Hedland®
Variable Area Flow Meters

Flow Transmitter

MR Model

Badger Meter®

XMT-UM-00498-EN-05 (August 2022)

User Manual

CONTENTS

INTRODUCTION

The MR flow transmitter is a state-of-the-art, microprocessor based variable area flow meter. It combines the rugged proven technology of a piston-type, variable area flow meter with solid-state circuitry including:

- Non-contact sensor electronics
- Electronic signal conditioning circuit
- Digital flow rate and total indication
- Proportional analog output

The product is sealed against industrial contamination by a NEMA 12 and 13 (IP 52/54) rated enclosure and is available for either liquid or gas service.

The MR flow transmitter is capable of calculating and displaying both flow rate and total accumulated flow. The flow rate and total flow can be displayed in any of the user selectable measurement units. The monitor's large 8 digit numeric liquid crystal display makes extended range viewing practical. The second 8 character alphanumeric display provides for selectable units viewing in *RUN* mode and prompts for variables in *PROGRAM* mode.

All MR flow transmitters come pre-calibrated from the factory. However, the unit may be adjusted by the user to meet specific system requirements. Calibration parameters are included for:

- Specific gravity compensation (all fluids)
- Viscosity compensation (petroleum-based fluids)
- Pressure and temperature compensation (pneumatic applications)

All meters include an analog output that can be configured for 0…5V DC, 0…10V DC, or 4…20 mA current loop.

SAFETY INFORMATION

The installation of this flow meter must comply with all applicable federal, state, and local rules, regulations, and codes.

Failure to read and follow these instructions can lead to misapplication or misuse of this product, resulting in personal injury and damage to equipment.

UNPACKING AND INSPECTION

Upon opening the shipping container, visually inspect the product and applicable accessories for any physical damage such as scratches, loose or broken parts, or any other sign of damage that may have occurred during shipment.

NOTE: If damage is found, request an inspection by the carrier's agent within 48 hours of delivery and file a claim with the carries. A claim for equipment damage in transit is the sole responsibility of the purchaser.

INSTALLATION

⚠CAUTION

THIS PRODUCT SHOULD BE INSTALLED AND SERVICED BY TECHNICALLY QUALIFIED PERSONNEL TRAINED IN MAINTAINING INDUSTRIAL CLASS FLOW INSTRUMENTATION AND PROCESSING EQUIPMENT.

⚠CAUTION

READ INSTRUCTIONS THOROUGHLY BEFORE INSTALLING THE UNIT. IF YOU HAVE ANY QUESTIONS REGARDING PRODUCT INSTALLATION OR MAINTENANCE, CALL YOUR LOCAL SUPPLIER FOR MORE INFORMATION.

⚠WARNING

DISCONNECT ELECTRICAL POWER BEFORE OPENING WIRING ENCLOSURE. FAILURE TO FOLLOW THESE INSTRUCTIONS COULD RESULT IN SERIOUS PERSONAL INJURY OR DEATH AND/OR DAMAGE TO THE EQUIPMENT.

⚠WARNING

ALL WIRING SHOULD BE INSTALLED IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE® AND MUST CONFORM TO ANY APPLICABLE STATE AND LOCAL CODES. FAILURE TO FOLLOW THESE INSTRUCTIONS COULD RESULT IN SERIOUS PERSONAL INJURY OR DEATH AND/OR DAMAGE TO THE EQUIPMENT.

⚠CAUTION

AIR/GAS METERS ARE NOT OXYGEN CLEANED. USE WITH OXYGEN MAY CAUSE HAZARDOUS OR EXPLOSIVE CONDITIONS THAT MAY CAUSE SERIOUS PERSONAL INJURY AND/OR DAMAGE TO THE EQUIPMENT.

⚠CAUTION

THIS METER MAY CONTAIN RESIDUAL AMOUNTS OF TEST FLUID AT THE TIME OF SHIPMENT. THIS FLUID SHOULD BE REMOVED PRIOR TO INSTALLATION AS THE FLUID MAY BE INCOMPATIBLE OR HAZARDOUS WITH SOME LIQUIDS OR GASES. FAILURE TO FOLLOW THESE INSTRUCTIONS COULD RESULT IN DAMAGE TO THE EQUIPMENT.

⚠CAUTION

THIS STANDARD METER IS UNIDIRECTIONAL. ATTEMPTS TO FLOW FLUIDS IN THE OPPOSITE DIRECTION OF THE FLOW ARROW WILL RESULT IN THE METER ACTING AS A CHECK VALVE, CREATING A DEADHEADING SITUATION. IF THE DIFFERENTIAL PRESSURE MAGNITUDE IS GREAT ENOUGH, DAMAGE TO THE INTERNAL PARTS OF THE METER WILL RESULT.

Installation Recommendations

The transmitter is a simple device to install. However, the following measures are recommended for reliable, trouble-free operation:

- Align pipe accurately. Piping should be accurately aligned and of correct length. The high pressure body of the transmitter can withstand shock and flow/pressure pulsation. However, the piping should be firmly supported by external mounting brackets, both upstream and downstream of the meter, to avoid any pipe flexing actions that could reduce meter life.
- Use rigid mounting. If the transmitter inlet or outlet are to be rigidly mounted, and the opposing port is to be connected to flexible hose, the end connected with the flexible hose must be rigidly mounted.
- Use Teflon® tape for sealing NPT fitting.
- Install unions. Install a union near the inlet or outlet of the transmitter. This will facilitate quick, easy meter removal and inspection during periodic maintenance procedures.
- Make sure the fluid is traveling in the direction of the flow arrow. See *"Figure 1: Flow direction arrow" on page 6*.

NOTE: The MR flow transmitter display board can be rotated 180° for optimal viewing. Simply remove the MR flow transmitter cover, disconnect the ribbon cable, rotate the display board 180°, reconnect the ribbon cable, and reinstall cover. See Figure 10 for cover screw tightening sequence.

- Use at least a 200 mesh (74 micron) filter. The transmitter will allow particulate to pass that would jam most valves and flow controls. Systems that do not have filtration should be equipped with at least a 200 mesh (74 micron) filter. Most hydraulic systems already have much finer filtration. Dirt, ferrous metal or sealing agents, such as Teflon® tape may lodge and cause malfunction. If the meter is jammed at a fixed position, follow cleaning and maintenance instructions.
- **Do not** use thread locking compounds as thread sealant.
- **Do not** install the transmitter near turbulence producing fittings such as elbows, reducers, or close coupled valves. The transmitter does not require flow straighteners or special lengths of straight inlet/outlet piping to stabilize turbulent flow patterns. However, to assure maximum operational reliability, avoid installation of elbows, valves and/or reducers immediately adjacent to the meter inlet.
- **Do not** install the transmitter near fast-acting valves. Fast-acting valves have the potential to create high magnitude hydraulic pressure spikes. These spikes can damage the internal components of the meter, resulting in inaccuracies or malfunction.
- **Do not** allow unidirectional transmitters to be operated against the direction of the flow arrow. The standard transmitter is a unidirectional flow meter. The piston acts as a check valve to block flow in the reverse direction. This causes an excessive pressure differential, which can result in damage to internal meter components.

Installing the Transmitter

1. Disconnect the electrical power from the target system before making or changing any transmitter connections.
2. Use 0.05 A fast-acting fuse if non-current limited power sources are used.
3. Terminate cable shield connection at either DC ground or earth ground.
4. Mount the transmitter so fluid is traveling in the direction of the flow arrow.

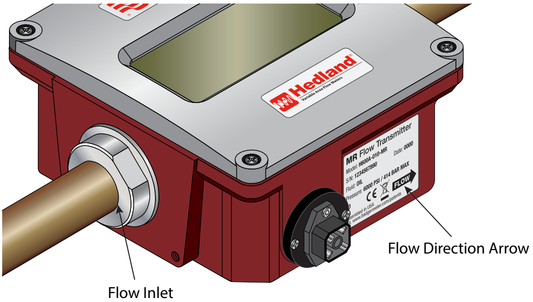

Figure 1: Flow direction arrow

5. Install unit in desired location. Use wrench on transmitter flats to hold the unit in place during installation. DO NOT TURN the transmitter using the wrench.
6. After installation, rotate the transmitter by hand to view the display.
7. Capture the zero flow position on the meter cone using the ZERO CAPTURE procedure.

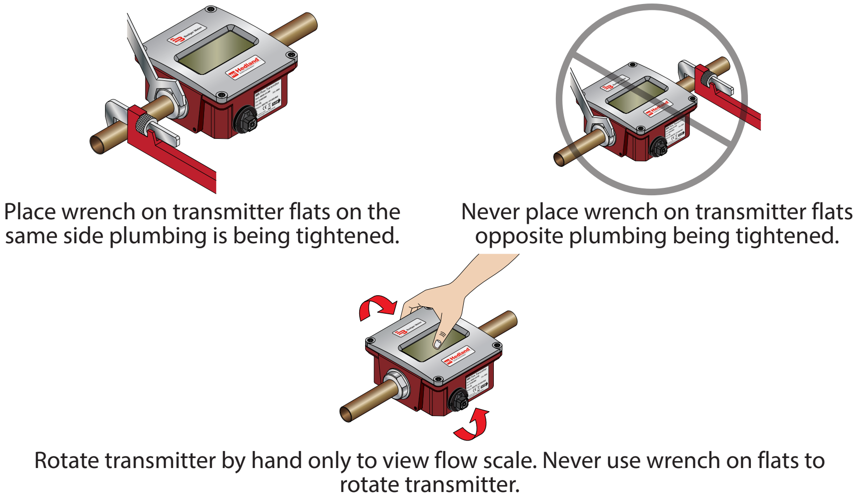

Figure 2: Installing and rotating the transmitter

ELECTRICAL CONNECTIONS

The standard cable length provided with an MR Transmitter is 15.0 ft. (4.57 m) and includes a soldered, Hirschmann cable connector, assembled from the factory. Additional cable lengths, shorter or longer, are available to match application requirements.

To connect the cable assembly to the transmitter, press the cable connector into the connector receptacle on the transmitter. The cable only inserts in one direction. If the connector does not seem to fit, do not force it. Rotate the cable connector 90 degrees and try again until it seats.

When the connector is fully seated, use a Philips screwdriver to tighten it.

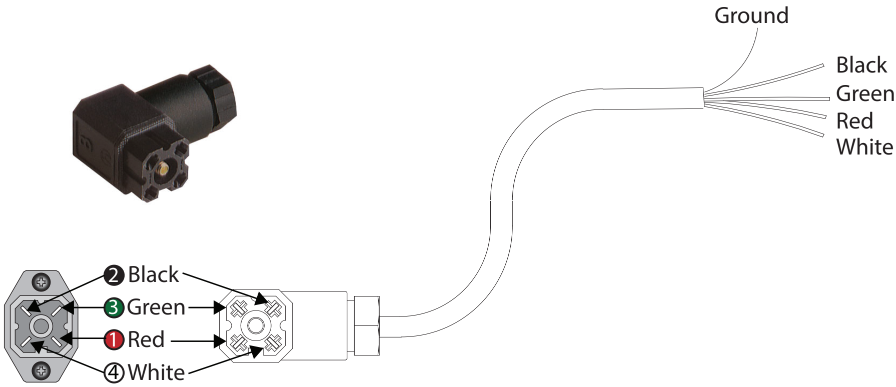

Figure 3: 4-pin cable connection

Ref. ID	DC Output Connection	Loop Power Connection
2 (Black)	No Connection	(-) 4…20 mA Out
3 (Green)	0V DC	No Connection
1 (Red)	(+) DC Power	(+) 4…20 mA In
4 (White)	0…5 or 0…10V DC Output	No Connection

Table 1: Reference for 4-pin connector

CAUTION

THE FLOW TRANSMITTER IS DESIGNED TO OPERATE ONLY ONE OF ITS THREE OUTPUTS AT A TIME (0…5V DC OR 0…10V DC OR 4…20 MA). CONNECTING MULTIPLE OUTPUTS SIMULTANEOUSLY WILL RESULT IN INACCURATE OUTPUT SIGNAL LEVELS.

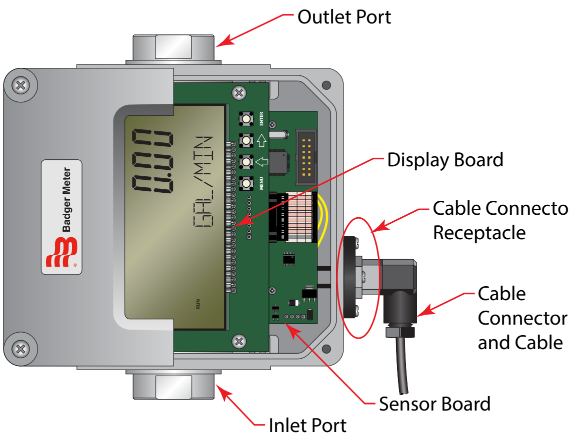

Figure 4: Terminology

Wiring Configurations

The transmitter can be wired in various configurations to allow interface with many different types of data collection and control instrumentation.

Figure 5 and Figure 6 represent typical wiring for a target powered by either AC power or DC supply. *Figure 7 and Figure 8 on page 9* are used when the flow transmitter is operated with loop-powered process indicators or data loggers that do not have external sensor excitation.

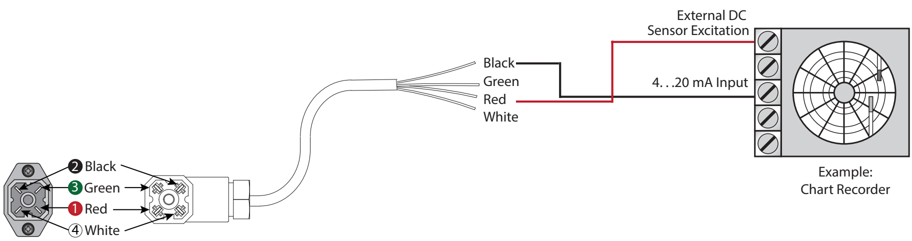

Figure 5: 4…20 mA using target's power supply

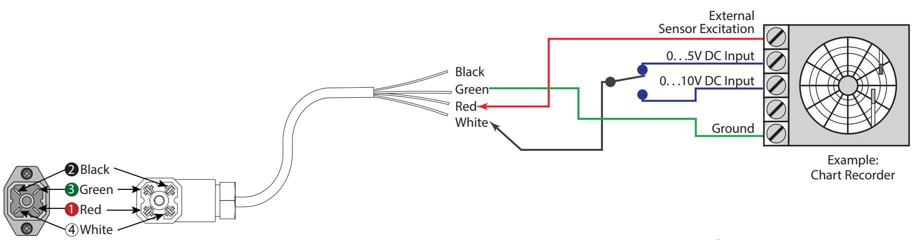

Figure 6: 0…5V DC or 0…10V DC connection using target's power supply

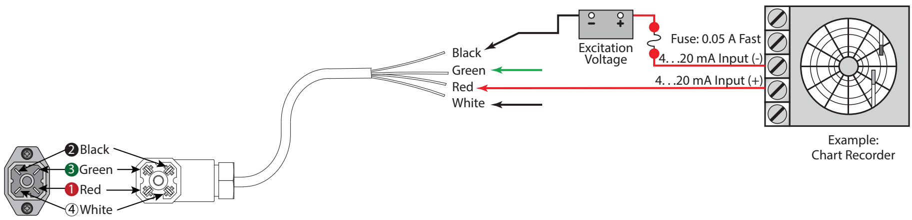

Figure 7: 4…20 mA connection using target's external power supply

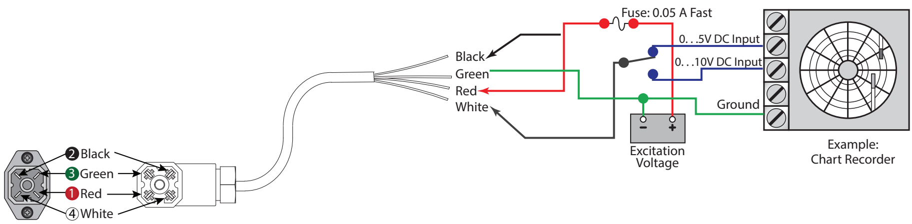

Figure 8: 0…5V DC or 0…10V DC connection using target's external power supply

Cover Removal/Reinstallation

You must remove the MR flow transmitter cover to access the programming keys. Use a Phillips screwdriver to remove the four screws that hold the cover in place, turning them counterclockwise. When programming is completed, reinstall the cover. To properly seat the built-in cover gasket, tighten the cover screws clockwise in a crisscross pattern as shown in the figure below.

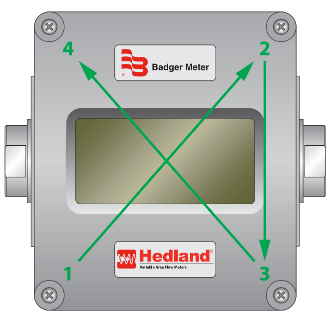

Figure 9: Cover screw tightening sequence

OPERATION

Operating the Meter

The monitor has two modes of operation, referred to as *RUN* mode and *PROGRAM* mode as indicated on the display screen readout. Normal operation will be in the run mode. To access the program mode, press **MENU** until the first programming screen "DISPLAY" appears.

NOTE: "PROGRAM" appears on left side of display.

After programming the meter, a password may be entered to prevent unauthorized access to programming.

Normal Operation (RUN) Mode

During normal operation, the transmitter shows "RUN" on the left side of the display. In *RUN* mode, the flow rate and total flow alternate being shown as the default. The meter can also be set to show only flow rate or only flow total.

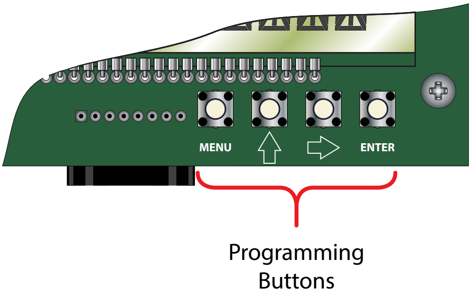

Figure 10: Programming buttons

In *RUN* mode, the four programming buttons have the following functions:

MENU		Selects programming mode.
⇧	**UP**	No function.
⇨	**RIGHT**	No function.
ENTER		The current total can be manually stored in the monitor's flash memory. Press and hold **ENTER** for 2 seconds. The display responds with a flashing *TOTALSVD* and then returns to *RUN* mode.
RESET TOTAL		To reset the monitor's total display, press **MENU** and **ENTER** simultaneously until *TOTALRST* starts to flash. The *TOTALRST* stops flashing and the display returns to *RUN* mode at the conclusion of the rest procedure.

Table 2: Button function in RUN mode

Programming Operation (PROGRAM) Mode

The *Program* mode lets you change the configuration and adjust the calibration of the meter. The MR flow transmitter has two types of configuration changes accessible in program mode:

- View or change selections from a pre-defined list
- View or change numeric entries

In *Program* mode, the four programming buttons have the following functions:

MENU	Enters and exits programming mode. Press **MENU** once to change to programming mode. The mode indicator on the display changes from "RUN" to "PROGRAM."
⇧	Scrolls through the configuration choices in a bottom-to-top order. For numeric setup, this button increments numeric values.
⇨	Scrolls through the configuration choices in a top-to-bottom order. For numeric setup, this button moves the active digit to the right.
ENTER	Used to enter menus, to change configurations and to save programming information.

Table 3: Button function in PROGRAM mode

NOTE: When any input value exceeds the meter's capabilities, the *LIMIT* indicator begins to flash, indicating an invalid entry. Press **ENTER** once to return to the entry screen to reenter the value.

Programming Flowchart for Water (Includes Water-Based Liquids)

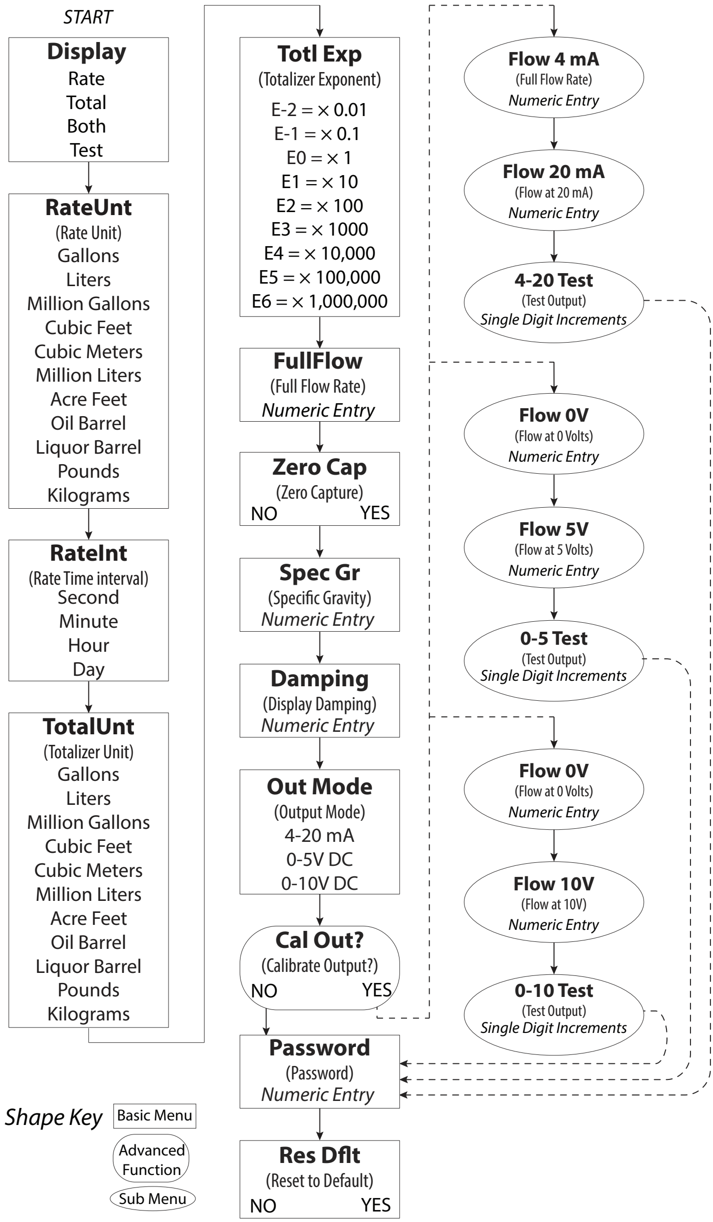

Figure 11: Water flowchart

Programming Flowchart for Oil (Includes Petroleum-Based, Phosphate Ester and Caustic/API Oil)

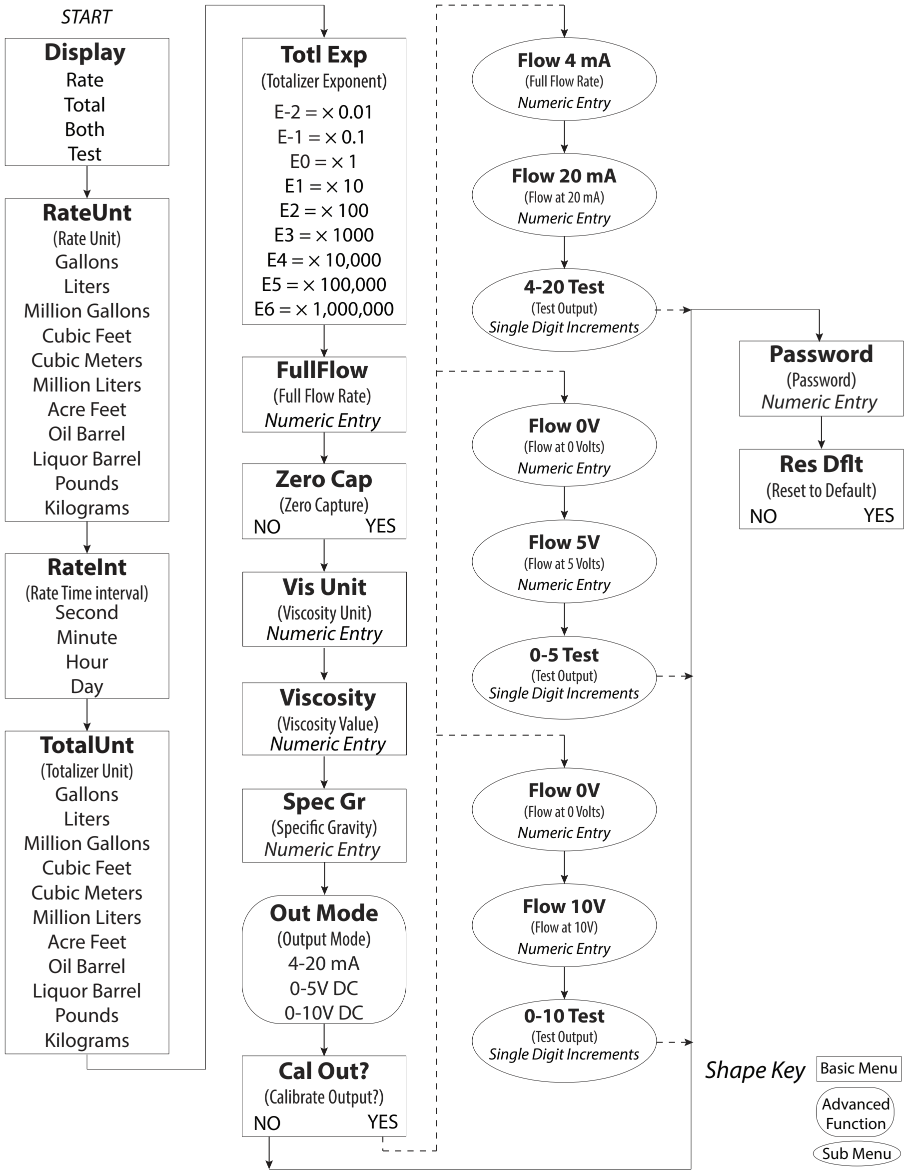

Figure 12: Gas Flowchart

Programming Flowchart for Air/Gases (Includes Caustic/Corrosive Gases)

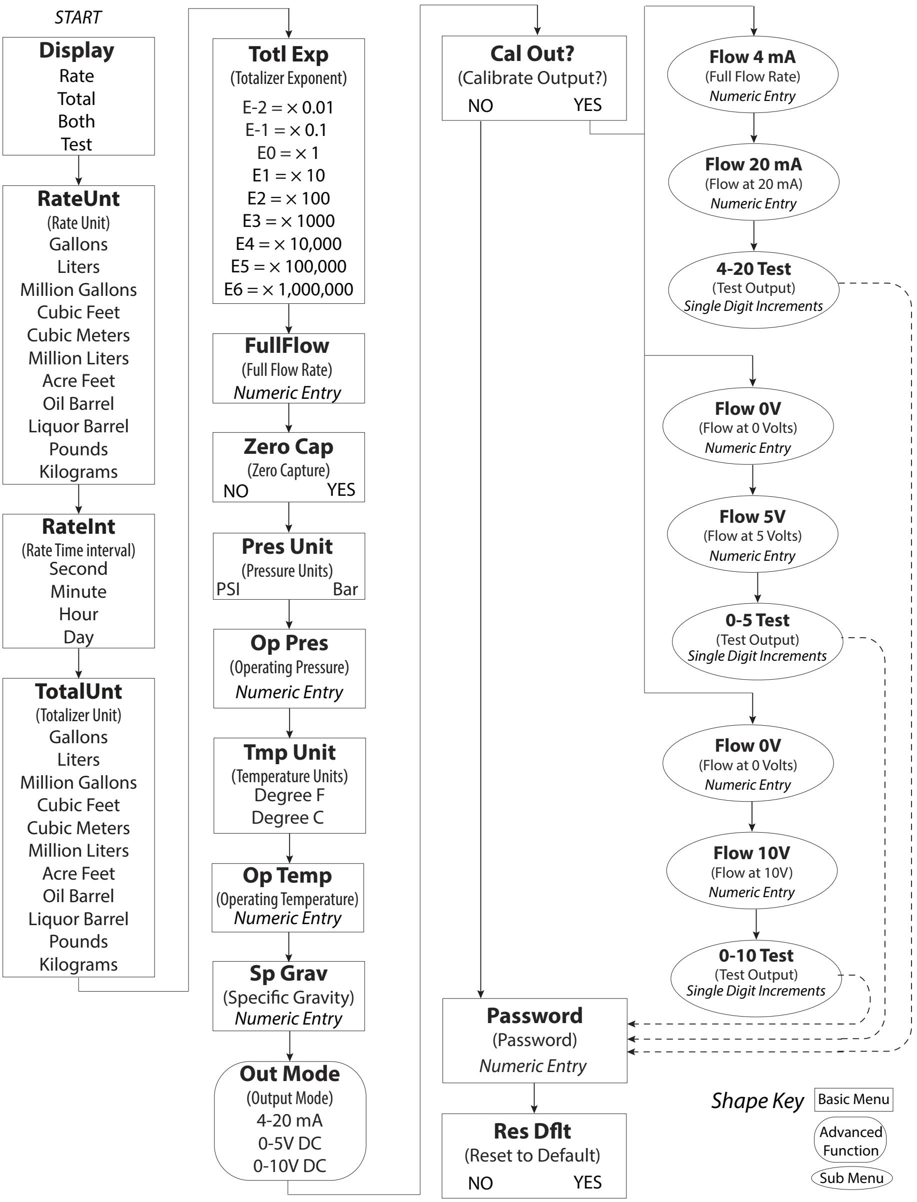

Figure 13: Air/gases flowchart

PROGRAMMING PROCEDURES

The MR flow transmitter is programmed at the factory according to the specifications provided at the time of order. No further programming is required unless a change has occurred in the original specifications.

List Item Selection Procedure

NOTE: If you are already in *PROGRAM* mode and the selection to view or change is displayed, proceed to step 3 below. If you are in *PROGRAM* mode and the selection to view or change is not displayed, press ⇧ or ⇨ and repeat pressing until the required selection appears, then proceed to step 3.

1. Press **MENU**. "PROGRAM" appears in the lower left corner and "DISPLAY" appears.
2. Press ⇧ or ⇨ to move to the required selection.
3. Press **ENTER** to view the current selection.
4. If the current selection is correct, press **ENTER** to confirm. The unit automatically advances.
5. To change the current selection, press ⇧ or ⇨ to scroll through the available choices. Press **ENTER** to confirm the selection. The unit automatically advances.
6. To exit programming, press **MENU**. The display changes to *RUN* mode.

Numeric Value Entry Procedure

NOTE: If you are already in *PROGRAM* mode and the selection to view or change is displayed, proceed to step 3 below.

If you are in *PROGRAM* mode and the selection to view or change is not displayed, press ⇧ or ⇨ and repeat pressing until the required selection appears, then proceed to step 3.

1. Press **MENU**. "PROGRAM" appears in the lower left corner and "DISPLAY" appears.
2. Press ⇧ or ⇨ to move to the required selection. The current numeric value for the selection appears in the upper area of the display.
3. If the displayed value is correct, press **ENTER**. The left-most programmable number flashes. Press **ENTER** again to confirm and keep the current setting. The unit automatically advances.
4. To change the current selection, press **ENTER**. The left-most programmable number flashes. Use ⇧ to scroll through the digits 0…9 and change the flashing digit to the required value. Use ⇨ to move the active digit to the right. Continue using ⇧ and ⇨ until all required digits are selected.
5. Press **ENTER** to confirm the selection. The unit automatically advances.
6. To exit programming mode, press **MENU**. The display changes to *RUN* mode.

Programming Flowcharts

See the following programming flowcharts for the menu structure of the MR flow transmitter and the available configuration selections:

- *"Programming Flowchart for Water (Includes Water-Based Liquids)" on page 12*
- *"Programming Flowchart for Oil (Includes Petroleum-Based, Phosphate Ester and Caustic/API Oil)" on page 13*
- *"Programming Flowchart for Air/Gases (Includes Caustic/Corrosive Gases)" on page 14*

Basic Programming Descriptions

Display Mode (Display)

In *Display* mode, the meter can display *RATE* (flow rate) or *TOTAL* (total accumulated flow) or alternate between *BOTH* rate and total. Edit with the *"List Item Selection Procedure" on page 15*.

Rate Units of Measure (RATE UNT)

The meter lets you select from many common rate units. Edit with the *"List Item Selection Procedure" on page 15*.

Rate (Time) Interval (RATE INT)

The meter lets you select intervals based on time. Edit with the *"List Item Selection Procedure" on page 15*.

Total Units of Measure (TOTL UNT)

To display the *Total Flow*, you must first select the engineering units for the total. The monitor allows the choice of many common totalization units. Edit with the *"List Item Selection Procedure" on page 15*.

Total Display Multiplier (TOTL EXP)

The meter can accumulate the flow total in multiples of ten. For example, if the most desirable totalization unit is 1000 gallons, the monitor can easily be set up for this requirement. Once back in *RUN* mode, every time the total display increments by one digit the actual total would be an additional 1000 gallons. At 1000 total gallons the total display would read 1, at 3000 gallons the total display would read 3. This feature allows the unit to accumulate totals that would exceed the 8-digit display capacity. Table 2 lists the available selection choices. Edit with the *"List Item Selection Procedure" on page 15*.

Exponent	Totalizer Multiplier
E-2	× 0.01 (÷100)
E-1	× 0.1 (÷100)
E0	× 1 (no multiplier)
E1	× 10
E2	× 100
E3	× 1000
E4	× 10,000
E5	× 100,000
E6	× 1,000,000

Table 4: Total flow units

Full Flow Rate (FULL FLOW)

The *Full Flow Rate* parameter is used to span the meter. Edit with the *"Numeric Value Entry Procedure" on page 15*.

Zero Capture (ZERO CAP)

You must set the zero position of the meter cone when installing the meter. To capture the zero calibration position, press **ENTER** at the *ZERO CAP* prompt. "NO" displays. Press either arrow key to change to "YES", then press **ENTER** to capture zero.

Viscosity Units (VIS UNIT) (Displayed for OIL meters only)

The *Viscosity Units* parameter is used in conjunction with *Viscosity* to perform viscosity correction for oil applications. You can select the viscosity units, SUS or cSt. Edit with the *"List Item Selection Procedure" on page 15*.

Viscosity (VISCOSITY) (Displayed for OIL meters only)

Viscosity is used in conjunction with *Viscosity Units* to perform viscosity correction for oil applications. Enter the viscosity in either SUS or cSt, depending on the viscosity units selected for the oil being used. Edit with the *"Numeric Value Entry Procedure" on page 15*.

Operating Pressure Unit (PRES UNIT) (Displayed for GAS Meters Only)

The *Operating Pressure Units* parameter is used in conjunction with *Operating Pressure* in gas applications to compensate for the actual pressure being measured at the meter. The operating pressure unit selections are Bar or PSI. Edit with the *"List Item Selection Procedure" on page 15*.

Operating Pressure (OP PRES) (Displayed for GAS Meters Only)

The *Operating Pressure* parameter is used in conjunction with *Operating Pressure Unit*s in gas applications to compensate for the actual pressure being measured at the meter. Enter the operating pressure in either Bar or PSI units, depending on the *Operating Pressure Units* selected. Edit with the *"List Item Selection Procedure" on page 15*.

Operating Temperature Unit (TMP UNIT) (Displayed for GAS Meters Only)

The *Operating Temperature Units* parameter is used in conjunction with *Operating Temperature* in gas applications to compensate for the actual temperature of the gas being measured at the meter. The meter allows the selection of the operating temperature units, °F or °C. Edit with the *"List Item Selection Procedure" on page 15*.

Operating Temperature (OP TEMP) (Displayed for GAS Meters Only)

The *Operating Temperature* parameter is used in conjunction with *Operating Temperature Units* in gas applications to compensate for the actual temperature of the gas being measured at the meter. Enter the operating temperature in either °F or °C, depending on the *Operating Temperature Units* selected. Edit with the *"List Item Selection Procedure" on page 15*.

Specific Gravity Correction Factor (SP GRAV)

The *Specific Gravity* parameter is used to compensate for the specific gravity of the liquid or gas being measured with the meter. Edit with the *"List Item Selection Procedure" on page 15*.

Damping (DAMPING)

The *Damping* factor is increased to enhance the stability of the flow readings. Damping values are decreased to allow the flow meter to react faster to changing values of flow. This parameter can range from 0…99. The factory default is 0. Edit with the *"List Item Selection Procedure" on page 15*.

Output Mode (OUT MODE)

The MR flow transmitter has three analog output modes:

- 4…20 mA Output Signal
- 0…5V DC Output Signal
- 0…10V DC Output Signal

The *Output Mode* required is determined by the type of peripheral device being connected to the MR flow transmitter. Edit with the *"List Item Selection Procedure" on page 15*.

NOTE: Setup prompts and descriptors for configuring and calibrating the analog output correspond to the selected *Output Mode*.

Password (PASSWORD)

Password protection prevents unauthorized users from changing programming information. Initially, the password is set to all zeros. Edit with the *"Numeric Value Entry Procedure" on page 15*.

Restore Defaults (RES DFLT)

Use this feature to restore factory calibration data. To restore factory calibration data, select **YES**, then press **ENTER**.

Advanced Programming Descriptions

Advanced programming allows for re-configuring the analog output. Calibration of the analog output is preset at the factory, but can be changed to customize calibration for your installation.

To access the *Advanced Programming* options, press and hold **MENU** for approximately 3 seconds until "DISPLAY" shows on the display panel. The programming menus begin with the *DISPLAY mode* and continue as described above through *Output Mode* (*OUT MODE)*.

After you enter *Output Mode*, *Advanced Programming* starts with the following:

Calibrating Analog Output (CAL OUT?)

NOTE: Setup prompts and descriptors for configuring and calibrating the analog output correspond to the output mode selected. Refer to the flowcharts on pages *page 12* through *page 14*.

To test or change the analog output calibration:

1. At the *CAL OUT?* prompt press **ENTER**. "NO" displays.
2. Press either arrow key to select **YES**.
3. The analog output goes to its minimum output level. A numeric value between 0…4000 displays. This is an internal number used to drive the analog output.
4. To increase the analog output signal level, press ⇧. To decrease the analog output signal level, press ⇨.
5. Press **ENTER** to store the setting.
6. The analog output goes to its maximum output level. A numeric value between 0…4000 displays. This is an internal number used to drive the analog output.
7. To increase the analog output signal level, press ⇧. To decrease the analog output signal level, press ⇨.
8. Press **ENTER** to store the setting.
9. The unit advances to the analog output test mode. The analog output goes to its minimum output level. A numeric value of 0 displays. For test purposes, the analog output signal can be run up or down in increments of 1 milliamp or 1 volt, depending on the *OUT MODE* selected.
10. To increase the analog output signal level, press ⇧. To decrease the analog output signal level, press ⇨.
11. Press **ENTER** to exit the analog calibration mode.
12. The unit automatically advances to the *PASSWORD* feature.

Password (PASSWORD)

Password protection prevents unauthorized users from changing programming information. Initially, the password is set to all zeros. Edit with the *"Numeric Value Entry Procedure" on page 20*.

Restore Defaults (RES DFLT)

Use this feature to restore factory calibration data. To restore factory calibration data, select **YES**, then press **ENTER**.

CARTRIDGE COMPONENTS

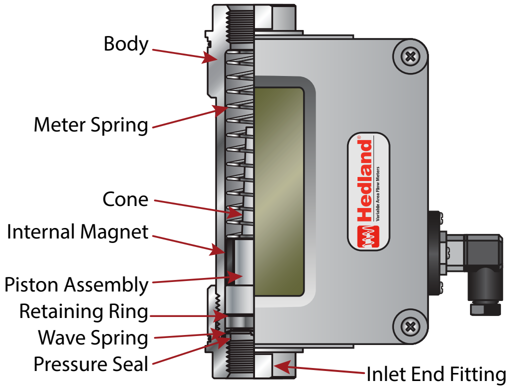

Figure 14: Cartridge components

MAINTENANCE

⚠WARNING

BEFORE ATTEMPTING TO REMOVE THE TRANSMITTER FROM THE LINE, CHECK THE SYSTEM TO CONFIRM THAT LINE PRESSURE HAS BEEN REDUCED TO ZERO PSI. FAILURE TO FOLLOW THESE INSTRUCTIONS COULD RESULT IN SERIOUS PERSONAL INJURY OR DEATH AND/OR DAMAGE TO THE EQUIPMENT.

⚠WARNING

DISCONNECT ELECTRICAL POWER BEFORE REMOVING METER COVER. FAILURE TO FOLLOW THESE INSTRUCTIONS COULD RESULT IN SERIOUS PERSONAL INJURY OR DEATH AND/OR DAMAGE TO THE EQUIPMENT.

Cartridge Cleaning

1. Disconnect the transmitter cable.
2. Remove the meter from the line. Remove excess piping from the transmitter. See *"Figure 2: Installing and rotating the transmitter" on page 6*.

NOTE: It is not necessary to remove the aluminum housing from the transmitter to remove it from the line.

3. Thoroughly wipe off the entire transmitter surface using mild detergent or isopropyl alcohol.

⚠CAUTION

DO NOT USE AROMATIC HYDROCARBONS, HALOGENATED HYDROCARBONS, KETONES OR ESTER-BASED FLUIDS ON POLYCARBONATE LENS. FAILURE TO FOLLOW THESE INSTRUCTIONS COULD RESULT IN DAMAGE TO THE TRANSMITTER.

4. Remove the inlet port wave spring, retaining ring, and cone from the body (see *"Figure 14: Cartridge components" on page 20*).
5. Using the end fitting flats, clamp the outlet end fitting, then remove the inlet end fitting by rotating it counterclockwise.
6. Remove the body from the enclosure by gently pushing the body towards the outlet end of the enclosure.

NOTE: If internal parts do not slide freely from cartridge, insert a wooden dowel into the outlet port of the meter to push out the parts.

7. Place all parts on a clean work surface. Clean and inspect all parts. Replace any that appear worn or damaged. Check the inlet port O-ring for damage and replace it, if necessary.

⚠CAUTION

FIELD REPLACEMENT OF THE SPRING, METERING CONE AND/OR PISTON/MAGNET ASSEMBLY MAY RESULT IN CHANGES TO THE CALIBRATION OF THE FLOW METER.

8. The remaining parts are secured with a retaining ring inside the body. Remove the retaining ring, piston/internal magnet and spring. Use caution to not bend or damage the retaining ring.
9. Place all parts on a clean work surface for cleaning and inspection. If parts appear to be damaged, consult factory for repair/replacement options. Check the pressure and end fitting/cap O-rings for damage and replace if required.

10. In reverse order, gently reassemble all parts back to their original configuration.
11. Reinstall the spring, followed by the piston/internal magnet and then the retaining ring.
12. Reinstall the cone/spider plate assembly and retaining spring, and secure with the inlet end fitting. Secure the lid and ensure proper seating of the cover gasket by tightening the screws in a crisscross pattern. See *"Figure 9: Cover screw tightening sequence" on page 9*.
13. Reinstall the flow meter in the line. Reconnect the transmitter cable.

Inspection

Inspect the transmitter at least once a year. The environment and frequency of use should determine a schedule for maintenance checks.

- Perform visual, electrical, and mechanical checks on all components.
- Visually check for undue heating evidence, such as discolored wires or other components, damaged or worn parts, or leakage evidence, such as water or corrosion in the interior.
- Make sure all electrical connections are clean and tight and that the device is wired properly.

TROUBLESHOOTING

No LCD Display

- For 4…20 mA operation, check for current flow in the loop.
- Check polarity of the current loop connections for proper orientation.
- For 0…5V or 0…10V operation, check for proper voltage being supplied to the unit.
- Check polarity of the supply voltage.

No Rate or Total Displayed

- Check flow meter body and internal components for debris. Piston should move inside the tube freely.
- Check setup programming of flow meter.

Unstable Flow Reading

This usually indicates pulsing or oscillation in the actual flow. Increase the *DAMPING* parameter to increase the filtering in order to provide a more stable display reading.

APPLICATION INFORMATION

Liquid

Viscosity Effect (SUS/cSt)

The design uses a precision machined, sharp- edged orifice and biasing calibration spring that assures operating stability and accuracy over the wide viscosity range common to many fluids. Generally, high flow models of each meter size provide good accuracy over a viscosity range of 40…500 SUS (4.2…109 cSt).

Density Effect (Specific Gravity)

Any fluid density change from stated standards has a proportional effect on meter accuracy. Corrections for more or less dense fluids can be made to standard scales using the following correction factor:

$$\sqrt{\frac{1.0}{\textit{Specific Gravity}}}$$ For water/water-based meters

$$\sqrt{\frac{0.876}{\textit{Specific Gravity}}}$$ For petroleum-based meters

Pneumatic

NOTE: Pressure and temperature readings must be taken at the flow meter inlet to ensure accurate correction factors.

The pneumatic flow meter is calibrated for air in standard cubic feet per minute (scfm) at 1.0 s.g. (70° F @ 100 psi), and liter per second (lps) at 1.0 s.g. (21° C @ 6.9 bar).

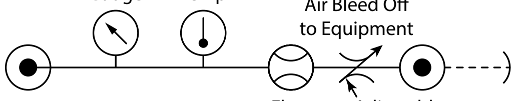

Figure 15: System schematic

Determine Flow Rates Using Different Pressures and Temperatures

$$scfm\,(actual) = \frac{scfm\,(indicated)}{f_1 \times f_2 \times f_3}$$

Where f_1 = Conversion Factor for Pressure
f_2 = Conversion Factor for Temperature
f_3 = Conversion Factor for Specific Gravity

psig	25	50	75	100	125	150	175	200	225	250
BAR	1.7	3.5	5.2	6.9	8.6	10.4	12.1	13.8	15.5	17.2
kPa	172	345	517	689	862	1034	1207	1379	1551	1724
f_1	1.700	1.331	1.131	1.00	0.902	0.835	0.778	0.731	0.692	0.658

$$f_1 = \sqrt{\frac{114.7}{14.7 + psig}} \qquad f_1 = \sqrt{\frac{7.914}{1.014 + BAR}} \qquad f_1 = \sqrt{\frac{790.857}{101.357 + kPa}}$$

Table 5: Temperature Correction Factor (f_1) Operating Pressure

°F	10	30	50	70	90	110	130	150	170	190
°C	–12.2	–1.1	9.9	21.0	32.1	43	54	65	76	88
f_2	0.942	0.962	0.981	1.00	1.018	1.037	1.055	1.072	1.090	1.107

$$f_2 = \sqrt{\frac{460 + °F}{530}} \qquad f_2 = \sqrt{\frac{273 + °C}{293}}$$

Table 6: Temperature Correction Factor (f_2)

$$f_3 = \sqrt{Sp.Gr.}$$

Table 7: Specific Gravity Correction Factor (f_3)

NOTE: *Table 6* is included to show the correction algorithms include in the program to perform pressure, temperature, and specific gravity corrections. When configuring the MR Model, enter the actual operating pressure, temperature, and specific gravity values, not the correction factors.

FLUID SELECTION CHARTS

Liquids

Fluid	Specific Gravity	Correction Factor		Aluminum	Brass	T16 SST	T303 SST	Viton®	EPR	Polycarbonate	Nylon	Pyrex®
		Oil	Water									
Acetic Acid (Air Free)	1.06	0.909	0.971	C	N	R	R	R	R	C	N	R
Acetone	0.79	1.053	1.125	R	R	R	R	N	R	N	R	R
Alcohol Butyl (Butanol)	0.83	1.027	1.098	C	C	R	R	C	R	R	R	R
Alcohol Ethyl (Ethanol)	0.83	1.027	1.098	C	C	R	R	C	R	R	N	R
Ammonia	0.89	0.992	1.060	R	C	R	R	N	R	N	C	R
Benzine	0.69	1.127	1.204	C	R	R	C	R	N	N	R	R
Carbon Disulphide	1.26	0.834	0.891	R	N	R	R	R	N	N	R	R
Castor Oil	0.97	0.950	1.015	C	R	R	C	R	N	C	C	R
Cotton Seed Oil	0.93	0.970	1.037	C	R	R	R	R	N	R	R	R
Ethylene Glycol 50/50	1.12	0.884	0.945	R	R	R	R	R	R	R	C	R
Freon II	1.46	0.774	0.828	R	R	R	R	R	N	R	R	R
Gasoline	0.70	1.119	1.195	R	R	R	R	R	N	C	R	R
Glycerin	1.26	0.834	0.891	R	R	R	R	R	R	R	C	R
Kerosene	0.82	1.033	1.104	R	R	R	R	R	N	R	R	R
Liquid Propane (LPG)	0.51	1.310	1.400	R	R	R	R	R	N	N	R	R
Mineral Oil	0.92	0.976	1.042	R	N	R	R	R	N	R	R	R
Naphtha	0.76	1.074	1.147	R	N	R	R	R	N	C	R	R
Perchloroethylene	1.62	0.735	0.786	C	N	R	R	R	N	N	N	R
Petroleum Oil	0.876	1.000	1.068	R	R	R	R	R	N	R	R	R
Phosphate Ester	1.18	0.862	0.921	R	R	R	R	N	R	N	R	R
Phosphate Ester Base	1.26	0.833	0.891	R	R	R	R	N	R	N	R	R
Phosphoric Acid (Air Free)	1.78	0.701	0.749	N	N	R	N	R	N	R	N	R
Sea Water	1.03	0.922	0.985	N	N	C	C	N	R	R	R	R
Synthetic Petroleum Base	1.00	0.936	1.000	R	C	R	R	R	N	R	R	R
Water	1.00	0.936	1.000	N	R	R	R	N	R	R	R	R
Water Glycol 50/50	1.07	0.905	0.967	R	R	R	R	R	N	R	R	R
Water-in-oil	0.93	0.970	1.037	R	R	R	R	N	R	R	R	R
R–Recommended; N–Not Recommended; C–Consult Factory												

Table 8: Liquids fluid selection chart

Gas

Fluid	Specific Gravity	Correction Factor	Aluminum	Brass	T16 SST	T303 SST	Viton®	EPR	Polycarbonate	Nylon	Pyrex®
Air	1.0	1.000	R	R	R	R	R	R	R	R	R
Argon (A)	1.38	1.175	R	R	R	R	R	R	R	R	R
Carbon Dioxide (CO_2)	1.53	1.237	R	R	R	R	R	R	R	R	R
Freon 11 (CCl_3F)	4.92	2.218	R	R	R	R	R	R	R	R	R
Freon 12 (CCl_2F)	4.26	2.060	R	R	R	R	R	R	R	R	R
Helium (HE)	0.14	0.374	R	R	R	R	R	R	R	R	R
Hydrogen (H_2)	0.07	0.265	R	R	R	R	R	R	R	R	R
Natural Gas	0.60	0.775	C	C	R	C	R	N	C	R	R
Nitrogen (N_2)	0.97	0.985	C	C	R	R	R	R	C	R	R
Oxygen (O_2)	1.10	1.049	R	R	R	R	R	R	R	R	R
Propane C_3H_8)	1.57	1.253	R	R	R	R	R	N	N	R	R
R–Recommended; N–Not Recommended; C–Consult Factory											

Table 9: Gaseous fluid selection chart

FLOW VS PRESSURE DROP

Petroleum Fluids

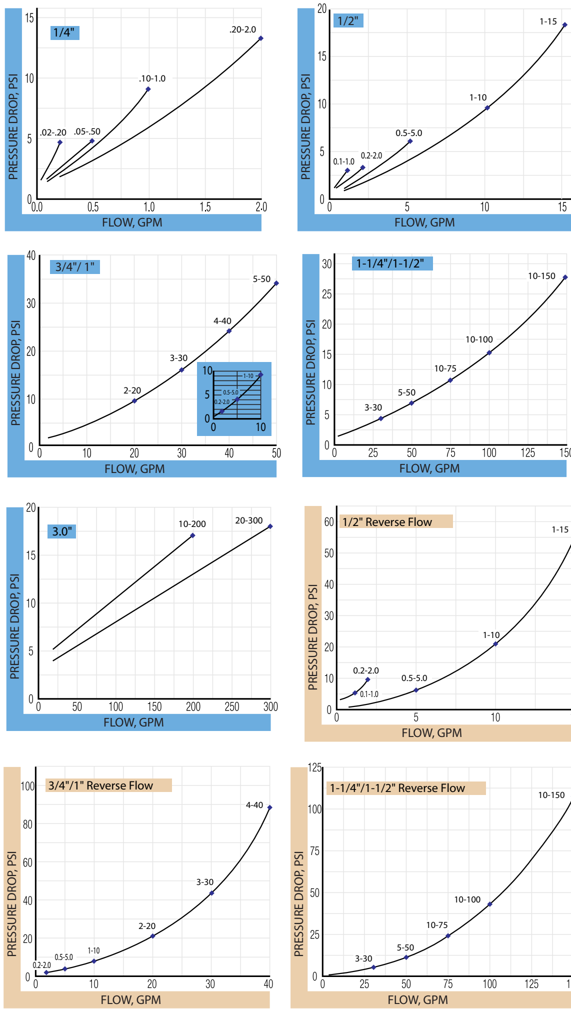

Figure 16: Petroleum fluids pressure drop charts

The pressure drop curves are valid for fluids with density and viscosity similar to factory test fluids. Fluids, especially with higher viscosity than these test fluids, will yield a higher pressure drop through the flow meter and piping system per a given flow volume.

A system needs adequate fluidic horsepower to move the system fluid at a prescribed rate at a pressure adequate to overcome all pressure reducing devices, including the flow meter.

Phosphate Ester

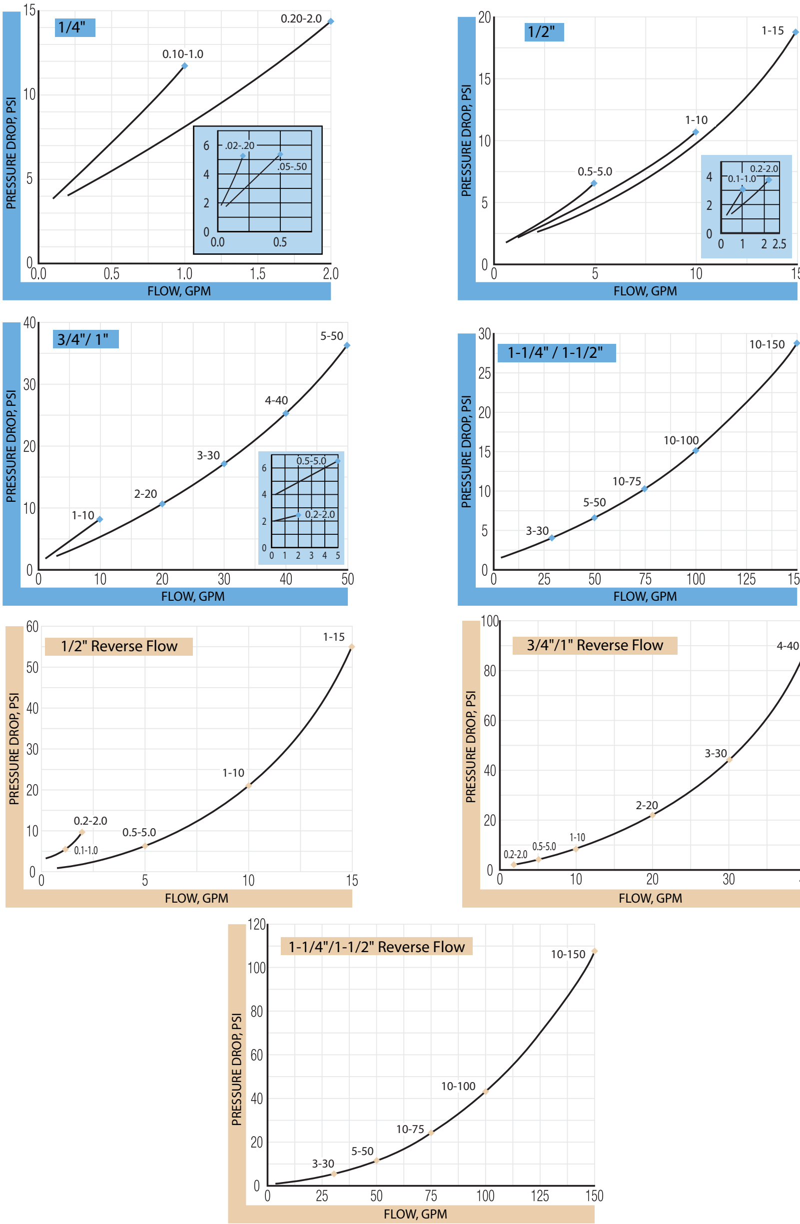

Figure 17: Phosphate ester pressure drop charts

API Oil

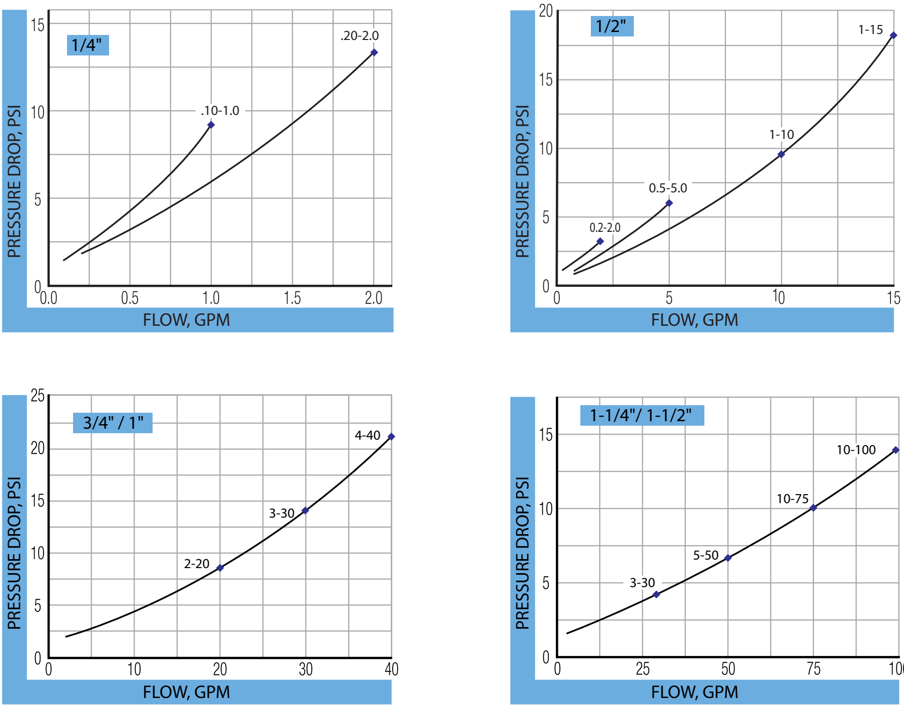

Figure 18: API oil pressure drop charts

Water-Based Fluids

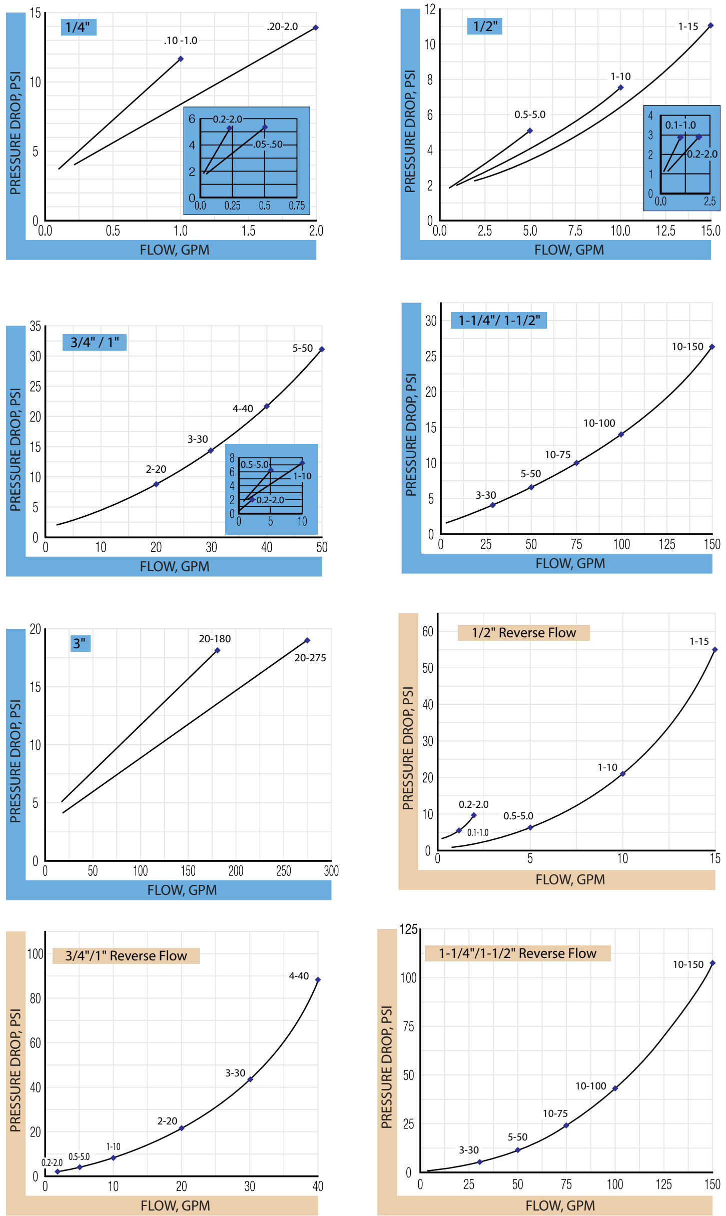

Figure 19: Water-based fluids pressure drop charts

Water

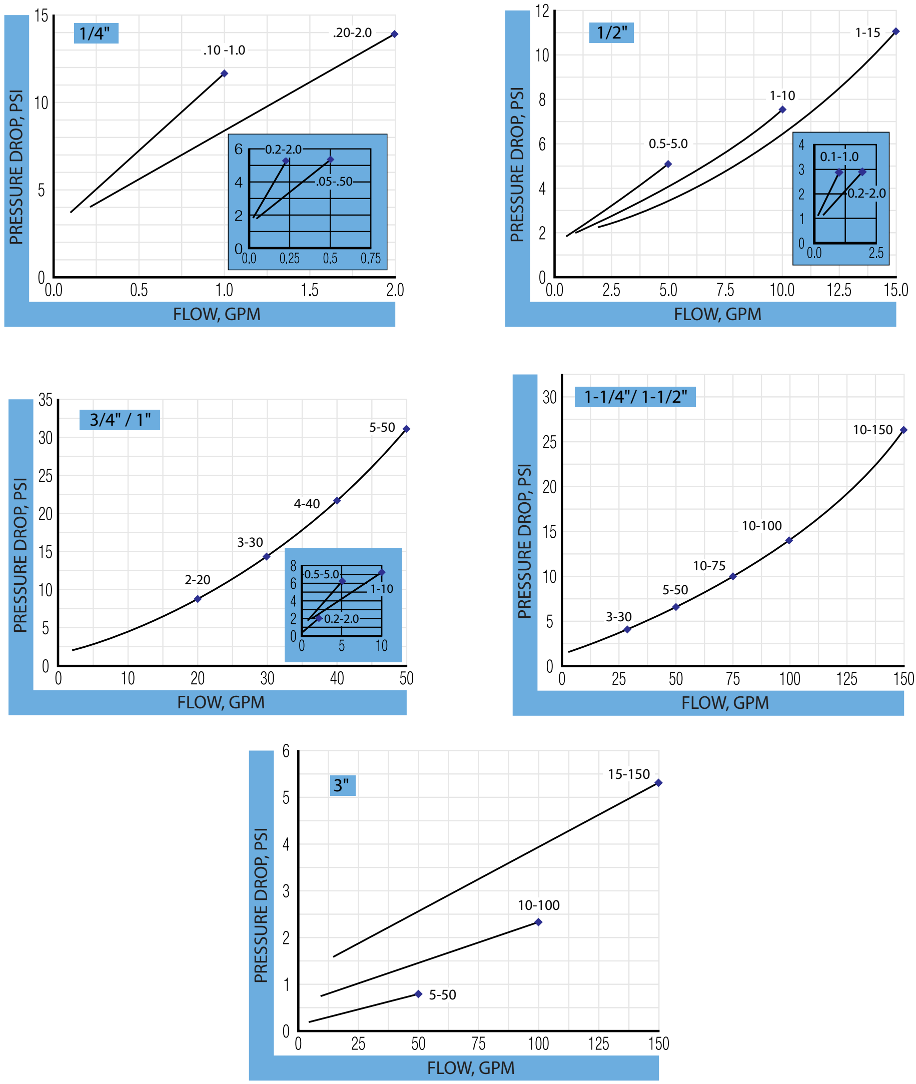

Figure 20: Water pressure drop charts

Caustic and Corrosive Liquids

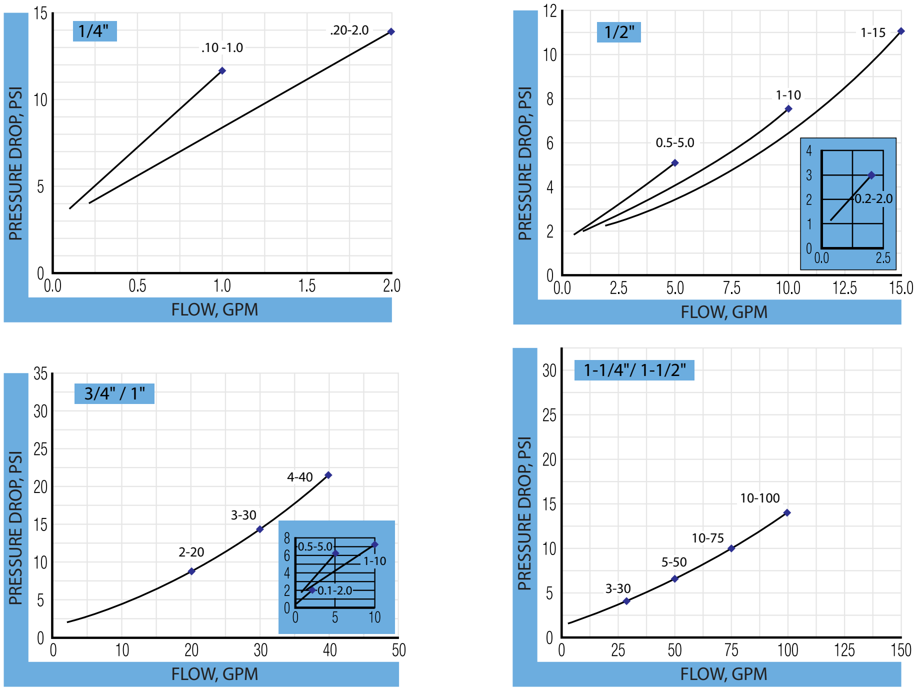

Figure 21: Caustic and corrosive liquids pressure drop charts

Air/Compressed Gases

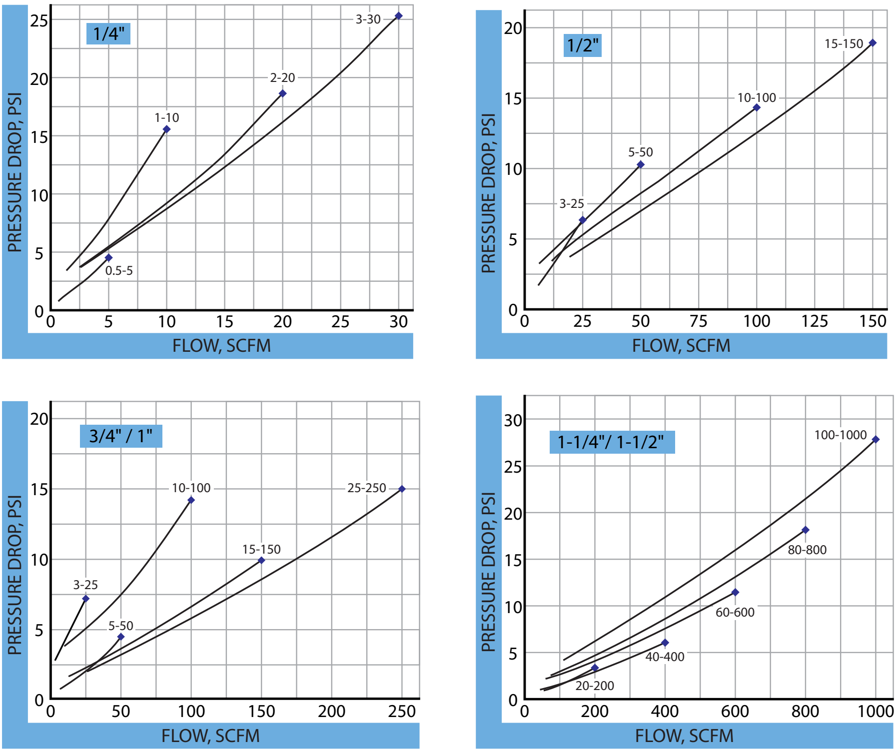

Figure 22: Air/compressed gases pressure drop charts

Air/Caustic and Corrosive Gases

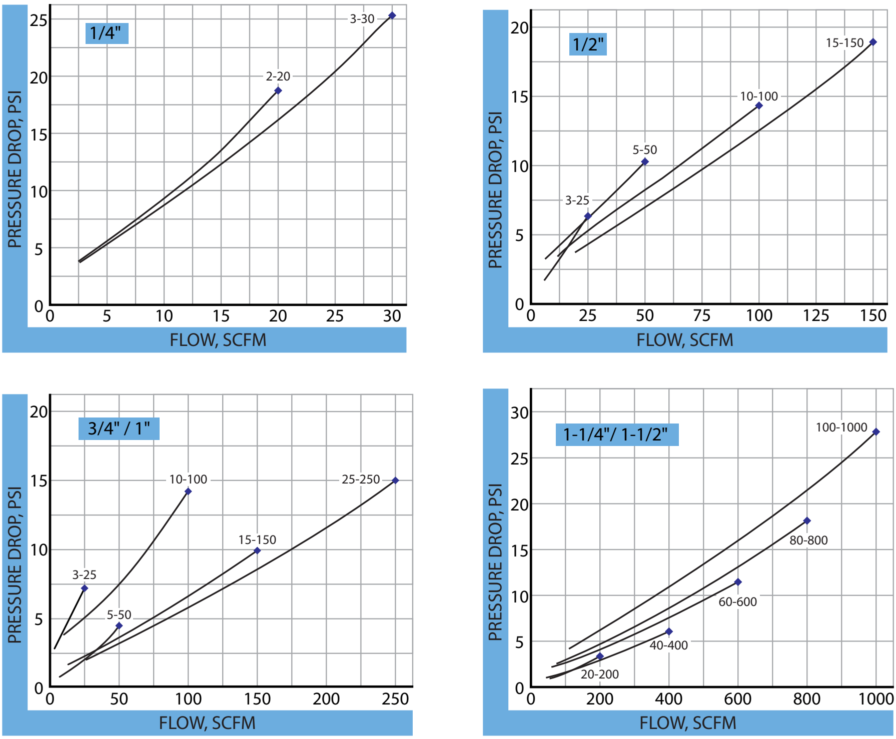

Figure 23: Air/caustic and corrosive gases pressure drop charts

SPECIFICATIONS

Enclosure Rating	NEMA 12 & 13 (equivalent to IP52 & 54)	
Accuracy	± 2% of full scale	
Repeatability	± 1%	
Threads	SAE J1926/1, NPTF ANSI B2.2, BSPP IS01179	
Temperature Range	–20…240° F (–29…116° C)	
Pressure Rating	Aluminum/ Brass Operating	Liquids: 3500 psi/241 bar maximum (3:1 safety factor) Gases: 1000 psi/69 bar maximum (10:1 safety factor)
	Stainless Steel Operating	Liquids (1/4…1/2 in.): 6000 psi/414 bar maximum (3:1 safety factor) Liquids (3/4…1-1/2 in.): 5000 psi/345 bar maximum (3:1 safety factor) Gases: 1500 psi/103 bar maximum (10:1 safety factor)
	CRN Models	Liquids (1/4 in or SAE 6) 5000 psi Liquids (1/2 in. or SAE 10) 3000 psi Liquids (3/4 in. or SAE 12…16) 2500 psi Liquids (1-1/4…1-1/2 in. or SAE 20…24) 2450 psi Gases (all sizes): 1500 psi
Power Requirement	0…5V DC Output: 10…30V DC @ 0.75W maximum	
	0…10V DC Output: 12…30V DC @ 0.75W maximum	
	4…20 mA Output: loop…powered, 30V DC maximum	
Power Consumption	25 mA maximum	
Analog Outputs	0…5V DC and 0…10V DC into 10,000 Ohms minimum	
	4…20 mA into 1000 Ohms maximum	
Circuit Protection	Reverse polarity and current limiting	
Transmission Distance	4…20 mA limited by cable resistance	
	0…5V DC and 0…10V DC 1000 feet (300 m) maximum	
Isolation	Inherently isolated from the piping system	
Display	Fixed or toggle modes of operation for rate and totalizer display	
	8 digit, 0.70 in. high numeric display for rate and total	
	8 digit, 0.35 in. high alphanumeric display for units and setup	
Temperature Drift	50 ppm / °C (max)	
Analog Output:	Resolution 1:4000	
Transient Over-Voltages	Category 3, in accordance with IEC 664	
Pollution Degree	Category 2, in accordance with IEC 664	
Approvals	EMC Directive 89/336/EEC	

Table 10: Unit specifications

MATERIALS

All Meters Common Parts	2024 – T351 Anodized aluminum body, piston and cone C360 Brass body, piston and cone T303 Stainless body, 2024 – T351 Anodized aluminum piston and con (Oil, PE WBF, & Air meters) T303 Stainless body, C360 Brass piston and con (Water meters) T316 Stainless body, piston and cone	
Petroleum (Oil) Common Parts	Spider Plate Retaining Ring Spring Retaining Spring Fasteners Internal Magnet Pressure Seals Enclosure Seal Lens	T316 SS SAE 1070/1090 Carbon Steel 302 SS SAE 1070/1090 Carbon Steel T303 SS Teflon® Coated Alnico 8 Viton® Silicon gasket Polycarbonate
Phosphate Ester (PE) Common Parts	Spider Plate Retaining Ring Spring Retaining Spring Fasteners Internal Magnet Pressure Seals Enclosure Seal Lens	T316 SS SAE 1070/1090 Carbon Steel 302 SS SAE 1070/1090 Carbon Steel T303 SS Teflon Coated Alnico 8 EPR Silicon gasket Polycarbonate
Water-Based (WBF), Water, Air Common Parts	Spider Plate Retaining Ring Spring Retaining Spring Fasteners Internal Magnet Pressure Seals Enclosure Seal Lens	T316 SS T316 SS T302 SS T316 SS T303 SS Teflon Coated Alnico 8 Viton Silicone gasket Polycarbonate
API Oil/Air/Caustic/ Corrosive Liquids and Gases Common Parts	Spider Plate Retaining Ring Spring Retaining Spring Fasteners Internal Magnet Pressure Seals Enclosure Seal Lens	T316 SS T316 SS T316 SS T316 SS T316 SS Teflon Coated Alnico 8 Viton Silicone gasket Polycarbonate

<table>
<tr><td rowspan="12">High Cycle Applications: Pressure Fatigue Rating</td><td colspan="7">Per NFPA/T2.6.1 R1 - 1991, C/90, the method of verifying rated fatigue pressure (or establishing the rated burst pressure, or both) of the pressure containing envelope conforms to NFPA/T2.6.1 R1, Fluid power systems and products – Method for verifying the fatigue and establishing the burst pressure ratings of the pressure containing envelope of a metal fluid power component.</td></tr>
<tr><td rowspan="2">Meter Size</td><td colspan="2">Aluminum</td><td colspan="2">Brass</td><td colspan="2">Stainless Steel</td></tr>
<tr><td>RFP*</td><td>Cycles</td><td>RFP*</td><td>Cycles</td><td>RFP*</td><td>Cycles</td></tr>
<tr><td>1/4</td><td>2000</td><td>1×10^6</td><td>**</td><td></td><td>3000</td><td>1×10^6</td></tr>
<tr><td>1/2</td><td>2000</td><td>1×10^6</td><td>**</td><td></td><td>3000</td><td>1×10^6</td></tr>
<tr><td>3/4</td><td>1500</td><td>1×10^6</td><td>**</td><td></td><td>3000</td><td>1×10^6</td></tr>
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<tr><td>1500</td><td>70×10^3</td><td>**</td><td></td><td>3000</td><td>1×10^6</td></tr>
<tr><td rowspan="2">1-1/2</td><td>1000</td><td>1×10^6</td><td>**</td><td></td><td>3000</td><td>1×10^6</td></tr>
<tr><td>1500</td><td>70×10^3</td><td>**</td><td></td><td>3000</td><td>1×10^6</td></tr>
<tr><td colspan="4">*RFP = Rated Fatigue Pressure</td><td colspan="3">**Consult Factory</td></tr>
</table>

Table 11: Materials specifications

DIMENSIONS

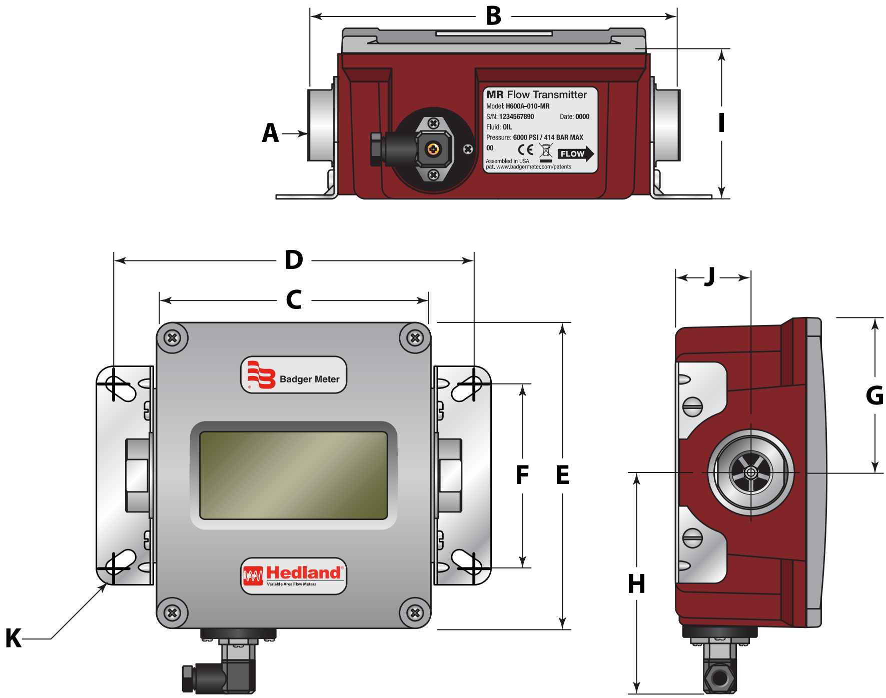

Figure 24: Dimensions

Nominal Port Size	B Length in. (mm)	C Length in. (mm)	D Length in. (mm)	E Width in. (mm)	F Width in. (mm)	G Width in. (mm)	H Cable in. (mm)	I Depth in. (mm)	J Offset in. (mm)	K Hole Dia. in. (mm)
1/4 in. SAE 6	6.60 (167.64)	5.27 (133.86)	6.92 (175.77)	6.00 (152.40)	3.60 (91.44)	3.00 (76.20)	4.20 (107)	2.94 (74.68)	1.46 (37.08)	0.28 (7.11)
1/2 in. SAE 10	6.60 (167.64)	5.27 (133.86)	6.92 (175.77)	6.00 (152.40)	3.60 (91.44)	3.00 (76.20)	4.20 (107)	2.94 (74.68)	1.46 (37.08)	0.28 (7.11)
3/4 in. SAE 12	7.20 (182.88)	5.27 (133.86)	6.92 (175.77)	6.00 (152.40)	3.60 (91.44)	3.00 (76.20)	4.20 (107)	2.94 (74.68)	1.46 (37.08)	0.28 (7.11)
1 in. SAE 16	7.20 (182.88)	5.27 (133.86)	6.92 (175.77)	6.00 (152.40)	3.60 (91.44)	3.00 (76.20)	4.20 (107)	2.94 (74.68)	1.46 (37.08)	0.28 (7.11)
1-1/4 in. SAE 20	12.20 (309.88)	10.68 (271.27)	11.65 (295.91)	7.63 (193.80)	4.84 (122.94)	3.82 (97.03)	5.02 (128)	4.50 (114.30)	2.20 (55.88)	0.28 (7.11)
1-1/2 in. SAE 24	12.20 (309.88)	10.68 (271.27)	11.65 (295.91)	7.63 (193.80)	4.84 (122.94)	3.82 (97.03)	5.02 (128)	4.50 (114.30)	2.20 (55.88)	0.28 (7.11)

Table 12: Dimensions

NOTE: Fractional sizes apply to NPT and BSP configurations.

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