E-M Flowmeter **User Guide**

BACKGROUND INFORMATION

The 9721 EM flowmeter is a full range instrument capable of measuring low flow rates of 50 milliliters per minute (0.01 gallons/min.) up to+/-40 liters per minute (10.6 gallons/min). It uses an electro -magnetic measuring electrode circuitry. The flowmeter uses Faraday's Law of Induction, which states that the voltage produced by a conductor moving at right angles through a magnetic field is directly proportional to the velocity. The flowing water then becomes the conductor, the electromagnet generates the magnetic field and the electrodes transmit the voltage proportional to the velocity of the water moving through the center of the flowmeter. 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, delta temperature, and fluid resistivity in continuous logging mode.

TOOL STABILIZATION AND SENSOR OPERATION

To avoid damage to the EM sensor from overheating do not turn on tool power unless the flow sensor is in water.

Prior to calibration and logging, allow the tool to stabilize in a water filled hole or calibration device for at least 15 to 20 minutes.

Primary Calibration of The Tool

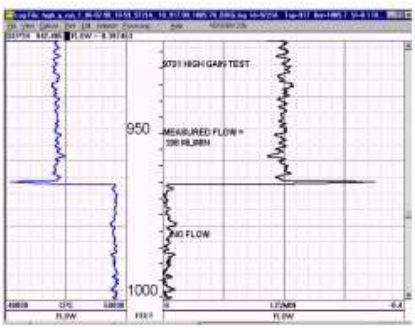
The EM flowmeter must be calibrated prior to use, with a known flow source. A simple calibration device consists of water filled PVC pipe of 6 inches in diameter and approximately 3 feet in length. A gate valve or small holes below the flow sensor is needed to generate the water flow. The borehole diverter must be located at approximately the middle of the sensor. This is very important both in calibration and in logging the tool to insure that the water is passing through the flowmeter sensor, and not going around the tool.

Two calibration points of the tool are measured using a graduated cylinder to plus or minus 5 ml / minute. These two reference points then become the standard response values. Usually in low flow situations, the calibration will be ZERO flow and 500 to 1000 ml / min flow ranges (conversion factor from Liters to Feet per Minute is 6.474). In holes with greater amounts of flow, calibration should be close to the amount of expected flows (if the borehole flows at 1 to 5 liters per minute, you should calibrate at approximately these flow rates).

To calibrate the tool, the PVC pipe must be filled with water, prior to placement of the tool inside. During calibration, the water level in the PVC calibration pipe must remain constant. Record the CPS values for the two desired calibration points, an example calibration would be as follows:

High Gain Standard	0 Ft/Min -6.21 Ft/Min
Response Limits	54,800 CPS 49,400 CPS
Low Gain Standard	0 Ft/Min -6.21 Ft/Min
Response Limits	54,720 CPS 53,400 CPS

Example Calibrated Flow Test



Calibration Ranges

Calibration Range	Standard	Response Limits
Temperature	50 Deg. F 80 Deg. F	9,500-0,500 CPS 5,000 - 5,400 CPS
Fluid Res.	0 Ohm/m 47.5 Ohm/m	1,000 CPS 48,500 CPS

Both sensors can be calibrated to known temperature and fluid resistivity values of a fluid filled bucket of water. A precise thermometer and fluid conductivity meter are used to measure the two different values of the water. Make sure the bucket is sufficiently large enough to cover the sensor being calibrated.

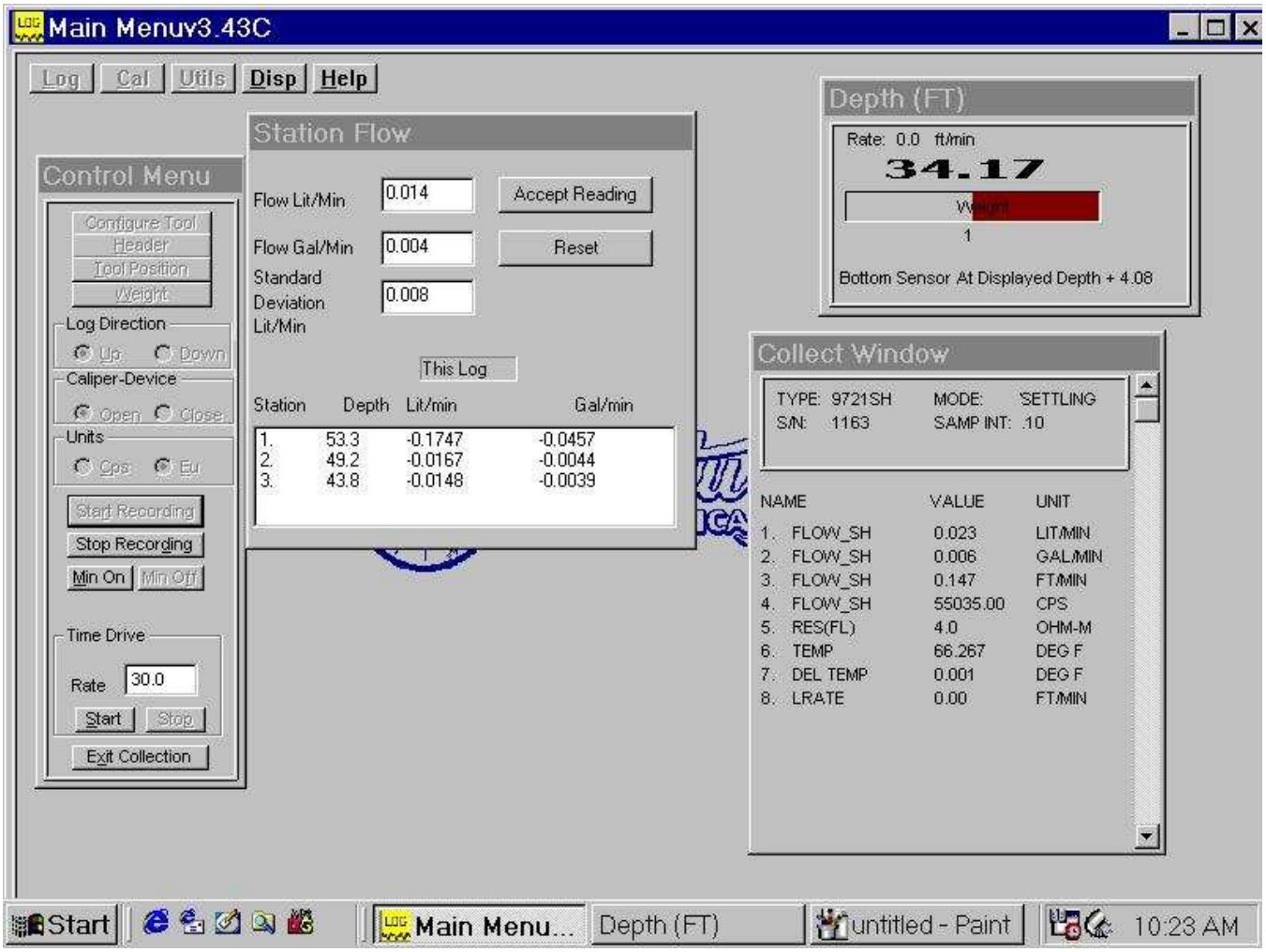
NOTES ON LOGGING THE 9721 TOOL

Two gain settings are available for use. The tool will default to low gain, and this should be used for recording high flow rates. To record low flow rates, the caliper open switch is toggled to change to the high gain setting. This gain setting is preferred in most applications requiring low flow measurements less than 10 liters per minute.

Logging procedures for the tool will vary with hole diameter, wall rugosity, and flow rates expected. Logging can be in boreholes with ambient flows to determine if there is any natural occurring flow due to pressure gradients, or with induced flow tests where water is either pumped from the well or injected into the well at a constant rate to determine the vertical distribution of the inflow or outflow.

Ambient flow tests are usually conducted first, with the flowmeter lowered to the bottom of the well. Acquisition of the data is similar to other logging tools with the Header, and Tool Position set prior to proceeding downhole. Upon reaching total depth of the borehole, select Start Recording and log to surface at a constant logging rate.

Stationary singular "depth stations" can also be recorded where the probe is allowed to "settle" and record the flow data. The sensor must be at the station for a minimum amount of time of at least be 2 minutes. When acquiring station data, you should watch both the "Station Flow" and the "Collect Window". The first readings in the station flow window will have bad values left over from moving the tool, therefore, you must hit the Reset button to start a new integration. After you are satisfied with the station, click on the "Accept Reading" prior to moving the probe to the next depth station. The probe is then raised the desired station length to the next station point.



Induced flow tests are also started at the probe on the well bottom. Water is pumped or injected from near the water surface at a low but constant rate to induce water to enter the well at the screened interval or through the natural fractures. Data is taken similarly as above with predetermined depth station intervals.

When using the flow diverter, it is best to pick a zone with concentric borehole wall so that the diverter works properly to isolate the zone. The borehole diverter must be slightly larger than (about 1/4") than the borehole size to assure proper isolation. This will require some customizing of the flow diverter for each borehole size.

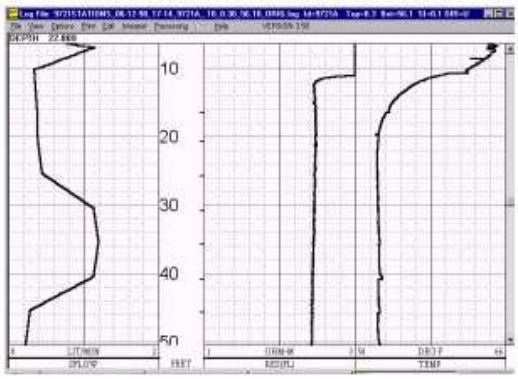
Additional logs such as the borehole televiewer, caliper, and conventional electric logs can help distinguish potential areas of flow.

Because the instrument measures voltage, it can be susceptible to ground currents from nearby underground cables. Depending upon the proximity, this can cause the signal to be noisy, but generally acceptable. Most of our applications have been at sites of contaminated groundwater at industrial facilities. Once we successfully conducted a test in downtown Los Angles, so the urban area does not necessarily cause any problem

DATA PRINTING

Flow station data is viewed and printed from the DISPLAY program. Select the log file similar to any other log file. To view the stations, from the VIEW menu button, select FLOW STATIONS. To print the data to the printer, from the PRINT menu button, select FLOW STATIONS.

Station data can also be viewed and printed in conventional chart form. From the Processing Menu in Display, select Add Flow Curve. This will take the stationary data and connect the data points to resemble a standard continuous log with the new curve called **SFLOW**



TOOL SPECIFICATIONS:

- Length: 56 Inches (142 cm)
- Temperature: 158 F (70 C)
- Diameter: 2.0 Inches (5.1 cm)
- Pressure: Not Yet Determined
- Weight: 13 Pounds (5.9 kg)
- Logging Speed: NA

SENSOR RESPONSE RANGES

Sensor	Sensor Response Limits	Accuracy
Flow	50 ml/min to+/-40 liter/min	+/-20 ml/min
Temp.	32 to 160 Deg.	+/-5%
Fluid R.	0 to 100 Ohm meters	+/-5%

Phone: 918-838-9811
Fax: 918-838-1532

Century
Geophysical Corp.
1223 S. 71st E. Ave
Tulsa Oklahoma, 74112

sales@century-geo.com
www.century-geo.com