White Paper

Optimize Flow Measurement in Challenging Slurry Applications

EMERSON

In This White Paper

Many technology options are available to measure flow of typical liquids, gases, or steam. One can choose from vortex, magnetic flow meters (magmeters), Coriolis, several differential pressure options, turbine, and many other types. However, the options dwindle when faced with the need to measure difficult fluids, such as thick and aggressive slurries, hot and viscous tars, or other materials like molten plastic and abrasive waste streams.

This paper focuses on two leading flow measurement technologies that are specifically designed for these challenging applications. One is a modified magnetic flow meter sensor and transmitter created to handle difficult slurry applications. The other is the wedge flow meter, now able for purchase as a single, all-inclusive unit with various options tailored for standard, abrasive, high temperature, and very cold applications.

The paper begins with an explanation of how each technology works, and it then details the strengths and limitations of these instruments. It then highlights the various applications best suited for each meter, and it offers a decision tree to help users choose the best flow technology for a specific need.

Magnetic Flow Meter of Operation

In the early 1830s, Michael Faraday was studying magnets and discovered that a voltage could be created by moving a magnet through a conductive coil of wire. Further experiments proved that the opposite was also true, a conductor moving through a fixed magnet field would also generate a voltage. These discoveries ultimately gave birth to electric generators, motors, and a host of other electrical equipment. It also provided a means to measure liquid flow moving through a pipe.

Magmeters are based on Faraday's discovery. In this case, the conductive liquid acts as the conductor moving through a fixed magnetic field passing through the pipe to create a voltage across the electrodes (Figure 1). The generated voltage varies directly with liquid velocity, allowing the magmeter transmitter to convert the sensor signal to fluid velocity, which can be converted to flow. Note that the pipe must be lined with a nonconductive material to keep the metal pipe from shorting the electrode signal to ground.

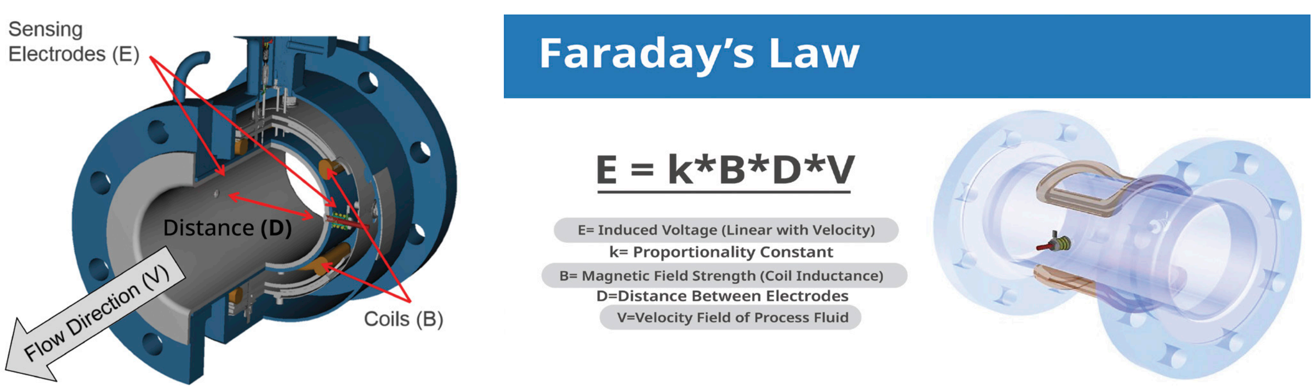


Figure 1. A magnetic flow meter measures the velocity of a conductive liquid as it moves between fixed magnetic coils in a lined pipe. The voltage across the electrodes varies with fluid velocity and can be converted to flow.

Faraday's law indicates that the electrode voltage (E) is proportional to the strength of the magnetic field (B), the distance between the electrodes (D), and the velocity of the fluid (V). Since the distance and area of the pipe are fixed and the strength of the magnetic field is kept constant, a magmeter can determine fluid velocity by measuring the voltage across the electrodes. Fluid velocity times the fixed cross-sectional area of the pipe provides volumetric liquid flow.

Standard magmeter designs work well for most any conductive liquid application. The meters are full bore, offering essentially no pressure drop, and they can read in either flow direction. They also have turndown rations of 100:1 and can operate with high process pressures. They come in a broad range of sizes and have short meter run requirements of a few pipe diameters upstream and downstream.

Unfortunately, the standard magmeter design can struggle when measuring slurries or high solid content flows, such as pulp stock. In these applications, the solids impinge on the sensors, creating electrical noise and eddies within the flow stream, which can result in erratic signals. To make any measurement at all, the standard magnetic flow meter signal must be excessively damped to minimize the noise, but such damping dramatically slows meter response and makes tight flow control extremely difficult.

Advanced Magnetic Flow Meter Design

To address the measurement challenges of slurries and other flows with high solids content, an advanced magmeter design has been introduced (Figure 2). The Rosemount™ 8782 Transmitter for Slurry Applications and Rosemount™ MS Magnetic Sensor for Slurry Applications incorporate several design revisions, allowing them to significantly outperform other magmeter designs in these applications.

Figure 2. The Rosemount 8782 Transmitter and MS sensor have been specifically designed for slurry and difficult flow applications. Strengthened magnetic fields, variable frequency capability, and digital signal processing provide significant performance improvements.

The new meter design includes these major modifications:

- The magnetic field strength is greatly increased to provide a higher signal level, which in turn provides a higher signal-to-noise ratio.
- The transmitter can operate at multiple frequency ranges, allowing easy and fast user customization to overcome process or system noise issues.
- The transmitter utilizes advanced digital signal processing to eliminate noise and achieve a far more stable flow signal without damping. The highly responsive signal provided by this technology enables much improved and tighter flow control than would be possible with a typical magmeter design.

The overall flow signal improvement is quite noticeable in Figure 3. The combination of stronger magnetic field, higher operating frequency, and digital signal processing allows the meter to measure 12% consistency pulp stock with far greater accuracy and reduced noise as compared to a standard design. More importantly, signal damping can be all but eliminated, providing a smooth, responsive flow signal that can be used for tight process control, which can result in significant savings through improved process optimization and operating reliability.

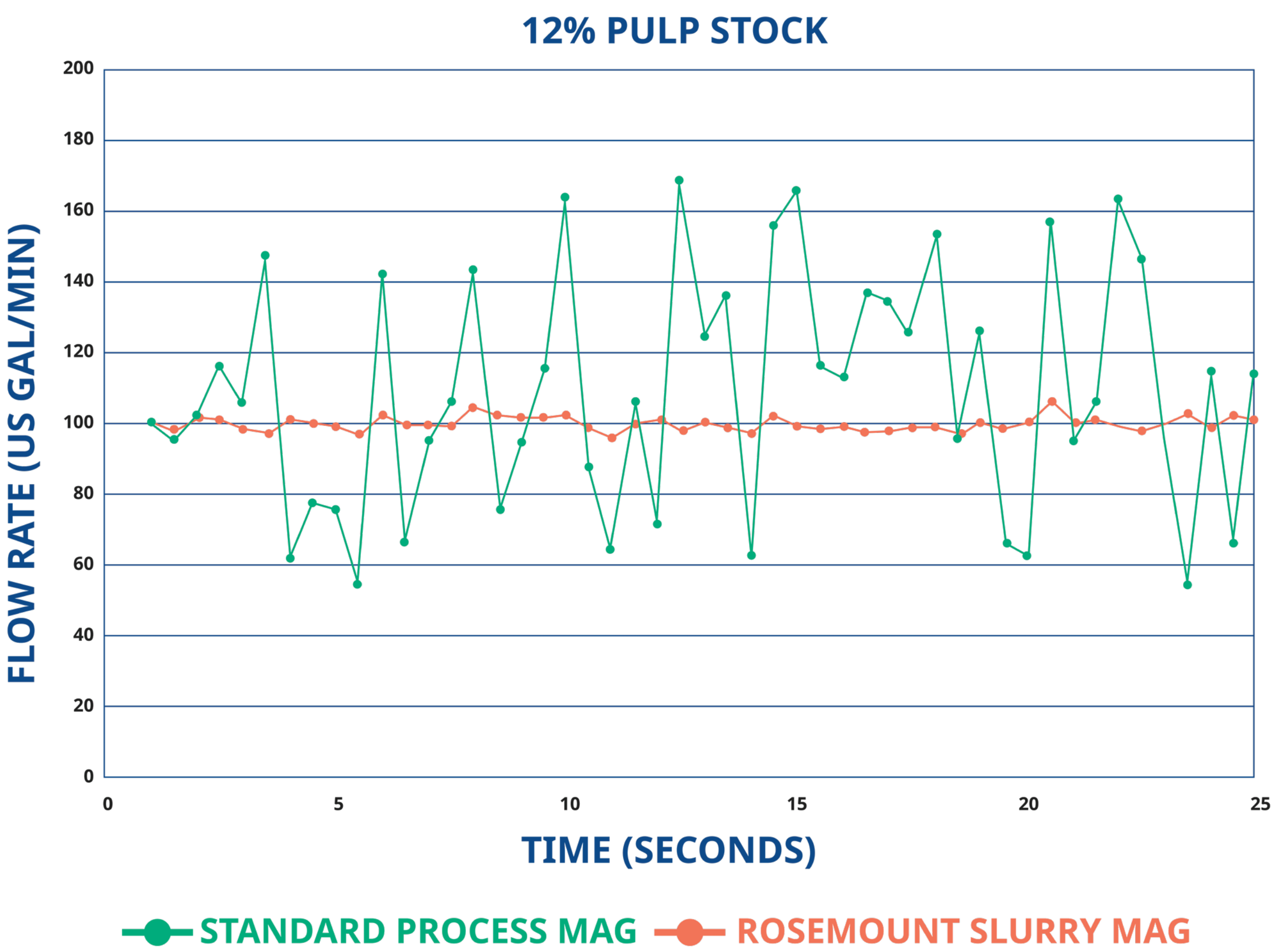


Figure 3. This chart shows the difference of a 12% pulp stock flow measurement using a standard magmeter versus the new Rosemount 8782 Transmitter and MS sensor. Signal damping is no longer required, enabling much tighter and reliable flow control.

The slurry magmeter is very well suited for any slurry or high solid flow. A broad selection of meter sizes (3'' to 36''), flange sizes (up to Cl 2500), and several liner and electrode material options enable the slurry magmeter to handle a range of applications that have historically been very difficult to measure (Figure 4). Industries such as mining, pulp and paper, and oil and gas will find the revised design particularly useful.

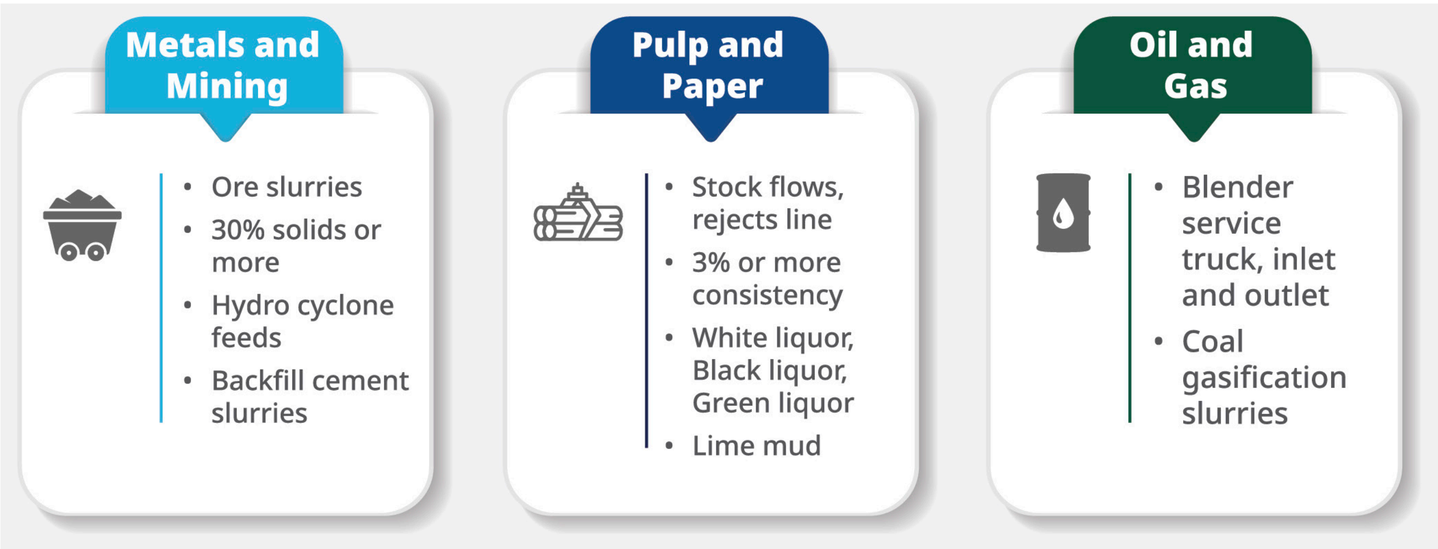


Figure 4. These challenging applications are just a few of the processes where the new slurry magmeter design provides significant flow measurement improvement.

There are limitations that may preclude the slurry magmeter from working in a particular application, including:

- The fluid must be a conductive liquid, generally 5 microSiemens/cm or higher, which is not an issue with most slurries.
- The meter cannot measure vapor or gas flows.
- Magnetic flow meters can be installed in lined (non-conductive) pipes, but they will likely require grounding rings for these applications.
- The slurry magmeter is generally limited to process temperatures of 350 °F or less, and some linings may have lower limits. This temperature limit applies even during cleaning cycles, regardless of duration.

Within these limits, the new slurry magmeter design is an excellent choice for many difficult slurry and high solid applications. However, there are other challenging flow applications where a different technology is required. Those challenges can be addressed with the wedge meter.

Flow Measurement Using a Wedge Meter

While a slurry magmeter is an excellent choice for many difficult flow applications, it may not be able to handle certain process conditions. In those cases, the wedge flow meter can be a great solution.

A wedge flow meter utilizes a differential pressure transmitter to measure the pressure drop across a wedge-shaped restriction built into a spool section (Figure 5). As the process fluid moves past the wedge, the restricted flow area forces the fluid to speed up, creating a pressure drop. The meter works with liquid, gas, and steam flows.

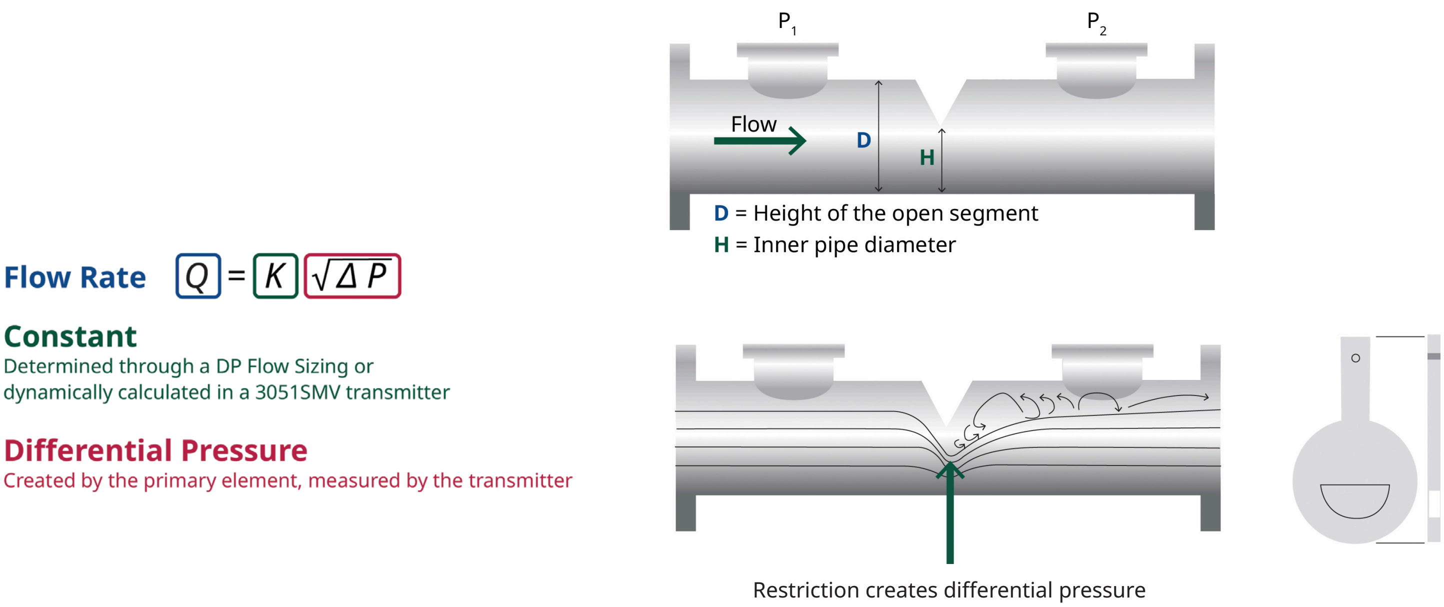


Figure 5. The wedge flow meter (top view) measures the differential pressure created as a flow moves past a wedge inserted in the flow stream. The wedge shape allows a smooth flow profile and the large diaphragm seals are difficult to plug, and the design can handle very high temperature or difficult coating applications.

Pressure can be measured using tubing for clean applications, but for more difficult applications two larger seal connections can be used in conjunction with a seal system. The large seals and smooth flow path resist plugging and blockage, and the all-metal construction handles abrasive slurries quite well. The meter is also capable of operating within an extended range of process pressures and temperatures.

Wedge Meter Design Options

The Rosemount™ 9195 Wedge Flow Meter comes in several configurations that are specifically designed for key applications challenges (Figure 6). The standard model with seals systems is well suited for common slurry and high viscosity applications, such as wastewater and pulp and paper, which are prone to plugging and coating. It is fabricated of all 316SS materials and can handle process temperatures up to 575 °F.

Figure 6. The Rosemount 9195 Wedge Flow Meter comes in standard, abrasive, and high and low temperature models for measuring flow in difficult slurry, viscous, hot, and coating/plugging processes.

An abrasive wedge meter package incorporates thicker diaphragms made of Duplex 2205 to better resist wear from aggressive process slurries. A high temperature version utilizes a different process fill fluid with a thermal range expander, allowing the meter to handle process temperatures up to 770 °F (410 °C) without the challenges usually associated with high temperature heat tracing. This can be particularly useful for molten plastics and tars, as well as for processes that require high temperature cleaning cycles. A cold temperature model is suitable for harsh ambient environments down to -40 °F (-40 °C), such as outside pipelines located in colder environments. The various models of the wedge flow meter are very well suited for a range of abrasive slurries, viscous liquids, and high temperature plastics and tar-like substances (Figure 7). They can handle processes that tend to coat and plug, and slurries with abrasive particles, and they operate in a broad range of temperatures – all while maintaining a highly repeatable measurement.

Figure 7. Wedge flow meters are an excellent choice to measure flows of dirty/debris filled fluids, viscous materials, abrasive slurries, and high temperature molten liquids.

As with any flow meter, wedge meters do have some limitations which should be considered. Potential issues include:

- A wedge meter imparts pressure drop on the system, and that pressure drop will generally increase as the square of the flow.
- In most cases, erosion of the wedge element will not affect measurement accuracy. However, the elements is welded in, so if any severe obstruction or damage occurs, the entire pipe spool would need to be removed.

Flow Meter Selection

The best flow meter option strongly depends on the specific application. Simple applications involving clean fluids can be addressed with a broad range of flow measurement technologies and are outside the scope of this discussion, which focuses on challenging slurry and viscous flow measurement.

Figure 8 provides a side-by-side comparison of the slurry magmeter and wedge flow meter offerings. As the table shows, the slurry magmeter is sold in larger line sizes with higher flange ratings and has better accuracy, but it is limited to 350 °F (176 °C) and can only operate on conductive liquids. Wedge meters can handle elevated temperatures and work well with any type of liquid, but they are limited to a maximum size of 8" (200 mm) and have reduced accuracy.

	Rosemount 9195 Wedge Flow Meter	Rosemount MS Magnetic Slurry Flow Meter
Line size	2 to 8 in; 50 to 200 mm	3 to 36 in; 80 to 900 mm
Temperature Limit	750 ˚F (398 ˚C) with seals; 1000 ˚F (538 ˚C) with impulse lines	350 ˚F (176 ˚C)
Max Pressure Rating	Class 600 flange	Class 2500 flange
Process Fluid	Liquids, gases or steam	Conductive liquid
Straight Pipe Run	7U/6D	5U/2D
Wireless Capabilities	Yes	No
Accuracy	1% Calibrated; 3% Uncalibrated	0.25% Standard; 0.15% High Accuracy Option
Transmitter Supported Protocols	4–20 mA Digital HART, Modbus, Profibus, Fieldbus, *Wireless* HART	4–20 mA Digital HART, Pulse

Figure 8. The Rosemount MS Magnetic Slurry Flow Meter is compared to the Rosemount 9195 Wedge Flow Meter in this table. The Slurry Mag is limited to conductive liquids but offers a wider range of sizes. The Wedge handles higher temperatures but has reduced accuracy and size options.

When choosing between the meter types, Figure 9 can provide some general guidance. For a given line size, the Rosemount 8782 Transmitter and MS sensor magmeter will cost less and provide minimal pressure drop, so if either meter suits the application, it may be a better option. The magmeter also requires less meter run, making installation easier to accommodate.

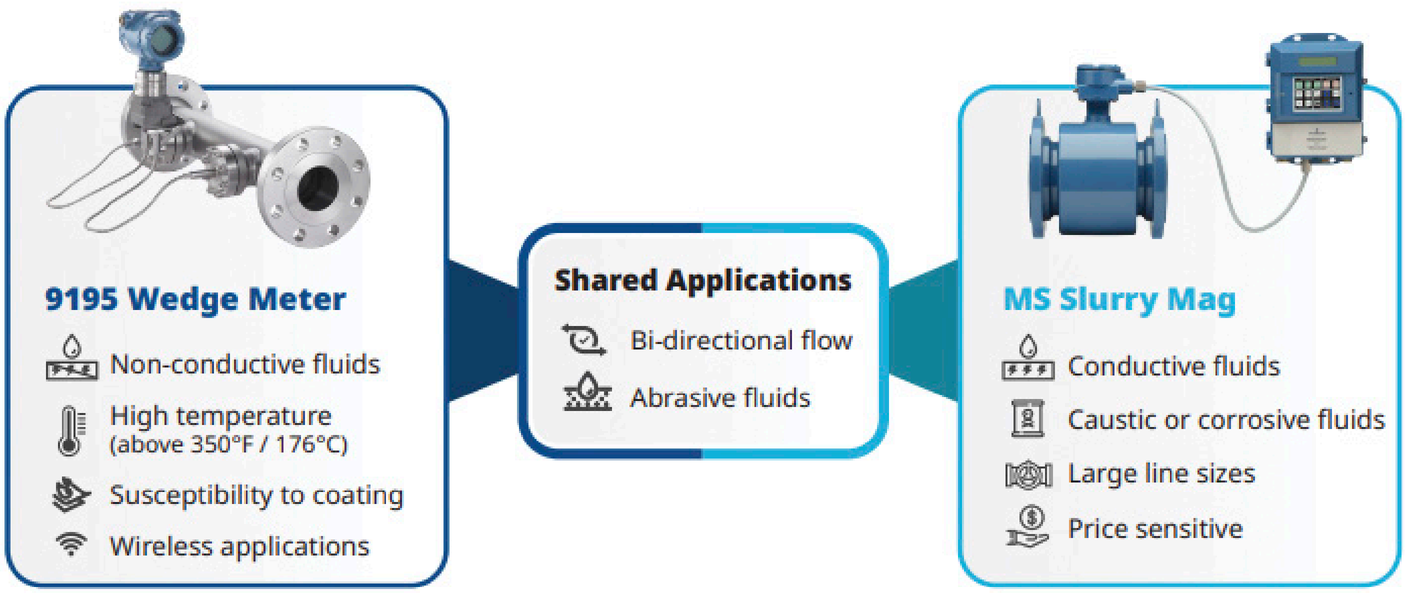


Figure 9. The wedge meter is the better choice for high temperature or non-conductive fluids or coating applications. The slurry magmeter is a cost-effective option that is better suited for large line sizes or corrosive fluids.

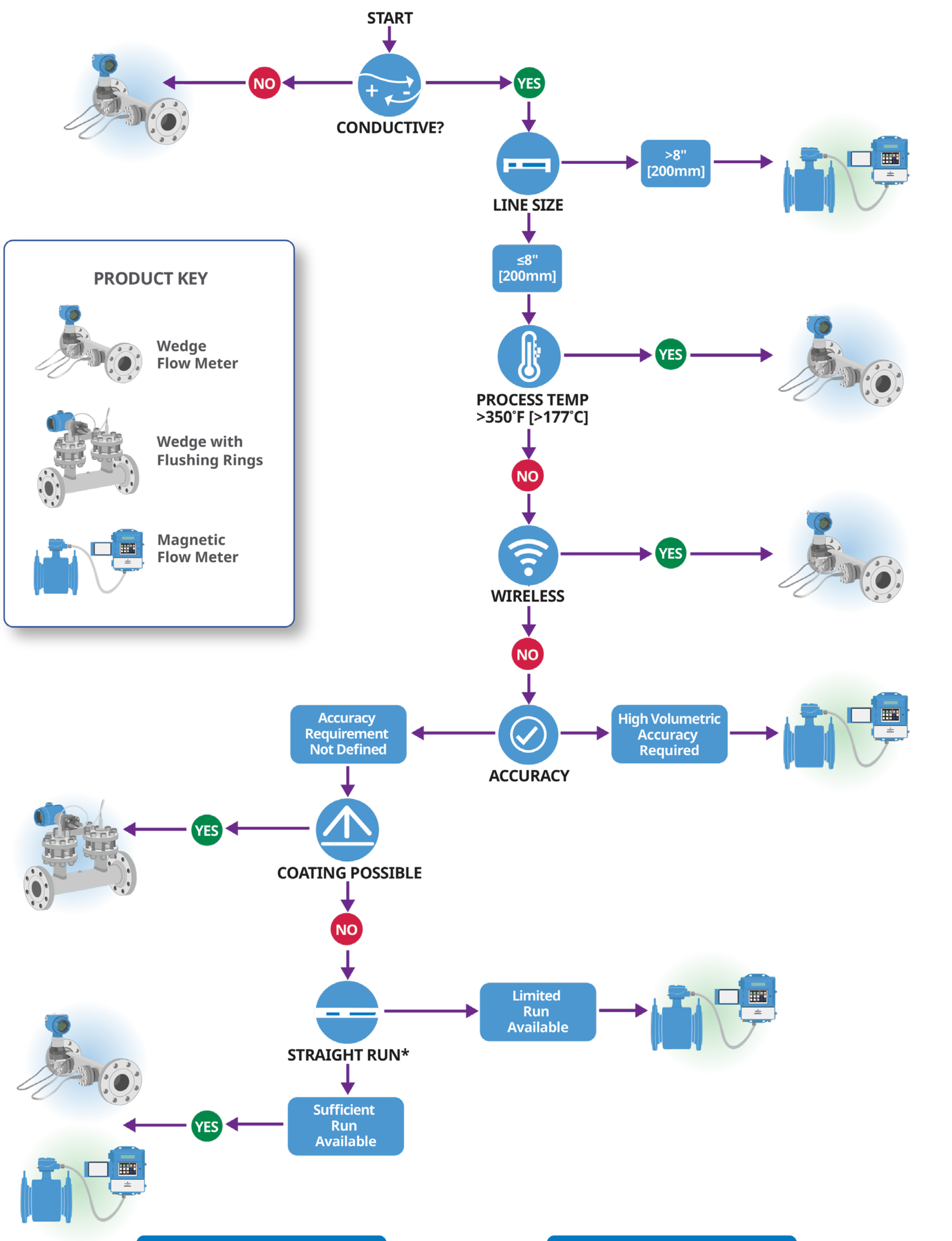
Conclusion

Simple flow measurement applications can be addressed using a host of metering technologies, but certain applications—such as slurries, thick and molten high temperature materials, and abrasive processes—demand a different alternative. The slurry magmeter design and the wedge meter both provide accurate and highly reliable flow measurement for these very challenging applications.

The best meter for a particular process will vary depending upon the dynamic range of flow, process conditions, and line size—but by using the decision tree provided in this White Paper–users can quickly determine the best solution for their specific application. If any questions remain or help is needed to choose the best materials of construction and/or available options, users are encouraged to contact their local Emerson representative.

Figure 10 offers a decision tree to help users determine the best flow measurement technology for their particular application.

How to Choose Between Wedge and Magnetic Flow Meter Technology for Your Slurry Application



Learn More About Wedge Flow Meter Technology

Learn More About Magnetic Flow Meter Technology

*Follow 13 diameters as a standard guideline; additional details can be found in product Quick Start Guides.

Product selection can be reliant on several additional factors, including technology familiarity, cost, and maintenance expectations. Please reach out to your local Emerson representative to discuss the best solution for your application.

Case Study

Both the slurry magmeter and the wedge flow meter have been successfully applied in processes where previous flow measurement devices were unable to provide accurate and reliable flow information.

In one large pulp and paper facility in Europe, a standard magmeter measuring the flow of high consistency stock generated wildly erratic flow signals that made control virtually impossible. The signal was somewhat calmed by applying significant damping, but the resulting signal responded so slowly that closed loop control could not function. The meter was replaced with the Rosemount 8782 Transmitter and MS sensor. The resulting flow signal was extremely accurate and virtually noise free, eliminating the need to apply damping. As a result, very tight closed loop control was achieved, increasing productivity, reducing raw material usage, and eliminating process disruptions.

Injection wells play a big role in oil and gas production. Typically, a fluid mixture is pushed through these wells to maintain reservoir pressure or to drive oil to the wells. These blends contain a composite of fluids, including produced water, oil, solids, and entrained gases. A site in west Texas was having difficulty making flow measurements in this type of application, running into issues with the abrasive mix and available compatible technology. However, using the Emerson solution, the end user was able to use a fully integrated wedge design complete with Rosemount transmitters. This solution resulted in a robust meter that provided an accurate and reliable measurement.

For additional information on Emerson's products, visit
Emerson.com/FlowMeasurement

00870-0200-3939 Rev AA, December 2024

ROSEMOUNT™ EMERSON™