IE Mag-Flo Electromagnetic Flowmeter

MAGNETIC FLOWMETERS

Description

The IE Mag-Flo 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-Flo 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 signals(s). The IE Mag-Flo 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-Flo 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. Optional analog current or factored/scaled pulse outputs are available for integral or remote mounting.

IE MAG-FLO ELECTROMAGNETIC FLOWMETER

Design Features

- Accuracy: +0.5% of rate
- Pulsed DC Magnetic
- Automatic Zero up to 75 times/sec
- Low Uniform Power Consumption
- Interchangeable Electronics (Integral or Remote)
- Digital Range Adjustment 1 fps to 10 m/sec
- Air Purge Connections
- Field Replaceable Components: Coils, Electrodes (1- 1/2” and larger), and wiring can be field serviced

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 α 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.

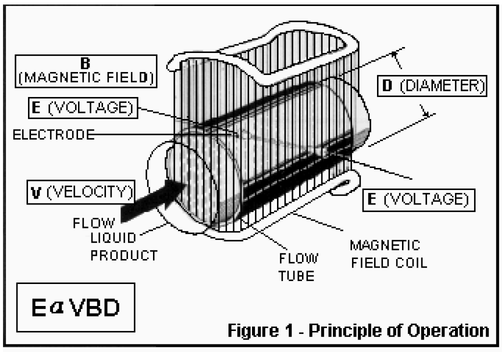

Figure 1 - Principle of Operation

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.

MATERIALS OF CONSTRUCTION

Metering tube: Standard – 304 SS; Optional – 316 SS

Metering tube liner: Teflon, Neoprene, Polyurethane or Gum Rubber (1/2” – 1” Teflon only)

Coil housing: Steel

Electronics housing: Die cast aluminium (Integral); Epoxy coated steel (Remote)

Paint and primer: Epoxy enamel, zinc chromate primer (Maximum Temperature 93^{o}C)

Electrodes: Standard – 316 SS; Optional – Tantalum, Titanium, Hastelloy C276, Platinum, Monel or Carpenter 20

SPECIFICATIONS

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

Temperature: Ambient: -15 to 65^{o}C; Process refer to Table 3

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, $\underline{+}$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, M3/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.

Output load: Load = (supply Vdc – 4 Vdc)*50 ohms; 0 - 800 ohms for units powered by ac or 20 Vdc; 0 - 300 ohms at 10 Vdc input; 0 - 1000 ohms at 24 Vdc input; Reduce 50 ohms per volt when dc is less than 20 volts.

Output over range: 120% without fold-over or latch-up.

Table 1 – Capacities (All values are approximate – actual values depend on tube K-factor)

Meter Model	Meter Size	Flow in LPM Velocity ft/sec			Flow in LPM Velocity mt/sec			Guideline flow @ 6 ft/sec
		1 ft/sec	10 ft/sec	Low Flow Cut-Off	1 m/sec	10 m/sec	Low Flow Cut-Off	
7585	½”	2.3	23	0.02	7.5	75	0.2	15.1
7501	1”	7.9	79	0.2	26.5	265	0.6	49.2
7515	1-1/2”	24.2	242	0.6	79.5	795	1.8	143.8
7502	2”	37.1	371	0.8	128.7	1287	3.0	234.7
7503	3”	98.4	984	2.3	321.7	3217	7.6	590.5
7504	4”	166.5	1665	3.8	548.8	5488	12.5	1006.8
7506	6”	374.7	3747	8.7	1230.1	12301	28.4	2244.5
7508	8”	643.4	6434.5	15.2	2108.3	21082.4	45.4	3853.1
7510	10”	1006.8	10068	22.7	3300.5	33005	75.7	6033.3
7512	12”	1423.2	14232	34.1	4666.9	46669	106	8909.9
7514	14”	1718.4	17184	37.9	5639.7	56397	128.7	10317.9
7516	16”	2259.6	22596	53	7418.6	74186	170.3	13569.2
7518	18”	2876.6	28766	68.1	9443.6	94436	215.7	17267.2
7520	20”	3546.5	35465	83.3	11635.1	116351	268.7	21275.5
7524	24”	5117.3	51173	117.3	16786.5	167865	386.1	30700.1
7530	30”	7993.9	79939	185.5	26230.1	262301	601.8	47974.9
7536	36”	11756.2	117562	268.7	38569.2	385692	885.7	70556.2
7542	42”	15953.8	159538	367.1	52346.5	523465	1203.6	95745.4
7548	48”	20904.6	209046	480.7	68584.2	685842	1578.3	125427.3
7554	54”	25908.3	259083	594.2	84973.3	849733	1953.1	1554450

Accuracy: System: $\underline{+}$0.5% of the rate from 1 unit per second to 10 units per second (1 unit = 1 foot or meter) $\underline{+}$0.005 units per second below 1 unit per second

Analog Output: Add $\underline{+}$0.1% full scale to above accuracy specifications.

Repeatability: 0.25% of rate

Pressure limits: Refer to Table 2 & 3

Low flow cut off: Factory set to 2.3% of analog span.

PZR (Positive Zero Return): Drives the output from the electronics to 0 Hz frequency and 4-mA dc upon a dry contact closure. The dry contact closure is user provided and can be activated by a pump or valve control switch. It should be used to prevent erratic output whenever process control results in the flowhead becoming empty.

Table 2 – Pressure Limits

Meter Size	Flange Rating (psi)	Teflon Liner (psi @ 300°F)	Gum Rubber Liner (psi @ 185°F)	Neoprene Liner (psi @ 185°F)	Polyurethane Liner (psi @ 150°F)
½" – 16"	150	230	260	260	270
	300	655	685	685	705
18" – 24"	150	230	260	260	270
30"	150	150	150	150	150
36"	150	-	150	150	150
42"	150	-	150	150	150
48"	150	-	150	150	150
54"	150	-	150	150	150

LIQUID FLOW CHARACTERISTICS

The characteristics of the fluid to be metered and the environment of the meter are determining factors in the accuracy of a particular meter.

Table 3 – Maximum Working Temperatures

Material	Characteristics	Maximum Liquid Temp.
Teflon	Chemical Resistant	149°C
Neoprene	Abrasion Resistant	85°C
Gum Rubber	Abrasion Resistant	85°C
Polyurethane	Abrasion Resistant	65°C

A. Conductivity

Electrical conductivity is simply a way of expressing the ability of the liquid to conduct electricity. Just as copper wire is a better conductor than steel wire, some liquids are better conductors that others. However, of even greater importance is the fact that some liquids have little or no conductivity. The conductivity of the metered liquid must be at least three Micromhos/cm for use with the flowmeter. The conductivity of the liquid can change through the process operation as long as it remains above the three Micromhos/cm threshold.

B. 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 a standard publication to determine the correct liner material for the process liquid. Many process slurries or liquids are designated by a 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.

C. Velocity

The liquid velocity must be in the range of 1 to 10 m/sec (32.81 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 above one unit per second (one foot for electronics set in the feet mode or one meter for electronics set in the meters mode).

D. Abrasive Slurries

Abrasive slurries may be handled with this magnetic flowmeter, 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 approximately 2 m/sec (6.5 ft/sec) maximum. An ideal slurry installation would have the meter in a vertical position with flow upward. This would ensure a uniform distribution of solids and avoid having the solids settle in the flow tube during no flow conditions.

E. 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. For a quick reference, refer to Table 1 and the guideline number.

F. Temperature

Liquid temperature is generally not a problem provided that it is within the flow tube liner limits (Refer to Table 3).

G. Liners

Magnetic flow meters are constructed with metallic tubes and flanges. It is necessary, therefore, to incorporate a non-conductive lining material to insulate the electrodes and liquid from the meter body to prevent the flow tube from short-circuiting the generated signal voltage. The selection of a specific liner material depends on three conditions: abrasion, corrosion and temperature. In a questionable application, information may be gained by knowledge of any lining existing in the intended pipeline. The user must make final choice of a liner material. Refer selections available under MATERIALS OF CONSTRUCTION.

H. Electrodes

Abrasion and corrosion must be considered in the selection of electrode material. Several types are available in field replaceable or non-field replaceable designs. The electrodes in the Mag-Flo are field replaceable in all 1-1/2" and larger size flow tubes. Meters for sanitary service or those meters with platinum or tantalum electrodes, are non-field replaceable. Because the electrodes are in contact with the process liquid, it is necessary to drain the meter before removing the electrodes. The replaceable electrode assembly consists of the electrode, available in several designs, and a non-field replaceable electrode housing. To prevent corrosion of the electrode and electrode housing, both must be of the same material. Coatings with a resistance of up to 1 x 10-12 k ohms on the electrodes will not normally affect performance; so most installations will not require electrode-cleaning options. The field replaceable feature enables changing from standard to bullet nose electrodes which project into the higher velocity portion of the process stream to enhance self cleaning by velocity energy. For coating process liquids, ultrasonic or heated/ultrasonic electrodes are available.

I. Grounding

Grounding is required to eliminate stray current and voltage, which may be transmitted through the piping system, the process liquid, or induced by electromagnetic fields in the same area as the flow meter. Grounding is achieved by connecting the piping system and flow meter to a proper earth ground. Grounding straps from each meter flange to the pipe-mating flange may be used but are not normally required.

1. In conductive piping systems, the 'third wire' safety ground to the power supply and a conductive path between the flowmeter and the piping flanges is normally all that is required.
2. In non-conductive or lined piping systems, at least one grounding ring or probe (12"flow meters and larger), must be supplied to provide a conductive path from the process liquid to the flowmeter.

Grounding rings are flat plate rings, which serve two functions. One function is grounding and the other is liner protection, depending on the application. Protective orifices are used in installations where the process liquid is abrasive. The leading edge of the liner is exposed to excessive wear from being impinged against by the slurry. To minimise this wear, a protective orifice is placed at the inlet end of the flow tube to cover the face and leading edge of the liner.

Grounding rings are used in installations where the pipeline is lined or made of a non-conductive material and it is necessary to provide a ground path to the liquid from the flow tube. This is accomplished by installing at least one grounding ring at the inlet end of the meter. A second grounding ring may also be required at the outlet end of the meter for liner protection. The grounding ring at the inlet of the meter may also function as a protective orifice. For flow meters 12" and larger, grounding probes are often a more economical method of sensing liquid potential than grounding rings. Probes are available in pairs for installation in ¾" NPT taps adjacent to each end of the flow meter and easily assembled by connecting the straps from the grounding probes to the flow meter using the threaded holes in the flanges.

GENERAL INSTALLATION/DESIGN INFORMATION

Prior to installing the flow meter, the following installation recommendations should be considered.

When installing the flowmeter, 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 flowmeter away from large electric motors, transformers, communications equipment, etc.

For accurate operation, it is mandatory that the flowmeter be installed so the flow tube will be completely full of process liquid under all operating conditions. When the meter is only partially filled, even though 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 obstructions or flow disturbances.

NOTE: Installation in vertical line with flow-up through the meter is preferred to assure that the meter is filled with liquid under all conditions.

NOTE: Electronics box on Mag-Flo can be oriented for access in either horizontal or vertical piping arrangements if specified at the time of order placement.

In some installations, due to space limitations, the standard mounting of the integral electronics/terminal enclosure cannot be used. The enclosure can be rotated in 90 degrees increments for these installations.

The customer must supply gaskets for each flow head, selecting them for compatibility with the piping and process conditions. The gaskets, flow head flanges and mating pipe flanges must be thoroughly dusted with gasket talk powder prior to installation. This is a precaution to prevent flowhead liner damage if the flow head must be removed from the line.

In order to prevent liner damage in applications where the meter must routinely be removed from the process piping, grounding rings, protective orifices or spool pieces should be installed.

NOTE: The flowmeter will measure flow in either direction by changing a jumper in the electronics assembly.

Location:

When selecting a location, remember that most electrodes, electrode leads, coils and printed circuit boards are field replaceable. Access should be provided to the meter to permit replacement of these parts.

COMPLETE REMOTE ELECTRONICS (CRE)

The CRE may be mounted up to 1,000 feet from the flow head (cable distance).

NOTE: Stray magnetic and electrostatic fields may cause some disturbance in operation. For this reason it is desirable to locate the electronics away from large electric motors, transformers, communication equipment, etc.

The CRE should be mounted to a vibration free wall or column with consideration given to reading the indicator/totalizer and servicing the internals.

NOTE: The CRE enclosure is rated for weather and corrosion resistance (NEMA 4X). However, whenever possible, the CRE should be located out of direct exposure to the elements. Consideration should also be given to protecting the enclosure from mechanical and/or chemical abuse.

The following wiring practices should be followed:

1. Conduit should conform to any applicable safety regulations and be sealed to prevent moisture entry.
2. The conduit should not run parallel to any power lines. If the conduit must cross a power line, it should cross at a right angle.
3. Conduits should not be run close to large induction equipment.
4. Do not run more than four bundles from four flowmeters in a single conduit.
5. The following conduit routing should be followed. The conduit numbers indicate their position from left to right

at the bottom of the unit, followed by the size of the conduit for each connection.

(3/4” NPT) Coil Drive and Electrode Cables

(3/4” NPT) Input Power

(3/4” NPT) Signals Out

(1/2” NPT) Pneumatic Purge

6. Field coil and electrode signal cable, must be a four conductor, $0.5mm^2$, individually shielded and twisted pair, along with overall shielding.

The remote electronics should be wired in accordance with the wiring diagram adjacent to the terminal block.

IE MAG CALIBRATOR MODEL 7797

IE Mag Calibrator Model 7797 is the recommended way to calibrate IE Series III Magnetic Flowmeter Electronics. The Calibrator produces a simulated flow signal of 12 meters/second to replace the transmitter (flow head) input. A second digital output of 0.000 to 9.999 units/second is used to range the analog output. The following is a detailed description of Calibrator and the calibration procedure for the electronics. The Calibrator front panel contains five pushbutton switches, one four-station thumbwheel switch and two LED’s. The functions of the switches are as follows:

Velocity Thumbwheel Switches

The VELOCITY switches are used when calibrating the analog output sections of the electronics when the factor option board is not supplied. The four-digit number (X.XXX) represents the flowmeter’s full-scale flow velocity in the units selected (units are determined by the setting of the flowmeter electronics in either feet or meters). During the calibration procedure, the setting of the velocity switches may be changed to check other ranges.

Flow Head/Analog Switch

The FLOW HEAD position is used when adjusting the reference voltage of Series III electronics. The ANALOG position enables the velocity switches on the front panel of the calibrator. The velocity switches allow you to set the full-scale flow velocity when calibrating the analog section of the flowmeter electronics.

Full Scale/Zero Switch

The FULL SCALE/ZERO switch is used for both flow head and analog calibrations. During a flow head calibration, the full-scale position sends a representation of the electrode signal to the flowmeter electronics. This enables the operator to adjust the reference voltage as described for the flow head switch at both full scale and zero values. The full-scale position sends a simulated 12 m/sec, or ft/sec, signal to the electronics (see Feet/Meters Switch below). The zero position sends a “no flow” signal to the flowmeter electronics. During an analog calibration, the full-scale position will output a signal to the flowmeter electronics equivalent to the setting of the velocity switches. When adjusting the full-scale analog output, the velocity switches should be set to process full-scale velocity. The zero position will output a zero velocity signal enabling the analog zero to be set.

Feet/Meters Switch

The position of this switch must match the setting of jumper J7 on the signal conditioner board of the flowmeter electronics; if the electronics under calibration are set to operate in the feet mode, the calibrator must be set to feet also.

Load/No Load Switch

During the calibration procedure for the Series III electronics, a coil load must be provided. For integral electronics with the six-pin jumper plug on the calibrator connector (J2), use the 7797 calibrator with the NO LOAD switch position key depressed. For remote electronics (CRE), which has a cable attached to the six-pin connector (J2), use the 7797 calibrator with the LOAD switch position key out.

Forward/Reverse Switch

This switch determines the phase of the calibrator output representing the electrode signal. The switch setting is determined by the position of the jumper J13/12 on the Signal Conditioner Board. If the jumper is in the J13 (forward flow) position, set the calibrator to FORWARD and if the jumper is in the J12 (reverse flow) position, set the calibrator to REVERSE.

ORDERING INFORMATION

The following information is required when ordering:

1. Meter Size
2. Connection Type and Rating
3. Liner Material
4. Electrode Material and Type
5. Pressure and Temperature Requirements (Process and Ambient)
6. Flow Rate: Normal, Maximum and Minimum
7. Electrical Requirements
8. Output Required
9. Name and conductivity of liquid to be measured
10. Accessories Required