LUCAS LABS

LUCAS/SIGNATONE CORPORATION

FLORIZEL
MFC TESTER

....

OPERATION MANUAL

Rev. 5/00

MODEL MT-820-DN

LUCAS LABS

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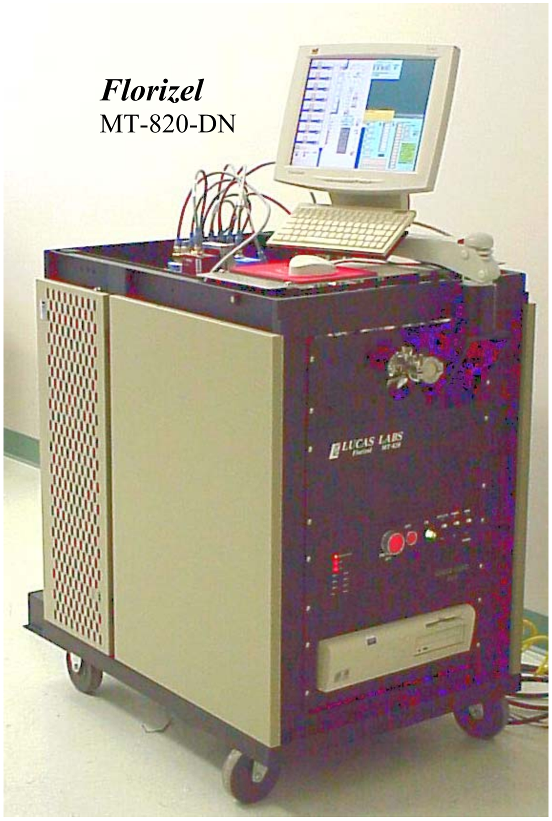
Introduction



Florizel is an instrument designed for batch testing of up to 8 MFCs without operator intervention. Florizel uses a PC interface. Test results are presented on the computer display and are also saved to hard disk. The Florizel program is configured to start automatically on power up of the computer. It is a Windows™ application and requires the full resources of the computer for correct operation.

The principle behind the MFC tests is "*Rate of Rise*". Gas flow can be defined as *a specific volume of gas at a specific pressure entering a specific volume vessel at a specific temperature and rate*. The change in vessel's pressure over time is then a measure of the amount of gas that has flowed into or out of it. Gas Mass Flow Rate can be calculated from the predictable behavior of *Ideal Gases* and the relationship…

$$\text{(1)} \qquad GAS\ FLOW = \frac{P_2 - P_1}{\Delta\ time} \times Vessel\ Volume$$

If pressure is expressed in Torr, time in Seconds and vessel volume in Liters, equation (2) gives gas flow in Torr liters per second. Equation (3) converts TL/s to SCCM, the more common unit of measure for MFC gas flow.

$$\text{(2)} \qquad SCCM = \left(\frac{1000\ cc \times 60\ sec}{760\ Torr}\right) \times \left(\frac{Torr \times Liters}{sec}\right)$$

$$\text{(3)} \qquad SCCM = 78.947 \left(\frac{Torr \times Liters}{sec}\right)$$

A Standard Cubic Centimeter per Minute is a cubic centimeter of gas per minute at a pressure of 760 Torr and a temperature of **273^{o} K** (0^{o} Centigrade). If the gas is at a higher temperature, gas molecules are more energetic and fewer are needed to express 760 Torr.

Fewer molecules mean fewer sccm… by the ratio of absolute temperatures (273/gas K^o). A more complete form of equation (3) is thus…

(4) $$SCCM = 78.947 \left(\frac{Torr \times Liters}{sec} \right) x \left(\frac{273\ K^o}{gas\ K^o} \right)$$

Florizel contains a vessel whose volume is precisely known. It uses a precision manometer to measure the change in vessel pressure produced by MFC flow. A clock determines the precise time of flow. Florizel software factors temperature and the vessel desorption/leak rate contribution to calculate…

Time to achieve flow control (seconds)
Maximum flow overshoot in achieving control (sccm)
Average flow over the control interval (sccm)
Flow variation during control (%)
Mean Flow deviation from the desired set point (%)
Step response time (seconds)
Dead Band time (seconds)

Florizel will test up to 12 different flow rates for a single MFC, plot the points and determine the degree of linearity the MFC provides. It will also project the generated linear plot through zero flow, to determine a “zero offset”. Both factors are useful in evaluating the performance of a particular MFC.

Florizel Components

The MFC tester has 7 major subsystems or components… a Computer/DAQ system, User Console/Interface, Electrical/Electronic Controller, Utility Panel, Precision Vessel/Manometers, and a Vacuum System.

Computer and Control Box

The computer is a Dell Optiplex series with a Pentium 3 processor, 64 Megabytes of RAM, > 6 Gigabyte Hard Disk, floppy disk and CD ROM drive. The backpanel includes PS/2 port for both a keyboard and mouse, USB port, LAN port, two serial ports and a printer port. A Device Net control board and DAQ board are installed in expansion slots. There is one available slot. The operating system is MS Windows 98 with MS Office 97 with Access, Excel and Word installed.

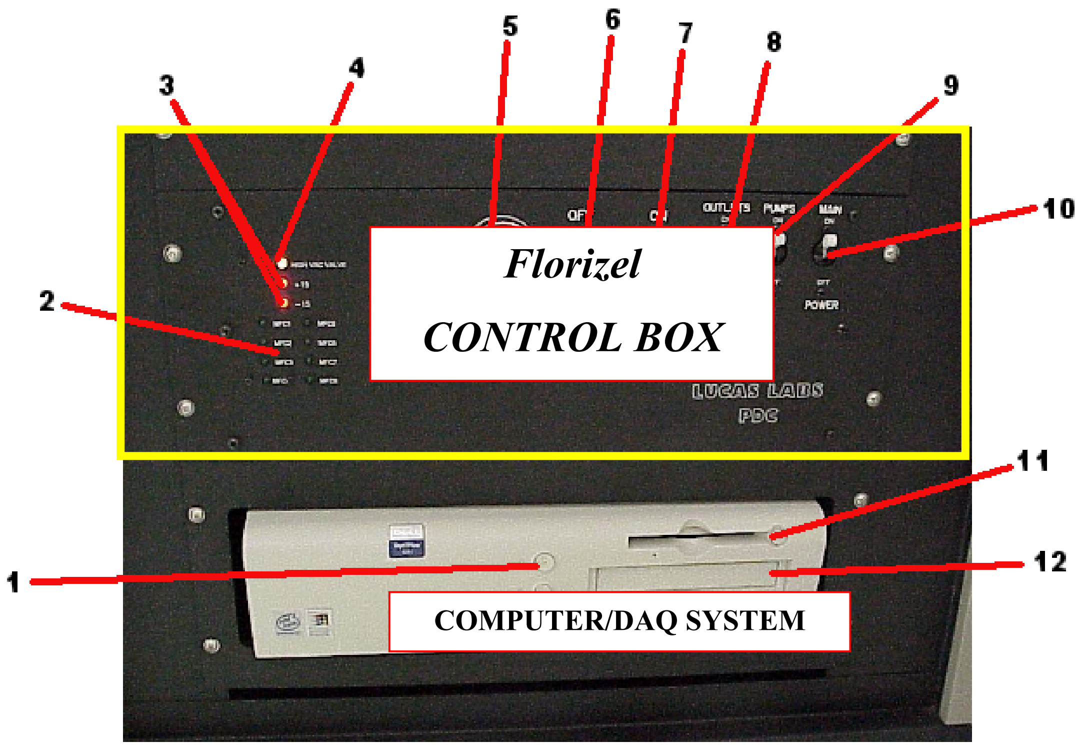


Figure 2-1

<u>Florizel Computer and Control Box</u> (continued)

1. Power switch for the computer. The computer automatically shuts off if Windows 98 is shutdown.
2. Green LED indicators show valve status for up to 8 installed MFCs.
3. Red LED ± 15 Volts indicates power to the (heated) manometers and installed analog MFCs.
4. Green Hi-Vac valve LED. When illuminated, the valve is open and the chamber is pumping.
5. Red EMO button. This immediately cut all power to the system.
6. Red Off button. This is the normal main power off switch for the entire system.
7. Green On button. This is the normal main power switch and illuminates when on.
8. Outlet power breaker. This is a circuit breaker but may be used to shut down the 120VAC outlets at the back of the control box. These power the pumps, Penning gauge, computer and Device Net power supply.
9. Vacuum pumps power breaker. This breaker serves both the turbo and backing pump. If the system is going to be idle for some time, the pumps can be independently powered off to save wear on them. The manometers will remain at operating temperature, thus avoiding their 8-hour warm-up period.
10. Main circuit breaker. This switch is on in normal operation.
11. Floppy disk drive for 1.44 MB 3.5" floppy disk.
12. CD-ROM drive.

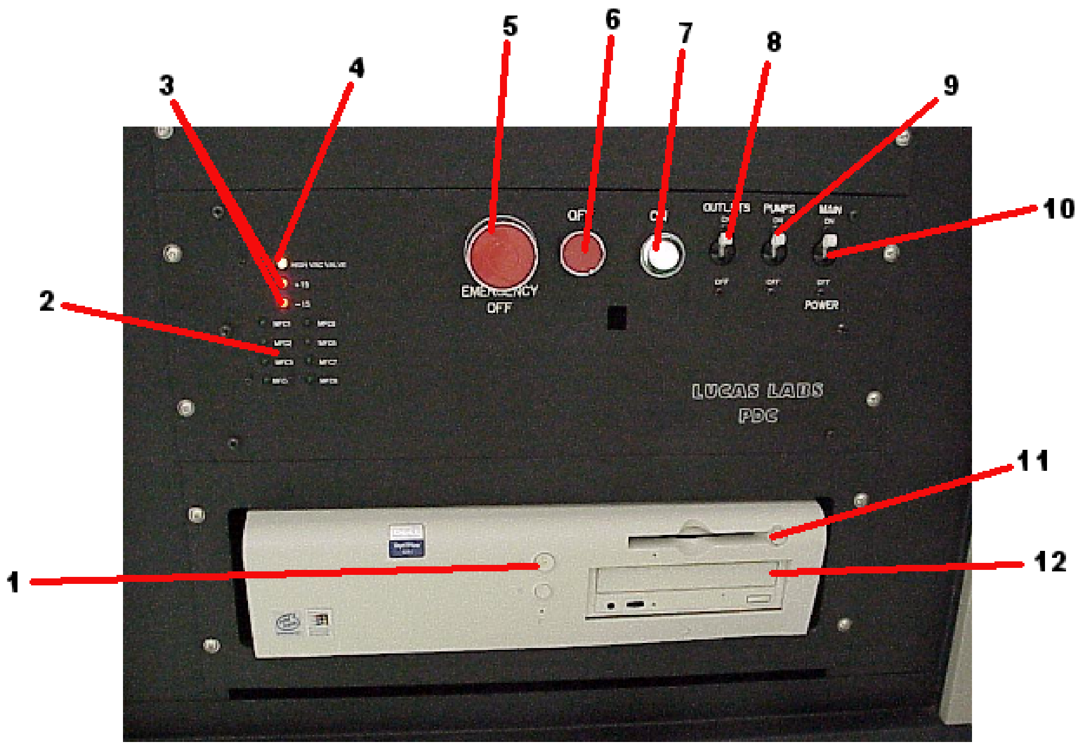
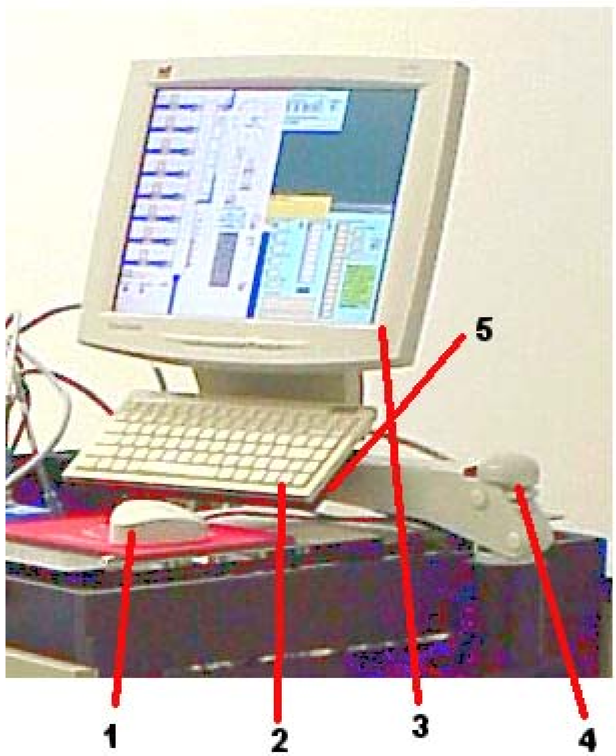


Figure 2-2

Console/User Interface

The console consists of the flat panel screen, keyboard and mouse. The flat panel screen is set-up with 1024 X 768, Large Font resolution.

Figure 2-3



1. Two button mouse.

2. Small, full function Keyboard

3. Flat Panel Display. This has an integral vertical swivel adjustment.

4. Mounting column. Display/keyboard may be adjusted to different heights by changing the position of the 1/2 inch spacers.

5. Adjustment allows for positioning the display horizontally.

Utility Panel
The utility panel is on the back of the system.

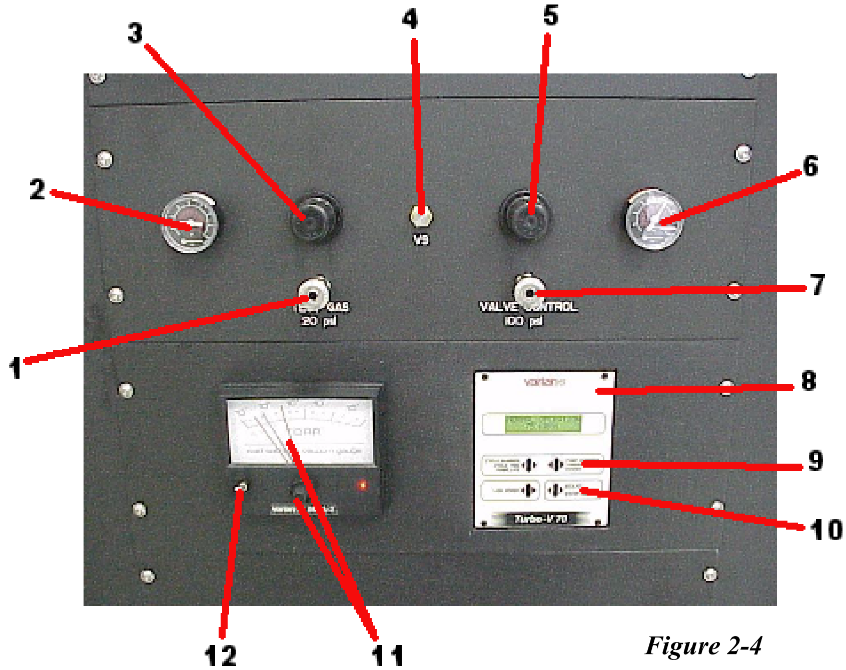


Figure 2-4

1. Test gas inlet connection. Inert gas connects here.
2. Inlet gas pressure gauge.
3. Inlet gas regulator control knob.
4. Vessel vent valve pressure regulator.
5. Pneumatic valve actuator pressure regulator.
6. Valve control pressure gauge
7. Pneumatic valve actuator gas connection. This may be any inert gas or compressed air set at 100 PSI. It is used only to actuate the valves.
8. Turbo pump controller.
9. Turbo pump status switch. Pressing this button displays RPM, temperature, Watts and Amperes.
10. Start or stop the turbo Pump.
11. In band indicator for the cold cathode ion gauge. The high point should always be set at 10^{-6} Torr and the low point at 10^{-7} Torr.
12. Cold cathode gauge main power switch. This is normally left in the on position. The Florizel software activates this gauge when needed during tests.

Figure 2-5

Vacuum Pumps
The pumping system consists of a Varian V70D turbo and a dry (diaphragm) backing pump. The turbo controller is mounted in the utility panel. In normal operation the turbo pump turns at 75K RPM, at a temperature <50°C.

Backing pump vibration can add to Florizel's manometer signal noise. The pump is best mounted directly on the floor, adjacent to the main frame (figure 2-5).

Manometers and Vessel

The vacuum manometers and precision vessel are the heart of Florizel hardware. A standard Florizel has 3 manometers (1 Torr, 10 Torr and 100 Torr). Up to 4 may be installed.

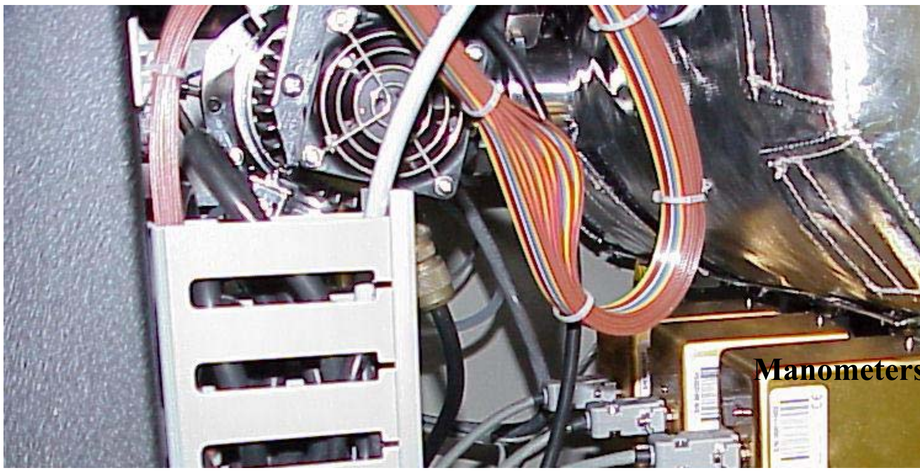


Figure 2-5

Florizel uses Millipore CMH series heated manometers for a high accuracy and low noise. They must be powered a minimum of 8 hours before they are ready for use. These manometers are mounted on the Vessel with diaphragms horizontal. Annual (horizontal) calibration is required to maintain NIST traceable measurements.

Security and User Levels

There are four levels of operational capabilities on the Florizel MFC Tester. Each higher level number may perform all functions of any levels below it. Levels are assigned users by "owner" level authority. Initially the MFC Tester is shipped with one installed user id of "owner" and a password of "password". Lucas Labs recommends that this id be used to create a new owner level user and then deleted.

Florizel User Levels

1. Operator - This level may install and test MFCs using pre-defined tests and configurations. Operator level may (from the main panel) manually control the high vacuum valve, select and deselect MFCs for testing, display and print graphs of tested MFCs and print summary reports.

2. Maintenance - This level may manually control all MFC isolations valves and manually set MFC flows. Maintenance level may also to force testing on a position even if it fails the MFC leak/ flow check (by entering a number from 1 to 8 into the box labeled "Force"). This level has all capabilities available to level 1.

3. Engineer - This level user may alter and save configuration files. Engineer level also has all capabilities available to level 2.

4. Owner - Owner level has all capabilities available to other levels and the exclusive capabilities of adding and removing users and assigning their levels.

Adding a User

Only owner level can authorize Florizel users. The owner logs on, selects the *new user* button, and types the name of the new user. If a user already exists with the same name, you will be requested to try again. Review the capabilities above and select the desired access level for the new user. When you have completed this task, press *continue.* The new user name is now in the database, but he/she still need to create their password. Press *Continue* again to get to the main screen. The owner level may continue to run the system or *Log Off* to allow the new user to create a password.

Removing a User

Only the owner level may remove other users. The owner logs on and selects the *rmv user* button. Type the name of the user to be removed and select *Continue.* The user is removed.

Assigning a Password for a New User

After the new user has been added to the database, he/she will need a password. *Log Off* to get to the Entry screen. The new user should enter his/her user name in the user box. In the password box, enter the word *password* and continue. On the next screen select, *New Pass.* Enter the desired password in the first box then repeat it in the second box. Press <enter> to accept the password. If the two entries are not identical, you must re-type them. The next time the new user logs on, this password will be required.

Changing a Password

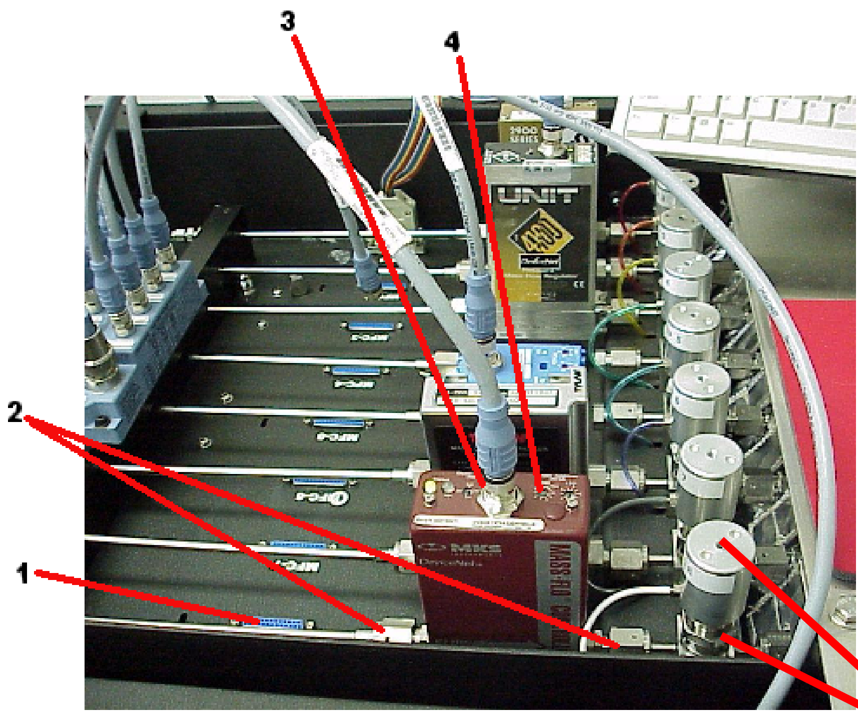
Log on with the current password. On the next screen select, *New Pass.* Enter the desired new password in the first box then repeat it in the second box. Press <enter> to accept the new password. If the two entries are not identical, you must re-type them. The next time this user logs on, the new password will be required.

Forgotten Password

The only way to recover from a forgotten password is to have an owner level user remove you as a user and re-enter you as a new user. Follow the same steps as for a new user.

Installing and Configuring an MFC

This chapter explains how to mount and set-up an MFC for test. Florizel is designed to accommodate up to 8 Mass Flow Controllers for sequenced automatic testing.



1) Florizel analog connectors (female)
2) VCR fittings for MFC connection
3) Device Net MFC connection
4) Device Net Address Selection
5) Nupro pneumatic isolation valves

Figure 4-1

Mounting the MFC

MFC Mounting requires three wrenches (one 5/8 inch, two 3/4 inch open end). Two VCR gaskets are needed for each MFC to be installed. All eight positions perform the same. Select the one you wish. Remove any line plugs using two wrenches, one to steady the tubing line and the other to remove the plug. Be sure to insert new VCR gaskets. First connect MFC output to the Nupro isolation valve, then carefully move the gas-input line to the MFC inlet. A 1/8 inch diameter coil section aids positioning this line, use care not to deform it. Tighten both connections using two wrenches (1/8 turn past finger tight for SS or Ni gaskets).

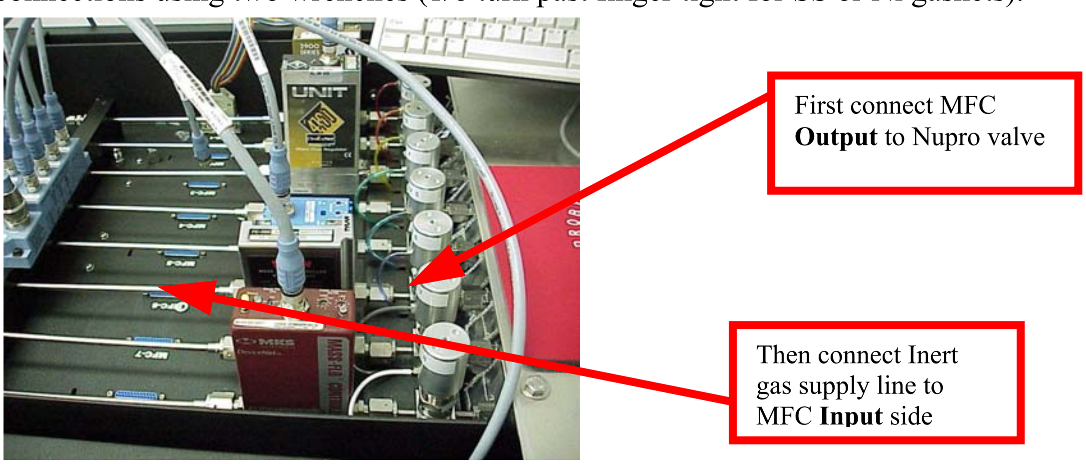


Figure 4-2

Connecting an Analog MFC

8 Analog cables are supplied. The Florizel connection is a male 25 pin D sub plug. Each plug is clearly labeled (MFC #1 to MFC #8). Connect only to the plug where the corresponding MFC is mounted.

Note:
If a different cable is needed for an MFC, Lucas Labs will gladly quote current price and delivery. You may wish to make your own from the 25 pin D sub pin out table shown in Figure 4-4 at the right.

Pin #	*Description*
1	Feedback Signal
2	Feedback return
3	Valve Voltage
4	Valve Voltage return
5	Set point read
6	Set point return
7	Set point
8	Set point return
9-13	Not connected
14	Valve open Lo
15	Valve Open Lo return
16	+ 15V DC
17	- 15V DC
18	Power Ground
19	Chassis Ground
20-25	Not Connected

Figure 4-3
Florizel Analog MFC pin outs for 25 pin male D sub plug

Connecting a Device Net MFC

Before connecting the Device Net cable to the MFC, the Baud rate and MAC ID must be set on the MFC itself. The baud setting is 500 and the MacID switch setting is the MFC FLORIZEL line position. Thus an MFC mounted on line 6 has a MacID of 06. See the manufacturer's specific instructions for changing MFC baud rate and the Mac ID.

Also, the MFC must be configured as specified in the Applied Materials Spec. This means flow is calculated using 'counts', not percent full scale or some other setting. Also, the MFC must use integer numerical data. These settings are usually preset by the manufacturer.

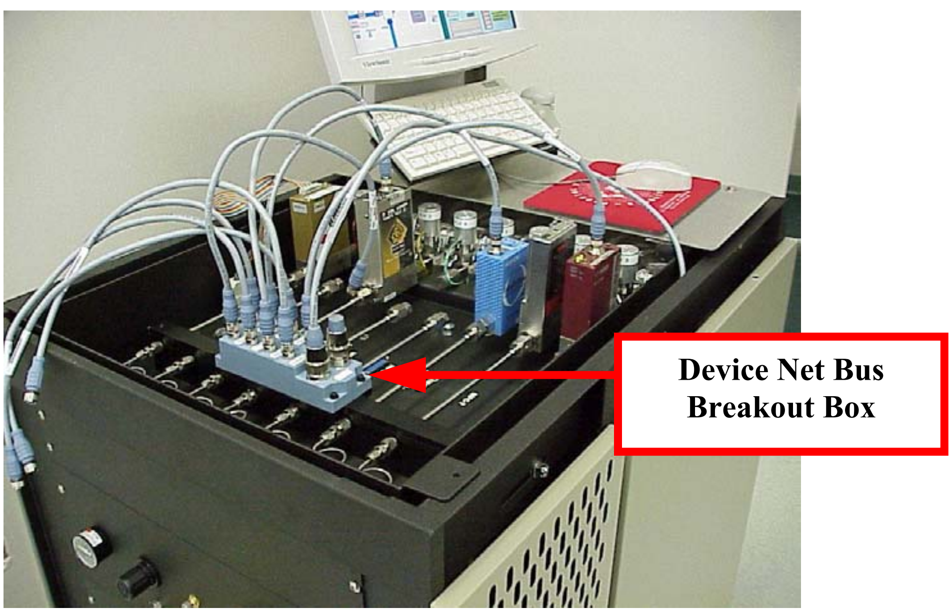
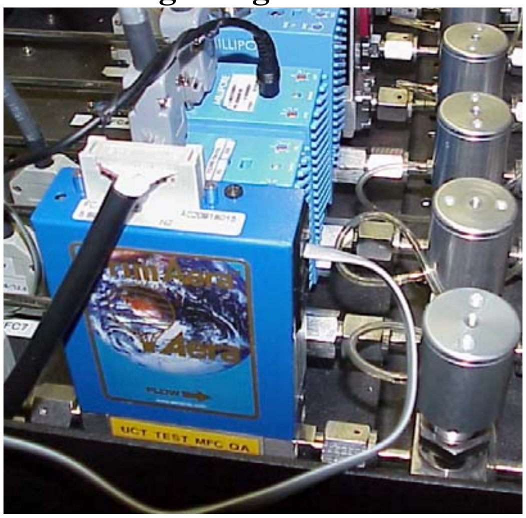


Figure 4-3

The Device Net Bus break out box accepts up to 8 cable connections. Any position may be used to power any MFC. Addressing is determined at the MFC itself and bus connections may be in any order.

Connecting a Digital MFC



Digital MFCs (DMFC) vary from manufacture to manufacture both in hardware connections, protocol and command structure. Florizel has several of these interfaces available. The most common interface is the LAM/Unit interface. Digital MFCs need power supplied from the analog connection; so, the regular analog connection is required. A digital connection is also required. The Digital adapter connects to a com port on the computer (the default is COM1 but may be altered in the MFCSYS.PRM file). The other end of the cable connects to the MFC. Short jumper cables between MFCs are supplied for connecting up 8 MFCs.

Caution: DMFCs must all be of the same DMFC protocol to operate during a single run. Example, if I run the LAM interface, only DMFCs that support LAM will work. If I run the Mykrolis interface, only Mykrolis will work. Since there is only one digital port used by Florizel, only one digital protocol may be specified per test run. This does not interfere with DeviceNET or Analog MFCs. So, a user may set-up 3 LAM interface DMFCs, 2 DeviceNET MFCS and 3 analog MFCs for a single testing session.

The MFC Configuration Screen

Click on the desired MFC icon on the main screen for the sub-menu to install, deselect or display data for the selected MFC. A configuration screen like the one in Figure 4-4 will appear when Install is double clicked.

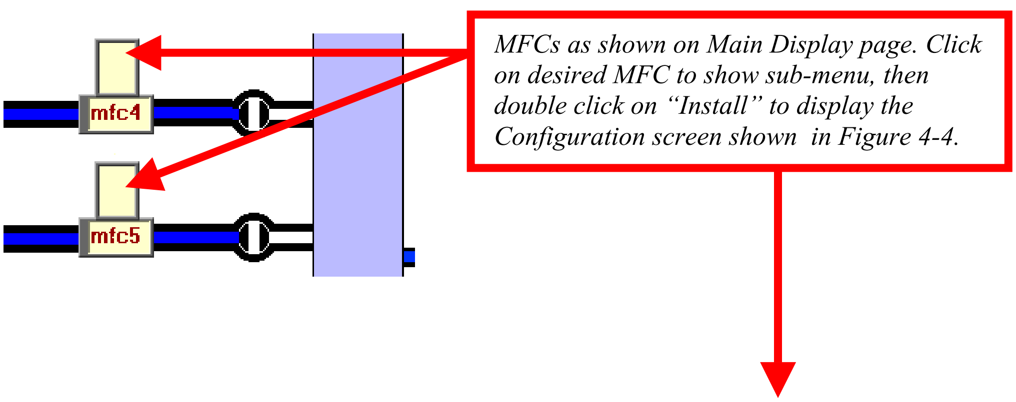
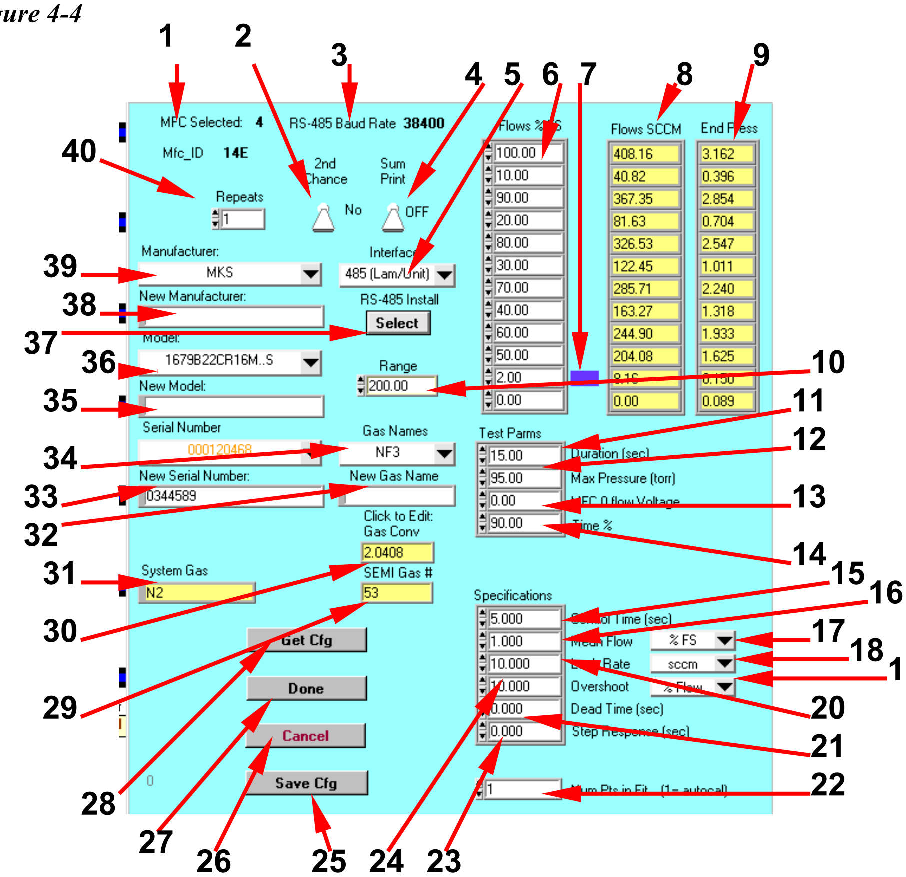


Figure 4-4



Reference Figure 4-4

1) Displays the MFC channel you are configuring.

2) **2nd Chance** toggled on or off. In the On position, if the MFC fails on any parameter during the first run, the data for that run is discarded and the same test run again. The second pass, all the data is stored pass or fail. When toggled off, the test data is stored automatically pass or fail.

3) Baud Rate selected for RS485 communications.

4) On/off switch for automatic summary report printing at the end of MFC test. (The Florizel must be connected to a printer to use automatic printing).

5) Indicates the MFC interface type. When the MFC is set up the first time, this information is entered and stored permanently in the database. Users may select analog, DeviceNet, or RS485 interfaces from the pull down list. Some options may not be available depending on the options purchased with Florizel.

6) The flow rates to be tested. Up to 12 different flow rates may be set. Entries are defined as a percentage of full scale.

7) Problem indicator. Blue dot displays only if the setting entered will not provide enough statistically significant data for a valid test. Additional test time should solve the problem. A red dot indicates the chamber will fill to maximum pressure too quickly for statistically significant data. The only cure for this is to increase the maximum allowable pressure.

8) Displays the SCCM rate defined by the FS setting (18). This number is calculated by multiplying the ((%Full Scale)x(Full Scale Range)x(Gas Conversion Multiplier)).

9) This column shows the expected chamber ending pressure of the test. This number allows the user to understand which pressure sensor will be used for the test.

10) **Range** Displays the full-scale range setting of the MFC. There must be an entry in this box or it will blink red.

11) Defines the length of flow time for each set point defined in (8).

12) Defines the maximum pressure allowed within the Vessel for the test. The largest manometer in the standard Florizel reads 100 Torr at full scale. The recommended setting is 95% of the largest manometer on the system (95 Torr).

13) The set point voltage used to define Zero Flow for the MFC. The default is zero. Some manufacturers may require a –1 volt.

14) This parameter allows the test to be performed if up to the defined percentage of flow duration time will be achieved.

15) **Pass/Fail parameter for maximum time allowed to come into control (seconds).**

16) **Pass/Fail parameter for mean flow defined as a percentage of (17).**

17) **Designates mean flow parameter (16) percentage of either Set Point (%SP) or Full Scale (%FS).**

18) **Designates Leak by rate parameter (20) as either standard cubic centimeters (sccm) or percent of full scale (%FS).**

19) **Designates overshoot parameter (24) percentage as a percent of full scale (%FS), set point (%SP) or measured flow rate (%Flow).**

20) **Pass/Fail parameter for leak by rate when the set point is 0 as defined by (18).**

21) **Pass/Fail parameter for allowable dead time defined in seconds.**

22) Smoothing factor to apply to the rate of rise data. Defines the number of points to use in the least squares fit. The number 1 will allow the software to automatically calculate the best smoothing factor based on the collected data.

23) **Pass/ Fail parameter for the allowable step response defined in seconds.**

24) **Pass/ Fail parameter for maximum overshoot defined as a % of (19).**

25) **Save Cfg** Once a test configuration has been defined, it may be stored on the hard disk for easy recall for use with other MFCs. The parameters stored in the configuration include all settings defined in parameters 2-4, 6, 11-24, and 40.

26) **Cancel** Cancels the configuration and returns all setting to the defaults.

27) **Done** Prescribes all of all the current settings as the test for this channel and returns to the main screen. If this button is grayed out, the configuration is not complete. “Done” may only be selected when a valid setup is complete.

28) **Get Cfg** Pressing this button brings up a pull down list of previously saved configurations to choose from.

29) **Gas Number** as defined in the SEMI specification Standard E52-95.

30) The number displayed is either the manufacturers stated conversion factor or it’s reciprocal. The number may be changed by double clicking on the box. (see MFCSYS.PRM explanation of line 33 in appendix A)

31) **System Gas** is the gas currently being used for testing. Florizel may use inert gases for testing. Most common gases used include N_2, Ar, He, SF_6, CF_4.

32) **New Gas Name** If the Gas Name pull down list does not display the MFC’s gas type, enter a new name here. You will also be prompted to enter the SEMI Gas number (29) and the Conversion Factor (30) for this gas.

33) **New Serial Number** If the serial number of the MFC you are testing is not already in the list above, then add a new serial number here.

34) **Gas Names**. Select the MFC configured gas from a list of previously entered and saved Gas Names.

35) **New Model.** Add new model numbers here if not found in the Model pull down list (36).

36) Select from a list of previously saved MFC Models. The list appears in alphabetical order.

37) If a Digital or DeviceNET MFC is being configured, the **Select** button appears. The user must press this button to define additional parameters specific to the interface type. For DeviceNET, a gas must be selected. For Digital, the MacID must be selected and possibly other parameters. The **Select** button pulls up the appropriate pop up menu for the MFC.

38) Enter a new Manufacturer

39) Pull down list of previously entered manufactures

40) Number of repeats at each flow rate.

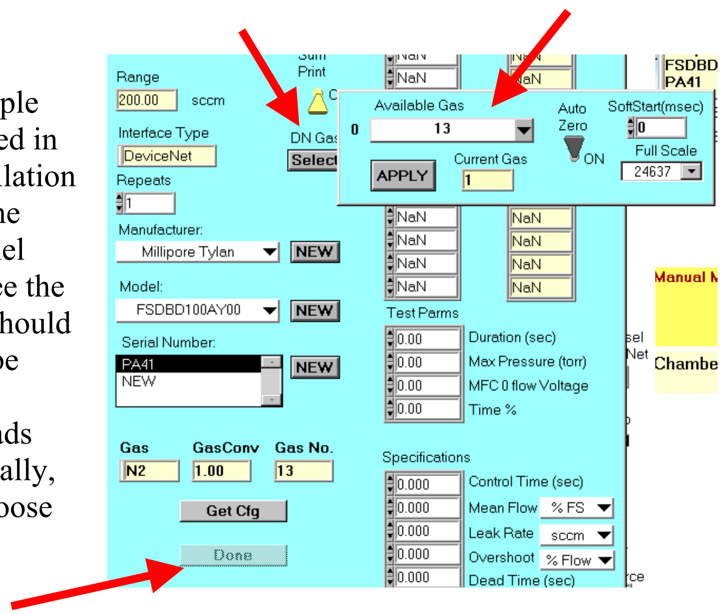
Configuring an Analog MFC for Testing

The user clicks on the desired MFC icon on the main operations panel and selects "install". The configuration window is presented. Operator and Maintenance level users use this window to specify Manufacturer, Model and Serial Number for the MFC to be tested. They can also specify the number of test repetitions and turn the summary printing option on or off. Test configurations are selected by clicking on "Get Cfg" and choosing from the list of pre-defined configurations.

For configuring a new MFC, enter the correct manufacturer, and model. Enter anew serial number into the New box. Several boxes that were yellow may now turn white. White field means that an entry is required.

Enter the serial number and press return. Enter the full scale range of the MFC and select either sccms or slpms. Next choose the interface type from the interface type pull down list. There are several choices including DeviceNet, Analog, RS485 LAM spec and depending on other digital MFC driver options that you may have purchased with the system. For analog, select analog. Next, choose the Gas symbol that this MFC configured for. A look-up table appears in alphabetical order of all of the SEMI Gases . Select the desired gas. The Semi Gas number associated with this gas automatically updates. Also, the default correction factor for that gas also updates. However, this number is not necessarily correct for your MFC and should be carefully scrutinized. Each manufacture and even model to model of MFCs may have slightly different correction factors. Enter the correct number. When everything on this screen is correct, select 'Done'.. The auto naming feature will take the Serial Number, Gas and Range to create a serial number and create a new serial number. For example if the serial number is 6789, the Gas is O2 and the full scale range is 250 SCCM the serial number created will be 6789-O2-250-A. A means Analog interface. This information is all stored in the data base. The selected MFC displays as a blue color.

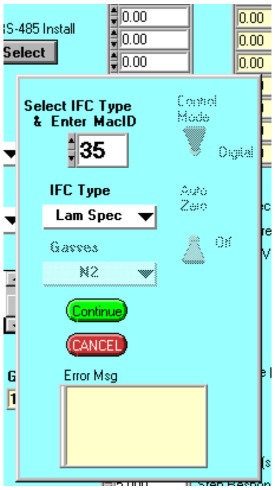
Configuring DeviceNET MFCs.



DeviceNET MFCs often have multiple Gases and multiple ranges configured in one MFC. Before starting the installation procedure, besure the MAC ID of the MFC is set to the same as the channel number (example MFC on line three the MacID is 03). Also, the baud rate should be set to 500. These settings must be made before the MFC is powered. Because the DeviceNet standard loads modes of the information automatically, after selecting the manufacturer, choose the interface type as Device Net. Immediately after choosing DeviceNet, a select button appears. Press the button. Florizel then reads the model and serial number. A list of available configured gas types appears as well. The list refers to the Semi Gas number stored in the data base. Choose the gas type for this test. Press apply to finish and close this pop up window specific to DeviceNET. Enter the Full Scale range and the desired test configuration to complete the set-up. With this set, when pressing done the serial number will be updated to reflect this configuration. For example if the serial number is 6789, the Gas is O2 and the full scale range is 250 SCCM the serial number created will be 6789-O2-250-D. D means DeviceNET.

MFC identification and configuration data thus entered, the user returns to the main operations panel by clicking on "Done". Clicking "Cancel" will return to the main operations panel without altering the previous setup of this MFC. Engineering level users may alter configurations and save them using the "Save Cfg" button.

Configuring a DMFC
Before starting, the digital MFC must be set in digital mode and the user must know the MacID number. Enter the manufacturer. Then select the interface type. Choose the RS485 interface for this MFC.



Enter the correct MacID number for the given MFC. Also, select the correct DMFC protocol. Press “continue”. If everything is set correctly, the grayed out switches will appear and the system has successfully communicated. Depending on the protocol, all switches may not appear because they are not supported by the selected protocol. Anyway, the MFC is now configured and press continue to close the box. If there are communication problems an error message will appear in the yellow box. The only option available is to cancel then open the box again. The most common reason failure is choosing the wrong MacID number.

About the Test Parameters

NOTE: Only engineer and owner user levels can modify these!

Flow % FS and Flows SCCM
The "Flows SCCM" indicators show the actual gas flow rate that will be achieved based on the full scale range of the MFC, the gas conversion factor and the % full scale flow selected. Only one 0 (Leak Rate) is measured, all other 0-flow rates are ignored. The area between “Flows % FS” and “Flows SCCM” will be red for a particular flow if that flow will cause the chamber pressure to exceed the maximum pressure measurable by the MFC tester. Dark blue shading indicates FLORIZEL may not be able to detect sufficient pressure change to calculate a flow rate. Both of the above are warnings only, no damage will occur to either the MFC under test or the MFC tester.

Test Parms:

Duration
Length of time MFC will flow after the set point has been achieved during a test. This time can be shortened during a test if the Max Pressure is reached.

Max Pressure
Usually set to 95% of the largest manometer on the system.

MFC “0” Flow

Voltage to apply to MFC set point for 0-flow condition. Usually 0 VDC or –0.5 VDC. This voltage is applied to the MFC set point when the MFC would normally be off during the flow rate tests. However, if it is set to a value greater than 0 then the leak rate (zero flow) is set to 0 VDC.

Time %
Percent of duration time a test must run in order for results to be valid. The software in selecting the optimum manometers and ADC ranges for each flow rate uses this value.

Specifications:

Control Time
Allowable time (seconds) for MFC to achieve a steady flow rate.

Mean Flow
Allowable variation in mean or average flow from the set point. Expressed either as a percentage of full scale (FS) or a percentage of set point (SP) as selected in the popup menu bar to the right of the control.

Example

	Set Point	Full Scale	Pass/Fail
2% of full scale	50 sccm	200 sccm	50 ± 4 sccm
2% of set point	50 sccm	200 sccm	50 ± 1 sccm

Leak Rate
Allowable flow at the 0 sccm set point. Expressed either as absolute flow or a percentage of the MFC full-scale capability (FS) as selected in the popup menu bar to the right of the control.

Overshoot
Allowable flow overshoot of the set point prior to reaching control. Expressed either as a percentage full scale (FS) or percentage of the measured mean flow (flow) or a percentage of the desired flow (SP) as selected in the popup menu bar to the right of the control.

Example

	Set Point	Average Flow	Full Scale	Pass /Fail
10% of Full Scale	50	53	200	50 ± 20 sccm
10% of Set Point	50	53	200	50 ± 5 sccm
10% of Flow	50	53	200	53 ± 5.3 sccm

Dead Time
Measured in seconds, dead time is the allowable time delay from the point that the set point voltage is applied until gas begins to flow as determined by the increase in pressure.

Step Response

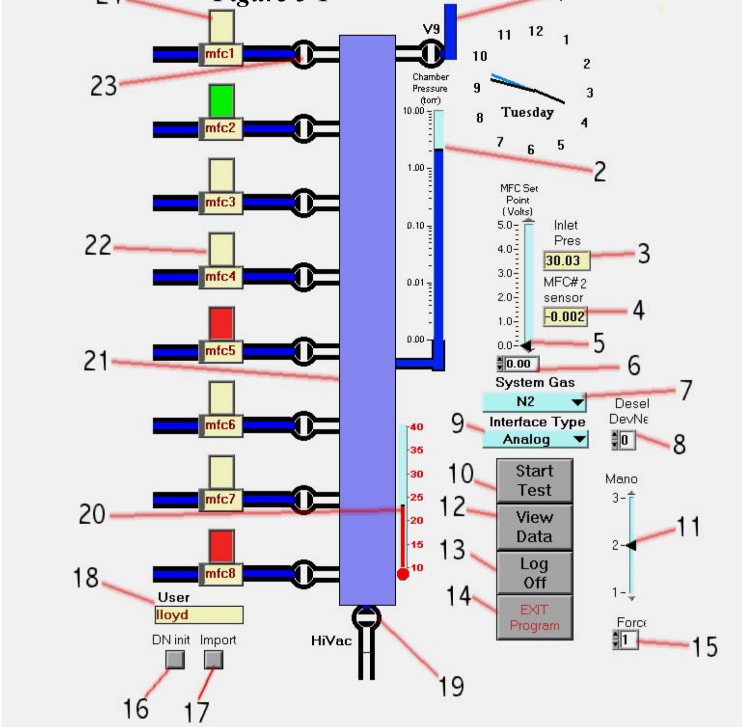
Measured in seconds, step response is the allowable time delay from the point that the set point voltage or signal is applied until the flow rate crosses the lower control band parameter for the first time.

Running and Testing the MFCs

The MFC is ready to test after installation and configuration. Florizel offers users the option of running an MFC manually in addition to automated, sequenced testing.

The Main Operation Screen in Manual Mode

Figure 5-1



1) V9 chamber vent valve.
2) Manometer pressure in Torr. Scale changes to match selected manometer.
3) Inlet pressure indicates the supply side gas pressure in psia.
4) Feedback voltage from the MFC.
5) Slide bar entry of MFC setpoint VDC
6) Direct entry of MFC setpoint VDC.
7) System gas used.
8) Deselect a DeviceNET MFC.
9) Interface of selected MFC.
10) Start test(s) of configured MF(s).
11) Slide selects desired manometer (1 Torr, 10 Torr or 100 Torr).
12) Processes previously collected data. Requests make, model, serial # and time of desired data.
13) Log Off exits the active screen to the log on screen.
14) Florizel pre-checks an MFC before testing. If this fails, it will not run automated test unless "forced". Selects the channel # of MFC to force.
15) Exits Florizel to Windows.
16) Attempts to manually initialize an MF.
17) Import a file
18) Logged On user.
19) Hi Vac valve. Switch toggles between open and closed.
20) Chamber Temperature indicator.
21) Chamber representation. When pumped down, it appears white. As pressure increases, the chamber darkens according to the scale (2). Black indicates the highest pressure on the scale.
22) MFC. Click on the desired MFC to install it for automated testing.
23) Opening this valve allows selected MFC to flow. It also initializes DeviceNET MFCs.
24) MFC #1 is selected and presently flowing in this graph. Set point is 1volt or 20% full scale.

Manual Operation

The user is presented the main operations panel immediately after Log On. This schematic representation of the Florizel allows varying degrees of manual control, depending on the log on level of the current user. Moving the mouse pointer over a valve and clicking changes the state of the valve. Entering an "MFC Set Point" (slide or direct entry) will apply the selected voltage to all installed MFCs. MFC isolation valves are software interlocked to permit chamber gas flow from only one MFC at a time. Chamber pressure and chamber temperature is displayed.

Automatic Testing

MFCs physically installed, configured and selected for testing have dark blue shading in their icons. Clicking "Start Test" on the main operations panel begins the automatic test sequence. The user should stand-by during steps 1 and 2 to verify Florizel and selected MFC initially perform correctly.

1) The chamber is pumped to base pressure and current "zero offsets" of the manometers are recorded. The Florizel cold cathode gauge is read and signals when the chamber has reached $5x10^{-6}$ Torr.

2) All installed positions are quickly checked for a functional MFC. Three tests are performed.
    a) A setpoint of about 50% full scale is run briefly to verify a pressure increase.
    b) Florizel watches for an unusually large leakup rate at zero setpoint (indicative of improper physical installation of an MFC).
    c) MFC feedback is monitored to verify the signal connection.

    Florizel deems an MFC connected and working if all three tests pass. The operator will then be asked whether or not to logoff at the end of testing. Failed MFC positions display in violet with failure mode(s) noted.

    Also, at this point the "Sensor Zero" test is performed. The Sensor Zero tests checks to see what the MFC feeds back when gas is not flowing. The test is performed by applying a 100% full scale set point then closing the valves. With the valves closed, no gas is actually flowing. The feed back voltage or reading is recorded after a 5 second delay for settling.

3) The chamber leak rate is measured with all MFC isolation valves closed. The chamber is pumped below 10 milliTorr. The Florizel lowest range manometer is used to measure the pressure increase over 90 seconds. This determines the normal leak rate of the chamber, which is subtracted from subsequent MFC flow rate calculations.

4) Individual MFCs are tested sequentially according to their defined configurations. A yellow colored icon distinguishes the MFC currently under test.

5) The approximate final pressure of an MFC test is estimated from the specific flow rates and durations entered. The manometer that will be used throughout the test is selected from this estimate.

6) The "zero flow" setpoint applied, the MFC's isolation valve is opened, and the chamber is pumped to base pressure.

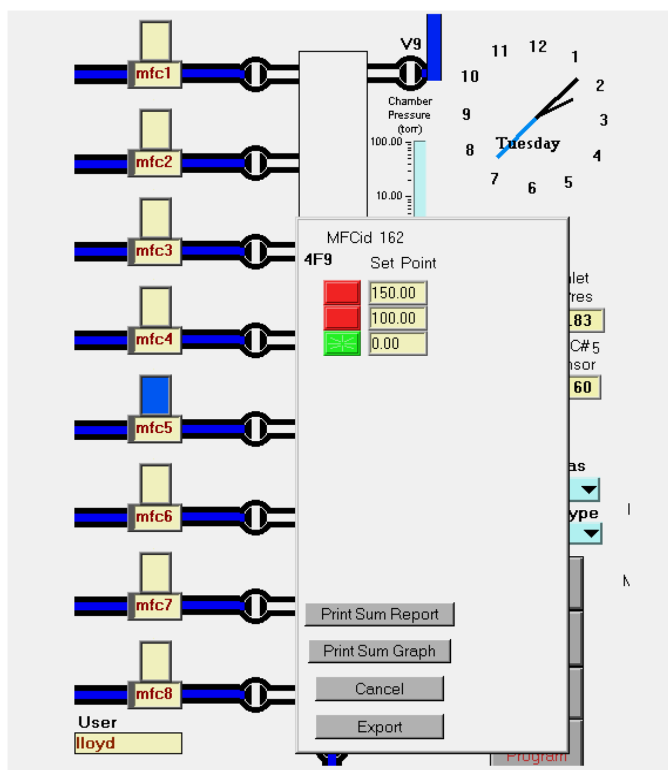
7) The hi-vac valve “close” signal is sent and data collection begins, after a specified delay. This delay is defined in the MFC parameter file to assure a fully closed hi-vac valve, adding roughly one second beyond normal valve reaction time.

8) The MFC flow rate setpoint is applied after approximately 1 second. Data is collected at 2KHz per channel. Four channels are used - pressure (selected manometer), temperature, feedback signal from the MFC, and gas input pressure. The data are averaged over 40 points therefore collecting 50 points per second. The data is stored on the hard disk.

9) Data collection continues until the end of the specified test time or until the maximum chamber pressure is achieved. The set point is returned to 0. The high vac valve is then opened and the chamber is pumped down to prepare for the next set point. The data is analyzed and a small graph of the results of the specified flow rate is displayed in the lower right quadrant of the screen. Steps 5-9 repeat until all set points and repetitions of all configured MFCs are run.

10) After the conclusion of testing a particular MFC, a green colored icon denotes “Pass”. A red colored icon indicates one or more parts of the tests failed. A summary report will print if the autoprint option is configured (requires an installed printer).

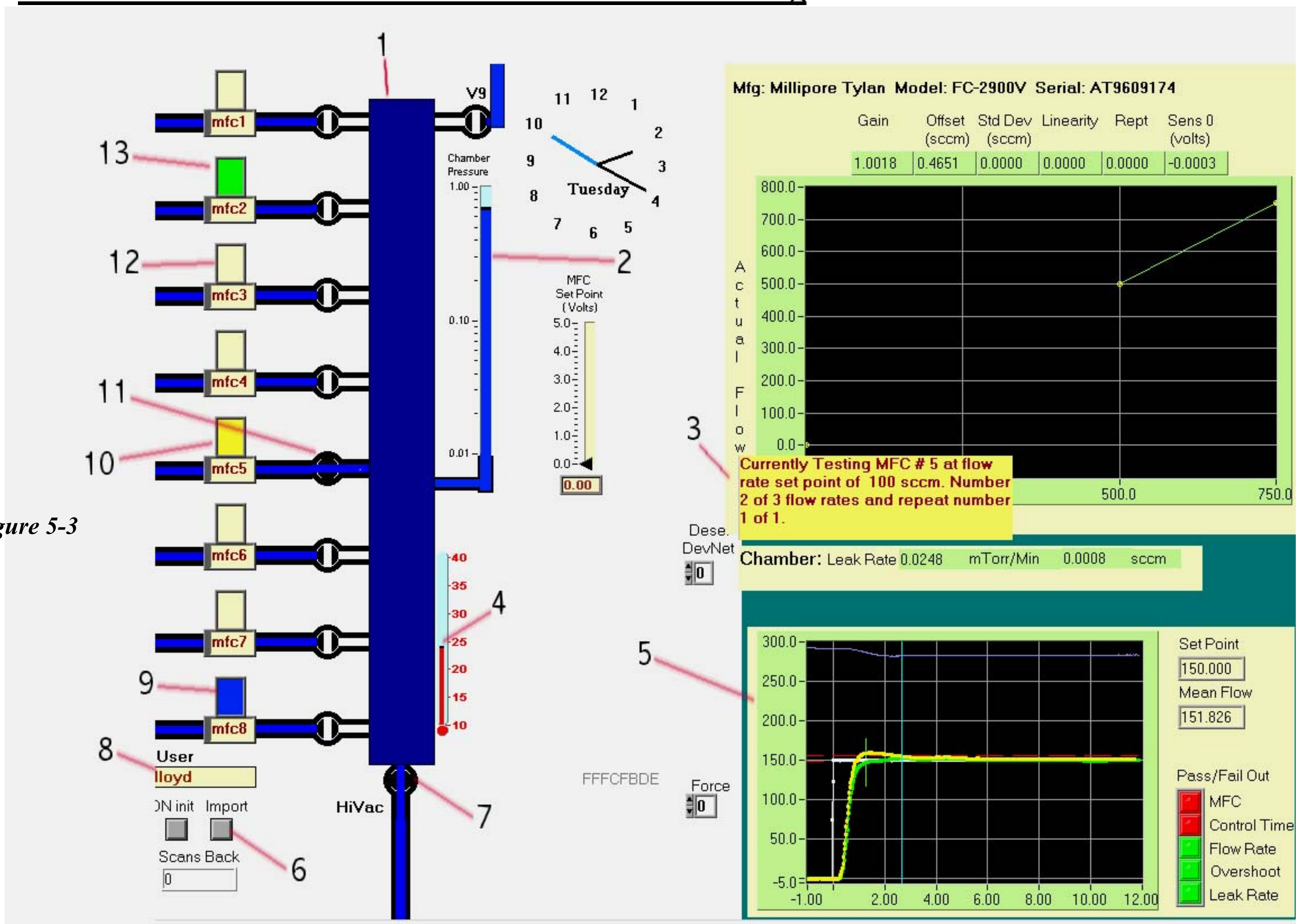
Figure 5-2



Pressing "Stop Flow" during tests terminates the current flow rate test and causes the Florizel to advance to the next. When all MFCs testing is completed (or if "End Test" has been pressed during testing), the green or red icons may be clicked to display test results.

The Main Screen while Automated Tests are Running

Figure 5-3



1. Chamber representation. Darkening color reflects increasing pressure.
2. Present chamber pressure indicator, scaled for the requirements of the specific test.
3. Message window informs user of test currently running on selected MFC.
4. Chamber temperature indicator.
5. Graph and results of last completed test.
6. Import file
7. Hi Vac Valve shown open.
8. The user who is currently logged on.
9. MFC 8 (blue) is configured and will automatically test immediately after MFC 6 tests complete.
10. MFC presently testing (yellow).
11. Valve open on MFC presently under test.
12. MFC not configured for testing.
13. MFC represented as having finished testing. It displays green, indicating it passed all test parameters. If an MFC fails any test, it displays red.

Data are stored on the hard disk in compressed ASCII files. After the testing is completed, raw A summary screen is displayed and the MFC is colored green if all test results passed the pass/fail criteria. The MFC is colored red if any of the tests failed the pass/fail criteria. Viewing and manipulating the results and may be accessed by one of two ways.

Recalling data just run

When the testing has completed and the main screen is showing, the MFCs tested will be displayed in green or red color. Using the mouse, click on the MFC you wish to study. Choose the *Display Data* option. The summary menu appears. Choose the flow rate of interest to bring up the graph.

Recalling previous test data

From the main screen, select the *Process Files* button. You are asked to select the make, model and serial number of the MFC you wish to look at. You will then be presented with a list of dates and times that tests were run on that particular MFC. Choose the date/time you are interested in. The summary menu appears. Choose the flow rate and repetition number of interest to bring up the graph.

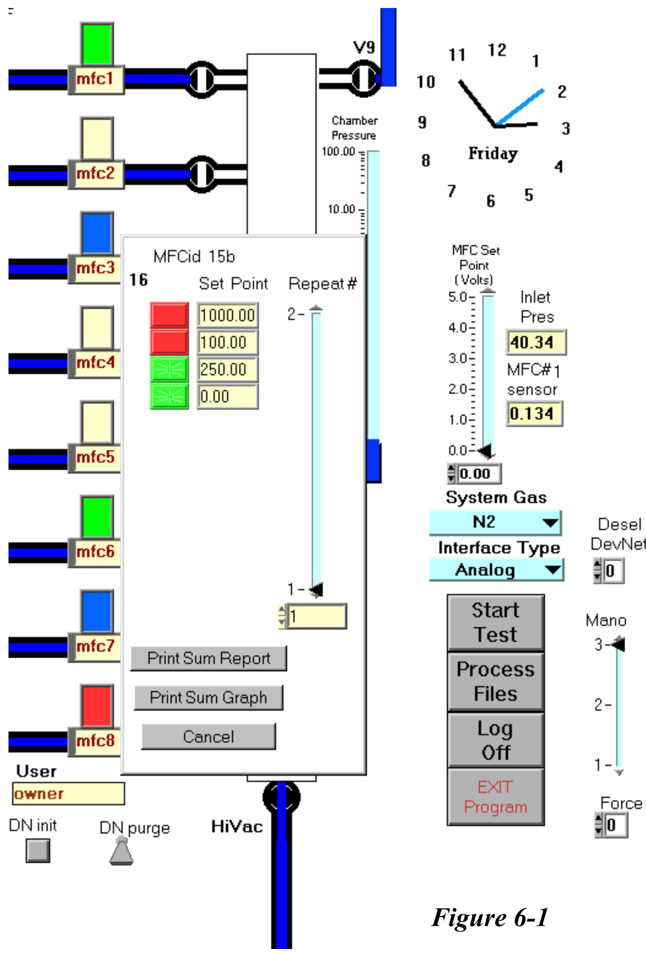


Figure 6-1

Interpreting the Graph

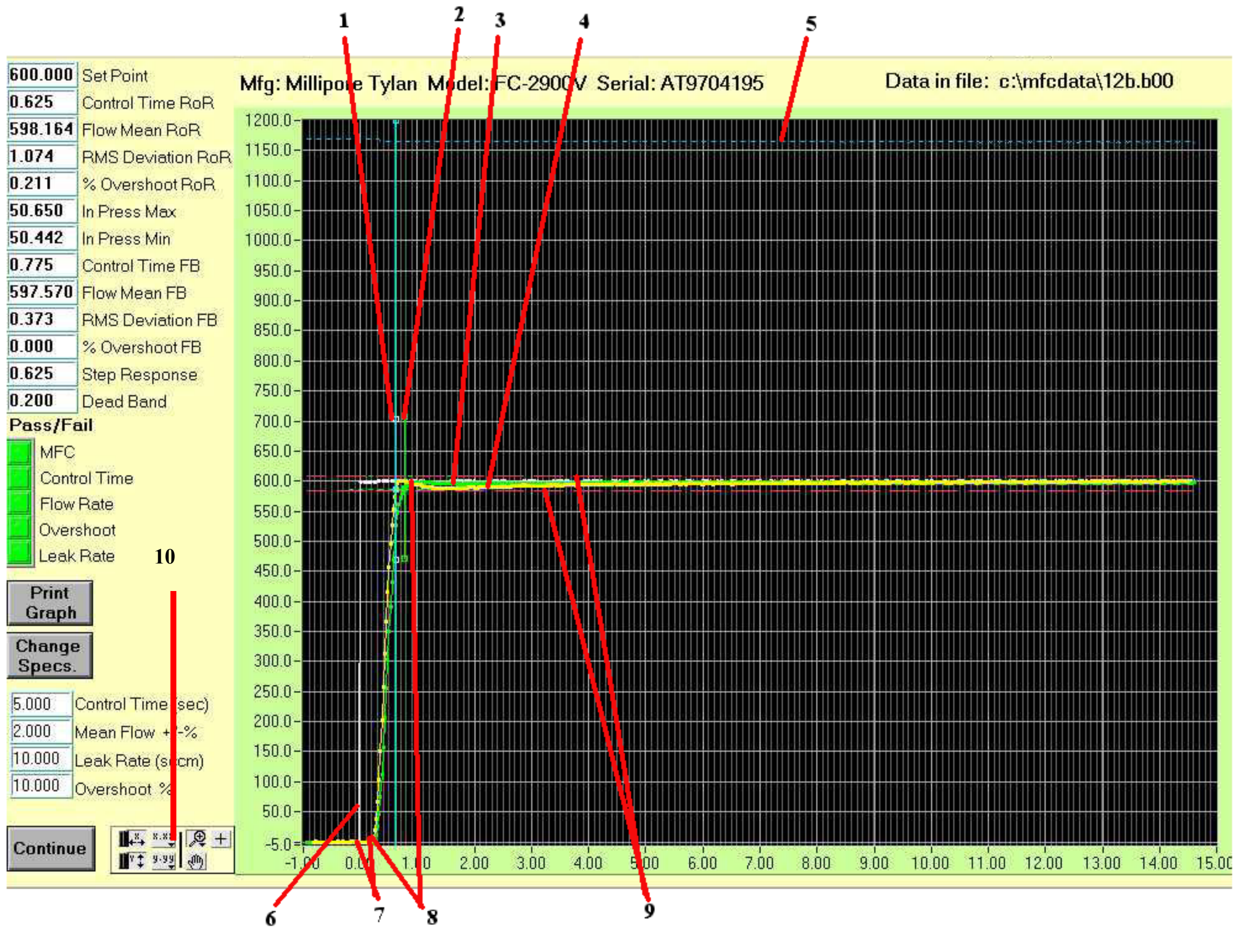


Figure 6-2

1) *Rate of Rise* time to control.
2) *Feed Back* time to control
3) *Feed Back* Flow Rate (Green)
4) *Rate of Rise* Flow Rate (Yellow)
5) Input pressure indicator (not to scale). The input pressure line indicates only that a steady input was provided.
6) Set Point Signal
7) Dead Band- The period of time from changing the set point until the MFC responded.
8) Step response time- indicates the time from which the MFC began to respond until it passed into the control band for the first time.
9) Control band as defined in the configuration file.
10) Utilities for zooming and scaling the graph are located near the "Continue" button at the bottom left of the graph screen display. These may be useful in clarifying the results.

Graph Terms – definitions

Setpoint:	Requested set point (sccm) sent to the MFC.
Control Time RoR:	Seconds from start, until flow enters and remains within the user specified control band, as calculated by Florizel.
Flow Mean RoR:	Average flow rate after coming into control as calculated by Florizel.
RMS Deviation RoR:	Deviation in flow rate after achieving control, as calculated by Florizel.
% Overshoot RoR:	Maximum flow above the setpoint as calculated by Florizel.
In Press Max PSIA:	Gas supply side pressure maximum in absolute pounds per square inch.
In Press Min PSIA:	Gas supply side pressure minimum in absolute pounds per square inch.
Control Time FB:	Seconds from start until controlled flow, as reported by the MFC.
Flow Mean FB:	Average flow rate after achieving control, as reported by the MFC.
RMS Deviation FB:	Deviation in flow rate after reaching control, as reported by the MFC.
% Overshoot FB:	Flow above the setpoint, as reported by the MFC.
Step Response:	Seconds from when the MFC began to turn on (after dead band) until it crossed the lower control band specification for the first time, as calculated by Florizel.
Dead Band:	Seconds from start until MFC began to respond, as calculated by Florizel.

PASS/FAIL Indicators   green = pass, red = fail

MFC	Green: MFC passed all parameters. Red: MFC failed one or more parameters.
Control Time	Passed/Failed acceptable Control Time limit, as calculated by Florizel.
Flow Rate	Passed/Failed acceptable mean Flow Rate, as calculated by Florizel.
Overshoot	Passed/Failed acceptable Flow above the set point, as calculated by Florizel.
Leak Rate	Passed/Failed acceptable zero setpoint Flow limit, as calculated by Florizel.

Settings for determining Pass/Fail – These are user defined in the MFC configuration file. Acceptable Control is defined as less than *xx* seconds. Acceptable Mean Flow deviation is defined as within (+ or -) a percentage of either the setpoint or full scale. Acceptable Leak Rate is defined as *xx* sccm. Acceptable Overshoot is defined as a percentage of setpoint, mean flow or the MFC's full-scale capacity.

Changing the specs and reprocessing data

Test data are stored in raw form. It is possible to change a completed test's pass/fail criteria and specifications and then reprocess and re-display the result. The *change specs* button produces the small menu shown below in *Figure 6-3*. Basic Pass/Fail specs are presented for view or modification as desired. Recall that Florizel permits specification changes only at *Engineer* and *Owner* access levels.

Florizel uses a "least squares fit" method of smoothing the data. The minimum number of points in the fit is 7. Florizel is normally left to automatically determine the best fit. However, the degree of graph smoothing is also user adjustable. A minus (-) number will produce a display of data points with no smoothing.

"*Mode*" currently has only one functional setting. The default is "*Full"* and utilizes the full set of data collected. The two other (*Half*) modes are currently under development.

"Done" re-processes and presents the data with the new parameters. The "reprocessed" display may be viewed and printed as desired.

"Continue" clears any altered specs and restores the data presentation to the original settings that were defined at the time of the test.

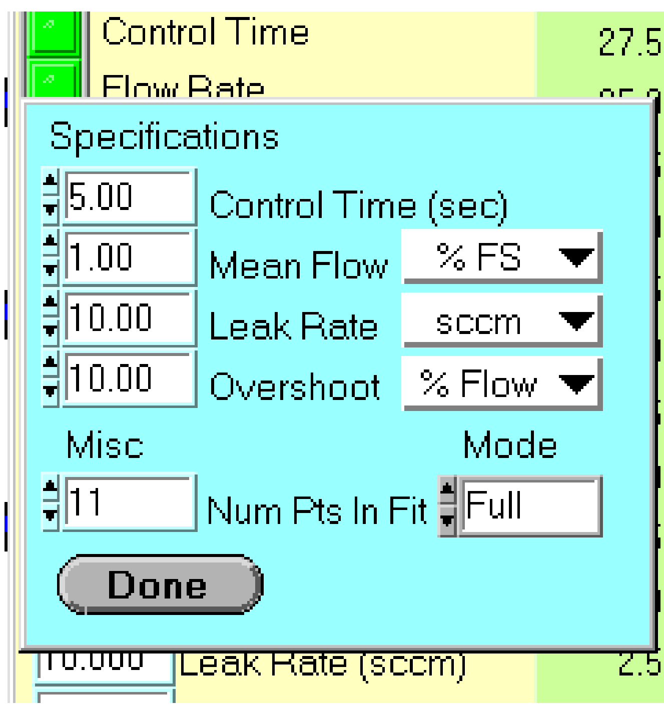


Figure 6-3

Printed Reports

Florizel does not include a printer. However, a printer may be connected through a number of methods to the Dell computer. The computer features a parallel printer port, LAN connection and USB connection. Use *add Printer* feature of Windows 98 to install your printer. Florizel's software may not be compatible with all printers but it works well with the HP Laser Jet III, and HP 970Cse that we use at Lucas Labs.

Printing the Graphs

There are two types of graphs available for printing; flow graphs and summary graphs. To print the graph, simply hit *print graph* from the graph screen. The summary graph is printed from the summary menu. Simply select the option *print sum graph*.

Printing the Summary Report

The summary report includes the data results from all set points of the tested MFC. The summary report may be printed automatically at the end of testing the MFC or after review.

Automatic printing is set up in the configuration screen (see page 4-3 #15). With the toggle set to the ON position, the summary is printed at the conclusion of testing all flow rates in the configuration. Thus it is possible to set-up 8 MFCs for multiple testing, walk away and return to 8 summary reports on your printer.

Printing the summary report from the summary menu allows some altering or adding comments. Selecting *print sum report* from the summary menu calls up the report in Notebook. The data file opens. You may then add comments or change the heading to make the report look exactly like you wish before printing. Once the editing is completed, simply use the Notebook print feature and print the results.

Copy and Paste data

Occasionally, users may wish to emphasize certain data in a report or performa additional calculations in a spread sheet. The summary data can easily be cut and paste transferred into another program. Simply, selecting *print sum report* from the summary menu calls up the report in Notebook. The data file opens. You may then highlight the data of interest and copy. From the Windows Start menu, open the desired program. Paste the data as desired into the new program as desired.

Caution: Close all external programs before running additional tests and collecting data. Running test requires the full capability of the processor and RAM.

The following pages are sample printouts.

Appendix A: System Configuration file

Parameters relating to the overall system are stored in the file "mfcsys.prm" in the "mfccfg" subdirectory. This is a flat ASCII file. The first entry in each line is a number that is used by the MFC Tester software to identify the parameter. The next entry in each line is parameter dependent and the final entry is a double quote enclosed comment that briefly describes the parameter. This is for user information only and not used by the program. An example file is shown below.

```
1 0.02 "Base Pressure (torr)"
2 8000  "Hi Vac Valve closing time in ms"
3 120   "Pumpdown time-out in secs"
4 24.95  "Chamber volume in liters"
5 1 10 100 "manometer range(s) in Torr lowest to highest "
6 60   "chamber leak rate test time (seconds)"
7 50   "# of AI manometer reading to average"
8 15     "# AI counts after MFC set back to zero"
9 2000   "scan rate, works with # AI mano readings"
10 2    "printer type for graphs -- 0=none 1=BW  2=Color"
11  N2  Ar   "Test gas(ses), 1st listed is machine standard."
12 1 "mean flow method  0 = avg all of flow in control; 1 = last half of flow test time"
13 1 1 1 1 "was mano cor factor - not used in releases starting with A9705.A"
14 1 "Num pts in running Least Sqr fit in RoR to Flow calc 1=self calc"
15 MS Access 97 Database "Data base type"
16 0 1 "Interface type(s) 0=Analog, 1=DeviceNet "
17 0 "Temperature calibration offset(deg C)"
18 d:\lvstuff\dns.llb "dns lib path (only used in development system)"
19 5136-DNP-PCI-0-14 "DeviceNET  Card Name(Driver250 or 5136-DNP-PCI-0-14)"
20 0 "Log off at end of run? 0 = No, 1 = Yes"
21 1 "Show DeviceNET explicit panel 0 = No, 1 = Yes"
22 55 "Pump overtemp protection  0 to disable, or temp °C"
```

Note: items 4, 7, 8, 9, 13, 17, 18, and 19 should not be changed without consulting Lucas Labs. This manual covers software version B0003.B. Earlier versions may not support all features mentioned here.

Appendix B: DeviceNET Addenda

Tester equipped with an S. S. Technologies DeviceNET scanner card support a limited subset of the DeviceNET MFC model to support flow testing. When testing DeviceNET MFCs, the MFC MAC id must be set to the same number as the MFC tester channel where it is installed. The baud rate must be set to 500. These switches must be set prior to connecting the DeviceNET cable.

When configuring a particular DeviceNET MFC, the “DN gas **Select**” button on the configuration panel is clicked to access the MFC gas table selection, soft start and zero controls.

For each DeviceNET MFC manufacturer an exception file must be generated and stored in the “c:\mfccfg” subdirectory for the specification of certain parameters. It uses the same format as the system configuration file. An example file is shown below.

```
1 5 "output buffer size"
2 2 "input buffer size"
3 32767 "set point 100% flow"
4 0 "set point buffer offset"
5 1 "sensor buffer offset"
6 0 "need start? 0=no 1=yes"
```

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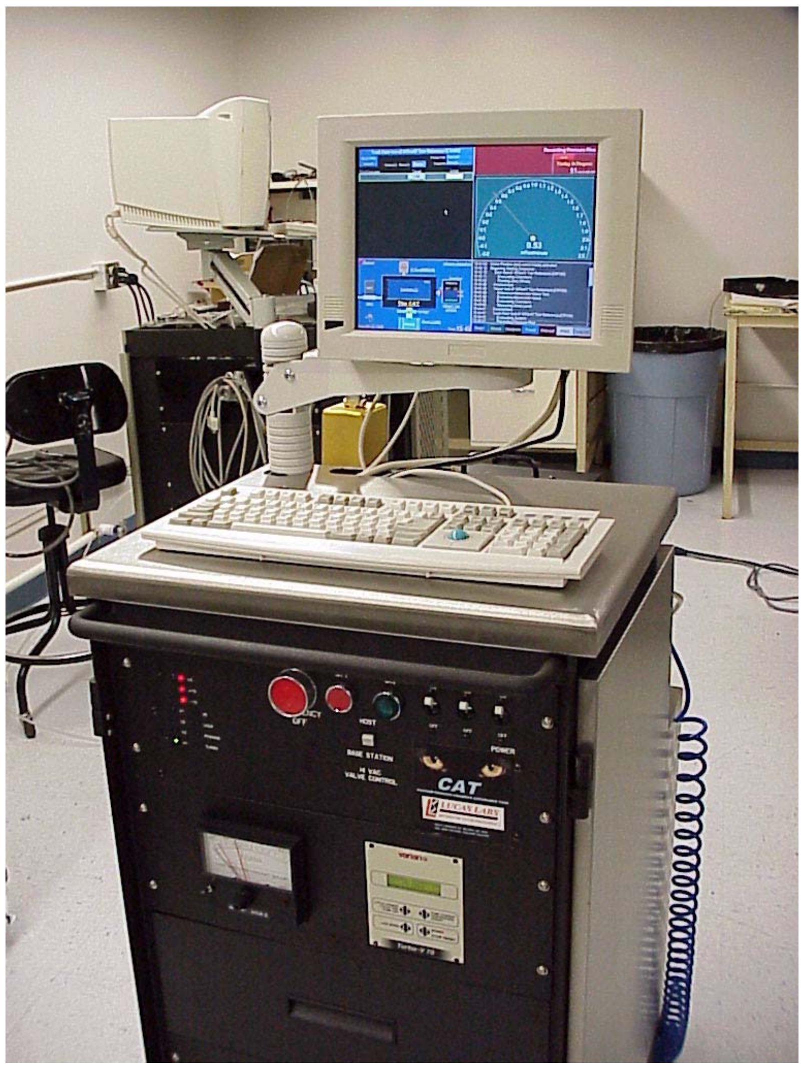
Chamber Assurance Tool Application Note

The following is an actual case where the Lucas Labs system was used for tool matching. In this case, three AMT 8300 series used for Oxide Etch were compared.

The tool labeled EO7 was achieving a yield rate of 97% while tools AEO11 and AEO21 were achieving yields in the 88% and 90% range respectively. The Lucas Labs served as a standard of comparison. The differences were noted and corrections made to all three systems. All systems now produce at the 97% yield rate expected. Following is the data and findings for your reference.



Summary of test results: System OE7

Reference Assembly Temperature = 25.8°C
as measured by internal sensor

OE7 Reference Installation & Host Transfer Curve Calculation

After Reference installation the Lucas Labs indicates an RMS error in the Host manometer transfer calibration curve of only 0.356 mtorr over the 0 to 1 Torr range.

OE7 Pressure Sensor Test

The pressure sensor test determined that the Host manometer was performing within reasonable specifications with the following results:

Zero Offset	-0.97 mtorr
Gain	0.977 (2.3% error)
Linearity Deviation	0.07 mtorr
RMS Noise level	< 0.002% FSR

The tested range was 3 mtorr to 40 mtorr with 11 data points taken.

OE7 Chamber Tests

The chamber tests include rate of rise and volume testing. The system was within the specification entered for all tests.

	Rate of Rise (leak rate)	Measured Volume
Test	0.06 mtorr/min	200.540 liters

OE7 Dynamic Pump Test

The dynamic pump test was run twice to look at the Host system pumping characteristic

	Speed @ 10mt Test Pressure	Time to Target Pressure	Working Base Pressure
Test 1	173.70 L/s	12.11 sec.	0.25 mtorr
Test 2	173.93 L/s	11.53 sec.	0.23 mtorr

Notes:

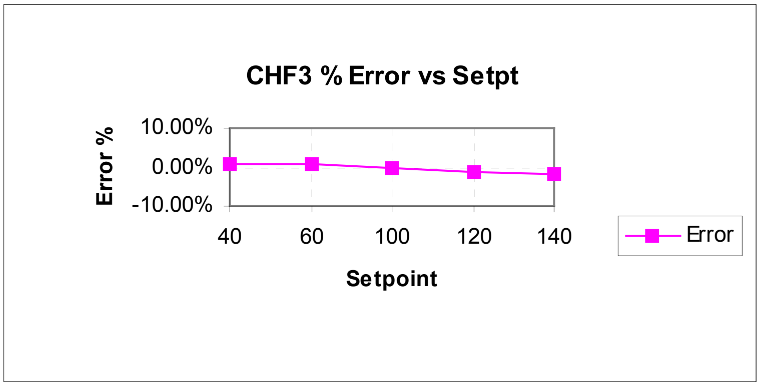
This system is the system that AOE21 is to be matched to. Significant differences noted between the two systems as illustrated in the analysis section. All of the 10 sccm O2 MFCs seemed to behave in a bizarre manner.

OE7- MFC Testing -

All MFCs were tested with the correction factors left as entered.

OE7 - MFC 1 - CHF_3

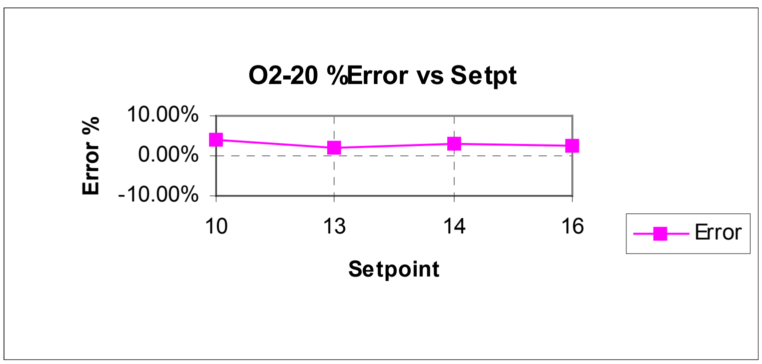
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Summary
Set Point	40	60	100	120	140		Zero Offset = 1.57 sccm
Actual	40.36	60.39	99.83	118.34	137.24		Gain = 0.977 (-2.3%)
Error	+0.90%	+0.65%	-0.17%	-1.39%	-1.97%		Linearity Err = 0.58 sccm



OE7 - MFC 2 - O_2 - 20sccm

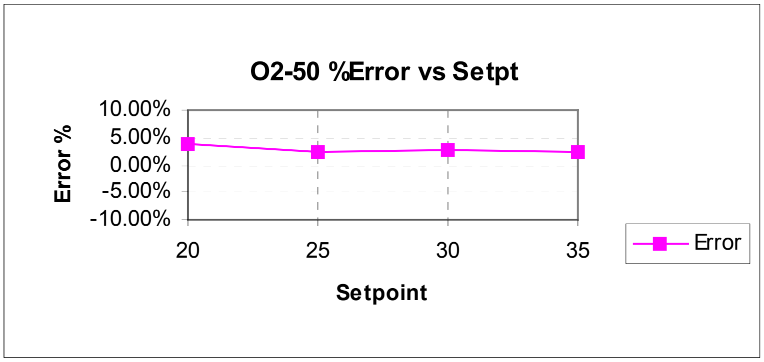
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Summary
Set Point	10	13	14	16			Zero Offset = 0.31 sccm
Actual	10.39	13.29	14.39	16.42			Gain = 1.005 (+0.5% err)
Error	+3.93%	+2.20%	+2.79%	+2.61%			Linearity Err = 0.07 sccm

A slight droop (falling off) in flow rate was exhibited at 13 sccm & 14 sccm



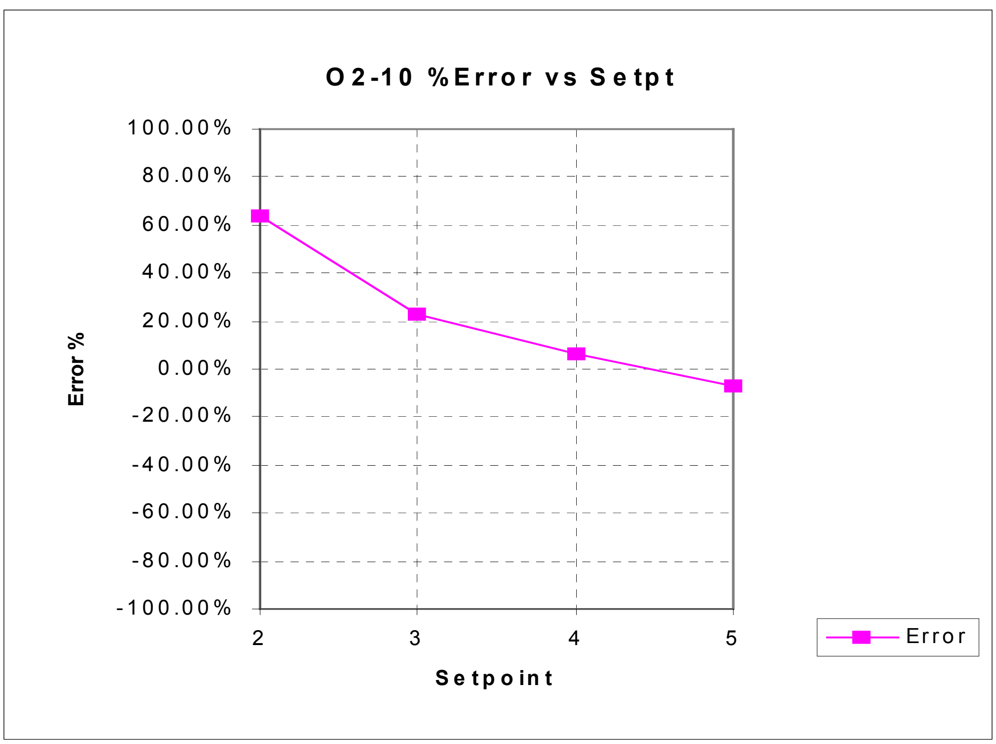
OE7 - MFC 3 - O_2 - 50sccm

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Summary
Set Point	20	25	30	35			Zero Offset = 0.56 sccm
Actual	20.75	25.62	30.80	35.81			Gain = 1.007 (+0.7% err)
Error	+3.76%	+2.49%	+2.65%	+2.31%			Linearity Err = 0.09 sccm



OE7 - MFC 6 - O_2 - 10sccm

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Summary
Set Point	2	3	4	5			Zero Offset = 6.34 sccm
Actual	3.27	3.69	4.24	4.66			Gain = 1.042 (+4.2% err)
Error	+63%	+23.13%	+6.09%	-6.79%			Linearity Err = 0.15 sccm
	Strong droop	less droop	no droop	no droop			



MFC feedback on 8300 screen indicated that MFC jumped to 19 or 20 sccm when turned on and then settled down.

Summary of test results: System AOE11

Reference Assembly Temperature = 26.8°C
as measured by internal sensor

AOE11 Reference Installation & Host Transfer Curve Calculation

After Reference installation the Lucas Labs indicates an RMS error in the Host manometer transfer calibration curve of only 0.212 mtorr over the 0 to 1 Torr range.

AOE11 Pressure Sensor Test

The pressure sensor test determined that the Host manometer was performing within reasonable specifications with the following results:

Zero Offset	-0.60 mtorr
Gain	0.994 (-0.6% error)
Linearity Deviation	0.04 mtorr
RMS Noise level	< 0.002% FSR

The tested range was 3 mtorr to 40 mtorr with 11 data points taken.
Pressure sensor performance matched OE7 within 1 mtorr across the tested range

AOE11 Chamber Tests

The chamber tests include rate of rise and volume testing. The system was within the specification entered for all tests. And volumes indicate that the system temperatures were within ±1°C of each other.

	Rate of Rise (leak rate)	Measured Volume
Test	0.06 mtorr/min	200.021 liters

AOE11 Dynamic Pump Test

The dynamic pump test was run twice to look at the Host system pumping characteristic. Significant differences are noted between AOE11 & OE7, AOE21. AOE11 with a new pump was pumping much faster that either of the other two systems. While pressure is normally throttle valve controlled and one would not think this to be an issue a speed difference of this magnitude should be considered a potential area of concern. I would note the throttle positions on both systems during process and see how large the differences are.

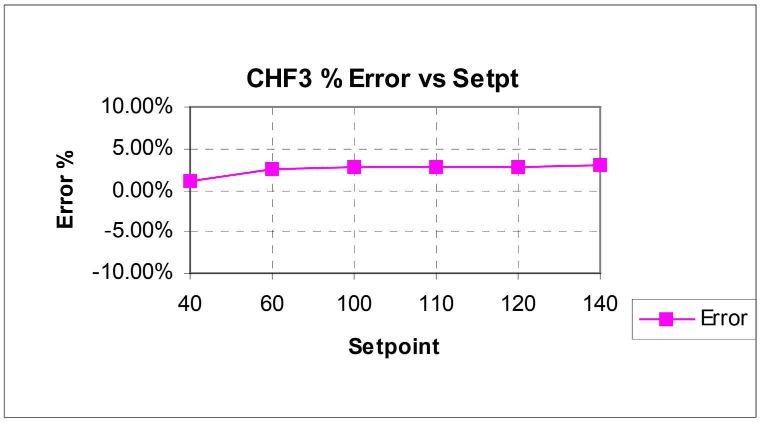
	Speed @ 10mt Test Pressure	Time to Target Pressure	Working Base Pressure
Test 1	240.87 L/s	8.64 sec.	0.17 mtorr
Test 2	241.14 L/s	8.50 sec.	0.20 mtorr

AOE11- MFC Testing -

All MFCs were tested with the correction factors left as entered.

AOE11 - MFC 1 - CHF_3

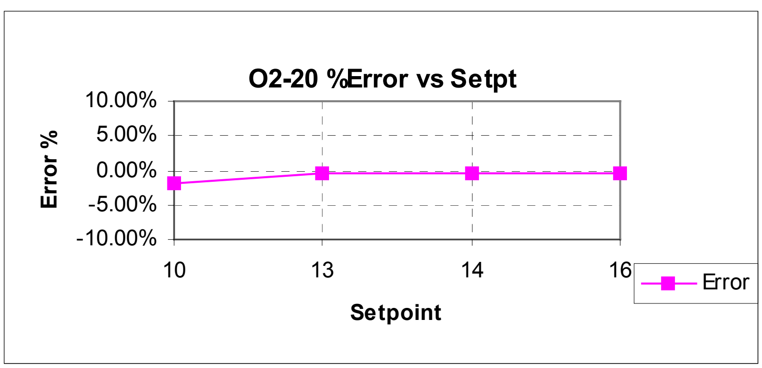
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Summary
Set Point	40	60	100	110	120	140	Zero Offset = -0.82 sccm
Actual	40.48	61.49	102.81	113.01	123.20	144.28	Gain = 1.035 (+3.5%)
Error	+1.20%	+2.48%	+2.81%	+2.74%	+2.67%	+3.06%	Linearity Err = 0.18 sccm



AOE11 - MFC 2 - O_2 - 20sccm

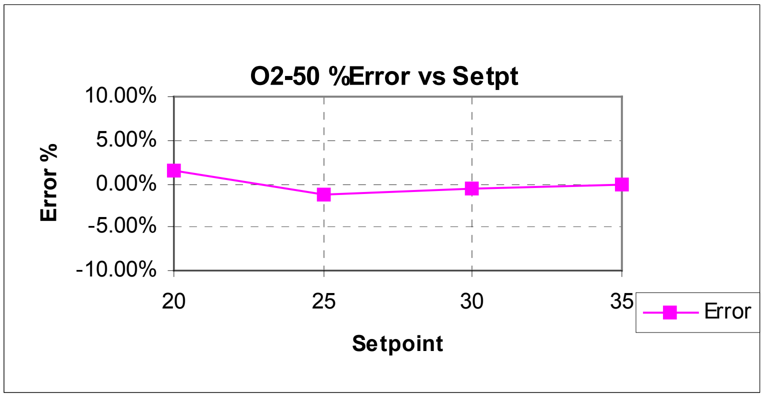
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Summary
Set Point	10	13	14	16			Zero Offset = -0.37 sccm
Actual	9.82	12.96	13.92	15.95			Gain = 1.021 (+2.1% err)
Error	-1.79%	-0.32%	-0.54%	-0.30%			Linearity Err = 0.04 sccm

A slight droop (falling off) in flow rate was exhibited at 10, 13 sccm & 14 sccm



AOE11 - MFC 3 - O_2 - 50sccm

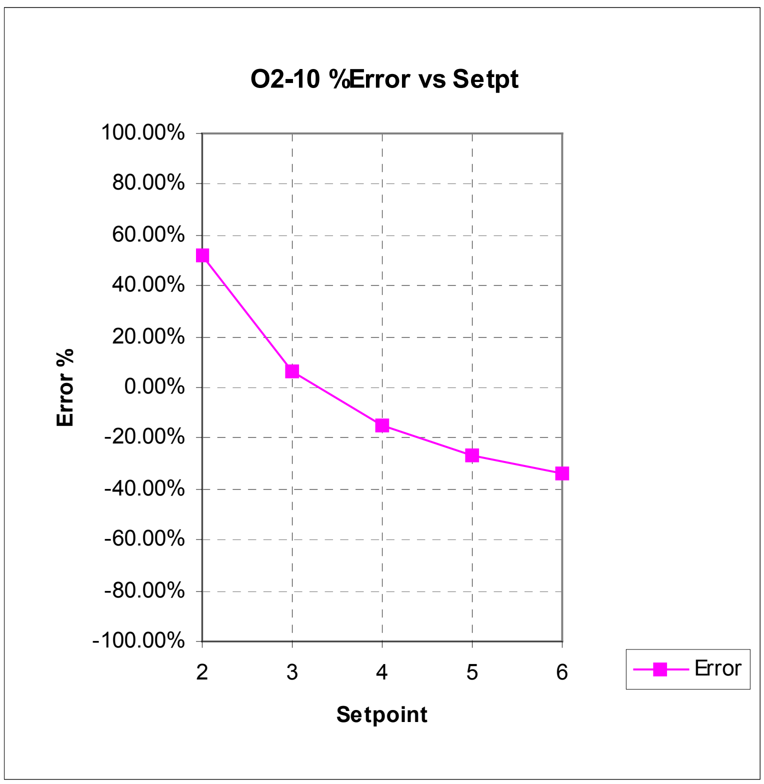
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Summary
Set Point	20	25	30	35			Zero Offset = 0.43 sccm
Actual	20.29	24.71	29.83	34.96			Gain = 0.983 (-1.7% err)
Error	+1.47%	-1.16%	-0.56%	-0.11%			Linearity Err = 0.28 sccm
		Some droop					



AOE11 - MFC 6 - O_2 - 10sccm

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Summary
Set Point	2	3	4	5	6		Zero Offset = 2.52 sccm
Actual	3.04	3.20	3.41	3.65	3.97		Gain = 0.233 (-76.7%% err)
Error	+51.89%	+6.54%	-14.74%	-26.92%	-33.78%		Linearity Err = 0.05 sccm
	Droop			Climbing	Climbing		

MFC feedback on 8300 screen indicated that MFC jumped to 19 or 20 sccm when turned on and then settled down.



Summary of test results: System AOE21

Reference Assembly Temperature = 26.5°C
as measured by internal sensor

AOE21 Reference Installation & Host Transfer Curve Calculation

After Reference installation the Lucas Labs indicates an RMS error in the Host manometer transfer calibration curve of only 0.098 mtorr over the 0 to 1 Torr range.

AOE21 Pressure Sensor Test

The pressure sensor test determined that the Host manometer was performing within reasonable specifications with the following results:

Zero Offset	-0.81 mtorr
Gain	0.983 (-1.7% error)
Linearity Deviation	0.03 mtorr
RMS Noise level	< 0.001% FSR

The tested range was 3 mtorr to 40 mtorr with 11 data points taken.
Pressure sensor performance matched OE7 & AOE11 within 1 mtorr across the tested range

AOE21 Chamber Tests

The chamber tests include rate of rise and volume testing. The system was within the specification entered for all tests. And volumes indicate that the all of the systems temperatures were within ±1°C of each other. The higher rate of rise was largely due to higher outgassing rates as indicated by a pressure dependency evident in the graph and probably caused by higher wafer counts since last clean.

	Rate of Rise (leak rate)	Measured Volume
Test	0.11 mtorr/min	200.990 liters

AOE21 Dynamic Pump Test

The dynamic pump test was run twice to look at the Host system pumping characteristic. Significant differences are noted between AOE11 & OE7, AOE21. AOE21 was performing almost identically to OE7

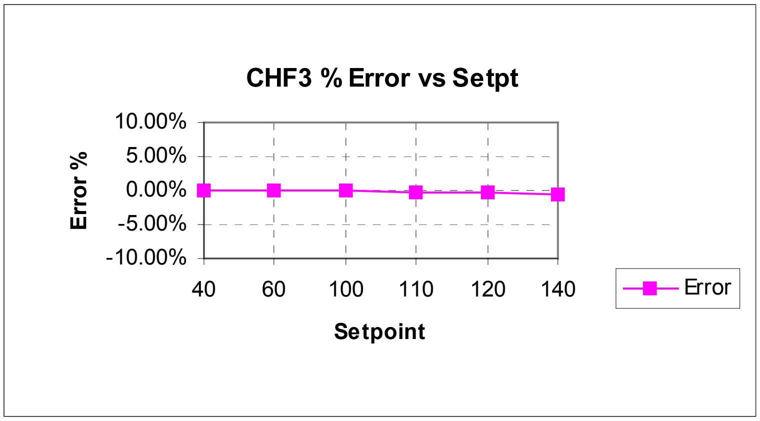
	Speed @ 10mt Test Pressure	Time to Target Pressure	Working Base Pressure
Test 1	177.10 L/s	11.76 sec.	0.01 mtorr
Test 2	177.32 L/s	11.85 sec.	0.03 mtorr

AOE21- MFC Testing -

All MFCs were tested with the correction factors left as entered.

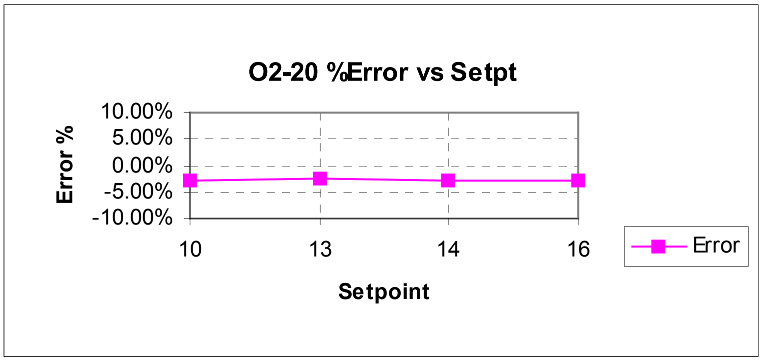
AOE21 - MFC 1 - CHF_3

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Summary
Set Point	40	60	100	110	120	140	Zero Offset = 0.42 sccm
Actual	40.02	59.97	99.98	109.74	119.50	139.23	Gain = 0.993 (-0.7%)
Error	+0.04%	-0.05%	-0.02%	-0.24%	-0.42%	-0.55%	Linearity Err = 0.19 sccm



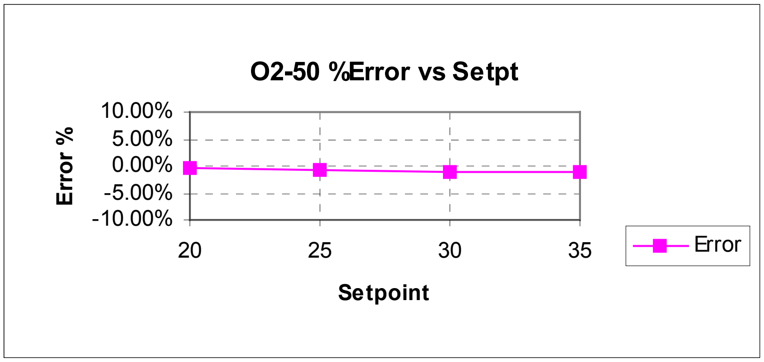
AOE21 - MFC 2 - O_2 - 20sccm

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Summary
Set Point	10	13	14	16			Zero Offset = 0.11 sccm
Actual	9.73	12.69	13.58	15.53			Gain = 0.964 (-3.6% err)
Error	-2.66%	-2.37%	-3.01%	-2.95%			Linearity Err = 0.04 sccm



AOE21 - MFC 3 - O_2 - 50sccm

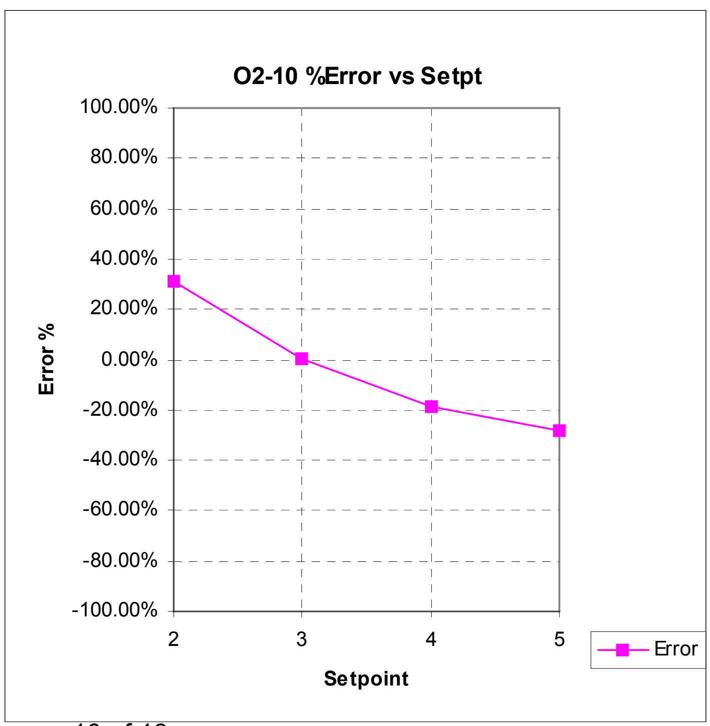
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Summary
Set Point	20	25	30	35			Zero Offset = 0.34 sccm
Actual	19.95	24.81	29.68	34.65			Gain = 0.979 (-2.1% err)
Error	-0.25%	-0.74%	-1.07%	-1.00%			Linearity Err = 0.04 sccm



AOE21 - MFC 6 - O_2 - 10sccm

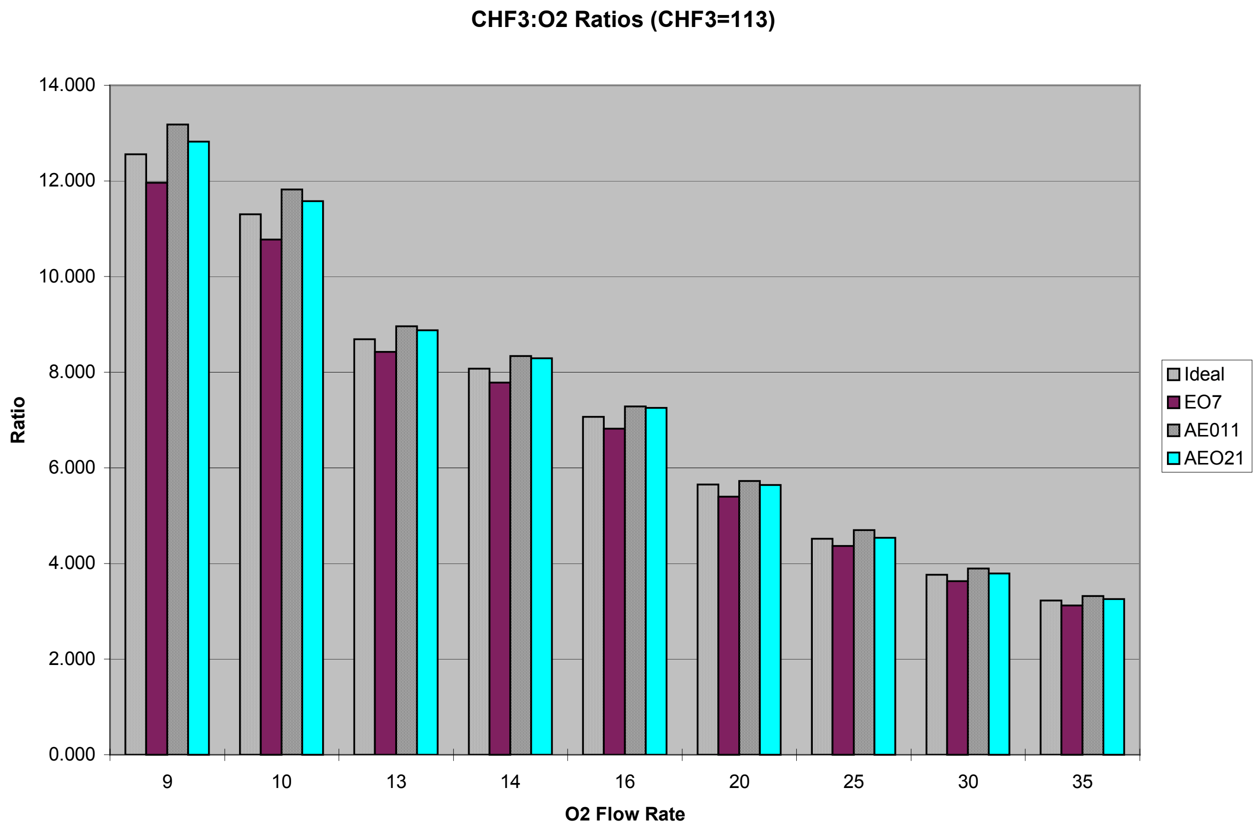
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Summary
Set Point	2	3	4	5	6	7	Zero Offset = 2.52 sccm
Actual	2.63	3.02	3.24	3.58	3.94	4.35	Gain = 0.233 (-76.7%% err)
Error	+31.45%	+0.75%	-18.94%	-28.28%	-48.27%	-37.90%	Linearity Err = 0.05 sccm
	Droop in flow rate	Flat flow rate	Slight rise in flow rate	rise in flow rate	Strong rise in flow rate	Severe rise in rate	

MFC feedback on 8300 screen indicated that MFC jumped to 19 or 20 sccm when turned on and then settled down. The Flow rate also varied as to time with the low flows rates declining over time and the higher rates rising over time.

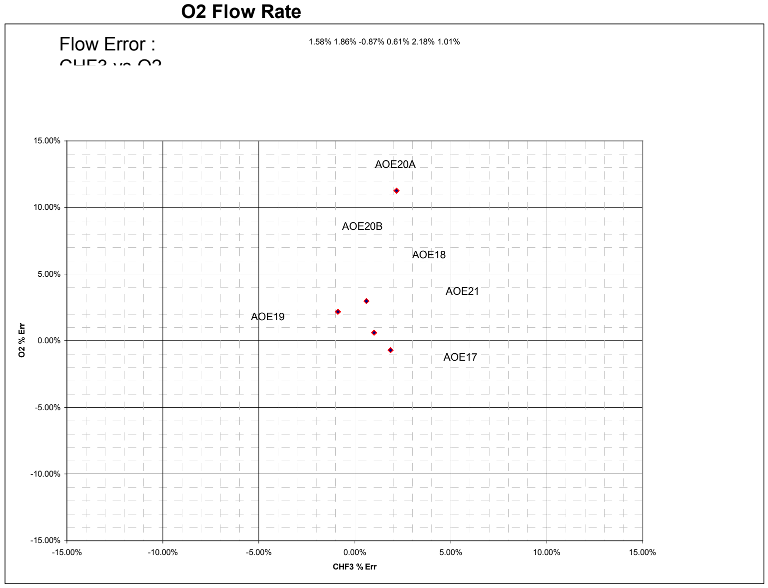


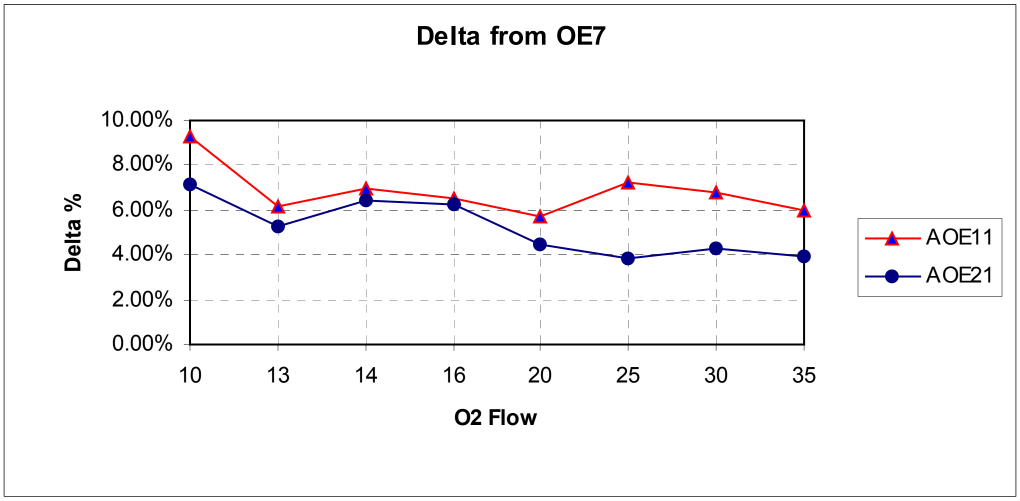
Summary & Recommended Action

AOE21 was the best calibrated of the three systems (and has the smallest correction factors entered for it's MFCs) but since OE7 is slightly out of calibration AOE21 is in error relative to OE7. AOE11 is out of calibration in the opposite direction than the errors measured on OE7 so it exhibits the most difference in process, followed by AOE21. In many cases the differences are small in terms of absolute flow rates - only 1 or 2 sccm, but with the low flow rates involved the differences can be as high as 10% in O_2 to CHF_3 Ratios between OE7 & AOE11. This difference may be the mechanism accounting for the process difference between OE7 & AOE11.

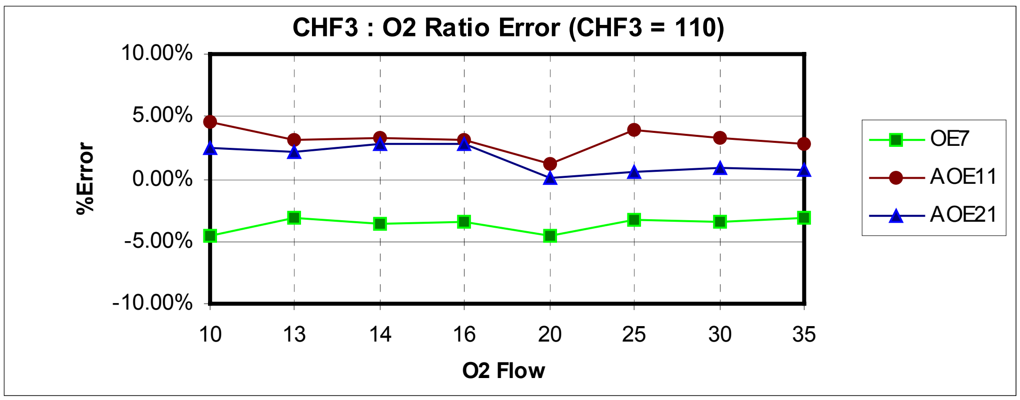


Reinforcing this conclusion is the results from AOE21, with the differences between it and OE7 being midway between the measured differences between AOE11 & OE7 it also exhibits process deviations that are similar but not as severe as those exhibited by AOE11.

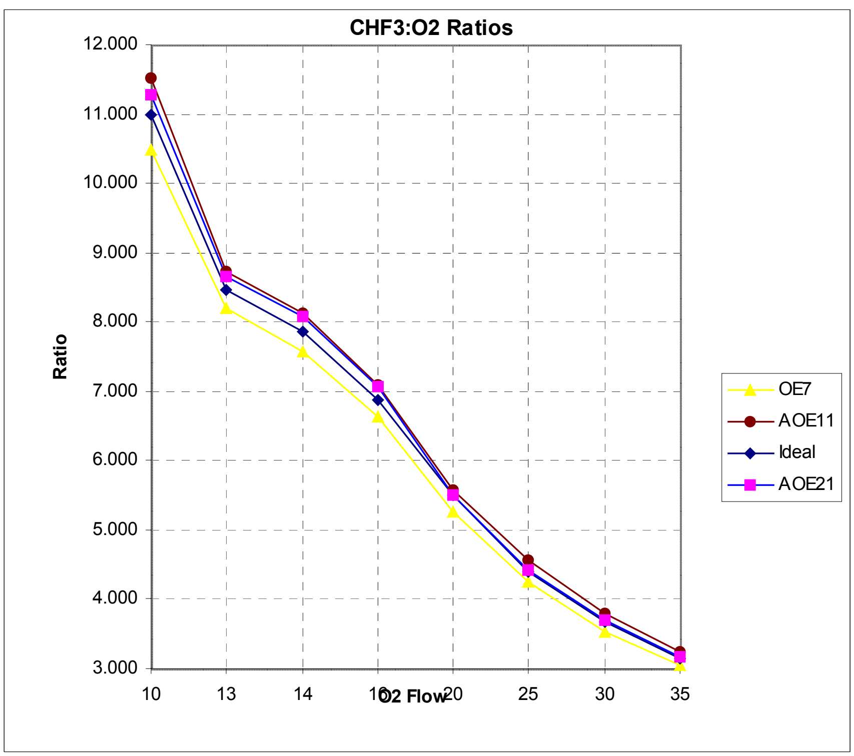




Delta from OE7
Delta %
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
10
13
14
16
20
25
30
35
O2 Flow
AOE11
AOE21



CHF3 : O2 Ratio Error (CHF3 = 110)
%Error
10.00%
5.00%
0.00%
-5.00%
-10.00%
10
13
14
16
20
25
30
35
O2 Flow
OE7
AOE11
AOE21



CHF3:O2 Ratios
Ratio
12.000
11.000
10.000
9.000
8.000
7.000
6.000
5.000
4.000
3.000
10
13
14
16
20
25
30
35
O2 Flow
OE7
AOE11
Ideal
AOE21

Also noted during testing was a strong difference in pumping speeds between AOE11 and the other two systems which should be investigated further to determine it's effects on process.

Many of the remaining issues may not present or cause and significant problems but are noted as potential sources of error or mismatching between systems:

It was observed that many of the MFC's inlet pressure regulators were set to pressures which are out of specification and did not match each other. This should be investigated and corrected. Through past direct research on this issue I know that inlet pressure and pressure regulation has a direct effect on the flow rates from any given MFC. Inlet pressure should be examined and corrected as part of any routine maintenance. In addition some systems have individual pressure regulators for each O_2 line and some have all O_2 MFCs connected to a single regulator for the whole system. While this gang-feeding arrangement may not cause a problem in many cases, especially if the MFCs are not flowed at the same time, a potential problem exists if the actions of one MFC cause upstream pressure fluctuations when it switches on and off or changes flow rates.

The MFCs in use (Tylan General FC2900 series) are not the same as the original Unit MFCs which were supplied with the system. Although not tested during this diagnostic session the power supplies, both voltage levels, current supplies and ground issues should be investigated at the MFC as significant differences exist between the power requirements of the Unit MFCs and the FC2900s. This has been seen to be a source of problems in other locations.