

INTRINSICALLY SAFE

MODEL I-106

LIQUID FLOW MEASURING SYSTEM FOR
INDUSTRIAL PROCESS APPLICATIONS

OPERATING MANUAL



McMillan

C•O•M•P•A•N•Y

P.O. BOX 1340

GEORGETOWN, TX. 78627-1340

PHONE: (512) 863-0231

TOLL FREE: 1-800-861-0231

FAX: (512) 863-0671

E-MAIL: tech@mcmillancompany.com

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U.S.A. Patents: 4,467,660
 5,542,302
 5,728,949

Other patents pending

FOREWORD



INTRINSIC SAFETY

Intrinsic safety reduces the risk of ignition by electrical apparatus or connecting wiring in hazardous locations.

The McMillan I-106 Flow Sensor when connected to the I-MSB-4 Barrier and installed according to instructions in this manual is a CSA and FM approved intrinsically safe system for measuring the flow of a liquid in a hazardous environment.

Risk of explosion, when operating the McM I-MSB-4 and I-106 is reduced when the apparatus is installed and operated within it's designated parameters.

Reducing risk of explosion related to mechanical, electrostatic sparking, chemical action, radio waves, or lightning strikes is not a requirement of intrinsically safe systems. Protection against such events should also be employed.

INTRODUCTION

FIRST THINGS FIRST

Your I-MSB-4 Barrier and I-106 Flow Sensor were packed by the manufacturer in such a way that you should receive it with no damage. If external damage is noted upon receipt of the package, please contact the shipping company (not McMillan Company) immediately. McMillan Company will not be liable for damage to the device once it has left the manufacturing premises.

UNPACKING THE DEVICES

After external inspection of the package, proceed to open the package from the top, taking care not to cut too deep. Remove all documentation (if any) resting on top of the packing material. Inspect all products for concealed shipping damage. If damage is noted, please contact the shipping carrier and/or McMillan Company to resolve the problem.

When unpacking the products from the shipment, please take care to remove *all* products from the box. Check thoroughly for extra cables, power adapters, and other options listed on the packing slip, if any.

CAUTIONS AND WARNINGS

Take care not to drop your MSB or Flow Sensor. Read the INSTALLATION section before providing power to the system. Any damage inflicted by the customer will not be repaired under warranty by McMillan Company. Follow wiring suggestions.

PRINCIPLE OF OPERATION

The McMillan model I-106 flow measuring system is capable of measuring extremely low liquid flow rates from 15 mL/min to 50 L/min. these sensors are suitable for a wide variety of industrial, commercial, and laboratory flow applications.

The flow sensors use a fast response Pelton type turbine wheel to determine the flow rate of a liquid. Rotation rate of the turbine wheel is linear over a large dynamic range. The electro-optical system consists of a diode emitting energy in the infrared spectrum. Light energy is interrupted and passed from 8 small holes in the rotating turbine wheel. The light-energy pulses are detected by means of a photodiode. As the turbine wheel rotates in response to liquid flow rate, electrical pulses are generated to drive a BOSFET optically isolated switch. Thus, opto-isolated, passive electrical pulses are produced. The on-off frequency of the pulses are proportional to the flow rate.

The Model I-106 Flow Sensor has PTFE, PFA, Kalrez®, and sapphire as wetted surfaces, has excellent life expectancy, and can be used in high purity and corrosive applications.

The I-MSB-4 is a single channel, grounded barrier that prevents all excess energy from a fault occurring on the safe side from reaching the hazardous area. Under normal conditions, the barrier allows the circuit to function properly by supplying power to the flow sensor and by allowing the signal to pass from the flow sensor to the recording or monitoring device. In a fault condition, the barrier limits voltage and current to levels that are not sufficient enough to cause ignition.

The barrier limits input energy via a series string diode, resistor, and fuse network followed by 4 parallel shunt connected zener diodes. The zener diodes regulate the output voltage to approximately 12 vdc and shunts excess input energy to ground. If a fault causes input current to exceed .125 amps. or the signal path to exceed .080 amps. the internal fuses will open and render the barrier inoperative, thus providing safety to the hazardous area.

The I-MSB-4 output signal is a square wave frequency generated by an optically isolated BOSFET switch. The output signal is the frequency of the flow sensor wheel pulses divided by F/2, F/3, or F/4 (switch selectable).

SPECIFICATIONS

SYSTEM

Rated for hazardous location: Class I, Division 1, Groups C & D.

FLOW SENSOR

- **APPLICABLE LIQUIDS:** Many low viscosity, transparent or translucent liquids.
Best performance is obtained with viscosity of < 10 centistokes.
Compatible with PTFE.
- **WETTED MATERIALS:** PTFE (Teflon®), Kalrez®, Viton®, PFA fittings, sapphire.
- **ACCURACY/ LINEARITY:** +/- 1.5% for flow rates of 20-100% of full scale. Calibration at factory with De-ionized water.
- **REPEATABILITY:** +/- 0.2% for flow rates of 20-100% of full scale except for the 20, 30, and 50 L/min flow sensors which are for flow rates of 25-100% of full scale.
 - Accuracy and linearity of +/- 0.5% can be obtained with addition of the McM Model 251 option.
- **TEMPERATURE RANGE:** 10-55 degrees C.
Storage temperature is 0-70 degrees C.
- **TEMPERATURE SENSITIVITY:** +/- 0.2% / deg. C.
- **PRESSURE RATING:** 60 psi maximum working pressure.
- **FLOW CONNECTIONS:** PFA tubing fittings standard.
PFA flare fittings available as option.
- **CLEANING:** 18 Meg. De-I water rinse.
- **DIMENSIONS:** I-106...2.45 x 1.88 x 2.13 (inches) without fittings.
I-106H...5.00 x 4.10 x 2.85 (inches) without fittings.
I-MSB...4.25 x 2.77 x 1.44 (inches).
- **MOUNTING:** I-106--- Back side mount of flow sensor...4-40 screw-holes, (or mounting plate).
Front side mount of flow sensor...polypropylene plate (option).
I-106H..Mounting ears with 2 holes on 2" centers, .25" dia.
I-MSB...Standard DIN clip.
- **WEIGHT:** 1.6 LB. (4 LB. Shipping, standard units).
- **FAIL SAFE:** For critical applications mandating an un-interruptible flow, a stuck sensor wheel will *NOT* impede the flow of a liquid through the flow sensor.

ELECTRICAL

POWER

- Input to I-MSB-4: 24vdc +/- 2vdc, 70 ma. typ.
- Polarity is internally diode protected in the MSB.

- Current is limited and fused at 125 ma.
- A user supplied power supply of transformer isolated design, capable of at least 150 ma. at 24 vdc. should be provided to supply power to both the flow sensor system and the output pulse power.
- The output pulse switch may also be powered from another source, if desired.

OUTPUT

- Opto-Isolated pulses – bi directional MOSFET switch.
- Isolation greater than 1kv.
- Pulse rate is proportional to flow rate.
- Switch selectable frequency divided ranges
- 0-5 volt amplitude standard, 0-35 volts max. @ 20 ma. (user determined).
- Lowest flow range (15-100 mL/min) produces approximately 180 HZ at full flow.
- Highest flow range sensors produce up to 600 HZ at full flow which is divided by the I-MSB by F/2, F/3, or F/4.
- Current limited and fused at 80 ma.
- Power source for output switch is user supplied. In some cases, the output switch need not be powered, depending on the requirements of the device that receives the pulses.

CONSTRUCTION

- This system is rated Installation Category I, Pollution Degree 2.
- The I-106 is rated NEMA-4X / IP65.
- The I-106 electronics is epoxy encapsulated in a splash proof Ryton® PPS housing with Viton® O-ring seals.
- The I-106 connection to the I-MSB is a 12ft. (3.6m.) 20 AWG 2 pair, shielded with drain wire, type ALPHA 2466C cable. Any length up to 100 ft. of cable can be supplied upon request.
- The I-MSB electronics is epoxy encapsulated in a PVC housing.
- The MSB must be installed in a weather protected environment in accordance with document ANSI/ISA S82.01 and S82.03. A dust and moisture free NEMA 4 or 12 enclosure is recommended.

Specifications are subject to change without notice.

Teflon®, Viton®, Kalrez® - Registered trademark of E.I. du Pont de Nemours & Co.

Ryton® - Registered trademark of Phillips Petroleum Co.

INSTALLATION

MECHANICAL

A common installation problem is caused to not allowing sufficient upstream and downstream straight-run plumbing for the flow sensor. Inlet and outlet should be straight-run tubing, matched to the fittings with no needle valves, shut off valves, or sharp bends in the tubing near the flow sensor. Without a normal flow pattern provided by proper plumbing, accuracy and performance can be adversely affected. Observe that the direction of flow of liquid through the flow sensor is correct. Inlet and outlet tubing should be kept straight-line for 10 to 30 diameter lengths for the input and 5 to 20 diameter lengths for the output.

If there is any possibility of entrained particulate matter being of sufficient size to affect operation of the flow sensor, a filter of proper size and mesh should be placed in line ahead of the flow sensor.

Either standard or customer specified fittings are supplied with the flow sensor.

The flow sensor should be mounted either flat or in a vertical position with the flow path being upward. This aids the escape of entrapped air bubbles that will affect the response of the flow sensor. Route the outlet line so liquid will not drain out and allow air near the outlet of the flow sensor. Air bubble induced turbulence near the outlet of the flow sensor can cause erratic signal output symptoms.

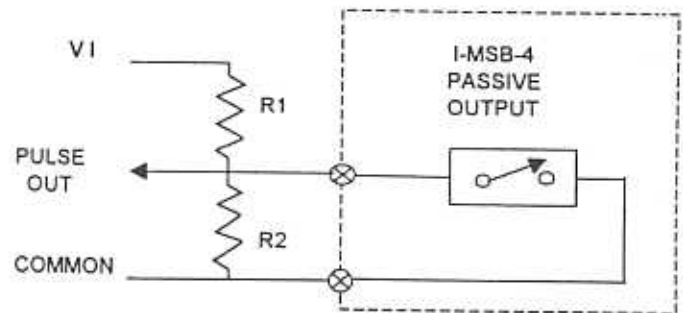
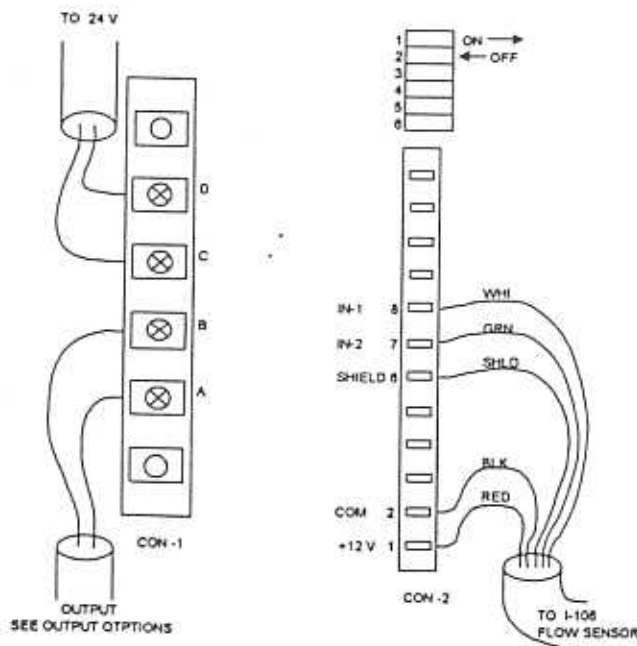
The I-MSB-4 clips on to a standard DIN rail.

An alternative is mounting with good quality double sided adhesive tape with the DIN clip removed.

ELECTRICAL

When installing the I-MSB-4 barrier, connect the I.S. ground wires first. Both wires should be connected to ground. When disconnecting the MSB, the I.S. ground wires should be disconnected last.

Take care to install wire ends into the terminal blocks as marked on the MSB device and as noted on the control drawing. Strip wire insulation to approximately 0.18 inches. Must have no frayed ends which can short to other terminals. The I-MSB-4 requires a power input of 24 vdc. This may be supplied near the MSB or from a source some distance away using twisted pair shielded cable. The output pulse (passive) should be connected with twisted pair shielded cable to provide for maximum noise rejection and best signal performance when using long cable lengths. Select a voltage source and current limiting resistors for the pulse output that provides for "ON" currents of typically 1 up to 20 ma. through the passive output. Connect wire cable shields to metal panels or earth grounded chassis - (NOT to MSB terminals). The I-106 connects to the MSB via a shielded cable permanently attached to the I-106. Do NOT connect any other wire or device to this dedicated connector.



EXAMPLE: $V_i = 15\text{VDC}$, $R_1 = 2\text{K}$, $R_2 = 1\text{K}$
THUS $V_{out} = 5\text{V}$, $I = .005\text{A}$

If V_i is 5 VDC, R_2 can be eliminated
and $V_{out} = 5\text{V}$.

Pulse output height is approximately $V_i \times (R_2 / (R_1 + R_2))$. Keep $V_i < 36$ vdc. Be sure that V_i / R_1 does not exceed 20 ma.

Resistors used to produce the desired pulse output can be standard 5% composition types – verify power to select resistor wattage. R_1 wattage = $V_i \times V_i / R_1$. (example: $15 \times 15 / 2K = 0.113$ worst case, so choose a 1/8 or 1/4 watt resistor for R_1). R_2 wattage = $V_{out} \times V_{out} / R_2$. (example: $5 \times 5 / 1K = 0.025$ watts so choose a 1/8 watt resistor). R_2 is not required if V_1 is the same as V_{out} – be sure that R_1 does not allow Maximum current to exceed 20 ma. through the passive switch ($V_i / R_1 < 20$ ma.). The V_i source should be low impedance and low noise. The 24 volts that supplies the MSB may be used.

FREQUENCY DIVIDER SWITCH SELECTION I-MSB-4

Selector switches provide for frequency division of F/2, F/3, F/4. See chart below.

	SWITCH NUMBER					
	1	2	3	4	5	6
F/2	ON	OFF	ON	OFF	OFF	OFF
F/3	OFF	ON	OFF	ON	OFF	ON
F/4	OFF	ON	ON	OFF	ON	OFF

Example: If a calibration point of sensor I-106-6 is 303 HZ at 1.0 L/min, then F/2 provides a frequency of 151.5 HZ at the I-MSB-4 output for 1.0 L/min. flow.

FLOW RANGES

Model Number	Flow Range	Max. Pressure Drop	Standard Fittings	"F" version fittings
106-3	15-100 mL/min	12 psi	1/8" tube	3/8" flare
106-4	30-200 mL/min	10 psi	1/4" tube	3/8" flare
106-5	50-500 mL/min	10 psi	1/4" tube	3/8" flare
106-6	100-1000 mL/min	6 psi	1/4" tube	3/8" flare
106-7	200-2000 mL/min	10 psi	1/4" tube	3/8" flare
106-8	400-5000 mL/min	10 psi	3/8" tube	3/8" flare
106-9	1.0-10.0 L/min	10 psi	3/8" tube	3/8" flare
106H-20	2.5-20.0 L/min	3 psi	3/4" flare	
106H-30	4.0-30.0 L/min	4 psi	3/4" flare	
106H-50	7.0-50.0 L/min	10 psi	3/4" flare	

Range and pressures are for water or similar viscosity. Pressure drop is typical at maximum flow rate. Pressure drop at 50% of range is 1/4 of maximum.

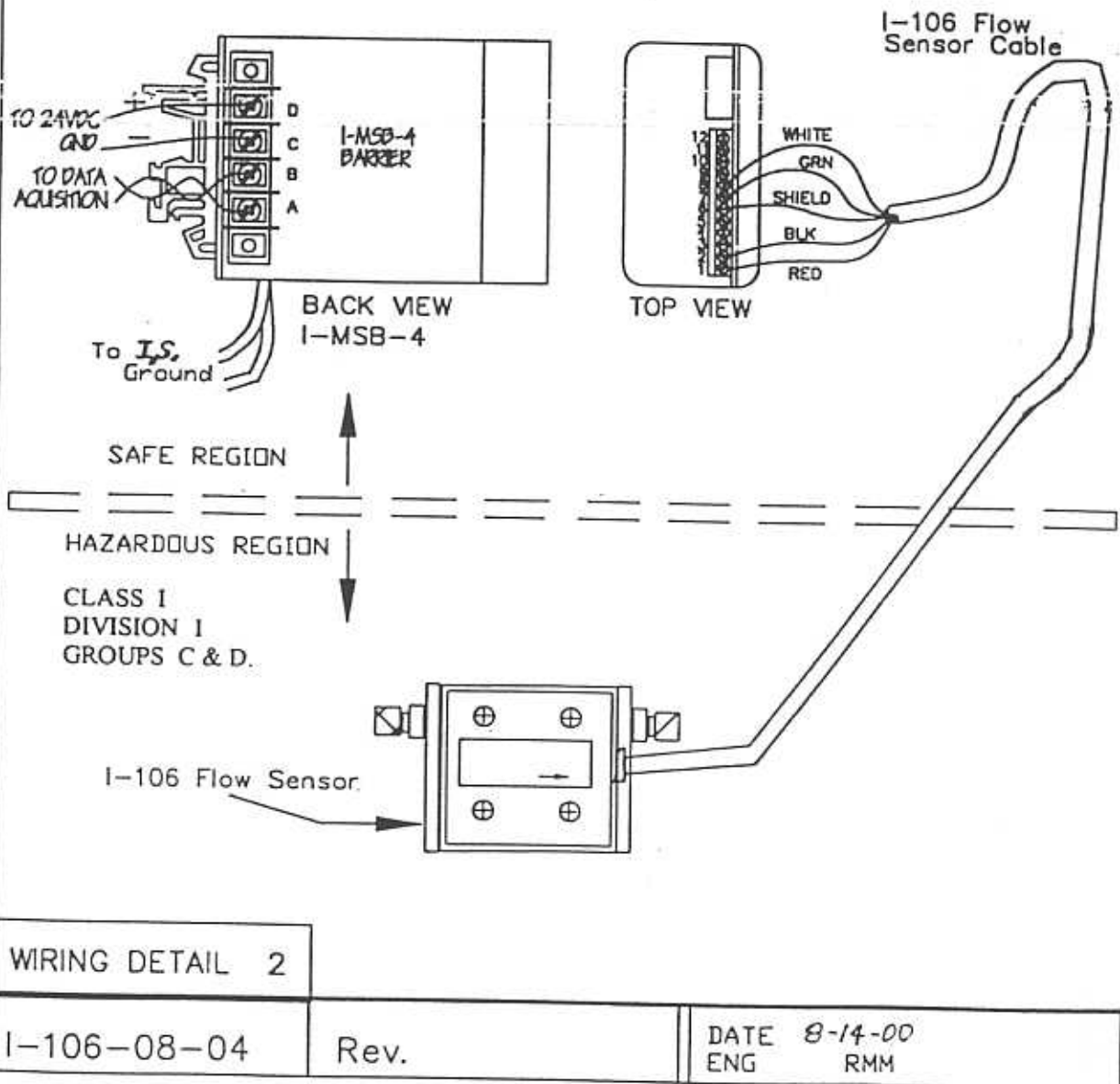
The above are standard ranges and fittings, custom ranges and fittings are available.

SAFETY SUMMARY

WARNING:

Be careful not to exceed voltage, temperature, or other parameters under SPECIFICATIONS.

This system, when installed and maintained according to safety regulations, local codes, and instructions in this manual, is CSA and FM approved INTRINSICALLY SAFE. If equipment is used in a manner not specified by the manufacturer, the safety and operation of the equipment can be impaired.



INSTALLATION NOTES

1. Maximum non-hazardous area voltage must not exceed 250 volts.
2. For installations in Canada, install in accordance with the Canadian Electrical Code, Part I.
3. For installations in the United States, install in accordance with the National Electrical Code (ANSI/NFPA 70) and ANSI/ISA RP12.6.
4. Information on installation, maintenance, and operating instructions is included in the instruction manual.

CALIBRATION

McMillan Company precision Flow Sensors are designed to give excellent performance and life expectancy. Accuracy, linearity, and repeatability for each flow sensor model have been determined by extensive testing.

The flow sensors are calibrated using De-I water at various flow rates. A calibration sheet accompanies every flow sensor stating flow rate vs. frequency output of the turbine wheel at ambient temperature and barometric pressure.

Each flow sensor is calibrated referenced to a flow meter that has been calibrated by time-volumetric and NIST traceable methods. Flow rates are calibrated at 100%, 50%, 20%, and the higher range flow sensors being able to measure a 10% point of full scale.

The calibration values stated in the calibration sheet are referenced to full-scale flow rates, the frequency being F/1 (or before the frequency division of the I-MSB-4).

The flow sensor wheel bearings are designed for extremely low friction and exceptionally long life, which results in excellent repeatability characteristics. Due to the small amount of inherent liquid drag on the sensor wheel, which inhibits it from turning at very low flow rates, there is a small amount of offset in the output frequency (HZ) to flow rate relationship.

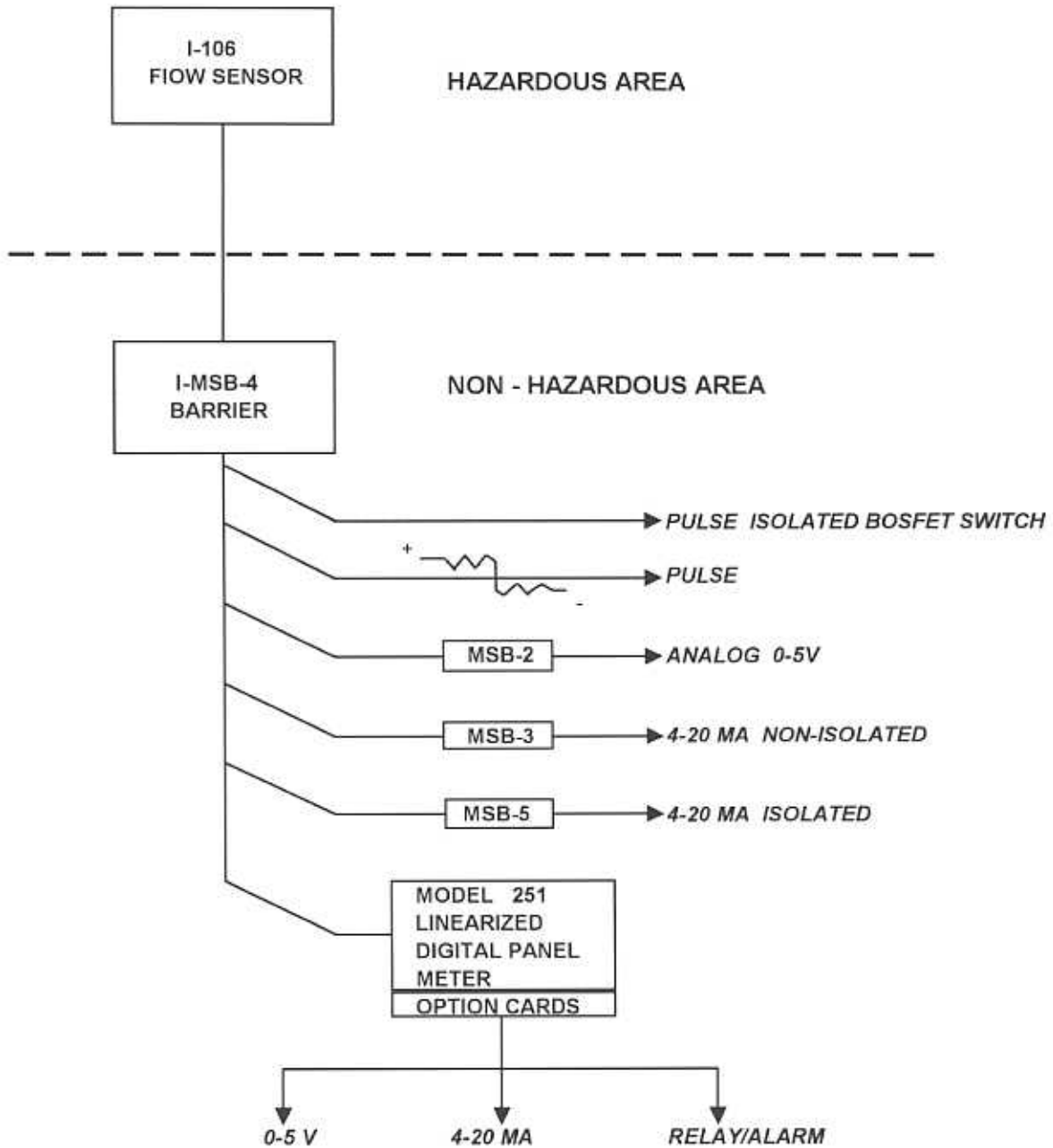
Flow rate response can be displayed to $\pm 0.5\%$ with the addition of McMillan Model 251 Digital Panel Meter that performs slope, offset, and multi-point correction.

There is no calibration for the I-MSB-4. It simply provides for frequency division and isolation of the signal.

OPTIONS / ACCESSORIES

- Model 251 Totalizer or Flow Rate Display Panel Meter.
Converts pulse output from the I-MSB-4 to a digital displayed count or flow rate in any engineering units. Multi-point correction (up to 9 points) can improve accuracy and linearity of the flow sensor output to $\pm 0.5\%$. Optional plug in cards provide outputs for up to 4 setpoints (alarms) with relay contacts, and analog signals of 0-5v. and 4-20 ma.
- MSB-2 Analog 0-5 volt output.
- MSB-3 4-20 ma. Non-isolated output.
- MSB-5 4-20 ma. Isolated output
- NIST traceable Calibration Certificate
- Polypropylene base plate for mounting flow sensor.
- Teflon coated flow sensor end plates for corrosion resistance.

SYSTEM OUTPUT OPTIONS



ANY OF THE ABOVE OUTPUT OPTIONS, WHEN TAKEN FROM THE OUTPUT OF THE I-MSB-4, OPERATES AS PART OF THE USER DATA ACQUISITION SYSTEM AND THUS DOES NOT AFFECT THE INTRINSIC SAFETY OF THE FLOW SENSOR SYSTEM.

MAINTENANCE

Normally no maintenance is required.

Applications where fouling or coatings can occur may require periodic flushing. If performance of the flow sensor becomes sluggish or inaccurate, flushing may be necessary. Frequency of flushing will be determined by the severity of contamination. The liquid medium used for flushing must be compatible with the materials of the flow sensor. Do not exceed the flow and pressure ratings of the flow sensor when flushing. Do not flush with air or gas, over-spin can damage the sensor wheel bearings.

TROUBLESHOOTING

WARNING:

Care must be exercised when troubleshooting problems with the flow sensor system so as not to violate the Intrinsic Safety of the system or cause damage to the flow sensor components.

To troubleshoot the flow sensor system, it shall be in a safe environment. The procedures to assure that condition will have been established by local authority, either by rendering the hazardous area safe or removing the flow sensor system from the hazardous area.

First determine whether the fault is a mechanical flow related problem or an electrical malfunction.

1. Determine that a flow of proper rate is flowing through the flow sensor.
2. Check dip switches set for desired frequency division. There are some combinations of switch settings where there is no output.
3. Using a voltmeter of 10 Meg. input impedance, polarity set on DC, range set to view at least 24 vdc. Check for the following conditions:
 - a. I-MSB input power, connector-1, pins C to D: Meter should read 24v. nom.
 - b. I-MSB output power to I-106, connector-2, pins 1 to 2: Meter should read 12v. nom.
 - c. I-MSB signal, connector-2, pins 7 to 8: This should be a square wave switching between 0 and 12 volts. The voltmeter (on a DC range), will show a somewhat varying voltage of approximately 6 volts (the average of the waveform). A steady voltage of 0 or 12 volts indicates that flow is not sensed and the I-106 flow sensor must be replaced.
 - d. If step "C" checks good, then monitor I-MSB connector-1, pins A to B. The signal out should be a square wave, frequency determined by the flow rate and the I-MSB frequency division switches. The amplitude of the signal will be determined by the requirements of the device that receives this signal. Remember that the output switches do not generate any power on their own, they only operate as open and closed switch contacts.
 - e. If there are no divider resistors used, then remove the output signal wires from connector-1, pins A and B. Remove the white and green wires from Connector-2, pins 7 and 8. With a multimeter set on lowest ohms range, measure across connector-1, pins A & B. At the same time, alternately jumper and release connector-2 pins 7 & 8 with a short piece of wire (or a paper clip bent into the shape of a U). the ohmmeter will alternately indicate a reading of approximately 20-30 ohms, (closed circuit), and infinity (open circuit). Just look for the output to change. The unconditioned wire "switch" will not give a controlled number of pulses to the input but will cause the output to change. If output does not respond to the changes on the input, then the I-MSB-4 must be replaced.
4. The easiest way to determine and cure the fault is to replace one or the other of the modules with spare units (if available) until the fault is found.

REPAIR

There are no user serviceable parts. Electrical components are sealed and encapsulated and each electronic module must be replaced if it becomes defective as a result of electrical or physical damage.

Keep in mind that the design parameters for Intrinsic Safety for this device requires that the internal fuses will limit the amount of energy that can be absorbed if an overload occurs. The fuses will "open" before energy levels reach a level that could cause ignition, and thus protects the hazardous area. Once a fuse opens, the device must be replaced. Replacements due to over-currents causing the fuse to open for any reason, will not be considered as warranty. PLEASE BE CAREFUL.

If it becomes necessary to return a flow sensor for repair or replacement of the electronics module, contact the factory. RMA numbers are required to be assigned. See below:

RETURNS

To return a product for repair to McMillan Company, please call first and request a RMA (Return Manufacturer Authorization) Number.

No returns will be accepted without the RMA number clearly visible on the outside of the box. Call McMillan Company to request a RMA.

Include model number and reason for return – call (512) 863-0231 or FAX the request to: (512) 863-0671

Shipping Address: Service Department, 7075 RR 2338, Georgetown, Texas 78628

Once the product is received by Customer Service, the repairs will be analyzed and a fee for repair will be determined (if any). The customer will be informed and must authorize work to be done, if charges to the customer are involved.

GUARANTEES

If at any time within 1 year after shipment, but not thereafter, it is determined that any part of the equipment furnished by McMillan Company was defective when shipped, McMillan Company will repair or replace the same free of charge, F.O.B. the factory. Notice of this claim must be made to McMillan Company within 1 year after shipment. McMillan Company's liability is limited to replacement of such defective parts or equipment. There are no guarantees or warranties expressed or implied other than those herein specifically mentioned.

McMillan Company shall herein not in any event be liable for any consequential damages, secondary charges, expenses for erection or disconnecting or losses resulting from any alleged defect in the apparatus. Damage due to corrosion, erosion or lightning is not covered in this guarantee.

CLAIMS AND SPECIFICATIONS

McMillan Company reserves the right to make changes to this product without notice.

McMillan Company reserves the right to make, from time to time, such departure from the detail specifications, as may be required to permit improvements in the design of its products.

The information included in this manual is believed to be accurate and reliable. However, McMillan Company assumes no responsibility for the use of said information or product; nor for any infringement of patents or other rights of third parties that may result from its use.