

Magnetic Flow Meters Function & Application

What Are Mag Meters and How Do They Work?

A magnetic flow meter, or mag meter, is a volumetric flow meter with no moving parts and is ideal for wastewater applications or any other dirty liquid that is conductive.

Magnetic flow meters will generally not work with hydrocarbons, distilled water, or many non-aqueous solutions. Magnetic flow meters are often selected and specified for applications because they are obstruction-less, cost-effective for aggressive chemicals and slurries, and provide highly accurate volumetric flow measurement. A range of liner materials, electrode options, and line sizes accommodate a wide variety of process applications.

Operation Theory

Magnetic flow meters utilize Faraday's Law of Electromagnetic Induction to determine the velocity of a liquid flowing through a pipe. Faraday's Law forms the basis for electrical generation systems where wires travel through a magnetic field and produce a voltage. In magnetic flow meters, a magnetic field is generated and channeled into the liquid flowing through the pipe.

To accomplish this, the electromagnetic coils can be located outside of the pipe (flow tube), however, the flow tube must be non-magnetic to allow penetration of the magnetic field into the liquid.

Locating the coils internal to the flow meter (closer to the liquid) can reduce the electrical power necessary to deliver the magnetic field, as well as reduce the size of the flow meter and fabrication costs.

Following Faraday's Law, the flow of a conductive liquid through the magnetic field will cause a voltage signal to be generated. This signal is sensed with electrodes located on the flow tube walls. When the coils are located externally, a non-conductive liner is installed inside the flow tube to electrically isolate the electrodes and prevent the signal from being shorted. For similar reasons, non-conductive materials are used to isolate the electrodes for internal coil designs. The fluid itself is the conductor that will flow through the magnetic field and generate a voltage

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signal at the electrodes. When the fluid moves faster, more voltage is generated. Faraday's Law states the voltage generated is proportional to the movement of the flowing liquid. The transmitter processes the voltage signal to determine liquid flow.

How to Use Magnetic Flow Meters

Magnetic flow meters measure the velocity of conductive liquids in pipes, such as water, acids, caustic, and slurries. Magnetic flow meters can measure properly when the electrical conductivity of the liquid is greater than approximately $5\mu\text{S}/\text{cm}$. Using magnetic flow meters on fluids with low conductivity, such as deionized water, boiler feed water, or hydrocarbons, can cause the flow meter to turn off and measure zero flow.

These flow meters do not obstruct flow, so they can be used for clean, sanitary, dirty, corrosive and abrasive liquids. Magnetic flow meters can be applied to the flow of liquids that are conductive, so hydrocarbons and gases cannot be measured with this technology due to their non-conductive nature and gaseous state, respectively.

Magnetic flow meters do not require much upstream and downstream straight runs so they can be installed in relatively short meter runs. Magnetic flow meters typically require 5-10 diameters of upstream straight run and 5-2 diameters of downstream straight run measured from the plane of the magnetic flow meter electrodes.

Industries that Use Magnetic Flow Meters

Magnetic Flow Meters represent about 24% of all flow meters sold today (with others such as Variable Area Flow Meters, Ultrasonic Flow Meters, and Turbine & Oval Flow Meters making up the rest). Applications for dirty liquids are found in the water, wastewater, mining, mineral processing, power, pulp and paper, and chemical industries. Water and wastewater applications include custody transfer of liquids in force mains between water/wastewater districts. Magnetic flow meters are used in water treatment plants to measure treated and untreated sewage, process water, water, and chemicals. Mining and mineral process industry applications include process water and process slurry flows and heavy media flows.

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With proper attention to materials of construction, the flow of highly corrosive liquids (such as acid and caustic) and abrasive slurries can be measured. Corrosive liquid applications are commonly found in chemical industry processes and in chemical feed systems used in most industries. Slurry applications are commonly found in the mining, mineral processing, pulp and paper, and wastewater industries.

Magnetic flow meters are often used where the liquid is fed using gravity. Be sure that the orientation of the flow meter is such that the flow meter is completely filled with liquid. Failure to ensure that the flow meter is completely filled with liquid can significantly affect the flow measurement.

Use caution when operating magnetic flow meters in vacuum service because some magnetic flow meter liners can collapse and be sucked into the pipeline in vacuum service, catastrophically damaging the flow meter. Note that vacuum conditions can occur in pipes that seemingly are not exposed to vacuum service such as pipes in which a gas can condense (often under abnormal conditions). Similarly, an excessive temperature in magnetic flow meters (even briefly under abnormal conditions) can result in permanent flow meter damage.

Typical Applications

The construction of the magnetic flow meter is such that the only wet parts are the liner and electrodes, both of which can be made from materials that can withstand corrosion. In addition, the straight-through (obstruction-less) nature of the design reduces the loss of hydraulic energy across the flow meter (pressure drop) and the potential for abrasion from the flowing liquid. Therefore, magnetic flow meters can measure many corrosive liquids and abrasive slurries. Magnetic flow meter liners and electrodes can be constructed of materials that do not contaminate the liquid. Therefore, these flow meters can be applied when liquid contamination is an issue, such as in sanitary applications.

For slurry service, be sure to size magnetic flow meters to operate above the velocity at which solids settle (typically 1.5 – 2 ft/sec), in order to avoid filling the pipe with solids that can affect the measurement and potentially stop the flow. Magnetic flow meters for abrasive service are usually sized to operate at low

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velocity (typically below 5 – 6 ft/sec) to reduce wear. In abrasive slurry service, the flow meter should be operated above the velocity at which solids will settle, despite increased wear. These issues may change the range of the flow meter, so its size may be different than the size for an equivalent flow of clean water.

Application Considerations for Magnetic Flow Meters

Do not operate a magnetic flow meter near its electrical conductivity limit because the flow meter can turn off. Provide an allowance for the changing composition and operating conditions that can change the electrical conductivity of the liquid.

In typical applications, magnetic flow meters are sized so that the velocity at maximum flow is approximately 75% of the max flow of the meter. Differential pressure constraints and/or process conditions may preclude application of this general guideline. For example, gravity fed pipes may require a larger magnetic flow meter to reduce the pressure drop to allow the required amount of liquid to pass through the magnetic flow meter without backing up the piping system. In this application, operating at the same flow rate in the larger flow meter will result in a lower liquid velocity as compared to the smaller flow meter.

Advantages and Disadvantages

There are numerous benefits to using electromagnetic flow meters to perform fluid flow measurements. They are generally non-invasive and have no moving parts, reducing the risk of breakdowns and the frequency of repairs. A decrease in flow meter pressure is also usually no greater than that of an equivalent pipe length, reducing the piping costs. Some of the other major advantages provided by magnetic flow meters include:

- Power usage is relatively low, with electrical power requirements as low as 15 watts for some models.
- They are mechanically obstruction-less and can be equipped with abrasion-resistant liners, making them effective for measuring slurries and other erosive fluids.

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- They are capable of dealing with most kinds of acids and bases, as well as water and water-based solutions, due to lining materials that are both insulators and corrosion resistant.
- Relatively small amounts of electrode metals are needed for magnetic flow meters.
- They can measure both very low flows and very high volume flow rates, with a minimum diameter of roughly 0.125 inches and a maximum volume of up to 10 cubic feet.
- They can usually measure multi-directional flow, either upstream or downstream.

Despite these advantages, magnetic flow meters also present certain difficulties for flow rate measurement. These flow meters are only effective on conductive fluids, and materials such as unmixed hydrocarbons and gases cannot be measured. However, magnetic materials themselves may also present problems, as hydrodynamic effects can alter the normal flow pattern and disturb the velocity rate enough to interfere with operations. Depending on their size and capacity, magnetic flow meters can be relatively heavy, and those with higher corrosion and abrasion resistance can be expensive.

If you want to know if magnetic flow meters might be right for your process or flow application, contact us today. Our team of flow experts can help you to find the right flow product for your application.