correct a data set that was gathered using an incorrect reference.

Level Modes

A pressure transducer measures the amount of pressure applied to the sensor diaphragm, and its output is pressure in PSI. A pressure sensor can be an absolute or a gauged sensor.

Data gathered with an absolute sensor must be post corrected to subtract the barometric pressure. For more information regarding absolute and gauged sensors, review the technical note, *Comparing Absolute and Gauged Pressure Sensors*. Setting a reference incorrectly with an absolute sensor creates an added variable in

the correction of the data file (this technical note does provide a detailed explanation for performing this data correction).

Three modes of level can be derived from pressure and a user input value of specific gravity: Level Depth, Level Surface Elevation, and Level Depth to Water.

Level Depth

Depth is the amount of water over the pressure sensor. It can be calculated in meters using the following equation:

$$D = (0.703073 \times P) / SG$$

D = Depth in meters
P = Pressure in PSI
SG = Specific Gravity

Level Surface Elevation

Level Surface Elevation uses a reference to measure water level with respect to water elevation or to a staff gage in streams or wetlands. It can be calculated in meters using the following equation:

$$Ls = Lr + ((0.703073 * (Pm - Pr)) / SG)$$

Ls = Level Surface in meters
Lr = Level Reference Set in meters
Pm = Pressure Measured in PSI
Pr = Pressure Head at Reference in PSI
SG = Specific Gravity

Level Depth to Water (DTW)

DTW is used to monitor water level in wells relative to the top of casing. The reference is determined by using a water level tape. DTW is also known as "positive down" because increasing values indicate water levels are dropping relative from the top of casing. It can be calculated in meters using the following equation:

$$DTW = Lr - ((0.703073 * (Pm - Pr)) / SG)$$

DTW = Level Depth To Water in meters
Lr = Level Reference Set in meters
Pm = Pressure measured in PSI
Pr = Pressure head at reference in PSI
SG = Specific Gravity

All of the above equations can substitute 2.30667 as the constant instead of 0.703073 to calculate the units in feet, and equations using Lr must be in the same units of feet.

Reference

From the above equations, Level Surface and DTW require a reference input. There are two ways to set the reference. One is to set the reference at the deployment location, also called "set new reference." Another is to set the reference when the pressure transducer starts logging, also known as "set first log reading to a value."

Set New Reference

In order to set a "good" reference, the pressure sensor must be deployed in its permanent location where it will not move throughout the duration of data collection. The user can connect to the pressure sensor while the sensor is in the water by using either a laptop or a RuggedReader® handheld PC. Setting a new reference will record the Pressure Head at Reference where all future readings in a data file will be relative to this value. This is the best option when programming a gauged (vented) pressure sensor, because it requires a vented cable.

Set First Log Reading to a Value

This option requires that the pressure sensor be programmed with a scheduled start and that the pressure sensor be deployed in the water before the scheduled start begins. The first reading recorded in the data file will be the Pressure Head at Reference, and all other readings are relative to the first reading. This option is typically used with absolute (non-vented) sensors deployed with a hanger instead of a cable. When an absolute transducer is deployed on suspension cable, the user can not communicate with it.

Correcting a "Bad" Reference

Setting a reference incorrectly using either Set New Reference or Set First Log Reading to a Value is common. The values in the data report will look incorrect to the user.

For example, a user can program a pressure sensor in the office to collect data at a later time. If the user selects Level Surface or DTW mode, the pressure sensor will not be in the water if they select Set New Reference. When this occurs, the Pressure Head at Reference is taken in air and not water, which is not a valid reference. DTW Level mode with a reference in air will generate lower to possible negative values when the pressure transducer is placed in water, because it would be the equivalent of water flowing closer to the top of casing or even out of the casing. DTW Level mode outputs decreasing values when the water level is rising.

Setting an incorrect reference does not ruin the data. However, in order to make the data viable, the user must manually post correct the data through Excel®, and the user must know the correct reference at the time the pressure sensor began to record data. There are two ways to post correct the data.

Method 1:

If the data collected from the pressure transducer recorded pressure, the user can use the pressure values to derive the Level Mode data. The pressure would have to be in PSI units. The user would then use the previous explained equations to derive the Level Mode data. If using Level Surface or DTW mode, the user would use the first recorded pressure value as the Pressure Head at Reference, and the user would have to know the correct Level Reference value. For example, the user would have to know the water level tape reading when the pressure sensor was in the water to enter the Level Reference in DTW mode.

Method 2:

If the data collected from the pressure transducer recorded level and not pressure, the user must perform calculations to correct Level Surface or DTW modes. Some users may use an offset to apply to the data set, but an offset does not show the calculations of how the level output should have been setup. Method 2 will describe how to back calculate Level to Pressure in PSI, and then show how to calculate level using the correct Pressure Head at Reference.

The following equations are used to back calculate to Pressure in PSI if Level Surface and DTW modes are recorded in meters. For feet, substitute the constant as 2.30667, and set Ls, Lr, DTW, and Pr in units of feet.

Level Surface Elevation:
PSI = (SG *((Ls - Lr) + (Pr))) / 0.703073

Where:
Ls = Level Surface in meters
Lr = Level Reference Set in meters
Pr = Pressure Head at Reference in meters
SG = Specific Gravity

Depth to Water:
PSI = (SG * ((Pr) - (DTW - Lr))) / 0.703073

Where:
DTW = Level Depth To Water in meters
Lr = Level Reference Set in meters
Pr = Pressure Head at Reference in meters
SG = Specific Gravity

Once pressure is defined, the same procedure from Method 1 is applied to calculate Level Surface or DTW.

Example

The user has the following sample data set from a gauged pressure transducer:

DTW (feet):
11.649
11.702
11.707
11.777
11.918
11.919

SG = 0.999
Pr = 0.0139523 PSI
Lr = 13.38 feet

From this data set, the Pressure Head at Reference was taken in air because the PSI value is about 0. The reference was not taken in water, and the DTW values are not near the manual measurements taken as indicated with the Level Reference set. The pressure sensor had a scheduled start, and it started when deployed in water near the time the manual DTW value was taken. Since PSI was not logged, the correction will use Method 2.

The first step is to back calculate DTW to PSI, and the following shows how this is done for the first DTW value: 11.649 feet.

1. Convert Pr from PSI to feet:
Feet of water = (PSI * 2.30667) / SG
(0.0139523 * 2.30667) / 0.999 = 0.0322155 feet

2. Use Method 2 DTW equation:
(0.999 * ((0.0322155) – (11.649-13.38))) / 2.30667 = 0.764 PSI

3. Apply the above equation substituting the rest of the DTW values with the value in red.
PSI:
0.764
0.741
0.739
0.708
0.647
0.647

4. With corrected PSI, the first logged value will now be used as the correct Pressure Head at Reference and the same Level Reference entered will be used since it was taken near the time the scheduled log started. Now, the DTW Level Formula can be used:

DTW = Lr – ((2.30667 * (Pm – Pr)) / SG)
13.38 – ((2.30667 * (0.764 – 0.764))/ 0.999 = 13.38 ft DTW

5. This equation will be repeated for the second value because the first value uses the SAME value for Pressure Measured and Pressure Head at Reference.

13.38 – ((2.30667 * (0.741-0.764)) / 0.999 = 13.433 ft DTW

6. Apply the above equation substituting the rest of the PSI values with the value in red.
DTW Corrected (ft):
13.380
13.433
13.438
13.509
13.650
13.650

Now, the values have been adjusted and are close to manual DTW hand measurements.

Conclusion

Level Surface and DTW modes require the user to set a reference on a pressure transducer. In order to set the reference correctly, the pressure transducer must be at its permanent deployment location to set a correct Pressure Head at Reference. Many times, the reference is taken incorrectly, but the user can recalculate Level Surface or DTW manually by using PSI.

Use Win-Situ® Software to Set the Correct Level Mode

Use Win-Situ software to select the correct Level Mode for the application. Depth mode is shown twice for two different applications, but it does not use a reference. Level Surface mode is represented in three different applications, and each requires a reference. Depth to Water mode is represented once, since it is only used in groundwater applications, and it requires a reference.

By selecting the correct Level Mode and setting a reference correctly, errors and extra post correction can be eliminated. Look for the following software screens when setting up a level reference.

1. Depth (no reference)

a.   Level Depth for groundwater
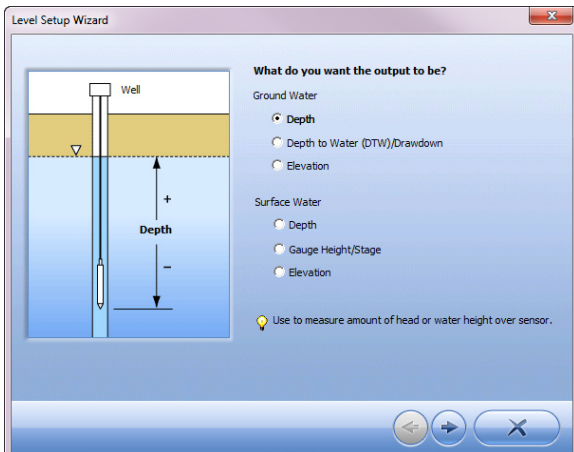
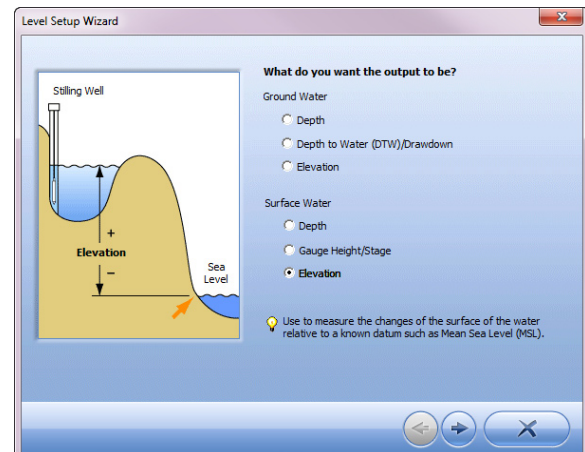b.   Level Depth for surface water
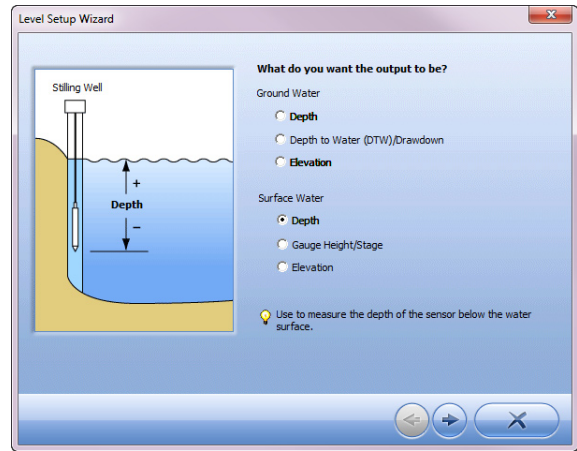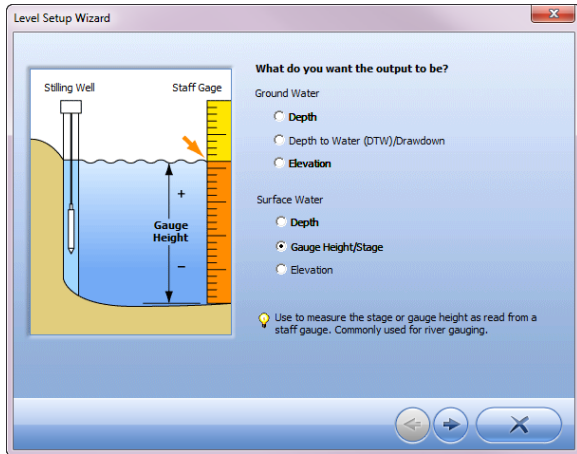

2. Level Surface Elevation (uses a reference)

a.   Level Surface Elevation for groundwater
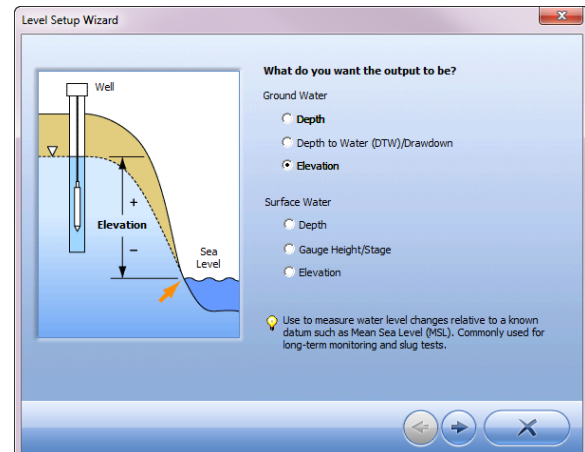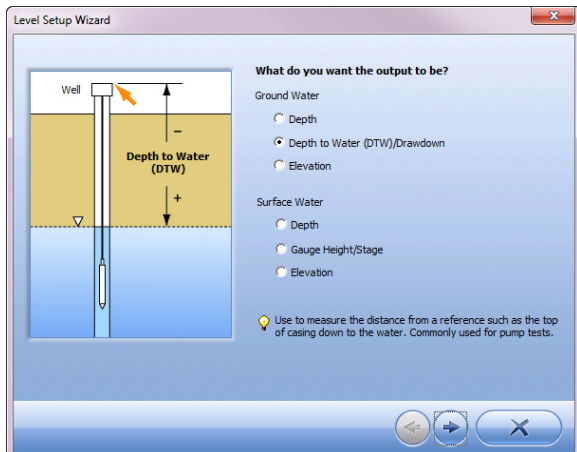

b.   Level Surface Elevation for surface water

c. Level Surface Elevation for gage height/stage

3. Level Surface Elevation DTW (uses a reference)

a. Level Depth to Water for groundwater

4. Set Level Reference Options

- **New Reference**—This value will be programmed in the transducer at the end of the wizard. Put the transducer in the water before completing the wizard.
- **Set first logged reading to**—This value will be programmed to the transducer when you start the log manually, or when the log starts via the scheduled start option. Ensure the transducer is in water before the log starts.
- **Remind me to set reference later**—This option will remind you to set a reference when you start the log. Make sure to place the transducer in water and set a correct level reference before the log starts.

Edit a Level Reference in an Active Log

An active log is a log that has been started or started and then paused. It is possible to edit the level reference in an active log with a transducer connected to a communication cable. However, the level reference is the only change that can be made after a log has been started. Adjusting a reference is not possible on a transducer deployed on a hanger.

1. Click the Sensor tab and highlight the transducer.

2. Click the Calibrate sensor button.

3. Select the Adjust Level Reference option
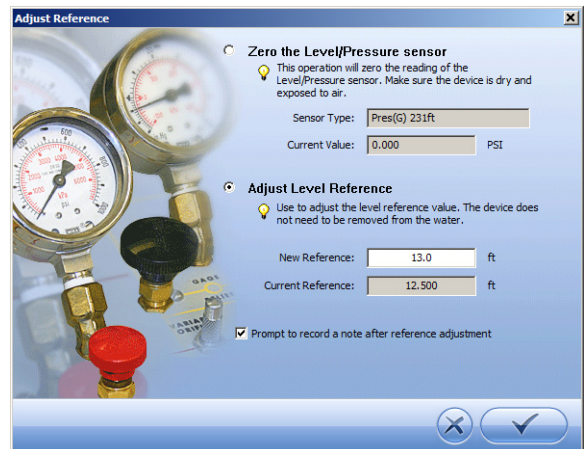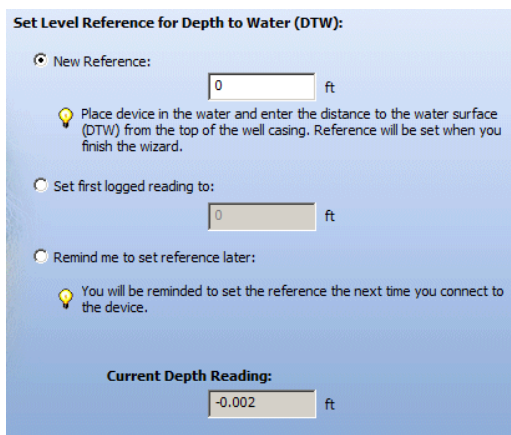
4. With the transducer in place in the water, enter the correct reference value and click the check mark.