

# Positive Displacement Flowmeters

## Operational Manual

For Models P001, P002, 213, 214, and 215



Model P001



Model 215



Model P002



Model 213



Model 214

## 210 Piston Series Positive Displacement Flow Meters

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Custom Instructions for Hazardous Locations/Explosion Proof Housing:

[www.maxmachinery.com/content/explosion-proof-installation-instructions](http://www.maxmachinery.com/content/explosion-proof-installation-instructions)

**DO NOT ATTEMPT TO INSTALL OR START FLOW METER WITHOUT READING THIS ENTIRE MANUAL**

Max Machinery, Inc. (MMI) reserves the right to make changes to the product in this Instruction Manual to improve performance, reliability, or manufacturability. Consequently, contact MMI for the latest available specifications and performance data. Although every effort has been made to ensure accuracy of the information contained in this Instruction Manual, MMI assumes no responsibility for inadvertent errors.

# Before You Install



Thank you for choosing to install a Max Machinery precision flow meter. To ensure the best experience please take a moment to read through this manual prior to installation.

When you purchased this meter a flow engineer helped determine many of the factors that will be reviewed on the following pages. You may find it useful to fill out the form below and keep it in your files for reference.

When you are ready to install there will be a few tools you will need:

## Meter Installation:

- The meter and transmitter
- A signal cable (available from factory)
- The display or signal processing device
- Indicator Manual
- Calibration Certificate
- Bypass plumbing supplies

Many Max meters are installed and operate for decades, so having the following information in your records may prove useful. We have provided this outline as a starting point.

Process Temperatures _____	Fluid Viscosity _____
Operating Range _____	Line Pressure _____
Max Sales # or PO # _____	Installation Date _____
Meter Model # _____	Meter Serial # _____
Transmitter Model # _____	Transmitter Serial # _____

Notes: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

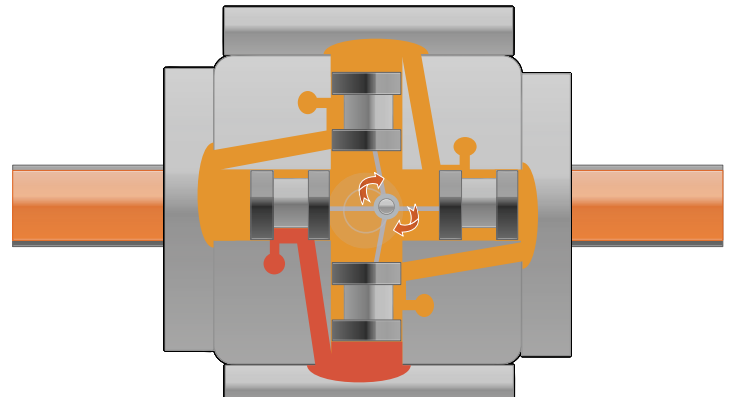
# Meter General Description

The Max P Series and 210 Series Flow Meters are positive displacement piston type units capable of great accuracy over a wide range of flow rates and fluid viscosities. The five basic sizes of this series will measure flows from 0.005 cc/min to 35 Liter/min. Various "O" ring and internal plating options are available to meet temperature and fluid compatibility requirements.

In a piston type flow meter, four pistons and cylinders are arranged in a radial fashion around a central crankshaft. Two fluid ports on the cylinder wall, a port at the top of the cylinder, and a grooved piston enable fluid entering the flow meter's central cavity to be measured and pumped out by each piston in turn. The valving action for each cylinder is accomplished by the piston adjacent to it. The accuracy of a piston flow meter is dependent on close tolerances in the cylinder wall and piston. Max Machinery regularly holds tolerances as fine as 0.00005 inches in the production of these meters.

The movement of the pistons is converted to a circular motion at the central crankshaft, which is coupled to a magnet in the flow meter. This motion is sensed by an external electronic transmitter, which converts flow into a voltage, pulse train, or current for further processing.

The Max Series of piston meters can be expected to perform superbly if operated within the confines of their design envelope. For this reason, it is important to read this manual and understand the operational requirements and limits of the meter. Our Technical Service staff will be happy to answer any questions that this manual does not cover.



Max Model 214

# Transmitter General Description

Max transmitters are designed to work with the entire family of Max Flow Meters to provide extremely precise flow measurement in a cost effective package. Different options of industrial housings or IP66 rated explosion proof enclosures, combined with a choice of one-part and two-part, high temperature designs with remote electronics cover a wide range of application environments - from the laboratory to harsh industrial processes.

This latest generation of transmitters use modern sensor technology coupled with advanced signal processing to deliver high levels of performance and reliability. Hall sensors are used to detect the position of a driven magnet inside a Max Flow Meter. Changes in position are tracked by a microprocessor, which generates an output proportional to the flow rate. Advanced signal processing provides both fine angular resolution (0.36 degrees rotation) and rapid response (output updated every one millisecond).

Max transmitters are typically mated to a mechanical flow meter, configured, and calibrated at the factory as a set. This ensures accuracy and allows quick setup in the field. For field installations where the transmitter has not been set up with a meter at the factory, an optional serial interface kit may be purchased to give full access to configuration options and parameters.

## Transmitter Features

High resolution measurement -

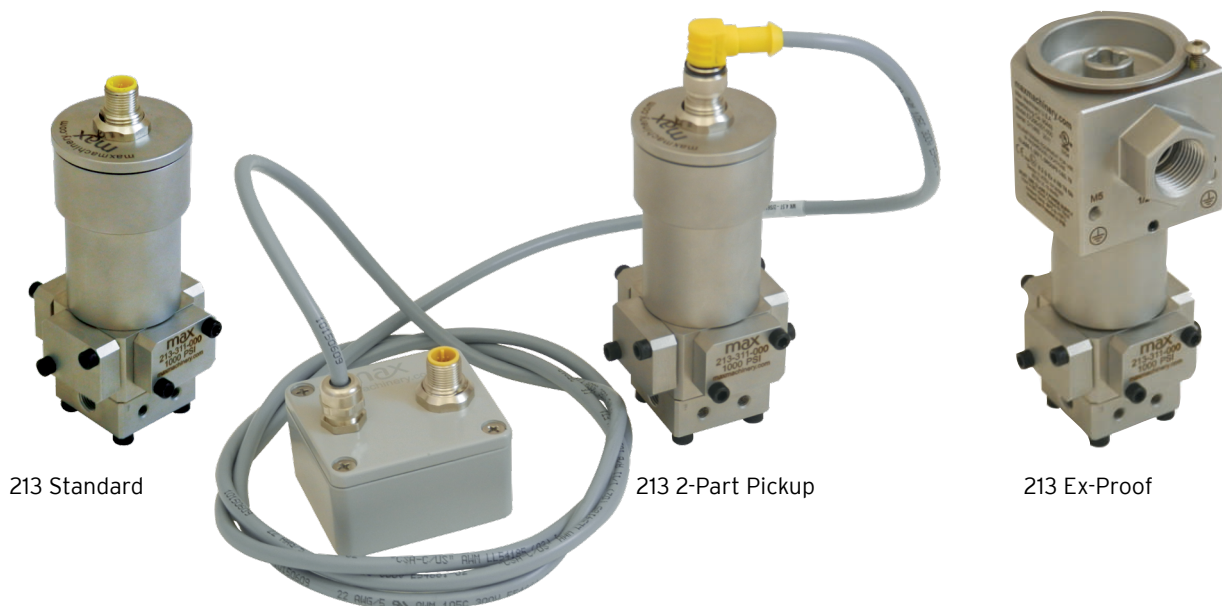
- Analog Output: Configured output ranges to any value within  $\pm 10$  Vdc or  $\pm 20$  mA.

- Frequency Output: Configured output resolution of 1 to 1000 pulses per revolution.

- Linearization of up to 16 points to fully describe the flow meter's output curve and achieve the highest system linearity over the meter's entire operating range.

Compensation Algorithm - Compensates for variations in Hall sensor and flow meter characteristics to provide a stable, undamped output that accurately represents the instantaneous flow rate. This feature is factory set when the meter and transmitter are mated together. If the transmitter is changed, the compensation can be performed via a button on the circuit board.

Anti-Dither Buffer - Masks the false output that may occur at very low flow rates in the presence of vibration or hydraulic noise. If the meter reverses direction the output signal will be interrupted for a user selected portion of a meter rotation. Reverse flow exceeding the buffer setting will result in an output proportional to reverse flow rate. The buffer quantity can be set from 1% to 100% of a revolution.



# Meter Specifications



Model	P001	213	P002	214	215
<b><sup>1</sup>Maximum flow rate</b>					
Gal/min:	0.053	0.48	0.53	2.64	9.25
Liters/min:	0.2	1.8	2.0	10	35
<b>Maximum pressure (psi)</b>					
2xx-3xx, 2xx-4xx:		1,000 psi (70 bar)			
2xx-6xx:		3,000 psi (210 bar)			
P001, P002, 214-5xx		7,250 psi (500 bar)			
<b>Pressure drop (PSIG)</b>					
Operating maximum:	10	15	15	28	30
Absolute maximum:	15	20	20	30	42
100% Flow (3cps):	1	3.25	3.25	3.5	5
<b><sup>2</sup>Maximum temperature</b>	----- 1 part: 195°F (90°C) -----				
<b><sup>2</sup>Maximum temperature</b>	----- 2 part: 435°F (225°C) -----				
<b><sup>3</sup>Recommended filtration</b>	5 micron	10 micron	10 micron	10 micron	10 micron
<b>Displacement (cc/rev)</b>	0.3	0.887	1.0	10.5	47.6
<b>Weight (lbs)</b>					
1000 & 3000 psi	---	1.25 (0.57kg)	---	6.25 (2.8kg)	22.75 (10.3kg)
7250 psi	2.0 (0.9kg)	--	4.2 (1.9kg)	14.4 (6.5)	---
<b>Typical k-factor (pulses/cc)</b>					
290 Frequency series					
Transmitter	12,000	1000	1000	90	20
<b>Port size</b>					
NPT	---	1/8"	---	3/8"	1/2"
SAE	---	#4	#4	#6	#8
TUBE	1/4" or 6mm				

<sup>1</sup> For viscosities of 30 cps or more, derate per pressure drop curves for higher viscosities.

<sup>2</sup> Dependent on meter seal material, transmitter model, orientation and ambient temperature. See transmitter manual; consult factory.

<sup>3</sup> Some materials may have different filter requirements, consult factory.

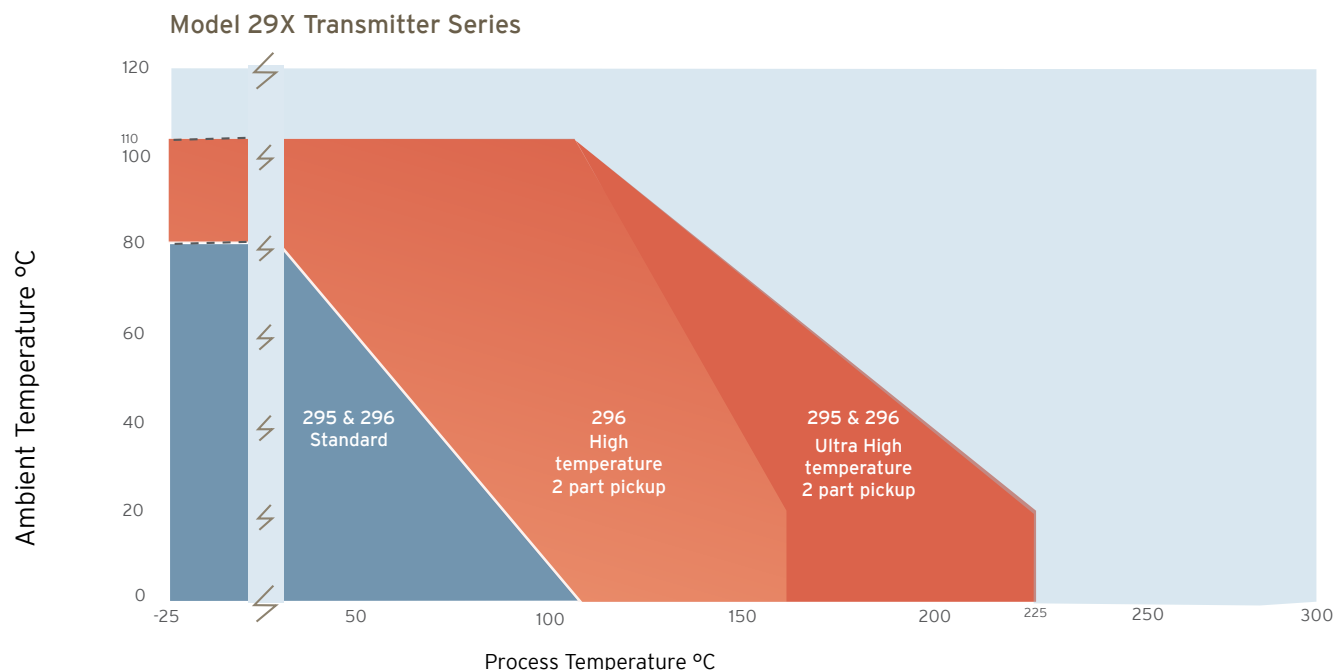
# Transmitter Specifications

## Analog

Supply Voltage	12 Vdc (Models 29X-XXX-100) 24 Vdc (Models 29X-XXX-000)
Supply Current	90 mA max@ 12 Vdc, 45 mA max@ 24 Vdc
Short Circuit Current	21 mA
<sup>1</sup> Output Update Rate	1 ms
Resolution	Adjustable without recalibration to any range of $\pm 10$ Vdc Model 29X-3XX-XXX or $\pm 20$ mA Model 29X-2XX-XXX
Ambient Temperature Range	Transmitter (Storage)-40°C to 85°C (-40°F to 185°F) <sup>2</sup> Transmitter (Operation)-40°C to 80°C (-40°F to 175°F)
Max Temperature, Process Fluid (20°C Ambient, 5V supply)	Standard Model 90°C (195°F) - Models 295 & 296 High Temp Model - Model 296 Ultra-High Temp Model 225°C (435°F) - Models 295 & 296
For explosion proof models see: <a href="http://www.maxmachinery.com/content/explosion-proof-installation-instructions">www.maxmachinery.com/content/explosion-proof-installation-instructions</a>	
Anti-dither Range	Software selectable from 1-100% of 1 revolution. 50% of a meter revolution - unidirectional 2% bidirectional are typical default settings
Signal Filtering	Software selectable from 1 ms to 64 sec. time constant

<sup>1</sup> Full step change is subject to signal damping

<sup>2</sup> Temperature of metered fluid will affect transmitter temperature, see graph below



# Transmitter Specifications

## Frequency (Pulse)



Supply Voltage	5-26 Vdc	
Supply Current	25-30 mA typical	
Output (5.0 Volt Supply) (TTL and CMOS compatible)	No Load	0.00 / 4.80 Volts
	2.5K Load to Common	0.00 / 4.60 Volts
	2.5K Load to +5 Volts	0.25 / 4.80 Volts
Short Circuit Current	45 mA	
Output Impedance	100 $\Omega$	
Rise/Fall Time	0.2 $\mu$ Sec	
<sup>1</sup> Output Update Rate	1 ms	
Min/Max Frequency	0-60 kHz	
Resolution	1 - 1000 pulses/rev, Single Phase 1 - 500 pulses/rev/phase, Quadrature	
Ambient Temperature Range	Transmitter (Storage)-40°C to 85°C (-40°F to 185°F) <sup>2</sup> Transmitter (Operation) -40°C to 80°C (-40°F to 175°F)	
Max Temperature, Process Fluid (20°C Ambient, 5V supply)	Standard Model 90°C (195°F) - Models 295 & 296 High Temp Model - Model 296 Ultra-High Temp Model 225°C (435°F) - Models 295 & 296	
For explosion proof models see:	<a href="http://www.maxmachinery.com/content/explosion-proof-installation-instructions">www.maxmachinery.com/content/explosion-proof-installation-instructions</a>	
Anti-dither Range	Software selectable from 1-100% of 1 revolution. 50% of a meter revolution - unidirectional - 2% bidirectional are typical default settings	
Signal Filtering	Software selectable from 1ms to 250ms time constant	

<sup>1</sup>Full step change is subject to signal damping

<sup>2</sup> Temperature of metered fluid will affect transmitter temperature, see graph on previous page



# Do's & Don'ts



## DO:

Install bypass plumbing around the flow meter. This is useful during start up for removing dirt and air from the plumbing or when measuring fluid that may freeze inside the line and need to be remelted before it can pass through the meter. It also allows removing the flow meter for service without disabling the system.

## DO:

Be very careful to keep parts clean during installation or teardown. A little dirt can look like a truckload compared to the 10 micron filtration requirement for series 210 Meters.

## DO:

Clean the filter on a regular basis.

## DON'T:

Run water or aqueous solutions not approved by Max through your flow meter because of internal galling.

## DON'T:

Steam clean the meter (bypass or remove the meter if necessary).

## DON'T:

Blow down the meter with compressed air or gas because it may over-speed and damage the meter.

## DON'T:

Remove the Transmitter from the flow meter body. The transmitter is phased to the meter and a measurement error will result. Re-calibration will be necessary; see the transmitter interface software manual.

## DON'T:

Disassemble the flow meter. These are precision devices which require special tools and techniques.

## DON'T:

Turn on the pump in a system filled with material that is solid at room temperature. Wait until the material is completely melted and use the flow meter bypass valve during start up.

## DON'T:

Apply excessive differential pressure across the flow meter as it will cause internal failure (see the pressure drop curves for safe area operation).

## DON'T:

Over pressurize the meter. Maximum pressure is either 1,000 PSI (70 bar) 3,000 PSI (210 bar) or 7250 PSI (500 bar) depending on model purchased.

## DON'T:

Exceed the maximum flow rates for the material viscosity.

## DON'T:

Allow materials which solidify in air to set up in the flow meter. These may be impossible to remove. If the meter needs to be removed for repair and cannot be completely cleaned. Plug the inlet and outlet ports at once.

# Installation



The following items and conditions should be considered:

**Line and Bypass Valves:** These valves allow filter cleaning or flow meter removal without completely shutting the system down and draining the lines. They also allow system start up under conditions which could damage the meter; such as: air in the lines, high temperature materials, or initial line surges.

**Filtration:** Clearances between the flow meter piston and cylinder wall are typically 0.0002" to 0.0004". Any dirt present in the system can jam or damage the unit. A 10 micron filter (such as a Max 381 Series stainless steel unit) is generally recommended, although materials with very high viscosities may require a coarser filter. For bidirectional flow applications, use a filter on each side of the flow meter. Materials with fibrous or non abrasive particulate matter may have to be run without filters. Follow the recommendation of your Max Sales Engineer or consult our Technical Service Department.

**Installation:** Use the "IN" port as the inlet for the predominant flow direction. Install the meter on the discharge side of the pump whenever possible. Excessive vibration at the meter should be avoided.

**Orientation:** The preferred orientation for the meter is dependant on the type of meter and is intended to optimize air purging and/or to minimize heat rising into the electronics. Standard piston meters with inline ports should be mounted with the transmitter either on the side or upside down. Ultra high pressure piston meters with offset inlet and outlet ports should be mounted with the transmitter on top. See diagrams on page 11.

**NPT fittings:** Always use either pipe sealant or pipe tape when installing fittings, but take great care to leave the first thread of the pipe exposed. This ensures that the tape or sealant will not accidentally fall inside the meter.

**SAE fittings:** Always lubricate the o-ring fitting when attaching to the meter.

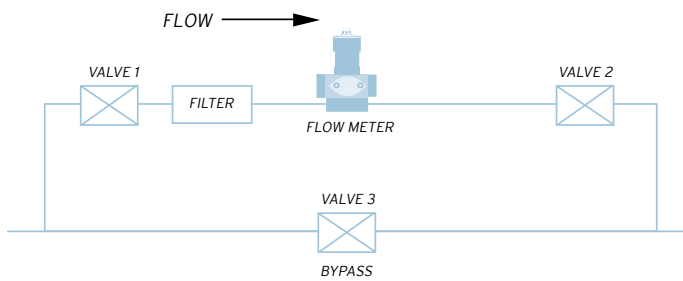
**Compression Fittings:** The P001 compression fittings are based on Swagelok style ferrules. Do not use other manufacturer's parts because the sealing angle may not be the same. Fitting kits contain detailed instructions and are shipped with every meter (spares are available: P001-2-040 for 6mm and P001-2-042 for 1/4 " tubing). Always select tubing grades that meet or exceed your system pressure requirements. If using flexible tubing, always install a tubing insert to provide the stiffness required for the compression ferrules to seal (such as Swagelok SS-405-2, SS-405-03 or SS-405-170). To reuse a tube fitting first mark the nut and meter and upon re-installing tighten enough to align the marks then tighten a quarter turn farther.

**High Temperatures:** Use the "Vertical Installation" drawing. This minimizes heat transfer by convection from the flow meter to the transmitter. The transmitter is the most heat sensitive element in the system and the transmitter manual should be consulted for specific limits. An optional fluid heater block can be used on the flow meter to keep it at operating temperature during standby conditions. For substances that are solid at room temperature, the block may be required to keep the material molten and flowing through the meter.

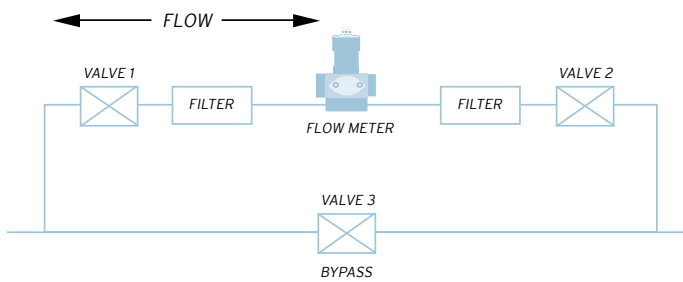
**Clean Plumbing:** Before installing the flow meter, clean the inside of the pipe line with compressed air or steam (especially when using new pipe). Don't use water, steam, or compressed air on the meter itself!

# Preferred Orientation

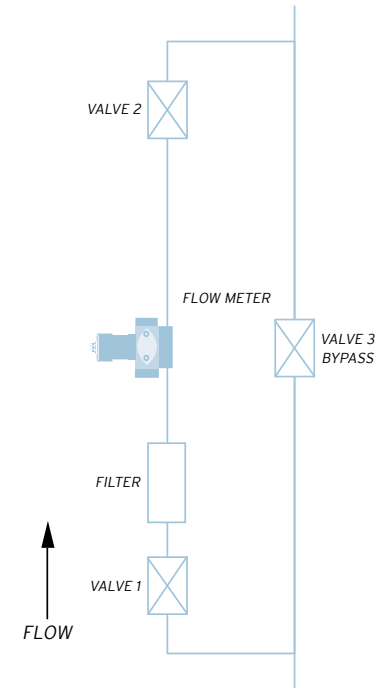
## Horizontal Installation



## Horizontal Two-Way Flow



## Vertical Installation \*



\* not appropriate for the  
Model P001 & P002

# Operation



Determine that the following parameters of your flow metering system are within the specifications for the specific meter being used:

- Maximum System Pressure (Specifications)
- Differential Pressure across meter (Pressure Drop Curves)
- Maximum Flow Rate (Pressure Drop Curves)
- Metered Fluid Temperature (Sales specification, transmitter specifications page 7)

If the metered fluid is greater than 80°F (28°C) over ambient, see the “High Temperature Start Up” section below.

With valves (#1) and (#2) closed, slowly open valve (#3) (bypass) to clear the lines of foreign particles and air. Slowly open the inlet valve (#1). Slowly open the outlet valve (#2). Completely close the bypass valve.

No routine maintenance, cleaning, or lubrication of the flow meter is required. A routine filter cleaning schedule should be established. The system should be shut down if abnormal noises occur or if unusual differential pressures across the meter are encountered.

High Temperature Start Up: For fluids above 150°F (82°C) based on 70°F ambient, a special procedure is required to prevent thermal shock and permanent damage to the flow meter. The warm up time is determined by the equation below:

$$\begin{aligned} \text{TIME (minutes)} &= \frac{\text{connector size (inches)} \times (\text{operating temperature (°F)} - 125)}{10} \\ &\text{– OR –} \\ \text{TIME (minutes)} &= \frac{\text{connector size (inches)} \times (\text{operating temperature (°C)} - 52)}{10} \end{aligned}$$

Valves (#1) and (#2) must be closed. Open the bypass valve (#3) in gradual steps until the bypass piping is stabilized at operating temperature. Open valve (#1) slightly and allow the temperature to stabilize around the flow meter. Valve (#1) can then be opened completely.

Open valve (#2) slightly. The flow meter may make unusual noises or bind at this point. Leave the valve at this setting until normal meter operation occurs, at which point valve (#2) can be gradually opened all the way. Slowly close the bypass valve (#3).

# Electrical Installation - Wiring

Removal note: The transmitter does not need to be removed from the flow meter for any field servicing or adjustments. Normally, the flow meter and transmitter are shipped back to the factory for calibration or service as a unit. If the transmitter needs to be removed from the flow meter for installation, be sure to retighten the transmitter snugly in order to ensure proper sensor alignment.

## Mechanical Installation

1. The transmitter is attached to the flow meter's threaded magnet shield. Hand tighten only. (~ 3 ft-lb)
2. The transmitter lid has four thread paths. To realign the cable, remove the lid and rotate up to 180° and retighten using an alternate starting point. Tighten to compress the O-ring seal.

## Removal

1. Remove electrical connections
2. Unscrew transmitter, using a wrench if necessary.



## WARNING

Installation and removal should only be facilitated by trained personnel  
Verify transmitter output type (ANALOG or FREQUENCY) before wiring, inappropriate wiring could result in damaging the circuit.

## Moisture Seal Protection

On all models, the housing is designed as a liquid and vapor-tight enclosure. There are O-ring seals at the lid and possibly also the base of the housing – these need to be fully seated. A properly sealed transmitter will prevent the formation of damaging moisture inside the housing.

Turck connector Model: The connector is sealed to the lid at the factory and is ready for use.

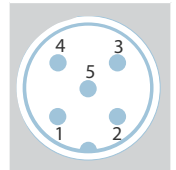
NPT Model: To ensure a moisture-tight seal, apply appropriate sealant to the threads at installation.

# Electrical Installation - Wiring

The electrical connector versions are pre-wired inside the transmitter and ready to accept a mating cable (available from the factory).

Frequency Single Phase†	Frequency 2 phase, Quadrature	Mating Cable Wire Color (Frequency)	Analog**	Mating Cable Wire Color (Abalog)	Turck Pin # (Male)
Case Ground	Case Ground	Blue	Case Ground	Blue	3
Common	Common	Black	Common	Black	4
Power 5-26 Vdc	Power 5-26 Vdc	Brown	Power *	Brown	1
Pulse Output	Output Phase A	White	Signal Output (-)**	White	2
N/A	Output Phase B	Grey	Signal Output (+)	Grey	5

Turck Connector (Female)

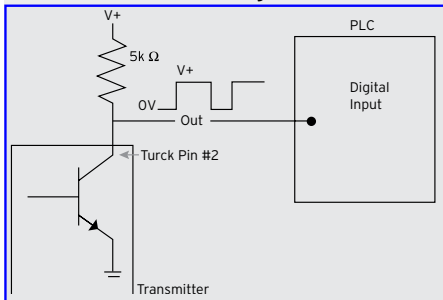


*Note:* There are no selections or adjustments to be made on the circuit board. The only method of altering the setup parameters is through the Serial Interface Program.

\* Analog output versions ending with A/1 or C/1, 24Vdc, ending with B/1 or D/1, 12Vdc; Analog output versions 29X-XXX-000, 24Vdc, 29X-XXX-100, 12Vdc

\*\* To minimize noise analog output transmitters are fully isolated. If your system does not ground the negative signal input you should install a 10k pulldown resistor between Common and Signal Output (-). This will avoid the risk of ground shifts driving the signal out of range.

## Current Sinking Wiring - Models 29X-6XX-XXX or versions ending with S/1



*Note:* 1. A current sinking device produces an output pulse which is the opposite of a sourcing device. A positive DC voltage must be applied to the wire running between pulse output and your PLC. When the output is triggered, this voltage will be grounded to zero volts. 2. Use a 5k ohm resistor to limit current if your system does not have other means to limit the current into the transmitter.

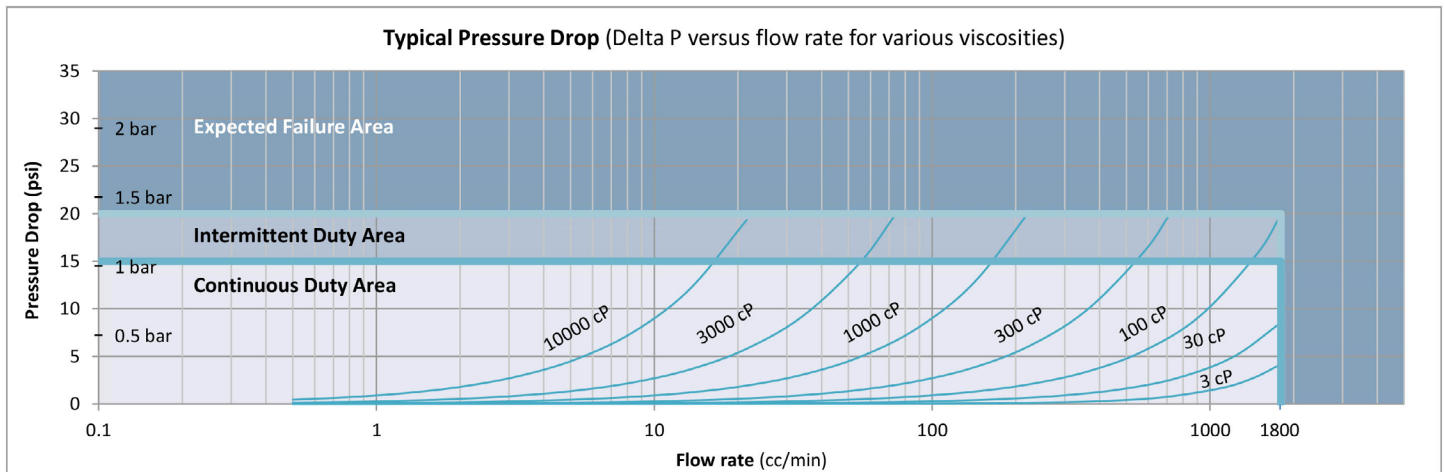
# Troubleshooting



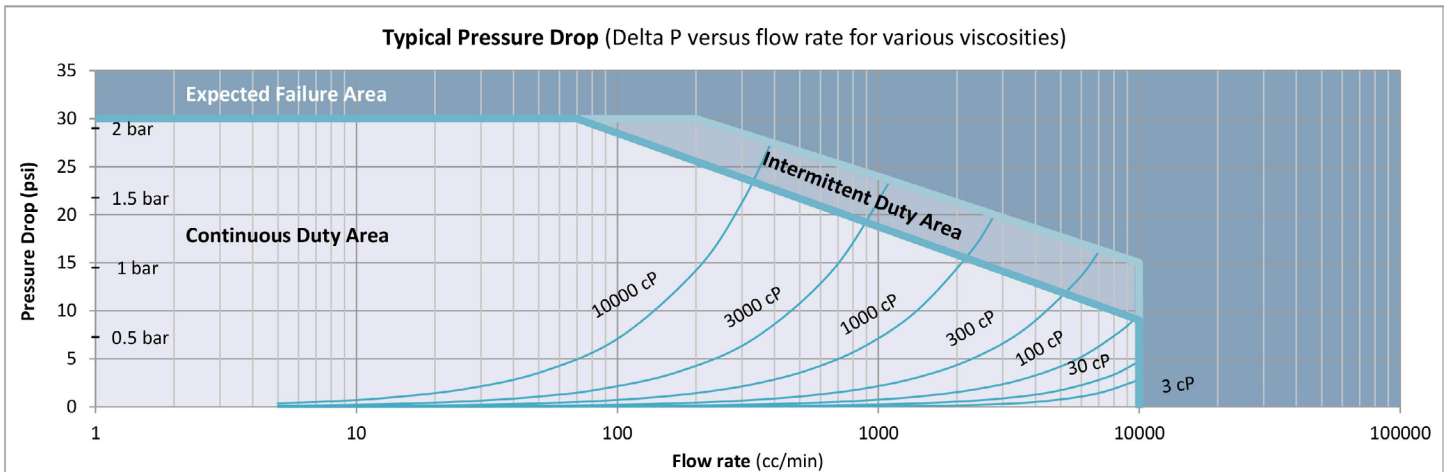
Trouble	Corrective Action
<b>No Flow through meter or high pressure drop across meter</b>	
Solidified material blocking rotation	Heat meter to melt material
Debris blocking rotation	Remove plumbing base, inspect crankshaft and piston rods for damage. If intact flush the inside of the meter and try to work pistons free by rocking the crankshaft back and forth gently with a small rod or retracted pen
Meter broken	If you find damaged parts in the meter, return the meter to the factory for repair
<b>Fluid is passing through the meter, but there is no indication of flow</b>	
Improper hook-up of transmitter	Verify that DC power is present at the PCA. Use a multi-meter to measure the transmitter output independent of the display or PLC
Meter not turning	Remove transmitter from meter and place a paper clip against the magnet shield. Clip should be drawn to magnet inside of the meter and move with the meter's rotation
<b>Indicated flow does not agree with expected readings</b>	
Air in the line	Air bubbles displace the meter just as a liquid would. If you are over-reporting, verify that there is no air in the lines.
Indicator not calibrated properly	Verify the K-Factor for the meter in use and compare this value to the setting used in the display.
Excessive reverse flow in system	Max transmitters have anti-dither functions which can buffer up to 1 revolution of reverse flow. An incorrect flow total can be reported if the pumping causes a flow and ebb of greater than 1 meter revolution.

# Pressure Drop Graphs

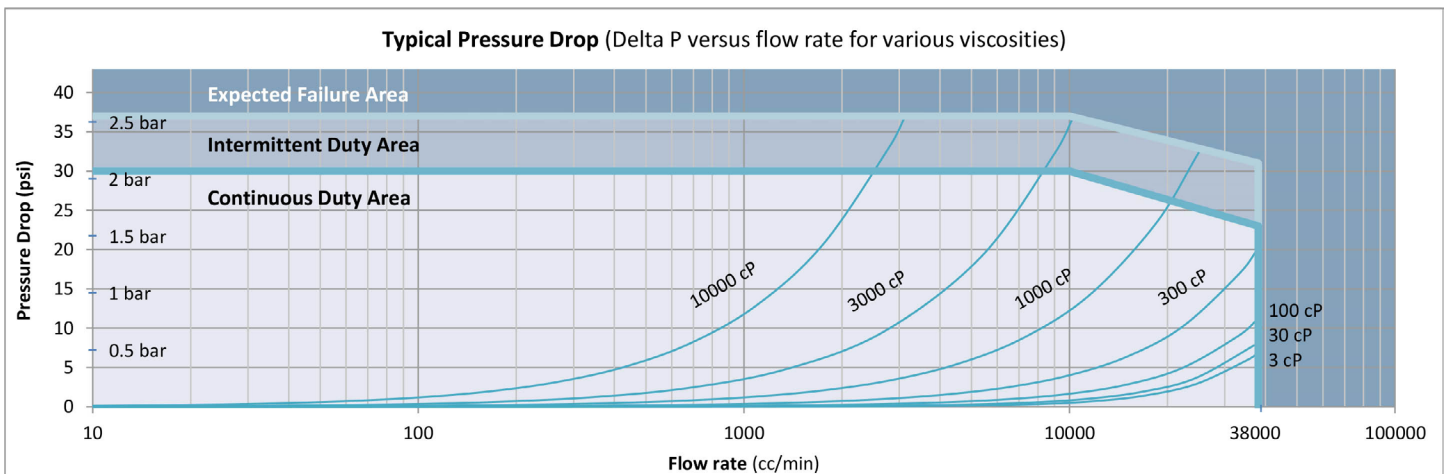
## Model 213



## Model 214



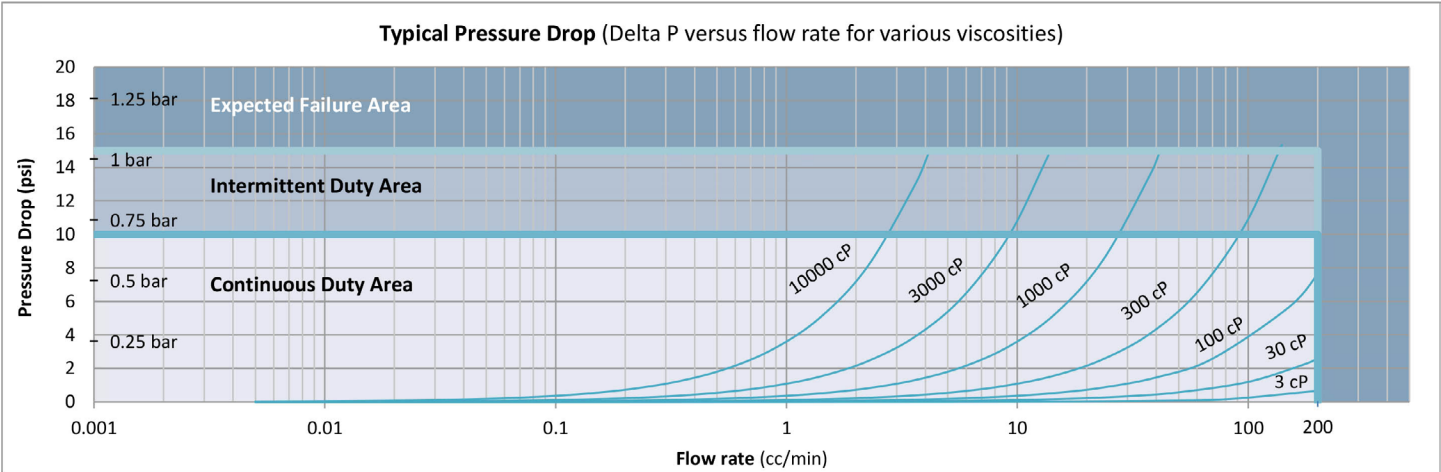
## Model 215



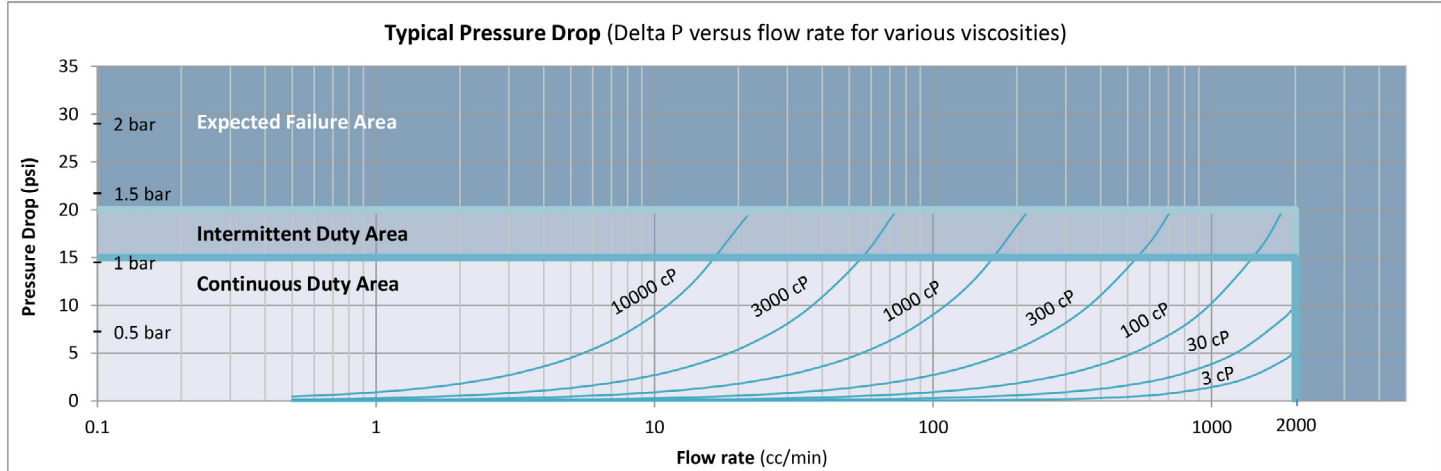


# Pressure Drop Graphs

## Model P001



## Model P002



# Contact for Repairs & Calibration Services



Your Max 210 Series Meter should be repaired at the factory or under the direct supervision of the Max Technical Service Department. Unauthorized repair work may damage the meter and will void the product warranty. Please make note of model and serial numbers on the flow meter before calling the factory. A return goods authorization number (RMA) will be issued if the flow meter has to be sent back for repair.

Max Machinery, Inc.  
33A Healdsburg Ave  
Healdsburg, CA 95448

Phone: 707-433-2662  
Fax: 707-433-1818  
[www.maxmachinery.com](http://www.maxmachinery.com)

## Limited Warranty

The Seller warrants all equipment manufactured by it to be free from defects in materials and workmanship in normal service for a period of twelve (12) months from the date of shipment. When given prompt notice by the Purchaser, the Seller shall, in complete fulfillment of its liabilities under this warranty, correct by repair or replacement any such defect without charge F.O.B. the Seller's factory, with the following stipulations:

1. Product is not to be returned to Seller without first obtaining a product-evaluation quote number from our Customer Service Department at (707) 433-2662.
2. Seller assumes no liability for charges incurred for repairing, removal or replacement, or for repairs made outside of its factory.
3. Seller reserves the right to inspect products claimed defective under warranty and is the final authority on the validity of the warranty claim. (Actions that void the warranty include, but are not limited to, disassembly of the meter, failure to install recommended filtration or passing incompatible liquids through the meter.)

IT IS EXPRESSLY AGREED THAT THIS WARRANTY OR ANY OTHER WARRANTY STATED OR REFERRED TO ON THE SALES ORDER DOCUMENT IS EXCLUSIVE AND IN LIEU OF ANY OTHER WARRANTY OF MERCHANTABILITY, FITNESS OF PURPOSE, OR ANY OTHER WARRANTY OF QUALITY, EXPRESS OR IMPLIED.