



TELEDYNE HASTINGS INSTRUMENTS
Everywhereyoulook™

201/203/205/207 Series Flowmeters/Controllers

INSTRUCTION MANUAL



TELEDYNE
HASTINGS INSTRUMENTS
Everywhereyoulook™

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CERTIFIED

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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 200 series mass flow meters (HFM-201/HFM-205) and controllers (HFC-203/HFC-207) are designed to accurately measure and control mass flow over the range of 30 slm to 2500 slm without corrections or compensations for gas pressure and temperature with an accuracy of better than $\pm 1\%$ from the mean ($\pm 2\%$ FS for 201/203 units in the $\frac{1}{2}$ " fitting size base with flows >500 slm). 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 (~ 500 psi/3.45 MPa) or overflows. Instruments are normally calibrated with the appropriate standard calibration gas (nitrogen) and a correction factor is used to adjust the output for the intended gas. Special 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

STABILITY. The Hastings HFM-201/203/205/207 instruments operate on a unique thermal electric principle using a heated metallic capillary tube and thermocouple temperature measurement. This results in an output that is stable with time.

THERMAL MASS FLOW MEASUREMENT. The 200 Series sensor output is a function of the mass flow rate and the heat capacity of the gas. Changes in gas composition usually only require a simple multiplier to account for the difference in heat capacity. This gas conversion factor allows Hastings flowmeters to measure a wide variety of gases.

LINEAR BY DESIGN. The HFM-201/203/205/207 Series is inherently linear (no linearization circuitry is employed). Should recalibration in the field be desired (a calibration standard is required), the customer needs to simply set the zero and span points.

MODULAR SENSOR WITH LOCKING CONNECTOR. The HFM-201/203/205/207 Series incorporates a removable/replaceable sensor module with a reliable sensor to board connection. Field repairs to units can be achieved with a minimum of production line downtime with confidence in the sensor to PCB connection.

SETTLING TIME. Filtering in the meter circuitry and more modern valve circuitry have improved the standard 200 Series response time in meters and controllers. Dual-stage valve controllers perform 10-100% flow changes in about 6 seconds. 200 Series flow meters perform 0-100% in under 6 seconds.

LOW TEMPERATURE DRIFT. 200 series flow instruments have a thermal coefficient of span that is no more than 0.06% of full scale/°C from -20 to 70°C and a thermal coefficient of about 0.035% of reading/°C from -20 to 70°C.

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

FLEXIBLE POWER REQUIREMENTS. 200 series instruments using the 24V board can operate with power supplies capable of providing 11 - 36 VDC via the 9-pin D connector provided the supply meets the current requirements (see sections 1.2 and 1.3).

1.2. Specifications HFM-201/205



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.

Accuracy¹ and Linearity:	±1% of FS
Repeatability:	±0.043% FS
Standard Pressure Rating:	500 psig
Pressure Coefficient:	+0.0067%/psig (0-1000 psig N2) typical
High Pressure Option:	Proof tested to 1500 psig
Leak Integrity:	Less than 1x10 ⁻⁹ sccs
Operating Temperature:	-20 °C to 70 °C
Temperature Coefficient:	Zero ±0.035% FS/°C (-20 to 70 °C), Span ±0.06% FS/°C (-20 to 70 °C)



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

Power (±15V meter, 0-5 VDC):	+ (14-16) VDC @ 35 mA, - (14-16) VDC @ 20 mA (~ 0.88 watts)
Power (±15V meter, 4-20 mA):	+ (14-16) VDC @ 55 mA, - (14-16) VDC @ 20 mA (~ 1.2 watts)
Power (24V meter, 0-5 VDC):	(11-36) VDC ~ 1.08 watts
Power (24V meter, 4-20 mA):	(11-36) VDC ~ 1.80 watts



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

Output Flow Signal:	0-5.00 VDC linear or 4-20 mA
Wetted Material²:	302 SS, 316 SS, Viton®, 82/18 Au/Ni Braze, Ni 200, Trace Silver Solder
Connector:	15-pin subminiature D / (9-pin for 24V)
Fittings:	½-in Swagelok® for 201L, ¾-in Swagelok® for 201H, 1-in Swagelok for 205
Weight (approx.)	3.55 lb. (1610 g) for 201L, 3.25 lb. (1470 g) for 201H, 8.10 (3650 g) for 205



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.

Response Time (0-100%):	5 seconds typical
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- 1 Stated accuracy is for nitrogen or other gas specific calibration and using this gas only.
 2 Other materials are available. Viton is the standard O-ring option.

1.3. Specifications HFC-203/207



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.

Accuracy¹ and Linearity:	±1% of FS
Repeatability:	±0.043% FS
Standard Pressure Rating:	500 psig
Pressure Coefficient:	+0.0067%/psig (0-1000 psig N2) typical
High Pressure Option:	Proof tested to 1500 psig
Control Valve Differential Pressure*	Per customer order
Leak Integrity:	Less than 1x10 ⁻⁹ sccs
Operating Temperature:	-20 °C to 70 °C
Temperature Coefficient:	Zero ±0.035% FS/°C (-20 to 70 °C), Span ±0.06% FS/°C (-20 to 70 °C)



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

Power (±15V controller, 0-5 VDC):	+ (14-16) VDC @ 21 mA, - (14-16) VDC @ 175 mA (~ 3.14 watts)
Power (±15V controller, 4-20 mA):	+ (14-16) VDC @ 40 mA, - (14-16) VDC @ 175 mA (~ 3.44 watts)
Power (24V controller, 0-5 VDC):	(12-36) VDC ~ 3.64 watts
Power (24V controller, 4-20 mA):	(13-36) VDC ~ 3.96 watts



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

Output Flow Signal / CMD Input:	0-5.00 VDC linear or 4-20 mA
Wetted Material²:	302 SS, 316 SS, Viton®, 82/18 Au/Ni Braze, Ni 200, Trace Silver Solder
Connector:	15-pin subminiature D / (9-pin for 24V)
Fittings:	½-in Swagelok® for 203L, ¾-in Swagelok® for 203H, 1-in Swagelok for 207
Weight (approx.)	5.2 lb. (2360 g) for 203L, 5.15 lb. (2340 g) for 203H, 14.9 lb. (6760 g) for 207



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.

Response Time (10-100%):	6 seconds typical
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¹ Stated accuracy is for nitrogen or other gas specific calibration and using this gas only.

² Other materials are available. Viton is the standard O-ring option.

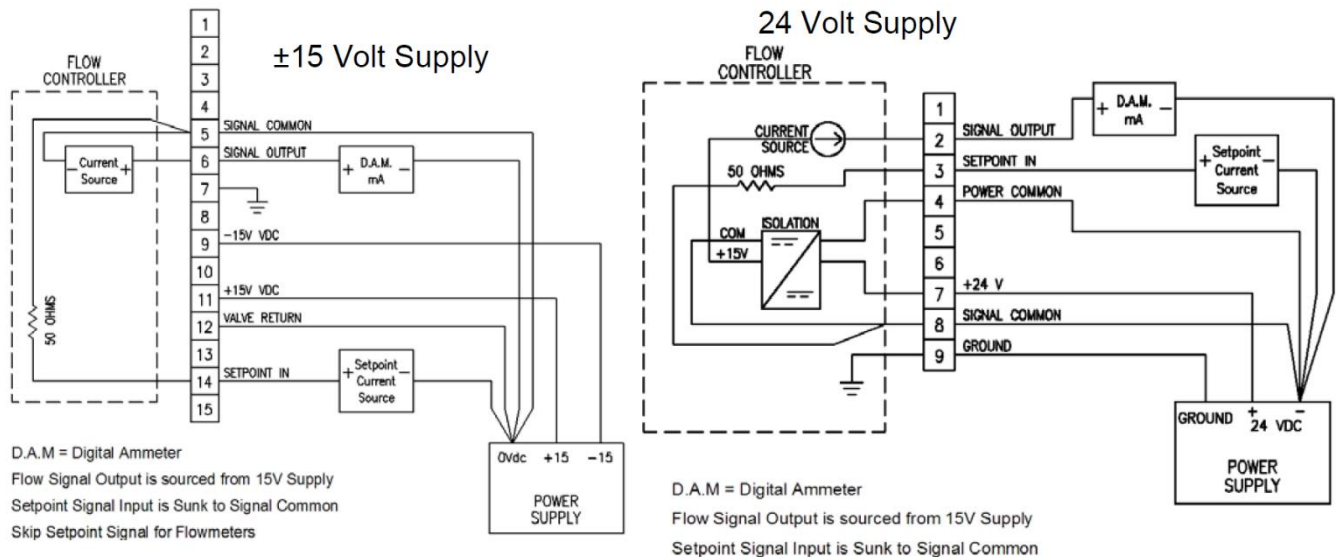
* Specifications may vary for instruments with ranges above 10 slm.

1.4. 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 (pin 2 of DE-9 24 Volt). The current loop is sourced internally from the +15 VDC supply and must be returned to the signal supply common after (pin 5 [± 15 VDC] or pin 8 [24 VDC]) passing through the monitoring circuitry to complete the loop. The load must be between 0 and 600 Ohm.

The 4-20 mA I/O option can accept a current input for flow controllers. The 0-5 VDC command signal on pin 14 (pin 3 for 24 Volts) can be replaced by a 4 - 20 mA command signal. The loop presents an impedance of 50 Ohms and is returned to the signal common. On the 24 Volt units, the signal common will need to be tied to the power supply common external to the flow controller to complete the loop since the signal common is galvanically isolated internally from the supply common. This line must be current limited (< 50 mA) to prevent short circuit currents from damaging the receiving circuit in the flow controller.



1.5. Accessories

1.5.1. Power Supplies

Hastings power supplies are available in one or four channel versions. They convert 100, 115 or 230VAC to the voltage required to operate the instruments and provide a digital indication of the flow rate. Hastings power supplies are power limited to no more than 150 VA max (fused) and use a switch compliant to EN 60601-1. 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. Designs and models offered as 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 200 series instrument should be no greater than 1.6 A. Hastings power supplies meet these requirements.



1.5.2. 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 200 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.

2.2. Power Requirements

See specifications in sections 1.2 and 1.3. The HFM-200/HFC-202 Series supply voltages should be reasonably regulated as power supply ripple may propagate to the output. Surge suppressors are recommended to prevent power spikes reaching the instrument. The Hastings power supplies in Section 1.5.1 satisfy these requirements. Hastings power supplies are limited to no more than 150VA max and it is strongly recommended that power supplies used with 200 Series instruments meet the recommendations in section 1.5.1.



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

2.2.1. ±15 VDC Option

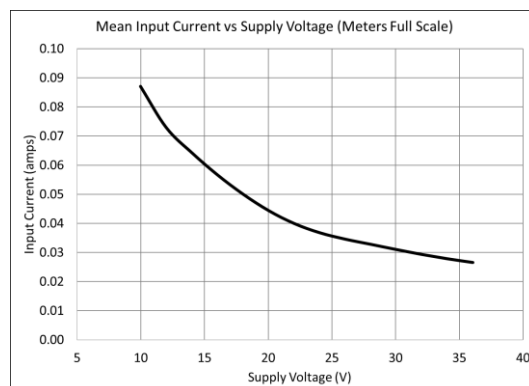
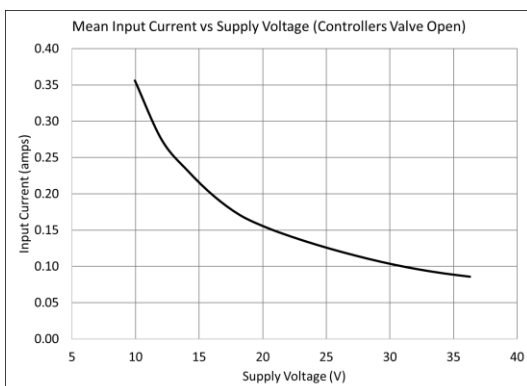
The supply voltage for bipolar units (±15 VDC option) can vary in magnitude from 14.0 to 16.0 VDC. The table below shows the recommended current draw and power requirements for ±15 VDC 200 series boards.

±15V Input Power Results	0-5 VDC		4-20 mA	
	Current Draw (mA)	Power (watts)	Current Draw (mA)	Power (watts)
Meters at Full Flow				
+(14 to 16 V)	34	0.55	54	0.87
-(14 to 16 V)	20	0.32	20	0.32
Controllers Open				
+(14 to 16 V)	21	0.34	40	0.64
-(14 to 16 V)	173	2.77	173	2.77

2.2.2. 24 VDC Option

The recommended operating range of 24V units is 11 to 36 VDC for meters, 12 to 36 VDC for 0-5 V controllers, and 13 to 36 VDC for 4-20 mA controllers.

24V Input Power Results	0-5 VDC		4-20 mA	
	Max Draw (mA)	Power (watts)	Current Draw (mA)	Power (watts)
Meters (Full Flow)	90	1.08	110	1.80
Controllers (Valve Open)	380	3.64	400	3.96



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 (pin 2 of the DE-9 for 24 Volt) and is referenced to pin 5 (pin 8 for 24 Volt). It is recommended that the load resistance be no less than 2k Ω . If the optional 4-20 mA output is used, the load impedance must be selected in accordance with Section 1.4.

2.4. Mechanical Connections

2.4.1. Mounting

If the instrument uses a dense gas or high pressures, the instrument **must** be installed horizontally. Outside of this special case, the flowmeter may be mounted in any position provided the direction of gas flow through the instrument follows the arrow marked on the bottom of the flowmeter case label. Having the inlet and outlet fittings in a horizontal plane is preferred. Whenever a flow instrument is mounted in a different orientation, the instrument should be re-zeroed at zero flow with the system pressurized to the expected 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.

2.4.2. Gas Quality

Impurities or foreign debris in the gas lines can have negative effects on device performance. The smallest of the internal passageways in the HFM-201/205 or HFC-203/207 series is the diameter of the sensor tube, 0.0125" (0.31 mm), so the instrument requires adequate filtering of the gas supply to prevent blockage or clogging of the tube.

2.4.3. Upstream & Differential Pressure

The pressure regulator and the plumbing upstream must be of sufficient size to minimize changes in the upstream pressure. In general, high capacity regulators and large internal diameter plumbing help to make the system more stable. When switching from full flow to zero flow, the inlet pressure of the instrument should rise to no more than 30% above the inlet pressure at full flow. The pressure drop between the upstream regulator and the instrument should be minimized (use shorter length or larger inner diameter pipe or tubing). The differential pressure across a meter should be less than 6" of H₂O (-0.217 psi) at maximum flow. Controllers may have higher differential pressures depending upon the size of the installed orifice.



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

2.4.4. Other Mounting & Fitting Options, Notes

There are two 8-32 threaded holes, located on the bottom of the base that can be used to secure it to a mounting bracket (screws provided). Other holes for special mounting can be added to the endcap upon request. The standard inlet and outlet fittings for the 201/203 are 0.50" and 0.75" Swagelok (optional VCR, VCO, metric, and NPT fittings). The standard inlet and outlet fittings for the 205/207 are 1" Swagelok (optional VCR, VCO, metric, and NPT fittings). The O-rings for the end cap and the sensor are Viton® (optional Kalrez®, Neoprene, Buna-N). It is recommended that all connections be checked for leaks after installation. Do this by pressurizing the instrument (do not exceed 500 psig unless

the Flowmeter is specifically rated for higher pressures), applying a diluted soap solution to the flow connections, and monitoring the connections for bubbles of escaping gas.

2.5. Electrical Connections

If a power supply from Hastings Instruments is used with a ± 15 Volt version of the HFM-201/205, HFC-203/207, installation consists of connecting the appropriate cable (#AF-8AM) from the “D” connector on the rear of the power supply to the “D” connector on the top of the flow instrument. If a different power supply is used, use the following instructions when connecting the flowmeter or controller.

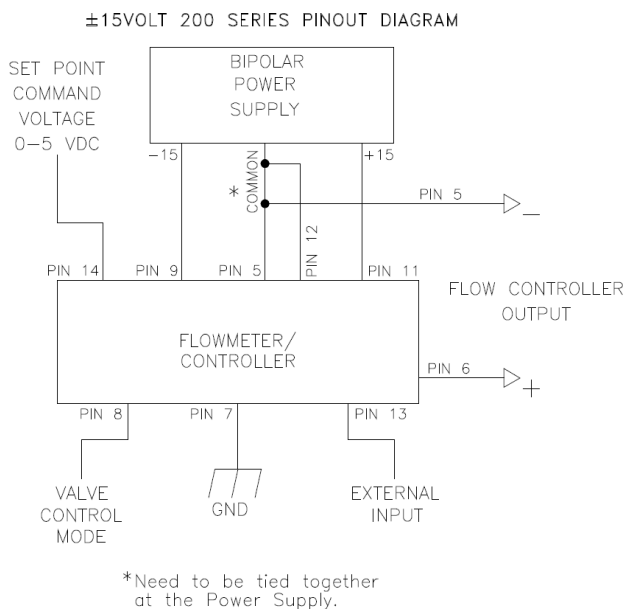


WARNING: Care must be taken to avoid any high voltages that may be present when dealing with power supplies. To prevent the spread of fires in the event of a fault, only use power supplies power limited to no more than 150 VA. Hastings power supplies meet this requirement. The available current for each 200 series instrument connected to a power supply should not exceed 1.6 A.

2.5.1. Bipolar (± 15 VDC) Power Supply to Bipolar Connections

Connecting the HFM-201/205, HFC-203/207 series flow instruments with anything other than the prescribed cables and power supplies discussed above, can severely damage the instrument and void the warranty. The figure below shows the schematic layout for connecting the instrument to an appropriate ± 15 Volt power supply. A pinout is also given to show the signals available to the user and the signals given and used by the power supply (Not all signals from the pcb are used by Hastings supplies).

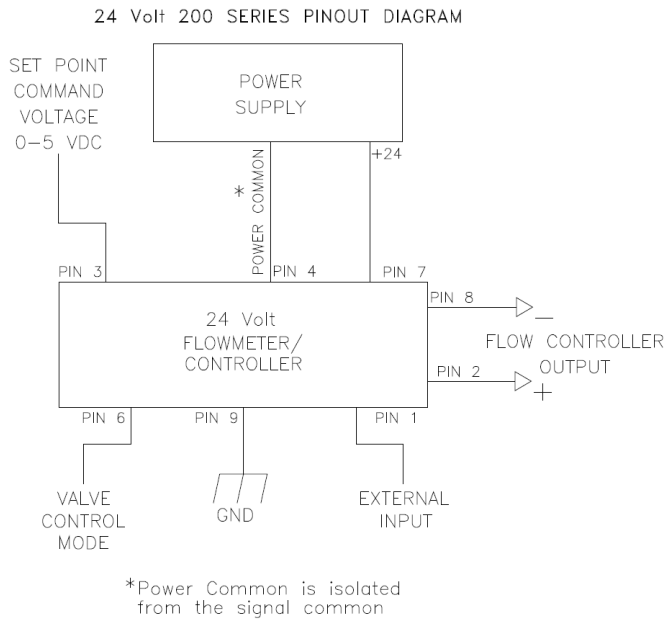
The power supply used must be meet the power requirements delineated in the specifications. If a bipolar supply is required, the voltages must be referenced to a common ground. Connect -15 VDC to pin 9 of the DA-15 connector and +15 VDC to pin 11. Pins 5 and 12 are both commons and they must be connected together and to the ground connection at the power supply. Do not connect them together at the flow controller as the resulting crosstalk could result in flow instabilities.



Pin #	PCB Signal	Hastings Power Supply
1	Option 1	Not used
2	Valve Control	
3	Thermocouple Downstream	
4	Thermocouple Upstream	
5	Signal Common	Signal Common
6	Signal Output (0-5V or 4-20mA)	Signal Output (0-5V or 4-20mA)
7	Case Ground	Case Ground
8	Control Valve Override	Control Valve Override
9	-15 VDC	-15 VDC
10	Option 10	Not used
11	+15 VDC	+15 VDC
12	Valve Return	Valve Return
13	External Input	Not used
14	Set Point (0-5V or 4-20mA)	Set Point (0-5V or 4-20mA)
15	5V Reference	Not used

2.5.2. Unipolar (24 VDC) Power Supply to Unipolar Connections

Refer to the diagram below when connecting 24 Volt units. Connect the positive lead of the power supply to pin 7 of the DE-9 connector and negative lead to pin 4. The supply input is diode protected such that reversing the input polarity will not damage the instrument. The power supply is galvanically isolated from all other pins. A pinout is also given to show the signals available to the user and the signals given and used by the power supply (Not all signals from the pcb are used by Hastings supplies). A special cable is available to connect the 9-pin unipolar power option 200 series instruments to ±15VDC power supplies.



Pin #	PCB Signal	Hastings Power Supply
1	5V Reference	Not used
2	Signal Output (0-5 V or 4-20 mA)	6
3	Set Point (0-5 V or 4-20 mA)	14
4	Power Common	9
5	Valve Voltage	Not used
6	Control Valve Override	8
7	Power Input (11 to 36 VDC)	11
8	Signal Common	5
9	Case Ground	7

2.5.3. General Connection Notes

Pin 7 of the DA-15 (15 Volt), and pin 9 of the DE-9 (24 Volt) are the case grounds. It should be connected to the cable shield if available and to the AC ground to the power supply. Pin 6 of the DA-15 (15 Volt), and pin 2 of the DE-9 (24 Volt) is the output signal from the flow controller. This output will be 0 - 5 VDC/(4 - 20 mA), 5 VDC/20 mA being 100% of rated or full flow. Pin 14 of the DA-15 (15 Volt), and pin 3 of the DE-9 (24 Volt) is the command input. This should be a 0 - 5 VDC or (4 - 20 mA) signal and must be free of spikes or other electrical noise, as these will generate false flow commands that the controller would attempt to adjust for. Pin 15 of the DA-15 (15 Volt), and pin 1 of the DE-9 (24 Volt) is a regulated 5 VDC output (±0.005 V) reference which is occasionally used as a full-scale command. If a valve override switch is not desired, the unit is now ready for use.

If an override switch is desired, connect the center pin of a single pole, three-position switch with the center off position to pin 8 of the DA-15 (15 Volt), pin 6 of the DE-9 (24 Volt). Connect a voltage source >10 VDC to one end of the switch, and negative voltage to the other end. This will result in the valve being full open when the positive voltage is supplied to the override pin, closed when the negative voltage is supplied, and auto-control when the valve override pin floats (OPEN-AUTO-CLOSE). This setup will be adequate for most purposes, but there will be a small delay for capacitors to charge between switch operation and control override.



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

2.6. Operation

The standard instrument output signal is 0 - 5 VDC and is proportional to the flow i.e., 0 Volts = zero flow and 5 Volts = 100% of rated flow. The 4 - 20 mA option is also proportional to flow, 4 mA = zero flow and 20 mA = 100% of rated flow. It is recommended that all connections be checked for leaks after installation. Do this by pressurizing the instrument (do not exceed 500 psig unless the Flowmeter is specifically rated for higher pressures), applying a diluted soap solution to the flow connections, and monitoring the connections for bubbles of escaping gas.



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

2.6.1. 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. The HFM-200/HFC-202 series is 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 / High Density Option

When operating at high pressure or with high density gases, the increased density of gas will cause natural convection to flow through the sensor tube if the instrument is not mounted in a level position. This natural convection flow will be proportional to the system pressure. This will be seen as a shift in the zero-flow output that is directly proportional to the system pressure. This zero shift can be corrected by adjusting the zero potentiometer after mounting the flow controller in its final operating position. See section 2.4.1 and 2.6.2. Additionally, because the specific heat of a gas changes with pressure, an associated error is introduced with increased pressure. It is directly proportional to the change in specific heat versus pressure for that particular gas. For helium, there is virtually no change in indicated output; for nitrogen, the indicated output will increase at approximately 0.0067%/psi, which is the pressure coefficient. So we have:

$$\text{Actual flow} = \frac{\text{indicated flow}}{(1 + (\text{pressure} \times \text{pressure coefficient}))}$$

2.6.4. Gas Blending

In the blending of two gases, it is possible to maintain a fixed ratio of one gas to another. In this case, the output of one flow controller is used as the setpoint or a scaled setpoint signal of a second flow controller. The output signal of the first flow controller controls the flow rate of the second gas as a percentage of the flow rate of the first gas. Multichannel Hastings Power Supplies allow users to configure this option (see Ratio Control), but other devices can be used to achieve this affect provided they can scale the output signal of one controller and feed it to the input of the other. The following formulas are useful:

$$A \text{ Flow} = \frac{(A \text{ Output})(A \text{ Full Scale Flow})}{(A \text{ Full Scale Output})}, \quad B \text{ Flow} = \frac{(A \text{ Output})(\text{Gain Factor of A})(B \text{ Full Scale Flow})}{(B \text{ Full Scale Output})}$$

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

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

In most cases the analog output full scales are the same so those two terms cancel out.

EXAMPLE: Controller A is a 5 V controller with a full scale flow rate of 100 SLM. Controller B is a 5 V controller with a full scale flow rate of 10 SLM. What gain factor on the output of controller A will result in controller B flowing 5% of controller A?

Use the formulas above:

$$\text{Gain Factor of A} = \frac{(0.05)(100)(5)}{(10)(5)} = 0.5$$

Cut the output of controller A in half and route the signal to the setpoint of controller B to flow 5% of controller A.

2.7. Operation with External Devices

2.7.1. Operation with a Hastings Power Supply

Hastings power supplies display flow instrument outputs (in flow units or percent of full scale) and offer users an easy setup for controlling and monitoring each instrument's status. Meters connected to Hastings power supplies simply have their output signals displayed on the front screen. Controllers have three states of operation when connected to a Hastings power supply: AUTO, OPEN, and CLOSED. Buttons on the supply front panel allow users to toggle between these states. Controllers in the "AUTO" state will accept setpoint commands from a Hastings power supply and control the flow rate accordingly. The valve changes its position with the user input setpoint, and the setpoint issued to a controller can be adjusted using the other available buttons on the supply front panel. Controllers in the CLOSED state have their valves overridden shut and will not accept setpoint commands. The OPEN state overrides the valve fully open regardless of any user setpoint. The OPEN position is useful for purging systems. See the following power supply feature guide.

Hastings Power Supply Feature Guide		
Feature	THCD-101	THCD-401
# of Channels	1	4
Front Panel Display	Yes	
± 15 Volts	Yes	
Analog Interface	Yes	
Valve Override	Yes	
Totalizer	No	Yes
Reads 4-20 mA	Yes	
4-20 mA Setpoints	No	Yes
Reads/Commands 0-5 VDC	Yes	
Reads/Commands 0-10 VDC	Yes	
Ratio Control	No	Yes
Alarms	Yes	
Communications	USB emulates RS232, Ethernet	



2.7.2. Operation with a Non-Hastings Power Supply

See the connection diagrams in sections 2.5.1 and 2.5.2.



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

To successfully operate a flow controller, a 0-5 VDC command signal proportional to the intended flow (0 Volts = zero flow; 5 Volts = 100% of rated flow) must be applied to pin 14 of the DA-15 (15 Volt), Pin 3 of the DE-9 (24 Volt) connector. A 0-5 VDC signal proportional to the flow rate through the instrument will be present on pin 6 of the DA-15 (15 Volt), Pin 2 of the DE-9 (24 Volt) connector. The control mode is selected via pin 8 of the DA-15 (15 Volt), Pin 6 of the DE-9 (24 Volt) connector. Apply > 10 Volts for full open, < 0 Volts for closed and allow the override to float for flow proportional to the command voltage. Refer to your power supply manual for the specifics of implementing these parameters.

2.7.3. Operation with an External Sensor (External Input)

In some instances, it might be desirable to use an external sensor to provide process information to the control circuitry in a Hastings flow instrument. For example, you might want to control the pressure in a vacuum system by adjusting the rate at which the system is backfilled with a gas. Hastings flow controllers have provision for accepting a 0-5 VDC output from an external sensor at pin 13 of the DA-15 (15 Volt), Pin 1 of the DE-9 (24 Volt) connector.

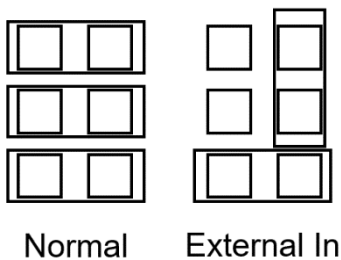
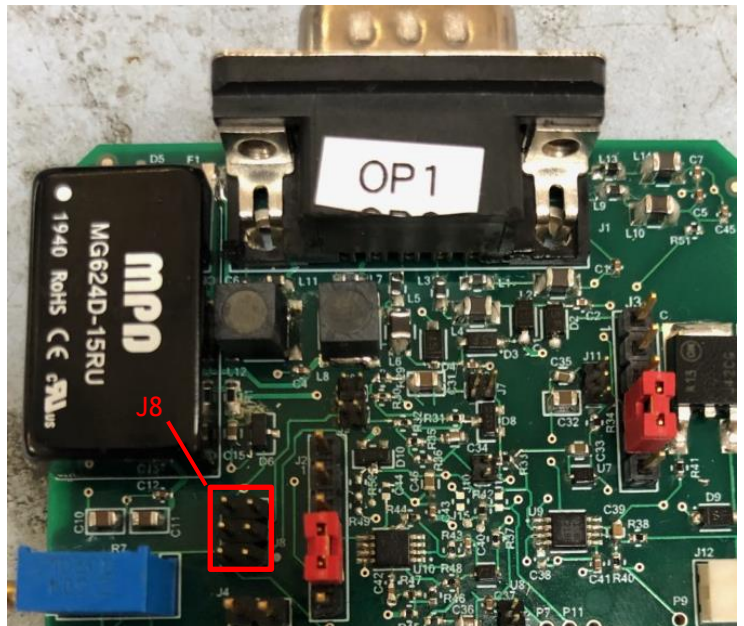
2.7.3.1. 15 Volt Units

To activate this feature, the cover of the HFC must be removed to gain access to the electronics card and move a jumper. For the 15 Volt units, J6 is located on the left side of the pcb between the span potentiometer (R7) and the large D connector (J1). In the normal operating mode, the jumper covers the left two pins. To select an external sensor input, move the jumper to the right two pins. This swaps the flow input to the controller circuit from the flow meter output to pin 13 of the “DA-15” connector.



2.7.3.2. 24 Volt Units

For the 24 Volt units J8 is a six-pin jumper block located down and to the right from the DC-DC converter. There are three jumpers installed horizontally. The middle jumper ties the flow output to the valve control circuit and the top jumper ties Pin 1 of the DE-9 connector to reference voltage circuit. Remove both of the upper two jumpers and reinstall one jumper vertically between the top two pins on the right side (see diagram below). This will tie Pin 1 of the DE-9 connector to the valve control circuit and allow the controller to maintain the external process variable equal to the desired setpoint. The 5 Volt reference is not available in this configuration.



2.7.4. Response to Command Changes

The response of the valve control circuit to command signal changes is set at the factory for a fast and stable response. The default configuration is the fastest response to command changes and allows some overshoot and undershoot in the actual flow rate while the control circuit is establishing the new command point. If excessive overshoot is present and not desirable, the response can be slowed by removing the jumper labeled J15 for 15 V boards or for 24 V boards, the jumper across the bottom two pins of J8 (see images in section 2.7.3 above). This setup results in no overshoot or undershoot in the actual flow rate as the controller circuit establishes control at the new command point. This jumper does not affect the system gain and will not dampen out oscillations. To adjust the response, you need a means of producing a step change in the command voltage from 10% of full scale to 100% of full scale. Follow the steps outlined below:

- 1) Cover J15 (bottom two pins of J8 for 24 V boards) with a jumper.
- 2) Set the command voltage to 10% of full scale and allow the flow to stabilize.
- 3) Step change the command voltage to 100% and observe the flow through the controller.

If the overshoot is tolerable, make no further changes. Else, remove the jumper and to prevent losing the unused jumper, place it over only one pin of J15 (one of the pins of J8 for 24 V boards).

2.8. Range Changing

The range of the flow controller can be changed in the field if recalibration facilities are available. The flow controller may require a different orifice, which can be purchased separately from the factory. A listing of the orifices available can be found in Section 3.7. A brief description of the steps needed to adjust the flow range of a Hastings flow instrument can be found in Section 3.3.



NOTICE: It is *strongly* recommended that adjustments to the span/calibration of a Hastings flow instrument be made by Hastings personnel with the appropriate equipment and training. Improper adjustments to the flow instruments will result in inaccurate data and poor instrument function.

2.9. Valve-Override Control

The valve override control line (pin 8 on 15 V boards, pin 6 on 24 V boards) provides a method to override the valve open or closed regardless of the flow or command signals. During normal operation this line must be allowed to float freely (no voltage source connected). This will allow the loop control to open and close the valve as it requires to meet the issued setpoint. If the valve override line is forced high (> +10 Volts) the valve will be forced full open. If the valve-override line is forced negative (< 0 Volts) the valve will be forced closed.

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 with 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.

3.1. Authorized Maintenance

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.

3.2. 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: Flow remains when 0.00 VDC is commanded or even when Override CLOSE function is enabled.

CAUSE: Orifice out of adjustment or faulty op-amp

ACTION: Check the valve voltage between pins 2 & 12 on the 15-pin D-connector for 15 Volt units and Pins 5 & 8 on the DE-9 connector for 24 Volts. If the voltage is less than 3.00 VDC, then turn the orifice slowly clockwise until flow stops.



NOTICE: adjusting the orifice too quickly or too far can damage the valve seat and cause leak paths that will not allow the controller to operate properly. Please adjust the orifice gently and with caution.

SYMPTOM: Output of unit is proportional to flow but extremely small and not correctable by span pot.

CAUSE: Sensor is not being heated.

ACTION: Unplug the sensor connector (J4 for 15 V boards, J5 for 24 V boards) and check the following resistances: The resistance between pins 2 & 3 of the sensor should be about $2.475 \text{ k}\Omega \pm 75 \Omega$ (see sensor section 3.2). The resistance between pins 1 & 4 should be somewhere around 2 to 3 Ω . The resistance between pin 2 or 3 and the base of the sensor should be essentially infinite. If not, the heater wire is contacting the sensor base and the sensor must be replaced. If the sensor passes the previous three tests, check the voltage output on pins 2 & 3 of the sensor connector on the pcb. If it does not read approximately 22 to 23 VDC then replace the sensor heater regulator (U1 on 15 V board, U2 on 24 Volt board).

SYMPTOM: Sensor has proper resistance readings, but little or no output with flow.

CAUSE: Plugged sensor.

ACTION: Shut off gas supply and power supply. Remove cover and PC board from unit. Remove sensor assembly and examine. If sensor has evidence of plugging, clean or replace as applicable

SYMPTOM: Flow controller oscillates.

CAUSE: Flow controller not adjusted for the dynamics of the flow system.

ACTION: Check upstream and downstream pressures. The gas supply regulator should not have excessive lockup when flow shuts off. Also ensure that there is not a large drop in pressure between the regulator and the instrument due to line resistance. Oscillations can also be caused if a large flow restriction is pneumatically close to the downstream end of the flow controller. The differential pressure across the unit must be between 10-50 psig.

SYMPTOM: Little or no flow, even with Valve Override OPEN enabled.

CAUSE: Plugged orifice.

ACTION: Verify the presence of a 10-50 psig pressure across the instrument. If present, shut off gas supply and power supply. Remove orifice per Section 3.7. Examine orifice. If plugged, clean or replace as applicable. Reassemble valve.

SYMPTOM: Flow meter reads other than 0.00 VDC with no flow, or there is a small flow when flow meter reads 0.00 VDC.

CAUSE: ZERO potentiometer is out of adjustment.

ACTION: Shut off all flow. Adjust ZERO potentiometer until output reads 0.00 VDC.

SYMPTOM: Flow meter out of calibration and nonlinear.

CAUSE: Leaks in 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 "O" rings if required or recalibrate as necessary.

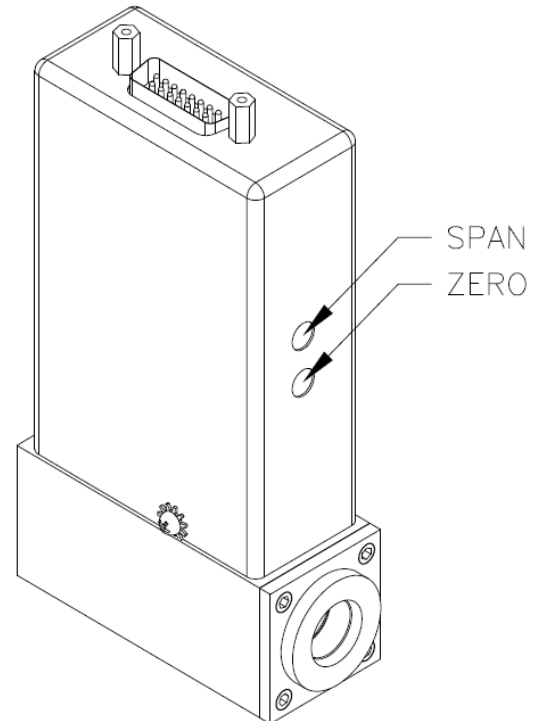
3.3. Adjustments

The following sections detail 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, such as the appropriate leak-tight fittings and a formidable flow reference.

3.3.1. Calibration Procedure (controller)

NOTE: Steps 5 and 6, adjusting the SPAN pot and performing a calibration run, will require the use of a calibration reference.

- 1) Connect power to the instrument, put in AUTO state, and allow 10% flow for 30 minutes as a warm-up.
- 2) After the warm-up period, set the flow to zero and wait for 2 minutes. Check to make sure there is zero flow.
- 3) Adjust the ZERO potentiometer (bottom hole on inlet side) so that the flow instrument outputs 0.000 VDC (6,5 on 15V, 2,8 on 24V).
- 4) Override the valve closed or give a 0% flow command. Turn on gas supply to inlet of instrument. Adjust the orifice underneath the controller to obtain zero flow.
- 5) Set the flow to 100% (don't forget to put the valve state back into AUTO if you closed it in step 4) and Ensure that full range flow can still be obtained at minimum inlet pressure.
- 6) **NOTE 1:** Controllers regulate flow to the analog command given. If a user commands 5 volts, the controller will move the valve to indicate 5 volts of flow regardless of how the span pot is set. If users keep turning the span pot, the controller will continue to regulate to 5 volts as long as the valve can physically pass the flow needed to get there.
NOTE 2: Users need a flow reference in series with the controller to tell exactly what flow rate is passing at the controller's full scale. Set the command to 100%. Adjust the SPAN potentiometer (top hole on inlet side, usually under a sticker) until the flow controller full scale (5.000 VDC) matches the desired flow rate indicated by the flow reference.
- 7) Record flow controller and flow reference outputs for flow rates of 20%, 40%, 60%, 80% and 100%. Take the data and make sure the output is within $\pm 1\%$ of full scale at each point (accuracy spec).



3.3.2. Miscellaneous Adjustments

Periodically, during normal operation, the ZERO should be checked and adjusted when required. If the instrument is not shutting completely off when the Valve Override CLOSE function is active, or a command of zero flow has been given, the orifice may require approximately 1/8 turn clockwise.

3.4. Endcap Removal

The endcap on the inlet side must be removed to gain access to the filter or shunt assembly. First shut off the supply of gas to the instrument. Disconnect the Swagelok fittings on the inlet and outlet sides of the unit and remove it from the system plumbing. Remove the four hex bolts holding the endcap to the instrument. Carefully remove the endcap, filter, wave spring (if present) and shunt, noting their order and proper orientation. The shunt can be severely damaged if dropped. Examine the filter and shunt. If either is dirty or blocked, clean or replace as applicable. Reassembly is the reverse of the removal procedure. Recalibration of the HFC is necessary.

3.5. Printed Circuit Board Replacement

In the unlikely event that the PC board fails, it is easily removed from the instrument and replaced with a spare to minimize instrument downtime. Replacement of the PC board will require the instrument to be recalibrated. Unplug the power cable from the top of the transducer. Remove the two jackscrews next to the "D" connector and the two screws on the sides of the cover. Lift off the cover and unplug the four-wire sensor plug and the two-wire valve plug, noting their orientation prior to removal. Remove the screw that holds the PC board to the sensor. Troubleshoot or replace as applicable. Installation is the reverse of the above procedure. Recalibrate if any components were changed or if any potentiometers were adjusted or new.

3.6. Sensor Replacement

If the sensor fails or becomes plugged it can be removed. Remove the cover and the PC board per Section 3.5 above. Remove the three bolts holding the sensor to the instrument base. Remove the sensor from the base noting the two O-rings between the sensor and the base. If the sensor is plugged it can be cleaned by running a fine wire (approximately 0.008" diameter) through the tube. If sensor needs replacement, obtain another from the factory and install it. Ensure that O-rings are clean and intact. Install O-rings on seating surface, then carefully place sensor over O-rings and tighten down the three screws evenly. Replacement of sensor will require recalibration per Section 3.3.1.

3.7. Main Orifice Changes

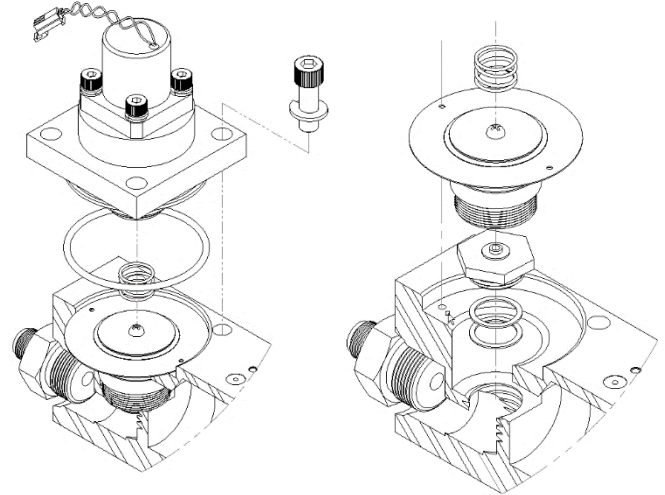
The orifice may require replacement if a large flow range change is desired, if changing to a gas that has a specific gravity significantly different than the original gas, if a large change in the differential pressures across the valve is desired or in the event that a small orifice becomes plugged. Replacement orifices can be acquired from the factory.

The available main orifice diameters (inches) are 0.023, 0.032, 0.046, 0.086, 0.130, 0.156, 0.250, 0.312, 0.375, and 0.500. The half inch main orifices are only available for the HFC-203 models with the larger base fittings (3/4") and for HFC-207 instruments. Hastings can offer orifices larger than half inch, but these items would need to be custom made.

3.7.1. HFC-203/207 Orifice

To change the orifice in the HFC-203/207 instrument, the valve must be dismantled. Remove the four ¼” Allen head machine screws in the top of the main valve. Lift off the valve top, exposing the spring and diaphragm. Note that a small brazed ball bearing is on the downstream side of the valve top. Remove the spring and diaphragm assembly. The orifice is located at the bottom of the valve body and can be removed with a 9/16 socket wrench. See the figure on right.

To re-install an orifice, first install the gasket onto the orifice (replacement gaskets can be obtained from the factory). Next screw the orifice into the valve base. Snug up the orifice but do not overtighten. Place diaphragm assembly into the base. Line up the two small holes in the diaphragm with the two small holes in the valve base. Place the spring on top of the diaphragm. Examine the O-ring on the valve top for damage if required. Install the valve top (bonnet), ensuring the bleed screw is on the upstream side. Tighten down the valve top evenly to ensure a proper seal at the diaphragm.



4. Warranty and Repair

4.1. Warranty Repair Policy

See the company website for warranty information at:

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

4.2. 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

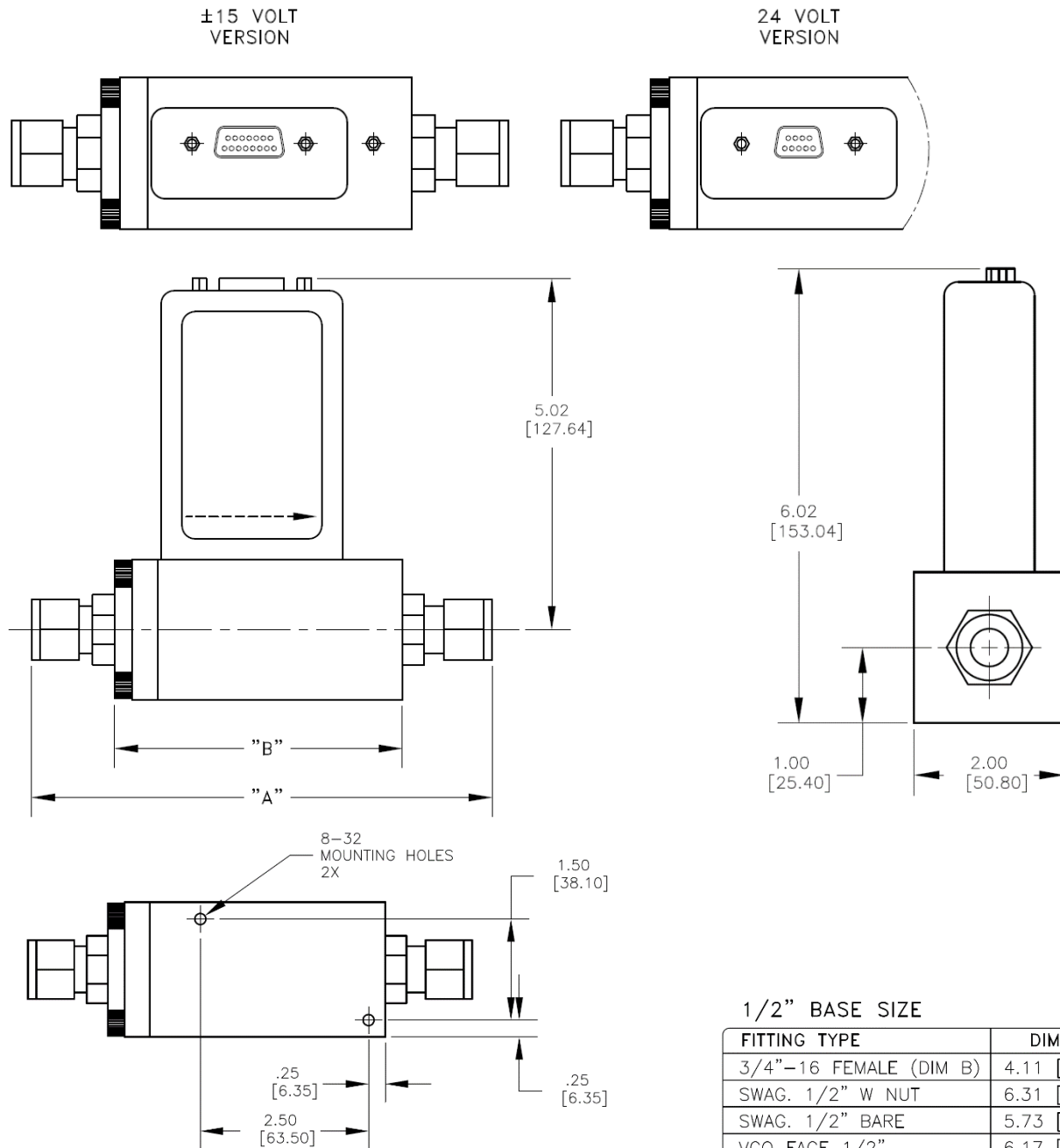
FAX (757) 723-3925

E MAIL mailto:hastings_service@teledyne.com

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

5. Drawings

5.1. HFM-201 Outline Drawings



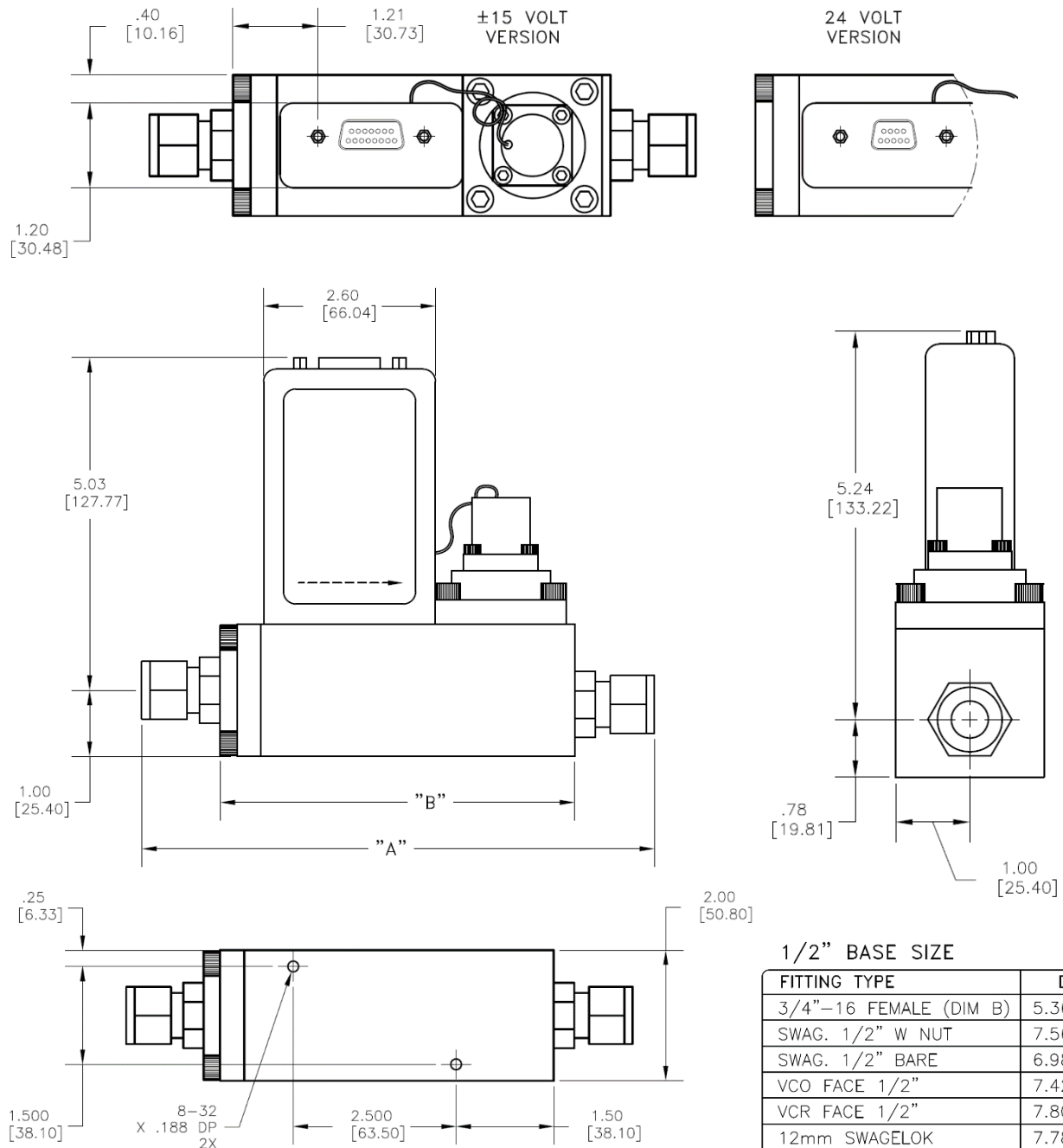
3/4" BASE SIZE

FITTING TYPE	inches—mm
1 1/16-12 FEMALE (DIM B)	4.31 [109.52]
3/4" SWAGelok	6.99 [177.60]
20mm SWAGelok	6.96 [176.83]
3/4" VCO FACE	6.59 [167.44]
3/4" VCR FACE	7.52 [191.06]

1/2" BASE SIZE

FITTING TYPE	DIM "A"
3/4"-16 FEMALE (DIM B)	4.11 [104.39]
SWAG. 1/2" W NUT	6.31 [160.27]
SWAG. 1/2" BARE	5.73 [145.54]
VCO FACE 1/2"	6.17 [156.72]
VCR FACE 1/2"	6.55 [166.37]
12mm SWAGelok	6.55 [166.37]
10mm SWAGelok	6.37 [161.79]
3/8" MALE NPT	6.01 [152.65]
1/2" MALE NPT	6.33 [160.78]

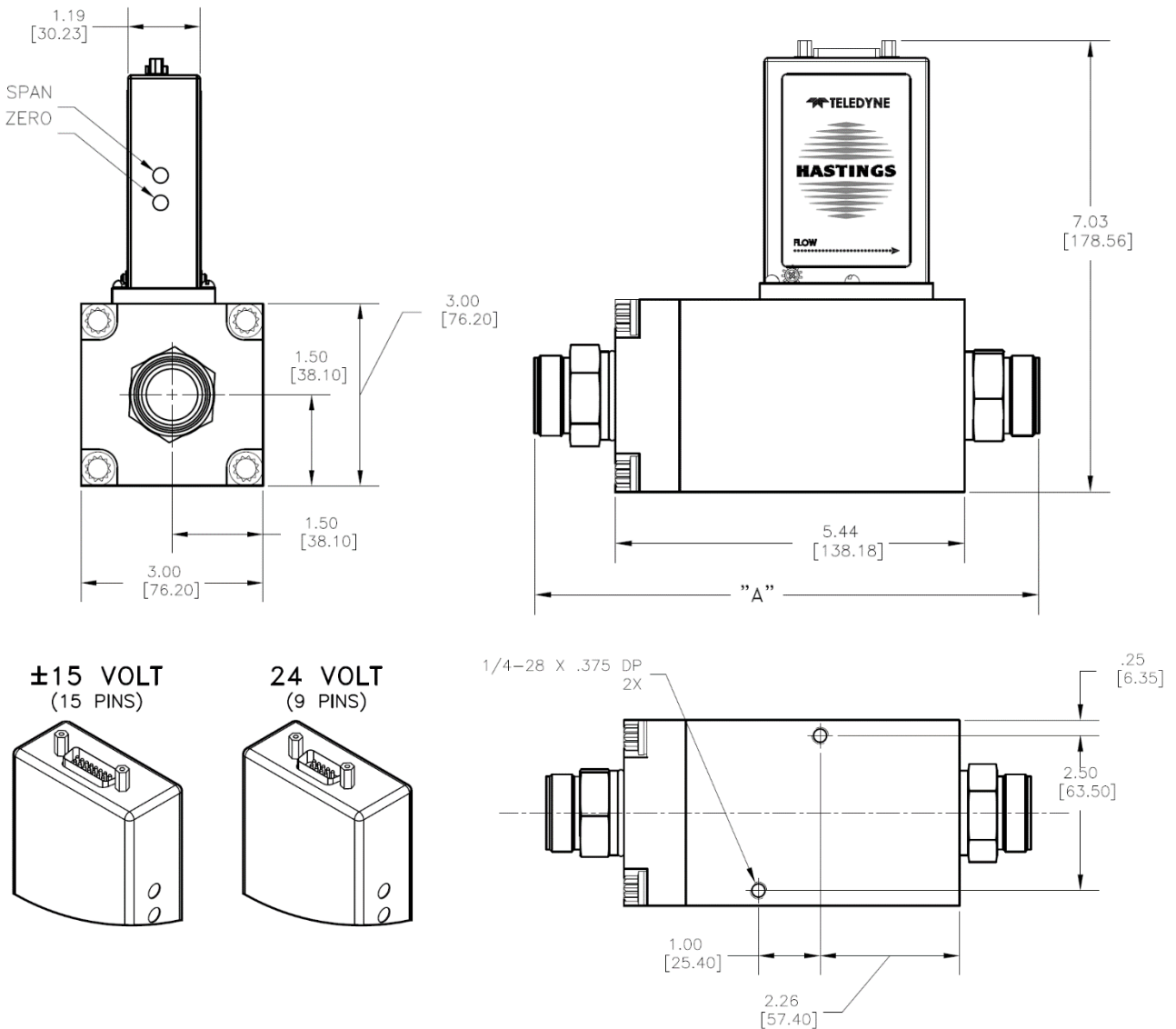
5.2. HFC-203 Outline Drawings



3/4" BASE SIZE

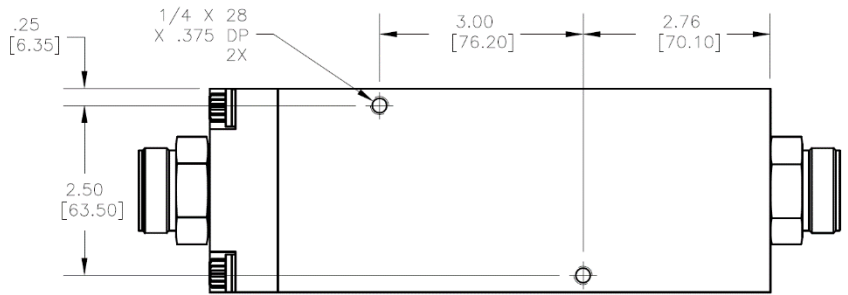
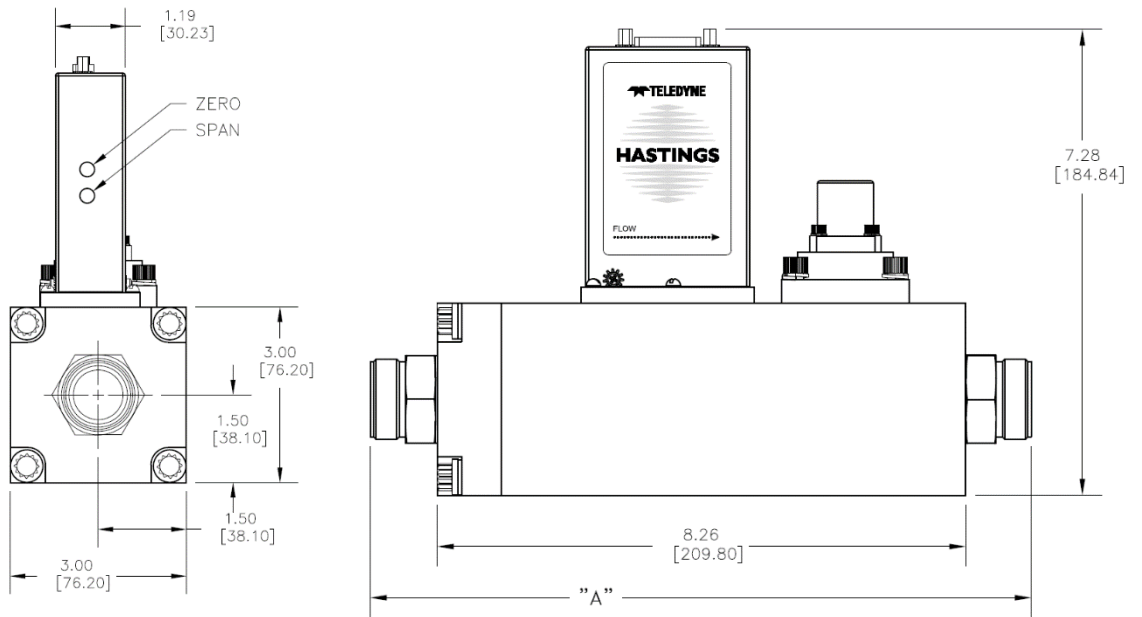
FITTING TYPE	inches-mm
1 1/16-12 FEMALE (DIM B)	5.76 [146.35]
3/4" SWAGELOK	8.44 [214.43]
20mm SWAGELOK	8.41 [213.66]
3/4" VCO FACE	8.04 [204.27]
3/4" VCR FACE	8.97 [227.89]

5.3. HFM-205 Outline Drawings



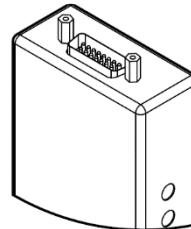
FITTING TYPE	DIM "A"
3/4" SWAGELOK	7.38 [187.45]
1" SWAGELOK	7.58 [192.53]
3/4" MALE NPT	7.84 [199.14]
1" MALE NPT	8.22 [208.79]
1" VCO	7.84 [199.14]
1" VCR	8.86 [225.04]
25mm	7.59 [192.79]
1 5/16-12 FULL THREAD	5.44 [138.18]

5.4. HFC-207 Outline Drawings



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]

±15 VOLT
(15 PINS)



24 VOLT
(9 PINS)

