9722 EM Flowmeter

Users Guide

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All changes must be approved by:

Phil Baker, Engineering Manager

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1. 9722 EM Flowmeter

A. Introduction

The 9722 EM Flowmeter tool is used in the environmental and hydrology industries to measure the direction and magnitude of vertical fluid movement in a borehole. The tool measures flow rates using the principal of Faraday's Law of Induction. The downhole probe consists of an electromagnet and two electrodes located 180 degrees apart and 90 degrees to the magnetic field inside of a hollow cylinder. The voltage induced by a conductor moving at right angles through the magnetic field is directly proportional to the velocity of the conductor (water) through the field.

The tool can measure low velocity flow rates down to 50 ml/min (0.013 gallons/min.) and increased flow rates up to 35 liters/min (9.2 gallons/min). When using the tool to measure low velocity flow rates, a rubber diverter skirt is attached to the outside of the sensor to block off the bore hole and force the fluid to pass through the 1-inch diameter opening inside the sensor coil. When measuring faster flow rates, the rubber skirt is typically removed, and the tool is run in either the static station or continuous mode.

As there are no moving parts associated with the flowmeter, mechanical problems associated with other types of flowmeters are eliminated. Precise calibration and proper operational procedures are critical to get accurate and quality results associated with very low flow rates. Additionally, the tool measures temperature and fluid conductivity then computes delta temperature and estimated TDS in continuous logging mode.

B. Tool Specifications

Please refer to our website at http://www.century-geo.com/ for the most up to date specifications and accessory items for the 9722 EM Flowmeter.

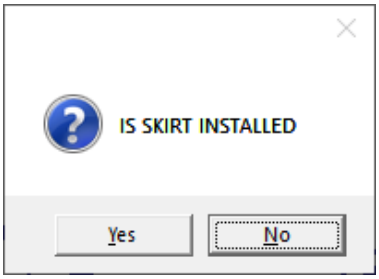
C. Tool Configuration

The 9722 tool has four main configurations. These are **Skirted High Gain, Skirted Low Gain**, **Non-Skirted High Gain** and **Non-Skirted Low Gain**. The Skirted configuration is if you are going to use a diverter skirt for station logs and the Non-Skirted configuration is normally used without a diverter skirt and generally in a continuous logging mode (trolling).

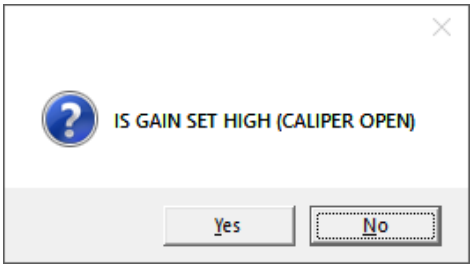
High Gain is more sensitive to low flow rates in the borehole and **Low Gain** is used for expected higher flow rates. If set to High Gain, the maximum flow rate that the tool will read is

approximately 15 liters per minute while Low Gain will allow you to achieve approximately 35 liters per minute.

1. To set the appropriate configuration, connect the tool to the cable head and turn on tool power. Open the LOG program and press on **Configure Tool** on the **Control Menu**.
2. The program will ask you **IS SKIRT INSTALLED.** Answer this based on your configuration.



3. The program will then ask you **IS GAIN SET HIGH (CALIPER OPEN).** You should answer this based on whether you want to run in high or low gain.



4. If you set the Gain to **HIGH**, you must click on **Open** on the **Caliper-Device** on the **Control Menu.** If you set the gain to **LOW**, you must click on **Close** on the **Caliper-Device** on the **Control Menu** (Even if already shown in Close position, you should press Close anyway).

5. After pressing Open or Close on the Caliper-Device, you will get a message box stating that Caliper is either opening or closing and will take 1 to 4 minutes. Simply press **OK** on this message box.

6. Depending on your configuration choices you will now have one of the following shown next to **TYPE** in the **Collect Window – 9722SH, 9722SL, 9722NH or 9722NL**. The **S and N refer to skirted or non-skirted** and the **H and L refer to either High or Low gain**.

D. General Logging Instructions

There are two main ways to log the 9722. The first is simply "trolling", either up or down the hole. The second is taking stations at different depth intervals with a diverter skirt attached. Both ways generally require the use of a centralizer on the upper end of the tool. Regardless of whether you are trolling or taking stations, you must select the correct direction that you are logging. If you are going down the hole, then you need to check the correct direction in the control panel before you start recording.

Skirted Station Logging

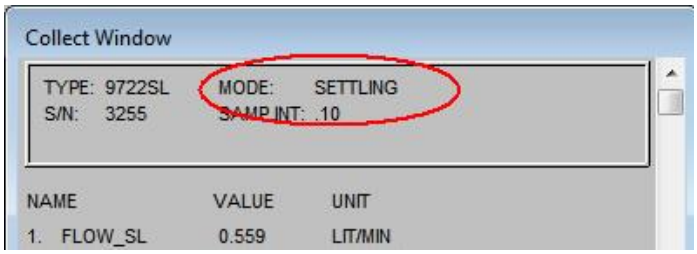
To begin station logging you will need to decide whether you will log down from the surface or go to the bottom and log upwards. The following steps explain collecting flow station readings.

1. Attach the diverter skirt to block flow from going around the tool and force all flow through the flow sensor.

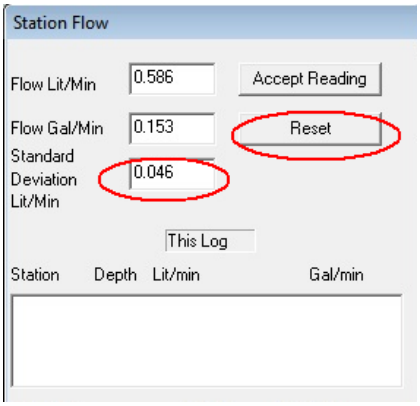
2. Configure the tool to SH or SL mode.

3. Set Header and Depth.

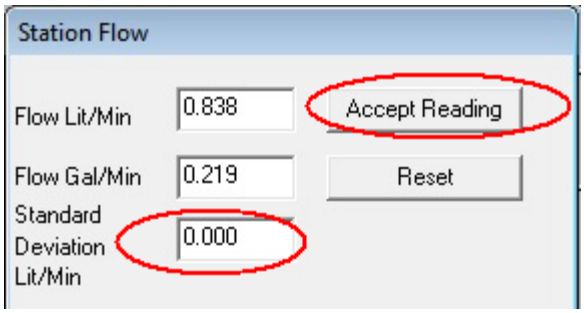
4. If you are going down the hole, then change the direction in the Control Menu to Down. If you are logging up, then you should take the tool to bottom and keep the direction to Up.
5. Start Recording. Begin going down or up the hole depending on your configuration.
6. When you are at the depth to take a station reading, stop movement of Drawworks completely.
7. Wait for the Collect Window to say SETTLING.



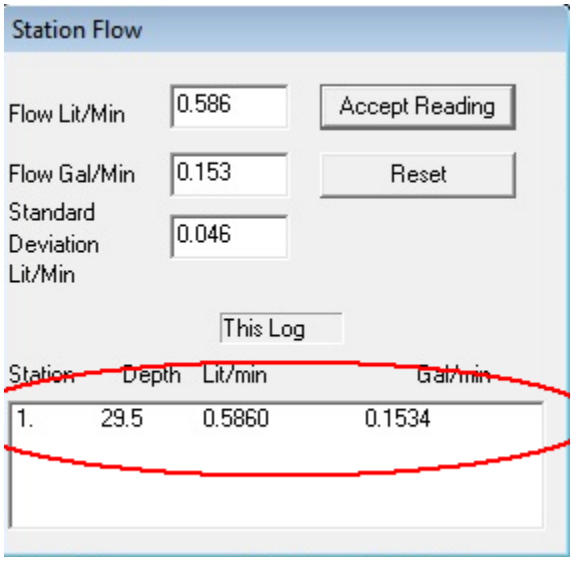
8. Allow the station flow to integrate the readings. This could take 30 seconds or more.
9. If the Standard Deviation in the Station Flow window is high, then click reset and it will begin to integrate again. Sometimes tool movement will produce a high Standard Deviation



10. If the Standard Deviation is low and you are satisfied that the flow readings are stable, then click on Accept Reading.



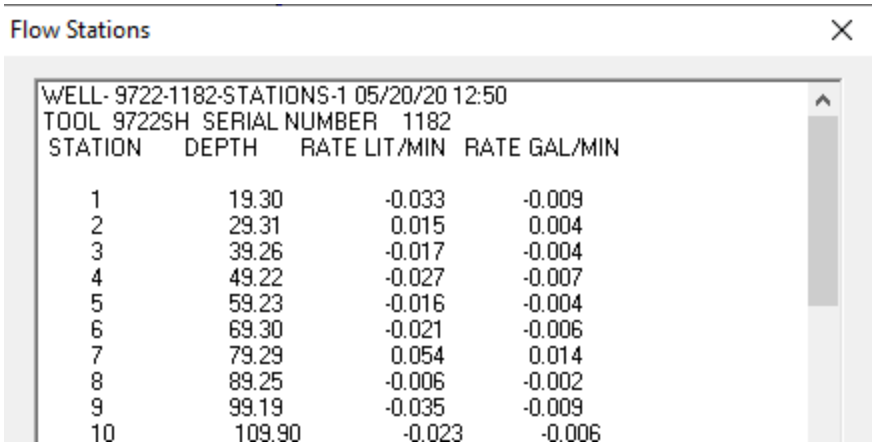
11. The Station Flow window will now show the first flow station.



12. To take more flow stations simply begin the drawworks movement until the next desired depth is reached. Repeat the steps from above to add to produce new flow stations.

13. Once all stations have been taken, simply click Stop Recording in the Control Menu.

From the Display program you will be able to view and print flow stations and plot a SFLOW curve that simply takes each station and connects the data points to resemble a standard continuous log. Please review Display Help for more information.



Non-Skirted Continuous Logging

1. Remove diverter skirt from tool.
2. Configure the tool to NH or NL mode.
3. Set Header and Depth.
4. If you are going down the hole, then change the direction in the Control Menu to Down. If you are logging up, then you should take the tool to bottom and keep the direction to Up.
5. Start Recording. Begin going down or up the hole depending on your configuration.
6. Logging speed can be 10- 30 feet per minute.
7. Depending on whether you are going down or up the hole, you should stop recording upon reaching the bottom or top of the hole.
8. Stop Recording**.**

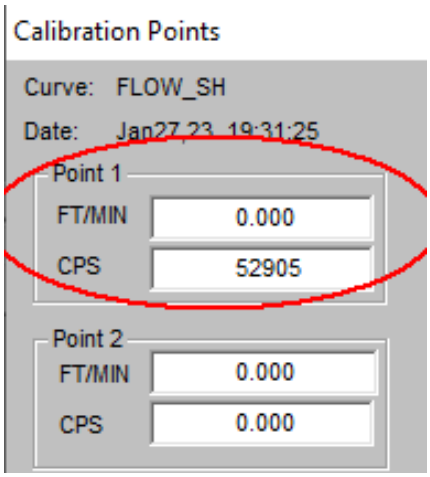
E. Skirted Calibration Procedures

The 9722 tool SH and SL modes are calibrated at the Century facility in Tulsa before shipping. However, included are instructions to verify proper calibration and re-calibrate if necessary.

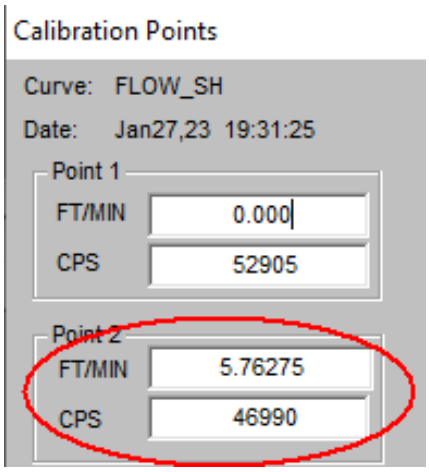
The EM flowmeter must be calibrated with a known flow source. A simple calibration device consists of water filled PVC pipe of 6 inches in diameter and approximately 4 feet in length. A water valve below the flow sensor is needed to generate the water flow. The borehole diverter skirt must be located at approximately the middle of the sensor. This is very important both in calibration and in logging the tool to ensure that the water is passing through the flowmeter sensor, and not going around the tool. A water supply such as a hose is used to fill the PVC pipe and keep the water level constant.

Skirted High Gain Calibration

1. Close the valve at bottom of PVC pipe.
2. Turn on water supply and fill stand until it begins to overflow from the top. Keep a slow overflow going throughout the calibration.
3. Attach the diverter skirt to the tool in the middle of the flow sensor.
4. Attach the test cable to tool and place tool in calibration stand.
5. You may need to use vice grips or a clamping device to help keep the tool centered and off the bottom of the PVC pipe about 6 inches (see picture above).
6. Turn on System VI tool power and let tool warm up for 20 minutes.
7. Open LOG program and configure tool answering Yes to IS SKIRT INSTALLED and Yes to IS GAIN SET HIGH (CALIPER OPEN).
8. Click on Open under the Caliper-Device section of the control menu.
9. Enter zero in the FT/MIN section in point one of the FLOW_SH calibration.
10. Enter the integrated FLOW_SH cps number in the CPS section in point one of the FLOW_SH calibration (see below)



11. Open the downspout valve.
12. Collect a one-minute sample of water from the downspout using a graduated cylinder. This collection should be measured in **Liters Per Minute**.
13. Take the **liters per minute** value and multiply by **6.4748** to get **feet per minute**. If you are using metric units then you need to multiply the **liters per minute** value by **1.973525** to get **meters per minute.**
14. Enter the number from step 13 in the **FT/MIN** section in point two of the FLOW_SH calibration. In this example, we collected **890 ml** in one minute. **0.890 * 6.4748 = 5.762572 feet per minute.**



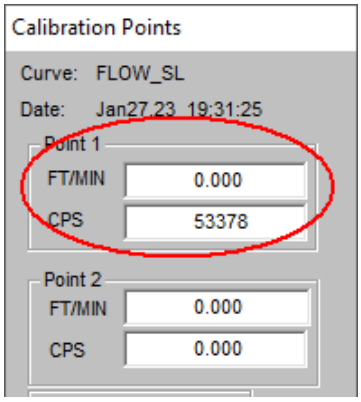
15. Enter the integrated FLOW_SH cps number in the CPS section in point two of the FLOW_SH calibration.

Skirted Low Gain Calibration

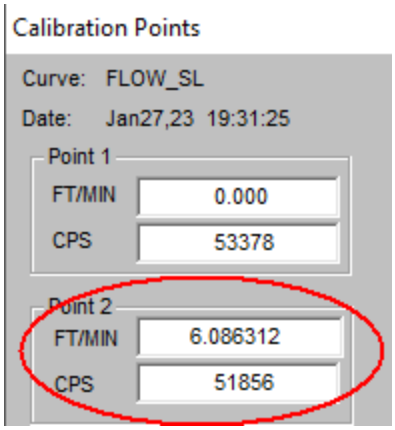
1. Close the valve at bottom of PVC pipe.
2. Turn on water supply and fill stand until it begins to overflow from the top. Keep a slow overflow going throughout the calibration.
3. Attach the diverter skirt to the tool in the middle of the flow sensor.
4. Attach the test cable to tool and place tool in calibration stand.
5. You may need to use vice grips or a clamping device to help keep the tool centered and off the bottom of the PVC pipe about 6 inches (see picture above).
6. Turn on System VI tool power and let tool warm up for 20 minutes.
7. Open LOG program and configure tool answering Yes to IS SKIRT INSTALLED and

NO to IS GAIN SET HIGH (CALIPER OPEN).

8. Click on **Close** under the Caliper-Device section of the control menu. (Even if already shown in Close position, you should press Close anyway).
9. Enter zero in the FT/MIN section in point one of the FLOW_SL calibration.
10. Enter the integrated FLOW_SL cps number in the CPS section in point one of the FLOW_SL calibration (see below).



11. Open the downspout valve.
12. Collect a one-minute sample of water from the downspout using a graduated cylinder. This collection should be measured in **Liters Per Minute**.
13. Take the **liters per minute** value and multiply by **6.4748** to get **feet per minute**. If you are using metric units then you need to multiply the **liters per minute** value by **1.973525** to get **meters per minute.**
14. Enter the number from step 13 in the **FT/MIN** section in point two of the FLOW_SL calibration. In this example, we collected **940 ml** in one minute. **0.940 * 6.4748 = 6.086312 feet per minute**



15. Enter the integrated FLOW_SL cps number in the CPS section in point two of the FLOW_SL calibration.

NOTE - These flow calibrations are for very low flowing situations however, the flow calibrations are linear and should read accurately on a linear trend. Some customers have also made higher flowing calibration stands because they expect high flows. The procedure for calibrating is the same whether low or high flowing rates.

F. Non-Skirted Calibration

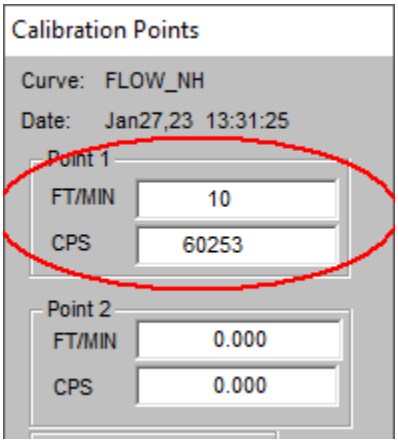
One way that the 9722 can be ran is to log the tool continuously either up or down the hole. No skirt is placed on the tool and no flow stations are recorded. It is much like logging any normal logging tool.

Downhole calibration is recommended mainly due to differences in the size of holes from one well to another. This is done by logging the tool through an unscreened cased portion of the well or in a well where there is no known flow.

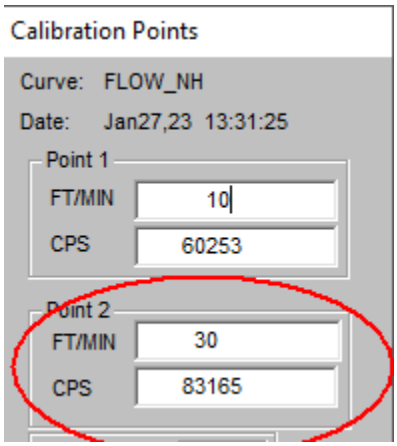
It is recommended that the calibration is made logging **down** the hole.

Non-Skirted High Gain Calibration

1. Power up tool and configure for **NH** mode.
2. Place tool in borehole and lower to water level.
3. Begin logging downward at 10 feet per minute.
4. Enter 10 in the FT/MIN section in point one of the FLOW_NH calibration.
5. Enter the FLOW_NH cps number in the CPS section in point one of the FLOW_NH calibration.



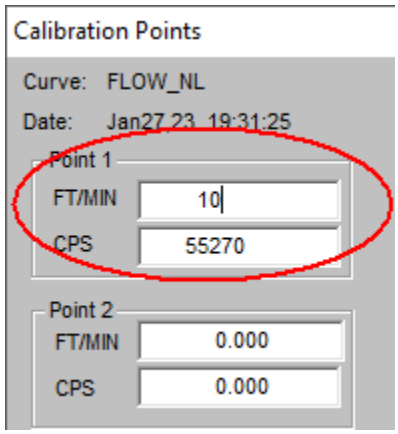
6. Increase winch speed to 30 feet per minute.
7. Enter 30 in the FT/MIN section in point two of the FLOW_NH calibration.
8. Enter the FLOW_NH cps number in the CPS section in point two of the FLOW_NH calibration.



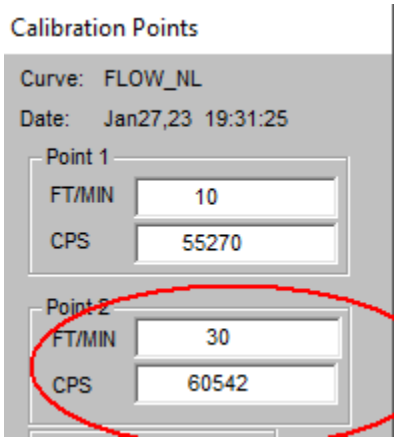
9. Save Calibration.

Non-Skirted Low Gain Calibration

10. Power up tool and configure for **NL** mode.
11. Place tool in borehole and lower to water level.
12. Begin logging downward at 10 feet per minute.
13. Enter 10 in the FT/MIN section in point one of the FLOW_NL calibration.
14. Enter the FLOW_NL cps number in the CPS section in point one of the FLOW_NL calibration.



15. Increase winch speed to 30 feet per minute.
16. Enter 30 in the FT/MIN section in point two of the FLOW_NL calibration.
17. Enter the FLOW_NL cps number in the CPS section in point two of the FLOW_NL calibration.



18. Save Calibration.

G. Temperature and Fluid Conductivity

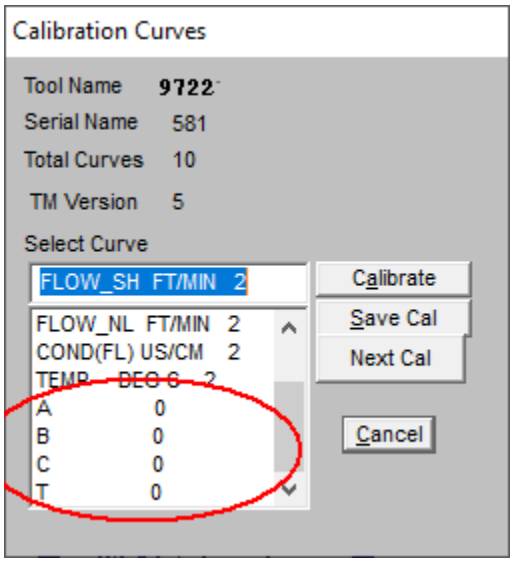
The 9722 flowmeter also measures water temperature, fluid resistivity, fluid conductivity and estimates total dissolved solids -

1. TEMP – reads the water temperature with a range of 0 C to 70 C (32 to 140 F).
2. RES(FL) – Is the fluid resistivity of the borehole fluid in ohm-m.
3. COND(FL) – The raw fluid conductivity in expressed in µS/cm. It is derived from the fluid resistivity calibration. It is not compensated or corrected for temperature.
4. SP COND – Specific Conductance is temperature compensated to adjust the fluid conductivity as if it were in 25 deg C fluid. Although this curve is derived from the Temp curve and the COND(FL) curve, it has a user adjustable temperature coefficient, and the reference temperature can be changed to some other value than 25 deg C if desired.
5. TDS – Much like a handheld conductivity meter, the total dissolved solids curve is an estimation based on Specific Conductance and a user enterable multiplier.

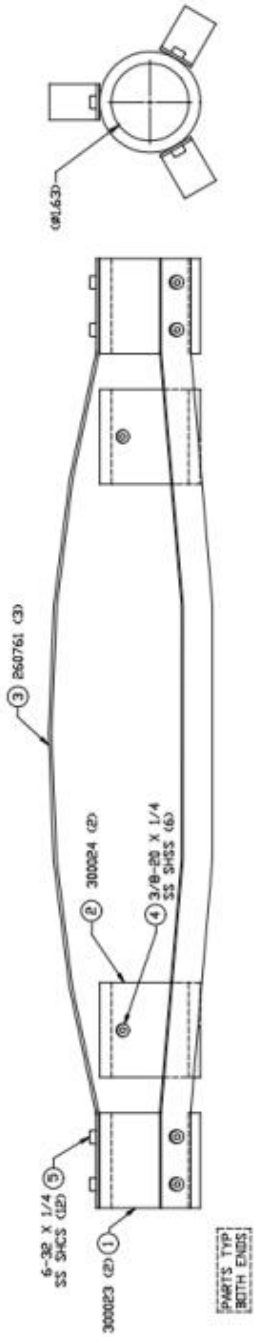
Advanced Calibration Instructions

In the calibration menu, you will notice five single letters – A, B, C, T, and F. The A and B are thermal coefficients for flow and should only be changed under the supervision of Century. The others are explained below –

1. The C constant is the coefficient number for the Specific Conductance curve. A coefficient of 0.0191-0.02 is commonly used based on KCl standards. NaCl-based solutions should have a temperature coefficient of 0.02-0.0214. The most commonly used is simply 0.02.
2. The T constant is the reference temperature for the Specific Conductance curve. In almost all cases this should be set to 25. The units are in Deg C.
3. The F constant is the factor used to multiply by the Specific Conductance to estimate Total Dissolved Solids. In most cases this number will be from 0.55 – 0.7. We recommend 0.62 and then adjust for the type of water you are in.



H. 9722 Upper Centralizer



I. 9722 Diverter Skirt

Modified diverter skirt allowing tool to go downhole easier and gives a better seal