qualiflow

QUALIFLOW Multicalibration
Mass Flow Controllers

1 Introduction

1.1 Analog MFCs

Analog MFCs are calibrated for one Full Scale and one gas by the manufacturer. If the user wishes to modify the process or change the Full Scale setting, the MFC has to be removed and replaced by another one. A purge of the system is also necessary. This modification is time consuming, expensive and inconvenient.
To obtain the optimal accuracy and results, the MFC needs to be operated close to its Full Scale.
For an analog MFC, the accuracy is a direct function of the Full Scale, it is common for typical specs to state: accuracy = ±1% Full Scale. This value is acceptable when the setpoint is close to the Full Scale. But when the setpoint is set at the low end of a specific calibration, the accuracy and linearity are degraded considerable. Therefore, 2 MFCs with different Full Scale will be required to maintain the accuracy, one for the low flow and another for the high flow.
This requires larger stocking levels and expense in order to cover full spares support.

1.2 Digital MFCs

With the digital MFCs, a new area is opened. The introduction of digital electronics provides new enhances features which were not available before.
Typically, up to 5 different curves are stored in one MFC (actually, a maximum of 10 curves can be stored, but this depends on the gases) , data acquisition and diagnostic functions are part of these advantages.
The Qualiflow MFC data acquisition function downloads every x seconds (x being adjustable), setpoint, valve voltage and readout to an Excel File. The data are accessible and can be read during the normal operation of the MFC without stopping the process. Maximum is 500 samples. So, total time depends on the acquisition period.

Example:
period = 1 second à total time = 8 min 20 sec
period = 1 min = 1 min à total time = 8 hours 20 min
and so on

Note: Never erase the history during a process

Our digital electronic processor enhances the accuracy by including setpoint setting as part of total accuracy.

- If the setpoint is less than 20% of Full Scale:
the accuracy depends directly on the Full Scale: Accuracy = ±0.2% Full Scale ; which is 5 times better than the analog MFC s accuracy for the same range of setpoint.

- If the setpoint is greater than 20% of Full Scale:
the accuracy is primary a function of the setpoint : Accuracy = ±1% of setpoint which is definitely better compared with the analog MFC accuracy = ±1% of Full Scale. (cf figure 1)

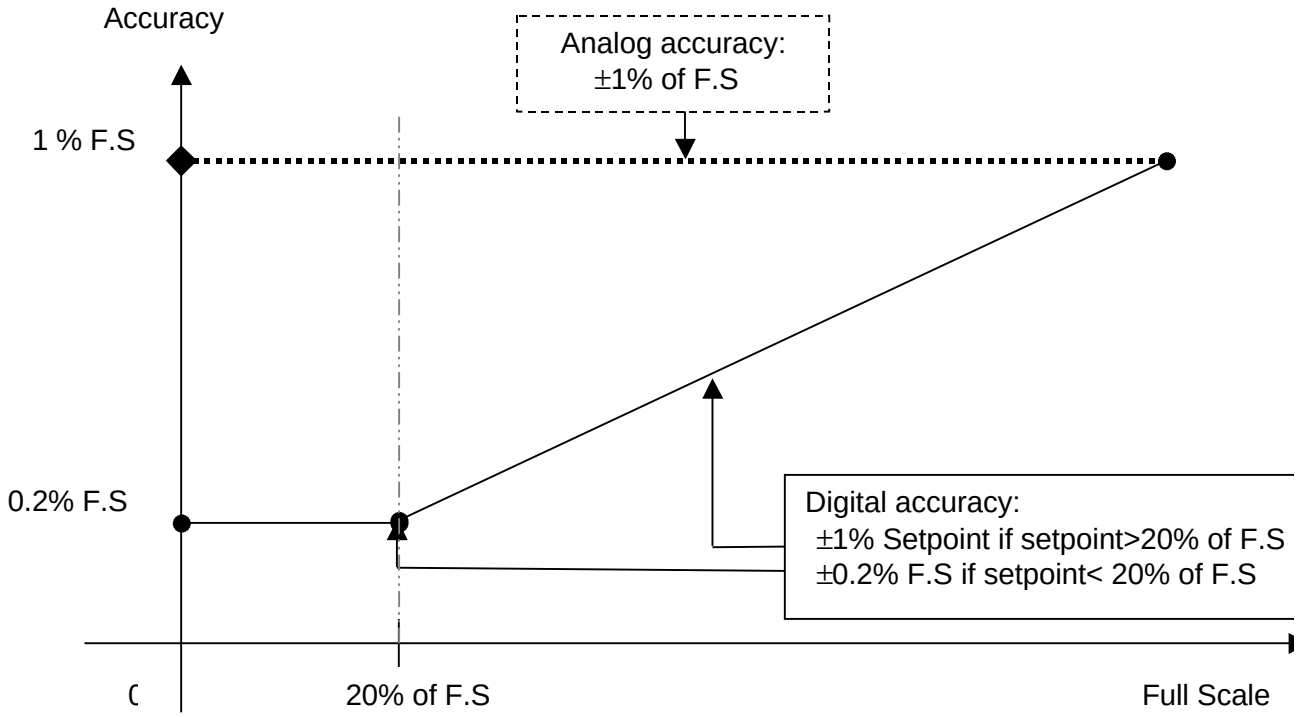


Figure 1: Analog and Digital Accuracy according to the Full Scale

The digital MFC maintains accuracy, linearity and repeatability whatever the setpoint is. The repeatability is improving from 0.2% of F.S for an analog MFC to 0.15% of F.S for a digital MFC.

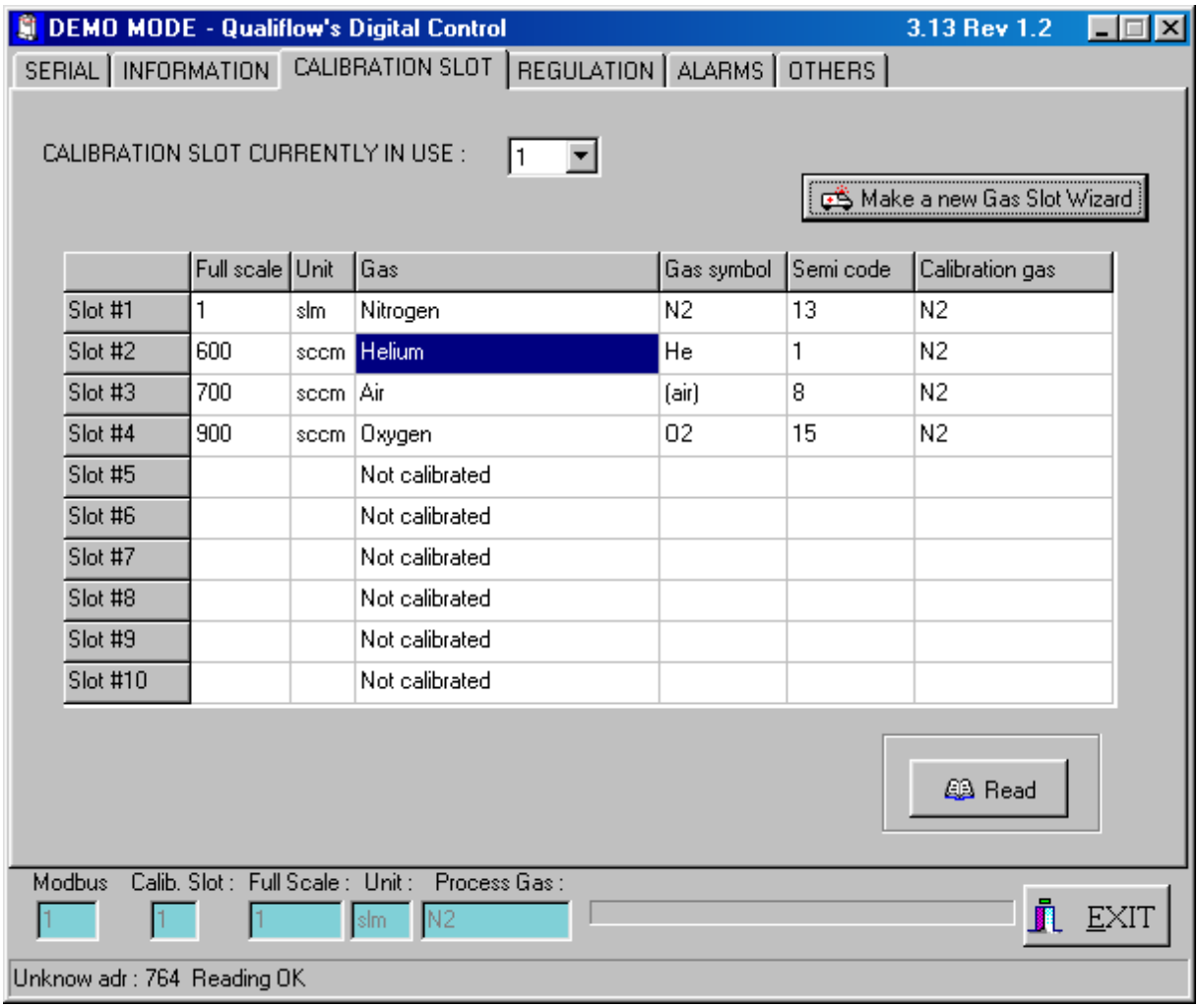
Qualiflow s digital MFC multicalibration allows:
Typically up to 5 curves stored inside the MFC, the user can shift from one calibration curve to another, by using Qualiflow s interface **Digisoft** , andselect the adequate flow and gas, without affecting the process.

Due to the benefits of the digital electronics, communication options (RS232, RS485, profibus, DeviceNet) have greatly increased using our digital MFCs over the analog MFCs.

2 Advantages of the multicalibration

Reduces MFC s inventory andits cost (This is very important for semiconductor industries which want to stock a minimum of MFCs).
Can store**typically up to 5 curves** in one MFC. Of course, this quantity can change (**maximum of 10 curves**) depending on the calibrated gases.
Easy toshift from one curve to another with **Digisoft**. This capacity enables the users to change the gas or the curves without opening the process line and without losing a lot of time.
The multicalibration MFC is a reliable device, with considerable flexibilites.

Note: The customer is responsible for handling non compatible gases in one MFC.
Using the Wizard , user can also create new calibration curves from one existing calibration.
The primary calibrations are done at Qualiflow.



So as we said, multicalibration is very convenient. However, there are some limitations to take into considerations. They are described in this document such as:

- the full scale flow
- the pressure
- the gas properties

3 Full Scale Flow

Typically, up to 5 calibration curves can fit in one MFC. However, there are some mechanical limitations due to the bypass and valve design.
Two calibration curves within one MFC can not have Full Scale flows (Equivalent N2) too wide apart.

3.1 Conversion Factor: CF

If you need to run x calibrations curves, the highest calibration curve (in Full Scale flow N2 equivalent) must be a maximum of 3 times larger than the smallest calibration curve (in Full Scale flow N2 equivalent): $\frac{Deq_{\max}}{Deq_{\min}} \leq 3$ avec : $Deq_{N2} = \frac{D_{gaz}}{CF_{gaz/N2}}$

Maximum factor between full scales (N2 equivalent) of two calibrations is 3.

The closer the Full Scales flows (N2 equivalent) are, the better it is for multicalibration.

It is better for multicalibration to have different gases with a same Full Scale Flow (N2 equivalent) rather than one gas with different Full Scale Flow.

Example:

curve #1 is 10slm CO2 (14slm N2 equivalent)
curve #2 is 7slm CO (7slm N2 equivalent)
curve #3 is 4slm O3 (6slm N2 equivalent)
curve #4 is 4slm O2 (4slm N2 equivalent)

Curves within 14slm and 14/3=4.66slm can fit in one MFC.

Therefore, curves #1, #2 and #3 will fit in one MFC.

However, curve #4 won t fit in the same MFC as 4.66slm is greater than 4slm.

Warning! Gases containing fluorine:

- SF6 Sulphur Hexafluoride
- WF6 Tungsten Hexafluoride
- C2F6 Perfluorethane (Freon-116)
- C4F8 Octofluorocyclobutane (Freon-C318)
- And so on

need to be worked out differently because of a diffusivity much higher which modifies the response curves in the sensor.

Indeed, in order to measure the flow of these gases, the sensor tube must see more gas compared with other normal gases (i.e. fewer gases will flow in the bypass). Twice as much gas will need to flow through the sensor tube in order to properly read the flow.

Therefore, when calculating the N2 equivalent for those gases, you need to multiply the result by 2.

Example: 10 slm SF6 will be 2X10slm/0.27=74slm

When trying to calculate multicalibration with SF6, C2F6 or C4F8, do not forget to multiply N2 equivalent flow by 2.

3.2 Small flow

Calibration of small flows is very difficult. Therefore, when calculating multicalibration, small flow calibrations less than 20sccm should be stored in the same MFC.

Example:

curve #1 is 10sccm CO2 (14sccm N2 equivalent)
curve #2 is 30sccm CO (30sccm N2 equivalent)
curve #3 is 10sccm O3 (14sccm N2 equivalent)
curve #4 is 40sccm O2 (40sccm N2 equivalent)

curve #5 is 10sccm O2 (10sccm N2 equivalent)

One would be tempted to fit all the curves in one MFC.
However, we prefer running curves #1, #3 and #5 in one MFC and curves #2 and #4 in a second MFC.

Small flow calibrations less than 20sccm should be stored in the same MFC.

4 Operating pressures

The major flow limiting component in a mass flow controller is the control valve. The inlet pressure applied to the controller acts to push gas molecules through the controller.

All calibration curves on one MFC should have very similar operating pressures.

If operating pressures are too different from one curve to one other, the valve won t open or close enough.

Dichlorosilane (DCS) SiH2Cl2 and Trichrolosilane (TCS) SiHCl3 can liquefy if the operating pressure is too high. Both gases are used with a low inlet pressure and the vacuum as outlet pressure (and usually a heated gas line).

Dichlorosilane (DCS) and Trichrolosilane (TCS) should definitely be run in one separated MFC with Kalrez or Metal Seals.

5 Gas properties

Some chemical properties of gases are limitation to multicalibration.

5.1 Inert gases

Inert gases such as N2, H2, O2, CO2, CO, He, Ar can be stored in the same MFC.

Air, AR, HCl, N2, CO, O2, CL2, NO2, CH4, NH3, N2O, O3, PH3, SO2, SiH4, GeH4, CHF3, NF3 calibration curves can be easily run in one MFC

5.2 Density

Gas Density is one of the factors that determine how the MFC control valve should be adjusted during the MFC assembly. So as a general rule, try to have gases with similar density in the same MFC.

Gases with low density such as He or H2 can be difficult to calibrate. Therefore if possible, try to have He and H2 in a second MFC. Nitrogen is approximately 14 times denser than Hydrogen and 7 times denser than Helium. If the control valves are properly adjusted for controlling these two relatively low density gases, often the MFCs will not allow full flow of the higher density Nitrogen. It will appear that the MFCs are defective because they will not flow the expected amount of gas, when actually the MFCs are adjusted correctly for Hydrogen or Helium.

Situation is analogous to attempting to flow a high density fluid.

5.3 Reactive gases

Viton® is typically the recommended elastomer for non-reactive gas service. Reactive gases require a more durable elastomer, such as *Kalrez*®, for safe and proper operation. If a mass flow controller equipped with seals made of *Viton*® is used to flow a reactive gas, very serious problems can occur:

- Safety problems
- Manufacturing delays
- Destruction of valuable equipment
- Production of scrap product
- Increased repair costs

Some gases require Neoprene or Kalrez seals.

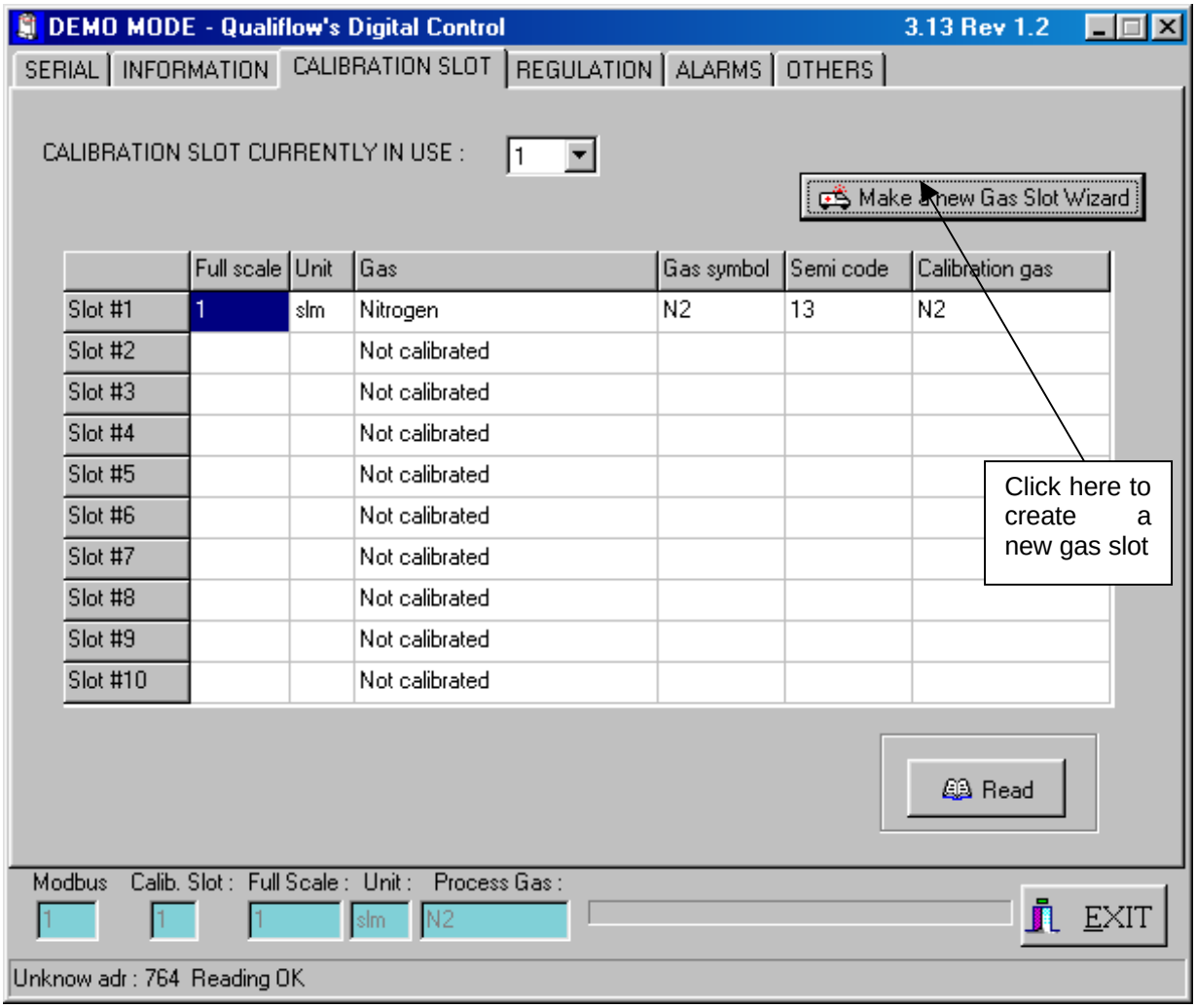
Unless Metal seals are used, corrosive gases should not be run with non corrosive gases in the same MFC.

6 Use of calibration Wizard

Specifying all calibrations first and having Qualiflow calibrating the MFC will assure high performances for every curve.

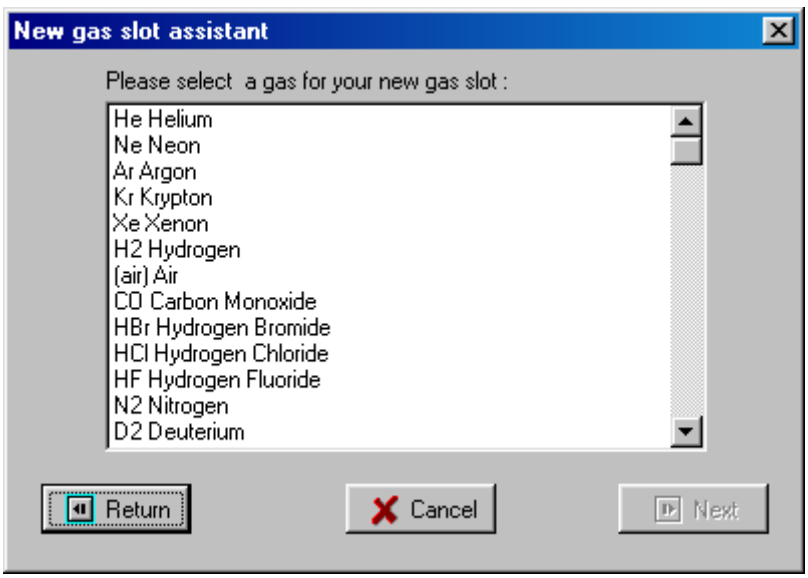
However, for more convenience, user can create extra calibration curves starting from one curve calibrated at Qualiflow (using the calibration assistant).

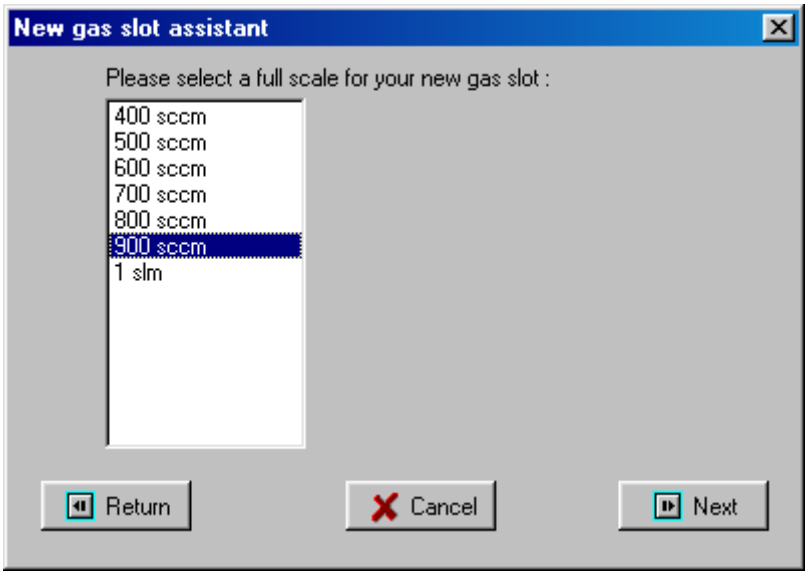
6.1 Calibration assistant



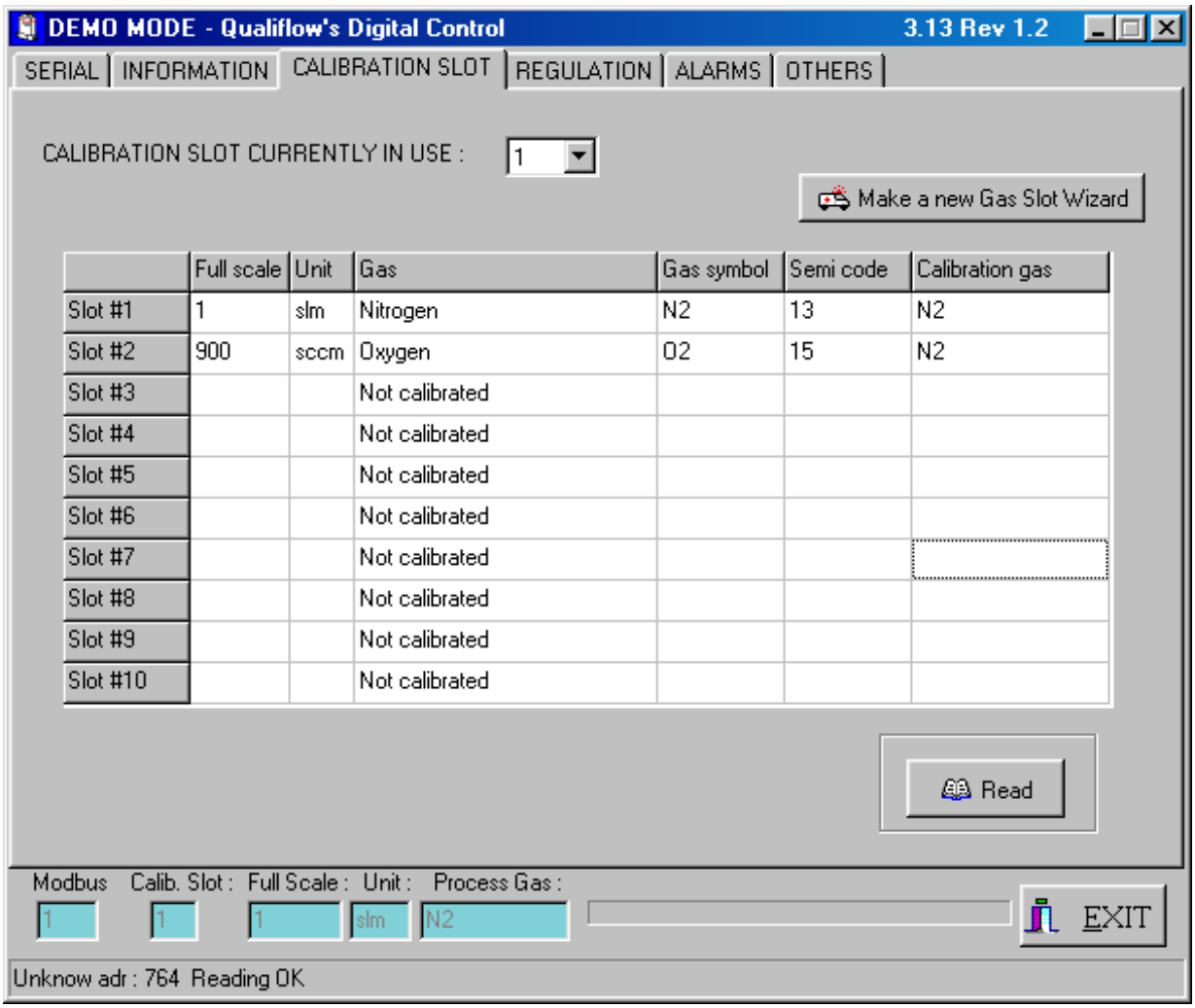
Starting from 1 slm N2, user can create extra curves just by using the wizard and selecting one gas and one Full Scale flow (in the example 900sccm O2).

Notes: Only limited Full Scale flow can be selected because of the 3 factor.
A curve cannot be created upper the reference curve.





Calibration will be worked out automatically from the first one.



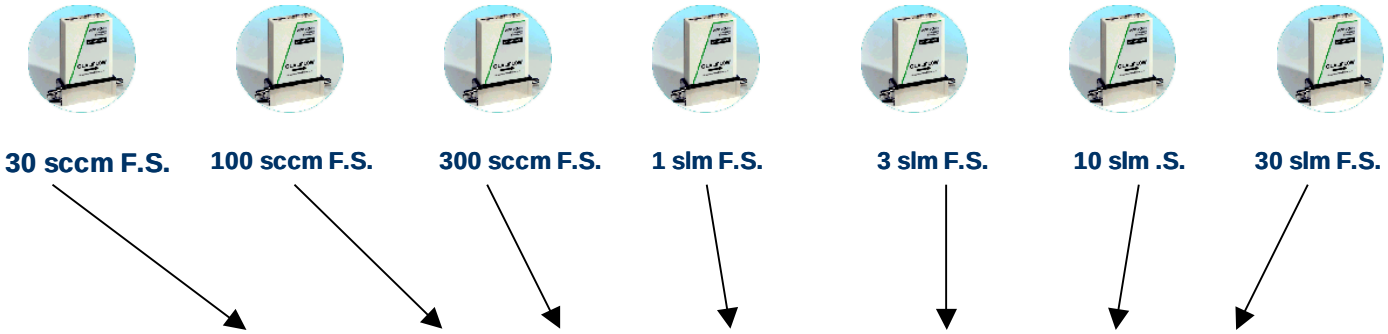
Warning: the Wizard is only taking the "3 factor" into account.

Using "gas slot Wizard", extra curves will give good accuracy for the following gases: Air, Ar, HCl, N2, CO, O2, CL2, NO2, CH4, NH3, N2O, O3, PH3, SO2, SiH4, GeH4, CHF3, NF3.

Of course the limitations described in this document apply to the "gas slot Wizard"

6.2 Universal MFCs

With the calibration assistant or wizard , 7 Generic MFC s (with N2) can easily be used to cover from 10sccm to 30slm for 20 gases



GAS	30 sccm N2	100 sccm N2	300 sccm N2	1 slm N2	3 slm N2	10 slm N2	30 slm N2
Argon	15 to 40 sccm	50 to 100 sccm	200 to 400 sccm	500 sccm to 1 slm	2 to 4 slm	5 to 10 slm	20 to 40 slm
He	15 to 40 sccm	50 to 100 sccm	200 to 400 sccm	500 sccm to 1 slm	2 to 4 slm	5 to 10 slm	20 to 40 slm
H2	10 to 30 sccm	40 to 100 sccm	200 to 300 sccm	400 sccm to 1 slm	2 to 3 slm	4 to 10 slm	20 to 30 slm
Air	10 to 30 sccm	40 to 100 sccm	200 to 300 sccm	400 sccm to 1 slm	2 to 3 slm	4 to 10 slm	20 to 30 slm
HCl	10 to 30 sccm	40 to 100 sccm	200 to 300 sccm	400 sccm to 1 slm	2 to 3 slm	4 to 10 slm	20 to 30 slm
N2	10 to 30 sccm	40 to 100 sccm	200 to 300 sccm	400 sccm to 1 slm	2 to 3 slm	4 to 10 slm	20 to 30 slm
CO	10 to 30 sccm	40 to 100 sccm	200 to 300 sccm	400 sccm to 1 slm	2 to 3 slm	4 to 10 slm	20 to 30 slm
O2	10 to 30 sccm	40 to 100 sccm	200 to 300 sccm	400 sccm to 1 slm	2 to 3 slm	4 to 10 slm	20 to 30 slm
CL2	10 to 25 sccm	30 to 80 sccm	100 to 200 sccm	300 to 800 sccm	1 to 2 slm	3 to 8 slm	10 to 20 slm
NO2	10 to 20 sccm	30 to 70 sccm	80 to 200 sccm	300 to 700 sccm	800 sccm to 2 slm	3 to 7 slm	8 to 20 slm
CH4	10 to 20 sccm	30 to 70 sccm	80 to 200 sccm	300 to 700 sccm	800 sccm to 2 slm	3 to 7 slm	8 to 20 slm
NH3	10 to 20 sccm	30 to 70 sccm	80 to 200 sccm	300 to 700 sccm	800 sccm to 2 slm	3 to 7 slm	8 to 20 slm
N2O	10 to 20 sccm	30 to 70 sccm	80 to 200 sccm	300 to 700 sccm	800 sccm to 2 slm	3 to 7 slm	8 to 20 slm
O3	10 to 20 sccm	30 to 70 sccm	80 to 200 sccm	300 to 700 sccm	800 sccm to 2 slm	3 to 7 slm	8 to 20 slm
PH3	10 to 20 sccm	30 to 70 sccm	80 to 200 sccm	300 to 700 sccm	800 sccm to 2 slm	3 to 7 slm	8 to 20 slm
SO2	10 to 20 sccm	30 to 70 sccm	80 to 200 sccm	300 to 700 sccm	800 sccm to 2 slm	3 to 7 slm	8 to 20 slm
SiH4	6 to 10 sccm	20 to 60 sccm	70 to 100 sccm	200 to 600 sccm	700 sccm to 1 slm	2 to 6 slm	7 to 10 slm
GeH4	6 to 10 sccm	20 to 50 sccm	60 to 100 sccm	200 to 500 sccm	600 sccm to 1 slm	2 to 5 slm	6 to 10 slm
CHF3	5 to 10 sccm	20 to 50 sccm	60 to 100 sccm	200 to 500 sccm	600 sccm to 1 slm	2 to 5 slm	6 to 10 slm
NF3	5 to 10 sccm	20 to 50 sccm	60 to 100 sccm	200 to 500 sccm	600 sccm to 1 slm	2 to 5 slm	6 to 10 slm

Example: user can safely create a 20sccm NO2 curve from a 30sccm F.S. N2 precalibrated MFC.