# Sonar Flow Meter versus Magnetic Flow Meter
# Application: Large Diameter Hydrocyclone Feed in a Minerals Processing Concentrator Plant

## A Cost and Performance Comparison When Measuring Volumetric Flow

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**Introduction**

Minerals processing plants typically use grinding mills in closed circuit with hydrocyclone batteries to produce slurry with a very specific particle size distribution. This size distribution is critical to the performance of the recovery stage of flotation. Therefore it is important to operate the hydrocyclone battery within its design set points. Tangential velocity and slurry feed density are critical to the operation of the hydrocyclone battery. Tangential velocity is inferred from either battery pressure or volumetric flow in the feed line while density is measured directly using a density meter. That is why most closed circuit grinding operations employ a volumetric flow meter and a density meter on the hydrocyclone feed line.

Measuring volumetric flow rate on a hydrocyclone feed line in a copper concentrator is a challenging endeavor. Doing so with highly abrasive ore which contains magnetite poses additional challenges. These challenges are in the areas of both performance and maintenance. The flow measurement device must make an accurate measurement with large changes in slurry density and magnetite content as well as entrained air content. Magnetic flow meters are not well equipped to deal with magnetite concentration changes or entrained air. It should be noted that the density measurement device is also subject to errors caused by the entrained air in the slurry which is usually caused by low sump levels. In this application instrumentation engineers, process engineers, and maintenance personnel are tasked with providing an accurate and repeatable measurement of flow rate with the least possible maintenance and process downtime. Typically a magnetic flow meter will last any where from six months to 5 years depending on the ore body and the slurry velocity. Therefore the maintenance of these devices is very costly when all factors are considered. These factors include the initial capital cost, installation cost, safety, meter performance, maintenance, spare requirements, equipment lead time, and process down time. The actual lifecycle cost of a magnetic flow measurement point in a concentrator is significantly greater than just the initial capital cost.

A sonar meter provides a more accurate, reliable, and repeatable measurement of volumetric flow with zero maintenance requirements. Sonar meters are the most cost effective volumetric flow solution for this application. In addition, novel performance gains can be achieved in recovery based on a more uniform particle size distribution feed to flotation. This is accomplished by correcting the slurry density measurement for the varying amounts of entrained air in the hydrocyclone feed line. CiDRA has many years of experience supplying value to the mining industry in these types of challenging concentrator applications. Sonar meters are deployed in 40 mining locations in eight countries.

**Magnetic Flow Meter and Sonar Flow Meter Technology Comparison**

The following is a comparison of the advantages and disadvantages of the magnetic flow meter technology and the sonar meter technology as applied to a large diameter hydrocyclone feed line application.

| Feature | Magnetic Flow Meter | Sonar Flow Meter |
|---|---|---|
| Installation | - In-line mag tube requires pipe flanging and gaskets<br>- Mag tube is heavy and requires heavy lifting equipment<br>- Installation time is typically 8 hours for a multi-person crew<br>- The process must be shut down to install | - Mounts on the outside of the process pipe (requires 1 meter of straight pipe)<br>- Installation time is typically 2 hours and may be done by one person<br>- The process may be running during the installation |
| Sensor Configuration | - The electrodes are in contact with the slurry which leads to reliability issues and leakage | - The sensor band mounts on the outside of the pipe and are not affected by the slurry properties |
| Elbow Sensitivity | - Requires 5 to 10 diameters of upstream straight section to meet stated accuracy | - Can be mounted at the exit of an elbow and still meet the stated accuracy<br>- 5 to 10 diameters is preferred if this can be accommodated |
| Safety | - Being an in-line device leakage is always a concern. The pipe integrity is compromised.<br>- During installation heavy lifting equipment is needed to lift and position the mag tube. This poses a safety risk each time this is done | - There are no safety concerns<br>- The pipe integrity is not compromised and each system component is easily lifted by a single person |
| Maintenance | - Electrodes and liners will become damaged due to the abrasive nature of the slurry<br>- Mag tubes and or liners will have to be replaced on a regular basis. The period will vary any where from every 6 months to every 3 years. | - Maintenance free |
| Accuracy | - Each mag flow tube is calibrated from the factory with a “meter factor”. This calibration is conducted using water. The mag tube will have inaccuracies associated with the slurry properties.<br>- Most mag tubes are not corrected for the effects of magnetite. Even the magnetite corrected mag tubes are only corrected for one magnetite density level. The density of the magnetite will change over time and thus the mag tube will be out of calibration.<br>- The mag tube is making an absolute measurement of voltage. Over time and temperature this measurement can drift and thus cause inaccuracies | - Calibration is done on a model number basis, not on a serial number basis. There is nothing to adjust from meter to meter.<br>- The calibration is also done using water, but the slurry properties do not affect the calibration. Therefore the slurry properties can change over time but the meter calibration will not. This includes the magnetite.<br>- Time and distance are the only two absolute measurements being made. Time is the clock in the transmitter and distance is the fixed sensor spacing controlled in manufacturing. All other measurements are relative and therefore there are no inherent drift mechanisms. |

| Feature | Magnetic Flow Meter | Sonar Flow Meter |
|---|---|---|
| Repeatability | - Years of experience has proven that mag tubes are sensitive to slurry properties. In this application the slurry properties are continually changing. This manifests itself in a flow reading repeatability issue. Mag tubes are known to present flow readings that do not track the pump load current on a repeatable basis. | - There is no sensitivity to slurry properties therefore the repeatability has proven to be excellent. In fact there are documented real world examples of head to head comparisons where sonar flow meters track the pump load current better than mag flow meters |
| Entrained Air Sensitivity | - Entrained air in the slurry can cause erratic flow readings with no means of correction<br>- When calculating volumetric flow the mag flow meter assumes a full pipe. Any air, or void fraction, will not be accounted for. 1% air will cause a 1% error in flow. | - There is no sensitivity to the entrained air. The flow reading will not be affect by varying amounts of air.<br>- The entrained air levels can actually be measured and the flow rate can then be corrected for the void fraction to produce a more accurate measurement of flow. |
| Magnetite Sensitivity | - It is a proven fact that mag flow meters are sensitive to magnetite in the slurry. Even the magnetite corrected meters are only corrected at one density level. If the density level changes over time the meter will be out of calibration. | - There is no sensitivity to the magnetite. The flow reading will not be affected by changing magnetite densities. |
| Diagnostics | - Mag flow meters have a limited set of diagnostics. This is highly dependent on the model. | - There is extensive diagnostic capability in the transmitter. Wiring problems are presented to the user in English statements such as “swap wire 1 with wire 7”.<br>- The transmitter has extensive on board memory. Up to a years worth of data can be stored and then downloaded using simple PC based software. This is very useful when running performance based tests without troubling the DCS room. |
| Product Lead Time | - Meters of this size typically have 12 to 16 week lead times | - Lead time is typically 2 to 4 weeks |
| Spare Parts | - With long lead times it is typically necessary to stock a mag tube on site. This can be very costly. | - No spare equipment is necessary |
| Total Cost of Ownership | - The total cost of ownership is made up of the following:<br>  - Capital cost<br>  - Installation<br>  - Annual maintenance and repair (up to 2x per year)<br>  - Spare equipment (one tube)<br>  - Safety incidents<br>  - Lost production due to process down time and chronic performance issues | - The total cost of ownership is made up of the following:<br>  - Capital cost<br>  - Installation |

## Sonar Meter Performance Benefits

The sonar meter provides more accurate, repeatable, and reliable flow measurement as well as the ability to provide a measure of the entrained air which may then be used to correct the density measurement. A more accurate reading of flow will enable a more accurate control of the mill circulating load. A 1% tighter control of the circulating load will equate to a 1% increase in mill

throughput. This mill throughput increase could translate to about $2,000,000 per year (100,000 tons per day, copper grade of 0.5%, 85% recovery, 28% con grade, $2.50/lbs). In addition, tighter control of the slurry feed density to the hydrocyclone battery will translate to tighter particle size distribution to the flotation. The sensitivity of product recovery to particle size distribution is highly dependent on site specific parameters. Assuming you can achieve a 1% increase in recovery by controlling feed density; then this would translate to about another $2,000,000 per year.

**Hydrocyclone Feed Line Installation**

The following are some pictures of example installations for a sonar flow meter and magnetic flow meter. Even though these are very challenging piping configurations the sonar meter performs exceptionally well. This is accomplished from outside the pipe so there is no possibility of leakage. The picture of the magnetic flow meter shows the leakage problems that can occur within a very short time in service.

Figure 1: Sonar VF-100 Flow Meter

Figure 2: Magnetic Flow Meter

**Summary**

The volumetric flow rate in a hydrocyclone feed line is an important measurement when processing ore in a closed circuit milling operation. The traditional magnetic flow meter technology suffers from both performance problems and high total cost of ownership. The sonar meter provides superior performance with a lower total cost of ownership. The sonar meter provides a strong value proposition in this application especially when there is magnetic ore present in the slurry such as magnetite, arsenopyrite, and pyrrhitite. An added benefit to the sonar meter is the ability to measure the varying amount of entrained air in the slurry. This information may then be used to correct the slurry feed density measurement. This additional accuracy can provide mill throughput and recovery gains.