

molbloc/molbox™
Low Mass Flow Calibration System
AFMETCAL Configurations
Installation and Operation
Manual Supplement

MOLBLOC/MOLBOX™ LOW MASS FLOW CALIBRATION SYSTEM AFMETCAL
CONFIGURATIONS
INSTALLATION AND OPERATION MANUAL SUPPLEMENT



High pressure liquids and gases are potentially hazardous. Energy stored in these liquids and gases can be released unexpectedly and with extreme force. High pressure systems should be assembled and operated only by personnel who have been instructed in proper safety practices.

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ABOUT THIS MANUAL

This manual provides information specific to installing and operating the AFMETCAL molbloc/molbox system configurations purchased under contracts F33660-99-F700 and F33660-00-F7007 and is defined by NSN 6680-01-466-2062. It is intended to be used as a supplement to the **molbox1 molbloc Terminal (Ver. 5.00 and higher) Operation and Maintenance Manual, RPM3 Operation and Maintenance Manual and COMPASS for molbox User's Manual Version 4.00**. The molbox1, molblocs and COMPASS for molbox software provided in AFMETCAL system configurations are standard products identical to the commercial versions covered in the standard product manuals.

Manual Conventions



(CAUTION) is used throughout the manual to identify user warnings and cautions.



(NOTE) is used throughout the manual to identify operating and applications advice and additional explanations.

[] indicates direct function keys (e.g., [UNIT]).

< > indicates molbox1 screen displays (e.g., <1yes>).

NOTES



system overview

An AFMETCAL configuration molbloc/molbox mass flow calibration system is made up of standard molbloc/molbox system components plus a special hardware kit. The kit includes this manual and several hardware items to provide pressure regulation and interconnections to devices under test (DUTs). These hardware items are selected to allow calibration of flow devices as defined by AFMETCAL, specifically, gas flow meters with 1/4 in. tube (Swage) or AN4 type fittings used at various pressures ranging from zero to 50 psig. The system's maximum calibrated flow rate is 40 slm.

There are two different AFMETCAL configurations. One is the basic configuration. The other is the calibration exchange system. Their differences are summarized below in Section 1.1.1. Table 1 lists the specific components included in each configuration.

the two system configurations

BASIC AFMETCAL CONFIGURATION

The basic configuration includes a molbox, molstics and five molbloes to handle flows up to 40 slm. COMPASS for molbox software, metering valve kits and the AFMETCAL Configuration Kit are also included in the basic configuration. This is the system configuration which will be in regular use in the PMEL labs, and is specifically defined by NSN 6680-01-466-2062.

CALIBRATION EXCHANGE SYSTEM

This system is intended for delivery to AFMETCAL for temporary use at the various PMELs while each PMEL's system is being serviced or recalibrated. The exchange system is identical to the basic configuration above with two exceptions:

- The exchange system is delivered with CalTool software instead of COMPASS software to provide AFMETCAL with the ability to recalibrate molbloes.
- Two custom shipping containers are included to facilitate the shipping of the exchange and PMEL systems back and forth for recalibration.

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Table 1. Components List for AFMETCAL Configuration Systems

DHI PART NO.	DESCRIPTION	QUANTITIES	
		BASIC	EXCHANGE
401265	molbox1 Terminal	1	1
3069609 (401182)	10 (1E1) sccm molbloc	1	1
3069611 (401183)	50 (5E1) sccm molbloc	1	1
3069648 (401198)	500 (5E2) sccm molbloc	1	1
3069037 (400483)	5 (5E3) slm molbloc	1	1
3069524 (401042)	30 (3E4) slm molbloc	1	1
3069773 (401318)	Dual Low Flow molstic	1	1
3069712 (401244)	Single Mid Flow molstic	1	1
3069764 (401317)	Dual Mid molstic	1	1
3069786 (401319)	Low Flow Metering Valve Kit	4	4
3069799 (401320)	Mid/high Flow Metering Valve Kit	1	1
3350751 (401578)	AF Config Mass Flow Kit	1	1
FAM0003	RPM3-A0100b Pressure Monitor	1	1
2758335 (100847)	RS232 Cable	1	1
3069666 (401211)	COMPASS Software Ver. 4.0	1	
3119808 (102848)	CalTool Software		1
NPN	Custom Shipping Container		2



This manual is a supplement to the molbox1 and COMPASS for molbox manuals. For molbox1 system specifications, refer to Specifications section in the molbox1 molbloc Terminal (Ver. 5.00 and higher) Operation and Maintenance Manual.



UNPACKING AND INSPECTION

Removing From Packaging

All molbloc/molbox system components and accessories are delivered in corrugated containers with custom inserts or foam to hold them in place. They are also enclosed in protective plastic bags within the containers.

Remove the components from the shipping containers and remove each element from its protective plastic bag. Retain the boxes and inserts for possible reuse.

Inspecting Contents

Use Table 1 to determine which components are included in your system. Descriptions of the components' packaging and accessories are below. Check that all items are present and have NO visible damage.

molbox1

molbox1 is delivered with caps installed over the pressure connections and communications ports on the rear panel. A piece of cellophane protects the front panel and may be removed. The molbox1 accessory kit is placed inside the box with molbox1. The Metering Valve Kits (see Section 2.1.2.6) and the AFMETCAL Configuration Kit (see Section 2.1.2.7) may also be placed in this box. The following items should be present in the molbox1 accessory kit:

- molbox1 molbloc Terminal (Ver. 5.00 and higher) Operation and Maintenance Manual
- molbox1 Calibration Certificate
- Power Cord
- Four molbloc to molbox1 Pneumatic Lines with Quick Connectors
- Two molbloc to molbox1 Electrical Connection Cables
- molTools Utility Software Disk
- COMPASS for molbox for Windows Demo Version Software Disks
- Four Rubber Feet Caps

COMPASS FOR molbox SOFTWARE

A COMPASS for molbox software installation CD is secured inside the COMPASS for molbox User's Manual Version 4.00. The CD may have **DHI** product literature and other support software stored on it in addition to the COMPASS for molbox installation program. The COMPASS manual is typically placed with other system manuals inside the box with molbox1.



AFMETCAL systems include COMPASS for molbox software version 4.0 (AF CPIN 88M-MOLBOX1AF-T001-00A)

CALTOOL SOFTWARE

For the "calibration exchange system" configuration, CalTool for molbox is included in place of COMPASS. It is on 3.5 in. floppy disks or a CD secured inside the back cover of its manual.

molblocs

molblocs are shipped and stored in hard cases with sliding covers. The cases are shipped inside cardboard boxes holding two molblocs each. There is a recessed square on the front of the hard cases on which to apply the molbloc's calibration sticker if you desire. Calibration stickers are delivered with each calibration certificate.

molbloc end fittings, pneumatic pressure quick connectors and communication ports are capped for protection and cleanliness. Each molbloc has a black label on one side listing the molbloc's part number, serial number and ordering description. There is a silver label on the other side listing the molbloc's usable pressure and flow ranges and indicating correct flow direction.

Four Viton O-rings and general molbloc mounting instructions are sealed in a bag with each molbloc case. The Viton O-rings should be used in the VCR fittings when mounting molblocs in molstics (see molstic Installation Instructions).



AFMETCAL configuration molblocs' usable flow ranges differ from their nominal ranges due to the high pressure calibrations performed on them. Both the operating pressure and flow range listed on each molbloc's silver label must be observed to ensure accurate flow measurements. See Section 3.1 for explanation of molbloc operating pressure and usable flow range.

molstics

molstics are packaged in long corrugated boxes surrounded by protective foam. Accessory kits are packaged with the molstics and include Viton O-rings, and installation instructions. Low flow molstic accessory kits also include a filler rod which can be inserted in the VCR close coupling fitting at the molbloc's outlet. The filler is used to reduce dead volume between the molbloc and DUT to help stabilize pressure when measuring very low flows (see molstic installation instruction sheet). In systems where there is already significant volume from tubing, the rod will not have much effect.

Both low and mid flow molstics are delivered with cradles to fit small molblocs installed. The cradles on the single mid flow molstic need to be replaced with the large molbloc cradles to fit the larger 30 slm (3E4) molbloc. All of the molstic parts downstream of the cradles also need to be moved further downstream to accommodate the 30 slm (3E4) molbloc's greater length. The molstic base has pre-drilled holes for each standard bracket and cradle in both positions (see the molstic installation instructions).

METERING VALVE KITS

Metering valve kits are made up of several items including the metering valve, a valve bracket and panel mounting nut, a coupling bracket and grommet, a VCR close coupling union, two Viton O-rings and Allen screws. Each item in the kit is packaged in a plastic bag. These kits are to be mounted on the downstream end of each molstic channel.

Four low flow metering valve kits and one mid/high flow metering valve kit are delivered. Mount the low flow metering valve kits on the dual low flow and dual mid flow molstics. Mount the mid/hi flow metering valve kit on the single mid flow molstic. The manufacturer's part number written on each metering valve's body differentiates the low flow valves from the mid/high flow valve. The low flow valve is SS-4BMG-VCR. The mid/high flow valve is SS-4BMRG-VCR. See Section 2.1.2.6 for specific mounting instructions for the metering valve kits.



Never forcefully tighten the molstic metering valves. They are not designed for positive shut-off, only flow control.

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AFMETCAL LOW MASS FLOW SYSTEM CONFIGURATION KIT

The AFMETCAL Configuration Kit is contained in a single plastic bag and includes each of the parts listed in Table 2.

Table 2. Parts List for AFMETCAL Configuration Mass Flow Kit P/N 401578

QUANTITY	DHI PART NO.	DESCRIPTION
5	3138039 (102821)	Male VCR Nut
5	3136739 (102454)	VCR to 4T Tube Adaptor
8	3132930 (100247)	4T Swage Nut
8	3132948 (100248)	4T Swage Front Ferrule
8	3132953 (100249)	4T Swage Rear Ferrule
2	3068350 (100109)	1/4 in. NPT M to Swage Adaptor
6	3372499 (102822)	Swage Male Union
4	3328885 (102664)	AN4 F to Swage Adaptor
2	3372514 (102824)	Back Pressure Regulator
2	3137757 (102727)	Regulator Panel Mounting Nut
2	3372506 (102823)	Back Pressure Gauge
2	3232378 (101450-Z)	20 in. (50 cm) PFA Tube, 1/4 in. OD
2	3232378 (101450-Z)	6 in. (15 cm) PFA Tube, 1/4 in. OD
1	3375667 (550110)	Manual, AFMETCAL Configurations
1	3372523 (102849)	VCR Plug
1	2758335 (100847)	RS232 Cable

CUSTOM SHIPPING CONTAINERS

The custom shipping containers are inside a corrugated box. No equipment is delivered inside the containers. Both containers have custom foam cutouts to hold up to four molblocs, one molbox1, and calibration documents.

RPM3

RPM3 is delivered with plugs installed in the pressure ports and caps over the communications ports on the rear panel. Cellophane protection also covers the front panel display. RPM3 is packaged with the RPM3 Operation and Maintenance Manual and a power cord. An RS232 cable is included in the AFMETCAL configuration system for PC communication with the RPM3, but it may be packaged with the other accessories.

general hardware setup

Site requirements

AFMETCAL configuration systems require a bench space that is at least 4 feet (1.3 m) long to arrange the molstic, device under test (DUT) and back pressure regulator in series. It is often convenient to locate molbox on a shelf above these components if one is available. Otherwise, it can be placed behind or beside the molstic on the bench. molbox's front feet can be extended so that the unit can be inclined slightly for easier viewing. The allowable distance between molbox1 and the molblocs is limited by the 3 feet (1 m) long pneumatic tubes that connect them. The computer interface should be located nearby to allow convenient data entry. See "Installation" in the molbox1 molbloc Terminal (Ver. 5.00 and higher) Operation and Maintenance Manual for other site requirements and connection instructions.

installation of metering valve kits

Install the metering valve kits on each molstic channel as shown in Figure 1. The single mid flow molstic needs to be configured for the large 30 slm (3E4) molbloc prior to installing the metering valve. The metering valve is inserted into its bracket leaving the panel mounting nut loose. The metering valve bracket is attached to the downstream end of the molstic by fastening the Allen screws into pre-drilled holes on the molstic. An arrow on the metering valve body indicates the proper flow direction. The male VCR fitting on the metering valve inlet connects with the VCR close coupling fitting to the molbloc. Install the bottom half of the two piece coupling bracket onto the molstic downstream of the metering valve. The VCR close coupling fitting is connected to the outlet of the metering valve and is supported by the coupling bracket in the rubber grommet. Use a Viton O-ring in each VCR connection.



The manufacturer's part number written on each metering valve's body differentiates the low flow kits from the mid/high flow kit. The low flow valve is SS-4BMG-VCR. The mid/high flow valve is SS-4BMRG-VCR.

install nuts and ferrules on swage tube parts

Numerical references refer to Figure 2.

Install the 4T Swage (Swagelok or equivalent) nuts and ferrules onto adaptor and tubes as follows:

- **VCR tube adaptor (1):** Slide male VCR nut on one side and swage nut and ferrules on the other.
- **20 in. (50 cm) 4T (8):** Swage nuts and ferrules on both ends.
- **6 in. (15 cm) 4T (3):** Swage nuts and ferrules on both ends.

Extra nuts and ferrules are included which can be kept as spares.

installation of MOLBLOCS

molblocs are mounted in the cradles on the molstic(s). The 10 sccm (1E1) and 50 sccm (5E1) molblocs are mounted in the dual low flow molstic, the 500 sccm (5E2) and 5 slm (5E3) molblocs are mounted in the dual mid flow molstic, and the 30 slm (3E4) molbloc is mounted in the single mid flow molstic. molblocs are easily swapped into and out of a molstic when necessary (see molstic instruction sheet).

Install the molblocs with the arrow on the silver sticker pointing in the direction of the flow. Be sure to use the Viton O-rings provided when connecting the molbloc VCR end fittings (see molstic instruction sheet). When using molstics with metering valve kits installed, it is easiest to install molblocs by connecting the downstream fitting first, then inserting the upstream O-ring and connecting the upstream fitting last. Store molblocs in their cases when not in use.

See molbox1 molbloc Terminal (Ver. 5.00 and higher) Operation and Maintenance Manual (Initial Setup) for instructions on making proper connections between molblocs and molbox1.

arrangement of flow path components

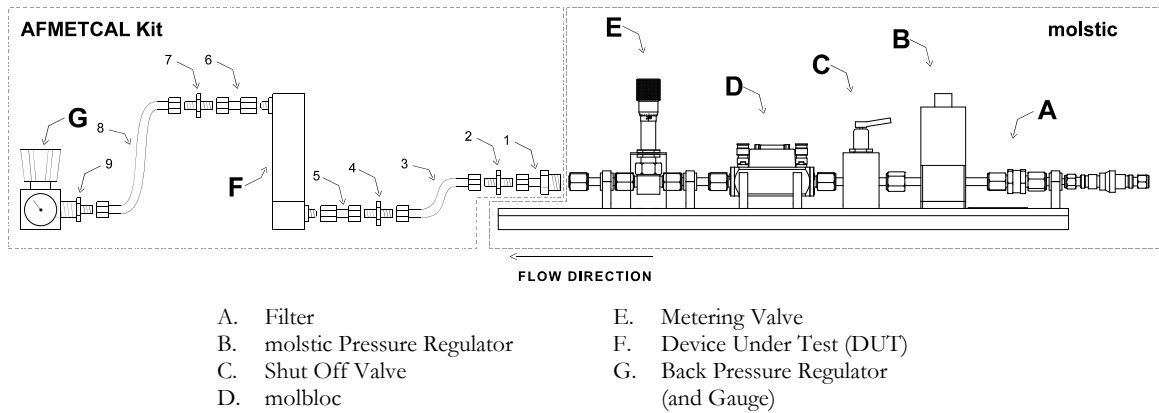


Figure 1. Arrangement of Flow Path Components

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Figures 1 and 2 show the system positioned so that the gas inlet is on the right side and the flow direction is to the left.

The standard arrangement is for the back pressure regulator (if it is needed) to sit freely on the bench. A regulator panel mounting nut and gauge mounting U-clamp and bezel are supplied in the AFMETCAL Configuration Kit in case you wish to mount these components on the bench or into a bracket. If you do mount them, keep in mind that the tubing length leading to the regulator should be minimized to reduce flow and pressure instability.

It is helpful to have a moveable vice or similar device to hold the DUT in the proper orientation during calibration.

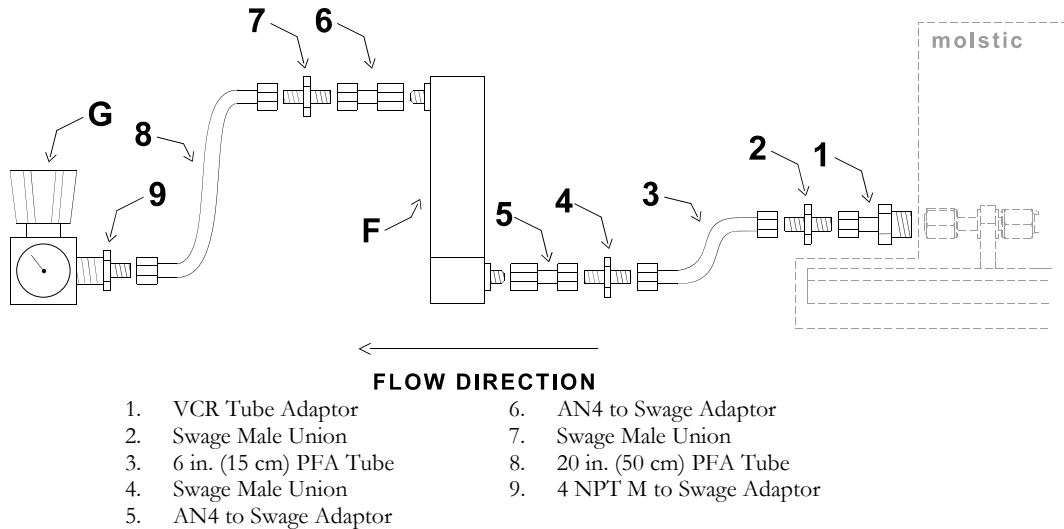


Figure 2. AFMETCAL Kit Downstream of molstic

Figure 2 shows the general setup for the portion of the system downstream of the molstic. Since DUT fittings, shapes and pressure requirements will vary, the exact setup will also vary. Figure 2 includes each of the fittings that are supplied in the AFMETCAL Configuration Kit. A description of which fittings can be omitted for each application is outlined below.

The lengths of the PFA tubes (3, 8) are chosen to accommodate likely positions of DUT ports and the height difference between the bench surface and molbloc platform. For some DUTs the tubes may be selected differently than shown in Figure 2. Since enough fittings are supplied in the AFMETCAL Configuration Kit to assemble two complete flow channel setups, duplicate tubes can be used to provide different lengths.

Whenever possible, tubing lengths between flow components (molbloc, DUT, back pressure regulator) should be minimized, especially for lower flows. For example, if the DUT outlet port is not elevated like the one on the rotameter in Figure 1 and Figure 2, then a shorter tube can be substituted for the 20 in. tube (8). Also, in some cases, the DUT's size and weight may allow it to be supported directly by adaptors downstream of the molstic and the 6 in. tube (3) can be omitted as described below.

DUTS WITH AN FITTINGS

If the DUT can be supported directly from the molstic outlet fittings, then union (2) and tube (3) can be omitted.

DUTS CALIBRATED WITH BACK PRESSURE

All fittings are connected as shown in Figure 2.

DUTS CALIBRATED WITHOUT BACK PRESSURE (AT ATMOSPHERIC PRESSURE)

Fittings 6, 7 and 9, and tube 8 and the back pressure regulator can be omitted. The DUT exhausts directly to atmosphere.

DUTS WITH SWAGE FITTINGS

If the DUT can be supported directly from the molstic outlet fittings, then union (2) and tube (3) can be omitted.

DUTS CALIBRATED WITH BACK PRESSURE

Since adapting to AN4 is not necessary, fittings 4, 5, 6 and 7 can be omitted. The 20 in. tube (8) is connected directly to the DUT's outlet.

DUTS CALIBRATED WITHOUT BACK PRESSURE (AT ATMOSPHERIC PRESSURE)

Fittings 4, 5, 6, 7 and 9, and tube 8 and the back pressure regulator are all omitted.

CONNECTIONS FOR DUT PRESSURE AND TEMPERATURE MEASUREMENT

Some kinds of DUTs require that flow corrections are made based on the density of the gas flowing through the DUT during calibration. The density correction is made from knowledge of the pressure and temperature of the gas as measured near the DUT. The measurements of pressure and temperature at the molbloc which are displayed on the molbox and/or COMPASS will not typically be accurate estimates of the pressure and temperature at the DUT, since the expansion of the gas through the metering valve can change both the pressure and temperature.

An RPM3-A0100b reference pressure monitor is included in the AFMETCAL Configuration System to provide accurate DUT pressure measurement. A small back pressure gauge is also included in the AFMETCAL Configuration Kit, but it will not generally be accurate enough for DUT pressure measurement and is intended only for reference indication. Pressure may be read from the RPM3 visually from the front panel or remotely through a computer connected to it. (See Section 1.1.4 of this manual, the COMPASS for molbox User's Manual Version 4.00 and the RPM3 Operation and Maintenance Manual for instructions on operating RPM3 and reading its pressure measurements via remote interface.)

The RPM3 test port must be pneumatically connected to the flow path at the point where the pressure is to be measured. Whether the pressure and temperature need to be measured at the inlet or outlet of the DUT, or simply estimated from some measurement of surrounding pressure and temperature, depends on Air Force procedures and the type of DUT being calibrated. For instance, fittings 4 or 7 in Figure 2 may be replaced by tees or other fittings which allow the RPM3 and a temperature measuring device to be connected to and inserted in to the flow path.

Frequently, pressure is measured at the outlet of the DUT, which is open to atmosphere when no DUT back pressure is required. In this case, the RPM3 can also be left open to atmosphere to effectively measure the outlet pressure of the DUT. When back pressure is to be applied to the DUT and measured, the RPM3 can either be pneumatically connected to the gauge port of the back pressure regulator or connected to a tee in place of fitting 7 as described above.

Temperature is usually measured near the same location that pressure is measured. The temperature measurement probe may create a flow restriction where it is inserted into the flow path and create a pressure drop which can affect the DUT pressure measurement. Make sure to either position the pressure measurement connection closer to the DUT than the temperature measurement connection, or avoid a temperature measurement connection that is significantly restrictive to flow. Also, when the temperature and pressure devices are connected between the molbloc and the DUT, care must be taken to make a leak-free connection.

Figure 3 shows an example of temperature and pressure connections made at the outlet of the DUT, when back pressure is applied to the DUT.

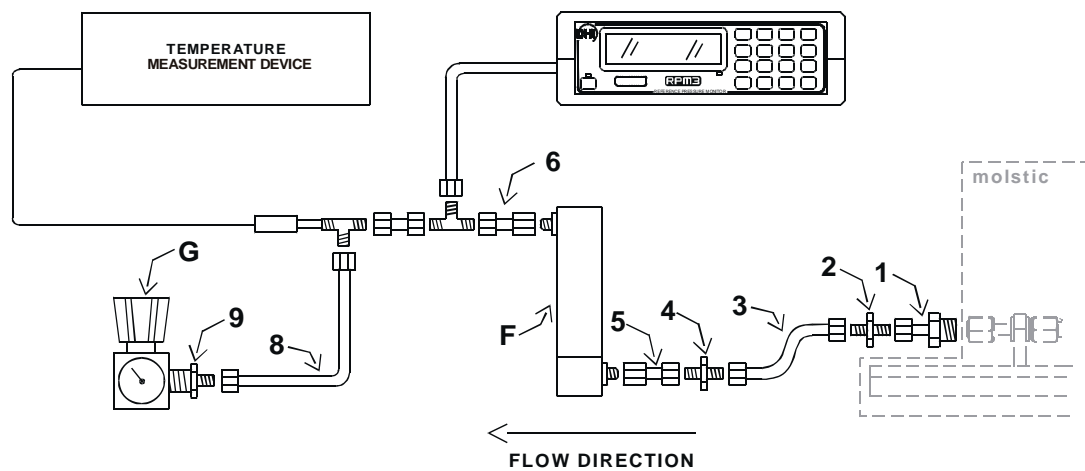


Figure 3. Connection of RPM3 and Temperature Measurement Device for DUT with Back Pressure



NOTES



Application Notes

MOLBLOC RANGES

To ensure in-tolerance measurements, the appropriate range molbloc should be chosen to calibrate each DUT. Remember that a molbloc's true usable range may be different from its nominal range designation due to the pressure-dependent calibration performed on the molbloc or due to the gas being used. It is also important that the molbloc is used at the correct pressure for the stated usable flow range and measurement specifications to be valid.



A silver label on each AFMETCAL configuration system molbloc displays the calibrated usable flow range and proper inlet pressure for that molbloc. An example of the label is shown below. The flow range stated on this label, not the nominal range designation referenced on the black label, should be observed. The arrow on the silver label indicates molbloc flow direction.

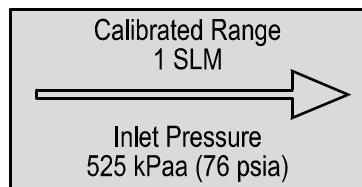


Figure 4. AFMETCAL Configuration molbloc Label

MOLBLOC PRESSURE AND Flow ranges

molbloc ranges are traditionally described according to the flow ranges they would have if they were calibrated in nitrogen for standard low pressure use. Since the usable range of a molbloc can differ from this nominal value depending on the gas and pressure used, newer molblobs are defined by a size designation instead to avoid confusion about the molbloc's true usable range. The size designations for each molbloc in the AFMETCAL system are included in Table 3 along with their nominal ranges. The black labels on the back of newer molblobs will display both the molbloc size designation, as part of the model name, and the nominal N2 flow range. Older molblobs display only the nominal flow range as part of the model name.

To accommodate elevated DUT back pressure applications, molblobs in AFMETCAL configuration systems have special, high pressure calibrations. The result is that the each molbloc's usable flow range is shifted upward from its nominal flow range. For example, a 500 sccm (5E2) molbloc with a high pressure calibration has a usable flow range up to 1 000 sccm (1 slm). For most range designations, the usable range of the molbloc is double the nominal range as in the previous example. An exception is the 30 slm (3E4) molbloc, which becomes a 40 slm range when given a high pressure calibration. molblobs are calibrated over their entire usable range; *usable flow range = calibrated flow range*.

The maximum flow and minimum flow at which molblobs can be most accurately used are both changed by a high pressure calibration. molbloc flow measurements have an uncertainty of $\pm 0.2\%$ of reading, or $\pm 0.02\%$ of full scale, whichever is greater (see note). This means that flow can be measured with $\pm 0.2\%$ of reading uncertainty from 10 to 100 % of the molbloc's range. A high pressure calibration shifts both the 10 and 100 % value. For example, measurements with a 500 sccm (5E2) molbloc can be made with $\pm 0.2\%$ of reading uncertainty from 100 to 1 000 sccm.

This does not mean that molblobs should not be used below their 10 % value. Below 10 % of a molbloc's full scale range, uncertainty is calculated as a percentage of its full scale range ($\pm 0.02\%$ FS). Since most, if not all, DUTs have uncertainties which are also calculated as a percent of their full scale range (typically 1 to 5 % FS), a sufficient accuracy ratio will still be maintained as you measure lower flow points. A general guideline is that the DUT's full scale range should fall between 10 and 100 % of the molbloc's usable (not nominal) full scale range if possible but this is not indispensable in all cases.



When using the 30 slm (3E4) molbloc with a high pressure calibration, the uncertainty specification is $\pm 0.3\%$ of reading when measuring flows between the upper and lower values listed in Table 3. At flows below the lower value, the uncertainty remains constant and is equal to 0.3 % of the lower value. The only difference between the usable ranges of molblobs in nitrogen and air is this lower value for 30 slm (3E4) molblobs.

Table 3 lists maximum usable flow rates in each calibration gas for nominal molbloc flow ranges. A bold value indicates that the maximum flow is limited by the maximum Reynolds number value of 1 200 which is reached before the normal differential pressure range is reached. In that case, the second value gives the minimum flow for which relative accuracy is $\pm 0.2\%$ of the measured value. Where there is only one value, the minimum flow at which this relative accuracy is valid is 10 % of the indicated value.

Table 3. molbloc Usable Ranges with High Pressure Calibration

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- full mod, high pressure
- single P, high pressure

RANGE & SIZE DESIGNATIONS					
GAS	10 sccm (1E1)	50 sccm (5E1)	500 sccm (5E2)	5 slm (5E3)	30 slm (3E4)
N2	20	100	1 000	10 000	40 000 7 500
Air	20	100	1 000	10 000	40 000 7 200

gases

All molblocs are calibrated for use in nitrogen. To make traceable measurements with the same uncertainty in another gas, molblocs should be calibrated in that gas also. Calibration data for several gases can be stored in each molbloc. All AFMETCAL configuration system molblocs **except 10 sccm (1E1) range molblocs** are calibrated for air in addition to nitrogen. Air calibrations for 10 sccm (1E1) ranges are not currently available.

Selecting the active gas from the molbox1 front panel or using COMPASS software automatically activates the molbloc calibration data for that gas. No special procedure is required other than being sure that the molbox1 gas selection is the gas that is actually flowing.



System accuracy specifications and the molbloc usable ranges listed in Table 3 are not valid for gases for which molblocs have not been calibrated.

MOLBLOC supply pressure

molblocs with high pressure calibrations should always be used with an inlet pressure of 76 psia (525 kPaa). AFMETCAL configuration molblocs are actually calibrated to operate with a range of inlet pressures from 47 to 76 psia (325 to 525 kPaa) but since the molbloc verification is performed at 525 kPaa, best results will be obtained when using the molbloc at this inlet pressure. Keeping the inlet pressure at this level also gives the user more freedom to set elevated back pressures on the DUT.

The molstic pressure regulator sets the molbloc inlet pressure. (This is not the supply pressure delivered to the molstic inlet. A higher pressure should be supplied to the molstic inlet according to the molstic Installation Instructions.) The molbloc inlet pressure can be observed on the molbox front panel or COMPASS software to be sure that the molstic regulator is set correctly. See Section 3.2 for instructions on setting molbloc inlet pressure.



Do not set the molstic pressure regulator to deliver a pressure greater than 80 psia (600 kPaa) to the molbloc.

operation

Specific instructions for operating molbox1 and COMPASS software while performing flow calibrations is provided in the molbox1 molbloc Terminal (Ver. 5.00 and higher) Operation and Maintenance Manual and COMPASS User's Manual Version 4.00. Sections 3.2.1 to 3.2.3 provide recommendations for the operation of hardware items unique to the AFMETCAL configuration systems.

setting/checking the MOLSTIC regulator

The pressure regulators installed on both the low flow and mid flow molstics are adjustable but should be set at a single molbloc inlet pressure then left unchanged. They should be set while at low flows since the regulator outlet pressure tends to drop slightly as flow increases and the molblocs are calibrated for pressures up to but not exceeding 76 psia (525 kPaa). Follow these steps to initially set/check the molstic regulators:

- ❶ Install a molbloc onto the molstic. For a mid flow molstic (high flow AFMETCAL configurations), install the 30 slm (3E4) molbloc; for a low flow molstic, install the 500 sccm (5E2) molbloc (with higher range molblocs the pressure stabilizes more quickly).
- ❷ Using the molstic metering valve, set a flow near the lowest flow point that will be measured using that molstic. (If using a low flow molstic, set a flow of at least 10 sccm.) Allow the flow to stabilize.
- ❸ Viewing the molbloc inlet (upstream) pressure using molbox1 (press **[P&T]** on the molbox1 (see molbox1 molbloc Terminal (Ver. 5.00 and higher) Operation and Maintenance Manual), adjust the regulator, if necessary, to deliver 74.5 to 76 psia (515 to 525 kPaa).

Preparing for flow measurements

Three steps should be taken before making flow measurements:

❶ **Purge**

When switching between air and nitrogen (or, in some cases, helium) as calibration gases, the previous calibration gas should be removed (purged) from the flow path and the molbloc to molbox pneumatic lines and replaced with the new calibration gas before making measurements. Doing so ensures that the calibration gas being measured is not an unknown mix.

To purge the old gas from the molbloc to molbox pneumatic lines, proceed as follows, with or without the DUT attached:

- a Connect new calibration gas.
- b Open shut off valve upstream of molbloc.
- c Using the metering valve or other flow control device, set a flow near the DUT's maximum flow rate. If the DUT flow range is less than 100 sccm, disconnecting the DUT and opening the metering valve to set a much higher flow will allow a faster purge.

If you are using molbox1 manually, press **[TARE]** and select **<2purge>**. Set the desired purge time then press **[ENTER]**. The time you will need to fully purge out the system depends on the flow rate you have set. If your flow rate is greater than 1 slm, one minute is usually sufficient. If you are flowing less than 100 sccm, you may need to purge for up to 5 minutes.

If you are using COMPASS software, there are two ways to execute a purge. When in **[RUN DUT]** or **[RUN molbox]**, select the **[Purge molbox]** icon, then enter the desired purge time. If you are running a test, an automatic purge can be scripted into the beginning of the test, with a selectable purge time and purge flow rate.

See the COMPASS for molbox User's Manual Version 4.00 for further instruction on purging within COMPASS.

When to purge: Whenever the gas in the flowpath or molbloc to molbox pneumatic lines is unknown or is different from the calibration gas to be used, a purge should be performed. Since there is no flow through the molbloc to molbox lines during normal operation, they will not purge out by the gas movement through the flowpath. The molbox1 or COMPASS purge function must be performed. The molbloc to molbox pneumatic lines have quick connectors with check valves, so the last gas used will remain in the lines when they are disconnected.

2 **Tare**

This procedure zeros the molbox1 differential pressure measurement. The tare should always be performed with the normal operating pressure supplied to the molbloc. The DUT does not need to be connected to perform the tare.

- a Open the molstic shut off valve allowing the gas supply to reach the molbloc.
- b Make sure that the flow rate is less than the molbloc's full scale flow. Taring can be performed with or without flow through the molbloc but it is usually easier to achieve pressure stability with a non-zero flow rate.
- c If you are using molbox1 manually, press **[TARE]** and select **<1tare>** and **<lupstream>**. Wait for stability and press **[ENTER]** when ready.

If you are using COMPASS software, there are two ways to execute a tare. When in **[RUN DUT]** or **[RUN molbox]**, select the **[Tare molbox]** icon, then select the **<upstream pressure>** button. If you are running a test, a fully automatic or manual tare can be scripted into the test on any flow point.

See the COMPASS for molbox User's Manual Version 4.00 for further instruction on taring within COMPASS.

When to tare: A tare should be performed at the beginning of each day that the molbox is used. This allows the user to track any changes in the molbox pressure transducers. When taring, the previous tare value is displayed and can be compared to the new tare value that is saved. These values should not differ by more than 10 Pa if the molbox was tared recently. The molbox should also be tared each time that the molbloc inlet pressure is changed significantly, but the inlet pressure should remain constant for AFMETCAL systems.

③ **Leak Check**

There are two leak check options available through molbox1: a molbox leak check and a system leak check. The molbox leak check is a diagnostic tool that is not used during normal operation. The system leak check is a tool that can be used regularly to make sure that the molbloc and other molstic components are installed properly and are free of significant leaks. Only the system leak check is available through COMPASS software.

The molbox1 system leak check tests for leaks by monitoring pressure decay in a closed, pressurized system. The test pressure will be the outlet pressure of the molstic regulator (Figure 1, B), 76 psia (525 kPaa). Since it is only reasonable to leak test system components in this way if they are normally operated at elevated pressures, the components downstream of the metering valve are not included in the closed system during a typical system leak check. The system should be plugged just downstream of the molstic metering valve using the VCR plug included in the AFMETCAL Configuration Kit. The plug is connected in place of Fitting 1 from Figures 1 and 2.

Procedures can be developed to leak check DUTs and their connections by closing off the system downstream of the DUT before running the system leak check. However, DUTs that are normally operated at lower pressures will usually fail the pressurized leak check even they do not leak at their normal operating pressures. DUTs may also be damaged by the elevated pressure if they are designed for low pressure use. In general, the components included in the closed system during a system leak check should not include the DUT unless it is a DUT that is normally used with a back pressure near the system's maximum, 50 psig.

Following are steps for performing a typical system leak check with the AFMETCAL hardware setup:

- a Install the molbloc to be used.
- b Connect the VCR plug to the outlet of the VCR close coupling downstream of the metering valve using a Viton O-ring in the VCR fitting.
- c Open the molstic metering valve.
- d If you are operating the molbox1 manually, select **[TARE]**, **<LEAK CHECK>**, **<SYSTEM>** from the molbox front panel so that the upstream and downstream pressure values are displayed.

If you are using COMPASS software, there are two ways to run a system leak check. When in **[RUN DUT]** or **[RUN molbox]**, select the **[Leak Test]** icon, then click **<OK>** in the first message box. Wait for the "Make any leak test preparations..." message. If you are running a test, a system leak check can be scripted into the beginning of the test. The same "Make any leak test preparations..." message will be displayed after test initialization.

- e Open the molstic shut off valve.
- f The system pressure is displayed on either the molbox1 display or the COMPASS screen, depending on where you are running the leak test. When the system pressure reaches the normal working pressure, close the molstic shut off valve.

Wait a short time for pressure stability and press **[ENTER]** on the molbox front panel, or **[OK]** in COMPASS. In manual molbox1 operation, you must follow the prompts on the molbox screen. Specific leak check steps and explanation of the on-screen messages during manual operation leak test are found in the molbox1 molbloc Terminal (Ver. 5.00 and higher) Operation and Maintenance Manual.

If you are running COMPASS, the leak test will proceed automatically, and the remaining test time is displayed. A pass/fail message will display briefly in the COMPASS status bar after the test has ended, before proceeding to the next part of the test. A COMPASS option will allow you to force the test to abort if the system leak test fails.

When to run leak check: Run a leak check whenever any components included in the leak check closed system are disconnected and reconnected. Typically, this only includes the molbloc.



When more than one molbloc is required within a single COMPASS test, a test option may be selected to run a molbox purge and/or system leak check after each molbloc change in addition to the beginning of the test.

setting DUT back pressure

Once the system is setup and the procedures described in Section 3.2.2 have been performed, the user can begin setting flows, establishing steady-state (stable) flow conditions and taking data. If the DUT is to be calibrated with back pressure (outlet pressure above atmospheric pressure), then the back pressure regulator must be adjusted on a non-zero flow point in addition to adjusting the flow. Follow these steps to set DUT back pressure.

- ❶ Begin with the back pressure regulator handle turned fully counter-clockwise (regulator wide open).
- ❷ Set the flow roughly to the desired flow setpoint.
- ❸ Adjust the back pressure regulator slowly clockwise to bring the pressure indicated by the DUT pressure measurement device (typically RPM3) to the desired level. This is likely to change the flow rate.
- ❹ Reset the flow rate using the metering valve. The back pressure should remain steady when the flow is changed by small amounts.
- ❺ To set the next point, adjust the metering valve to the desired flow. Once the desired flow is reached, check the DUT pressure measurement device. The back pressure may need small adjustments at each point depending on the magnitude of the change in flow and the level of precision needed on back pressure.

Entry of DUT pressure and temperature measurements

The AFMETCAL configuration system includes an RPM3-A0100b reference pressure monitor for accurate measurement of the gas pressure at the DUT. No temperature measurement device is included in the AFMETCAL configuration system. COMPASS software uses the DUT pressure and temperature measurements to make flow corrections for the effect of density changes on the DUT. Pressure and temperature measurements can be manually entered into COMPASS and some devices, like RPM3, can be read automatically by the computer running COMPASS. See Section 2.3.5.3 for instructions on connecting pressure and temperature measurement devices to the flow path.

In the case of RPM3, a default hardware profile is already set up in COMPASS to collect its readings automatically. All of the necessary commands to read the RPM3 pressure measurement are pre-set so that successful communication should be easy. An RS232 cable is supplied with the AFMETCAL configuration system to connect the RPM3 COM1 port to your PC. If you do not have an extra COM port available on your PC, molbox1's COM2 port can be used to relay the RPM3 pressure reading to the PC. Use the following steps to complete the communication setup with RPM3:

- 1 In the COMPASS **[Setup]** menu, select **[System]**. Set the **<Pressure Measurement>** selection to **<RPM3 / Ex.>**, and click **[OK]**. If the **<Pressure Measurement>** selection is left as **<Manual>**, then the user will be prompted to enter visually collected pressure data during tests.
- 2 In the COMPASS **[Setup]** menu, select **[Hardware]** and go to the **[Pressure]** tab. Double-click **<RPM3 / Ex.>** in the list to display the **[Edit Pressure Measuring Device]** window.
- 3 Select the correct RS232 port. If you are using the molbox1 COM2, select **<Ref COM2>** as the RS232 port. Otherwise select the COM port on your PC that is being used to read the RPM3.
- 4 The default command set in the RPM3 hardware configuration does not change the current measurement range used by the RPM3. Whatever range is manually selected before a test will be used to supply pressure readings for the test. If you would like your RPM3 hardware configuration to set the RPM3 to the same pressure range each time it is used by COMPASS, add the following command to the Initialization Commands: **CONFIGURE1 HI**. This command will put the RPM3 into its highest range, 100 psia. Substitute LO or MED for HI in the command to select one of the other ranges.
- 5 Make sure click **[SAVE]** before exiting the RPM3 hardware configuration.

If you have a temperature measuring device capable of remote communication, you must set up a hardware configuration for it using the remote commands for that device and select the device by selecting **[System]** under the **[Setup]** menu and changing the **<Temperature Measurement>** field. If the field is left as **<Manual>**, the user will be prompted to enter visually collected temperature data into COMPASS during tests.

See the COMPASS for molbox User's Manual Version 4.00 for more complete information on remote interfacing and temperature and pressure data collection.

Warranty and Recalibration

Warranty statement (for deliveries under F33660-99-F7000)

molbloc/molbox systems delivered to the United States Government under contract F33660-99-F7000 are covered by a limited, five (5) year worldwide warranty. The warranty start date is the date of the original **DH Instruments, a Fluke Company (DHI)** calibration certificate and the finish date is five (5) years thereafter. The five year warranty extends the standard **DHI** one (1) year commercial warranty, below, to five years.

Except to the extent limited or otherwise provided herein, **DHI** warrants for one year from purchase, each new product sold by it or one of its authorized distributors, only against defects in workmanship and/or materials under normal service and use. Products which have been changed or altered in any manner from their original design, or which are improperly or defectively installed, serviced or used are not covered by this warranty.

DHI and any of its Authorized Service Providers' obligations with respect to this warranty are limited to the repair or replacement of defective products after their inspection and verification of such defects. All products to be considered for repair or replacement are to be returned to **DHI** or its Authorized Service Provider after receiving authorization from **DHI** or its Authorized Service Provider. The buyer assumes all liability vis-a-vis third parties in respect of its acts or omissions involving use of the products. In no event, shall **DHI** be liable to purchaser for any unforeseeable or indirect damage, it being expressly stated that, for the purpose of this warranty, such indirect damage includes, but is not limited to, loss of production, profits, revenue, or goodwill, even if **DHI** has been advised of the possibility thereof, and regardless of whether such products are used individually or as components in other products.

The provisions of this warranty and limitation may not be modified in any respect except in writing signed by a duly authorized officer of **DHI**. The above warranty and the obligations and liability of **DHI** and its Authorized Service Providers exclude any other warranties or liabilities of any kind.



All molbloc/molbox systems not delivered under contract F33660-99-F7000 are covered by the standard DH Instruments, a Fluke Company one (1) year commercial warranty.

recalibration

Each molbloc/molbox system delivered under contract F33660-99-F7000 includes one recalibration by **DHI** of the molbox1 and molblobs delivered with the system. molbloc recalibrations are available only from the **DHI**, Phoenix, AZ Service Center location.

The recommended recalibration interval for the molbloc/molbox system is one (1) year.

Warranty service centers

Table 4. Warranty Service Centers

DH INSTRUMENTS, A FLUKE COMPANY AUTHORIZED SERVICE PROVIDERS 2008 JAN			
COMPANY	ADDRESS	TELEPHONE, FAX EMAIL	NORMAL SUPPORT REGION
DH Instruments, a Fluke Company	4765 East Beautiful Lane Phoenix AZ 85044-5318 USA	Tel 602.431.9100 Fax 602.431.9559 cal.repair@dhinstruments.com	Worldwide
Minerva Meettechniek B.V.	Chrysantstraat 1 3812 WX Amersfoort the NETHERLANDS	Tel (+31) 33.46.22.000 Fax (+31) 33.46.22.218 info@minervaipm.com	European Union
Ohte Giken, Inc. Technology Center	258-1, Nakadai Kasumigaura-machi, Niihari-Gun, Ibaraki 300-0133	Tel 81/29.840.9111 Fax 81/29.840.9100 tech@ohtegiken.co.jp	Japan/Asia
DH Products Technical Service Division	National Institute of Metrology Heat Division Pressure & Vacuum Lab NO. 18, Bei San Huan Donglu Beijing 100013, PR China	Tel 010-64291994 ext 5 Tel 010-64218637 ext 5 Fax 010-64218703 cxcen@mx.cci.go.cn	Peoples Republic of China