



TELEDYNE HASTINGS INSTRUMENTS
Everywhereyoulook™

HFM-301/305/306 Flow Meters HFC-303/307 Flow Controllers

INSTRUCTION MANUAL



TELEDYNE
HASTINGS INSTRUMENTS
Everywhereyoulook™

ISO 9001

C E R T I F I E D

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Manual Print History

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Visit www.teledyne-hi.com for WEEE disposal guidance.

Description of Symbols and Messages used in this manual



WARNING: indicates a hazardous situation, which, if not avoided, could result in death or serious injury. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood.



CAUTION: indicates a hazardous situation, which if not avoided, could result in minor or moderate injury. Do not proceed beyond a CAUTION notice until the indicated conditions are fully understood and met.



NOTICE: calls attention to a procedure or practice that if not correctly performed or adhered to, could result in equipment damage, loss of data, or inaccurate data.



NOTE: is used for tips and other digressions.

Hastings Instruments reserves the right to change or modify the design of its equipment without any obligation to provide notification of change or intent to change.

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1. General Information

The Hastings 300 series high range mass flow meters and controllers are designed to accurately measure and control mass flow at ranges between 25 slm and 10,000 slm with an accuracy of better than $\pm 1\%$ Full Scale (HFM-306 is 2% FS). Hastings mass flow instruments do not require any periodic maintenance under normal operating conditions with clean gases. No damage will occur from the use of moderate overpressures or overflows (~300 psig/2.07 MPa for HFM-306, ~500 psi/3.45 MPa for all other models). Instruments are normally calibrated with the appropriate standard calibration gas (nitrogen) then a correction factor is used to adjust the output for the intended gas. Calibrations for other gases, such as oxygen, helium, and argon, are available upon special order.



NOTICE: The instruments described in this manual may be available with multiple pinouts. Ensure that all electrical connections are correct.



NOTICE: The instruments described in this manual are designed for INDOOR and DRY use only.



NOTICE: The instruments described in this manual are designed for Class 2 installations in accordance with IPC standards.



CAUTION: There are no operator serviceable parts or adjustments inside the product.



CAUTION: If this equipment is used in a manner other than that specified, the protection provided by the equipment may be impaired.

1.1. Features

LINEAR BY DESIGN. The HFM-301/305/306 and HFC-303/307 series are intrinsically linear (no linearization circuitry is employed). Should field recalibration (a calibration standard is required) be desired, the customer needs to simply set the zero and span points. There will be no appreciable linearity change of the instrument when the flowing gas is changed.

NO FOLDOVER. The output signal is linear for very large overflows and is monotonically increasing thereafter. The output signal will not come back on scale when flows an order of magnitude over the full-scale flow rate are measured. This means no false acceptable readings during leak testing.

MODULAR SENSOR. The Hastings 300 series incorporates a removable/replaceable sensor module. Field repairs to units can be achieved with a minimum of production line downtime. Replacing the sensor requires a recalibration.

FAST SETTLING TIME. Changes in flow rate are detected in less than 250 milliseconds when using the standard factory PC board settings.

FIELD RANGEABLE. The Hastings 300 series is available in ranges from 0-5 sccm to 0-25 slm. Each flow meter has a shunt which can be quickly and easily exchanged in the field to select different ranges. Calibration, however, is required.

CURRENT LOOP. The 4-20 mA option gives the user the advantages of a current loop output to minimize environmental noise pickup.

1.2. Specifications



WARNING: Do not operate instruments exceeding the specifications listed below. Failure to heed this warning could result in serious personal injury and/or damage to the equipment.

Accuracy: HFM-301/305 & HFC-303/307: $\pm 1\%$ FS ($\pm 2\%$ FS for HFM-306)

Repeatability: $\pm 0.2\%$ FS

Standard Pressure Rating: HFM-301, HFC-303: 500 psig [3.45 MPa]
with High Pressure Option of 1000 psig [6.89 MPa]

HFM-305, HFC-307: 500 psig [3.45 MPa]

HFM-306: 300 psig [2.07 MPa]

Pressure Coefficient: $< 0.016\%$ of reading/psi (N₂)

See pressure section for more information

Operating Temperature: -20 - 70 °C in non-condensing environment

Temperature Coefficient (zero): Maximum $\pm 0.12\%$ FS / °C (-20-70 °C)

Temperature Coefficient (span): Maximum $\pm 0.08\%$ Reading / °C (-20-70 °C)



WARNING: Operation above 60 °C ambient may result in case temperatures capable of causing burns.

Leak Integrity: $< 1 \times 10^{-9}$ sccs

Flow Ranges: 25 to 10,000 slm (N₂ Equivalent)

Standard Output: 0-5 VDC (load min 2k Ω)

Optional Output: 4-20 mA (see load requirements in section 1.3)

Power Requirements: $\pm 14\text{-}16$ VDC @ 70 mA (meters absolute max)

$\pm 14\text{-}16$ VDC @ 185 mA (controllers absolute max)

Class 2 power 150VA max fused



NOTICE: Use of an underpowered or under-voltage supply could result in equipment damage.



WARNING: Do not power with isolated drive circuits that are more than 36 volts above ground potential or could reach 36 volts in the event of a fault. Failure to heed this warning could result in serious personal injury and/or damage to the equipment.

Wetted Materials: Stainless Steel, Nickel, Viton,
Kalrez ® (Controller only)

Attitude Sensitivity of zero: $< \pm 1.4\%$ FS for 90° without re-zeroing
(N₂ @ 50 psig [446 KPa])

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Weight:	HFM-301 = 3.5 lbs. [1.6 kg] HFC-303 = 5.3 lbs. [2.4 kg] HFM-305 = 8.1 lbs. [3.7 kg] HFM-306 = 28.8 lbs. [13.1 kg] HFC-301 = 15.2 lbs. [6.9 kg]
Electrical Connector:	15 pin subminiature "D"
Fitting Options:	HFM-301/HFC-303: $\frac{1}{2}$ ", $\frac{3}{4}$ " tube, 10, 12, 20 mm tube, 3/8", $\frac{1}{2}$ " Male NPT, $\frac{1}{2}$ " and $\frac{3}{4}$ " VCR® and VCO®, $\frac{3}{4}$ -16 and 1-1/16 MS straight female, Surface Mount (301 small base only) HFM-305/HFC-307: $\frac{3}{4}$ ", 1" tube, 25 mm tube, $\frac{3}{4}$ ", 1" Male NPT, 1" Female NPT, 1" VCR® and VCO®, 1 5/16-12 SAE/MS Female thread HFM-306: 1", 1 $\frac{1}{2}$ ", 2" tube, 25 mm tube

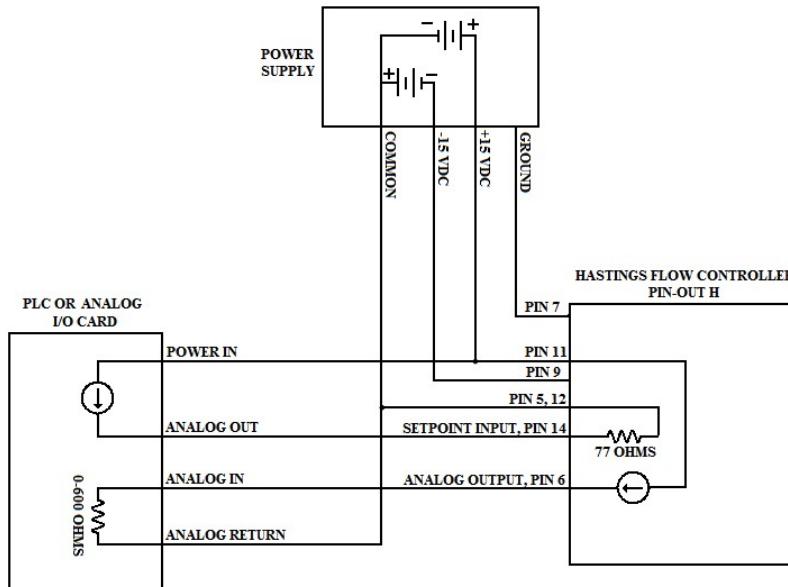
1.3. Optional 4-20 mA Current Output

An option to the standard 0-5 VDC output is the 4-20 mA current output that is proportional to flow. The 4-20 mA signal is produced from the 0-5 VDC output of the flow meter. The current loop output is useful for remote applications where pickup noise could substantially affect the stability of the voltage output or long cable runs where cable resistance would cause a voltage signal to decay.

The current loop signal replaces the voltage output on pin 6 of the DA-15 connector. The current loop is sourced internally from the +15 VDC supply and must be returned to either the signal common (pin 5) or the supply common (pin 9) after passing through the monitoring circuitry to complete the loop. If returning the current to pin 5 (signal common), the load must be between 0 and 600 ohms. If returning current to pin 9 (supply common), the load must be between 600 and 1200 ohms. Failure to meet these conditions will cause the current transmitter to fail.

The 4-20 mA I/O option can accept a current input for flow controllers. The 0-5 VDC command signal on pin 14 can be replaced by a 4 - 20mA command signal. The loop presets an impedance of 75 Ohms and is returned to the power supply through the valve common.

Current Return Pin	Load Resistance R Ω
5 (Signal Common)	0<R<600
9 (Negative Rail)	600<R<1200



1.4. Accessories

1.4.1. Power Supplies

Hastings power supplies are available in one or four channel versions. They convert 100, 115 or 230VAC to the ± 15 VDC required to operate the instruments and provide a digital indication of the instrument output. Hastings power supplies are power limited to no more than 150 VA max (fused). Interface terminals for the analog output signals and a main power on/off switch are located on the rear panel as well. For safety reasons it is recommended that the power supply (and on/off switch) be kept near the flow instruments and that the on/off switch not be blocked. Throughout this manual, when reference is made to a power supply, it is assumed the customer is using a Hastings power supply. Hastings Power supplies change as new technology becomes available. For knowledge of the most up-to-date Hastings power supplies, please consult either Hastings sales staff or our website at <http://www.teledyne-hi.com>



WARNING: To prevent the spread of fires in the event of a fault, only use power supplies power limited to no more than 150 VA. The current available from a power supply used with a 300 Series instrument should be no greater than 1.6 A. Hastings power supplies meet these requirements.



1.4.2. Cables

Cables to power Hastings flow instruments connect from the 15 pin "D" connector on the back of the power supply directly to any of the 300 Series flow instruments. More information about the available cables can be found on our website at <http://www.teledyne-hi.com>

2. Installation and Setup

This section contains the necessary steps to install a new flow meter/controller into operation as quickly and easily as possible. Please read the following thoroughly before attempting to install the instrument.

2.1. Receiving Inspection

Prior to opening, inspect for obvious signs of damage to the shipment. Immediately advise the carrier who delivered the shipment if any damage is suspected. If the shipment has arrived intact, carefully unpack the instrument and any accessories that have been ordered. Check each component shipped with the packing list. Ensure that all parts are present (i.e., flowmeter, controller, power supply, cables, etc.). Optional equipment or accessories will be listed separately on the packing list. There may also be one or more OPT (option) items on the packing list. These normally refer to special ranges or special gas calibrations. They may also refer to special helium leak tests, or high-pressure tests. In most cases, these are not separate parts, but special options or modifications built into the flow instrument.

Quick Start

- 1. Ensure flow circuit mechanical connections are leak free**
- 2. Ensure electrical connections are correct (see label).**
- 3. Allow 30 min. to 1 hour for warm-up.**
- 4. Note the flow signal decays toward zero.**
- 5. Run ~20% flow through instrument for 5 minutes.**
- 6. Insure zero flow; wait 2 minutes, then zero the instrument.**
- 7. Instrument is ready for operation**

2.2. Power Requirements

At their maximum power draws, the HFM-301/305/306/307 meters require ± 15 VDC @ 70 mA, and the HFC-303/307 controllers require ± 15 VDC @ 185 mA (See specifications in sections 1.2). The HFM-300/HFC-302 Series supply voltages should be reasonably regulated as power supply ripple may propagate to the output (less than 50 mV ripple is preferred). The supply voltage can vary from 14.0 to 16.0 VDC. Surge suppressors are recommended to prevent power spikes reaching the instrument. The Hastings power supplies in section 1.4.1 are limited to no more than 150VA max and it satisfies all the recommended requirements. If using non-Hastings power supplies with 300 Series instruments, it is strongly advised that they meet the recommendations in section 1.4.1. The specs given earlier state the max assuming a 0.026" sensor and 4-20 mA output. In addition to the specs reported in 1.2, the table below may be useful (the table assumes a 0.026" sensor):

Recommended Current Draws for 300 Series Instruments		
Instrument Type\Analog Output	0-5 V	4-20 mA
Meter, ± 14 -16 VDC @	55 mA	70 mA
Controller, ± 14 -16 VDC @	170 mA	185 mA



NOTICE: Use of an underpowered or under-voltage supply could result in equipment damage.

2.3. Output Signal

The standard output of the flow meter is a 0-5 VDC signal proportional to the flow rate. In Hastings power supplies, the output is routed to the display and is also available at the terminals on the rear panel. If a Hastings supply is not used, the output is available on pin 6 of the DA-15 connector and is referenced to pin 5. It is recommended that the load resistance be no less than $2k\Omega$. If the optional 4-20 mA output is used, the load impedance must be selected in accordance with Section 1.3.

2.4. Mechanical Connections

2.4.1. Gas Quality (Filtering)

Impurities or foreign debris in the gas lines can have negative effects on device performance. The smallest of the internal passageways in the HFM-300/HFC-302 Series is the diameter of the sensor tube, which can be 0.026" (0.66 mm), 0.017" (0.43mm), or 0.014" (0.36mm), so the instrument requires adequate filtering of the gas supply to prevent blockage or clogging of the tube.

2.4.2. Mounting

There are two mounting holes (#8-32 thread) in the bottom of the transducer that can be used to secure it to a mounting bracket, if desired (HFM-306 has 4 mounting holes of 1/4-28 size).

As explained in section 2.6.3 (High Pressure Operation), pressure can significantly affect readings and accuracy. When mounting a flow instrument in anything other than a horizontal attitude, consideration must be given to the fact that the heater coil can now set up a circulating flow through the sensor tube, thereby throwing the zero off. This condition worsens with denser gases or with higher pressures. Always check and match the direction of gas flow through the instrument and the arrow marked on the flow instrument label. Whenever possible, install the instrument horizontally.

Always re-zero the instrument with zero flow, at its normal operating temperature and purged with its intended gas at its normal operating pressure.



NOTICE: The flow instrument should be installed in a clean and careful manner. Take care not to drop the product and avoid impacts to prevent damage.



WARNING: Make sure the work area is safe (de-pressurized) before installing a flow instrument. Make sure emergency shutoff or pressure release valves are available for safe working conditions. Do not exceed 500 psig unless the flowmeter is specifically rated for higher pressures

2.4.3. Plumbing

The pressure regulator and the plumbing upstream must be of sufficient size to minimize changes in the upstream pressure. When switching from full flow to zero flow, the inlet pressure of instrument should rise to no more than 30% above the inlet pressure at full flow. In general, high-capacity regulators and large internal diameter plumbing help make the system more stable. The pressure drop between the regulator and the instrument due to line resistance should be minimized.

See the fitting options in the specifications section (1.2). Note the O-rings for the end cap are Viton (optional Kalrez, Neoprene or Buna-N). It is suggested that all connections be leak-checked after installation. This can be done by pressurizing the instrument (do not exceed pressure rating of the instrument) and applying a diluted soap solution to the flow connections (bubbles would indicate leaks).

2.5. Electrical Connections

If a power supply from Hastings Instruments is used, installation consists of connecting the 300 series cable from the "D" connector on the rear of the power supply to the "D" connector on the top of the flow meter/controller. The "H" pin-out requires cable AF-8-AM (grey molded back-shell). The "U" pin-out requires cable # 65-791 (black molded back-shell).

If a different power supply is used, follow the instructions below when connecting the flow instrument and refer to either table 2.1 or 2.2 for the applicable pin-out. Also see section 1.3 for the 4-20 mA connections.

The power supply used must be bipolar and capable of providing the appropriate current draws mentioned in section 2.2. These voltages must be referenced to a common ground. One of the "common" pins must be connected to the common terminal of the power supply. Case ground should be connected to the AC ground locally. The cable shield (if available) should be connected to AC ground at the either the power supply end, or the instrument end of the cable, not at both. Pin 6 is the output signal from the flow meter. The standard output will be 0 to 5 VDC, where 5 VDC is 100% of the rated or full-scale flow.

The command (set point) input should be a 0-5 VDC signal (or 4-20mA if configured as such) and must be free of spikes or other electrical noise, as these would generate false flow commands that the controller would attempt to follow. The command signal should be referenced to signal common.

A valve override command is available to the flow controller. Connect the center pin of a single pole, three-position switch (center off) to the override pin. Connect +15 VDC to one end of the three-position switch, and -15 VDC to the other end. The valve will be forced full open when +15 VDC is supplied to the override pin, and full closed when -15 VDC is applied. When there is no connection to the pin (the three-position switch is centered) the valve will be in auto control and will obey the 0-5 VDC commands supplied to command (set-point) input.



WARNING: Care must be taken to avoid any high voltages that may be present when dealing with power supplies. Power supplies used with 300 Series instruments should be power limited to no more than 150 VA max. The available current for each 300 Series instrument connected to a power supply should not exceed 1.6 A.



WARNING: Care must be taken to avoid any high voltages that may be present when dealing with power supplies.

Figures 2.1/2.2, and Tables 2.1/2.2, show the 300/302 pin out.

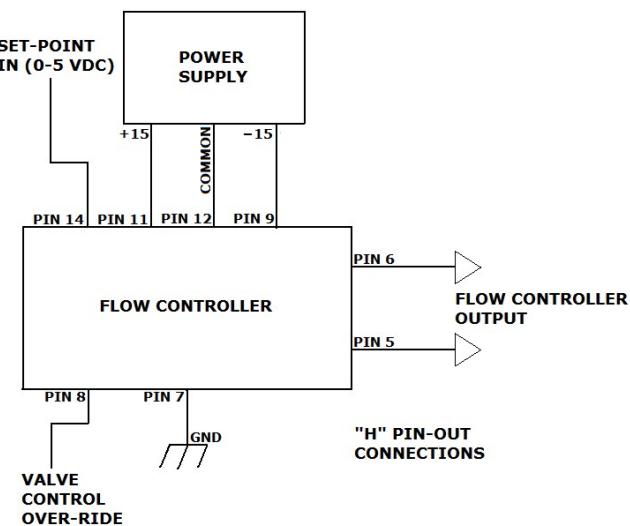
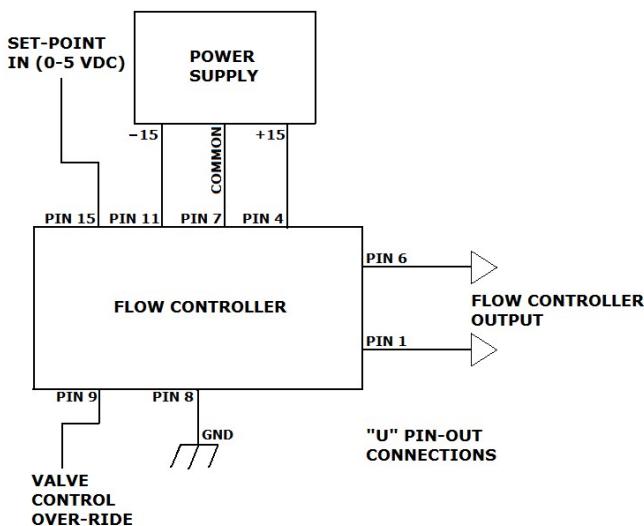


Table 2.1
"U" Pin-Out

Pin #	
1	Signal Common
2	Do not use
3	Do not use
4	+15 VDC
5	
6	Output 0-5 VDC (4-20mA)
7	Signal Common
8	Case Ground
9	Valve Override
10	
11	-15VDC
12	External Input
13	Signal Common
14	Signal Common
15	Set Point 0-5 VDC (4-20mA)

Table 2.2
"H" Pin-Out

Pin #	
1	Do not use
2	Do not use
3	Do not use
4	Do not use
5	Signal Common
6	Output 0-5 VDC (4-20mA)
7	Case Ground
8	Valve Override
9	-15VDC
10	Do not use
11	+15VDC
12	Signal Common
13	External Input
14	Set Point 0-5 VDC (4-20mA)
15	Do not use

2.6. Operation

The standard instrument output signal is 0 - 5 VDC and is proportional to the flow (0 volts = zero flow, 5 Volts = 100% flow). The 4 - 20 mA option is also proportional to flow (4 mA = zero flow and 20 mA = 100% flow).

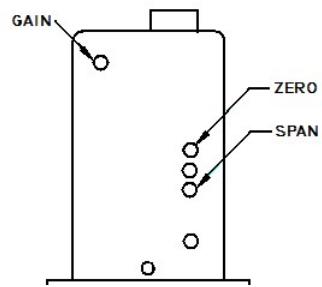
2.6.1. Operating Conditions

For proper operation, the combination of ambient temperature and gas temperature must be such that the flow meter temperature remains between -20 and 70 °C. The most accurate measurement of flow will be obtained if the flow meter is zeroed at operating temperature as temperature shifts result in some zero offset. Hastings 300 series instruments are intended for use in non-condensing environments only. Condensate or any other liquids which enter the flow meter may destroy its electronic components.

2.6.2. Zero Check

Turn the power supply on if not already energized. Allow for a 1 hour warm-up. Stop all flow through the instrument and wait 2 minutes.

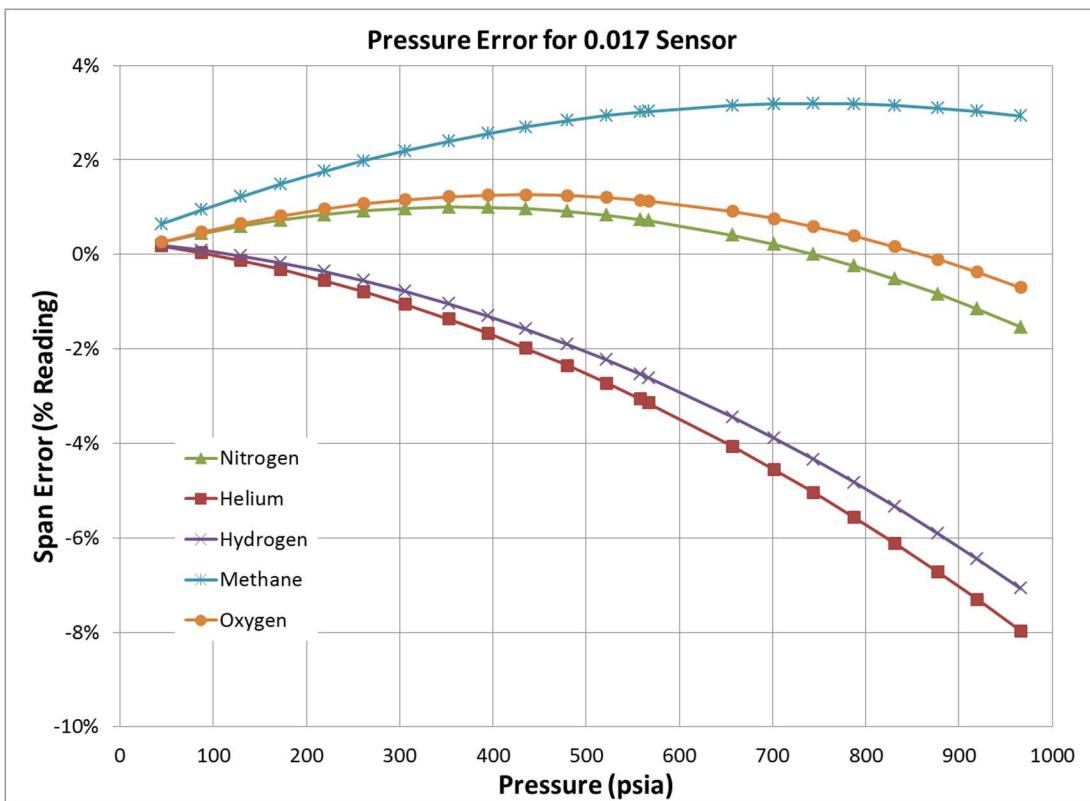
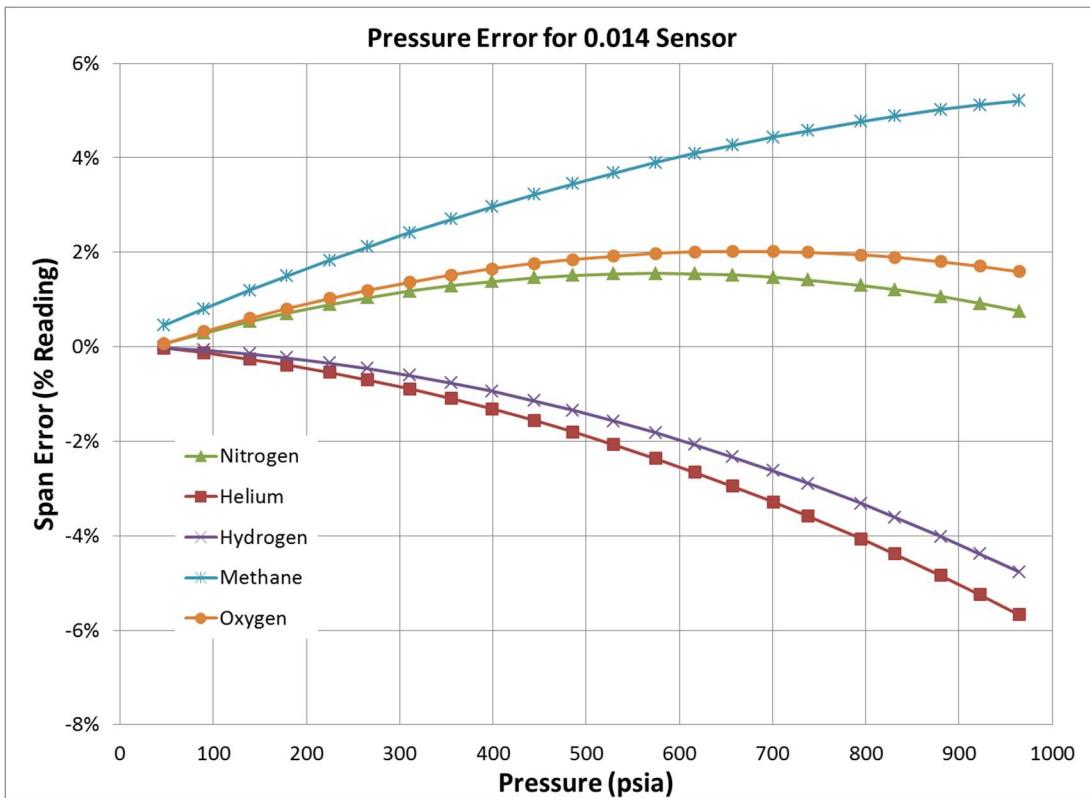
Caution: Do not assume that all metering valves completely shut off the flow. Even a slight leakage will cause an indication on the meter and an apparent zero shift. For the standard 0 - 5 VDC output, adjust the zero potentiometer located on the inlet side of the flowmeter until the meter indicates zero. For the optional 4 - 20 mA output, adjust the zero potentiometer so that the meter indicates 4 mA. This zero should be checked periodically during normal operation. Zero adjustment is required if there is a change in ambient temperature, or vertical orientation of the flow meter/controller.

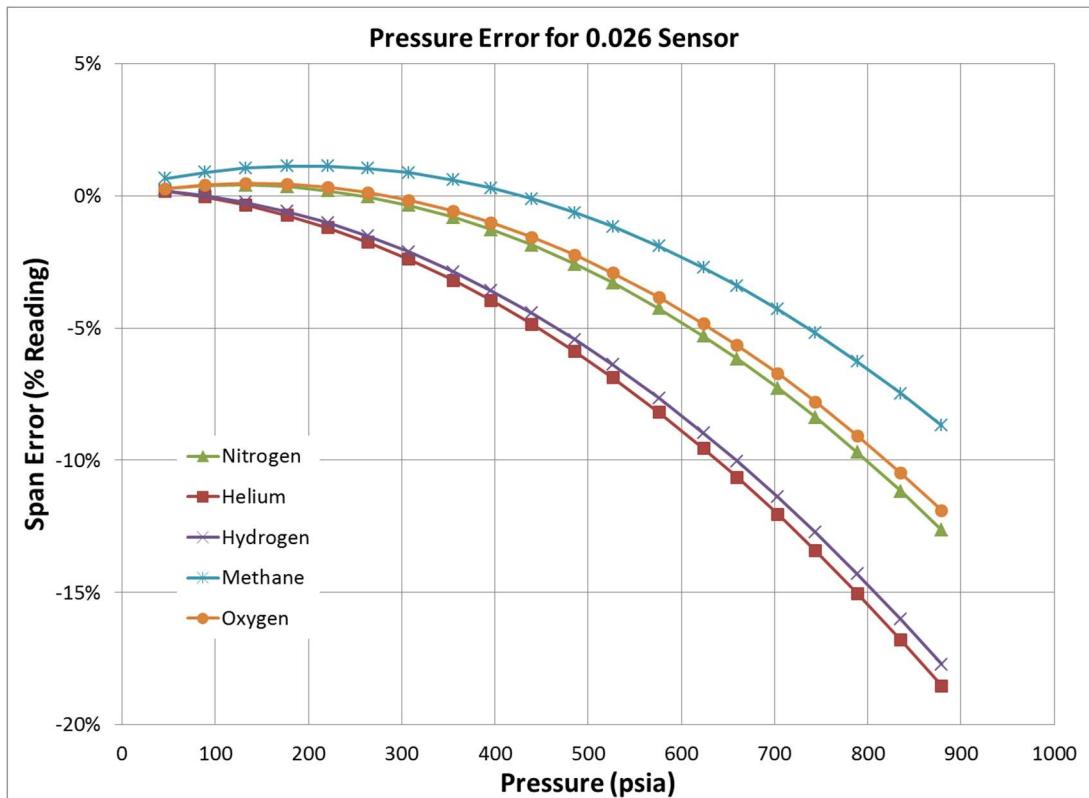


2.6.3. High Pressure Operation

Thermal mass flow meters measure the heat transfer caused by gas flow. This heat transfer is a function of the constant pressure specific heat (C_p) of the gas. For monatomic gases the specific heat is essentially a constant for all normal pressure/temperature conditions. As the gas structure becomes more complex and as the molecular weight of the gas increases, the pressure inside of the sensing tube increases and so does the specific heat of the gas. This is compensated somewhat by the effect of the hoop strain of the tube wall caused by the internal pressure on the resistance heaters wrapped around the sensing tube.

Larger tubing will have more strain than the smaller tubing and a larger associated pressure affect. Charts of the effects of various gases on the span of the flow instruments as a function of pressure are shown below for each of the available sensor diameters. The sensor tubing diameter is written on a label mounted on the side of the sensor and is listed in the options in the order acknowledgement.





If the system pressure is higher than 250 psig (1.7 MPa) the pressure induced error in the span reading becomes significant. This error will approach 16% for nitrogen at 1000 psig. For accurate high-pressure measurements this error must be corrected.

The formula for predicting the nitrogen mean error expressed as a fraction of the reading are:

Sensor Type	A	B
0.026"	-2.2915×10^{-7}	5.7198×10^{-5}
0.017"	-7.1066×10^{-8}	5.2403×10^{-5}
0.014"	-5.3091×10^{-8}	6.1278×10^{-5}

$$\text{Error}_{\text{sensor}} = AP^2 + BP$$

Where P is the pressure in psig and Error is the fraction of the reading in error.

The flow reading can be corrected as follows:

$$\text{Corrected} = \text{Indication} - (\text{Indication} \times \text{Error})$$

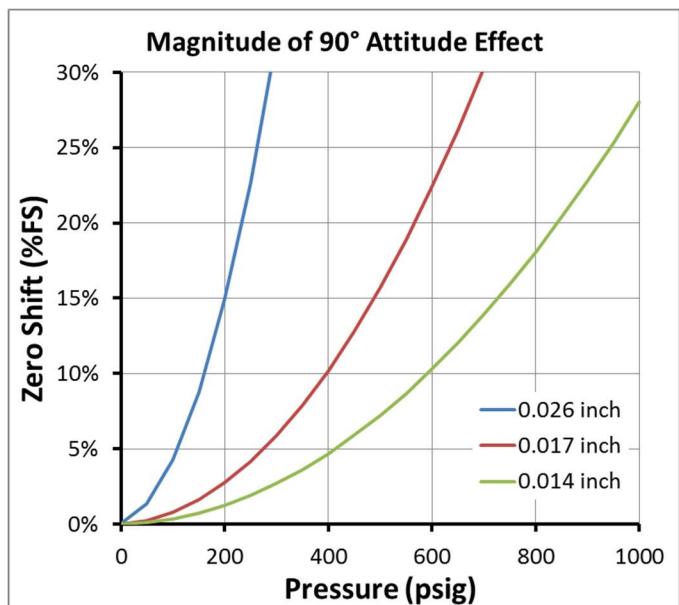
Where the Indication is the indicated flow and Error is the result of the previous formula (or read from charts above).

2.6.4. Vertical Mounting

It is not recommended to mount the instrument vertically if high pressure or high density gas is being measured.

If the instrument is not mounted in a level position and is operating at high pressure or with high density gases, the increased gas density will cause convection to flow through the sensor tube. This natural convection flow will be proportional to the square of the gas density and therefore to system pressure. This will be seen as a shift in the zero flow output that changes as the system pressure changes. Heavier gases will have more of an effect than light gases.

If the error exceeds 20-30% (of full scale), the zero circuit installed in the instruments may no longer be able to be adjusted to compensate for the error.



If the instrument is measuring light gases or low pressure, the change in the zero due to natural convection will be minimal. Larger shifts could be zeroed out with the zero pot as long as the upstream pressure is stable. A chart is shown here for nitrogen/air versus pressure.



CAUTION: The HFM-306 does not have a high pressure option and is only rated for a 300 psig max working pressure.

2.6.5. Gas Blending

Gas blending is achieved by using the output of one flow controller as the control signal (setpoint or scaled setpoint) to a second flow controller (maintaining a fixed ratio of one gas to another).

Multichannel Hastings Power Supplies allow users to configure this option, but other devices can be used, provided they can scale and feed the output signal of one controller to another. The following formulas are useful (Two controllers, unit A and unit B, where FS = Full Scale):

$$A \text{ Flow} = (A \text{ FS Flow}) \left(\frac{A \text{ Output}}{A \text{ FS Output}} \right), \quad \text{let } B \text{ Setpoint} = A \text{ Output} \times \text{Scale Factor}$$

$$B \text{ Flow} = (B \text{ FS Flow}) \left(\frac{A \text{ Output} \times \text{Scale Factor}}{B \text{ FS Output}} \right),$$

$$\text{Flow Ratio} = \frac{B \text{ Flow}}{A \text{ Flow}} = \frac{(\text{Scale Factor})(B \text{ FS Flow})(A \text{ FS Output})}{(A \text{ FS Flow})(B \text{ FS Output})}$$

$$\text{Scale Factor} = \frac{(\text{Flow Ratio})(A \text{ FS Flow})(B \text{ FS Output})}{(B \text{ FS Flow})(A \text{ FS Output})}$$

In most cases the analog full scale output terms are the same so those two terms cancel out. The flow ratio is usually known, so the only challenge is finding the value of the scale factor between the output of A to generate the setpoint of B.

EXAMPLE: Controller A is a 100 SLM Nitrogen 5V controller. Controller B is a 10 SLM CO₂ 5V controller. What needs to happen to maintain CO₂ at 5% of the Nitrogen flow rate? See solution on following page.

SOLUTION:

Use the formulas above:

$$\text{Flow Ratio} = 5\% = 0.05, \quad \text{Scale Factor} = \frac{(0.05)(100)(5)}{(10)(5)} = 0.5$$

Scale the output of controller A by 0.5 (half) and route the signal to the setpoint of controller B to flow 5% of controller A.

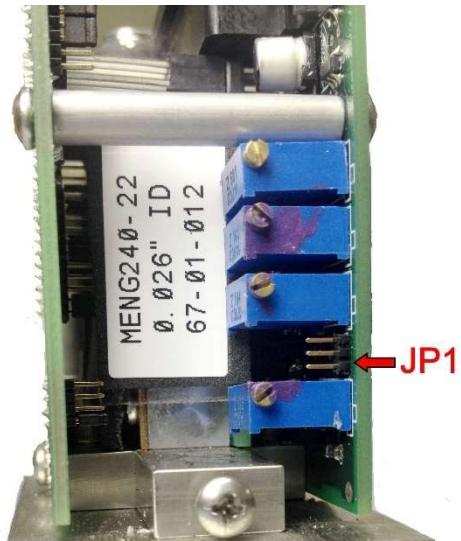
2.7. Output Filter

Occasionally noise from a user's system is superimposed on the output signal voltage. This noise may be due to high turbulence in the flow stream (the sensor is fast enough to measure this) or it could be electrical noise when the flow instrument has a high internal gain (flow instruments with low full-scale flows ~ 25 slm). Varying levels of radio frequency noise or varying airflow over the electronics cover can also induce noise.

Noise can be most pronounced when measuring the flow output with a sampling analog/digital (A/D) converter. When possible, program the system to take multiple samples and average the readings to determine the flow rate.

If less noise is desired, install a jumper over the pins of JP1 on the flow measurement card. See Figure above and right. Covering the two bottom pins (2 & 3), will activate a resistor-capacitor (RC) filter that has a time constant of 0.1 second. This will increase the settling time of the indicated flow rate to approximately 0.4 seconds and remove much of the noise. Covering the top two pins (1 & 2), will increase the filter time constant to 1 second. This will increase the settling time to approx. 4 seconds and remove most of the noise.

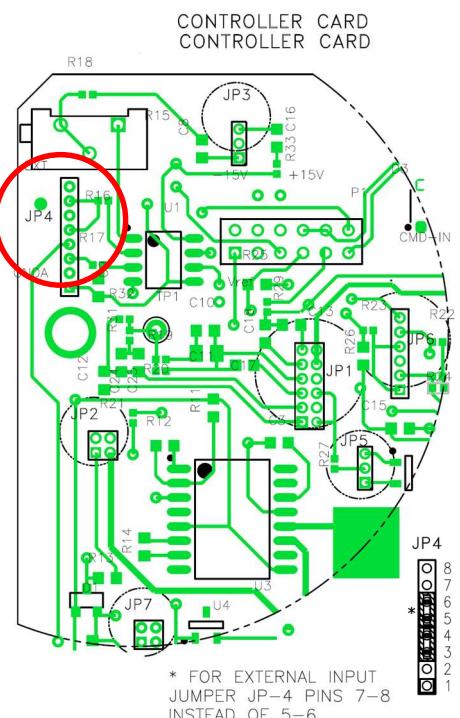
This adjustment will not affect the calibration of the flow meter circuit or the actual flow response to change in command signal (flow controllers). This will only slow down the indicated response (output voltage/current).



2.8. Controlling Other Process Variables (External Input)

Flow controllers usually control mass flow. The control loop opens and closes the valve to make the output flow signal match the command signal. Occasionally, gas is added or removed from a system to control some other process variable. This could be system pressure, oxygen concentration, vacuum level etc. If this process variable has a sensor that can supply an analog signal proportional to its value, the flow controller may be able to control this variable directly. This analog output signal could be 0-5 volts, 0-10 volts (or 4-20 mA for units with 4-20 mA boards) or any value in between.

On the controller card, JP4 sets whether the control loop controls mass flow (5,6) or an external process variable (7,8). See right. This process variable signal must be supplied on pin 13 of the D connector for H pinout units (pin 12 for U pinouts) of the meter card. When the controller is set for external input, it will open or close the valve as necessary to make the external process variable signal match the command signal. If the process variable has a response time that is much faster or slower than the flow meter signal it may be necessary to adjust the gain potentiometer (see section 2.11).



2.9. Command Input

The flow controller will operate normally with any command input signal between 0-5 volts (4-20 ma for units with 4-20 ma input/output cards). If the command signal exceeds ± 14 volts it may damage the circuit cards. During normal operation the control loop will open or close the valve to bring the output of the flow meter signal to within ± 0.001 volts of the command signal. The flow signal will not match the command signal if there is insufficient gas pressure to generate the desired flow. If the command signal exceeds 5 volts, the controller will continue to increase the flow until the output matches the command signal. However, the flow output does not have any guaranteed accuracy values under these conditions.

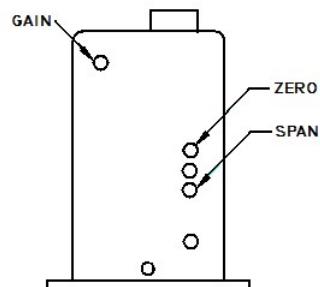
If the command signal is less than 2% of full scale (0.1 volts or 4.32 ma) the valve override control circuit will activate in the closed position. This will force the valve completely closed regardless of the flow signal.

2.10. Valve Override Control

The valve override control line provides a method to override the loop controller and open or close the valve regardless of the flow or command signals. During normal operation this line must be allowed to float freely. This will allow the loop control to open and close the valve as it requires. If the valve override line is forced high ($> +5$ volts) the valve will be forced full open. If the valve-override line is forced negative (< -5 volts) the valve will be forced closed.

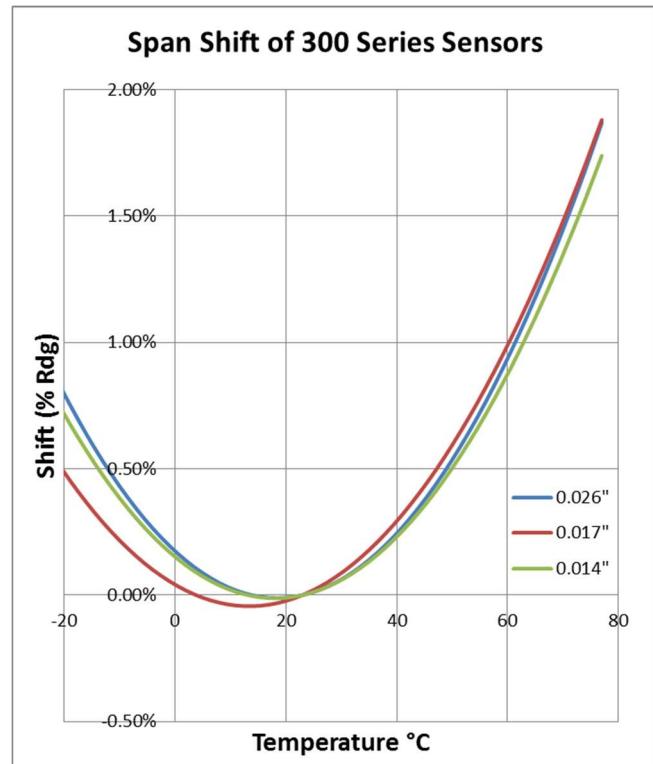
2.11. Gain Potentiometer

On the top left of inlet side of the flow controller there is a hole through which the gain potentiometer is accessible (See right). This gain potentiometer affects the gain of the closed loop controller. Normally this potentiometer will be set at the factory for good stable control. It may be necessary to adjust this potentiometer in the field if the system varies widely from the conditions under which the controller was setup. Turning this gain potentiometer clockwise will improve stability. Turning the potentiometer counter-clockwise will speed up the valve reaction time to changes in the command signal.



2.12. Temperature Coefficients

As the ambient temperature of the instrument changes from the original calibration temperature, errors will be introduced into the output of the instrument. The Temperature Coefficient of Zero describes the change in the output that is seen at zero flow. This error is added to the overall output signal regardless of flow but can be eliminated by adjusting the zero potentiometer of the flow meter/controller to read zero volts at zero flow conditions. The Temperature Coefficient of Span describes the change in output after the zero error is eliminated. This error cannot be eliminated but can be compensated for mathematically if necessary. The curve pictured in Figure 2.8 shows the span error in percent of point as a function of temperature assuming 23°C is the calibration temperature.



3. Maintenance

This section contains service and calibration information. Some portions of the instrument are delicate, so please use extreme care when servicing the flow controller.



NOTICE: It may prove more prudent in the long run to delegate the maintenance of Hastings flow instruments to Hastings personnel who have the appropriate equipment and training. Improper adjustments to the flow instruments can result in inaccurate data, poor instrument function, and may lead to sending the unit back for repair.



CAUTION: Some parts of the instrument are delicate and other parts are heavy enough to cause an injury if dropped. Use extreme care when servicing the instrument.

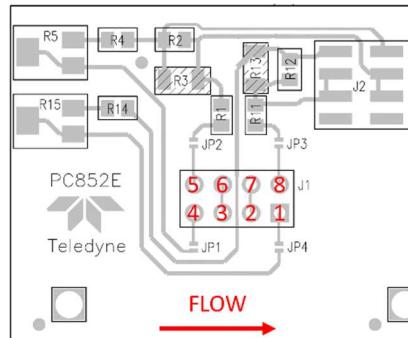
With proper care in installation and use, the flow controller will require little or no maintenance. If maintenance does become necessary, most of the instrument can be cleaned or repaired in the field. Some procedures may require recalibration. Do not attempt these procedures unless facilities are available. Entry into the sensor or tampering with the printed circuit board will void the warranty. Do not perform repairs on these assemblies while unit is still under warranty.

3.1. Troubleshooting

This section includes some of the more common issues that may arise when using a Hastings flow meter or controller. Symptoms, causes, and recommended actions are grouped with each problem.

Symptom: Output reads strong indication of flow with no flow present. Zero pot has no effect.
Cause: Power shorted out.
Action: Turn power supply off for a few seconds, and then turn it on again. If this is ineffective, disconnect the power supply from the unit. Check that the power supply voltages are correct. Incorrect voltages most likely signify a faulty regulator chip inside the supply. If using a Hastings power supply and the display returns to zero after the instrument has been disconnected, there may be a short from the unit to ground.

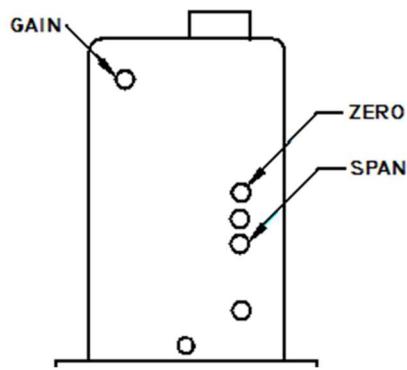
Symptom: Hastings 300 output continues to indicate flow with no flow present or indicates ± 14 volts. Power supply inputs are correct and zero pot has no effect.
Cause: Faulty IC chip(s) on the main PC board.
Action: Replace main PC board. (See 3.4)

- Symptom:** Output of flow meter is proportional to flow, but extremely small and not correctable by span pot.
- Cause:** Sensor is not being heated.
- Action:** Shut off gas supply and disconnect the power to the flow meter. Remove cover and PC board from unit. Check the resistance from pins 1 to 2 and 3 to 4 of the sensor module. Both sets of pins should read approximately the same value between 1 and 2 kΩ nominal resistance. Also check that the resistance from pins 5 to 6, and 7 to 8 are both nearly the same value between 200 and 400 Ω, See Figure 3-1. Incorrect resistance values indicate that the sensor unit needs to be replaced.
- 
- Symptom:** Sensor has proper resistance readings, but little or no output with flow.
- Cause:** Plugged sensor.
- Action:** Shut off gas supply and disconnect the power to the flow meter. Remove cover and PC board from unit. Remove and inspect sensor. If sensor has evidence of clogging, clean or replace as applicable.
- Symptom:** flow meter reads other than 0.00 VDC with no flow or there is a small flow when the flow meter reads 0.00 VDC.
- Cause:** Zero pot is out of adjustment.
- Action:** Shut off all flow. For the standard 0-5VDC output, adjust the zero potentiometer located on the upper right inlet side of the flow meter until the meter indicates zero (See figure in section 2.12). For the optional 4-20 mA output, adjust the zero potentiometer so that the meter indicates slightly more than 4 mA, i.e. 4.03 to 4.05 mA. This slight positive adjustment ensures that the 4-20 mA transmitter is not in its cut-off region. The error induced by this adjustment is approximately 0.3% of full scale.
- Symptom:** Flow meter is out of calibration and non-linear.
- Cause:** Leaks in the gas inlet or outlet fittings.
- Action:** Check all fittings for leaks by placing soap solution on all fittings between gas supply and final destination of gas. Check flow meter for leaks. Replace or recalibrate as necessary.
- Symptom:** Little or no flow, even when the valve is overridden OPEN.
- Cause:** Blocked orifice or incorrect pressure across the flow controller.
- Action:** Verify that the pressure drop originally specified on the instrument is across the instrument. If the differential pressure across the instrument is correct, the orifice may be obstructed. If the orifice is suspected to be obstructed or blocked, it is advised that the unit be returned to a qualified technician so the valve can be reworked.

3.2. Adjustments (Calibration Procedure)

The following section details adjustments that can be made to a Hastings flow instrument's calibration. The process of making these adjustments is only recommended if appropriate calibration equipment is available, (appropriate leak-tight fittings and a valid flow reference).

1. Calibration must take place with cover firmly in place.
2. Connect power to "D" connector as specified in Section 2.5. Allow the instrument to warm up for 60 minutes with 10% of full scale flow.
3. Completely shut off the flow and wait for 2 minutes. Adjust the zero pot located on the inlet side of the unit until it indicates zero (0 V for voltage units or 4 mA for current units). Turn on gas supply to inlet of instrument and adjust the flow rate to the desired full scale flow as indicated by a reference flow meter/controller.
4. Adjust Span pot until the indicated flow reads full scale (5.00 VDC or 20 mA). Perform this step only if a calibrated reference flow meter is available.
5. Record flow meter/controller and flow reference outputs for flow rates of 20%, 40%, 60%, 80% and 100% and make sure data are within $\pm 1\%$ of full scale.



Periodically, during normal operation, the ZERO should be checked and adjusted as needed. Refer to step 3 above.

3.3. Endcap Removal

The end cap on the inlet side must be removed to gain access to shunt assembly. First remove power and shut off the supply of gas to the instrument. Disconnect the fittings on the inlet and outlet sides of the transducer and remove it from the system plumbing. On the HFM-301/305 and HFC-303/307, Remove the four screws holding the end cap to the instrument. Carefully remove the end cap, spring, and shunt, noting their order and proper orientation. The shunt position and orientation is critical to the flow dynamics and can substantially affect the instrument linearity. The shunt can be severely damaged if dropped. Examine the shunt. If damaged, dirty or blocked, clean and replace as applicable. Reassemble in the reverse order of disassembly. Use of a fastener other than the one mentioned here may result in leakage at the seal. **Recalibration of the Hastings 300 is necessary.**

For the HFM-306, remove the six hex socket bolts from the inlet end cap. Note the order and orientation of the internal parts. Remove the end cap and ensure that the o-ring is not damaged. Remove the flow conditioning screen assembly and if damaged, dirty or blocked, clean and replace as applicable. Carefully remove the flow straightener and shunt assembly. The shunt position and orientation is critical to the flow dynamics and can substantially affect the instrument linearity. If damaged, dirty or blocked, clean and replace as applicable. Reassemble in the reverse order of disassembly. **Recalibration of the HFM-306 instrument is necessary.**

3.4. Printed Circuit Board Replacement

NOTE: This instrument contains static sensitive PC boards. Maintain static protection when handling the PC boards.

If any of the PC boards fail, they are easily removed from the instrument and replaced with a spare. It is recommended that the metering printed circuit board and sensor be replaced as a unit because they are electronically matched to optimize response time. This ease in disassembly and replacement substantially reduces instrument downtime.

1. Replacement of the 4-20 mA option PC board: Unplug the power cable from the instrument's "D" connector. Remove the fasteners and steel can. The 4-20 mA board is the PC board marked PC854 in the lower left-hand corner just above the Teledyne logo. Remove the screws and lift off the 4-20 mA board. Be careful not to damage the main board and 4-20 mA board connectors.
2. Replacement of the main PC board: Unplug the power cable from the instrument's "D" connector. Remove the fasteners and steel can. Remove the 4 screws which fasten the main PC board to the sensor module. Gently unplug the main board from the sensor (and from the 4-20 mA board, if present).

3.5. Sensor Replacement

Follow instructions for removing the PC board(s) as described in Section 3.4. Remove the 4 Allen head cap screws that fasten the sensor to the main instrument base. Remove the sensor module from the base, discarding the used nickel gaskets. **New nickel gaskets are required for re-assembly, and the unit must be recalibrated after the new sensor is installed.**

To place an order or to obtain information concerning replacement parts, contact the factory representative in your area. See the last page in this manual for the address or phone number. When ordering, include the following information: Instrument model number, part description and Hastings part number.

4. Gas Conversion Factors

Gas conversion factors (GCFs) for gases metered using Hastings Instruments products, can be found by visiting the Hastings Instruments web site. The web address can be found at the end of this document. The GCFs provided by Hastings Instruments have accuracies dependent on the method by which they are found (empirical, NIST data, independent researcher data).

Most Hastings flow meters and controllers are calibrated using nitrogen and the GCF is calculated to convert from nitrogen to another process gas. To apply the GCF's, simply multiply the gas flow reading and the GCF for the process gas in use. For example, to calculate the actual flow of argon passing through a nitrogen-calibrated meter that reads 20 sccm, multiply the reading and the GCF for argon.

$$20 \text{ sccm N}_2 \times 1.4047 = 28.094 \text{ sccm Ar}$$

Conversely, to determine what reading to set a nitrogen-calibrated meter to get a desired flow rate of a process gas other than nitrogen, you divide the desired rate by the GCF. For example, to get a desired flow of 20 sccm of argon flowing through the meter, divide 20 sccm by 1.4047.

$$20 \text{ sccm Ar} / 1.4047 = 14.238 \text{ sccm N}_2$$

That is, you set the Nitrogen calibrated meter to read 14.238 sccm.

Some meters, specifically the high flow meters, are calibrated in air. The flow readings must be corrected for the case where a gas other than air is flowing through the meter. In addition, there must be a correction for the difference in the GCF from nitrogen to air. In this case, multiply the reading by the ratio of the process gas' GCF to the GCF of the calibration gas. For example, a meter calibrated in air is being used to measure the flow of propane. The reading from the meter is multiplied by the GCF for propane divided by the GCF of air.

$$20 \text{ slm Air} * (0.3499/1.0015) = 6.9875 \text{ slm C}_3\text{H}_8$$

To calculate a target setting (20 slm) to achieve a desired flow rate of propane using a meter calibrated to air, invert the ratio above and multiply.

$$20 \text{ slm C}_3\text{H}_8 * (1.0015/0.3499) = 57.2449 \text{ slm Air}$$

Gas conversion factors can be found at the Hastings Instruments web site.

<http://www.teledyne-hi.com>

Follow the link to Mass Flow Products and then to Gas Conversion Factors.

5. Warranty and Repair

5.1. Warranty Repair Policy

See the company website for warranty information at:

<http://www.teledyne-hi.com/terms&conditions.htm>

5.2. Return Policy

See the company website for return information at:

<http://www.teledyne-hi.com/terms&conditions.htm>

Any product returned for either warranty or non-warranty repair must have been issued a Return Material Authorization (RMA) form.

RMA Forms may be obtained from the Information section of the Hastings Instruments website:

<http://www.teledyne-hi.com/inforeq.htm>



WARNING: Contaminated parts can be detrimental to health and environment. Ensure instruments are free of hazardous contamination prior to shipment.

Company contact information

TELEDYNE HASTINGS INSTRUMENTS

804 NEWCOMBE AVENUE

HAMPTON, VIRGINIA 23669 U.S.A.

ATTENTION: REPAIR DEPARTMENT

TELEPHONE (757) 723-6531
1-800-950-2468

FAX (757) 723-3925

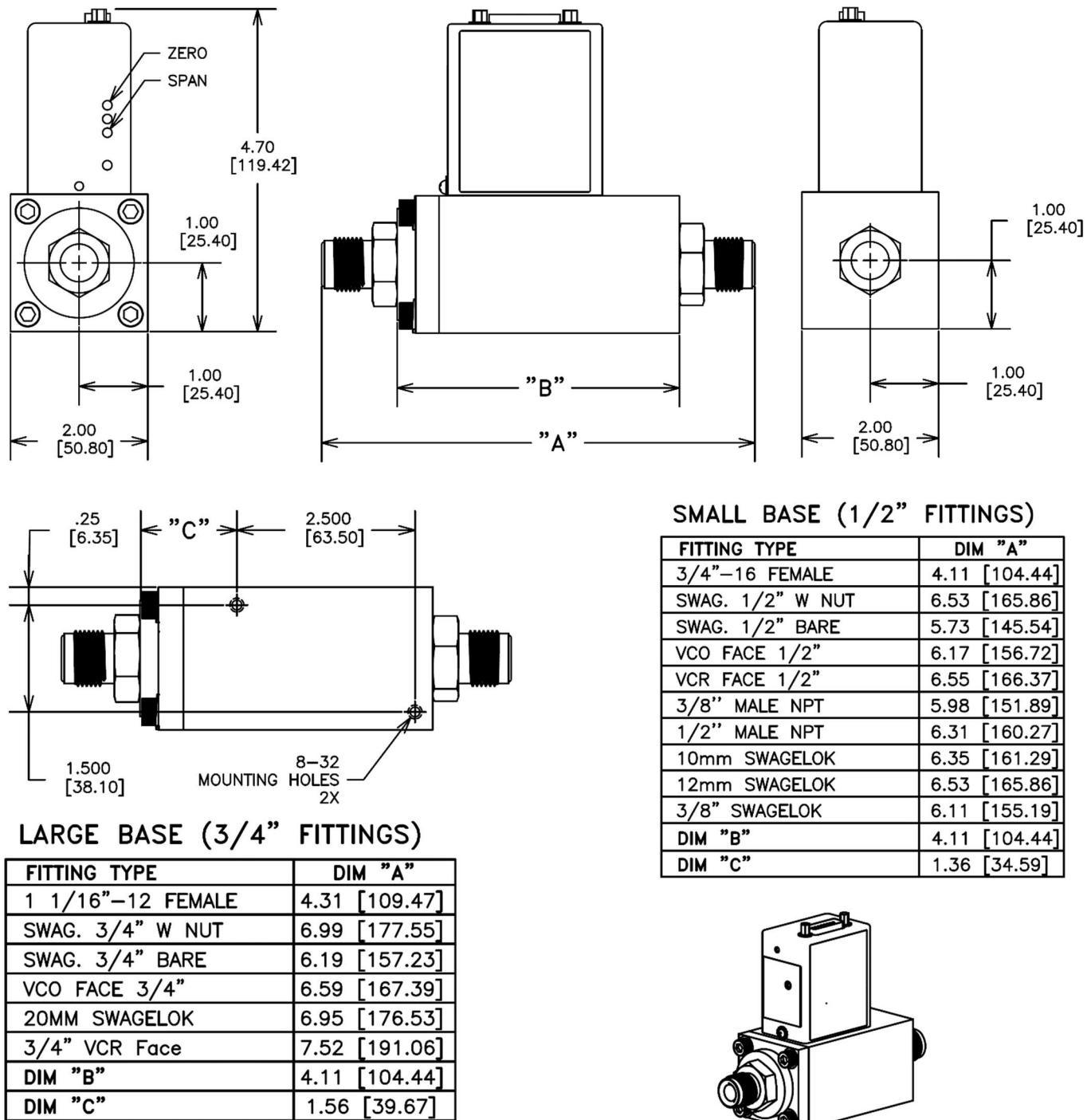
E MAIL mailto:hastings_service@teledyne.com

INTERNET ADDRESS <http://www.teledyne-hi.com>

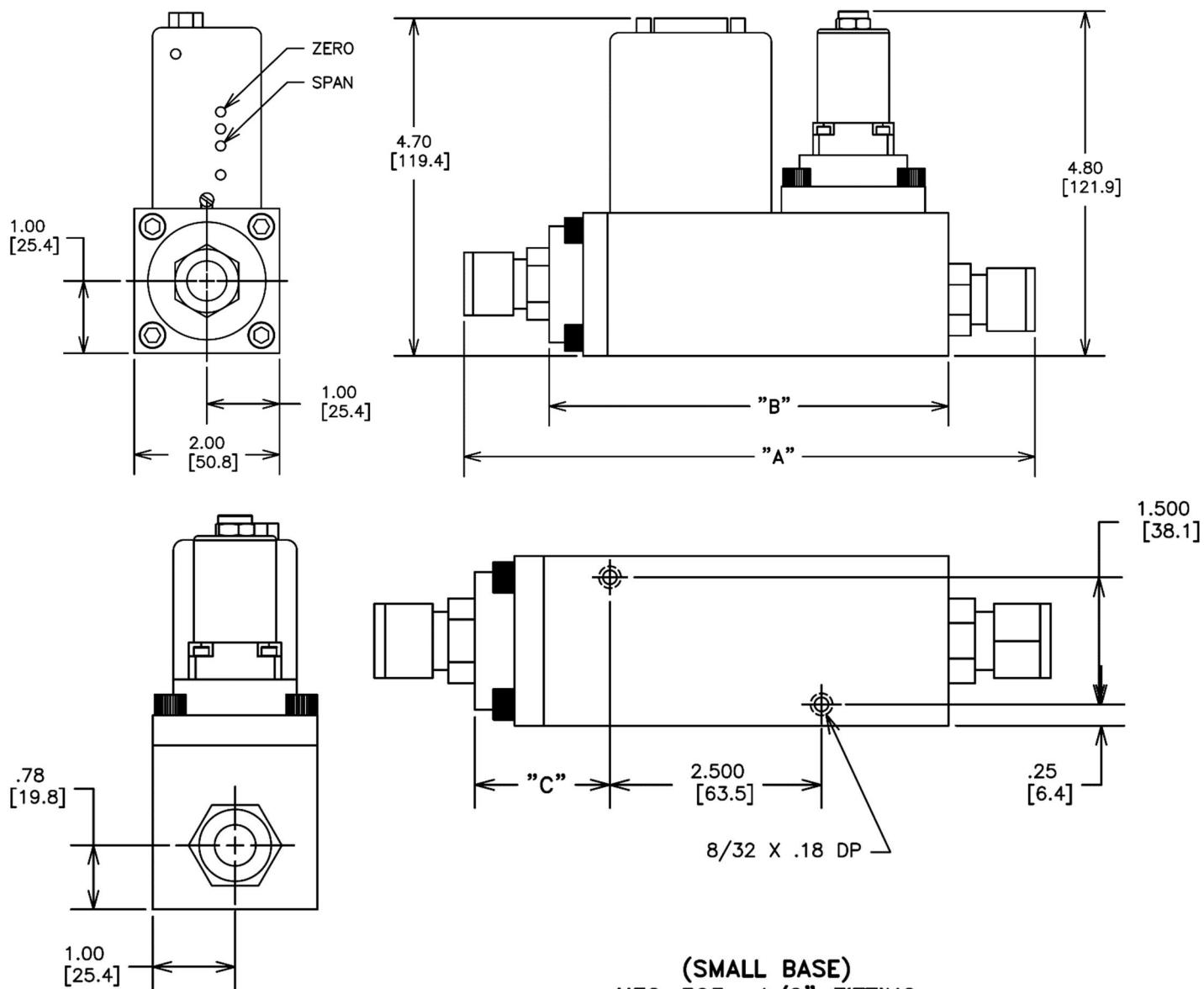
6. Drawings

The following pages display the top level drawing dimensions for the HFM-301, 305, 306, and the HFC-303, 307.

6.1. HFM-301



6.2. HFC-303



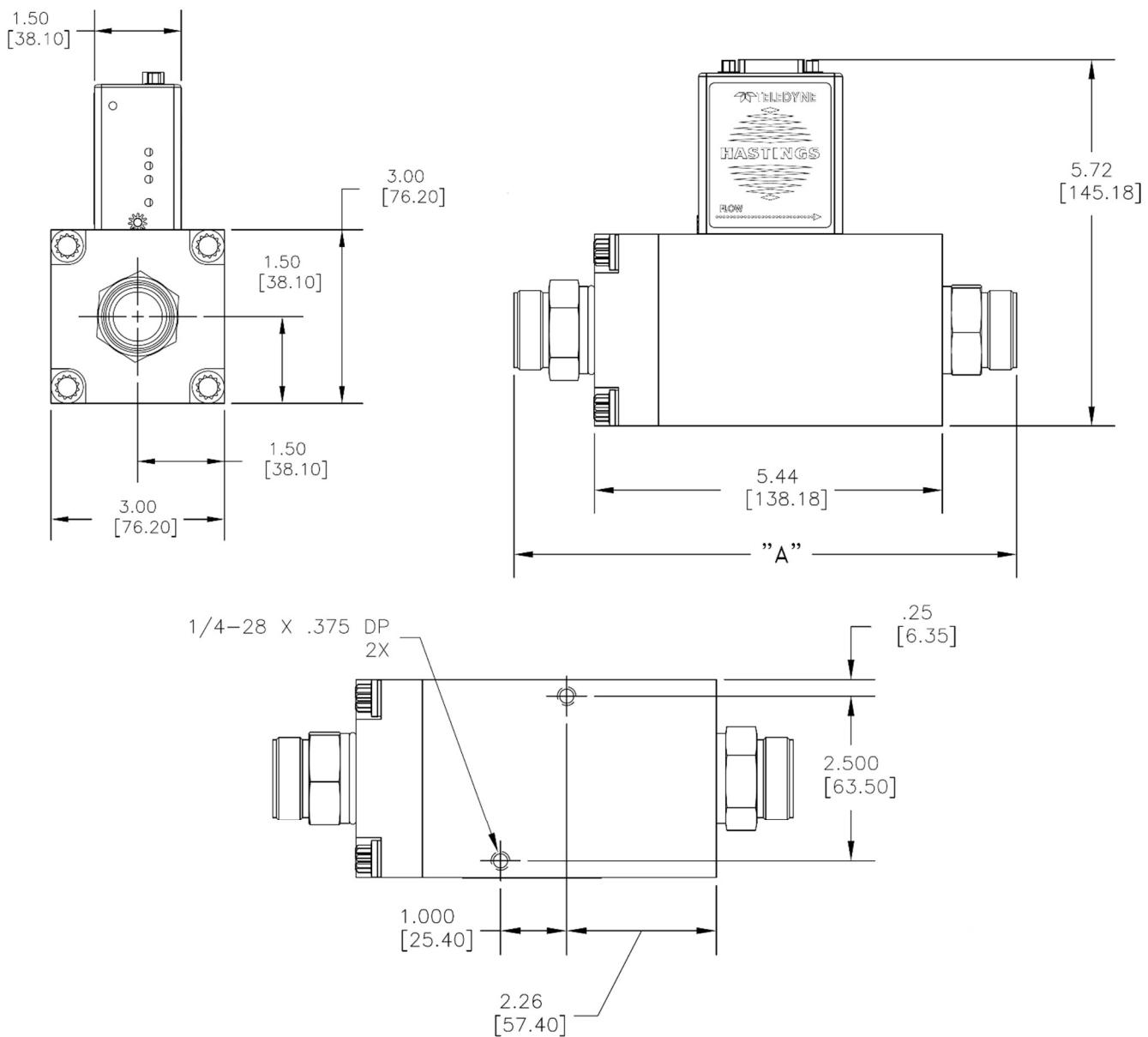
**HFC-303 3/4" FITTING
(LARGE BASE)**

FITTING TYPE	DIM "A"
1 1/16"-12 FEMALE	5.76 [146.30]
SWAG. 3/4" W NUT	8.44 [214.38]
SWAG. 3/4" BARE	7.64 [194.06]
VCO FACE 3/4"	8.04 [204.22]
20mm SWAGELOK	8.40 [213.36]
3/4" VCR FACE	8.97 [227.89]
DIM "B"	5.76 [146.30]
DIM "C"	1.56 [39.67]

**(SMALL BASE)
HFC-303 1/2" FITTING**

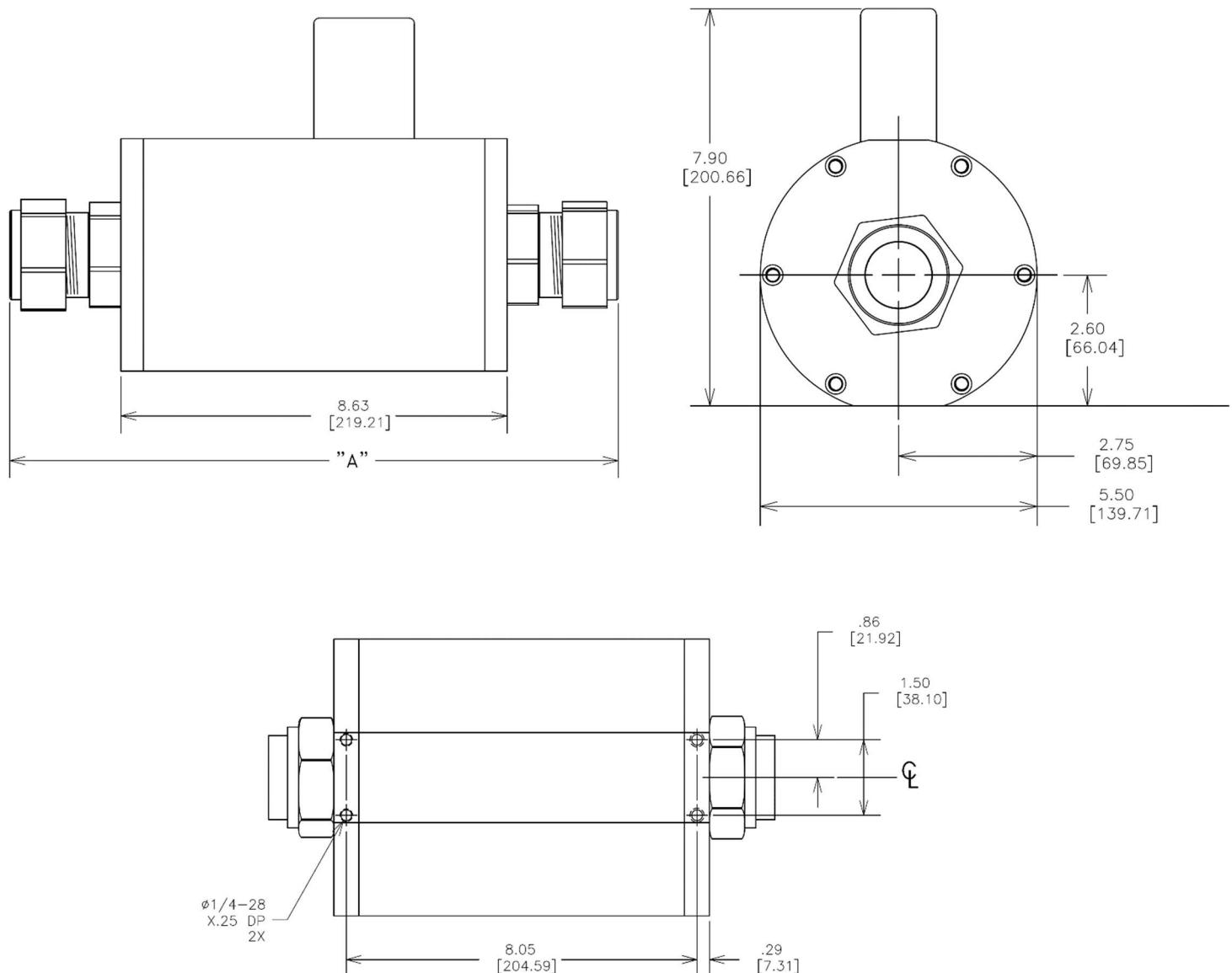
FITTING TYPE	DIM "A"
3/4"-16 FEMALE	5.36 [136.14]
SWAG. 1/2" W NUT	7.78 [197.61]
SWAG. 1/2" BARE	6.98 [177.29]
VCO FACE 1/2"	7.42 [188.47]
VCR FACE 1/2"	7.80 [198.12]
3/8" MALE NPT	7.23 [183.64]
1/2" MALE NPT	7.56 [192.02]
10mm SWAGELOK	7.60 [193.04]
12mm SWAGELOK	7.78 [197.61]
3/8" SWAGELOK	7.36 [186.94]
DIM "B"	5.36 [136.14]
DIM "C"	1.36 [4.59]

6.3. HFM-305



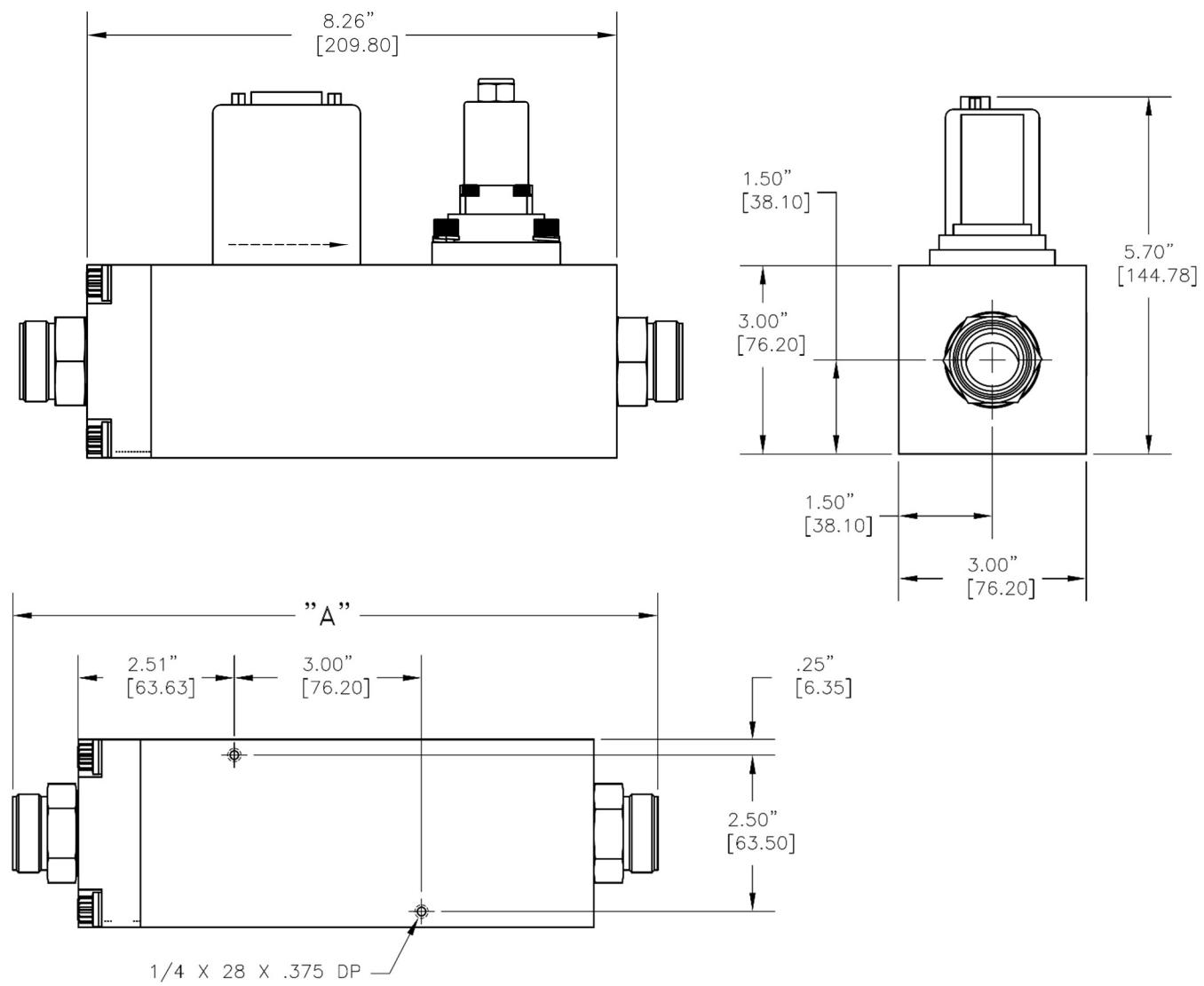
FITTING TYPE	DIM "A"
3/4" SWAGELOK	7.38 [187.45]
1" SWAGELOK	7.58 [192.53]
3/4" MALE NPT	7.84 [199.14]
1" MALE NPT	8.22 [208.79]
1" VCO	7.84 [199.14]
1" VCR	8.86 [225.04]
25mm	7.59 [192.79]
1" 5/16-12 FULL THREAD	5.44 [138.18]
1" FEMALE NPT	8.02 [203.71]

6.4. HFM-306



FITTING	DIM "A"
SWAGELOK, 1"	11.66 [296.04]
SWAGELOK, 1 1/4"	12.84 [326.01]
SWAGELOK, 2"	15.46 [392.56]

6.5. HFC-307



FITTING TYPE	DIM "A"
3/4" SWAGELOK	10.20 [259.08]
1" SWAGELOK	10.40 [264.16]
3/4" MALE NPT	10.66 [270.76]
1" MALE NPT	11.04 [280.42]
1" VCO	10.66 [270.76]
1" VCR	11.68 [296.67]
25mm	10.41 [264.41]
1" 5/16-12 FULL THREAD	8.26 [209.80]
1" FEMALE NPT	10.84 [275.34]