MAGNETIC FLOWMETERS

Flow Reference Section

INTRODUCTION

Magnetic flowmeters are low pressure drop, volumetric, liquid flow measuring devices. The low maintenance design–with no moving parts, high accuracy, linear analog outputs, insensitivity to specific gravity, viscosity, pressure and temperature, and the ability to measure a wide range of difficult-to-meter fluids (such as corrosives, slurries and sludges)–differentiates this type of metering system from other flowmeters. Two basic styles of magnetic flowmeter are currently available from Engineering:
1) Wafer-style, where highest accuracy (up to +0.5% of reading) measurements are required; and 2) Insertion-style, for greater economy and particularly for larger pipe sizes.

All magnetic flowmeters employ the state-of-the-art dc pulsed magnetic field system. The following discussion details the principle of operation, as well as the advantages, of dc pulsed type magnetic flowmeters.

PRINCIPLE OF OPERATION

Faraday's Law

The operation of a magnetic flowmeter is based upon Faraday's Law, which states that the voltage induced across any conductor as it moves at right angles through a magnetic field is proportional to the velocity of that conductor.

Faraday's Formula:

E is proportional to V x B x D

where:

E = The voltage generated in a conductor

V = The velocity of the conductor

B = The magnetic field strength

D = The length of the conductor

To apply this principle to flow measurement with a magnetic flowmeter, it is necessary first to state that the fluid being measured must be electrically conductive for the Faraday principle to apply.

As applied to the design of magnetic flowmeters, Faraday's Law indicates

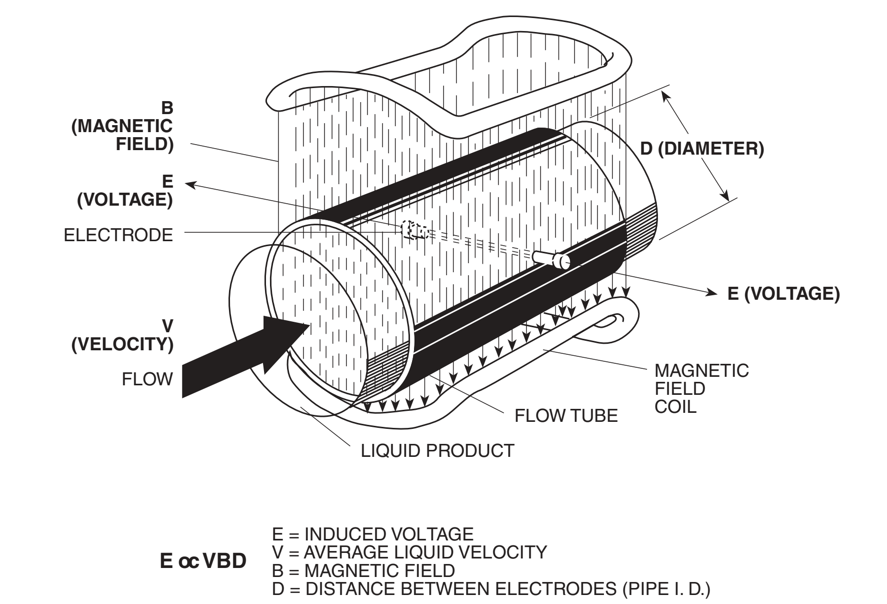

Figure 1: In-line magnetic flowmeter operating principle

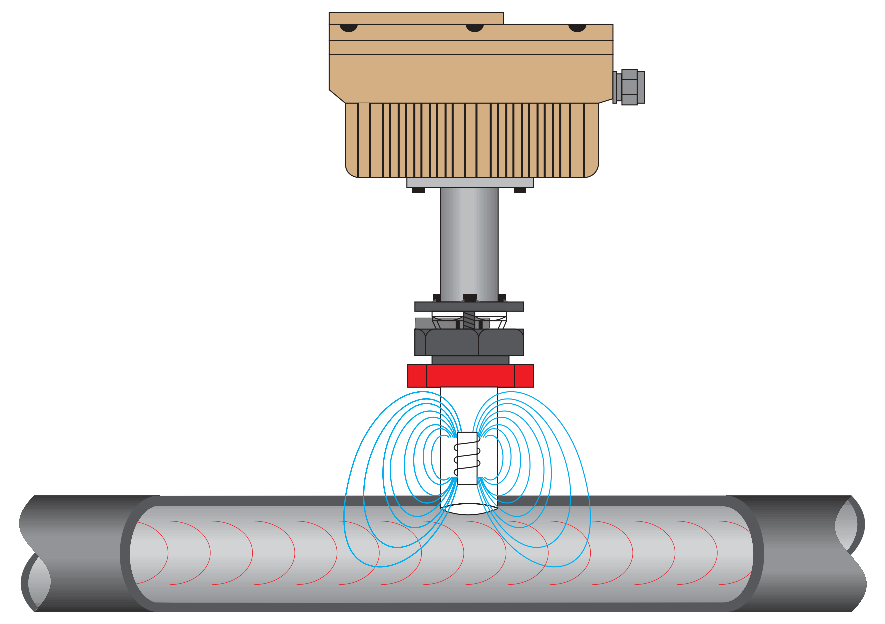

Figure 2: Insertion-type flowmeter operating principle

that signal voltage (E) is dependent on the average liquid velocity (V) the magnetic field strength (B) and the length of the conductor (D) (which in this instance is the distance between the electrodes).

In the case of wafer-style magnetic flowmeters, a magnetic field is established throughout the entire cross-section of the flow tube (Figure 1). If this magnetic field is considered as the measuring element of the magnetic flowmeter, it can be seen that the measuring element is exposed to the hydraulic conditions throughout the entire cross-section of the flowmeter. With insertion-style flowmeters, the magnetic field radiates outward from the inserted probe (Figure 2).

MAGMETER SELECTION

The characteristics of the fluid to be metered, the liquid flow parameters, and the environment of the meter are the determining factors in the selection of a particular type of flowmeter.

Conductivity

Electrical conductivity is simply a way of expressing the ability of a liquid to conduct electricity. Just as copper wire is a better conductor than tin, some liquids are better conductors than others. However, of even greater importance is the fact that some liquids have little or no electrical conductivity (such as hydrocarbons and many non-aqueous solutions, which lack sufficient conductivity for use with magmeters). Conversely, most aqueous solutions are well suited for use with a magmeter. Depending on the individual flowmeter, the liquid conductivity must be above the minimum requirements specified. The conductivity of the liquid can change throughout process operations without adversely affecting meter performance, as long as it is homogeneous and does not drop below the minimum conductivity threshold. Several factors should be taken into consideration concerning liquids to be metered using magnetic flowmeters. Some of these are:

1. All water does not have the same conductivity. Water varies greatly in conductivity due to various ions present. The conductivity of “tap water” in Maine might be very different from that of “tap water” in Chicago.
2. Chemical and pharmaceutical companies often use deionized or distilled water, or other solutions which are not conductive enough for use with magnetic flowmeters.
3. Electrical conductivity is a function of temperature. However, conductivity does not vary in any set pattern for all liquids as temperature changes. Therefore, the temperature of the liquid being considered should always be known.
4. Electrical conductivity is a function of concentration. Therefore, the concentration of the solution should always be provided. However, avoid what normally is a logical assumption, such as: That electrical conductivity increases as concentration increases. This is true up to a point in some solutions, but then reverses. For example, the electrical conductivity of aqueous solutions of acetic acid increases as concentration rises up to 20%, but then shows a decrease with increased concentration to the extent that, at some concentration above 99%, it falls below the minimum requirement.

Acid/Caustics

The chemical composition of the liquid slurry to be metered will be a determining factor in selecting the flowmeter with the proper design and construction.

Operating experience is the best guide to selection of liner and electrode materials, especially in industrial applications, because, in many cases, a process liquid or slurry will be called by a generic name, even though it may contain other substances which affect its corrosion characteristics. Commonly available corrosion guides may also prove helpful in selecting the proper materials of construction.

Velocity

The maximum (full scale) liquid velocity must be within the specified flow range of the meter for proper operation. The velocity through the flowhead can be controlled by properly sizing the meter. It isn’t necessary that the flowhead be the same line size, as long as such sizing does not conflict with other system design parameters. Although the meter will increase hydraulic head loss when sized smaller than the line size (because the meter is both obstructionless and of short lay length), the amount of increase in head loss is negligible in most applications. The amount of head loss increase can be further limited by using concentric reducers and expanders at the pipe size transitions. As a rule of thumb, meters should be sized no smaller than one-half of the line size.

Because of the wide rangeability of magnetic flowmeters, it is almost never necessary to oversize a meter to handle future flow requirements. When future flow requirements are known to be significantly higher than start-up flow rates, it is imperative that the initial flows be sufficiently high and that the pipeline remain full under normal flow conditions.

Abrasive Slurries

Mildly abrasive slurries can be handled by magnetic flowmeters without problems, provided consideration is given to the abrasiveness of the solids and the concentration of the solids in the slurry. The abrasiveness of a slurry will affect the selection of the construction materials and the use of protective orifices. Abrasive slurries should be metered at 6 ft/sec or less in order to minimize flowmeter abrasion damage. Velocities should not be allowed to fall much below 4 ft/sec, since any solids will tend to settle out. An ideal slurry installation would have the meter in a vertical position. This would assure uniform distribution of the solids and avoid having solids settle in the flow tube during no-flow periods.

Consideration should also be given to use of a protective orifice on the upstream end of a wafer-style magnetic flowmeter to prevent excessive erosion of the liner. This is especially true since Tefzel liner have excellent chemical resistance, but poor resistance to abrasion. In lined or non-conductive piping systems, the upstream protective orifice can also serve as a grounding ring.

Sludges and Grease-bearing Liquids

Sludges and grease-bearing liquids should be operated at higher velocities, about 6 ft/sec minimum, in order to reduce the coating tendencies of the material.