



MODEL 401 MODEL U401 MODEL U801 Liquid Flo-Controllers

Installation Manual & Operating Instructions



READ THIS MANUAL COMPLETELY <u>BEFORE</u> ATTEMPTING TO CONNECT OR OPERATE YOUR FLO-CONTROLLER. FAILURE TO DO SO MAY RESULT IN INJURY TO YOU OR DAMAGE TO THE FLO-CONTROLLER.

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A. Introduction

1. Unpacking the Flo-Controller

The Flo-Controller was packed by McMillan in such a way that you should receive it with no damage. If external damage is noted upon receipt of the package, please contact *the shipping company* immediately. McMillan Company is not liable for damage to the device once it has left the manufacturing premises.

After external inspection of the package, proceed to open the package from the top, taking care not to cut too deeply into the package. Remove all documentation. Inspect all products for concealed shipping damage. If any damage is noted, please contact the shipping company and/or McMillan Company to resolve the problem.

While unpacking the products from the shipping container, please take extra care to remove all enclosed devices and documentation. Check thoroughly for cables, adapters, and other options listed on the packing slip.



2. Caution

Take care not to *drop* your Flo-Controller. Read the installation section before providing power or tubing connections to the unit. Any damage caused by improper installation or careless handling will not be repaired under warranty (see limited warranty on page 30 for more details).

Model U801 ONLY: Note that your Model U801 Flo-Controller has been assembled, tested, and sealed under cleanroom conditions. To maintain that clean condition, only open under cleanroom conditions and with appropriate equipment.

3. Product Overview and Principle of Operation

The Model 401, U401, and U801 Liquid Flo-Controllers provide precision flow rate control for many low viscosity liquids. Flow is maintained automatically regardless of small pressure changes. This has many benefits including a reduction in process costs, reduced maintenance and improved consistency.

McMillan Flo-Controllers combine smart electronics with a precision control valve and flow sensor. The output from the flow sensor is analyzed and compared to the flow rate set point. The control valve is then automatically adjusted to achieve the required flow. The flow rate set-point may be input manually by the user or supplied by an external electrical source. The logic used by the Flo-Controller is illustrated in the diagram below.



Flow control can be suspended by activating the "Standby" function. This overrides control functions and freezes the valve position. Control functions resume when "Standby" is disengaged. On some models "Standby" is automatically engaged when the set-point drops below 5% of full scale. Use of the "Standby" function when control is not needed improves performance and valve life.



McMillan Flo-Controllers can be easily installed in most systems. As a stand alone unit the Flo-Controller only needs a 24VDC power supply to function. For the most advanced systems there are many features that can be integrated into the process control system to provide optimum control and monitoring.

It is also possible to use several Flo-Controllers together for precise mixing of liquids. Improved yields and consistency result when blending and dispensing are monitored and controlled.

4. What is the difference between the 401, U401, and U801?

- 401 This product is primarily designed for control of industrial fluids. The 401 usually features a stepper-motor-controlled valve to regulate flow rate.
- U401 This product designation only applies to customers who purchased a Model 401, then desired to have it upgraded to the diaphragm valve (see Model U801 below). This upgrade is recommended for customers who plan to use their Model 401 for abrasive applications.
- U801 This product is specifically designed for ultra-high-purity (UHP) applications. It features an advanced steppermotor-controlled diaphragm valve for reliable performance with abrasive media, including CMP slurry. It is also suitable for concentrated acids and alkalis, solvents or other UHP fluids.



5. Non-Standard Versions of Flo-Controllers (Z Suffixes)

Please note that the installation instructions, operating instructions, and specifications included within this manual apply to standard production model Flo-Controllers only. For certain applications, customized options and/or specifications may be configured. If your Flo-Controller has a "Z" suffix (i.e. U801-5-J-F6-C10-P20-*Z908*) then your Flo-Controller is non-standard. Contact the factory to verify whether or not the installation, operation, or specifications of your Flo-Controller are different than outlined within this manual.

Units without a Z suffix should be installed and operated as instructed within.

B. Installation

1. Tubing Connections

The Flo-Controller provides male flare connections. Flare nuts are required to facilitate installation. These may be ordered as options from McMillan or provided by the customer.

The inlet and outlet of the flow controller are clearly marked next to the appropriate connection. These connections are either $\frac{1}{4}$, $\frac{3}{8}$, or $\frac{1}{2}$ " depending on flow range (see specifications for size). Flare connections are designed to mate to standard Entegris[®] Fluoroware PFA flare fittings.

For best results, keep inlet and outlet pressure fluctuations to a minimum.

The outlet tubing should be elevated above the outlet port to allow any air that may accumulate inside the valve to escape. For this reason, the flow connections should never be pointed down, but either level or at an upward angle from the ground.



Flo-Controller mounting orientation

As long as the outlet tubing is elevated, the Flo-Controller can be mounted in horizontal or vertical orientation. Straight lengths of tubing are not required before or after the Flo-Controller.

Care should be taken to eliminate as much air from the system as possible before installation. Once the unit is connected in the flow path, air should be removed from the controller by alternately blocking and releasing the outlet (to build pressure in the lines and then release it). It may be possible to either pinch or kink the outlet tubing for 5 seconds, then release for 5 seconds, and so on until no more air bubbles are released from the unit.

The maximum system pressure the Flo-Controller can safely handle is 80 psig. Any pressure higher than 80 psig could result in leakage and injury to the operator. For best performance, keep gauge pressure below 60 psig.

For best results, keep the differential pressure within the recommended range (see chart below). Differential pressure can be determined by measuring the upstream pressure and subtracting the downstream pressure. To reduce differential pressure, apply a flow restriction downstream from the controller.

To increase differential pressure, increase the supply pressure or reduce flow rate.

Operating the Flo-Controller at differential pressures higher than recommended may result in degraded performance, including possible valve oscillation. Differential pressures below recommended range will result in inability to reach higher flow rates.

Model	Suffix	<i>Recommended Diff. Pressure at 100% rated flow</i> ^{1F}
401	n/a	15-35 psid ^{2F}
U401	n/a	15-35 psid ^{3F}
	P5	5-10 psid
	P10	10-20 psid
U801	P20	20-40 psid
	P25	25-50 psid
	P40	40-60 psid

1F. See information below for minimum required differential pressure at flow rates below 100% of rated flow.

2F. unless otherwise indicated on calibration data sheet

3F. unless otherwise indicated on valve module label (near cable port)

Required differential pressure decreases exponentially with decrease in flow rate. To calculate minimum required differential pressure at a certain flow rate, use the formula:

$DP = (YourFlow \div MaxFlow)^2 x MinDP$

where:

- DP = minimum required differential pressure at YourFlow
- YourFlow = flow rate (in mLpm or Lpm) where you wish to calculate DP
- MaxFlow = 100% rated flow rate for your Flo-Controller (in same units at YourFlow)
- MinDP = Minimum differential pressure required at 100% rated flow (see chart above) in psid

For example: You have a Flo-Controller with a 100-**1000** mLpm range. The recommended differential pressure, according to the chart above, is **15**-35 psid. You wish to calculate the minimum pressure drop at **200** mLpm. Your formula would be:

DP = $(200 \div 1000)^2 \times 15$ or DP = 0.6 psid @ 200 mLpm

All Flo-Controllers follow this graph for minimum pressure drop (minimum differential pressure required) vs. flow:



Differential pressure, or pressure drop, in a system is cumulative. For instance, consider this system:



Though it starts with 30 psig of supply pressure, other components (minus the Flo-Controller) total 30 psid – leaving no pressure for the Flo-Controller. Either the supply pressure would have to be increased, and/or a source of pressure drop (such as the post-pump filter) would have to be eliminated:



2. Electrical Connections

CAUTION: Miswiring the Flo-Controller may cause damage to the unit that can only be serviced at the factory. Please read instructions carefully! Applying AC voltage (115VAC or 230VAC) to the Flo-Controller will cause damage! Applying DC voltage (24VDC) to pin 6 or 7 may cause damage!

The Flo-Controller requires 24VDC (1.0 A max) power. Please consider this current requirement when selecting wire gauge and power supply type. A 2 amp power supply will provide best results. Power supply should be well-regulated with low noise and dedicated to Flo-Controller if possible. Power supply should not simultaneously be powering heavy loads for other applications.

The Flo-Controller consists of two modules: the Valve Module and the Control Module. The two are connected through a 15-pin connector. The female receptacle is located on the side of the Control Module; the male plug is located at the end of the cable coming out of the Valve Module. Before power is applied, the plug should be inserted into the receptacle and the locking screws tightened to secure the connection.



Control module connected to cable plug

To connect wires to the pluggable terminal strip on the control module, remove the terminal strip connector by lifting up (towards display) and pulling out. Strip each connecting wire 0.125" and tin the exposed copper. Insert the wire into the appropriate slot and tighten the screw using a 1/8" flat screwdriver. Pull on the wire to ensure a tight, secure connection.

Plug removed



Plug inserted



When wiring is complete, reinsert terminal strip connector into receptacle. Make sure it snaps and locks into place.

NOTE: Do not remove or insert the terminal strip connector when power is applied. Doing so may damage the Flo-Controller.

Connections will depend on signal configuration type (set at factory, not fieldselectable). For Model 401, see calibration sheet for signal I/O type. For Models U401 and U801, see label on back of valve module (where cable comes out).



Valve Module Back Panel on U401 & U801



Pin #	Description	Notes		
1	Setpoint Output	For reference only (1-5 VDC)		
2	Setpoint Common	Use as common for pin #1 signal		
3	External Setpoint Common	Use as common for pin #4 signal		
4	External Setpoint Input	For remote control (4-20 mA)		
5	Flow Output Loop Return	Use as loop return for pin #6 signal		
6 Flow Rate Output		Monitor Flow Rate (4-20 mA)		
7	Error Output	Factory Use Only		
8	Standby Input	Connect 24VDC to enable standby [#]		
9 +24VDC Power		Connect +24VDC Power		
10	+24 VDC Power	Extra, no connection required		
11	Power Common	Connect 24VDC Power Ground		
12	Power Common	Extra, no connection required		

For units with suffix "RS", standby mode will be enabled unless 24VDC is connected to pin # 8.



Pin #	Description	Notes		
1	Setpoint Output	For reference only (0-5 VDC)		
2	Setpoint Common	Use as common for pin #1 signal		
3	Signal Common	Use as common for pin #4 signal		
4	External Setpoint Input	For remote control (0-5 VDC)		
5 Not Used		Jumper to Pin #6		
6 Flow Rate Output		Monitor Flow Rate (0-5 VDC)		
7	Error Output	Factory Use Only		
8	Standby Input	Connect 24VDC to enable standby [#]		
9	+24VDC Power	Connect +24VDC Power		
10	+24 VDC Power	Extra, no connection required		
11	Power Common	Connect 24VDC Power Ground		
12	Power Common	Extra, no connection required		

For units with suffix "RS", standby mode will be enabled unless 24VDC is connected to pin # 8.



Pin #	Description	Notes		
1	Setpoint Output	For reference only (0-10 VDC)		
2	Setpoint Common	Use as common for pin #1 signal		
3	Signal Common	Use as common for pin #4 signal		
4	External Setpoint Input	For remote control (0-10 VDC)		
5	Not Used	Jumper to Pin #6		
6 Flow Rate Output		Monitor Flow Rate (0-10 VDC)		
7 Error Output		Factory Use Only		
8	Standby Input	Connect 24VDC to enable standby [#]		
9 +24VDC Power		Connect +24VDC Power		
10	+24 VDC Power	Extra, no connection required		
11	Power Common	Connect 24VDC Power Ground		
12	Power Common	Extra, no connection required		

For units with suffix "RS", standby mode will be enabled unless 24VDC is connected to pin # 8.

PINS 1 & 2 (SET POINT MONITORING)

Use pins 1 & 2 for connection to an external high-impedance volt meter to monitor the current setpoint (for 4-20 mA units, 1 VDC equals zero flow and 5 VDC equals 100% rated flow; for 0-5VDC output unit, 0 VDC equals zero flow and 5 VDC equals 100% rated flow; for 0-10 VDC output unit, 0 VDC equals zero flow and 10 VDC equals 100% rated flow).

PIN 3 (SIGNAL COMMON)

For 4-20 mA units, use as common for external setpoint input (pin #4). For 0-5 and 0-10 VDC units, use as common for both external setpoint input and flow rate output (pins #4 and #6).

PIN 4 (EXTERNAL SETPOINT INPUT)

Use pins 3 & 4 in conjunction with the appropriate DIP switches (see the Operation section) to disable the internal setpoint and provide an external setpoint for remote control of flow rate.

PIN 5

For 4-20 mA units only, this is the flow rate output loop return. For 0-5VDC and 0-10VDC units, this pin should be jumpered to pin #6.

PIN 6 (FLOW RATE OUTPUT)

Use pin 6 to monitor the realtime flow rate passing through the controller. On 4-20 mA units, 4 mA represents zero flow; 20 mA represents 100% rated flow. On 0-5 VDC units, 0 VDC represents zero flow and 5 VDC represents 100% rated flow. On 0-10 VDC units, 0 VDC represents zero flow and 10 VDC represents 100% rated flow. See Section G for a quick reference chart showing flow vs. output.

NOTE: On 4-20 mA units, pins 5 & 6 must be connected together; if not in use, then they should be jumpered (as shipped by the factory). The signal loop should not exceed 500 ohms in resistance.

Do not connect this output through a resistor to ground. This will alter the calibration of the unit.

PIN 7 (FACTORY USE ONLY)

Factory use only.

PIN 8 (STANDBY INPUT)

Applying 24VDC (from the same source as pin # 9) will enable standby mode, disabling control functions.

On Flo-Controllers with suffix "RS" (reverse standby), applying 24VDC (from the same source as pin # 9) will disable standby mode, enabling control functions. Unit will remain in standby until signal is applied.

U801 models may feature an "Auto Standby" function. If the label on the back of the valve module (where the cable comes out) indicates "AS" in the bottom right hand corner, your unit has this feature. Units with Auto Standby will engage Standby mode when setpoint falls below 5% of full scale. Standby will be disengaged when the setpoint rises above that point. Pin #8 may still be used to enable/disable Standby if 24 VDC is applied.

Note that DIP Switch 6 must be OFF for Auto Standby (AS) to function.



Auto Standby marking on bottom right corner of Valve Module back panel

For units without Auto Standby, the use of the Standby feature is highly recommended. Better performance and longer life will result with proper use of the Standby function. See section C.2 for more details on Standby.

PINS 9 & 10

Connect your 24 VDC positive power source here. Internally, both pins are connected to each other, so it is not necessary to wire both pins unless your wiring configuration requires it.

PINS 11 & 12

Connect your 24 VDC common here. Internally, both pins are connected to each other, so it is not necessary to wire both pins unless your wiring configuration requires it.

Error relay option



If your control module has an additional 3-pin fixed terminal strip on the side next to the main 12-pin terminal strip, your Flo-Controller also includes a SPDT relay that is activated when an error is detected. See Section C.3 for more information on Error Mode.

Three pins are provided: NO, C, and NC. NO stands for normally open; C stands for common; NC stands for normally closed. When error mode is activated, the NO pin and C pin are connected. When normal operation resumes, those pins are disconnected and the NC and C pins are connected.

3. Mounting the Flo-Controller Valve Module

See section B.1 above for orientation considerations.

Recommended hardware (not provided):

#8 bolt (at least $\frac{3}{4}$ " long to pass through $\frac{1}{2}$ " deep hole in Flo-Controller) #8 washer (no more than 0.38" outer diameter for clearance)

Recommended Hardware



Mounting the unit (see dimension drawings in Section E for panel drilling):

Mounting Holes on Flo-Controller Valve Module



The Valve Module of the Flo-Controller may be lightly sprayed or quickly rinsed, but should not be submerged.

Two ports are provided for venting: one on the front of the Valve Module, where the fluid connections are, and the other on the rear where the cable comes out.

These 1/8" barb connections can be used to flow clean, dry air or nitrogen purge gas through the Flo-Controller. This is recommended if the fluids passing through the Flo-Controller or within the same fluid cabinet as the Flo-Controller are corrosive or hazardous. Some cooling will also result. 1-2 Lpm of gas is sufficient for venting.

This purge gas may enhance reliability. If purge gas is not required and ports are not in use, they should be capped.

No liquid should be allowed to pass into unit through vent holes.

Vent ports on Flo-Controller



4. Mounting the Flo-Controller Control Module

The control module should be mounted in a dry, moisture free location. A DIN-rail clip is provided on the control module for easy mounting.



Control Module clipped onto DIN rail

If a DIN-rail is not available, Velcro may be attached to the back side of the control module (opposite the display) for easy removal if necessary.

NOTE: Do not DRILL any holes into the control module. It houses sensitive electronics that will be damaged if any holes are created. Do not apply excessive force to mounting DIN-rail clip.

C. Operation

1. Setting the DIP switches

The control module features 6 SPST DIP Switches for configuration of the controller.

Switch	Description	Notes		
1	Display Setpoint	Display setpoint in mA/VDC*		
2	Display Output	Display actual flowrate in mA/VDC*		
3 Factory configured		Leave in factory setting (OFF)		
4	Use Internal Setpoint	Controller utilizes internal setpoint		
5	Use External Setpoint	Controller utilizes external setpoint		
6	Auto Standby Override	Enable/Disable Auto Standby [#]		

* Units configured for voltage will display in VDC; units configured for current will display in mA..

[#] For units without Auto Standby, switch #6 will place the unit in Standby.

DIP switches as configured at factory



SWITCH 1

When switch #1 is ON and switch # 2 is OFF, the display on the control module will show the current setpoint, whether internal or external.

SWITCH 2

When switch #2 is ON and switch #1 is OFF, the display on the control module will show the realtime, current flow rate passing through the controller.

SWITCH 3

This switch is factory set to OFF, and should not be turned ON unless directed by the factory.

SWITCH 4

With switch #4 ON and switch #5 OFF, the controller will operate using the internal setpoint (see adjusting the internal setpoint below).

SWITCH 5

With switch #5 ON and switch #4 OFF, the controller will operate using the external setpoint signal provided to pins 3 & 4 (see Electrical connections in the Installation section).

SWITCH 6

For units with Auto Standby (AS, see section C.2), turning switch #6 ON will disable Auto Standby.

For units without Auto Standby, turning switch #6 ON will enable standby mode and override any signal to pin #8. For units without Auto Standby and with the "RS" suffix, turning switch #6 OFF will enable standby mode and override any signal on pin #8.

2. Normal vs. Standby Mode

When the unit is in Normal mode, it operates as a standard flow controller, comparing the setpoint to actual flow and acting accordingly. All control functions are enabled.

When the unit is in Standby mode, all control functions are disabled. Setpoints are ignored, and only flow output signals are provided. The unit freezes the valve in its current position and does not resume control until the standby signal is removed. Error mode is disabled in Standby mode.

Standby mode should be used any time the control function is not required to extend the life of the controller and speed recovery times. Since the valve is frozen, less valve movement will be required to restore flow control. Standby mode also consumes very low power (<0.15 A).

U801 models may feature an "Auto Standby" function. If the label on the back of the valve module (where the cable comes out) indicates "AS" in the bottom right hand corner, your unit has this feature. Units with Auto Standby will engage Standby mode when the external setpoint is enabled and falls below 5% of full scale. Standby will be disengaged when the setpoint rises above that point.



Auto Standby marking on bottom right corner of Valve Module back panel

For units without Auto Standby, the use of the Standby feature is highly recommended. Better performance and longer life will result with proper use of the Standby function.

3. Error Mode

The Flo-Controller features an error mode which will disable motor function when the Flo-Controller is unable to reach the setpoint due to:

If the unit is in error mode (amber), the flow controller has determined that it cannot achieve the setpoint. Possible causes are:

- The pressure is too low, and even with the valve fully open the requested flow rate cannot be achieved.
- The unit has been wired incorrectly.
- The lines may be clogged or blocked make sure that the flow is not restricted.
- Make sure all fittings are tight and no leaking is occurring.
- Doublecheck all cables are tight and secure.
- Setpoint below controllable flow range (i.e. <10% of rated flow)
- Power supply is not providing adequate current/voltage
- Flo-Controller failure

When the condition is corrected, the Flo-Controller will immediately resume normal operation. No user reset is required.

Error mode is indicated by an amber status LED (see section 4 below). Pin #7 also can be used to detect error conditions. This pin provides a signal based on the status of the unit (Normal or Error). Special external circuitry is required to use this feature – consult the factory for details.

If your control module has an additional fixed 3-pin terminal strip on the side next to the main 12-pin terminal strip, your Flo-Controller also includes a SPDT relay that is activated when an error is detected. See illustration on page 17 for pin diagram.

Three pins are provided: NO, C, and NC. NO stands for normally open; C stands for common; NC stands for normally closed. When error mode is activated, the NO pin and C pin are connected. When normal operation resumes, those pins are disconnected and the NC and C pins are connected.

4. Using the LED indicators

LED indicators are provided on the control module for visual confirmation of status and operating mode.



Top of Control Module

STATUS LED

When GREEN, unit is operating normally & controlling properly. When AMBER, an error has been detected (see section 3 above for information on errors). When standby mode is enabled, this LED should be disregarded.

STANDBY LED

When RED, unit is in standby mode and will not control. When OFF, unit is performing control functions.

5. Adjusting the internal setpoint

If DIP switch #4 is ON and switch #5 is OFF, the internal setpoint is selected. In this mode, external setpoint input is disabled.

Model 401 CONTROL MODULE STATUS STANDBY GM STANDBY CONNECT TO MODEL 401 S/N 01046

Adjustment of internal setpoint

To adjust the internal setpoint, use a small, flat-bladed screwdriver to turn the potentiometer located on the side of the control module (labeled Set Point). You can monitor the setpoint either with a digital voltmeter (connected to pins 1 & 2) or by turning DIP switch #1 ON and switch #2 OFF and monitoring setpoint on the control module display.

6. Calibrating for liquids other than water

All Flo-Controllers come precalibrated from the factory for deionized water.

If you will be measuring a fluid other than deionized water, to obtain maximum accuracy you must determine the calibration difference when flowing that fluid. Most liquids will require minimal, if any, compensation.

The unit should be set to control flow at 100% rated flow. Once the flow rate has stabilized, use a primary standard (i.e., accumulation over time with stopwatch and graduated cylinder, or total weight over time with stopwatch and weight scale) to establish error. Repeat test at 20% of rated flow. Using

these two values, calculate the error of the unit across the full scale and adjust your setpoints accordingly.

Please note that no adjustments should be made to the Flo-Controller itself. Rather, if you require 200 mLpm of flow, and the Flo-Controller reads 198 mLpm at 200 mLpm of actual flow, adjust your setpoint to 198 mLpm to achieve 200 mLpm.

Recalibration of the Flo-Controller itself is not recommended. Doing so will void the warranty and may cause linearity problems and other issues.

D. Specifications

Accuracy, including Linearity & Hysteresis

±1.0% Full Scale* (±2.0% Full Scale for Model 401 only)

Repeatability

 $\pm 0.20\%$ Full Scale* (based on data accumulated over thousands of cycles)

Power Requirements

24 VDC \pm 1.0 VDC; 1.0 A peak, 250 mA typical. See notes on page 9.

Pressure Rating

Over pressure limit is 80 psig (5.4 bar). Recommended maximum pressure is 60 psig (4.08 bar)

Temperature Rating

Standard fluid temperature range (internal): 10 to 60°C ** Option Code "HT" fluid temperature range (internal): 0 to 90°C ** Ambient environment range (external): 0 to 50°C Storage range: -10 to 70°C

Materials of Construction

Wetted parts - PTFE, sapphire, Kal-Rez[®] Exterior surfaces - PTFE, polypropylene, PVC, FEP-jacketed cable, PVDF, Viton[®]

*Full Scale is from 10% to 100% of rated flow (except range 3, which is 15 to 100%). Linearity is best fit straight line. All calibrations performed with deionized water.

**Temperature affects fluid viscosity, and changes in viscosity will have effect on full scale output. Zero is unaffected by temperature.

Recommended Filtration

25 microns or less

Compatible Fluids

Most liquids compatible with wetted materials. Entrained gas should be kept to a minimum. Contact the factory for calibration information on fluids with high viscosities.

Input/Output

Code "B" (0-5VDC)

Analog voltage input/output, 0-5 VDC. Voltage level is proportional to flow rate (zero VDC is zero flow). Input load approximately 2.4 Kohms; output load should be at least 2.5 Kohms.

Code "C" (4-20 mA)

Analog current input/output, 4-20 mA. Current level is proportional to flow rate (4 mA is zero flow). Input load loop is 250 ohms; output current loop should not exceed 500 ohms.

Code "J" (0-10 VDC)

Analog voltage input/output, 0-10 VDC. Voltage level is proportional to flow rate (zero VDC is zero flow). Input load is approximately 2.4 Kohms; output load should be at least 5 Kohms.

Optional Relay Error Output "R"

This provides three-wire connections to a relay - common, normally closed, and normally open. The relay is activated when the controller cannot maintain the desired flow rate. Current load should not exceed 500 mA @ 24 V.

All units also provide internal setpoint selection, which overrides external setpoint input and allows user to adjust setpoint using provided internal potentiometer.

Reliability

Testing shows no valve performance degradation with over 1 million full cycles on deionized water at room temperature. At a typical rate of 0.5 million cycles per year, units in similar installations should perform well for at least two years before service. Longer valve life will be experienced in many applications. Reliability tests are ongoing. Microturbine flow sensor life is over 50,000 hours MTBF (tests ongoing).

Flow Connections

Entegris[®] / Fluoroware-type PTFE male flare connections on all units. If PVDF flare nuts are required, add option code "FN". For alternative nut materials, or to specify other connection types, please contact the factory.

Electrical Connections

Connections between valve unit and control module

FEP-jacketed shielded cable, terminated with 15-pin connector. Length determined by part number - contact factory for custom cable lengths.

Connections to control module (all power and signal connections)

12-pin removable connector plug. Connector plug features screw-type terminals that accept wires up to 18 gauge.

Connections to error relay output on control module (if so equipped)

3-pin fixed terminal strip. Screw-type terminals that accept wires up to 18 gauge.

Standby Mode

Standby mode inhibits the valve function upon command. Flow sensor output continues, but all controller functions (including error output and control functions) are disabled. Standby mode may be activated externally by a 24VDC signal applied to pin #8, or will automatically be enabled when the external setpoint falls below 5% of full scale (on units with Auto Standby).

Packaging

U801 Model provides final packaging performed in Class 100 environment. All U801 units double-bagged before shipment.

E. Maintenance

1. Calibration

McMillan Flo-Controllers do not require calibrations at any specific intervals – the calibration should remain very consistent over time.

The microturbine wheel technology does not require any periodic adjustment, such as re-zeroing. No routine maintenance is required.

2. Cleaning and flushing the Flo-Controller

NOTE: It is very important to never flow large amounts of any gas, such as nitrogen or air, through the Flo-Controller! Doing so, even for short periods of time, may damage the Flo-Controller!

If a system requires periodic air or nitrogen flushes, the Flo-Controller must be bypassed during such flushes. In many cases, a 3-way valve may be used to bypass the Flo-Controller without disconnecting lines in the system.

Any fluid with a tendency to harden, coagulate, or precipitate should never be allowed to settle in the Flo-Controller for extended periods of time. All such fluids, such as CMP slurries, should be flushed as soon as possible.

If you wish to clean the Flo-Controller, run hot deionized water (temperature within operating specifications of the Controller) or a mild solvent (compatible with the wetted materials) through the Flo-Controller. The Flo-Controller will not be damaged if flow is run backwards through the unit. All flush flow rates should not exceed the maximum recommended flow rate of the unit.

3. Service

Since the Flo-Controller integrates a valve to control flow rate, the life of the unit is finite. The life of the valve is comparable to industry-standard valves commonplace in many applications. When the unit no longer performs within required specifications, it may be returned to the factory for refurbishing. Contact the McMillan Service Department for more details.

F. Dimensions

VALVE MODULE





G. Limited Warranty

DURATION OF LIMITED WARRANTY, MATERIALS & WORKMANSHIP

R.D. McMillan Co., Inc., hereinafter referred to as "McMillan", warrants these products and their associated standard accessories manufactured by McMillan and supplied hereunder, to be free from defects in materials and workmanship for a period of twelve (12) months from the date of shipment to the customer when installed, serviced and operated in its recommended environment. This warranty is not affected in any part by McMillan providing technical support or advice.

Replacement parts are warranted to be free from defects in material or workmanship for ninety (90) days or for the remainder of the Limited Warranty period of the McMillan product in which they are installed, whichever is longer. Parts not installed by factory authorized service centers may void the warranty.

PRODUCT RETURNS

GENERAL POLICY:

Any product or parts determined by McMillan's inspection to have failed per this warranty, will at McMillan's option, be repaired or replaced with an equivalent or comparable product without charge. McMillan's obligation hereunder shall be limited to such repair and/or replacement and shall be conditional upon McMillan's receiving written notice of any alleged defect within ten (10) days of its discovery. The customer will, however, be responsible for returning the product to McMillan's manufacturing facility in Georgetown, Texas, U.S.A., and for assuming the cost of removing the original product and reinstalling the repaired or replaced product. A written specific explanation of the problem must be included with each returned product. Returned goods should be properly packaged to prevent shipping damage and shipped **prepaid** to McMillan.

SAFETY REQUIREMENTS:

For safety reasons, McMillan must be advised of any hazardous fluid or toxic materials that were in or on the product to be returned. Customer must certify in writing that all such hazardous, corrosive or toxic substances have been completely removed, cleaned or neutralized from the returned product prior to shipment to McMillan. McMillan shall hold the returned items pending receipt of customer's statement for defect and certification of cleanliness of returned items, provided that, prior to such receipt, risk of loss of returned items shall remain with customer. Flow sensors, flow meters and flow controllers must be thoroughly cleaned to remove any toxic, corrosive or hazardous fluids that may internally remain therein before shipping product to McMillan.

SHIPPING REQUIREMENTS:

Customer is responsible for all shipping charges (except for those products under warranty, in which cases customer shall bear the cost of inbound shipping as described herein below, and McMillan shall bear the cost of outbound shipping). Customer is responsible for the costs of out of warranty repairs and/or recalibration. McMillan will ship items repaired under warranty back to customer by the most economical shipping means. Expedited shipping methods may be available at customer's expense. All returned items shall be returned to a McMillan authorized service center., freight prepaid, accompanied or preceded by a particularized statement of the claimed defect and with a clearly readable Returned Material Authorization ("RMA") number affixed to the shipping label. Contact McMillan Customer Service Department for RMA number. Warranty claims shall be made only by using the McMillan's Returned Material Authorization form, completely filled out and returned to McMillan in accord with McMillan's Product Return Policy and Procedure Form.

Contact McMillan's Customer Service Department as follows for instructions: Telephone calls in U.S.A. (CST) 1-800-861-0231 or Outside U.S.A. 512-863-0231 Or Fax: 1-512-863-0671 or e-mail: <u>sales@mcmflow.com</u>

DESIGN, PROCESS AND MANUFACTURING CHANGES

McMillan may make changes in the design or manufacture of any products sold hereunder without incurring any obligation to incorporate such changes into products manufactured prior to incorporation of such design or manufacturing changes. McMillan reserves the right to make design or manufacturing changes without prior notice. McMillan products and replacement parts are manufactured using new materials or new and equivalent to new in appearance, performance and reliability. Due to continuous research, testing, product improvements and enhancements, McMillan reserves the right to change product specifications without notice, except to the extent an outstanding bid obligation exists.

LIMITATION OF LIABILITY

Except as expressly set forth in this limited warranty, McMillan makes no other warranties or conditions, express or implied, including any implied warranties of merchantability and fitness for a particular purpose. McMillan expressly disclaims all warranties and conditions not stated in this limited warranty. Any implied warranties that may be imposed by law are limited in duration to the limited warranty period. Buyer/customer agrees that models or samples shown to buyer/customer were merely used to illustrate the purchased product and not to represent, promise or guarantee that any purchased products delivered hereunder would conform to such models or samples. McMillan's distributors or sales representatives have no authority to give warranties beyond those provided in this limited warranty.

If customer's product fails to work as warranted herein, customer's sole and exclusive remedy shall be the repair or replacement at McMillan's option. McMillan is not liable for any damages caused by the product or the failure of the product to perform, including any lost profits or savings, incidental or consequential damages. McMillan is not liable for any claim made by a third party or made by a buyer for a third party. No actions arising out of sale of the products sold hereunder or this limited warranty may be brought by either party more than two (2) years after the cause of action accrues. This limitation of liability applies whether damages are sought, or a claim made, under this limited warranty or as a tort claim (including negligence and strict product liability), a contract claim, or any other claim. This limitation of liability cannot be waived or amended by any person. This limitation of liability will be effective even if customer has advised McMillan or an authorized representative or distributor of McMillan of the possibility of any such damages.

This limited warranty gives customer specific legal rights. Customer may also have other rights that may vary from state to state or country to country. Customer is hereby advised to consult applicable state or country laws for a full determination of customer's rights.

EXCLUSIONS FROM WARRANTY

This limited warranty provided herein shall not apply to any product which:

- A. has been repaired or altered outside of McMillan's factory (or authorized service center) in any way so as, in McMillan's judgment, to affect such purchased item's reliability or performance.
- B. has been subject to misuse, mishandling, negligence, accident, or acts of God.
- C. has been operated other than in accordance with the printed instructions prepared by McMillan and provided by McMillan with the product.
- D. has been returned to McMillan after more than thirty (30) days following the date of the alleged product failure.
- E. has been returned to McMillan without complying with the Safety Requirements or the Shipping Requirements contained herein.
- F. requires calibration and/or routine maintenance, unless this calibration or routine maintenance is required as a result of a product failure that is covered under terms of this warranty.
- G. are consumable parts, such as filter elements, batteries or tube fittings.
- H. requires replacement or repairs resulting from buyer's improper choice of product flow range, or require repair or replacement due to buyer subjecting product to corrosive fluids or other fluids not suited for use in product
- I. has flow passages clogged due to failure to use a filter to protect product from particulates in fluid flow stream, or other cause to produce clogged passages
- J. has been operated outside of recommended specifications (such as voltage, temperature, or flow range, etc.)
- K. has been damaged as a result of gross over-speeding, or prolonged over-speeding of the micro-turbine wheel
- L. has been damaged as a result of severe sudden impact forces (example: dropping the product)

METHOD OF SETTLEMENT OF ANY CLAIMS, DISPUTES AND CONTROVERSIES

The provisions of this warranty are severable and if one or more provisions are deemed invalid, the remaining provisions shall remain in effect. Further, in the event that any provision is held to be over broad as written, such provision shall be deemed

amended to narrow its application to the extent necessary to make the provision enforceable according to applicable law and shall be enforced as amended. This warranty shall be construed and interpreted in English.

All claims, disputes and controversies arising out of or relating in any way to claims under any warranties, either express or implied (including implied warranty of merchantability), or claims based on any consumer protection act or deceptive trade practice act, contract, tort, statute, or common law, or any alleged breach, default, and/or misrepresentation, will be resolved by means of final and binding arbitration. This limited warranty, including any contests to the validity or enforceability of this limited warranty, shall be finally settled by arbitration under the Rules of Conciliation and Arbitration of the International Chamber of Commerce by one or more of its arbitrators appointed in accordance with the Rules, and judgment upon award rendered may be entered in any court having jurisdiction thereof. The place of arbitration shall be Austin, Texas U.S.A., and the Texas Uniform Commercial Code, as then enacted shall govern the rights and duties of the parties of this agreement without regard to conflicts-of-law principles. The arbitration shall be conducted in English. The UN Convention on Contracts for the International Sale of Goods shall not apply to this Limited Warranty.

H. Contacting McMillan

Website: www.mcmflow.com Email: techem.ncmflow.com

Mailing address:

P.O. Box 1340 Georgetown, TX 78627 U.S.A.

Shipping address:

7075 RR 2338 Georgetown, TX 78628 U.S.A.

Phone: (512) 863-0231 **Fax**: (512) 863-0671

For repairs and/or return information, please contact our service department any of the ways shown above.

I. Quick Reference

4-20 mA units

Current Input/Output	% of rated flow
4.0 mA	0
5.6 mA	10
7.2 mA	20
8.8 mA	30
10.4 mA	40
12.0 mA	50
13.6 mA	60
15.2 mA	70
16.8 mA	80
18.4 mA	90
20.0 mA	100

0-5 VDC units

_ Voltage Input/Output	% of rated flow
0 VDC	0
0.5 VDC	10
1.0 VDC	20
1.5 VDC	30
2.0 VDC	40
2.5 VDC	50
3.0 VDC	60
3.5 VDC	70
4.0 VDC	80
4.5 VDC	90
5.0 VDC	100

0-10 VDC units

Voltage Input/Output	% of rated flow
0 VDC	0
1.0 VDC	10
2.0 VDC	20
3.0 VDC	30
4.0 VDC	40
5.0 VDC	50
6.0 VDC	60
7.0 VDC	70
8.0 VDC	80
9.0 VDC	90
10.0 VDC	100

U801 -<range> - <signal> - <fitting> - <cable> - <valve> - <opt>

Flow Range 15 – 100 mL/minute 20 – 200 mL/minute 50 - 500 mL/minute 100-1000 mL/minute 0.2 – 2.0 L/minute 0.5 – 5.0 L/minute 1.0 – 10.0 L/minute					<range> <range> <range> <range> <range> <range> <range></range></range></range></range></range></range></range>	= "3" = "4" = "5" = "6" = "7" = "8" = "9"				
I/O Signal Configuration 0 – 5 VDC 4 – 20 mA 0 – 10 VDC For relay error output, add "R" aft	er the sigr	nal code (i.e	. "JR")		<signal> <signal> <signal> <signal></signal></signal></signal></signal>	> = "B" = "C" = "J"				
Fitting Type <fitting></fitting>		Range:	3	4	5	6	7		8	9
1/4 " male flare <fitting> = "</fitting>	F4″	available	\checkmark	1	1	no	no		no	no
3/8 " male flare <fitting> = "</fitting>	F6″	available	no	\checkmark	\checkmark	\checkmark	1		no	no
1/2 " male flare <fitting> = "</fitting>	F7″	available	no	no	no	no	~		~	V
Cable Length (cable betwee control module) 3 feet (0.92 meters) 6 feet (1.85 meters) 10 feet (3.1 meters) 15 feet (4.6 meters) 20 feet (6.2 meters) 25 feet (7.7 meters)	en valve	e and		<cables <cables <cables <cables <cables <cables< td=""><td>> ="C3" ="C6" ="C10" ="C15" ="C20" ="C25"</td><td></td><td></td><td></td><td></td><td></td></cables<></cables </cables </cables </cables </cables 	> ="C3" ="C6" ="C10" ="C15" ="C20" ="C25"					
Differential Pressure /	<valve:< th=""><th>> Ra</th><th>ange:</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th></valve:<>	> Ra	ange:	3	4	5	6	7	8	9
4F 2-10 psid (5 psid*)	<valve></valve>	= "P5"		no	1	\checkmark	1	1	no	no
4-20 psid (10 psid*)	<valve></valve>	= "P10"		no	\checkmark	\checkmark	\checkmark	\checkmark	no	no
5-40 psid (20 psid*)	<valve></valve>	= "P20"		1	\checkmark	\checkmark	\checkmark	\checkmark	1	no
7-50 psid (25 psid*)	<valve></valve>	= "P25"		no	no	no	no	no	no	\checkmark
10-60 psid (40 psid*)	<valve></valve>	= "P40"		\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark

*Range shown n indicates recommended differential pressure operating range. Low number or range indicates minimum pressure required to flow 50% of rated flow. High number of range indicates maximum differential pressure recommended for stable control. Value in parenthesis indicates minimum pressure required to flow 100% of rated flow. Please note that P5 and P10 will only control 20 – 100% of rated flow. P20, P25, and P40 will control 10-100% of rated flow range (exception range 3, which is 15-100% of rated flow).

Additional Options (leave off if none)	Option Code
High Temperature Operation (Fluid Temp: 0 -90°C)	<opt>="HT"</opt>
Include Pair of PVD Flare Nuts	<opt>="FN"</opt>

Example: "U801-8-CR-F7-C10-P20-HT" would be a U801 flow controller rated for 0.5-5.0 L/minute. The input and output signals would be 4-20mA. A relay error output would be included. The fluid connections would be $\frac{1}{2}$ " male flare. The cable length would be 10 feet, and the differential recommended pressure range would be 5-40 psid. The unit would be rated for fluid temperature from 0 to 90°C.

J. Troubleshooting Guide

Symptom	Possible Cause	Method of Correction	
The status light indicates an error	The control module is not	Check to make sure the 15-pin	
(amber color) immediately upon	properly connected to the valve	connector is properly installed	
power up. It never turns green.	module.	onto the control module.	
	The control module has been	Check wiring as instructed in	
	miswired.	instruction manual.	
The flow controller display	The output current or voltage	If your unit has 4-20 mA	
indicates no flow (4 mA or 0	loop is not completed.	inputs/outputs, check to make	
VDC) even when flow is passing		sure pin #5 and pin #6 are	
through unit.		connected together either by	
		jumper or by current loop.	
		For voltage output units, make	
		sure pins 5 & 6 are jumpered	
		together.	
	The output is shorted.	Check wiring as instructed in	
		instruction manual.	
The analog output and/or display	The actual fluid flow conditions	Ensure pressure supply is stable	
are fluctuating (bouncing) up and	are fluctuating rapidly.	and all fluid components are	
down.		operating within range.	
		Certain pumps, such as peristaltic	
		or diaphragm, may be inherently	
		noisy. With pulse dampeners	
		installed, the Flo-Controller will	
		try to overcome those pulses by	
		opening and closing, but may be	
		unsuccessful at higher frequency	
		pulses. Installing pulse	
		dampeners in the line may	
		improve Flo-Controller	
		performance.	
	The differential pressure (PSID)	Reduce differential pressure by	
	across the Flo-Controller exceeds	reducing supply pressure or	
	the recommended amount.	increasing back pressure on	
		outlet of Flo-Controller.	
The unit will not control below	The unit is not designed to	Increase setpoint, or contact	
10% of rated flow.	control flow rates below 10% of	factory for a Flo-Controller with a	
	rated flow.	lower operating flow range.	
Valve does not regulate flow	The unit is in Standby mode.	See instruction manual for tips	
even when flow rates obviously		on how to use standby. For	
cnange.		models with Auto Standby,	
		Increase setpoint above 5% of	
		rated flow to resume normal	
	The estimate southing of the	operation.	
	approximation of the Flo	foll within recommended flow	
	Controller	range for the unit	
		range for the utilt.	

The unit will not shut flow completely off.	The unit is not designed to be a positive shutoff valve.	Add a solenoid valve upstream of the Flo-Controller to perform the positive shutoff functions
The Flo-Controller is taking a long time to achieve the setpoint.	Under large flow changes, the Flo-Controller may take up to 8 seconds to adjust.	Higher differential pressures (as long as they are within recommended range) will improve response time. Smaller flow adjustments, along with the use of the Standby function, will also result in improved response.
The Flo-Controller calibration seems unrepeatable or erratic.	Air may be trapped inside unit from initial installation.	Follow instructions in section B.1 to remove air from Flo-Controller.
The Status LED goes amber when the unit is in Standby mode.	This is normal behavior – disregard the Status LED when the Standby LED is illuminated red.	No correction is necessary. The error functions do not operate when the unit is in Standby mode.