qualiflow

AFC 50D

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SECTION 1 - INTRODUCTION

The QUALIFLOW Digital Mass Flow Controller AFC50.D offers the highest degree of accuracy and reliability in controlling gas flows.
This range has been designed specifically to prevent contamination and particle deposition. It is therefore ideal when using in semiconductor and optical fiber manufacturing processes. It takes benefit from the digital technology : new features such as alarm and maintenance functions are available (with the free QUALIFLOW's PC interface digisoft). With a specially developed algorithm, the regulation is obtained without overshoot and during the transient time, the readout matches the real flow.

This manual includes the following sections :

Section 1. Introduction : contains specifications and calibration features.

Section 2. Installation : contains all the information necessary to unpack the AFC50.D without causing contamination, install the AFC50.D and check the installation before starting up. All data related to digital card and use of a PC with RS232 connection are developed.

Section 3.Maintenance.

Section 4.Trouble-shooting.

1.0 SPECIFICATIONS

Ratings

Flow Range (equivalent N2) : .... from 10 sccm to 30 slm
Control Range : .... between 2 and 100% F..S.
Valve Type : .... Electromagnetic
Valve Rest Position : .... Normally Open or Close
Accuracy : .... +/- 1% of setpoint. if setpoint > 20% of F.S., +/- 0.2% of F.S. if setpoint < 20% of F.S.
Linearity : .... +/- 0.2% of setpoint. (per Calibration Gas)
Repeatability : .... +/- 0.15% of F.S.
Sensibility to Mounting Position :.................... +/- 0.1% of F.S.
Step Response Time : .... <= 2 sec. (SEMI E17-91)
Temperature Range : .... between 5 and 50°C, Up to 80°c with separated electronic option
Temperature Coefficient : .... < 0.05% F.S. /°C
Maximum Inlet Pressure : .... 10 bar
Minimum Differential Pressure :...................... 0.5 bar, 30 mbar minimum with low DP option
Maximum Differential Pressure :..................... 3 bar
Pressure Coefficient : .... < 0.1% F.S./bar
Wetted Materials : .... 316 L Stainless steel, Kel-F, seals material
Surface finish : .... 0.4 mm(16 minch) Ra max
Leak Integrity : .... < 2.10-8 scc/sec (He)
Standard Seals : .... Viton, Neoprene or Kalrez
Fittings : .... ¼" VCR, Swagelok,, other on request

Power Input Requirement :

Mass Flow Controller : .... +/- 15 VDC, 150 mA
Mass Flow Meter : .... +/- 15 VDC, 25 mA
Analog Set Point Signal : .... from 0 to 5 VDC
Analog Flow Output Signal : .... from 0 to 5 VDC
Digital control : .... RS232C, active full time
Electrical Connector : .... Sub-D 15 pins Male

Options :

- Separated electronics
- External Readout
- Low differential pressure
- Device net fieldbus connection
- RS485/Modbus with 2 RJ11 connections

1.1 CALIBRATION FEATURES

The Mass Flow Controllers are calibrated close to customer's process. Without customer's information, the MFCs are calibrated under standard conditions.

1.1.0 STANDARD CONDITIONS

Without special conditions specified by the customer, the MFC is calibrated under the following standard conditions :

Pressure conditions :

Pressure Outlet : Atmospheric

Delta Pressure : between 500 mbars and 3 bars (With Low DP option 30 mbars)

Dynamic adjustment : no overshoot

The mounting position (horizontal, vertical inlet up or down) should be specified by the customer to ensure the best accuracy .

1.1.1 MANUFACTURING ENVIRONMENT

The MFCs are assembled, calibrated, packaged and controlled in a class 100 cleanroom.

1.1.2 QUALITY CONTROL

Each MFC is controlled 24 hours after manufacturing on a different calibration bench. The accuracy, the dynamic response, the stability to pressure variations are double checked.

SECTION 2 - INSTALLATION

2.0 INTRODUCTION

WARNING: Toxic, corrosive or explosive gases must be handled with extreme care. After installing the mass flow controller, the system should be thoroughly checked to ensure it is leak-free. Purge the mass flow controller with a dry inert gas for one hour before using corrosive gases.

IMPORTANT: When installing the mass flow controller, ensure that the arrow on the back of the unit shows the same direction as the gas-flow.

This four part section contains all the information necessary to install the AFC50.D mass flow controllers.

- 2.1 - UNPACKING;
- 2.2 - MECHANICAL INSTALLATION;
- 2.3 - ELECTRICAL INSTALLATION;
- 2.4 - CHECK BEFORE START UP.
- 2.5 - DIGITAL CARD.
- 2.6 - COMMUNICATION MODES.

2.1 UNPACKING

The AFC50.D mass flow controller are manufactured under clean room conditions, and has been packed accordingly upon receipt. The cardboard packing should be checked for damage. If there is visible damage, please notify your local QUALIFLOW sales office at once. In order to minimize contamination of clean rooms, the unit has been packed in two separately sealed plastic bags. The outside bag should be removed in the entrance to the clean room. The second bag should be removed when you install the unit.

2.2 MECHANICAL INSTALLATION

2.2.0 GENERAL

Most applications will require a positive shutoff valve in line with the mass flow controller. Pressurized gas trapped between the two devices can cause surge effects, and consideration must be given to the sitting of the shutoff valve (upstream or downstream) in relation to the process sequencing. As far as the process parameters will allow this, it is recommended that you install an in-line filter upstream to the controller in order to prevent from contamination.
The AFC50.D can be mounted in any position. The atmosphere should be clean and dry. The mounting should be free from shock or vibration. Mounting dimensions are shown in figure 2-1. Prior to installation, ensure that all the piping is thoroughly cleaned and dried. Do not remove the protective end caps until you are ready to install the controller.

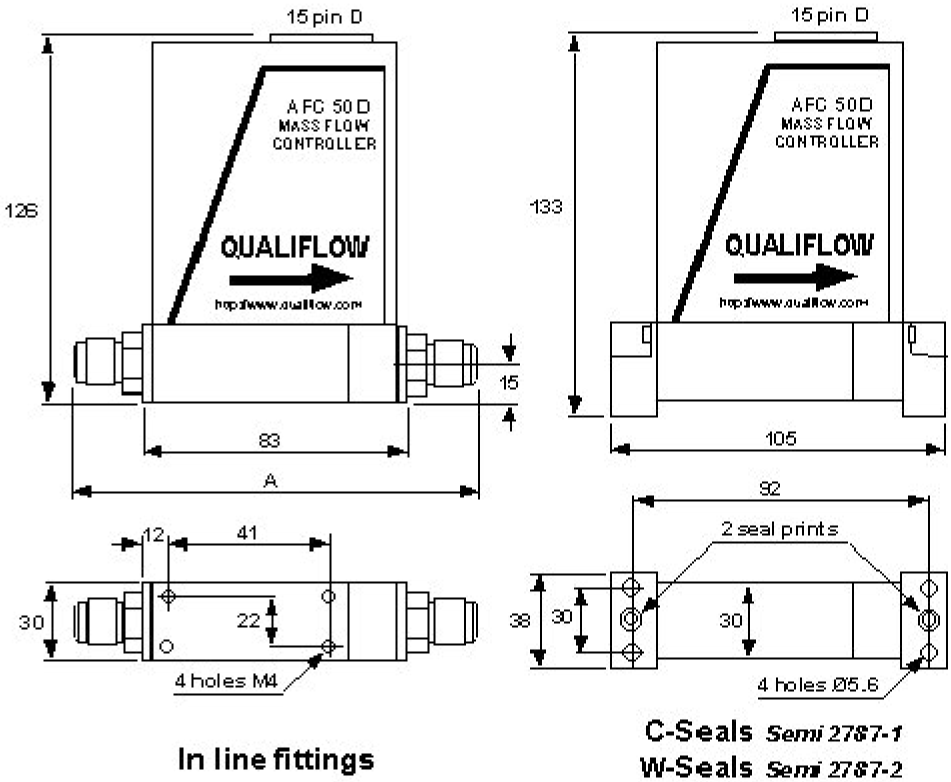
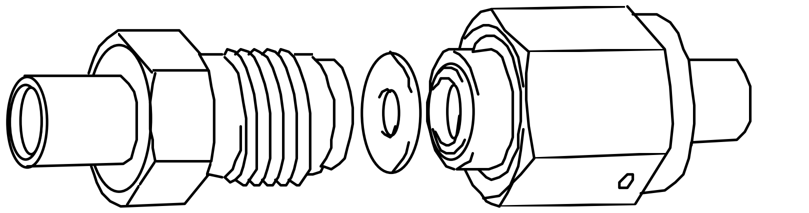


Figure 2-1 Dimensions (mm)

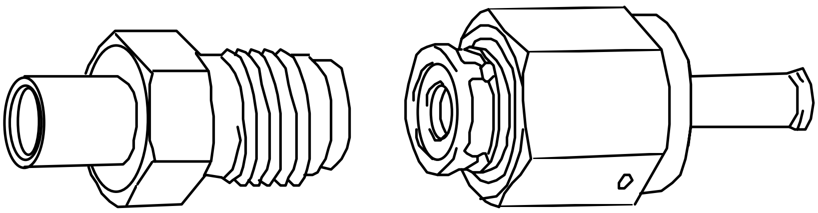
2.2.1 INSTALLATION

The AFC50.MD mass flow controller is normally supplied with 1/4" male VCR compatible couplings on both sides. To install the AFC, follow the steps listed below. Refer to figure 2-2.

1. Check the gland to gland space, including the gaskets.
2. Remove the plastic gland protector caps.
3.
   a) When using loose VCR "original" style gaskets, insert the gasket into the female nut.
   b) For VCR retainer gaskets, snap the gasket onto the male coupling. See figure 2-2.
4. Tighten the nuts finger tight.
5. Scribe both nut and body in order to mark the position of the nut.
6. While holding the body with a wrench, tighten the nut : 1/8 turn past finger tight for 316L stainless steel and nickel gaskets.



VCR original style gasket



VCR retainer gasket

Figure 2-2 VCR compatible couplings

2.3 ELECTRICAL INSTALLATION

2.3.0 GENERAL

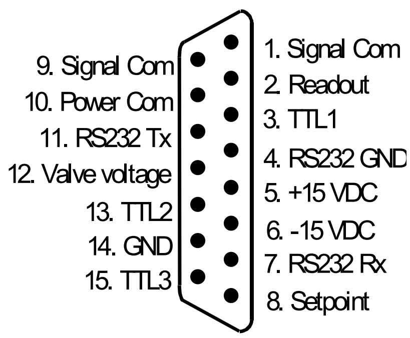
Within this section, you will find the following sub-sections:

- Connections.
- Digital functions (see Section 3 - "DIGITAL CARD").
- Pressure control.
- Ratio control.
- Communication plug (section 2.7).

2.3.1 CONNECTIONS

The electrical connections of the AFC50.D are made through a sub D 15 connector (see figure 2-3). RS 232 adapters for use in maintenance functions are available (model 4).

Digital's card sub D 15 connector :



Note : 1. Signal Com pin is used for External Read Out Option if required

Figure 2-3 Pin arrangement for digital Card connector.

Dedicated interface connector is available to allow digital MFC connection to work with other pin arrangement, according to figure 2.4. This second pin arrangement is compatible with the AFC 50 analog QUALIFLOW Mass Flow Controller. A card edge adapters coupled with a RS232 cable is available. The card edge connection is widespread in the industry.

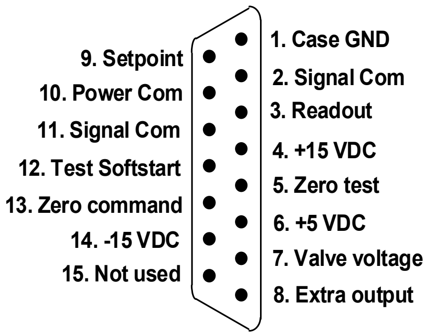
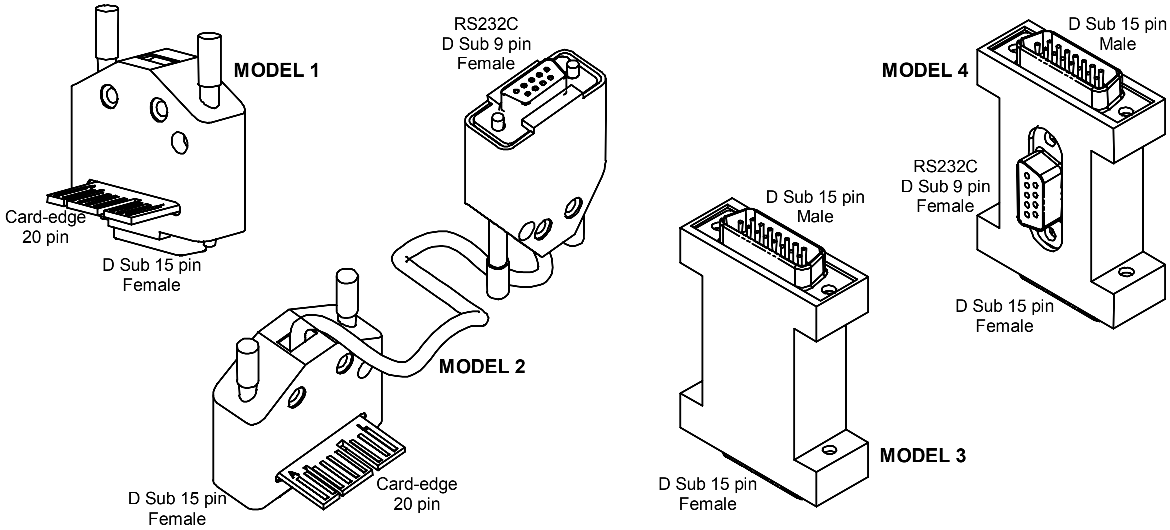


Figure 2-4 Adapters pin arrangement
(compatible with QUALIFLOW's analog MFC 50)



Connectors Conversion Adapters					
QUALIFLOW MFC / Connector		**Replaced MFC / Connector**		**Model**	**Part Number**
Analog AFC50/AFM 55	D Sub 15 pin	Main MFC's	Card-edge	1	Q201733-01
Digital All Series	D Sub 15 pin	Main MFC's	Card-edge	1 2	Q201733-07 Q201733-08
Digital All Series	D Sub 15 pin	Analog AFC50/AFM 55	D Sub 15 pin	3 4	Q201733-09 Q201733-10
Digital All Series	D Sub 15 pin	Main MFC's	D Sub 15 pin	4	Q201733-06
0-5V to 4-20mA Conversion Adapters					
MFC Type				Model	**Part Number**
QUALIFLOW Analog AFC50/AFM55				3	Q201733-05
QUALIFLOW Digital and Main MFC's with D Sub 15 pin connector				3	Q201733-15

Other Accessories	Part Number
Control and Power Supply Kit for QUALIFLOW Digital MFC's all series : When connecting individually a Digital MFC to a computer use this interface kit, which includes: • Connector conversion adapter, P/N q 2001733-06 • Power supply assy 120/230 VAC, ±15VDC, P/N Q2001733-14 • Power cord from power supply to MFC, length 1 meter, P/N Q2001733-13 • RS232C cord from MFC to computer, length 2 meters, P/N Q2001733-11	**Q 2001733-12**
Connecting cord for Analog AFC50/AFM55 or digital MFC's all series : • D Sub 15 pin female connector (MFC side), wires ready to weld at the other end • Length 5 meters	**2990924Q**

2.4 CHECKS BEFORE STARTING UP

Before operating the mass flow controller the following checks should be completed :

1. Check that tubing is leak proof.
2. Check the process sequence and proper function of all other gas components involved.
3. Check the voltage of command signals and power supply to the mass flow controller.
4. Check that the appropriate gas type is being supplied at the rated pressure.
5. Allow the mass flow controller to warm up for 20 minutes, then check the zero level output.
6. Use dry inert gas for test runs.
7. Prior to using the mass flow controller for extremely corrosive gases, purge with a dry inert gas for one hour.

2.5 DIGITAL CARD.

2.5.0 INTRODUCTION

QUALIFLOW has designed and developed a digital card for its Mass Flow Controllers (MFC) that take advantages of the full potential of digital technology. Not only enabling digital communication, these cards improve MFC accuracy and control using a numerical control algorithm. They store several calibration curves, therefore QUALIFLOW customers can reduce the number of references that they use. They also make maintenance operations easier : through alarm functions and PC diagnostic via RS232.

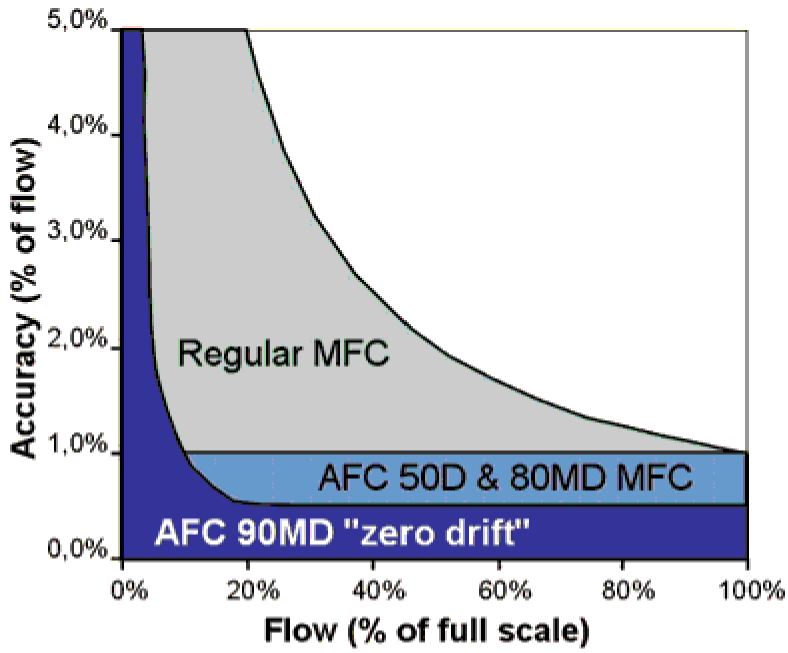
The development of the digital technology has brought great improvements in :
-Accuracy
-Control
-Additional capabilities

This new digital card is 100% compatible with previous QUALIFLOW analog Mass Flow Controllers. However the digital mode is best used for maintenance functions or in calibration mode. The RS485 communication and the device net communication allow the use in digital communication mode with standard industry protocol.

2.5.1 A BETTER ACCURACY

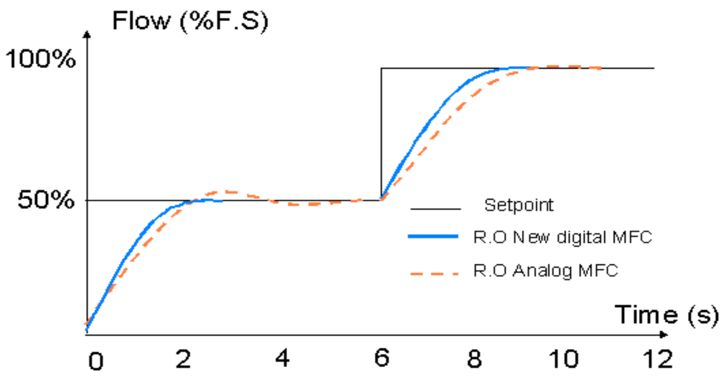
All analog MFC's are calibrated with potentiometers at three points : 2%, 50% and 100% FS to make the error at 0%, 25%, 50%, 75% under 1% FS. The numerical MFC's are calibrated at more than 6 points and the response curve is then calculated. Their accuracy is ± 1% of

setpoint if setpoint > 10% of F.S., ± 0.1% of F.S. if setpoint < 10% of F.S. So the linearity is much better at small setpoints (see the following graph).
Most of digital MFCs use linear interpolation to calculate the response curve whereas the QUALIFLOW digital board achieved better accuracy, with lower calibration points thank to polynomial interpolation.
The RS232 or RS 485 or Device net connection let you to change the calibration curve by choosing the corresponding number without disconnecting the MFC. 10 calibration curves can be stored in memory. To maintain the best accuracy the maximum factor between two full scales of two several calibrations is 3.
The set point and the measure are converted by 16 bits CAN for the best accuracy. The analog readout is converted by 12 bits CNA which does not alter the accuracy of the flow.



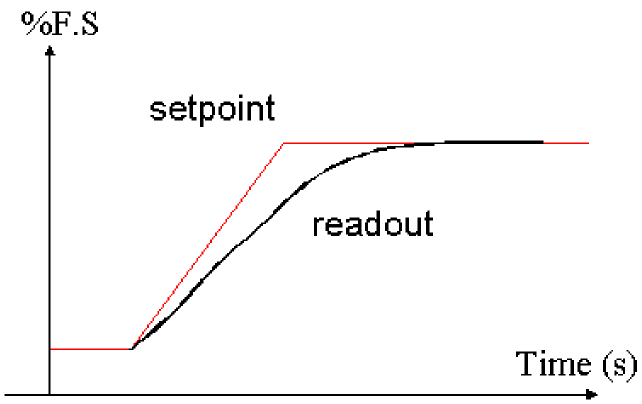
2.5.2 AN OPTIMIZED NUMERICAL CONTROL

The control of the gas flow is made by a numerical algorithm which assumes a control without overshoot at any set point. Each calibration curve is stored with its own optimised regulation parameters which are determined by calculation. An analog control is fixed by the electronic components and can not be adapted to each gas and to each full scale. For example, an analog regulation can not avoid overshoot at low flow rates whereas an algorithm gives fine control at any set point. The following typical curves compare the analog regulation with the numerical one. As the response time of the digital MFC's are more repeatable and do not depend on electronic components. So digital MFC's have closer transient behaviours, which brings a great improvement in process with mixed gases.



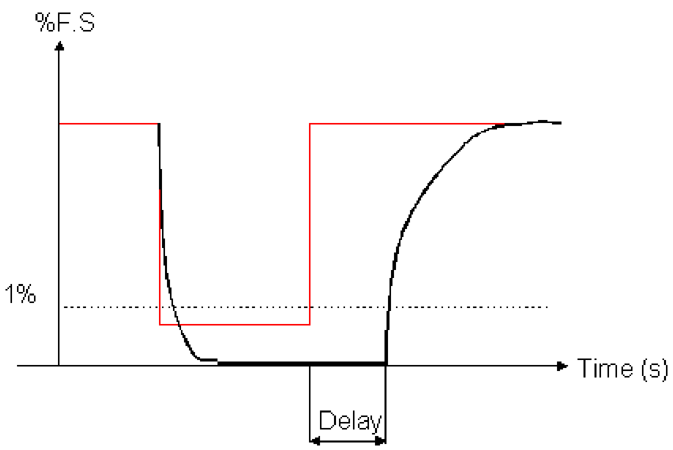
2.5.3 RAMPING

The ramping function increases linearly the set point in order to give a progressive raise in the flow. It could be used to keep stoechiometric values during transient response of a process. The increase of the set point by unit time is chosen by the user (see software manual).



2.5.4 SOFT-START

The soft start function closes the valve if the set point is lower than 1%F.S. For a new set point greater than 1%F.S, the regulation starts after a delay that is chosen by the user.
This way you can avoid big overshoots caused by pressure drop, when starting a process.

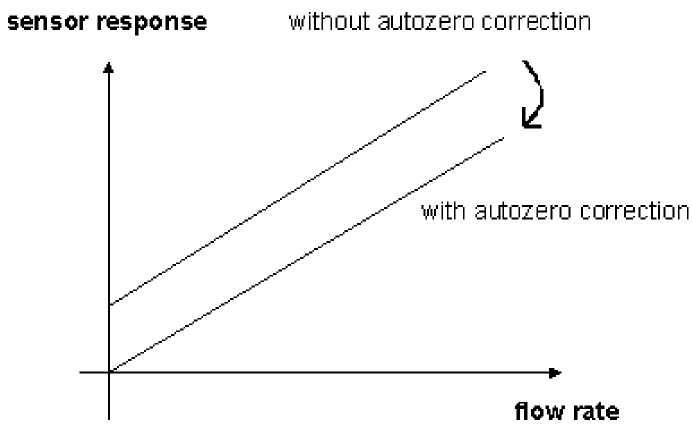


2.5.6 IN SITU CALIBRATION

The calibration can be automatically made by calibration devices with a serial communication. The calibration is made with six points without potentiometers. The QUALIFLOW software allows to calibrate the MFC from the 'Molblox' device (Caltechnics).

2.5.7 AUTO-ZERO

The function AUTO-ZERO corrects the drift of the MFC. It can be done automatically or by the user. The correction can not exceed 0.5%.



sensor response after a long-term drift

2.5.8 ADDITIONAL CAPABILITIES

Additional capabilities are customized by a free PC Interface (see the software's manual in the CD).

2.5.8.0 LED INDICATOR

The MFC contains three LEDS located on the left hand side.

The left LED is the watchdog LED. When blinking, it indicates whether the MFC is on power or not. A quick blinking (several times per second) indicates that the MFC is working on a analog mode.

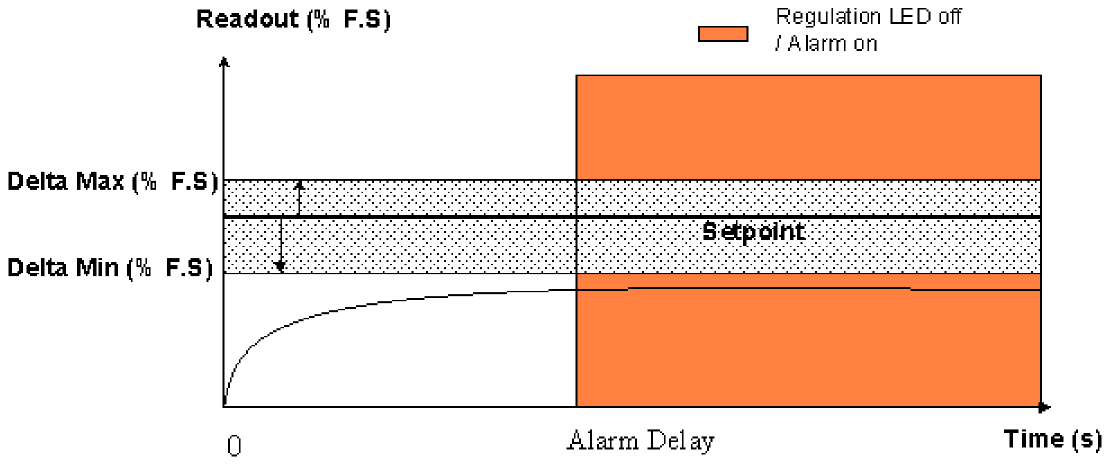
The second LED indicates whether the regulation is obtained (switched on) or not (switched off).

Switched on, the third LED indicates an error as :
- a sensor error
- a communication error
- a EEPROM error
- a valve type error
- a converter (A/D) error

2.5.8.1 ADJUSTABLE ALARM

The user chooses three parameters, the delta min, the delta max and the delay alarm, in order to adjust the regulation alarm. Delta min and delta max (in ‰ FS) are the maximum differences between the readout and the set point to get before the delay time. If the MFC

does not correctly control, the alarm is on until the user switches it off. For example, if the pressure is too low, the MFC could not regulate the flow The alarm signal will be generated until the user switches it off.
This alarm can be switched off by soft .



ADJUSTABLE ALARM

2.5.8.2 TOTALIZER

The totalizer indicates the cumulative flow in % FS since the last initialisation. It is useful to have a look on your gas consumption.
Example : 5000 with 20slm as FS means 1000sl total.

2.5.8.3 DATA STORING / RETRIEVING

The set point, the valve voltage and the readout are stored at a frequency of 2 times a minute during 6 hours and can be saved as an excel file. These data allow the diagnostic of sensor drift or pressure drop.
For example an increasing in valve voltage for the same set point could be due to contamination or corrosion.
Data can be scanned and retrieved at any time without interruption while the MFC runs in control mode.

2.6 COMMUNICATION MODES.

In addition to the ability to use this digital MFC on analog mode with the advantage of communication via serial RS-232C for maintenance, calibration or individual control (DB 15 connector, following options are available :

RS-485 option: can control up to 32 MFC's under MODBUS protocol (RJ11 connector).

DeviceNet or PROFIBUS option: this mode allows communication with high speed protocol.

For more information during utilization, contact QUALIFLOW, France.

SECTION 3 – MAINTENANCE

3.0 GENERAL

No routine maintenance is required on the meters or controllers, other than occasional cleaning and re-calibration :
After 3 or 4 years when the unit is run with a ultra-clean and non corrosive gas.
After 1 or 2 years when the unit is run with a low purity gas and/or a corrosive gas.

Cleaning can be performed by removing the unit from the system, cleaning inlet and outlet-fittings separately and pumping alternately reverse and forward for 5 minutes in each direction with a solvent system (one micron maximum absolute filtration).
Next, the unit must be blown with N_2 for 30 minutes minimum.
Reinstall cleaned fittings.
In extreme cases of contamination, it may be necessary to separately clean the sensor, the bypass and the valve.

3.1 DISASSEMBLY AND ASSEMBLY PROCEDURES

If you disassemble the mass flow controller, it will need recalibration in order to reach the specifications given in this manual. If the mass flow controller appears to have a fault, first perform the checks in the troubleshooting section, as it may not be necessary to dismantle the valve. Prior to disassembly, make sure the unit has been purged with a dry inert gas.

WARNING : if it becomes necessary to remove the controller from the system after exposure to toxic, pyrophoric, flammable or corrosive gas, purge the controller thoroughly with a dry inert gas such as nitrogen, before disconnecting the gas connections. Failure to purge the controller could cause a fire or explosion resulting in death.

CAUTION : the electronic circuitry contains CMOS and NMOS components. These are easily damaged by static electricity, and usual precautions should be taken when installing, dismantling or adjusting the mass flow controller.

3.2 DISASSEMBLY

Refer to exploded view.

1. Remove cover screw 31 and carefully remove the cover.
2. Disconnect the sensor wiring from the PC-board by careful unsoldering.
3. Disconnect the actuator wiring from the PC-board by careful unsoldering.
4. Remove the PC-board from the sensor assembly by removing screws 25.
5. Remove sensor assembly 22 from the base block. Handle the sensor with care.
6. Remove O-rings from the chambers in the base block.
7. Remover integral fitting plates 2 and 20 by removing screws 1 and 21. Remove the O-rings from the chambers in base block.
8. Cut the base block sticker on the line dividing the base block and the actuator using a sharp knife.
9. Remove nozzle 18 from the outlet-side fitting plate using an appropriate size screwdriver. Turn clockwise to remove.
10. Remove O-ring from the nozzle.
11. Remove the actuator base by carefully pulling it out of the base block.
12. Remove the O-ring from the base block chamber.

NOTE : Further disassembly is only necessary in cases of extreme contamination.

13. Remove the multi-tube bypass by pulling the plastic ring in direction of thread.
14. Remove cap 8 from the actuator base using appropriate size screwdriver.
15. Carefully unscrew valve stem tip 17 while holding lock-nut 10 at the opposite of the plunger.
16. Check that spacer ring 9 can be freely turned inside the housing.
17. Remove the plunger including spacer ring and magnetic pole 11. Carefully pull the parts out by holding the lock-nut.
18. Remove O-rings 12 and 13/
19. Unscrew lock-nut 10 remove spacer ring 9.
20. Remove magnetic pole 11 from plunger.
21. Remove magnet coil 15 from actuator base.
22. Remove O-ring 16.

3.2 SENSOR CLEANING AND REPLACEMENT

If it is determined that the sensor is contaminated, flush with a solvent in hypodermic needle, while running a small wire (0.15 mm diameter, available on request).
Do not immerse the entire sensor assembly in a solvent; the solvent will keep under the cover and destroy or at least change the sensor characteristics. Slow dry with nitrogen.

If the sensor resistance has changed or even open circuit is measured, the assembly should be replaced. The measured resistance between red and green (R1) and between red and yellow (R2) must be between 160 and 190 Ω and ΩR = R2-R1 must be less than ±1 Ω. Check also that there is no short-circuit between the tube and the red wire.
Examine the sensor seals, and replace when damaged.

3.3 REASSEMBLY

We recommend that new O-Rings are used in all instances when the unit is reassembled. The use of O-Ring lubricant is not recommended. The following procedure must be followed for reassembly :

1. Examine all parts for signs of damage and replace as necessary.
2. Fit O-ring onto lead wire side of magnetic coil.
3. Insert pick-up wire through hole in actuator base and attach coil lead wires using a small amount of tape. Pull lead wires through opening with care.
4. Insert the magnetic coil into the actuator base while gently pulling the pick-up wire.
5. Fit O-rings onto magnetic pole 11.
6. Pre-assemble the plunger, magnetic pole and spacer ring9. Avoid any loads on the crown spring. Tighten, by holding the locknut in socket wrench and turning clockwise until finger tight.
7. Carefully insert plunger assembly into magnetic coil. Avoiding damaging the crown spring on the valve side.
8. Press against the outside edge of the spacer ring in order to overcome the friction of the O-rings on the magnetic pole.
9. Fasten the valve stem tip firmly finger tight.
10. Re-assemble the bypass unit.
11. Screw on actuator cap 8 and tighten until finger tight using an appropriate size screwdriver.
12. Move the bypass unit over the actuator base and press it against the shoulder.
13. Fit O-ring onto edge of actuator base.
14. Insert actuator base into base block.
15. Fit O-ring into groove of nozzle.
16. Push nozzle into fitting plate 20 and gently turn counter clockwise with appropriate size screwdriver until it locks against shoulder.

17. Fit O-ring onto edges of fitting plates.
18. Fit fitting plates on both ends with mounting screws, applying a torque of 2 Nm.
19. Insert O-rings onto edges of fitting plates.
20. Mount the sensor assembly 22 onto the baseblock and tighten the screws to a torque of 2 Nm.
21. Connect sensor wiring blue-top/red-middle/orange-lower.
22. Connect the actuator wiring.
23. Leaktest the assembled mass flow controller.
24. Start the calibration procedure.
25. Replace cover 30
26. Before reinstallation in gas system, purge with dry nitrogen for 30 minutes.

SECTION 4 – TROUBLESHOOTING

4.0 INITIAL CHECK

1. Check the gas supply pressure and check that the flow-path to the mass flow controller has been opened.
2. Ensure that the power supply and command signals are correctly transmitted to the D-connector pins on the PC-board.
3. Check that the output signal matches the external reading. For pin assignments see figure 2-3.

Use the following table to locate the fault.

4.1 SYMPTOMS

Problem 1: Output reading, without gas flow, is not zero.

Possible cause	Action
1. Gas flow is actually present	Check closure of series shutoff valve.
2. Zero reading has drift less than 1.5%	Try 'Autozero function' by the software

Problem 2: Zero reading cannot be adjusted by autozero.

Possible cause	Action
Defective sensor.	Check that sensor voltage between red and orange wires is equal to the voltage between red and blue wires. Both must be 4 to 6 volts. Contact *QUALIFLOW* for advice. If defective, the controller may need replacing.

Problem 3: Valve will not close

Possible cause	Action
1. Check the Mfc is properly connected on the gas line	Disconnect the MFC after following the procedure
2. Set-point is not zero	Check set-point voltage on PC-board pin 9
3. Incorrect solder pad connections	See the strap configuration
4. The Mfc is in digital mode and you use it with a set-point voltage	Change the control mode by the software
5. The parameters min valve (for a NC) is too high The parameters max valve (for a No) is too low	Increase or decrease one of this parameter by the software
6. Incorrect actuator voltage	Voltage across actuator wires must be : between 0V and 30V
7. Incorrect nozzle adjustment	Remove mass flow controller and readjust nozzle.
8. Plunger stuck	Remove controller and clean up.

Problem 4: Controller will not open to full scale flow

Possible cause	Action
1. Check the MFC is connected in the good way on the gas line	Disconnect the MFC after following the procedure
2. Incorrect setpoint on PC-board (pin 8)	Check setpoint voltage.
3. Incorrect supply pressure	Check gas pressure at inlet side of mass flow controller
4. The Mfc is in digital mode and you use it with a set-point voltage	Change the control mode by the software
5. Incorrect flow reading	Check the numerical readout found by the software is correct
6. Incorrect solder pad connections	Check the strap configuration
7. The parameters max valve (for a NC) is too low The parameters min valve (for a No) is too high	Increase or decrease one of this parameter by the software
8. Incorrect actuator voltage	Voltage across actuator wires must be :between 0V and 30V

Problem 5: Unstable control

Possible cause	Action
1.Unstable pressure	Check inlet and outlet pressure stability
2. Defective electronics	Replace mass flow controller and contact *QUALIFLOW* for advice.
3. Bad Regulation parameters	Contact *QUALIFLOW*
4. Defective Mechanics	Contact *QUALIFLOW*

For any other problems, contact QUALIFLOW.

SECTION 5 - WARRANTY AND SERVICES

5.0 PRODUCT WARRANTY

1. Qualiflow products are guaranteed against defects in materials and workmanship if used in accordance with specifications and not subject to physical damage, contamination, alteration or retrofit.
   Warranty periods (from the date of shipment) are the following :

AFC90MD series	3 years
AFC80MD, AFC310MD series	2 years
INFLUX, AFC50, AFC202, AFC260 & AFC261 series	1 year

2. Buyers undertake to check and inspect the goods and to notify Qualiflow of shipment incidents by fax, phone or e-mail as soon as possible after receipting the goods.

3. During the warranty period, products must only be repaired by authorized Qualiflow service centers; otherwise, the Qualiflow product warranty will be invalidated.

4. Repairs will be performed free of charge during the one-year warranty period. If MFCs are out of warranty, Qualiflow will notify the owner of replacement or repair costs before proceeding. Factory service and repairs are guaranteed 90 days. The warranty excludes consumable materials and wear parts (in teflon, viton, etc.).

5. No MFC will be accepted for repair or warranty without a decontamination and purge certificate.

6. Each MFC is individually checked (visual inspection of fittings, helium leak test and flow calibration). Qualiflow shall not be responsible for any damage caused by gas leakage or the use of a dangerous gas. Users are responsible for following the safety rules applicable to each gas they use. Improper use of a Qualiflow MFC will void the warranty, and MFCs that have been damaged as a result of improper use will not be replaced by Qualiflow.

7. Specific warranty requirements are as follows :

   a. Gas must be clean and particle-free, which means a filter must be fitted in the gas line upstream of the MFC.
   b. Gas must comply with the following pressure specifications:
      i. Gas pressure must never exceed 10 bars.
      ii. Differential pressure must be more than 500 mbar for full-scale flow through the MFC valve unless an other value is specified in the user's manual.
      iii. Differential pressure must be less than 3 bars for the MFC valve to regulate without gas-flow oscillation unless an other value is specified in the user's manual.
      iv. Pressure at the mass-flow inlet must be regulated by an accurate pressure regulator to prevent gas-flow oscillation.
   c. Electrical connection requirements are as follows:
      i. The system must be wired carefully: non-observance of the pinout may irreversibly damage the electronic board inside the MFC, in which case the warranty will be invalidated.
      ii. A stable power supply is required, with ripple below 5mV.

d. Gas connections: the fittings must be handled carefully. Qualiflow guarantees that all fittings have been individually inspected and are scratch-free.
e. Fitting procedure: the fitting procedure set out in the manual must be followed meticulously. Specifically, the purge procedure is very important if corrosive gases or toxic gases are used.
f. The mass-flow must not be dismounted: the MFC warranty will be invalidated if the seal between the MFC block and cover is torn.

5.1 SERVICES

QUALIFLOW Products Engineers will help you to solve your problems regarding operation, calibration, connection, gas flows, gas mixture, etc.

We deliver technical support or maintenance within 24 hours.

QUALIFLOW offers factory training on mass flow controllers.

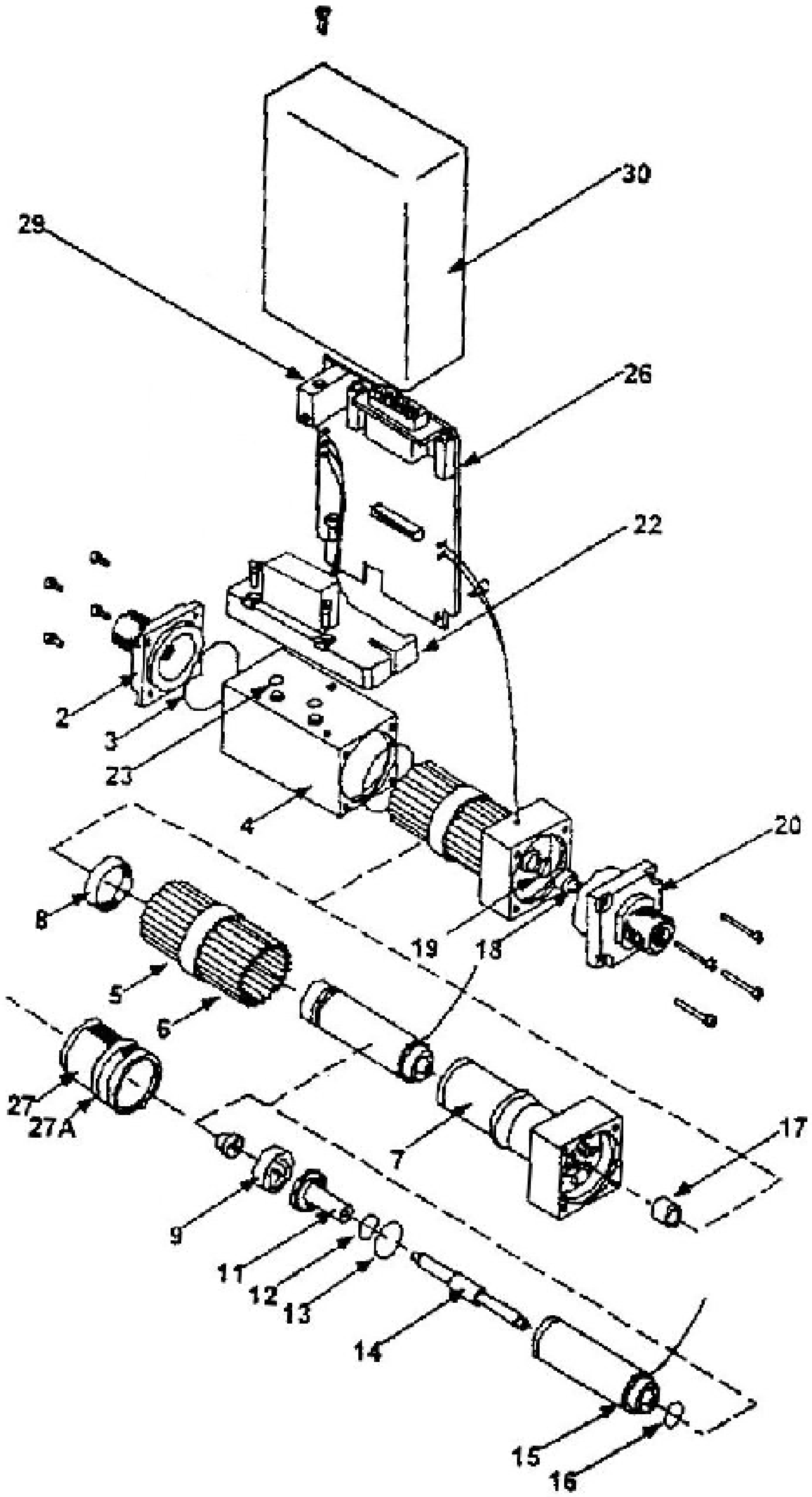
Visit www.qualiflow.com and find your nearest repair and calibration center.

Hotline : +33 (0)4 67 99 84 31

APPENDIX A Gas Process Number

Symbol	Gas Name	Number	Density SEMI E52-0298	Sp. Heat	C [cal/g/°C]
	Air	**008**	1.2929	0.2401	1.000
NH3	Ammonia	**029**	0.7710	0.519	0.68
Ar	Argon	**004**	1.7842	0.1246	1.453
AsH3	Arsine	**035**	3.481	0.1178	0.666
BCl3	Boron Trichloride	**070**	5.26	0.130	0.40
CO	Carbon Monoxide	**009**	1.2500	0.495	1.000
CCl4	Carbon Tetrafluoride	**101**	6.86	0.141	0.309
Cl2	Chlorine	**019**	3.209	0.116	0.83
B2H6	Dibirane	**058**	1.24	0.495	0.44
SiH2Cl2	Dichlorosilane	**067**	4.54	0.141	0.43
CHF3	Fluoroform	**049**	3.125	0.173	0.506
CCl2F2	Freon-12	**084**	5.5	0.149	0.34
CF4	Freon-14	**063**	3.96	0.167	0.41
GeH4	Germane	**043**	3.423	0.138	0.58
He	Helium	**001**	0.1788	1.242	1.454
H2	Hydrogen	**007**	0.0899	3.400	1.016
HCl	Hydrogen Chloride	**011**	1.635	0.1937	0.981
C2F6	Hexafluoroethane	**118**	6.16	0.185	0.24
Kr	Krypton	**005**	3.73	0.0596	1.45
CH4	Methane	**028**	0.7166	0.528	0.722
CH3SiCl3	Methyltrichlorosilane	**183**	6.670	0.164	0.250
N2	Nitrogen	**013**	1.2503	0.2484	1.000
NO2	Nitrogen Dioxide	**026**	6.675	0.194	0.41
NF3	Nitrogen Trifluoride	**053**	3.173	0.178	0.434
N2O	Nitrous Oxide	**027**	1.98	0.206	0.206
O2	Oxygen	**015**	1.429	0.2183	0.996
O3	Ozone	**030**			
PH3	Phosphine	**031**	1.523	0.2607	0.688
C3H8	Propane	**089**	1.98	0.392	0.35
SiH4	Silane	**039**	1.438	0.3188	0.596
SiF4	Silicon Tetrafluoride	**088**	4.68	0.168	0.35
Si2H6	Disilane	**097**			
SO2	Sulphur Dioxide	**032**	2.91	0.149	0.67
SF6	Sulphur Hexafluoride	**110**	6.5	0.1590	0.27
TiCl4	Titanium Tetrachloride	**114**	8.465	0.22	0.30
C4F8	Octafluorocyclodutane	**129**			
SiHCl3	Trichlorosilane	**147**	6.047	0.130	0.348

APPENDIX B Exploded view of the AFC 50.D



	item	part number
Fitting		
Inlet fitting plate Male 1/4 VCR	2	Q2018535-03
Inlet fitting plate Male 1/4 VCR (AFC 50.61)	2	Q2018535-04
Inlet fitting plate Female 1/4 VCR MODUC	2	Q2018535-01
Inlet Fitting plate SW 1/4	2	Q2018535-02
Inlet Fitting plate SW 6 mm	2	Q2018535-06
Outlet fitting plate Male 1/4 VCR	20	Q2002203-02
Outlet fitting plate SW 1/4	20	Q2063131-01
Outlet fitting plate SW 6 mm	20	Q2063131-06
Seals (items 3, 12 , 13, 16, 19, 23)		
Viton seals kit		Q2002148-011
Neoprene seals kit		Q2002148-022
Kalrez seals kit		Q2002148-033
Bypass		
Bypass ring (24 holes)	5	Q2001598-01
Bypass tube ID:0.0mm	6	Q8088017489
Bypass tube ID:0.7mm	6	Q2001911-01
Bypass tube ID:1.0mm	6	Q2001911-02
Bypass tube ID:1.5mm	6	Q2001911-03
Spacer ring	9	Q2001555-01
Assy screen bypass	27	Q2002164-01
Covering screen bypass	27A	Q2002067-01
Valves		
Actuator base	7	Q2001628-02
Actuator cap	8	Q2001552-01
Spool hub and crown spring	11	Q2001946-01
Actuator assembly	14	Q2001814-01
Magnetic coil	15	Q2005584-01
Stem tip with viton O-Ring	17	Q2001882-02
Stem tip with neoprene O-Ring	17	Q2001882-03
Stem tip with kalrez O-Ring	17	Q2001882-04
Nozzle 0.5mm	18	Q2001696-02
Nozzle 0.8mm	18	Q2001696-03
Nozzle 1.5mm	18	Q2001696-04
Nozzle 2.5mm	18	Q2001696-05
Sensors		
Sensor assembly ID 0.4mm	22	Q2002032-01
Sensor assembly ID 0.7mm	22	Q2002032-02
Others		
Digital assembly ID 0.4	22	Q5180001
Digital assembly ID 0.7	22	Q2002113-01
Body	4	Q2001563-02
Digital Cover	30	Q2002090-01

APPENDIX C GENERAL MFC PRINCIPLES

Mass Flow Controllers (MFCs) are used wherever accurate measurement and control of a mass flow of gas is required independently of flow pressure change and temperature change in a given range.

Mass Flow Meters (MFMs) are used wherever accurate measurement of gas is required without control of the flow which is done by another device.

To help understand how an MFC works, it can be separated into 4 main components: a bypass, a sensor, an electronic board and a regulating valve :

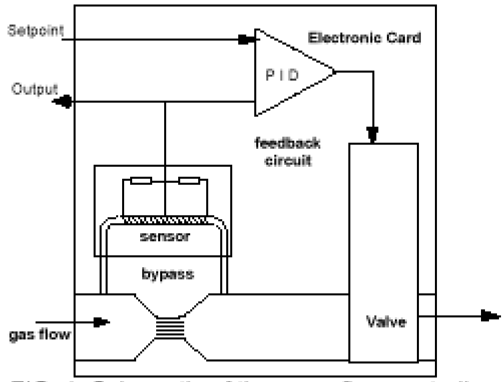


FIG. 1. Schematic of the mass flow controller.

The bypass, the sensor, and one part of the electronic board are the measurement side of the mass-flow controller and makes a Mass Flow Meter.

The regulating valve and the other part of the electronic board are the controlling side of the mass-flow controller and exist only on a Mass-Flow Controller.

So every Mass-Flow Controller includes a Mass-Flow Meter.

MEASUREMENT PRINCIPLES

The flow is divided between a heated sensing tube (the sensor), where the mass flow is actually measured, and a flow restriction or bypass, where the majority of flow passes.

The bypass is designed in a way that flow thru the sensor and thru the bypass is always proportional to the flow range for which the mass-flow is build.

The sensor is designed to deliver an output voltage almost proportional to the gas flow circulating thru it which is due to the bypass design proportional to the total flow circulating thru the mass-flow meter or controller.

The electronics board amplifies and linearizes the sensor signal so the output of the electronics board named “readout” gives a signal proportional to the total flow circulating thru the mass-flow meter or controller. Most of the time this signal is a 0-5 V voltage signal. 0 means “no flow” and 5 V means Full scale of the mass-flow. The full scale is the maximum flow for which the mass-flow is designed and calibrated to work with a good accuracy. It is always written on the stickers which are on the top of the cover and the side of the mass-flow stainless steel base. Also written on the sticker is the gas for which the mass-flow is calibrated to work with.

Why using a bypass ? Because the sensor element can only measure small flow (typically 5 sccm). So the bypass allow to measure greater amount of flow. On a 5 sccm full scale mass-flow, there is no bypass, all the gas flows thru the sensor. On a 100 sccm full scale mass-flow, the bypass is adjusted as when 100 sccm flow thru the mass-flow 5 sccm will flow thru the sensor and 95 sccm will flow thru the bypass.

SENSORS PRINCIPLES

Basically, the sensor uses the thermal properties of a gas to directly measure the mass flow rate. The sensor uses the basic principle that each gas molecule has a specific ability to pick up heat. This property, called the "specific heat" (Cp), directly relates to the mass and physical structure of the molecule and can be determined experimentally. The specific heat is well known for many gases and is generally insensitive to changes in temperature or pressure.

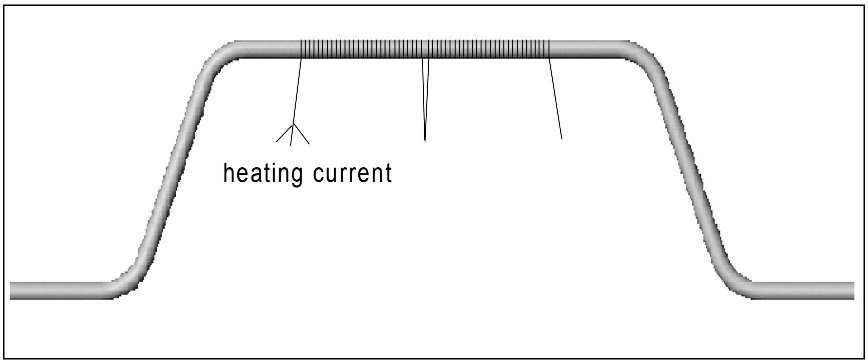
By adding heat to a gas and monitoring the change in temperature, the mass flow rate can be determined. To illustrate this concept, take the case of cool gas flowing through a heated tube. Mathematically, the heat loss can be described by the First Law of Thermodynamics,

$q = F.\ Cp\ \Delta T$

Where
q is the heat lost to the gas flow,
F is the mass flow,
Cp is the specific heat for a constant pressure,
ΔT is the net change in gas temperature as it traverses the tube.

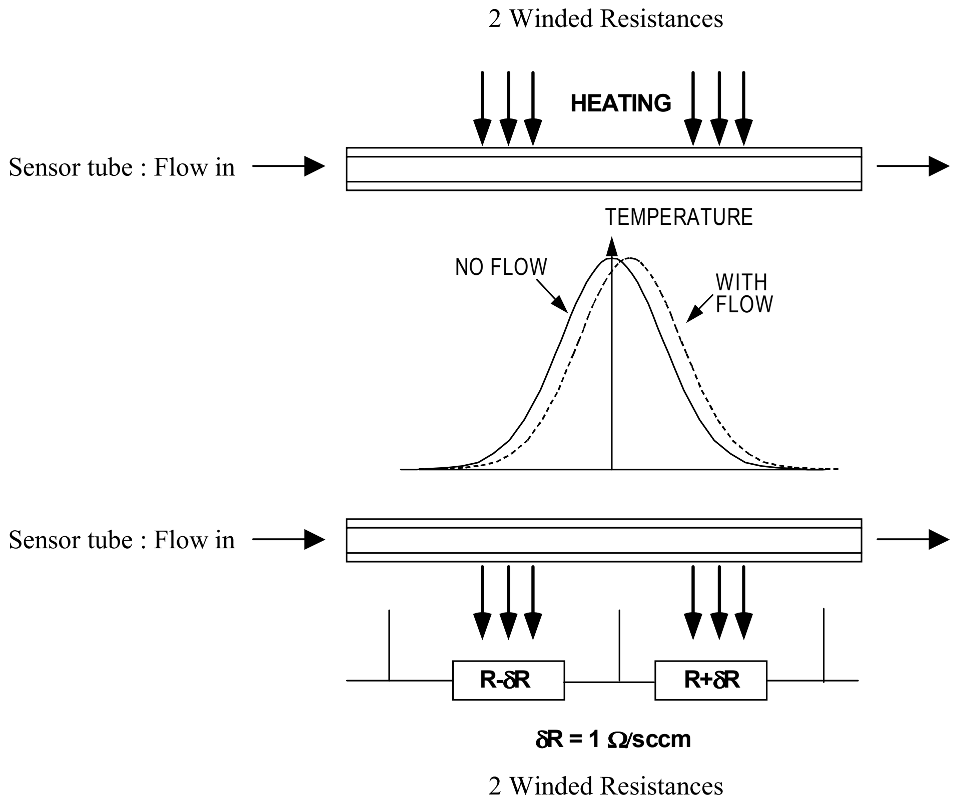
It is important to realize that both the specific heat and the flow rate determine the amplitude of the heat flux. As the mass and physical structure of molecules vary widely from gas to gas, so does the specific heat Cp. For the same molar flow rate, the heat flux can differ significantly for different gases. If this heat flux is monitored, the amplitude can be converted into an electrical signal. Given that the specific heat is known for the gas, then the mass flow rate can be determined directly from the electrical signal.

Now the MFC sensor includes capillary tube wound with two heated resistance and thermometers, measuring the change in temperature distribution created by the gas flowing inside this tube :



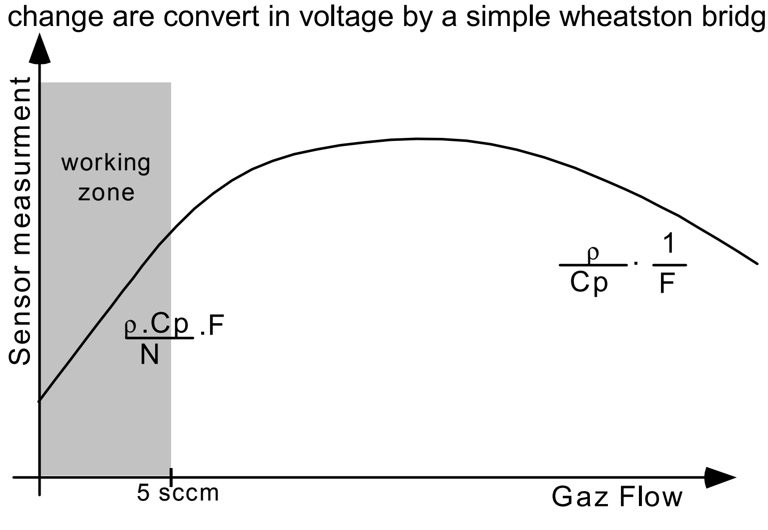
Sensor schematic

For zero flow, the upstream and downstream temperature will be equal. The windings are heated electrically to 80°C above the ambient temperature. When the gas is flowing, the upstream region cools down whereas the downstream region heats up causing a temperature gradient along, the length of the tube(see the sensor temperature profile figure).



Sensor temperature profile

The coils of the heating resistances are made with a thermal sensitive wire so that the temperature differences due to the flow are directly converted into resistances change. Those resistance change are convert in voltage by a simple wheatston bridge.



sensor response

For flow under 5 sccm the measurement is proportional to the flow with a coefficient which depends on :
ρ : Volumic mass of the gas
Cp : specific heat for a constant pressure,
N : “spin factor” Constant which depend of the molecular structure of the gas and compensates for the temperature dependence of Cp.

Value of N :
Monoatomic gas 1.04
Diatomic gas 1.00
Triatomic gas .94
Polyatomic gas .88

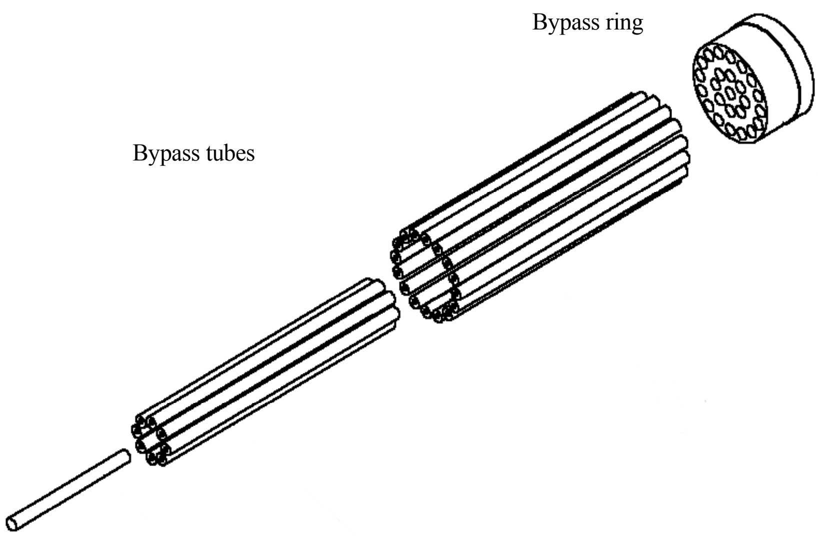
For flow higher then 5 sccm the sensor is first non linear then the measurement starts to decrease with flow because the gas flow is too fast and cool the 2 winded resistances instead of cooling the first one and heating the second one. This is the reason why bypass is necessary for higher full scale than 5 sccm.

Also the fact that the coefficients N and Cp are different from one gas to another explains why mass-flow can NOT be changed from one gas to another without using a special coefficient to converter the measurement or recalibrate the mass-flow.

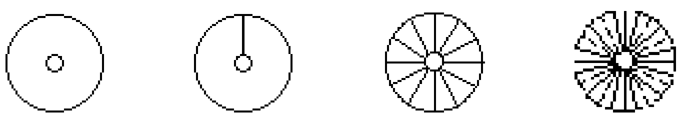
Because of sensor saturation, if flow is ten time the full scale, output will be almost “no flow”! This will never happen on a mass-flow controller as the valve of the mass-flow will act as a restriction and will not allow the gas to flow ten times the full scale. But it can easily happened on a mass-flow meter, as, if there is no restriction on the gas line nothing in the mass-flow meter will limit the gas flow.

BYPASS PRINCIPLES

Acting as a restrictive element, the bypass is composed of a series of capillary tubes (or bypass washers that also comes in different slot sizes for different flow range) held in a special bypass ring. The ring fits around the body and may hold up to 24 tubes. The number of tubes and their diameter depend on the customer’s specifications of gas type and flow range. For high flow rates the bypass tubes are replaced by a screen.



Bypass tubes



Bypass washers (equivalent to several thin tubes)

The bypass principles are based on the laminar flow theory : When flow is laminar, the flow is proportional to the differential pressure between inlet and outlet of the tube :

$$F_m = \rho .. \frac{\pi .. R^4}{8.\eta .. l} . (P_{up} - P_{down})$$

ρ : Volumic mass of the gas
η : Viscosity of the gas
l : length of the tube
R : radius of the tube

So when a sensor tube (radius Rs, length ls) and a bypass tube are in parallel (radius Rb, length lb), the flow in the sensor tube is proportional to the flow in the bypass :

$$F_s = \frac{R_s^4 . l_s}{R_b^4 . l_b} . F_b$$

However this is true only if the flow is laminar so if the tube are small enough. This is way bypass are made by several thin tube instead of only one tube.

It is important to notice that a mass-flow meter or controller measure the flow thru the sensor which is not the total flow but only one part of the flow split by the bypass according to last equation. In this equation radius of the sensor tube and bypass tube is at power 4. Consequently any deposition in one of the tube changing the diameter will change the accuracy of the measurement. Also because of the need to have a laminar flow, bypass tube and sensor tube may have clogging. This why mass-flow meter and controller must be used with clean, filtered gases.

CONTROL PRINCIPLES

The electronic compares the amplified mass flow rate value (measured by the sensor) to the desired set point. This comparison generates an error signal that "feeds" the regulating valve. The difference is used to drive the control valve. The control valve will proportionally open or close until the output is equal to the setpoint.

Note that valve can be normally open or normally close. This is the position that will have the valve when the mass-flow is not connected on power supply.

The valve can be actuated by a magnetic solenoid. Then it can be normally open or normally close and response time of the valve itself is almost instantaneous. In practise response time of the mass-flow controller is limited by the response time of the sensor. As sensor is based on thermal exchange it takes 1 to 5 s for the sensor to measure a gas change. Several techniques allows to increase this response time and allow to get on the best mass-flow response time bellow 5s.

The valve can be also made by a heating wire which heat a small tube then dilation will move a ball at the end of the tube. This kind of valve can be only normally open and is quite slow. Mass-flow controller using such valve will have response time around 5 to 6 s for flow bellow 5 slm and up to 10 s for flow up to 5 slm !! However this technology is simple and reliable and can be recommend for many low cost application when response time is not critical.