



AFC 202

QUALIFLOW Montpellier (headquaters)

350, rue A. Nobel
BP7- 34935 MONTPELLIER
CEDEX 9
France
tel: +33 4 67 99 47 47
fax: +33 4 67 99 47 48

QUALIFLOW Inc,

24 Goose Lane
TOLLAND CT-06084
CALIFORNIA - USA
tel: +1 860.871.92.33
fax: +1 860.871.92.33

QUALIFLOW Technology Center

909 Boggs Terrace
Fremont, CA-94539
CALIFORNIA - USA
tel: +1 510 440 93 74
fax: +1 510 440 93 75

QUALIFLOW NRT Korea

10 Block-17 Lot, Namdong Ind.
CLX. #623-16n Namchon-Dong, Namdong-Ku
KOREA
tel: +82 (0)2 3401 6491
fax: +82 (0)2 3401 6493

Identification					
Reference	D-10-032	Revision	00	Date	07/02/01
Document Name	User's Manual AFC 202				
File Name	AFC202 Manual.doc				

Control					
Author		Verified		Approved	
Visa	Date	Visa	Date	Visa	Date
Olivier Léonel	07/02/01	Pierre Navratil	07/02/01	Pascal Rudent	07/02/01

History				
Author	Date	Description	Revision	Status
Olivier Léonel	07/02/01	Initial Version	00	Issued

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SECTION 1 - INTRODUCTION

1.0 AFC 202: MASS FLOW CONTROLLER

This manual covers the massflow controller AFM 302 and also the massflow meter AFC 202.

QUALIFLOW Massflowmeters are rigid, accurate transducers which measure the massflow rate of a gas, calibrated in standard ranges in sccm or slm.

They include of a thermal flow sensor, a bypass assembly which is a laminar flow device that splits up the flow in order to achieve the required range and a p.c. board that contains the amplifier and the literaliser.

These items are built together upon a stainless steel base block. All metal parts which are in contact with the gas, are made of 316 type Stainless Steel, the seals are viton or neoprene (depending on the type of gas).

The output of the flowmeter is a linear signal, 0 to 5 VDC, directly proportional to the massflow rate.

Massflow controllers include the same units, but extended with a built-in, automatic control valve. An electronic circuit, that amplifies the difference between the output signal of the flowmeter and an external selected setpoint value, drives the valve in such a way that this difference is reduced to zero.

Massflow controller AFC 202 can be delivered with a normally open or normally closed valve. Fast and smooth control is secured by appropriate feed-back and speed-up arrangements. Both units have the same, rigid small housing, which is particularly suitable for compact, rational built gas systems, the more so as they can be mounted in any position.

1.1 AFC 202 : "USER's MANUAL"

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 AFC 202 without causing contamination, install the AFC 202 and check the installation before starting up.

Section 3. Adjustment.

Section 4. Maintenance.

Section 5. Trouble-shooting.

1.2 SPECIFICATIONS

Spec.	AFC-202
Input	$\pm 15\text{VDC} \pm 5\%$, 25mA $-15\text{VDC} \pm 5\%$, 180mA
Setpoint Signal	0.1 - 5 VDC
Output Signal	0 - 5 VDC
Respons time (typ)	4s

Repeatability	0,3% of Full Scale
Accuracy	± 1% of Full Scale
Gas T°. Range	5 - 40°C
T° coefficient	less than 0.1%/°C
Gas Pressure	10 at max.
Minimum differential gas pressure	1.5 bar for 30 slm F.S. 2 bar for 50 slm F.S. 2.5 bar for 100 slm F.S. 3 bar for 200 slm F.S.
Pressure Coefficient	0.1%/atm (typ)
Leak Rate	<2.10 ⁻⁹ scc/sec.

Specifications values.

Note : AFC and AFM are delivered with viton® seals except NH3 mass-flow which are delivered with neoprene seals. Please contact your local representative for other kind of seal material.

1.3 CALIBRATION FEATURES

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

1.3.0 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

Dynamic adjustment : no overshoot

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

1.3.1 MANUFACTURING ENVIRONMENT

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

1.3.2 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

This four part section contains all the information necessary to install the AFC 202.

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

2.1 UNPACKING

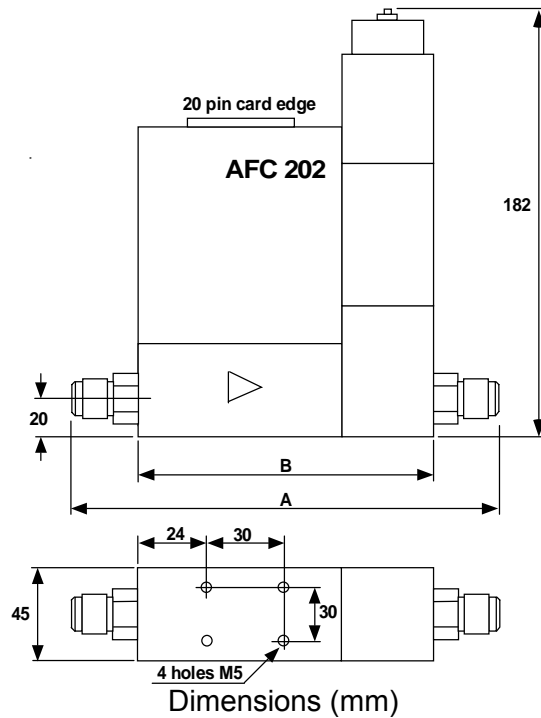
The AFC 202 mass flow controller are manufactured under clean room conditions, and has been packed accordingly upon receipt. The cardboard packing should be checked for damage. If there is visible damage, please notify your local QUALIFLOW sales office at once. In order to minimize contamination of clean 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 siting 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 AFC 202 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 below. 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.



	AFC 202		AFM 302	
	VCR 3/8" MM	SWAGELOCK 3/8"	VCR 3/8" MM	SWAGELOCK 3/8"
A (mm)	181.4	183.3 (incl. Nuts)	141.9	143.8 (inc. nuts)
B (mm)	123	123	83.5	83.5

2.2.1 INSTALLATION

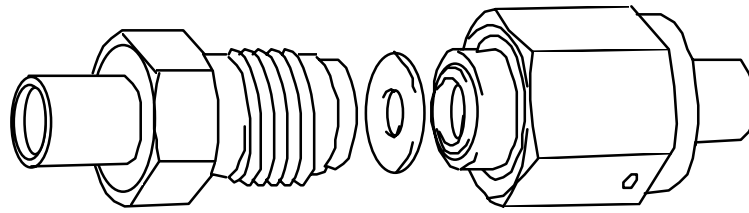
WARNING: Toxic, corrosive or explosive gases must be handled with extreme care. After installing the mass flow controller, the system should be thoroughly checked to ensure it is leak-free. Purge the mass flow controller with a dry inert gas for one hour before using corrosive gases.

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.

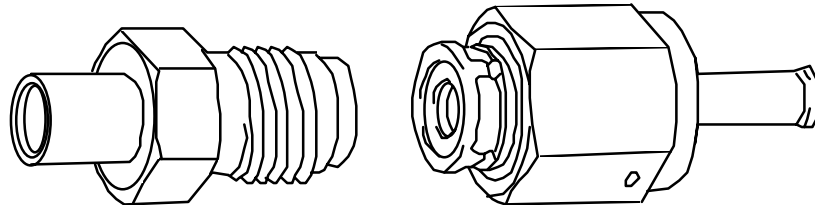
2.2.1.1. VCR COMPATIBLE COUPLINGS

The AFC 202 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.

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 below.
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

VCR compatible couplings

2.3 ELECTRICAL INSTALLATION

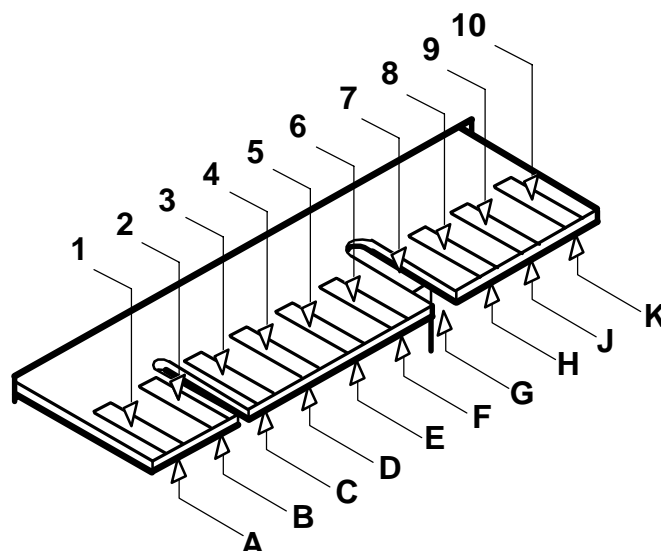
2.3.0 GENERAL

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

- Connections.
- Pressure control.
- Ratio control.

2.3.1 CONNECTIONS

The AFC 202 includes a cardedge connector.



1 Case Ground

A Control Input 0.1 – 5 VDC (AFC 202 only)

2 Common

B Common valve ***

3 Output O – 5 VDC	C Common
4 +15 VDC	D Valve test point; Soft start connection *
6 Zener Test Point	F –15 VDC
7	J Sensor Up-stream **
8	K Sensor Common **
9	L Sensor Downstream **
10	Extra Output

Notes: * 1. Soft start connection.

**2. Not available in earlier PC boards.

***3. Valve common is jumpered to C. Remove this jumper (J 3) and use separate common is advise every time it is possible.

4. Any DC voltmeter or recorder can be used to visualize the output signal. Input impedance should be at least 5000 ohms.

5. The control Input signal should be from any voltage source with maximum impedance 2500 ohms.

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.

SECTION 3 – ADJUSTEMENT

3.0 REQUIRED FACILITIES

To do any adjustment, cleaning or replacement on massflow equipment, appropriate tools and facilities must be present, as these are high accuracy transducers.

The facilities are:

1. An accurate reference massflow measuring system or a flow meter.(note the pressure and temperature corrections). Normal rotameters are not accurate enough. The only suffice when relative rough measurements or flow monitoring are necessary.
2. A clean room, clean tools.
3. A voltmeter (at least 1000 Ω/V).
4. Supply of gas, preferably N2 for safe working.

3.1. POTENTIOMETERS ADJUSTMENT

To gain access to the p.c. board, carefully remove the cover from the body. Every flowmeter and –controller is calibrated at the factory for a particular gas and flow range, as indicated on the top sticker, within $\pm 1\%$. If any adjustment is necessary, a reference measuring system with at least the same accuracy should be used.

1. To remove containment's, the unit must be flushed and dried with nitrogen.
2. Apply power to the unit and monitor the output signal. Obey a warm-up time of about 20 minutes.
3. With no flow (caps on in- and outlet fittings) adjust the ZERO potentiometer R3 of the unit to obtain a readout on the unit between 5 mV and 15 mV. For normally close version, set zero to obtain a readout between 20mV and 40 mV to prevent heating up of the magnet with zero setpoint.

Caution : Be careful to avoid contact between the valve connector and the sensor connector close to the zero potentiometer : This will destroy the transistor BC107B. When this transistor is damaged the readout stay at the same value even with gas flow.

4. Apply gas to the inlet fitting and put the reference flowmeter in series. If your reference flow meter is a flow controller you need to let the valve fully open : for that, disconnect the valve wires of your reference flowmeter if it is a normally open valve or connect pin C and D of your reference flowmeter if is a normally close valve.
5. Calculate Vref at full scale :

$$V_{ref} = \frac{C_{ref}}{C_{unit}} * \frac{F_{unit}}{F_{ref}} * 5.00$$

Where:

C_{ref} is the conversion factor of the calibration gas.

C_{unit} is the conversion factor of the gas that the unit will control.

F_{unit} is the full scale value of the unit.

F_{ref} is the full scale value of the reference flow meter.

Example 1 (complicated):

Unit to calibrate : 30 slm Oxygen

Reference flow meter : 50 slm Nitrogen / calibration gas : Nitrogen

$$C_{ref} = 1$$

$$C_{unit} = 0.996$$

$$F_{unit} = 30 \text{ slm}$$

$$F_{ref} = 50 \text{ slm}$$

$$\text{then } V_{ref} = 3.012 \text{ V}$$

Example 2 (simple) :

Unit to calibrate : 200 slm nitrogen

Reference flow meter : 200 slm Nitrogen / calibration gas : Nitrogen

$$C_{ref} = 1$$

$$C_{unit} = 1$$

$$F_{unit} = 200 \text{ slm}$$

$$F_{ref} = 200 \text{ slm}$$

$$\text{then } V_{ref} = 5.00 \text{ V}$$

6. Full scale adjustment : Apply a 5.00 VDC setpoint to the unit (i.e. ask to the unit to regulate at 100% of the full scale). Then look at the readout given by the reference flow and compare it to V_{ref} . Previously calculated.

if the readout given by the reference flow = V_{ref} the gain is well calibrated

if the readout given by the reference flow is slightly different from V_{ref} (difference is less than 3% of V_{ref}) the full scale adjustment can be done electronically only with the the gain potentiometer : Go to step 11.

if the readout given by the reference flow is very different from V_{ref} (difference is more than 3% of V_{ref}) the bypass need to be adjusted before any electronic adjustment : go to next step.

7. Previously to adjust the bypass put the linear potentiometer and the gain potentiometer to half of their stroke (both potentiometers are 15 turns models).
8. Adjust the bypass :
9. First remove the inlet fitting with a 1" wrench to access the bypass : (the bypass is a preadjusted assembly which can be removed and reinstalled with the use of a screwdriver. It consist of a stainless steel grid cylindrical net with a Kel-f plug inside. By adjusting the position of the kel-f plug the grid allow less or more the flowing of the gas).

10. Adjust the bypass by pushing the Kel-f plug inside the bypass if the ref flow is lower than the full scale of the unit. Or you need to pull the Kel-f plug inside the bypass if the ref flow is higher than the full scale of the unit.
11. To push the bypass just push the plug slowly with a special tool and a hammer.
12. To pull the bypass dismount the bypass with a screw-driver and push the plug by the backside.
13. Assemble again the bypass, the inlet fitting in the gas line and come back to step 7.
14. Turn the gain potentiometer until you get V_{ref} on the readout of the reference flow meter. If you can not get the V_{ref} on the readout of the reference flow meter, than the bypass need to be readjusted : come back to step 8.
15. Linearity adjustment : Apply a 2.50 VDC setpoint to the unit (i.e. ask to the unit to regulate at 50% of the full scale). Then look at the readout given by the reference flow and compare it to half of V_{ref} calculated at step 6.
16. The readout of the reference flow meter should be equal to half of V_{ref} . If not, adjust the LINEARITY potentiometer R29 to get half of V_{ref} on the readout of the reference flow meter.
17. Check again the ZERO as explained in step 3. the gain potentiometer as explained in step 11 and the linearity potentiometer as explained in step 12. Check the 3 potentiometers neither of the 3 need to be adjusted.

3.2 VALVE ADJUSTMENT

4.2.0. NORMALLY OPEN VALVE

In this valve version, there is a screw and a locknut on the top of the magnet.

Adjustment:

1. Remove electrical connector.
2. Connect a reference flow meter before the unit.
3. Apply inlet gas pressure to : 1.5 bars for 30 slm, 2 bars for 50 slm, 2.5 bars for 100 slm and 3 bars for a 200 slm full scale.
4. Adjust screw until desired flow is reached. Lock with nut.

4.2.1. NORMALLY CLOSE VALVE

There is normally few external valve adjustment necessary on the normally close version however :

1. Connect the unit to gas supply
2. Adjust setpoint to 5.00 V (100% full scale).
3. Apply inlet gas pressure to maximum working pressure required for application.
4. Check that the power supply of the valve when flow is stable is between 8 and 10 V.

If not :

1. Switch of the gas
2. Remove screws 41, magnet 25A.

3. Adjust the spring 6 by turning ring 31 across the crown spring of the top ring 29.
4. Put magnet 25A, then screw the threaded rods 39 and nuts 41
5. Apply inlet gas pressure to maximum working pressure required for application.
6. Check that the power supply of the valve when flow is stable is between 8 and 10 V. If not come back to step 5.
7. Connect a reference flow meter before the unit.
8. Remove electrical connector.
9. Check the valve closing is good : less than 2% of the flow ie less than 100 mV on the readout of the reference flow meter. If not disassemble the valve and assemble it again.
10. If the magnet (step 6) or the whole valve (step12) have been dismantled leak test must be performed.

3.3 CHANGE OF CALIBRATION

3.3.0. NORMALLY OPEN VALVE

Follow 4.3. "Valve adjustment", then 4.2 "Potentiometers adjustment"

3.3.1. NORMALLY CLOSE VALVE

Follow 4.2 "Potentiometers adjustment", then 4.3. "Valve adjustment".

3.4 DYNAMIC RESPONSE ADJUSTMENT

Transient response is adjusted by C6, C3, R24, R11. However AFC 202 is working with high flow and overshoot phenomenon can be critical. So it is not recommended to change the factory adjustment. Contact you local supplier for special application.

SECTION 4 – MAINTENANCE

4.0 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 N₂ 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.

4.1. 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.

4.1.0 DISASSEMBLY PROCEDURE

0. Remove any mounting plate that may be under the mass-flow.
1. Unscrew in- and outlet-fittings 7 and 8 with a 1" wrench.
2. Unscrew 14 and remove the cover 19.
3. Remove the sensor-screws 15 with a 2.5mm hex screw driver, after having the lead wires unsoldered from the p.c. board. Handle the sensor 2 with care.
4. Remove the screw 33 in the bottom of the valve.
5. Unsolder the magnet actuator wire from the pc board, then remove the 4 screws which hold the magnet to valve body. Then carefully lift the magnet. Do not turn the mass-flow controller now.
6. Carefully remove the top housing 24 with the bellows and plunger assembly from the valve housing 23. Then carefully unscrew the lower bellow.
7. Remove the 4 screws 9 in the top of the top housing 24 which hold the top ring assy 29. Then remove the bushing 32.

Note: If o-rings are dirty, cut or cracked, they have to be exchanged with appropriate new, clean ones.

4.1.1 ASSEMBLY PROCEDURE

First mount sensor, inlet and outlet fittings.

Caution : The sensor capillary sometimes extends beyond the seals o-rings. When positioned on the base without verifying that capillary ends fit in the holes in the base, the capillary can be bend or damaged. Therefore, center the sensor by means of the mounting screws, hold it up and then fasten the screws.

Normally open valve

1. Check the quality of the contact between 3/8" ball and its seat on top housing 24. Both parts should be polished without any scratch.
2. Place upper bellow 40 in top housing 24.
3. Select number of washers M3, crown spring 30 and ball, so that the end of the stem of the upper bellow assy is 1 to 1.5 mm below top surface of the top housing (with ball on the seat).
4. Select now place of the crown spring between the washers so that when the crown spring is on its seat, the ball is lifted halfway the space adjusted in step 3 (0.5 to 0.75 mm).

Note : keep ball, washers and crown spring together with nut M3.

5. Now, lengthen carefully the upper bellow so that it just contact the crown spring.
6. Mounting assy in top housing.
7. Place spring 6 over the upper bellow. Add spring adjustment ring 31 and screw these over half way the thread length.
8. Place the O-ring over the upper bellow and put in place in the top.

Caution : The O-ring must be very clean (clean with alcohol if necessary) without any scratch. Same think for its chamber in the top housing. If not, very small leak may occur and with time full the top housing with high pressure with consequence that the valve will stay permanently in open position.

9. Place bushing 32, topring 29 and the 4 M3 screws 9, do not yet tighten.
10. Preparing lower bellow assy : Be assured there is no gap between bellow and and the part screw at the bottom. Unscrew and counter sunk the bellow part as necessary.
11. Now, screw and tighten the lower bellow to the stem, coming out the top housing (remove first the M3 nut putted during step 4).
12. Press on the stem, so to center the ball into the seat, then tighten the 4 screws 9. Tight the screws together in order to keep the inner assy in its centered position.
13. Adjust the lower bellow lenght at 47.5mm as when it will be mounted into the housing 23 it should not be compressed or extended.
14. Assemble top housing 24 to the housing 23 with O-ring 37 on bellow assy and O-rings 36 and 38 on top housing but without magnet in place for first leak test of the O-ring 26.

15. Assemble top housing now with O-rings 36 and with magnet in place.
16. Adjust valve according the normally open valve adjustment procedure then test the valve.
17. Do final leak test

Normally close valve

1. Check the quality of the contact between 3/8" ball and its seat on top housing 24A. Both parts should be polished without any scratch.
2. Place upper bellow 40 in top housing 24A and adjust bellow by pulling or pushing so that the top of the upper bellow stem 40 is adjusted to the top of the housing 24A.
3. Remove upper bellow 40.
4. Place washers M3 27 over stem and place crown spring 30. Add washers that crown spring 30 just touches the bottom of the bellow assy (+/- 0.5 mm). (Normal value : 3 washers of 0.8 mm).
5. Place the assy 40 (up side down) in top housing 24 and put on solid surface (seat up). Now place ball over the stem from 40 with ball O-ring groove faced to the seat. Look for contacting ball to seat. And measure the exposed end of M3 from the stem (length is A).
6. Disassemble again. Place now the ball 29 over the stem (same way as above) and screw a M3 nut on the stem. Adjust nut to the same dimension as A.
7. Measure space B between crown spring and ball. Disassemble ball and nut M3.
8. Prepare a package of small washes M3 27 to a thickness B. (Normal value : 6 washers of 0.8 mm. May be necessary to put 5 0.8mm + 1 0.5mm or 5 0.8mm + 2 0.5mm).
9. Mounting assy in top housing.
10. Place spring 6 over the upper bellow. Add spring adjustment ring 31, screw these over half way the thread length.
11. Place the O-ring 26 over the upper bellow and put in place in the top housing.
Caution : The O-ring 26 must be very clean (clean with alcohol if necessary) without any scratch. Same think for its chamber in the top housing. If not, very small leak may occur and with time full the top housing with high pressure with consequence that the valve will stay permanently in open position.
12. Place package washers B, O ring 28 and the ball over the stem and place M 3 nut to prevent dropping of the parts.
13. Place bushing 32, topring assy 29 and the 4 M3 screws 9, do not yet tight.
14. Preparing lower bellow assy: Be assured there is no gap between bellow and the part screwed at the bottom. Unscrew and counter sunk the bellow part as necessary.
15. Now, screw and tighten the lower bellow to the stem, coming out the top housing (remove first the M3 nut puttied during step 12).
16. Adjust the lower bellow at 47.5mm as when it will be mounted into the housing 23 it should not be compressed or extended.

17. Assemble top housing to the housing 23 with O-ring 27 on bellow assy and O-rings 36, 38 but without magnet in place for first leak test of O-ring 26. Do not forget the snap ring on the top of the upper bellow stem 40.
18. Assemble top housing with magnet in place. Do not Install the O-rings 36 with inert gas.
19. Test valve.
20. Do final leak test.

Note : For leak testing of the AFC 202 normally close it is necessary to put power on it to open the valve or pumping down from inlet and outlet side at the same time.

4.2. 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 $\Omega R = R2 - R1$ must be less than $\pm 1 \Omega$. Check also that there is no short-circuit between the tube and the red wire.

Examine the sensor seals, and replace when damaged.

4.2. VALVE CLEANING AND REPLACEMENT

After having disassembly the valve, the status of the shut-off ball and the seat in the top housing can be examined. The shut-off ball can be cleaned with alcohol, freon or even a HF solution (5% HF, 95% deionised water).

The conical seat and the ball can be treated with solvent and a felt tip. If appropriate polishing equipment is available, the seat and shut-off ball can be polished.

After polishing, the parts must be cleaned.

If the critical parts are unfortunately corroded or attacked too much, replace.

Afterwards, follow assembling instruction and adjustment instruction.

SECTION 5 - TROUBLESHOOTING

5.0 INITIAL CHECK.

1. Check the set-up and procedure against installation instructions. Permanent damage to the unit may result if purging procedures are not followed, or if a line power is accidentally applied to the signal leads.
2. Test line cord for compliance with pin assignment, and continuity from all wires to correct pins. Use hipot tester to check for any pin-to-pin shorts ; during this test, flex the cable coming out of the connector to find intermittent shorts.
3. Check insulation resistance from pins to base. All except pin 1 should exceed 50 M Ω at 50 VDC. Pin 1 to base should measure less than 1 Ω .

5.1 SYMPTOMS.

Symptom	Possible Cause	Remedy
No output	Faulty meter No actual Flow Sensor clogged Valve closed Electronics failure Faulty power supply	Read output at pins 3 and 2 directly with alternate meter. Check pressure, valve positions line or filter blockage. Follow Sensor Cleaning Maintenance Follow Valve Cleaning Maintenance See below Check input / output voltages (± 15 VDC, +5VDC).

Symptom	Possible Cause	Remedy
Maximum signal (between 150% and 200% of full scale)		Check valve voltage as measured across valve lead wires. Valve should close when voltage rises to 14 Volt for normally open and valve should open when voltage rises to 14 volt for normally close.
a) Indication correct: flow is high	Valve defective	
b) Indication erroneous	Open resistance on sensor element Electronics failure	Replace sensor See below
Signal offset at zero flow Valve will not close	Electronics not adjusted Contamination Electronic failure Mechanical damage from overpressure or other cause	Follow Potentiometers Adjustment procedure Follow General Maintenance or Valve Cleaning/Replacement procedure See below Adjust valve (Valve Adjustment procedure) or replace valve (Change of Calibration procedure)
Valve will not open	Operation on wrong gas (often the case when tested with H ₂ , He or Ar). Contamination Electrically commanded closed or potentiometer	Test on proper gas Follow General Maintenance or Valve Cleaning/Replacement procedure Check command signal (pins A and B) and pot.

Valve controls at higher flow rates, but not at minimum	shorted.	Check for electronics failure
	Clogged inlet fitting screen, appearing as closed valve.	Clean filter screen.
	Contamination Erosion or corrosion, improper adjustment or inadequate drive	Follow General Maintenance or Valve Cleaning/Replacement procedure Follow Valve Cleaning/Replacement procedure Adjust valve (Valve Adjustment procedure)

Symptom	Possible Cause	Remedy
Valve oscillate or hunts	Jumpy pressure regulator Improper system dynamics due to excessive inlet pressure. Improper dynamics in electronics.	Replace Reduce upstream pressure regulator setting See Dynamic Response Adjustment.
General failure or miscalibration	Power supply voltage not nominal	Check +15 VDC, -15 VDC and +5.00 VDC
Flow indication saturated (0.7 or +12 VDC) regardless of flow	Bridge or sensor failure Component Failure	Check sensor resistance Voltage Yellow to common (8 to 10 VDC) Pin 6 to common should read -6.2 ± 2 VDC. Check R3, R9, other- components and solder joints.
Valve drive open or saturated	TS2 open or short, IC LM-324 failed.	Check TS2, LM-324 and other components.
All circuit functional but out of calibration	Contamination, or as a result of cleaning or repairing.	Adjust (see Adjustment procedure)
Unit controls but output voltage does not agree with potentiometer setting	+ 5.00 VDC not nominal Large input voltage offset in Op Amp A. C6 leaks	Check supply. Adjust if necessary. Check and replace if necessary. Replace.

SECTION 6 - WARRANTY AND SERVICES

6.0 PRODUCT WARRANTY

1. Qualiflow products are guaranteed against defects in materials and workmanship for a period of one year from the date of shipment, if used in accordance with specifications and not subject to physical damage, contamination, alteration or retrofit.
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.
 - iii. Differential pressure must be less than 3 bars for the MFC valve to regulate without gas-flow oscillation.
 - 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 VCR gland must be handled carefully. Qualiflow guarantees that all glands 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 dismantled: the MFC warranty will be invalidated if the seal between the MFC block and cover is torn.

6.1 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.

APPENDIX A PART NUMBER DESCRIPTION

[t, t, t] [v] [s] [f, f] [r, r, r, r] [g, g, g] [m] - [o, o]

[t]- Type

- [100] for AFM 10
- [260] for AFC 260 or AFM 360
- [261] for AFC 261 or AFM 361
- [202] for AFC 202 or AFM 302
- [500] for AFC 50 or AFM 55
- [700] for AFC 70
- [800] for AFC 80 or AFM 85
- [900] for AFC 90 or AFM 95

[v]- Valve Configuration

- [N] for No valve (only for AFM)
- [O] for Advanced Flow Controller Normally Open
- [C] for Advanced Flow Controller Normally Close

[s]- Seals

- [V] for Viton
- [N] for Neoprene
- [K] for Kalrez
- [M] for Metal

[f, f] Inlet and Outlet Fittings

- [SB] for B-SEAL - [SC] for C-SEAL
 - [SW] for W-SEAL - [SZ] for Z-SEAL
- Or specify first Inlet, then Outlet.
- [F] for 1/4" VCR Female - [B] for Swagelok 1/8"
 - [M] for 1/4" VCR Male - [C] for Swagelok 1/4"
 - [L] for 1/4" VCR High Flow Male - [G] for Swagelok 6mm
 - [N] for 1/4" VCR High Flow Female - [H] for Swagelok 3/8"
 - [D] for 3/8" VCR Female - [K] for 1/8" BSPP (AFM 10 only)
 - [E] for 3/8" VCR Male

[r, r, r, r]- Flow rate

Specify C for sccm, L for slm.

Example :

- 200C for 200 sccm
- 030L for 30 slm

[g, g, g]- Gas Process

See chart on the left page

[m]- Mounting Position

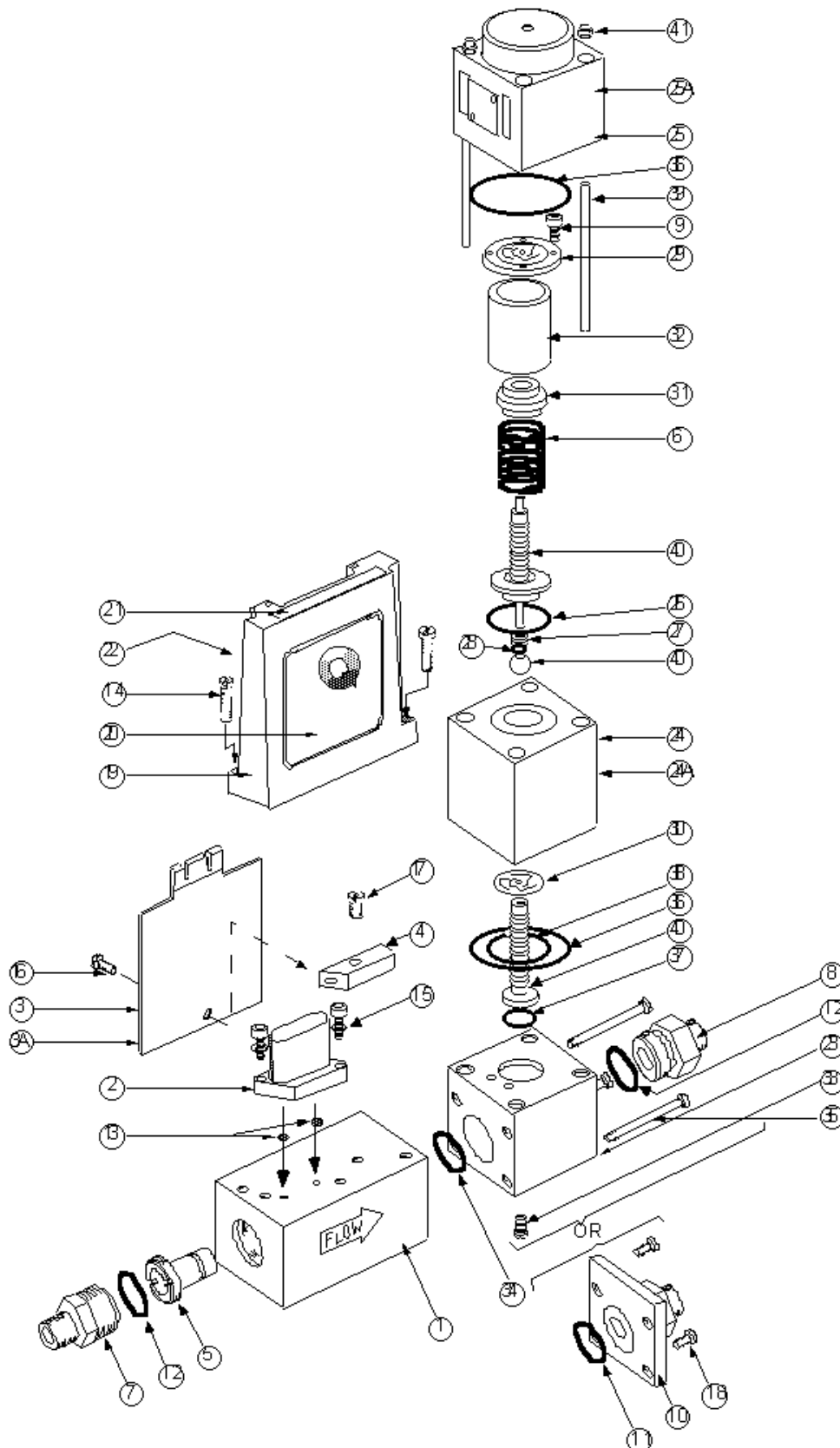
- [H] for Horizontal
- [U] for Vertical Inlet Up
- [D] for Vertical Inlet Down

[o, o]- <u>Options</u>	AFC 260		AFC 261		AFC 202		AFC 50		AFC 70/80/90	
	AFM 360	AFM 361	AFM 361	AFM 302	AFM 302	AFM 55	AFM 55	AFM 10	AFM 85/95	AFM 85/95
- [L] for Low Delta Pressure	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
- [S] for Separated Electronics	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
- [E] for External Readout	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
- [D] for Digital Card	✓	✓	✓	✓	✓	✓	✓	✓	Standard	Standard
- If Digital [N] for DeviceNet	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
[R] for RS485 / MODBUS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
[x] for nb of calibr. curves	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
- [61] for AFC 50 compatible AFC 261	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
- [P] for Special Pitch	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
- [T] for Low Temperature Sensitivity	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
- [A] for High Accuracy	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
- [B] for Brass body	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
- [C] for Signal 4 to 20 mA	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
- [M] for Power Supply +24 VDC	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

APPENDIX B 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	Octafluorocyclobutane	129			
SiHCl3	Trichlorosilane	147	6.047	0.130	0.348

APPENDIX C EXPLODED VIEW OF THE AFC 202



Item	qty	Description	PN
1	1	High flow meter base	580812011.11
2	1	Sensor Assy	997200000
3	1	P.C. Assy	Q5180001.**.04.
4	1	Plate print	580812062.11
5	1	Bypass assy	280812030.00
6	1	Spring	800100204
7	1	Intlet fitting 3/8" sw	2055880-02
7A	1	Intlet fitting 3/8" VCR	2055880-01
8	1	Outlet fitting 3/8" sw	500210005
8A	1	Outlet fitting 3/8" VCR	800211203
9	1	Screw M3x8 hex head	
10	1	Fitting plate assy AFM 302 sw	-
10A	1	Fitting plate assy AFM 302 VCR	-
11	1	O-ring 25x2 (Viton)	-
12	2	O-ring 910 (Viton)	808092028
13	1	Sensor seal (Viton)	580212030.11
14	2	Screws M3x16 pan head	
15	2	Screws M3x10 Hex head	
16	1	Screws M3x5 pan head	
17	2	Screws M4x10 hex head	
18	4	Screws M5x10 hex head	
19	1	cover	580213020.11
20	1	Sticker name plate	
21	1	Sticker gas range & S/N	
22	1	Sticker pin assignment	
23	1	Valve housing 1	580810230.11
24	1	Valve top housing Normaly.Open.	580810180.11
24 A	1	Valve top housing Normaly.Close.	580810180.21
25	1	Magnet actuator Normaly.Open.	500600001.NO
25A	1	Magnet actuator Normaly.Close.	500600001.NC
26	1	O-ring 20x2 Viton	808092043
27	x	Adjustment washer M3	
28	1	O-ring 3x1 viton	808092040
29	1	Assy top ring	580810200.11.assy
30	1	Crown spring	580810040.11
31	1	Spring adjustment ring	580810190.11
32	1	Bushing 1	580810210.11
33	1	Screw M3x5 pan head	
34	1	Oring 25x2 viton	808092044
35	4	screw M5x50 hex head	
36	2	Oring 37x2 viton	808092045
36A	0	Do not use on normaly close.	
37	1	Oring 904 viton	808092031
38	1	Oring 16x2 viton	808122001
39	4	Threated rod M5x120	717Q001.**.02
40	1	Assy inner valve 202	580810240.00
41	4	nut M5	

APPENDIX D 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 :

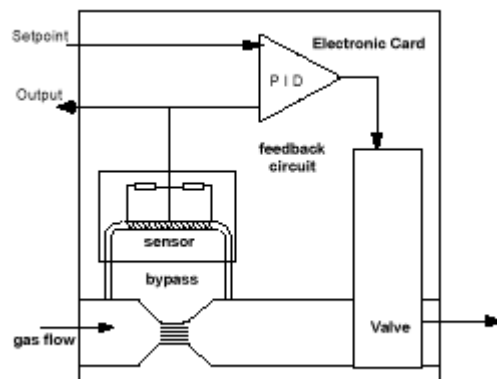


FIG. 1. Schematic of the mass flow controller.

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" (C_p), 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,

$$q = F \cdot C_p \Delta T$$

Where

q is the heat lost to the gas flow,

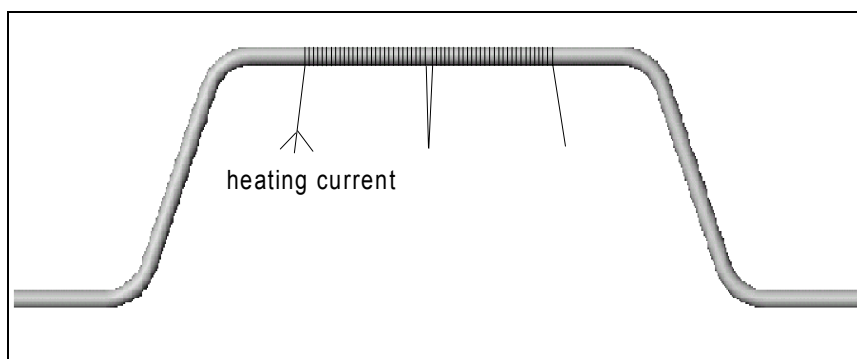
F is the mass flow,

C_p is the specific heat for a constant pressure,

ΔT is the net change in gas temperature as it traverses the tube.

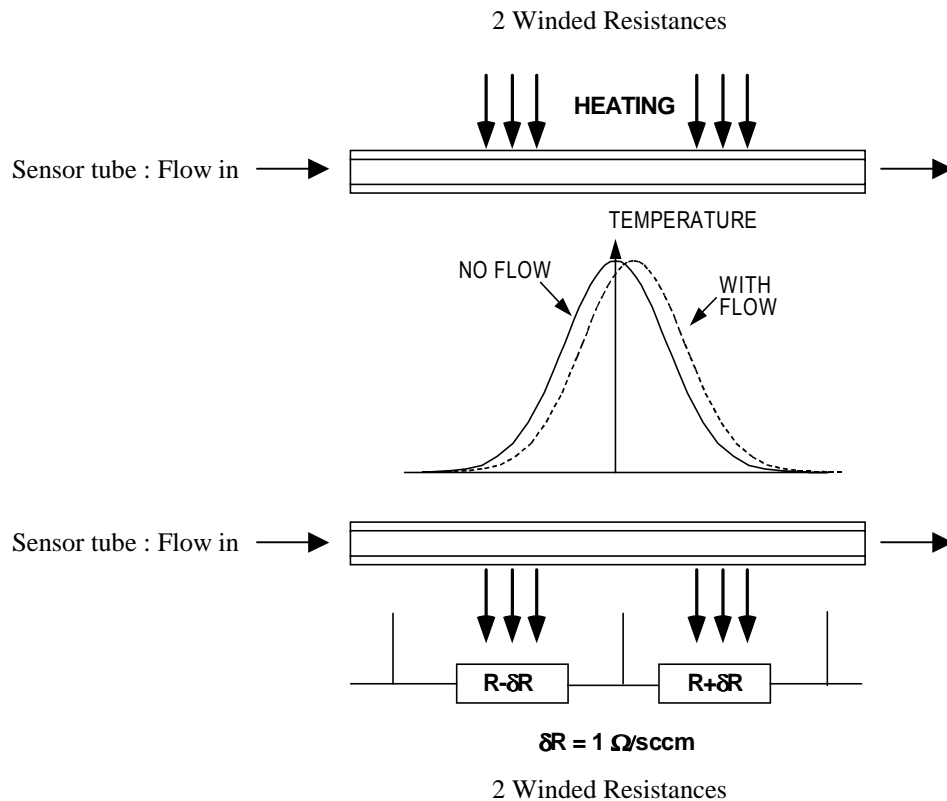
It is important to realize that both the specific heat and the flow rate determine the amplitude of the heat flux. As the mass and physical structure of molecules vary widely from gas to gas, so does the specific heat C_p . For the same molar flow rate, the heat flux can differ significantly for different 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 :



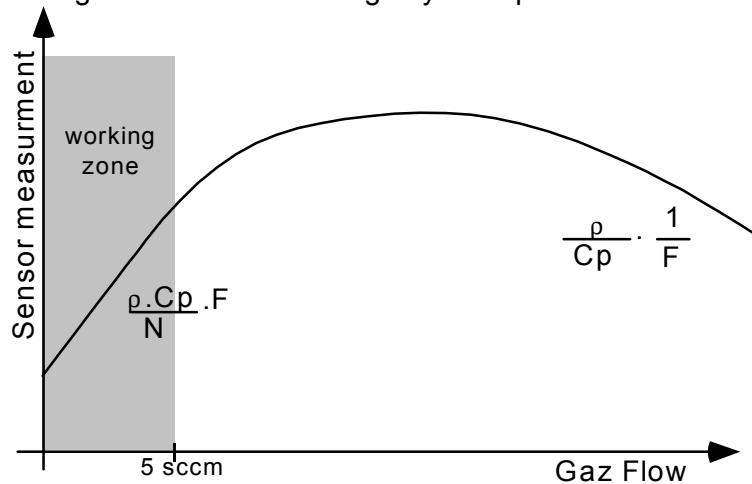
Sensor schematic

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 resistance change. Those resistance change are converted into 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

C_p : 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

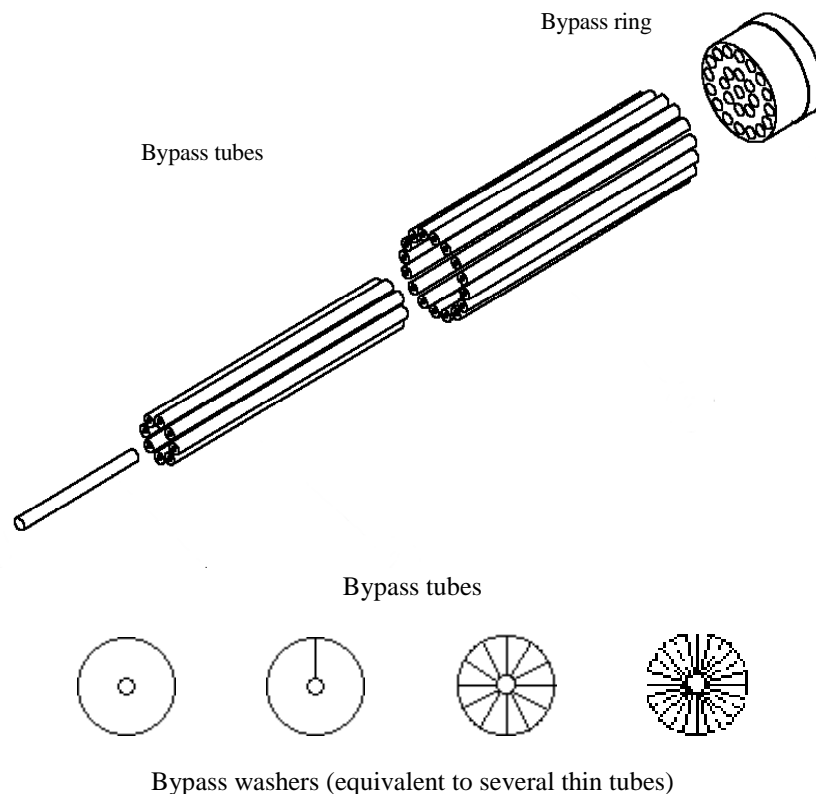
For flow higher then 5 sccm the sensor is first non linear then the measurement starts to decrease with flow because the gas flow is too fast and cool the 2 winded resistances instead of cooling the first one and heating the second one. This is the reason why bypass is necessary for higher full scale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



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 :

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

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 R_s , length l_s) and a bypass tube are in parallel (radius R_b , length l_b), the flow in the sensor tube is proportional to the flow in the bypass :

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

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.