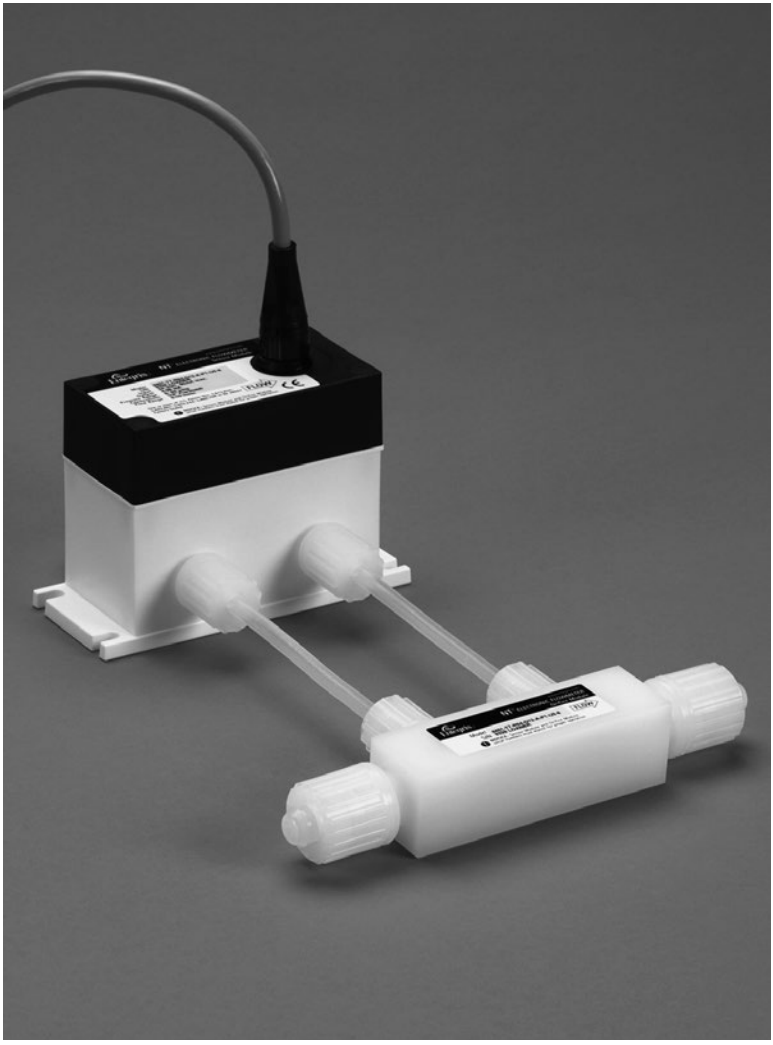
P/N 1400 (Rev. A 08/12)

Entegris

NT® HIGH-TEMPERATURE ELECTRONIC FLOWMETER, MODEL 4401

User Guide



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Introduction

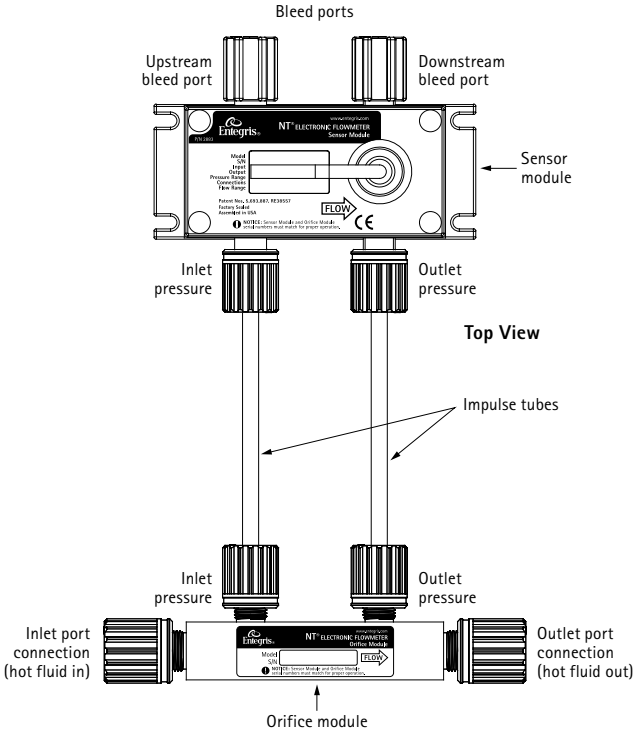
This user guide is for use with the NT® high-temperature electronic flowmeter, model 4401.

The flowmeter is designed for use in high-temperature, high-purity applications, primarily in the semiconductor industry and is compatible with highly corrosive processes.

The instrument measures flow rate without using moving parts or fill fluids, reducing the possibility of a contaminated process.

The flowmeter utilizes a remote orifice module which the high temperature media passes through. This maintains cooler and relative constant temperatures in the flowmeter sensor module.

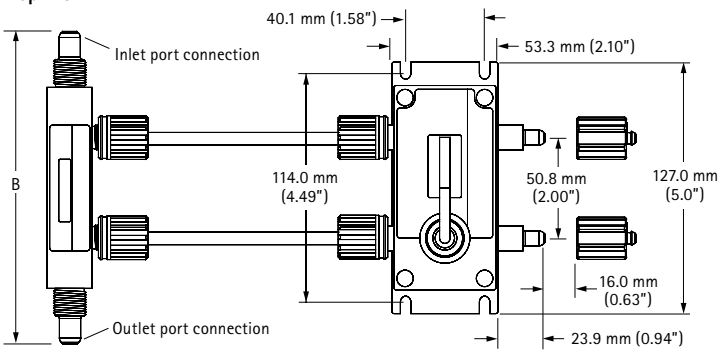
The flowmeter calculates fluid flow from the differential pressure measured by two sensors separated by a venturi style integral orifice. The unit provides two electrical output signals, each 4–20 mA, one for flow rate and another for pressure measurement. The pressure measurement is taken from the outlet of the flowmeter.



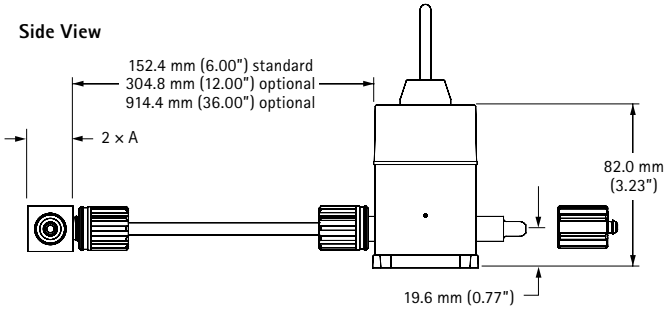
Dimensions

FlareLock® II

Top View

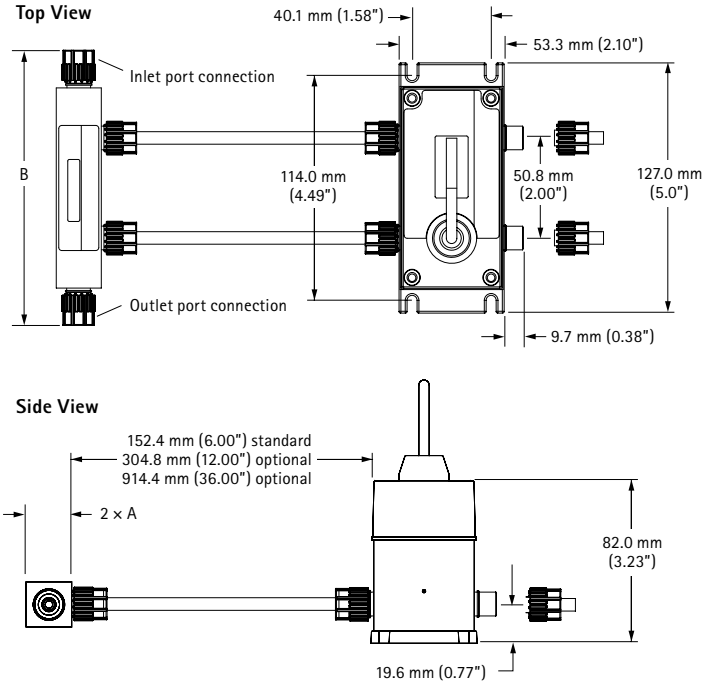


Side View



Inlet/Outlet Port Connection	Dimensions	
	A	B
R02	22.9 mm (0.90")	151.9 mm (5.98")
R03	22.9 mm (0.90")	158.0 mm (6.22")
R04	30.5 mm (1.20")	162.0 mm (6.38")
R06	38.6 mm (1.52")	165.6 mm (6.52")
R08	48.3 mm (1.90")	180.3 mm (7.10")

Super 300 Type Pillar® Fitting



Inlet/Outlet Port Connection	Dimensions	
	A	B
W02	22.9 mm (0.90")	140.0 mm (5.51")
W03	22.9 mm (0.90")	153.0 mm (6.02")
W04	30.5 mm (1.20")	157.0 mm (6.18")
W06	41.6 mm (1.64")	171.0 mm (6.73")
W08	59.4 mm (2.34")	187.6 mm (7.39")

Installation

Provided Equipment

The product ships complete with the orifice module, sensor module and associated impulse tubes and fitting components. For units with FlareLock II connections, two nuts are included. For units with PrimeLock® connections, two nuts and two inserts are included. For units with Pillar connections, two nuts, two sleeves and two gauge rings are included.

NOTE: This unit has been assembled and double-bagged under cleanroom conditions. To maintain purity, only open in cleanroom environment.

! CAUTION: Do not tighten the nuts that protect the tube connections during shipment unless the proper tubing has been installed. Tightening these nuts may result in damage to the PFA and PTFE flowmeter tube connections.

Operating Environment

The flowmeter sensor module is to be mounted in an indoor, climate controlled environment. Refer to *Reference* section on page 17 for specifications.

Mounting Requirements

The flowmeter may be mounted in any orientation. The orifice module can be oriented vertically or horizontally or any angle in between. The orifice module can be above or below the sensor module. However, during normal operation, orienting the flowmeter with the orifice module higher in elevation than the sensor module may allow for any possible bubble accumulation in the impulse tubes to rise up and be dispersed into the main media flow stream (see Figure 1).

The flowmeter does not require straight lengths of tubing at the inlet or the outlet port connection.

For best performance, mount the flowmeter orifice module at relative elevation lower than the point of dispense and maintain positive of at least 6.9 kPa (1 psig) of internal pressure on the sensors at all times.

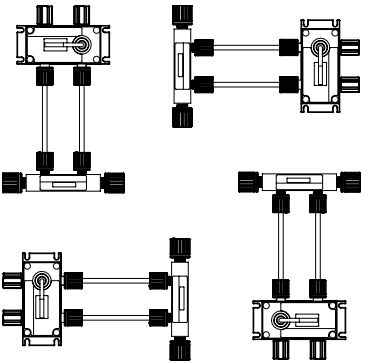


Figure 1. Mounting options

The flow direction of both the orifice module and the sensor module must match (see Figure 2). If disassembly is required, ensure that the unit is reassembled properly, matching the serial numbers of the orifice module to sensor module.

NOTE: When connecting the flowmeter to the process tubing, verify the direction of flow corresponds to the inlet and outlet port connections of the flowmeter orifice module (the process fluid must enter at the inlet and exit at the outlet). A flowmeter installed backwards will output an erroneous flow and pressure signal (see Figure 2).

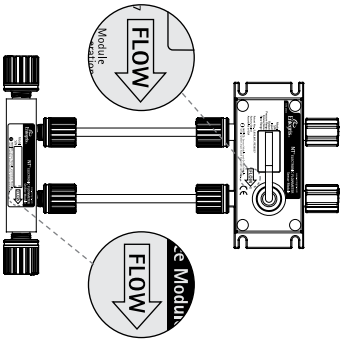


Figure 2. Flow direction

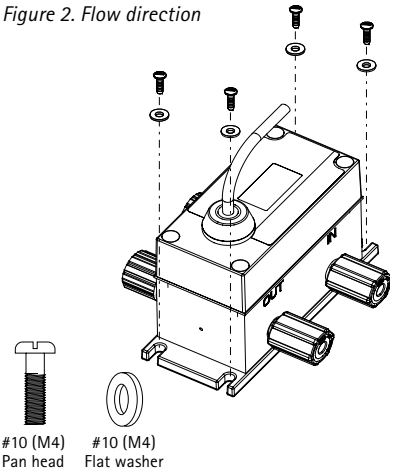


Figure 3. Recommended hardware

Bleed Ports

Bleed ports are provided on the sensor module to remove air bubbles or flush liquids from the impulse tubes and sensor module internal areas.

Tubing can be installed permanently with with manual valves or other types of valves for repeated bleeding, if needed. Tubing may also be temporarily attached for bleeding and then removed and the connections capped.

Mechanical Installation

Do not subject the flowmeter sensor module to high heat during installation. The sensor module base bracket must be mounted to a solid surface to ensure stability. Verify all fitting connections and the signal cable are free from mechanical stress from the surrounding equipment. Use #10 or M4 pan head screws with flat washers for mounting (see Figure 3).

Care should be taken when installing the flowmeter to avoid leaks. Do not use excessive torque when tightening the tubing connections. The flowmeter must be used with the proper tubing size and fittings.

Install a two-way valve downstream from the flowmeter. The valve is required to perform the flowmeter re-zero function. Please refer to *Maintenance* section on pages 15–16 for more information concerning the re-zero function.

Electrical Installation

Power Supply Requirements

The power supply for the flowmeter must provide **clean** power and must be used only to power similar measurement-type devices. The power supply must not be used to power inductive loads, such as motors, relays or solenoids. These devices may produce transients that may affect the flowmeter measurements when such an inductive device is powered up or powered down.

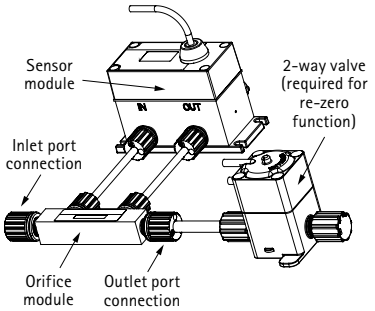


Figure 4. Flowmeter with 2-way valve

In addition to providing clean power, the instrumentation signals and power return lines must not be run within the same conduit or cable. Heavy current demands from motors, charging capacitors or other inductive loads may cause a voltage change within the instrumentation signal line, causing erroneous output readings from the flowmeter.

Circuit Protection

Use a 1 Amp rated, time lag fuse. A single fuse can be used for all three input power lines combined, or individually, as preferred.

Input Power

The flowmeter requires a nominal 24 VDC (12–28 VDC input voltage) to operate. The *Electrical Specifications* section on page 17 describes the unit input power requirements.

Output Signals

The flowmeter provides two optically isolated analog 4–20 mA output signals, one signal for flow and one signal for pressure. Each analog output signal uses a standard two-wire system that requires a 24 VDC (12–28 VDC) power supply with less than 2% ripple at 100 or 120 hertz. The required power supply voltage (VPS) for the output signal(s) varies with the maximum load resistance, R_{Load} (see Figure 9 on page 10). Flowmeter output signals are described in Figures 11 and 12 on page 11. Input and output signals to the flowmeter are supplied through an 8-wire FEP-jacketed pigtail cable or 8-wire removable PVC-jacketed electrical connector (D-Series connector), located on the cover of the flowmeter.

Electrical Connections

Refer to Figure 6 on page 8 for the

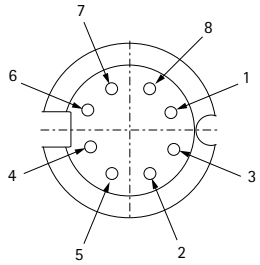


Figure 5. 8-wire connector (D series connector)

pigtail and 8-pin connector wiring diagram.

8-wire Pigtail	D-Series Connector	Function
Black	Pin 1/Black	Ground (+24 VDC common)
Red	Pin 2/Red	+24 VDC
Brown	Pin 3/Brown	Pressure output, 4–20 mA output
Yellow	Pin 4/Yellow	Pressure output, +24 VDC supply
Orange	Pin 5/Orange	Flow output, +24 VDC supply
Blue	Pin 6/Blue	Flow output, 4–20 mA output
Violet	Pin 7/Violet	Re-zero input
White	Pin 8/White	Factory use only – do not connect
Shield	Shield	Earth ground or chassis ground

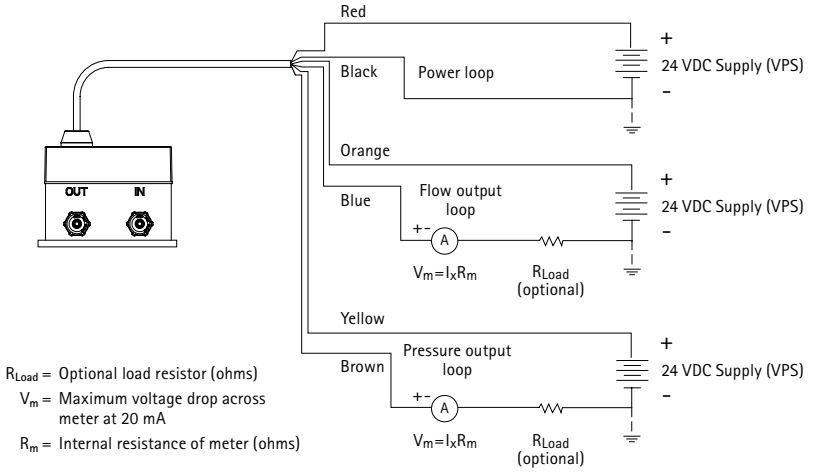


Figure 6. Wiring diagram

Wiring Diagram

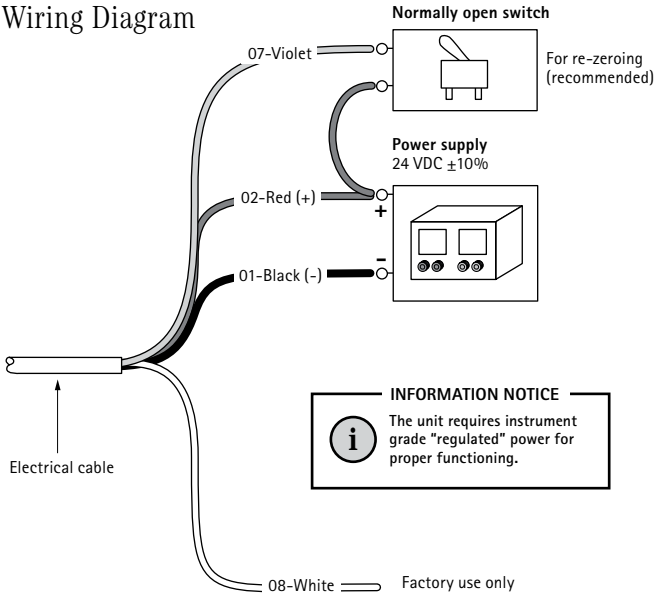


Figure 7. Power and re-zero wiring

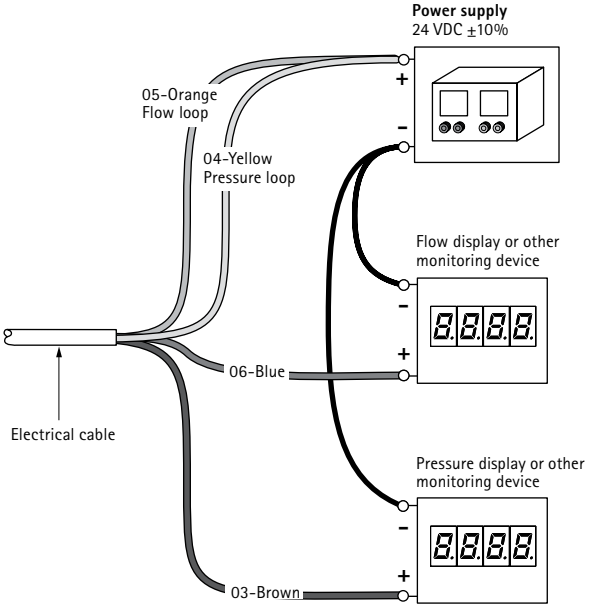


Figure 8. flow and pressure signal wires

Load Resistance

If a load resistor, R_{Load}, is used in series with the current output (flow and pressure outputs), the value of R_{Load} is dependent on the supply voltage and the meter resistance and is calculated from the following formula:

$$R_{Load} = \frac{V_{PS} - 12}{0.02} - R_{meter}$$

where:

R_{Load} = maximum load resistance

V_{PS} = power supply voltage

R_{meter} = meter resistance (theoretically = 0)

If R_{Load} is calculated using a voltage drop across the meter (V_m), the following equation is used:

$$R_{Load} = 50^* (V_{PS} - 12 - V_m)$$

Figure 9 shows the power required for a 4–20 mA loop.

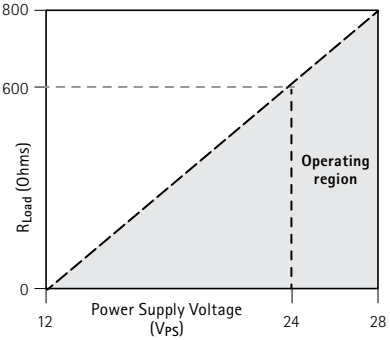


Figure 9. Power required for a 4–20 mA loop.

Unit Operation

Sensor Module

The sensor module is factory sealed and should not be tampered with.

NOTE: Any attempt to remove or tamper with the sensor module or any other parts of the unit will void the warranty.

Operating Pressure Requirements

The flowmeter calculates fluid flow from the difference in pressure (measured by two sensors) across a venturi style orifice. For the flowmeter to perform within specification, a minimum of 7 kPa (1.0 psig) must be present at the outlet of the orifice module. Maximum pressure is 414 kPa (60 psig).

Follow fitting design maximum pressure capability for the maximum temperature of your fluid media.

! CAUTION: The flowmeter may be damaged if it is subjected to any level of vacuum pressure (less than atmospheric pressure).

Flow Accuracy

The accuracy of the analog flow output is ±1% of full scale, or ±2.5% of full scale. Please refer to page 19 to determine flow range. The flowmeter accuracy includes the effects of linearity, hysteresis and repeatability, measured using deionized water at 23°C (73°F).

Pressure Accuracy

The accuracy of the analog pressure output is ±1% of full scale. These calculations include the effects of linearity, hysteresis and repeatability, measured at 23°C (73°F).

Pressure Drop Charts

The following pressure drop charts detail the pressure drop developed using deionized water at 23°C (73°F).

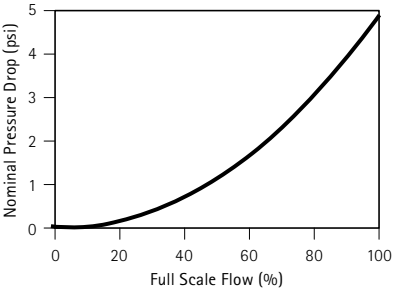


Figure 10. Pressure drop vs. full scale flow – T flow ranges.

Figures 11 and 12 illustrate the expected current outputs for the flow and pressure measurement signals from the flowmeter. Outputs below 4 mA or above 20 mA signify low or high alarm conditions.

NOTE: Specifications are subject to change without notice. Please consult the factory for the most current information.

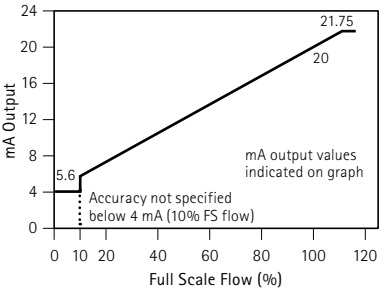


Figure 11. mA output vs. full scale flow – T flow range.

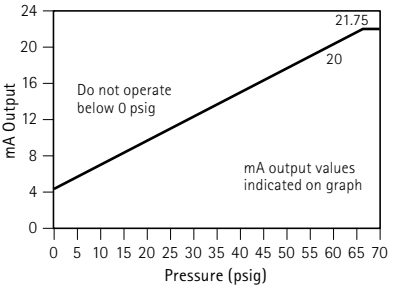


Figure 12. mA output vs. pressure.

Determining the Flowmeter C_V

The C_V of the flowmeter using deionized water at 23°C (73°F) is listed in Table 1. C_V coefficient is the number of gallons of water that will pass through the orifice in one minute at a pressure drop of 7 kPa (1.0 psig).

TABLE 1. C_V COEFFICIENTS OF FLOW RANGES

Flow Range	C_V
T0	0.006
T1	0.015
T2	0.031
T3	0.061
T4	0.15
T5	0.31
T6	0.61
T7	1.2
T8	2.4
T9	4.9
T10	7.3
T11	11.0
T12	14.6

Diagnostics

Troubleshooting the flowmeter may be accomplished by measuring the current (4–20 mA) output signal of the flowmeter with a battery powered current/voltage meter. The meter may be placed in series with a flowmeter output to measure the current output or it may be used to directly measure the voltage from a load resistor. Using the battery powered current/volt meter is an effective method to determine whether the Entegris device or the on-site data acquisition system is not functioning properly.

Diagnostic Guide*

Symptom	Possible Causes	Suggestions
1. Current output reads 4 mA or less when fluid flow is present.	The flowmeter is installed backwards.	Install the flowmeter so the direction of flow is from inlet port connection towards outlet port connection.
	The flowmeter was accidentally re-zeroed while flow was present.	Make sure the flow is stopped and that there is a minimum of 7 kPa (1 psig) static line pressure present; then re-zero the flowmeter. See Re-zero Function, page 15.
	Insufficient back pressure.	If the back pressure is being created by a column of liquid, the column height must be greater than 28 inches of water 7 kPa (1 psig). Some liquid may require greater height due to lower density.
	The actual flow is lower than the specified flow range for the flowmeter.	A flowmeter configured to a different flow range is required. For example, if the flowmeter is a T7 0–101 L/min. unit, any flow less than 1.0 L/min. will read 4 mA. Please contact Entegris for additional product information.
	Impulse tubes are crossed.	Reinstall impulse tubes with proper orientation.
	Bubbles in impulse tube(s).	Purge the bubbles.
2. Output reads above 4 mA when there is zero flow.	The flowmeter needs to be re-zeroed.	Perform the re-zeroing procedure. Make sure the flow is stopped and a minimum of 7 kPa (1 psig) static line pressure is present; then re-zero the flowmeter. Verify the re-zero pressure using the flowmeter's pressure output. See Re-zero Function, page 15.
3. Current output does not vary with changes in flow.	The pressure output is being monitored instead of the flow output.	Check the wiring to ensure the flow output is wired correctly.
	Insufficient back pressure.	If the back pressure is being created by a column of liquid, the column height must be greater than 28 inches of water 7 kPa (1 psig). Some liquid may require greater height due to lower density.

** Please contact Entegris for further diagnostic assistance.*

Diagnostic Guide (continued)

Symptom	Possible Causes	Suggestions
	Impulse tubes are crossed.	Reinstall impulse tubes with proper orientation.
	Bubbles in impulse tube(s).	Purge the bubbles.
	The 4–20 mA loop signal is shorted to the power (+24 V) of the flowmeter.	Examine all electrical connections. Note that. if wires are stripped back too far before insertion in a terminal block, they may cross and short together.
4. Current output is extremely high (>25 mA).	The actual fluid flow or pressure conditions are excessive.	Lower the flow rate or applied fluid pressure Select higher range flowmeter.
5. Output is extremely noisy (spiking above and below 20 and 4 mA)	The supply power (+24 V) is noisy.	If the power supply is shared with other systems, components such as solenoids, DC motors, valves, etc., the flowmeter may be receiving "dirty" power. The noise spikes on the power supply will cause the flowmeter output to be noisy. See page 7 (Electrical Installation).
	The actual fluid flow or pressure conditions are noisy.	Flow turbulence may be caused by "noisy" pumps used in a system. Examples of noisy pumps are diaphragm pumps without pulsation dampeners and peristaltic pumps operating at low flow rates.
6. Flow inaccuracy at low operating flow rates.	The flowmeter needs to be re-zeroed.	Perform the re-zeroing procedure. Make sure the flow is stopped, and a minimum of 7 kPa (1.0 psig) static line pressure is present, then re-zero the flowmeter. Verify the re-zero pressure using the flowmeter's pressure output. See Re-zero Function, page 15.
	Insufficient back pressure (< 7 kPa (1.0 psig).	Check pressure output value. If below 4.26 mA (1.0 psig) at all operational flow rates (including zero flow), move flowmeter or increase back pressure.
	Heat loss due to low flow.	Increase flow. With low flow, heat can escape the chemical media affecting of the viscosity of the media. The unstable viscosity will diminish the flow measurement.

Diagnostic Guide (continued)

Symptom	Possible Causes	Suggestions
7. Flow inaccuracy such as hysteresis, linearity, repeat-ability and no output.	Damage by heat.	Sensor module can be damaged by excessive heat from the impulse tube during setup or purging air bubbles. Do not purge bubbles with heat or allow the sensors to be heated by the media. See page 15 (Maintenance) for details.
	Sensor module serial number does not match orifice module serial number.	Match sensor module to orifice module.
	Bubbles in impulse tube(s).	Purge the bubbles.

Maintenance

Normal Operation

During normal operation, the flowmeter requires little maintenance, other than a periodic re-zero of the flowmeter and possible periodic flushing of bubbles in the impulse tubes between the flowmeter orifice module and the sensor module.

Flowmeter Re-zero Function

The calibration of the flowmeter can be re-zeroed, meaning that the analog output that corresponds to zero flow may be reset.

⚠ **WARNING! When executing the re-zero function, there must be 7–414 kPa (1–60 psig) of static pressure. Best results when re-zero is performed at the operating pressure.**

NOTE: The following procedure must be followed precisely to ensure proper flowmeter re-zero.

1. The flowmeter re-zero function requires the same power supply of 24 VDC (±12–28 VDC) as is used to power the unit.
2. Stop the process fluid flow and verify that the flowmeter is experiencing **absolutely no flow** (typically requires a fully closed process valve in the fluid stream located on the **outlet** side of the orifice module).
3. Using the pressure output signal of the flowmeter, verify that there is **at least** 7 kPa (1.0 psig) [414 kPa (60 psig)] maximum of **stable** static line pressure.
4. Apply 24 VDC (12–28 VDC) to the violet wire for a minimum of three seconds. This voltage supply must use the same ground as the power supply for the flowmeter.
5. Release the 24 VDC (12–28 VDC) from the violet wire. Re-zero sequence is now complete.

In most applications, the re-zero procedure may be automated using switches, a PLC or other logic controller devices. In order to obtain best performance, the re-zero function should be performed, if possible, every day of service when operating at ambient temperature conditions. The re-zero function should be performed more often if operating at higher temperature. It is also recommended to perform a re-zero after start-up and after fluid temperature changes of greater than 5°C (9°F). Best performance will be achieved by re-zeroing between each dispense cycle.

Flushing Impulse Tubes and Internal Areas

The impulse tubes and sensor module internal areas can be fully flushed of all liquids or purged of all air bubbles.

1. Allow fluid media to fill the tubing of your system.
2. Open the upstream bleed port line valve to purge all air bubbles or flush existing liquid. Limit time to 25 seconds maximum with media exceeding 40°C. Close the bleed port line valve.
3. Open the downstream bleed port line valve to drain all air bubbles or flush existing liquid. Limit time to 25 seconds maximum with media exceeding 40°C. Close the bleed port line valve.
4. Monitor any air bubble accumulation in the impulse tubes and repeat purge as necessary.
5. Do not run for extended periods of time with bleed ports open. Short bleed durations keep the flowmeter sensor module temperature as close to ambient as possible.
6. Bleed ports must be closed to properly measure flow during system operation.

Reference

Physical Specifications

Materials of construction:	Wetted parts	Sensor module body	PTFE
		Orifice module body	PFA
		Sensor interface	PFA or CTFE (CTFE is temperature limited)*
		Impulse tubes	PFA
		Primary seal	Kalrez® 6375 UP
	Nonwetted parts	Polypropylene, polyethylene, PVDF and PVC or FEP-jacketed cable (in addition to materials listed above)	
Inlet/outlet connection:	FlareLock II tube fitting, PrimeLock tube fitting, Super 300 Type Pillar tube fitting		
Bleed port connection:	Flaretek® tube fitting, PrimeLock tube fitting, Super 300 Type Pillar tube fitting – ¼"		
Impulse tube connection:	FlareLock II tube fitting, PrimeLock tube fitting, Super 300 Type Pillar tube fitting – ¼"		

** If CTFE is chosen for chemical capability, the sensor module temperature must be maintained below 40°C during purging.*

Electrical Specifications

Electrical input:	24 VDC (12–28 VDC)
Electrical current (signal):	50 mA device current (+20 mA +20 mA for each analog output)
Signal output range:	4–20 mA (externally powered with 24 VDC; output varies proportionately with flow or pressure measured)
Maximum load resistance:	0 Ω @ 12 VDC
	800 Ω @ 28 VDC
Maximum output current:	22 mA for flow signal, 22 mA for pressure signal
Electrical enclosure:	NEMA 5/IP54

Performance Specifications

Process temperature:	10°C – 180°C (20°F– 356°F) with PFA interface*
Storage temperature:	10°C – 65°C (20°F – 149°F)*
Operating pressure:	0 – 414 kPa (0 – 60 psig)
Minimum outlet pressure:	7 kPa (1.0 psig)
Non operating maximum pressure:	0 – 690 kPa (0 – 100 psig)**
Response time:	50 msec update rate
Flow measurement accuracy:	20–100% of range ±1.0% of full scale
	10–20% of range ±2.5% of full scale
	Accuracy stated as % of full scale using deionized water at 23°C (70°F) and includes the combined effects of linearity hysteresis and repeatability
Flow measurement repeatability:	20–100% of range ±0.5% of full scale
	10–20% of range ±1.0% of full scale
Pressure output range:	0–414 kPa (0 – 60 psig)*
Pressure measurement accuracy:	±1.0% of full scale, includes the combined effects of linearity, hysteresis and repeatability
Pressure measurement repeatability:	±1.0% of full scale

** Contact Entegris for specific application support and expanded capabilities.*

***Follow fitting design maximum pressure capability for the maximum temperature of your fluid media.*

Ordering Information

The model number can be established using the following chart.

NT High-temperature Electronic Flowmeter

4401	High-temperature electronic flowmeter

Flow Range

T0	0–50 mL/min
T1	0–125 mL/min
T2	0–250 mL/min
T3	0–500 mL/min
T4	0–1250 mL/min
T5	0–2.5 L/min
T6	0–5 L/min
T7	0–10 L/min
T8	0–20 L/min
T9	0–40 L/min
T10	0–60 L/min
T11	0–90 L/min
T12	0–120 L/min

Inlet/Outlet Connection

R02	1/4" FlareLock II tube fitting
R03	3/8" FlareLock II tube fitting
R04	1/2" FlareLock II tube fitting
R06	3/4" FlareLock II tube fitting
R08	1" FlareLock II tube fitting
K02	1/4" PrimeLock tube fitting
K03	3/8" PrimeLock tube fitting
K04	1/2" PrimeLock tube fitting
K06	3/4" PrimeLock tube fitting
K08	1" PrimeLock tube fitting
W02	1/4" Super 300 Type Pillar tube fitting
W03	3/8" Super 300 Type Pillar tube fitting
W04	1/2" Super 300 Type Pillar tube fitting
W06	3/4" Super 300 Type Pillar tube fitting
W08	1" Super 300 Type Pillar tube fitting

Ordering Information (continued)

Electrical Connector Type	
B06	FEP-jacketed 6' pigtail electrical cable
B12	FEP-jacketed 12' pigtail electrical cable
B30	FEP-jacketed 30' pigtail electrical cable
D00	8-pin polypropylene connector (mating cable not included)
D06	8-pin polypropylene connector with 6' PVC-jacketed mating cable
D12	8-pin polypropylene connector with 12' PVC-jacketed mating cable
D30	8-pin polypropylene connector with 30' PVC-jacketed mating cable

Electrical Outputs	
A	4–20 mA (12–28 VDC input)

Sensor Interface	
P1	CTFE sensor interface
P2	PFA sensor interface (default)

Primary/Secondary Seal	
U3	Kalrez 6375 UP/Viton® (default)
S3	Kalrez 6375 UP/Kalrez 6375 UP

Orifice Module to Sensor Module Stance	
6	6" (default)
12	12"
36	36"

Certifications

CE Certification

Please visit *www.entegrisfluidhandling.com* for the most current information.

UL Certification

Please visit *www.entegrisfluidhandling.com* for the most current information.

Repair and Warranty Service

Repair and warranty service is available at the Entegris factory. To expedite the return and repair of the product, contact Entegris at +1 800-394-4084. A Return Materials Authorization (RMA) number, MSDS requirements and a product packaging and return procedure will be provided at that time. If the product being returned was exposed to a hazardous substance, a copy of the Material Safety Data Sheet (MSDS) for each hazardous substance identified must be included with the returned product.

⚠ WARNING! Mishandling products exposed to a hazardous substance may result in death or serious injury.

Technical Support

For technical support, contact the factory at +1 800-394-4084. Please have the complete model number, chemical and application information ready when calling.

For More Information

Please call your Regional Customer Service Center today to learn what Entegris can do for you. Visit *www.entegris.com* and select the Customer Service link for the center nearest you.

Terms and Conditions of Sale

All purchases are subject to Entegris' Terms and Conditions of Sale. To view and print this information, visit *www.entegris.com* and select the Legal Notices link from the footer.

Product Warranties

For Product Warranties, visit *www.entegris.com* and select the Legal Notices link from the footer.

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