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I. INTRODUCTION

The HFM Series flowmeters are a no-frills, non-invasive line of measuring instruments which utilize the Doppler principle to monitor liquid flow. The system is highly accurate and user friendly. They provide ease of use and reduce operator error. The transducer is designed to automatically align itself to the axis of the pipe.

The Doppler Effect is the change in the frequency of sound created by the movement of an object, as related to a fixed point, which is directly proportional to the speed of the object.

II. PRINCIPLE OF OPERATION

The system consists of a transmitter crystal which emits a continuous wave of ultrasonic energy, and a receiver crystal which receives a reflected signal with a frequency shift. The signal transmitted from the crystal penetrates the pipe and is reflected back to the receiver crystal from discontinuities* in the moving media. (This reflected signal contains an audio frequency component which is directly proportional to the flow rate.)

* To provide a satisfactory Doppler return, the liquid to be measured must contain reflective media, i.e., air bubbles, minute particles, density interfaces, or other discontinuities.
III. EQUIPMENT SPECIFICATIONS

Flow Range 0.5 to 20 ft/sec (standard) or 0.3 to 6 m/sec (metric)
Accuracy
- Digital readout: ±2.0 least significant (L.S.) digits
- Repeatability: ±0.2% of full scale (F.S.) range
- Linearity: ±0.5% of full scale (F.S.) range
- Resolution: 0.1 m/sec.
Power Supply
- Rechargeable nickel cadmium batteries (5 volts)
  - 4 hours operating time with full charge
  - Maximum charge time = 15 hours
Temperature Range
- Transducer: -40°C to 150°C
- Electronics: -25°C to 85°C
Transducer
- Dual crystal, hinged housing with 1 meter of cable
Weight 1.8 kilograms
Environmental Protection
- Acrylic conformally coated to protect electronics from hostile surroundings.
Charging Requirements
- 6 VDC @ 180 mA, center contact (+)
Analog Output (HFM-2)
- 4 to 20 mADC proportional to flow
IV. OPERATING INSTRUCTIONS

1) Connect transducer to flowmeter.
2) Set "ON-OFF" switch to "ON".
3) Check "VELOCITY" readout; it should indicate 00.0.
4) Set "VELOCITY CAL." control to 5.0.
5) Apply a generous amount of couplant to the transducer faces.
6) Place the transducer against the outside of the pipe. (See Section V.
   TRANSDUCER SITTING AND PIPE PREPARATION for correct transducer
   placement.) If there is a sufficient amount of reflective material in the flowing
   liquid, the "RETURN SIGNAL" LED will glow steadily indicating that the velocity
   can be read on the display.
7) Read the velocity on the "VELOCITY" display and using the equation below,
calculate the flowrate.

   **English**
   \[ \text{GPM} = (2.45) (V) (ID)^2 \]
   where:
   \[ \text{GPM} = \text{Gallons Per Minute} \]
   \[ V = \text{Velocity in feet per second (ft/sec)} \]
   \[ ID = \text{Inside Diameter in inches} \]

   **Metric**
   \[ \text{LPS} = (.08) (V) (ID)^2 \]
   where:
   \[ \text{LPS} = \text{Liters Per Second} \]
   \[ V = \text{Velocity in meters per second (m/sec)} \]
   \[ ID = \text{Inside Diameter in centimeters} \]
V. TRANSUDER SITTING AND PIPE PREPARATION

To obtain reliable velocity indications, the transducer should be placed on the outside of the pipe observing the following:

1) Select a transducer site at least 10 pipe diameters downstream from bends, fittings or pumps.
2) The transducer should be mounted at the 1 to 5 o'clock position or the 7 to 11 o'clock position on the pipe. (See Figure 1.) The 12 o'clock and 6 o'clock positions should be avoided as bubbles may be traveling along the top of the pipe and sediment may be accumulated in the bottom of the horizontal pipe. Which will greatly attenuate the ultrasonic signals being injected into and received out of the flow profile.
3) For a vertical section of pipe, the flow must be upward to ensure a completely full pipe.
4) Select the location where the transducer is to be mounted.

Prepare the intended area for mounting by removing all paint, scale, and insulation. Degrease the contact surface. Using a generous amount of transducer couplant grease (supplied with the flowmeter), apply the couplant to the two dark surfaces of the transducer. Press the transducer to the surface of the pipe and hold. If prolonged monitoring is going to be needed, use a pipe clamp or plastic ty-rap as shown in Figure 1.
VI. USE OF "VELOCITY TRIM" CONTROL

Some variation in accuracy will occur between various pipe materials and liquids. If the flowrate is known for a particular application, the "VELOCITY TRIM" control can be adjusted to field calibrate the flowmeter for that application. This calibration setting can then be duplicated for future measurements on similar applications.

VII. CHARGING THE BATTERIES

During normal operation of the meter, the batteries will eventually discharge. At the point when the batteries need to be recharged, an outline of a battery will appear in the upper left-hand corner of the velocity display. At this time, turn the flowmeter "OFF" and connect the battery charger to the flowmeter. (The charging jack is located in the lower right-hand corner of the front panel.) Plug the charger into the AC power line. The batteries require 12 to 14 hours to completely recharge.
VIII. FIELD CALIBRATION

The HFM series flowmeter can be field calibrated using a known flowrate.

A. Calibration With A Known Flowrate
1) Remove flowmeter from carrying case.
2) Connect transducer to flowmeter.
3) Apply a generous amount of couplant to the faces of the transducer and fasten the transducer to the pipe carrying the known flowrate using tape or a pipe clamp.
4) Set the "VELOCITY TRIM" control to 5.0.
5) From the known flow rate in GPM or LPS, calculate the flow velocity using the following formula:

\[ V = \frac{\text{GPM}}{(\text{ID})^2 (2.45)} \quad \text{or} \quad V = \frac{\text{LPS}}{(\text{ID})^2 (0.08)} \]

where:
- \( \text{GPM} \) = Gallons Per Minute
- \( \text{LPS} \) = Liters Per Second
- \( V \) = Velocity in feet per second (ft/sec) or meters per second (m/sec)
- \( \text{ID} \) = Inside Diameter in inches or centimeters

6) While noting the velocity readout, adjust the CAL. pot (accessible through a small access hole on the right side of the flowmeter) to indicate the velocity calculated in Step 5.
IV. ELECTRONIC CALIBRATION

This procedure applies to the following serial numbers:

- HFM-1 Serial # 402 and up,
- HFM-2 Serial # 2185 and up, and
- HFM-4 Serial # 206 and up.

The HFM series flowmeter can be electronically calibrated as follows:

Equipment required:

- (1) Audio Signal Generator capable of outputting a 20 Volt (P-P) square wave signal
- (1) 4 1/2 Digit Multi-Meter (DMM), Data Precision #495 or equivalent
- (1) Frequency Counter
- (1) Plastic tune-up tool

1) Remove flowmeter from its carrying case.
2) Remove (4) hexhead cap screws from the bottom panel of the flowmeter.
3) Slide the rear panel out of the instrument. The batteries and test points will then be exposed.
4) Set the "VELOCITY TRIM" control to 5.0.
5) Connect the ground lead of the audio oscillator as shown on the white label on the black plastic filler panel.
6) Connect the hot lead of the audio oscillator to the test wire as noted on the white label.
7) Set the digital voltmeter to measure DC volts and connect the negative lead to ground and the positive lead to the 200 mV test wire.
8) Set the audio oscillator to the C.F. frequency stated on the label. Set the audio oscillator to 25 volts (P-P) square wave.
9) Turn on the flowmeter. Adjust the Calibrate pot (accessible through a small access hole on the right side of the flowmeter) to indicate 200 mV on the multi-meter.
10) Re-assemble the flowmeter and replace it into case.
X. DYNAMIC FLUID SYSTEMS WARRANTY

Dynamic Fluid Systems warrants that the Model HFM sold hereunder will conform to written specifications, drawings and other descriptions, including any modifications thereof by Dynamic Fluid Systems for a period of 12 months from the date of shipment. Dynamic Fluid Systems warrants the goods sold hereunder against faulty workmanship and materials. If any goods manufactured by Dynamic Fluid Systems fail to conform to these warranties, liability hereunder repair or replace such goods if they are returned within the following warrantee period for specific express condition that: (1) Dynamic Fluid Systems is given prompt written notice upon discovery of such non-conformity, with a detailed explanation of the alleged deficiencies; (2) such goods are returned to Dynamic Fluid Systems at the expense of the buyer; (3) examination of such goods by Dynamic Fluid Systems discloses that the non-conformity actually exists and was not caused by accident, misuse, neglect, alteration, improper installation, improper repair or improper testing; (4) the goods have not been altered, modified or changed in any manner by anyone other than Dynamic Fluid Systems; (5) repairs to the goods have not been made by anyone other than Dynamic Fluid Systems or an Dynamic Fluid Systems authorized service facility. Dynamic Fluid Systems will have a reasonable time to repair or replace such goods. Dynamic Fluid Systems will not in any event be liable for incidental or consequential damages.

These warranties exclude all other expressed or implied warranties, oral or written, including without limitation, warranties of merchant-ability and fitness for a particular purpose. No terms, conditions, understandings or agreements purporting to modify the terms of those warranties shall have any legal effect unless made in writing and signed by an authorized officer of Dynamic Fluid Systems.