IE FLOW METERS
A Measure Of Excellence

TECHNICAL DATASHEET

DS-7400

IE Mag-Cell Electromagnetic Flow Meters

MAGNETIC FLOWMETERS

Description

The IE Mag-Cell electromagnetic flow meter is a solid state, obstructionless, flow rate measuring device, which is capable of measuring a wide range of conductive liquids, clear or slurried. The Mag-Cell is comprised of two basic parts: a flow transmitter, which becomes a part of the pipeline, and a signal converter. A magnetic field is generated by compact high-density field coil mounted to a short section of straight pipe. As a conductive liquid passes through the pipe section and its magnetic field, a voltage is generated that is directly proportional to the velocity of the conductive liquid. The voltage induced is sensed by electrodes mounted at right angles to the magnetic field and in contact with the conductive liquid or slurry. The electrodes are insulated from the pipe by a non-conductive liner that encapsulates all wetted parts of the pipe. From the electrodes the voltage is transmitted to a signal conditioner where it is conditioned to the desired output signal(s). The IE Mag-Cell employs a keyed bi-directional D.C. field and digital electronics to establish new criteria in wide rangeability, high accuracy and low power consumption. Meter operation is independent of span setting. The Mag- Cell generates an open collector frequency (proportional to liquid velocity) of 10kHz at maximum flow rate. Convenient terminal connections are provided to permit local or remote verification of proper meter operation. Analog current and factored/scaled pulse outputs are available for integral or remote mounting.

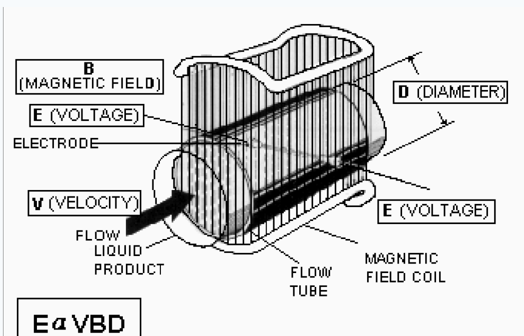

Figure 1 - Principle of Operation

IE MAG-CELL ELECTROMAGNETIC FLOW METERS

Design Features

- Stable Operation: Flow measurement is unaffected by changes in temperature, pressure, specific gravity, viscosity and/or conductivity above a minimum of 3 Micromhos/cm, over a wide range of ambient temperatures
- DC Magnetic Field: Bi-directionally driven magnetic field
- Automatic Zero - 75 times per sec
- Low Power Consumption
- Interchangeable Electronics
- Potted Coil Housing
- Separate Sealed Customer Wiring Compartment
- Digital Analog Span
- Accuracy: +0.5% of rate
- Compact wafer designed minimum lay length for ease of

Installation

- Light Weight
- Unobstructed flow and low pressure drop

Principle Of Operation

Magnetic flow meters can only be used to measure conductive liquids. In a magnetic flow meter, the liquid is the conductor. Operation of the magnetic flow meter is explained by Faraday's Law, which simply states "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 V x B x D Where: E = The voltage that is generated by the flow of the conductive liquid through the magnetic field of the flow meter. V = The average velocity of the conductive liquid through the cross section of the flow meter. B = The magnetic field strength generated by the field coils. D = The distance between the electrodes which detect the signal voltage (E) that is generated.

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Wafer-Mag
MAGNETIC FLOWMETER

As indicated in Figure 1, a magnetic field is constructed throughout the entire cross section of the flow tube. If this magnetic field is considered as the measuring element of the magnetic flow meter, it may be seen that the measuring element is exposed to the hydraulic conditions throughout the entire cross section of the flow meter.

LINER

The Mag-Cell Teflon liner insulates the electrodes and process liquid from the meter body to prevent the flow tube from short circuiting the flow generated signal voltage.

The Teflon liner affords maximum flexibility in process application as it is suitable for acids, caustics and mild abrasives.

ELECTRODES

The standard Mag-Cell electrode material is 316L Stainless Steel. Ultrasonic electrode cleaning option is not available. However, like the Mag-Flo, the Mag-Cell uses very high input impedance amplifiers. Therefore, coatings with resistance approaching 10 M Ohms on the Mag-Cell electrodes will not normally affect performance.

GROUNDING

Proper earth grounding is required to eliminate stray current and voltage that may be transmitted through the piping system and/or process liquid, or induced by electromagnetic fields in the same area as the magnetic flow meters. Grounding straps are provided with the Mag-Cell and must be properly connected to the mating piping flanges on each end of the Mag-Cell to assure a proper grounding path to the liquid.

MATERIALS OF CONSTRUCTION

Metering tube: 304 Stainless Steel

COIL HOUSING: Steel, Aluminium (½" & 1")

ELECTRONICS HOUSING: Die cast aluminium

PAINT AND PRIMER: Epoxy enamel, Zinc chromate primer, Maximum temperature approximately 93^{o}C

LINER: Teflon, Maximum process temperature 149^{o}C

ELECTRODES: Standard: 316L Stainless Steel; Optional: Tantalum, Titanium, Hastelloy C, Platinum-Iridium

CONNECTIONS

Mechanical: Wafer style ½" through 8" – See ratings below

ELECTRICAL: Two ¾" conduit openings

RECOMMENDED WIRE SIZE: Line power – 12 AWG, Signal – 18 AWG

SPECIFICATIONS

WARNING: Do not operate this instrument in excess of the specifications listed below. Failure to heed warning may result in serious personal injury or damage to equipment.

CAPACITIES: Meter range: 1 to 10 metres/second or 1 to 10 feet/second, jumper selectable with no special calibration required. (Refer to Table 1)

ACCURACY: System: $\pm$0.5% of the rate from 1 unit per second to 10 units per second (1 unit = 1 foot or meter) $\pm$0.005 units per second below 1 unit per second

Analog Output: Add $\pm$0.1% full scale to above accuracy specifications.

REPEATABILITY: 0.25% of rate

PRESSURE LIMITS: 740 psig @ 40^{o}C

TEMPERATURE: Ambient: -18 to 65^{o}C; Process refer to Table 2

PRESSURE DROP: Equal to an equivalent piece of straight pipe.

MINIMUM CONDUCTIVITY: 3 Micromhos/cm

POWER REQUIREMENTS: Selectable by jumper plug – 115 Vac or 230 Vac, $\pm$15%; 47-63 Hz; 10-30 Vdc

POWER CONSUMPTION: 15 Watts maximum

ANALOG OUTPUT: The span of the analog output (20mA dc) is selected using direct reading detent switches to set a maximum velocity for 20 mA dc output between 1.000 m/sec and 10.000 m/sec, regardless of meter calibration. The standard analog output is 4-20 or 0-20 mA dc into a 1000 ohm maximum load.

DIGITAL OUTPUT: The output option board can be set to provide a factored and/or scaled pulse output. Factoring, to convert to engineering unit output (GPM, LPM, M^3/HR, etc.), is accomplished by dividing the pulse output frequency by 1.000 to 15.000 using direct reading detent switches (1.000 to F.000). Scaling is accomplished by setting field-selectable jumper for divide by 1, 10, 100, 1000 or 10,000.

Table 1 Capacity Table – Velocity-to-Flow Conversion Factors 0.15" to 8"*

Meter			Flow in gpm Units = Feet						Flow in gpm Units = Meters							
Model	Size In	Size mm	1.000 ft/sec		10.000 ft/sec		Low Flow Cut-off (1)		1.000 m/sec		10.000 m/sec		Low Flow Cut-off (1)		Guideline Flow 6 ft/sec	
			gpm	lpm	gpm	lpm	gpm	lpm	gpm	lpm	gpm	lpm	gpm	lpm	gpm	lpm
7481E	0.15	4	0.055	0.21	0.55	2.1	0.001	0.004	0.18	0.68	1.8	6.8	0.004	0.02	0.33	1.3
7482E	0.3	8	0.22	0.83	2.2	8.3	0.005	0.02	0.72	2.7	7.2	27	0.02	0.06	1.3	4.9
7485E	½	15	0.86	3.3	8.6	33	0.02	0.08	2.8	10.6	8	106	0.06	0.23	5	19
7401E	1	25	2.3	8.7	23	87	0.05	0.20	7	28	75	284	0.16	0.6	14	53
7415E	1 ½	40	5.5	21	55	208	1.03	0.48	18	68	180	681	0.41	1.6	36	136
7402E	2	50	9.1	34	91	344	0.21	0.79	30	113	300	1136	0.69	2.6	55	208
7403E	3	80	21	80	213	806	0.48	1.8	70	265	700	2650	1.6	6	128	485
7404E	4	100	37	138	365	1382	0.85	3.2	120	454	1200	4542	2.8	10	220	833
7406E	6	150	83	314	830	3142	1.9	7.2	270	1022	2700	10220	6.2	24	495	1874
7408E	8	200	152	575	1520	5753	3.5	13	500	1893	5000	18925	11.5	44	915	3463

* **All values are approximate – actual values will depend on flow tube K-factor**

(1) Low flow cut-off is 2.3% of the selected analog setting adjustable from 23 Hz as listed in the above table through 230 Hz at the MAXIMUM FULL SCALE ANALOG SETTING AT 10 FEET OR 10M PER SECOND

Table 2 Maximum Working Pressures and Temperatures						
Materials (Liner)	**Characteristics (Liner)**	**Available in Meter Sizes**	**Pressure kPa 150/300 lb. Flanges**			**Maximum Allowable Liquid Temperature (1)**
			40°C	**93°C**	**149°C**	
Teflon	Chemical Resistant	0.15" through 8"	5202 kPa	4745 kPa	4605 kPa	149°C

Note (1): Temperature limits may vary depending on liquid being metered.

REMOTE ELECTRONICS

It is also possible to use the Model 3560 Remote Electronics with the Mag-Cell. These electronics provide analog, digital outputs and rate indication 0-100% or engineering units. Eight digit totalizers are also available. The Model 3560 may be mounted up to 1,000 feet from the flow tube.

VELOCITY TO FLOW CONVERSION FACTORS

Table 3 provides its approximate flow conversion factors for the mag-cell flow meter. Actual values are based on the individual meter k-factor for each flow tube, which will vary slightly among meters of the same size. The k-factor for a particular flow tube is stamped on the stainless steel tagged permanently affixed to the flow tube coil housing. Approximate M_{ax} values are listed in table 1.

Table 3 Conversion Factors	
ft^3/sec	2.228×10^{-3}
ft^3/min	1.337×10^{-1}
ft^3/hr	8.021
ft^3/day	1.925×10^{2}
cc^3/min	3.785×10^{3}
litre/sec	6.309×10^{-2}
litre/min	3.785
m^3/hr	0.227
m^3/day	5.451

$$Q\ max = \frac{600{,}000}{K}$$

Maximum Flow Capacity: (Q max.) in gpm

Conversion Factors:

$$\text{To convert } Q = \frac{600{,}000}{\text{K - factor}} \text{ in gpm}$$

Example: Find Q max expressed in litres/sec:

K-factor = 19355 pulses/gal

$$Q = \frac{600{,}000\ \text{pulses/min}}{19{,}355\ \text{pulses/gal}} = 30.999\ \text{gpm}$$

30.999 gpm x 6.309×10^{-2} = 1.956 litres/sec

OPTIONAL EQUIPMENT

PROTECTIVE GROUNDING ORIFICE

In installations where the pipeline is lined (rubber, glass, Teflon, etc.) or of a non-conductive material (PVC, etc.) it is necessary to provide an adequate ground path to the metered liquid.

The protective grounding orifice protects the upstream edge of the meter liner from excessive wear and provides a ground path to the liquid. Standard material for the protective grounding orifice is 316 stainless steel. Tantalum is an available option.

GENERAL INSTALLATION DESIGN INFORMATION

Prior to installation design, the following recommendations should be considered:

When installing the meter, it is important to consider its location. Electromagnetic fields of high intensity may disturb the normal operation. For this reason, it is desirable to locate the flow meter away from large electric motors, transformers, communications equipment, etc. wherever possible.

The flow meter should be kept in its shipping the container until ready for installation. Shipping plugs should remain in conduit connections until the conduit is connected and sealed.

For accurate operation, it is mandatory that the flow meter be installed so that the flow tube will be completely full of process liquid under all operating conditions. When the meter is only partially filled, even though the electrodes are covered, an inaccurate measurement will result

It is desirable that the meter be installed in a vertical pipe run with flow upward. In slurry applications, the vertical position ensures a more even distribution of solids under all flow conditions and minimises the chances of suspended solids adhering to the flow tube.

The position of the flow tube in relation to other devices in the system is also important in assuring system accuracy. Any upstream tee, elbows, valves, etc. should be placed at least five pipe diameters from the flow head to minimise any obstruction or flow disturbances.

LIQUID FLOW CHARACTERISTICS

The characteristics of the liquid to be metered, the liquid flow parameters and the environment of the meter are determining factors in the accuracy of a particular meter

CONDUCTIVITY – electrical conductivity is simply a way of expressing the ability of a liquid to conduct electricity. Just as copper is a better conductor than steel wire, some liquids are better conductors than others. Of even greater importance, however, is the fact that some liquids have a little or no conductivity.

The conductivity of a metered liquid must be at least three Micromhos/cm for use with the flow meter. The conductivity of the liquid can change throughout the process operation as long as it is homogeneous and remains above the three Micromhos/cm threshold.

ACIDS/CAUSTICS – the chemical composition of the product to be measured must be compatible with the meter liner and electrodes to assure maximum service life from the meter.

Refer to the publication such as the corrosion survey, national association of corrosion engineers, etc., to determine the compatibility of the liner for the process liquid. Many process slurries or liquids are designated by the generic name but may contain other substances which affect its corrosion characteristics; therefore, operating experience is often the best guide in determining the corrosive nature of the product in specific applications. In cases where there is no operating experience, it may be necessary to conduct material compatibility tests.

VELOCITY – the maximum (full-scale) liquid velocity must be in the range of 1.000 m/sec (3.28 ft/sec) to 10.000 m/sec (32.8 ft/sec) for optimum meter operation. The velocity through the meter can be controlled by properly sizing the meter. For optimum accuracy, the minimum velocity should be maintained above 1.000 m/sec.

ABRASIVE SLURRIES – abrasive slurries may be handled with this magnetic flow meter provided consideration is given to the concentration of the solids in the slurry and their abrasiveness. The abrasiveness of the slurry may affect the service life of the flow tube and electrodes. Velocity of the product should be limited to 2 m/sec (6.5 ft/sec) maximum. An ideal slurry installation would have the meter in the vertical position with flow upward. This would insure a uniform distribution of solids and avoid having the solids settled in the tube during no flow conditions.

SLUDGE AND GREASE BEARING LIQUIDS – sludges and grease bearing liquids should be measured at higher velocities, above 2 m/sec (6.5 ft/sec) minimum in order to reduce the coating tendencies of the material.

TEMPERATURE – liquid temperature is generally not a problem provided that it is within the flow tube limits –18°C to 149°C for Teflon.

ORDERING INFORMATION

1. Meter size
2. Liner material
3. Electrode material
4. Pressure and temperature requirements (ambient and process)
5. Flow rate (normal, maximum, minimum)
6. Electrical requirements
7. output(s) required
8. Liquid to be metered (name, conductivity)
9. Meter orientation (horizontal or vertical)
10. Accessories required