Sierra Instruments
BG-1™ Micro-Dilution Test Stand

Instruction Manual

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Warnings and Cautions

Warning!
All installation procedures must be performed with the power off.

All maintenance procedures must be performed with the power off.

To avoid potential electric shock, follow National Electric Code or your local electrical code when troubleshooting or repairing the BG-1 system. A hazard of personal injury and/or equipment damage exists if codes are ignored. Only qualified persons should perform service on the BG-1 system.

All repair procedures must be performed with the power off.

Caution!
The dilution probe, sampling line and filter assembly are all susceptible to the radiant heat generated by the exhaust stack. Sierra strongly recommends installing an insulating blanket to protect the dilution probe.

To avoid limiting sample line flow, do not bend the sample line in a radius tighter than 18 inches.

The BG-1 system must be in an idle state before making changes to any unit of measurement.

If the engine is operating and the BG-1 is not sampling, invoke the Purge mode. This ensures repeatable samples with minimal deposits forming in the probe.

To ensure proper system output, it is important that all calibrations using an external standard are performed at 20 psig at the dilution flow controller.

To prevent damage to the pump when using manual switching mode, always ensure an open flow path.

For proper operation, ensure that the compressed air supply pressure to the system is at least 80 psig.

When flowing 200 slpm through the dilution flow controller make sure the system pressure is set between 20 to 22 psig.

Chapter 1 Introduction

BG-1 Micro-Dilution Test Stand

The Sierra BG-1 Micro-Dilution Test Stand is a fully automated, easy-to-operate particulate sampling system. The BG-1 accurately tests diesel engines of any size, regardless of RPM, power output, or stack size. Sampling times for a 2-milligram net sample mass typically range from two to five minutes for a steady-state sample, greatly reducing fuel costs for routine testing. The BG-1 satisfies all ISO 8178 requirements for equivalency as compared with full-dilution systems operated on a steady-state basis.

The advanced BG-1 software allows easy collection of particulate samples during test programs using simple keyboard commands. An optional communications package allows remote operation of the BG-1 from a host computer such as test cell computer. Using a host computer you may read data from the BG-1 in real time and copy BG-1 files. With this functionally, the BG-1 can be used for raw transient exhaust testing.

Using This Manual

The BG-1 system software is designed to allow successful sampling by novice users. To operate the BG-1, you should have:

- some experience in the operation of engine emission measurement systems
- basic understanding of MS Windows 95 based computers and text processing

This manual provides the information needed to install and operate the BG-1 Micro-Dilution Test Stand. The five chapters of this manual cover these areas:

- Chapter 1 includes the introduction and product description
- Chapter 2 provides installation advice and sampling instructions
- Chapter 3 describes system operation
- Chapter 4 covers preventive maintenance procedures
- Chapter 5 outlines troubleshooting and repair

The system configuration files are found in Appendix A. Appendix B includes BG-1 subassembly drawings.

Note and Safety Information

We use note, caution and warning statements throughout this book to draw your attention to important information.

Warning!
This statement appears with information that is important to protect people and equipment from damage. Pay very close attention to all warnings that apply to your application.

Caution!
This statement appears with information that is important for protecting your equipment and performance. Read and follow all cautions that apply to your application.

Note
This statement appears with a short message to alert you to an important detail.

Receipt of System Components

When receiving the components BG-1 Micro-Dilution Test Stand, carefully check the outside packing crates for damage incurred during shipment. If any carton is damaged, notify the local carrier and submit a report to the factory.

Remove the packing slip and check that all ordered components are present. Make sure any spare parts or accessories are not discarded with the packing material. Do not return any equipment to the factory without a Return Material Authorization (RMA, see Chapter 4).

Technical Assistance

If you encounter a problem with the BG-1 Micro-Dilution Test Stand, review the configuration information for each step of the set up and operation procedures. Verify that your settings and adjustments are consistent with factory recommendations. Refer to Chapter 5, Troubleshooting, for specific information and recommendations.

If the problem persists after following the troubleshooting procedures outlined in Chapter 5, contact Sierra Instruments, Technical Support at (800) 866-0200 or (831) 373-0200 between 8:00 a.m. and 5:00 p.m. PST. When calling technical support, have the following information on hand:

- the BG-1 serial number
- software version number
- your Instruction Manual
- the problem you are encountering.

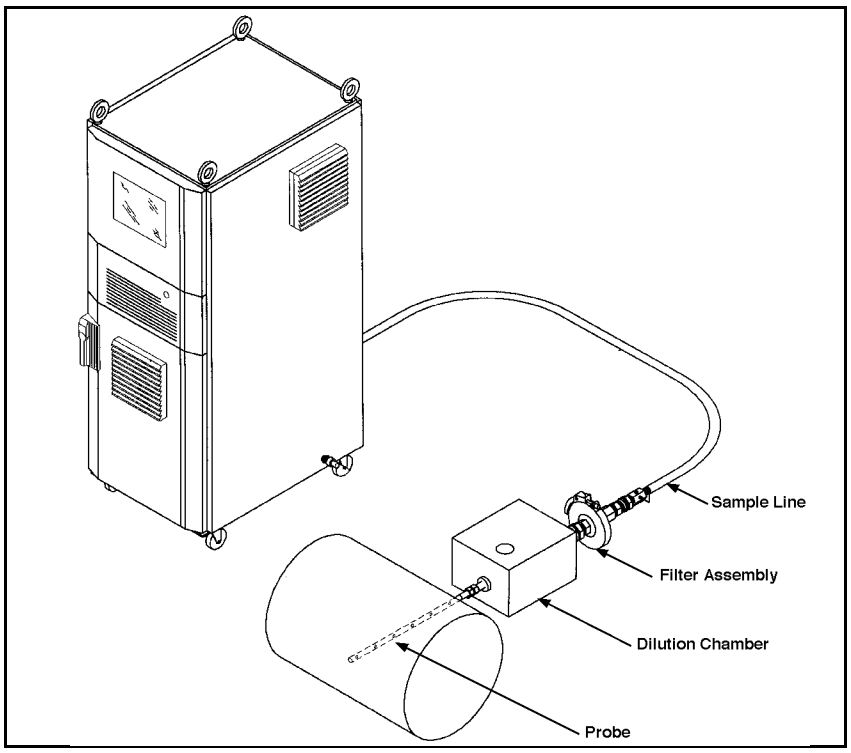


Figure 1-1. BG-1 Micro-Dilution Test Stand Components

How the BG-1 Test Stand Works

A typical measurement procedure involves setup and calibration, thirty minutes; engine equilibration–about 20 minutes to stabilize exhaust and coolant temperatures, depending on engine size; system purge and sampling which takes about two to five minutes per mode for a 2-milligram net sample mass. Since it is a true fractional sampler, the BG-1 is insensitive to engine size. The BG-1 requires only a simple probe change to provide accurate representative diesel sampling on any engine size.

As engine exhaust is drawn from a stack, the particulate sample is diluted and chilled with a measured amount of dry, hydrocarbon-free air and passed through a pair of filter membranes for sample collection. The dilution occurs in a unique chamber that consists of a porous stainless steel tube mounted concentrically within a stainless steel cylinder. During sampling, dilution air (25° ±5° C maximum) is introduced under pressure into the chamber through the walls of the porous tube . The air permeates the porous tube creating a virtual “wall” of hydrocarbon-free air. As a result, deposition of particulate on the walls is eliminated in the dilution chamber and the equilibration zone of the system is very short. This minimizes the effect of the dilution system’s “history” on the test sample.

To eliminate settling time delays, the standby mode brings both flow controllers up to the desired flow level in advance of sample collection. (This is particularly important for EEC R49 or TA Luft certification testing with single-filter protocols.)

After sampling, the filters are weighed on a scale to determine the mass of deposited exhaust. This is then combined with the flow meter measurements in a weighted-factor calculation to determine the specific particulate emission levels. To ensure accurate filter measurements, the filter assembly restricts the motion of the filter media during removal and replacement.

All components of the BG-1 including pumps, desiccant, flow-monitoring system, calibration functions and dilution air conditioning and cooling are enclosed in a compact cabinet that rolls from one test location to the next.

The BG-1 computer allows control of all test procedures through simple data prompts and graphic displays. The computer controls sampling functions and the system's two mass flow controllers allowing adjustment of flow rates and dilution ratios.

The advanced BG-1 software gives you convenient data recording capabilities that facilitate data management procedures. You can preprogram a series of steady-state test points and create a file containing setpoints for any number of steady-state samples. Before each sampling mode goes into effect, the system displays the setpoints for confirmation that are changeable if necessary. All relevant test data is recorded regardless of the number of sample modes used during a test.

BG-1 Specifications

- Range: any size engine
- Sample time: 2 to 5 minutes for multiple filter testing
- Dilution air supply: 90 psi, 8.5 scfm
- Sample flow accuracy: exceeds ISO requirements; typically 1 to 2 percent
- Measurement repeatability: typically 0-3% of dilution ratios of 10:1 or less depending on engine performance
- Correlation with full dilution: exceeds ISO requirements; typically ± 2.5% of full dilution weighted results (see ISO 8178.1)
- Input power: 110 VAC, 30 Amps
- Weight: 600 pounds
- Dimensions: 24"W x 36"D x 72"H
- Sample line hose length: 25 feet standard; other lengths available

Series 860 Mass Flow Controllers

A pair of Sierra Instruments' Series 860 digital mass flow controllers (MFCs) provide varied control of the exhaust and air dilution ratios and the overall flow rate. The Series 860 is an advanced microprocessor-based controller that provides superior sample flow accuracy and measurement repeatability. To ensure repeatability and system accuracy, automatic calibrations and precise meter-to-meter correlation are built into the BG-1 operating system.

The Series 860 MFCs are rated at ± 0.15% of reading repeatability per controller. Values demonstrated while directing a common flow through both controllers verify this claim. The table below illustrates representative sample errors for different dilution ratios and meter to meter differences. By following proper calibration procedures (described later in this manual) sample errors will be greatly minimized. As shown in Table 1-1, entering small differences between the two flow controllers is of much greater importance than the absolute accuracy of the meters.

Error	Dilution	Bias
Absolute 1%	10:1	1%
	4:1	0.4%
Relative 1%	10:1	10%
	4:1	4%
Relative 0.5%	10:1	5%
	4:1	2%
Relative 0.25%	10:1	2.5%
	4:1	1%

Table 1-1. MFC Error Contribution versus Dilution Ratio

Glossary of Terms

The following terms are commonly used throughout this manual.

Autobalance–instructs the mass flow controllers to sit idle (no flow) for a few minutes to stabilize and automatically balance to read zero. This process is also called zeroing.

860 Bypass–a small passage in parallel with the main mass flow controller body with windings around it that sense flow. Flow through the bypass is proportional to flow through the main body.

Calibrate–the MFCs in the BG-1 using an external calibration standard.

Dilution chamber– a porous stainless steel tube mounted concentrically within a stainless steel cylinder. Dilution of sample gases takes place in the dilution chamber.

Filter media–you may sample using a single filter or a filter pair depending on testing requirements.

LFE–laminar flow element. A passage or series of passages within the mass flow controller that ensure laminar flow; i.e., flow that is proportional to ΔP.

MFC–mass flow controller (Series 860 Mass Flow Controller)

Mirror–calibrates the total MFC relative to the dilute MFC output signals by setting the same flow rate through both MFCs. The output signals must be within 0.4% of one another to pass verification.

Normalization Run–is collecting a sample and then discarding the results. Also referred to as a "dummy run."

Probe–a perforated stainless steel tube inserted into the exhaust stack. The exhaust gases are exhausted from the stack through the sample probe

Purge–a process in which air is blown through the dilution probe for cleaning and cooling.

Sample line–the hose providing power, sensor and dilution air and sample return connections between the BG-1 cabinet to the dilution chamber.

Valve–in the BG-1, the flow control ball valves are DC solenoids that are servo-controlled by the system electronics.

Chapter 2 Installation and Sampling

Installing the BG-1 Micro-Dilution Test Stand is simple and straightforward. The BG-1 is portable and can be moved easily and set up quickly for use with almost any configuration of engine type and test cell design. This chapter provides an installation procedure that is applicable to most facilities. The installation instructions are general in nature as each test site will differ.

The sampling instructions included in this chapter are intended to provide a generic sampling procedure that you may customize to meet your testing requirements. See Chapter 3 for more specific information on entering sampling parameters and system settings.

Facility Requirements

Input power: 110 VAC, 30 amp, 50/60 Hz power. Connection is a single 25-foot cord that powers all instrumentation within the BG-1 enclosure.

Clean dry air: 80 psi minimum to 100 psi maximum. Usage rate of 120 to 200 standard liters per minute (4.24 to 7.07 scfm).

Space required: the BG-1 cabinet is 24”W x 36”D x 72”H. Standard sample line hose length is 25 feet.

Determine Sample Probe Location

Follow these guidelines when determining the sample probe location in the exhaust stack:

- Install the probe at least five pipe diameters downstream of any exhaust stack bends, restrictions or protrusions.
- Allow at least three feet downstream of the engine exhaust manifold (if possible) and five feet above floor level for convenient probe access. The sample probe should hang vertically from the exhaust stack.
- If possible, locate the BG-1 cabinet outside the test cell in the control room or other controlled environment and feed the sample line through a cell port, maximum distance 25 feet.

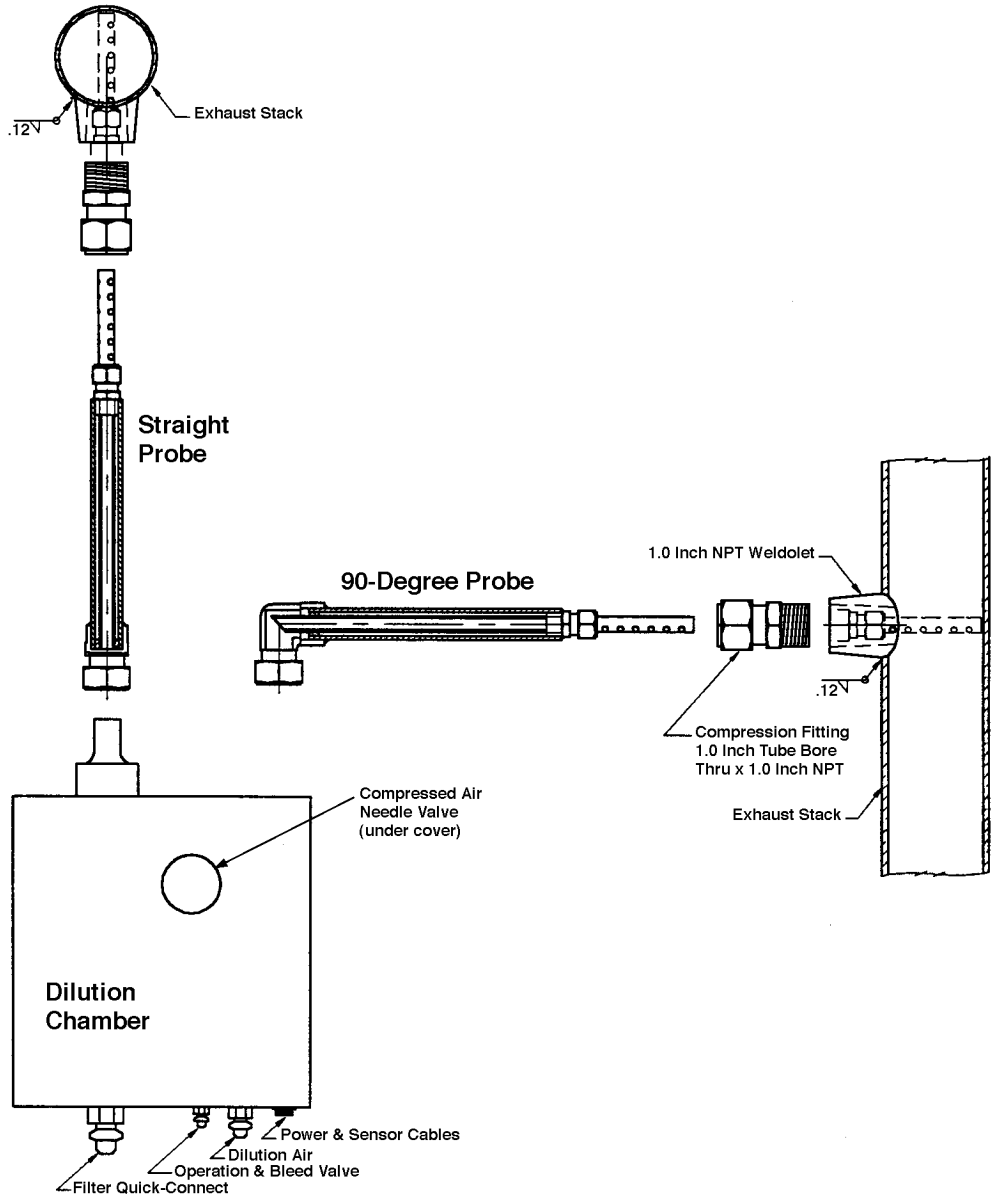


Figure 2-1. Sample Probe Installation

Installation

Warning!
All installation procedures must be performed with the power off.

Caution!
The dilution probe, sampling line and filter assembly are all susceptible to the radiant heat generated by the exhaust stack. Sierra strongly recommends installing an insulating blanket to protect the dilution probe.

1. Determine correct probe location as recommended on page 2-1.
2. If needed, insulate the stack at least one foot downstream and four to five feet upstream of the dilution probe. If testing large engines, these lengths may be insufficient and may require additional insulation.
3. Weld a one-inch female NPT weldolet to the exhaust stack.
4. Secure the probe tip to the probe body using the supplied compression fitting. Attach the probe to the exhaust stack by threading the one inch adapter fitting into the sample port (the adapter fitting has a one inch pipe thread on one end and a one inch compression fitting on the opposite end).
5. Position the probe tip within 1/2-inch from the opposite side of the exhaust stack with the 90-degree bend in the probe (if so equipped) pointing vertically towards the floor.
6. Tighten the compression fitting to secure the probe in the exhaust stack using a high-temperature anti-seize lubricant. To allow for future removal or adjustment, do not over-tighten the compression fitting.
7. Slide the dilution chamber into the one inch compression fitting on the sample probe with the dilution chamber hanging vertically. Tighten the fitting securely.
8. Attach the sampling line's three fittings for the dilution air, pilot valve supply air and the sample return to the dilution chamber.
9. Connect the thermocouple and the small plastic tube to the sample return line.

Caution!
To avoid limiting sample line flow, do not bend the sample line in a radius tighter than 18 inches.

10. Carefully unroll the sampling line from the dilution chamber to the base of the BG-1 test stand and connect. Do not walk on the sampling line. This could cause crimps in the hoses and limit flow potential. Also do not bend the sample line in a radius tighter than 18 inches.
11. Attach the facility compressed air line to the BG-1 cabinet. Connect electrical power to the BG-1 cabinet.
12. To extend solenoid life in the dilution chamber, a cooling air control valve provides a flow of compressed air into the chamber enclosure. To adjust the valve, turn clockwise to close then open 3/4 turn.

Sampling Guidelines

- Prior to performing sample runs, subject the engine oil to at least 25 hours of fairly high load factor operation (above 50%). This allows for the fractional volatilization of the light lube oil and results in a more consistent sample.

- Allow the engine under test to stabilize for a minimum of five minutes between samples. Allow additional stabilization time between samples for engines with long exhaust stack runs to avoid unburned fuel from being carried over into the stack.

- Always take particulate data in the same order with respect to power and RPM; i.e., from high load to low load and from high speed to low speed.

- Keep the dilution ratio between 4:1 and 15:1 with a sample exhaust temperature not exceeding 52°C. Adjust dilution flow, dilution ratio, and sample flow as needed to maintain a consistent sample temperature throughout each test. The sample filter temperature is shown at “Filter Temp” on the BG-1 Main Screen.

- Perform a “dummy run” whenever unusual circumstances occur that may affect data integrity. If you leave the dilution probe in the stack during extended periods of engine operation (i.e., overnight) particulate may diffuse into the probe and the dilution chamber. The first datapoint taken could yield an erroneously high particulate value. To correct, use a dummy filter pair to perform a normalization run. After the test, discard the filter pair.

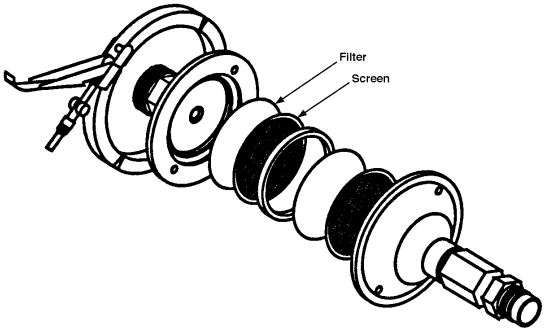
- To avoid system leakage, lubricate the O-rings and clean the backup screens in the filter housing daily (see Chapter 4).

- If the dilution air temperature rises above 25° C, purge the BG-1 between sample runs. This will cool the lines and maintain the temperature at 25° C (± 5° C).

- Rapid change in ambient environmental conditions could affect test samples taken over an extended period of time. Try to avoid drastic shifts in temperature or humidity at the BG-1 test site.

Sampling Instructions

When using filter papers in a micro-dilution process, they must be suitably prepared for soluble fraction extraction protocol; for example, using a methylene chloride rinse or vacuum sublimation. Verify that your sample filters are suitable for use in a micro-dilution system. (See Chapter 4 for purchasing information.)



1. Insert the sample filter pair into the filter holder and attach to the outlet of the dilution chamber. Connect the sample return line.

2. Turn on the main power switch on the BG-1 front panel. The BG-1 program starts automatically. Click continue to sequence through the startup prompts and allow the system to warm-up.

3. Perform the Mirror calibration procedure if prompted by the BG-1 software.

4. Click the Sample button on the BG-1 screen. Select Keyboard input. Select the output file for the data. To begin, you can use the default file, *datalog.out*.

5. Enter the required sample set point data. Until you are familiar with the exhaust characteristics of the engine under test, use a total flow of 180 slpm and a dilution ratio of 6:1 (150 slpm).

6. Make sure the standby time is set to a minimum of one minute. Adjust the sample time to an appropriate value, for example, five minutes.

7. Click the Begin Sample button. At the end of the sample, the sample information will be displayed on the BG-1 Main screen and also stored in the output data file selected in Step 6.

8. Remove the sample filters for further analysis. Insert new filter pair for next sample.

For more information on entering custom sampling parameters and system settings, see Chapter 3.

The BG-1 should repeat to within 2 to 5% when consecutive runs are performed at a given, well-controlled load. Steady-state runs do not repeat as well as transient runs, either with micro-dilution or full-dilution. If the weighted modal value of two repeated runs (back-to-back) do not agree to within ±5%, contact Sierra Instruments Technical Support for assistance.

Chapter 3 Operating Instructions

Using the BG-1 Software

The BG-1 Main screen shown on the next page contains the key selections required for system operation. This screen appears when the BG-1 system is idle, in standby mode or during or after a sample run. When in sample mode, the Main screen displays real-time sample collection data. The BG-1 Main screen mode buttons are described below. Other features are covered on page 3-2. The only adjustable parameter on the BG-1 Main screen are the units of measurement.

Setup

Use the Setup screens to enter purge mode setpoints, maximum sample ΔP, maximum inlet air filter usage, select dilution flow rate or ratio, set trip mode parameters, adjust leak testing parameters and to view or convert datalog files. See page 3-7 for complete BG-1 setup information.

Sample

Use the Sample screen to select an output datafile, enter parameters for sample setpoints, standby mode and trip mode, begin sample collection and system purging. See page 3-11 for more information on using the sampling screens.

Purge

Use the Purge button to provide clean dry air to the sample probe to keep probe free of exhaust particle buildup.You may select a continuous purge or a time-limited purge. See page 3-17 for a full description of the BG-1 purge functions.

Calibrate

To calibrate the BG-1 you may select a mirror calibration (performed daily), or calibration using an external standard. See page 3-18 for calibration instructions.

Diagnostics

The Diagnostic screen is available for BG-1 troubleshooting and system adjustment. The diagnostic feature enables manual valve switching, leak testing and autobalance operations. See page 3-28 for more information on BG-1 diagnostic functions.

Shutdown

Click the shutdown button to turn off the BG-1 system.

Stop

Depending on the selected mode, clicking the stop button terminates the current process.

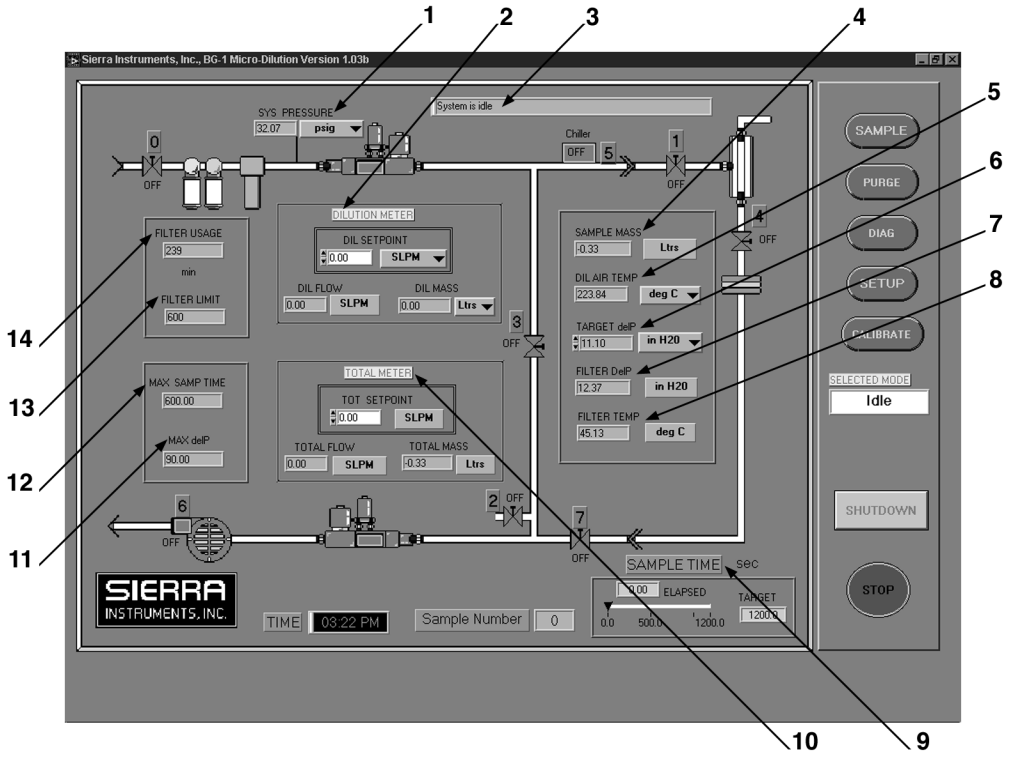


Figure 3-1. BG-1 Main Screen Features

1. System Pressure

Represents the incoming air pressure from the facility.

2. Dilution Meter

Dilute setpoint is the value entered in the Sample screen for the dilute MFC. Dilute flow multiplied by sample time equals the dilute mass value displayed on the screen.

3. Status bar

Indicates the current system status.

4. Sample Mass

Sample mass is the actual amount of gas passed through the filter during a sample. The sample mass (or volume) value is the result of the total mass minus the dilution mass.

5. Dilution Air Temperature

Displays the current temperature of the dilution air.

6. Target ΔP

When sampling system pressure trip settings, the target ΔP is the required pressure drop across the filter to trigger the system to complete the sample.

7. Filter ΔP

Displays the current pressure drop across the sample filter.

8. Filter Temperature

Displays the current sample gas temperature.

9. Sample Time

The lower section of the Main screens shows the current sample number, the elapsed time and the target time.

10. Total Meter

Total setpoint is the value entered in the Sample screen for the total MFC. Total flow multiplied by sample time equals the total mass value displayed on the screen.

11. Maximum ΔPressure

When sampling for a prescribed time (time trip) this value triggers the sample and prevents overloading of the sample filters. This system safeguard value is entered in the Setup screen.

12. Maximum Sample Time

Prevents "runaway" samples when using a pressure trip for sample collection. This system safeguard value is entered in the Setup screen.

13. Filter Limit

The filter limit displays the factory default value of 600 minutes before requiring an inlet air filter replacement.

14. Filter Usage

Indicates the total inlet air filter usage time.

Changing the Units of Measurement

Caution!
The BG-1 system must be in an idle state before making changes to any unit of measurement.

When the BG-1 is in an idle state, you may change the unit of measurement for Flow Units, Sample Units, Temperature Units and Pressure Units within the BG-1 Main screen. When changing units of measurement, verify system settings to ensure that all appropriate values are properly adjusted. For example, if you change the Sample ΔP units, the Maximum Sample ΔP setting in the Setup screen must be also be changed.

The default time multiplier used by the BG-1 is seconds. This value is adjustable to whatever time unit is desired. The time multiplier is contained in the configuration file, bguser.cfg, and can be modified manually by editing the configuration file. If you want to change the time multiplier, see Appendix A.

Saving Changes

Any change in units will return to the system default settings when exiting the BG-1 program. To permanently save new settings:

1. Select SETUP from the Main screen menu.

2. In the Setup Dialog Box, select SAVE AND EXIT. This updates the configuration file with the new unit information.

Changing Flow Units

You may select from four flow units: slpm, scfm, g/min, and lb/min. The system default is slpm. To change the flow units, click the down pointing arrow next to DIL SETPOINT and highlight the new selection.

The conversion factors are as follows:

UNIT	slpm	scfm	g/min	lb/min
slpm	---	0.0353147	1.2	0.00264555
scfm	28.316847	---	33.9802	0.074914
g/min	0.833333	0.0294289	---	0.00220462
lb/min	377.9936	13.3487	453.592	---

Table 3-1. Flow Units and Sample Units Conversion

Changing Sample Units

The total sample flow measured by the two MFCs during a sample is displayed on the screen as dilution mass and total mass. Sample mass is the difference between the total mass and dilution mass and is equal to the total exhaust sample collected.

The sample units are liters, cubic feet, grams and pounds. The system default is liters. Although liters is a volume measurement, total mass, dilution mass and sample mass represent the actual amount of gas through the filter regardless of the selected units.

The sample units use the same conversion factors as shown in Table 3-1. To change the sample units, click the down pointing arrow next to DIL MASS and highlight the new selection.

Changing Temperature Units

The software displays two measured temperatures, the dilution air temperature and the sample filter temperature. Three temperature units are available, degrees C, degrees F and Kelvin. Degrees C is the system default. To change the temperature unit, click the down pointing arrow next to DIL AIR TEMP and highlight the new selection.

The conversion factors are as follows:

UNIT	°C	°F	Kelvin
°C	---	*9/5 + 32	+273.15
°F	–32 * 5/9	---	(–32) * 5/9 + 273.15
Kelvin	–273.15	((–273.15) * 9/5) + 32	---

Table 3-2. Temperature Units Conversion

Changing Pressure Units

There are two system pressures displayed on the BG-1 Main screen, the inlet system air pressure and the filter target ΔP. Each pressure unit is selected independently. Six pressure units are available: psig, kPa, in H2O, cm H2O, in Hg and mm Hg. Psig is the system default for inlet pressure and in H2O for the target ΔP.

To change the inlet pressure unit, click the down pointing arrow next to SYS PRESSURE and highlight the new selection. To change the target ΔP pressure unit, click the down pointing arrow next to TARGET delP and highlight the new selection.

The conversion factors are as follows:

UNIT	psig	kPa	in H2O	cm H2O	in Hg	mm Hg
psig	---	6.8947	27.680	70.308	2.036	51.74
kPa	0.14504	---	4.0147	10.1973	0.2953	7.5006
in H2O	3.6127×10^{-2}	0.2491	---	2.54	7.3554×10^{-2}	1.8683
cm H2O	1.4223×10^{-2}	0.09806	0.3937	---	2.8958×10^{-2}	0.7355
in Hg	0.4912	3.3864	13.596	34.532	---	25.4
mm Hg	1.9337×10^{-2}	0.13332	0.53525	1.3595	3.937×10^{-2}	---

Table 3-3. Pressure Units Conversion

Entering Setup Parameters

The BG-1 Setup screen allows easy configuration of the various settings in the program to meet specific requirements. To access setup parameters click the Setup button on the BG-1 Main screen.

The Setup Dialog screen contains the adjustable values of Purge flow rate, Maximum Sample ΔP, Maximum Inlet Air Filter Usage, and two switch settings that select sample default parameters. A third switch enables the optional remote control function. The Options subscreen is password protected and allows access to the Leak Test parameters and other system settings. View Datalog File opens a dialog box for file access.

To permanently save new Setup values, click the Save and Exit button. The new values are now the default for the BG-1 system and remain in effect until changed again using the Setup screen. To discard any changes, click Cancel to return to the BG-1 Main screen.

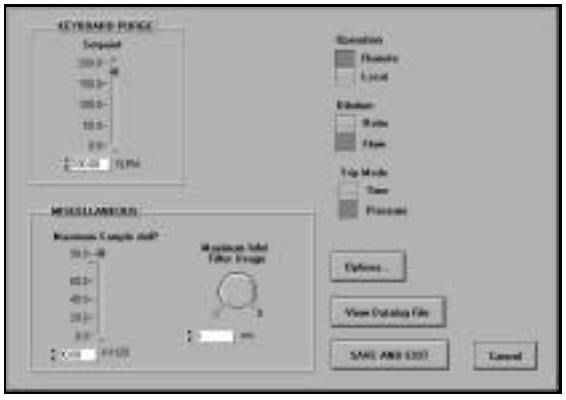


Figure 3-2. Setup Dialog Screen

Keyboard Purge

Setpoint

When the Purge button on the BG-1 Main screen is selected, the flow rate used during purging is the value entered here. Typically the purge flow is equal to or greater than the total sample flow set during a sample.

Miscellaneous

Maximum Sample ΔP

When collecting a sample, the pressure drop across the sample filter increases as the filter becomes loaded with particulate. To prevent the pressure drop from becoming too high, the sample process stops if the pressure drop exceeds the Maximum Sample ΔP. This value is preset at the factory but can be reset based on your specific requirements. If the default factory units are changed from inches H_2O to other units, the Maximum Sample ΔP parameter must be reset to an appropriate number in relation to the units selected.

Maximum Inlet Air Filter Usage

The inlet compressed air filters in the BG-1 are designed to remove contaminants from the dilution air supply. There are filters to remove oil, water, particulate, and hydrocarbons from the air supply. The specifics regarding the specifications and maintenance instructions are discussed in Chapter 4. These filters must periodically be checked and replaced as they become contaminated. The filter use counter measures the amount of time that air is passing through the inlet air filters. When the use time exceeds the maximum time set here, a prompt appears on screen informing you to check the filters the next time the program is started. The maximum filter use time setting depends on the specific conditions of the compressed air source to the BG-1. The cleaner the air source, the longer the time. The factory set value is 600 minutes.

Setup Screen Switches

Operation

Use the operation switch to initialize remote control of the BG-1. By placing the BG-1 system in remote operation it is now ready to accept commands from a master computer. This option allows control of nearly all BG-1 functions from a remote host computer such as the main test cell computer.

Dilution

This switch selects the default method of entering the dilution air setting used during a sample. There are two different methods of entering the value in the Sample screen. Depending on this switch setting, you can enter either the actual dilution air flow rate, or the desired dilution ratio. If selecting dilution ratio, the program automatically calculates the correct dilution air flow rate for the sample. The dilution setting can be modified for any sample.

Trip Mode

This switch sets the default mode of either time or pressure where the sample will normally trip or stop. After selecting the desired trip mode, use the Sample screen to enter a specified period of time or pressure drop across the sample filter. The trip mode setting can be modified for any sample.

Options Subscreen

The password protected Options Dialog screen contains system settings which affect the accuracy of the system. The option parameters are leak test time and allowable pressure loss, system warm-up time and the auto-balancing options. These are set by the factory to yield accurate system results and should not be changed without proper consideration.

Figure 3-3. Options Dialog Subscreen

View Datalog File

During sampling, the results of each sample are stored on the computer for later retrieval. The stored data is in a binary file format to reduce the file size and to reduce the time required to save the data. Because the stored data is in a binary format, the file must be converted before using outside of the BG-1 program. The BG-1 system software includes a standard file viewer which allows external data conversion.

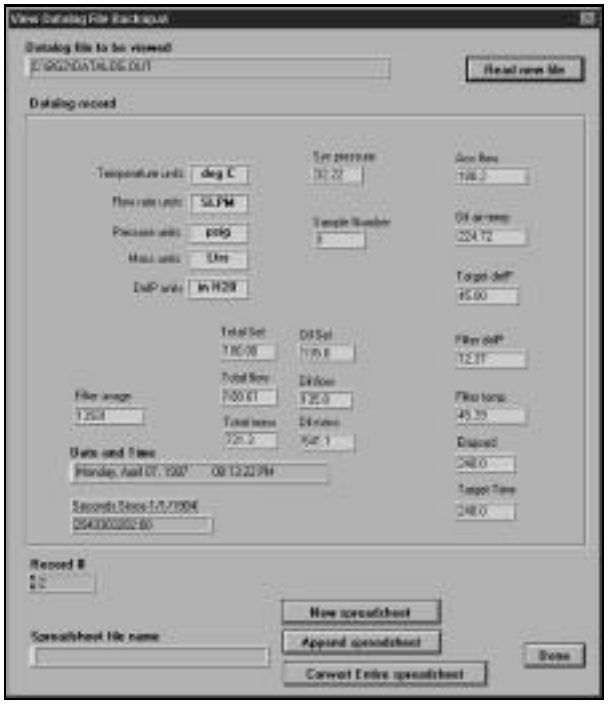


Figure 3-4. View Datalog File Screen

Read New File

To view or convert a file click the Read New File button and select the desired file. The file name is displayed in the Datalog file to be viewed box. The Datalog record displays all sample information for the sample, including the sample number, data values in use by the system and the date and time the sample was collected. The bottom section of the screen displays the current record number in the data file and screen buttons used to convert the raw data file to an ASCII spreadsheet file format.

New, Append, Convert Spreadsheet

Select the appropriate screen button to convert the data file to a spreadsheet format. The most common method is to convert an entire data file by selecting Convert Entire Spreadsheet. This displays a dialog box asking for the output file name. You can either use the current file name or enter a new name.

To convert only the current record or just a few records from the file, choose the New Spreadsheet option and enter the new file name. This displays the new file name in the box on the View Datalog screen. To save this and any further records to this spreadsheet file, scroll through the data file records until the desired record is selected on the screen. Click the Append Spreadsheet button.

Since data is appended to the end of the chosen datalog file, the record number and sample number will not coincide if a data file is used for multiple sample sessions. To ensure that all data is saved in the appropriate data and spreadsheet files, Sierra recommends saving all sample sets in different files.

Another method to view and convert raw BG-1 data files is performed external to the main BG-1 program. Included with the BG-1 software is the program BG-1VIEW.EXE. This program is a standalone version of the subroutine used in the main BG-1 program, and functions identically.

Collecting a Sample

Sample Mode Dialog Screen

When you select SAMPLE from the BG-1 Main screen you are given the option of providing input conditions from the keyboard or from an input datafile. All variables are adjustable for each sample for both the keyboard and datafile method. Sample data is saved to a file regardless of the method used to input the setpoints or the number of setpoints used. After choosing the method of input, the Test Sample Dialog screen appears.

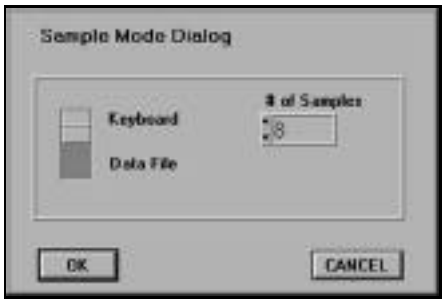


Figure 3-5. Sample Mode Dialog Screen

Keyboard Method

When using the keyboard method, you are required to enter all sample variables in the Test Sample Dialog Screen.

1. To input data from the keyboard, enter the number of samples to collect.
2. Select an output file for the data or use the default file, *datalog.out*. When using an existing output file, the new data is added to the end of the file.
3. Click OK to continue or Cancel to return to the BG-1 Main screen.

Datafile Method

Input data files are easy to create using Windows Notepad or other text editing programs. The input data file can be prepared to collect any number of predetermined sample points. See Appendix A for an example data file containing setpoints for five samples. If selecting an input data file:

1. Use the mouse to select Data File on the screen, click OK to continue.
2. At the prompt, enter the name of the input datalog file. Click OK to continue.
3. Select an output file for the data or use the default file, *datalog.out*. When using an existing output file, the new data is added to the end of the file.
4. Click OK to continue or Cancel to return to the BG-1 Main screen.

Test Sample Dialog Screen

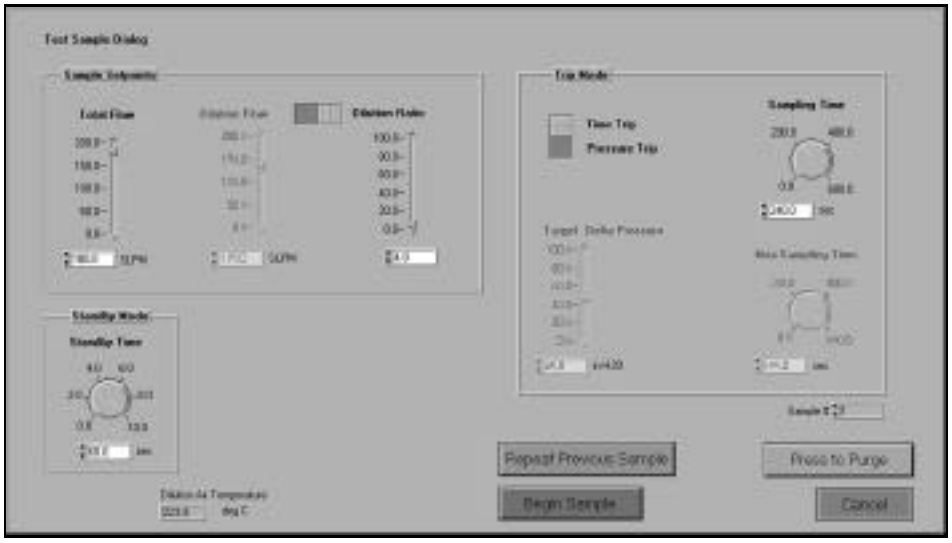


Figure 3-6. Test Sample Dialog Screen

Sample Setpoints

Total Flow

Enter the actual flow setpoint for the total MFC and dilute MFC.

Dilution Flow or Dilution Ratio

When entering the amount of dilution air used during a sample, there are two different methods of entering the value. You can either enter the actual dilution air flow rate to be used, or the desired dilution ratio. If the dilution ratio is entered, the program automatically calculate the correct dilution air flow rate for the sample. You may override the default switch setting, if desired. To permanent change the switch setting, use the Setup screen.

Dilution ratio settings depend on the exhaust sample temperature. Typically, higher exhaust temperatures require higher dilution ratios. Table 3-4 provides sample dilution ratio settings.

For reference, the dilution air temperature is shown at the bottom of the BG-1 test sample dialog screen.

The formula for determining sample ratios is:

$$\text{Dilution Ratio} = \frac{\text{Total Flow}}{\text{Total Flow} - \text{Dilution Air}} = \frac{\text{Total Flow}}{\text{Sample Flow}}$$

Ratio	Dilution Air	Total Flow
4:1	150	200
4:1	135	180
4:1	90	120
5:1	144	180
5:1	96	120
6:1	150	180
7:1	154.3	180
7:1	120	140
8:1	175	200
9:1	170	180
10:1	180	200
10:1	135	150
11:1	163.6	180
11:1	100	110
12:1	165	180
12:1	110	120
13:1	184.6	200
13:1	120	130
14:1	138	140
14:1	185.7	200
15:1	140	150

Table 3-4. Sample Dilution Ratio Settings

Standby Mode

When collecting a sample the system will enter standby mode prior to the actual sample. Standby mode performs two important functions:

- purging the sampling system
- stabilizing the sample flows

During standby mode both flow controllers are initialized to the set-points used during the sample. But, instead of the system collecting a sample, the purge air and total flow is stabilized by pulling air through the standby valve indicated as valve number 2 on the BG-1 Main screen. The purging function is accomplished by delivering dilution air through the dilute flow meter, into the dilution chamber and out into the exhaust through the sample probe. The flow rate used during the standby mode is the same as selected for the actual sample.

Enter the length of time desired for standby prior to sampling. This is typically 1 minute but can be any time length. If the time selected is too short, the flow controllers will not have sufficient time to stabilize prior to the beginning of the sample and the test results will be more variable. If you are ready to begin sampling before the end of the standby period, briefly press the stop button on the BG-1 Main screen and the sample will begin. Entering a long standby time allows purging for an extended period of time. This is helpful when changing engine operating conditions between samples. However, if the standby time is expected to be longer than 5 minutes and the goal is to purge the sample probe, use the purge button.

Trip Mode

Trip mode determines the normal method for terminating the sample. Both trip modes have safety settings to ensure that the system will not sample too long or overload the sample filter. For Time Trip, there is a maximum ΔP setting entered using the Setup screen. As the filter loads and the pressure drop exceeds the maximum, the system automatically stops the sample. For Pressure Trip, there is a maximum sample time setting in addition to the target ΔP for the sample. If the sample time exceeds this setting, the system automatically stops the sample. This is important in the event of a break in the sample filter or if the system develops a leak during a test where the filter ΔP may never reach the desired trip value.

By selecting Time Trip, the system samples for a preset period of time. To select Time Trip:

1. Set the option switch to the Time Trip position.
2. Enter the time required for sample collection.

By selecting Pressure Trip, the system collects exhaust particulate until the loading on the sample filter causes the pressure drop across the filter to exceed a user-selected pressure. To select Pressure Trip:

1. Set the option switch to the Pressure Trip position.
2. Enter the pressure required for sample collection.
3. Enter the maximum sampling time.

Begin Sample

After the setpoints are adjusted to the desired values, click the Begin Sample button to begin sample collection.

At the end of standby mode, the system automatically switches the valves and begins sampling exhaust. During the sample process, the valves on screen reflect their current on or off state.

At the beginning of sample collection, the totalized or accumulated flow values begin to count up the actual flow through the two mass flow controllers. At the completion of the sample, the valves reset and the final accumulated values are displayed on the Sample Complete screen. All necessary values are stored in the data output file selected at the beginning of the sample process.

Caution!
If the engine is operating and the BG-1 is not sampling, invoke the Purge Mode. This ensures repeatable samples with minimal deposits forming in the probe.

Press to Purge - Purging Between Samples

In addition to the standby mode, you can purge the system by clicking the Purge button on the Test Sample Dialog screen. Purge mode causes dilution air to purge the system, but does not turn on the total flow. This allows the system to be purged between samples without exiting the sample screen and maintains the integrity of the sample data file. If the system is in purge mode between samples and you initiate the next sample, the system automatically enters standby mode and begins the normal sample process. When the sample is complete, with more samples remaining, the system automatically re-enters the purge mode state that was in effect prior to the most recent sample.

Repeat Previous Sample

If you need to re-run the most recently completed sample, press the Repeat Previous Sample button. This will "back-up" the system and retrieve the setpoints for the previous sample, whether by datafile or keyboard input. Since all sample data is retained by the system, the resulting datalog file will contain sample information for both the first and repeated sample.

This option is most relevant when the setpoints are entered from a datafile, since in keyboard mode, the setpoints from the most recently completed sample are automatically displayed for the next sample. For keyboard mode Repeat Previous Sample can be useful if you need to collect additional samples in the current data set.

Sample Number

The Test Sample Dialog screen shows the sample number for the next sample to be taken. After the last indicated sample, the system returns to the BG-1 Main screen. The sample setpoints for the most recently completed sample are saved in the file *kbd.set*. The next time the Test Sample Dialog screen is displayed using keyboard entry, this data is displayed.

Sample Complete Screen

The Sample Complete screen displays the total mass, dilution mass, sample mass, dilution air temperature, filter temperature and the filter ΔP of the completed sample.

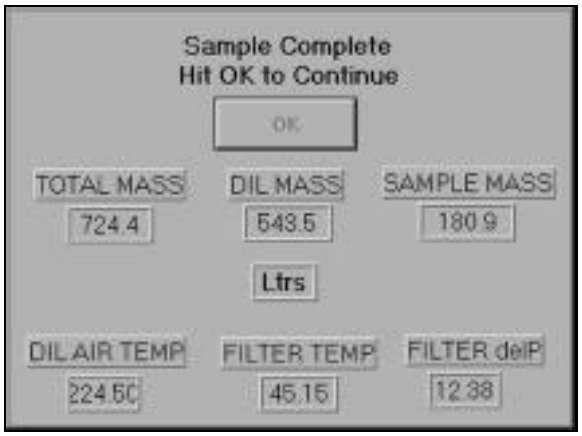


Figure 3-7. Sample Complete Screen

Using the Purge Function

To purge the sample probe and dilution chamber, click the Purge button on the BG-1 Main screen. Purging the system sends clean, cool, compressed dilution air through the dilution chamber and out the sample probe. This removes loose particulate and prevents excessive build-up on the sample probe.

Caution!
If the engine is operating and the BG-1 is not sampling, invoke the purge mode. This ensures repeatable samples with minimal deposits forming in the probe.

After selecting purge you have two options, either continuous purge or purge for a designated time period. To purge continuously click the button that indicates Run Until I Hit Stop. This initiates a continuous purge. Click the red Stop button on the BG-1 Main screen to terminate purging.

To enter a period of time for purging, select Run on Timer. Enter the length of purge time. Click OK to begin purging. Click the red Stop button at any time to terminate purging.

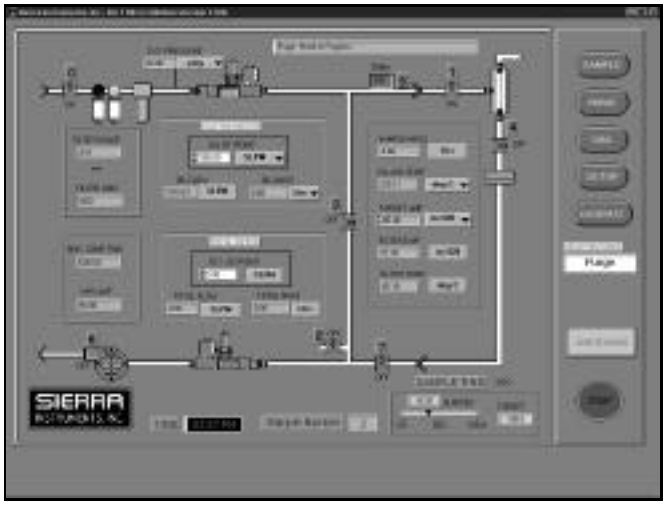


Figure 3-8. Purge Mode Screen

Calibrating the BG-1 System

The two Sierra Series 860 Mass Flow Controllers used in the BG-1 are calibrated at the factory. The dilute MFC is calibrated first using a NIST standard calibration technique. The total MFC is then calibrated using a technique known as mirroring. Using the dilute MFC as the standard, the total MFC is calibrated or mirrored to the dilute meter. This ensures that the two devices yield the same output for the same flow. The mirror process uses sixteen breakpoints or flow values with equal intervals to achieve a high accuracy in the indicated flow of the total MFC. Even though the two mass flow controllers are factory calibrated, re-calibration may be necessary due to certification requirements and sensor contamination.

The BG-1 software is designed to perform two different types of calibration functions, calibration and mirror. The procedure for performing a calibration or mirror is essentially the same. In the first case you are calibrating the mass flow controllers in the BG-1 using an external calibration standard. In the second case you are calibrating (mirroring) the total MFC in the BG-1 using the dilute MFC as the calibration device as described above.

The BG-1 default is to perform a daily mirror calibration. The system prompts for the mirror calibration at the beginning of the sampling process. Performing a daily mirror calibration ensures that the sampling data meets required testing standards.

Calibration characteristics and flow coefficients calculated by the BG-1 program are stored on the computer in the file *bgcal1.cfg* (see Appendix A). Any new calibration information generated is stored on the BG-1 computer as a result of either a mirror or an independent calibration of either MFC.

File Dialog Screen

When the calibrate sequence is initiated, a file dialog screen appears. You may select the default calibration configuration file or an alternative configuration file. This allows multiple calibration configurations for different purposes.

Multiple calibration configuration files are useful if you sample from different engine sizes. If you use the system as both a primary raw exhaust sampler and a secondary dilute sampler. Under these situations you may collect samples over different extremes of flow rates. You can calibrate the flow meters over their entire range, which is typical for raw exhaust sampling or over a narrow range which will give high accuracy within that range. However, if a narrow range is selected, accuracy outside of this range is not ensured.

Two files on the BG-1 computer are used during the calibration process. These are the files *bgcal1.cfg* and *bgcal2.cfg*. The bgcal1.cfg file contains the calibration coefficients of the two mass flow controllers. The bgcal2.cfg file contains the calibration flow setpoints and associated calibration parameters. Newly entered calibration setup parameters are stored in the file bgcal2.cfg. See Appendix A for examples of the BG-1 calibration configuration files.

After selecting the configuration file, the program reads in the calibration setpoint values and displays them on the Mirror and Calibration Setup Parameters screen.

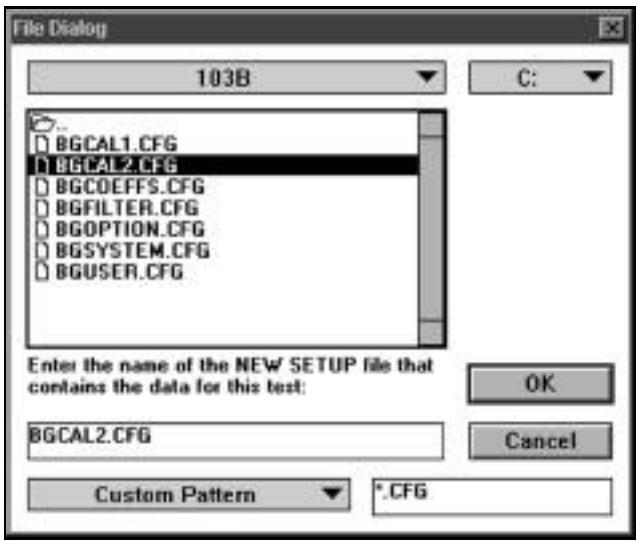


Figure 3-9. Calibrate File Dialog Screen

Mirror and Calibration Setup Parameters Screen

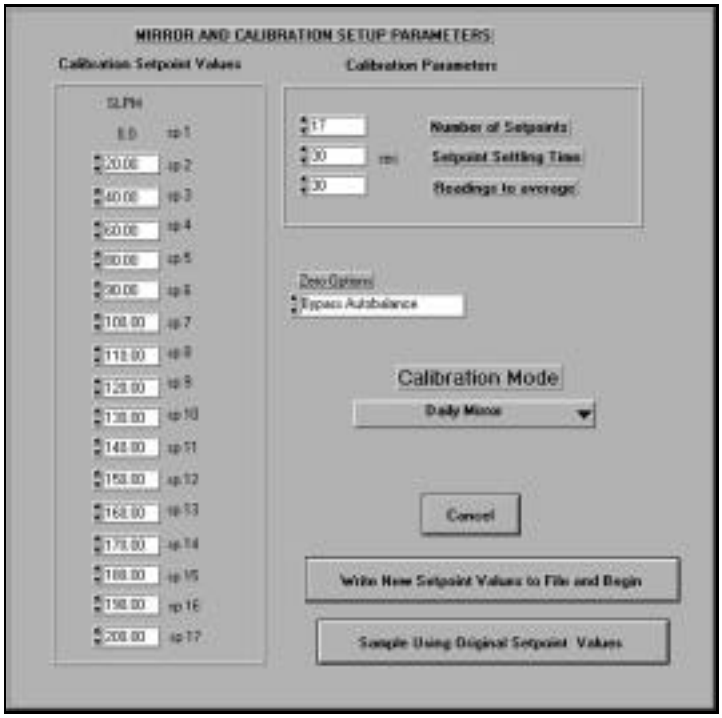


Figure 3-10. Mirror and Calibration Setup Parameters Screen

Calibration Setpoint Values

The BG-1 program allows up to seventeen different calibration flow setpoints (with the 1st point always defined as zero) spanning the range of the flow meters. These can be entered with any division size and frequency. To achieve high accuracy over a narrow range of flows, say from 160 to 200 slpm, select all setpoints within that narrow range. However, if a narrow range is selected, accuracy outside of this range is not ensured.

Calibration Parameters

Number of Samples

Number of Samples defines the number of calibration setpoint values. If fewer than seventeen calibration setpoints are desired, enter an appropriate number.

Setpoint Settling Time

When making a step change from one flow rate to another, setpoint settling time allows the flow rate to stabilize before reading sample flow. For this value, the greater the number, the greater the accuracy. However, note that higher settings increase calibration time.

Readings to Average

After the stabilization period, select the number of readings to average to ensure an accurate calibration. For this value, the greater the number, the greater the accuracy. However, note that higher settings increase calibration time.

Zero Options

When calibrating the BG-1 there are two different zero options available, autobalance or bypass autobalance. Autobalance is a special function built into the mass flow controller which zeros the output of the controller at zero flow. This function corrects for any drift in the controllers over time. If the autobalance function is bypassed, the BG-1 software will adjust the calibration coefficients appropriately to correct for controller drift over time. Regardless of which function is used, the BG-1 will effectively perform the same.

Calibration Mode

The default BG-1 calibration mode is Mirror. When using Mirror, the system calibrates or mirrors the calibration of the total MFC to that of the dilute MFC. By this definition, the dilute meter is the "master" and the total meter is the "slave."

In addition to Mirror, there are three other calibration options: Series Calibration, Dilute Calibration, and Total Calibration which are explained under the heading, "Calibration Procedure Using an External Standard." These three calibrations allow connection of an external calibration device to the BG-1 for independent calibration the two MFCs either in series, or individually.

Cancel

Click the Cancel button to discard changes and select the values set in the default calibration file.

Write New Setpoint Values to File and Begin

After all sample setpoints, sample parameters, and the calibration mode are properly selected, there are two options to initiate the calibration or mirror. By selecting Write New Setpoint Values to File and Begin new calibration setpoints and any modified parameters, such as the number of points, are written to, and replace the original values in the file bgcal2.cfg for future use. The calibration procedure then begins.

Sample Using Original Setpoint Values

If you want to perform a calibration using the original values and not the newly entered parameters, click the Sample Using Original values button.

Using the BG-1 Mirror Procedure

When running the mirror procedure, the total MFC opens to 100%, flow is controlled by the dilute MFC and passed in series through the two MFCs. During mirroring, the BG-1 program automatically steps through the pre-defined setpoints until the entire range of setpoints is complete. When the mirror procedure is complete, the Regression screen appears.

During a mirror, only the calibration information for the total MFC is saved, since you are not performing a calibration on the dilute MFC, but rather forcing the total MFC to match the dilute MFC.

Calibration Using an External Standard

The BG-1 has three options available for calibrating the two MFCs using an external standard. You can either calibrate each meter, dilute and total independently, or both meters in series. There are different connection requirements for each option because of the location of the valves and available calibration ports. Use the applicable directions below to setup the components and then follow the calibration procedure shown on page 3-25.

Setup to Calibrate the Dilute MFC

To calibrate the dilute mass flow controller the default flow path is from the incoming air supply, through the dilute MFC, through the bypass valve, number 3 on Figure 3-1, and exiting through the standby valve, marked number 2.

If the calibration device uses its own compressed air supply:

1. Disconnect the compressed air line from the outlet of the inlet air supply line marked 0 and cut off the line to prevent air leakage.

2. Connect the calibration devise to the connector fitting exposed in Step 1 above. The pressure at the dilute MFC must be approximately 20 psig at a flow of 200 slpm . This is the normal operating pressure of the system and the MFC is calibrated at this pressure.

Caution!
To ensure proper system output, it is important that all calibrations are performed at 20 psig at the dilution flow controller.

If the calibration device does not require its own air supply remove the diffuser screen from valve number 2 and connect the calibration device to this point.

Setup to Calibrate the Total Flow Controller

To calibrate the total mass flow controller the default flow path is through the standby valve number 2, through the total MFC and out through the pump.

Because the BG-1 uses the internal pump during the calibration process, a compressed air supply is not needed to calibrate the controller. Connect as follows:

- Remove the diffuser screen from valve number 2 and connect the calibration device to this point.

If using a calibration device that requires a compressed air supply a regulator must be included to reduce the pressure to the total MFC to approximately one atmosphere.

Setup for Series Calibration

To calibrate both mass flow controllers in series, the total MFC opens to 100% flow is controlled by the dilute MFC and passed in series through the two MFCs. Calibrating the MFCs in series reduces the time necessary to perform a periodic calibration of the system.

The calibration device must supply the compressed air source for the calibration. Connect as follows:

Caution!
To ensure proper system output, it is important that all calibrations are performed at 20 psig at the dilution flow controller.

1. Disconnect the incoming compressed air supply at the BG-1 inlet.

2. Connect the calibration device to the fitting marked 0 on Figure 3-1. When connecting a calibration device at this location, the pressure at the dilute MFC must be approximately 20 psig. This is the normal operating pressure of the system and the MFC is calibrated at this pressure.

If your standard does not use its own supply pressure, contact the factory for configuration instructions.

Begin the Calibration

When performing a calibration using an external device you are prompted to:

- initialize the external calibration device prior to each setpoint at the desired flow
- enter the actual flow indicated by the external device at the end of each sample segment

The mass flow controller being calibrated (or the dilute MFC in the case of a series calibration) controls the flow at a given setpoint instead of an external calibration device. This allows connection of any flow measurement device to the system without using an external flow control valve.

When performing a calibration the system uses the original factory calibration of the flow controller to adjust the setpoint of the controlling MFC. During the calibration sequence, the collected data is then used to calibrate the new calibration coefficients. The BG-1 calibration coefficients (stored in bgcal1.cfg) are bypassed during the calibration process, this allows the true output from the MFC to be obtained for the calibration.

To perform a calibration on the dilute MFC only, follow the steps below. These steps are similar for a series calibration or a calibration of the total flow controller only.

1. Select Calibrate on the BG-1 main screen. Enter setpoints and other parameters on the Mirror and Calibration Setup Parameter screen.

2. Select appropriate screen button to begin the calibration. If Zero Flow Autobalance is selected, the system performs an autobalance on the MFC and measures the zero flow of the MFC and the calibration device for the regression calculations.

3. Prepare the external standard for the flow range desired. Depending on the standard, you may need to change orifice plates, etc. The flow is adjusted based on the setpoint of dilute MFC corresponding to the setpoint in the calibration routine.

4. The system measures the indicated flow of the MFC while you input the actual flow from the calibration standard. Repeat from step 3 for as many points as selected.

5. The program calculates the new calibration coefficients.

Determining Calibration Coefficients

After the mirror or calibration is complete, the Regression screen appears. The display shows the recorded X (dilute MFC or transfer standard if a calibration) and the Y (total for mirror or calibration, or dilute for calibration) flow values, the calculated Y values and the % difference. The calculated Y values are determined using the new calibration or mirror coefficients and the % difference displays the difference between the actual Y values and the calculated values.

The X and Y values represent different items depending on the calibration mode selected. For mirror, the X values represent the dilute MFC flows, and the total MFC flows are represented by the Y values. The new and original (or previous) calibration coefficients are displayed as well as a graphical representation of the of the actual calibration curve fit.

Viewing the Calibration Coefficients

The lower portion of the display shows the high and low values of the actual data, the calibration equation with the alpha coefficients, and a number of options including the order of the curve fit equation selected and the curve fit mean squared error. Before accepting the updated calibration coefficients, verify that the calibration was performed correctly and that the results are satisfactory.

There are a couple of methods used to verify the results. First examine the % difference values comparing the calculated Y values to the actual mirrored Y values. The error values should be generally 0.5% or less. The second method used to calculate the effectiveness of the calibration is to compare the curve fit error for different orders of the equation. The curve fit error should not change dramatically as you change from the 5th order to the 1st order. If there is a large change in the fit error, evaluate the system for leaks or other problems or contact the factory for assistance.

By clicking Original or New you may switch between New and Original Coefficients to observe how the “new” calibration data matches the original calibration coefficients.

During normal operation of a calibrated flow device, the calibration curve is only valid between the high and low points of the calibration data. Outside these points there is no guarantee that the displayed value accurately represents the actual flow within the specified tolerance of the device. The % X Overshoot dial allows you to observe the results if the flow overshoots the calibration range by up to 10%.

Write New Coefficients

The values displayed for X values and Y values on the regression screen can be modified if necessary. For example if an error was made in entering a value during the calibration routine, you may correct this error before saving the new calibration coefficients. As you change values for either X or Y, the graph and calibration coefficients are automatically adjusted in real-time to reflect the changes.

After you are satisfied with the results of the mirror/calibration, click Write New Coefficients. This updates the coefficients used by the BG-1 program and saves the new coefficients to the file *bgcal1.cfg*. After saving the coefficients, select "Calibration Complete" to return to the BG-1 Main screen. To retain the original coefficients, click Calibration Complete only and the new calibration data and coefficients are discarded.

Whenever calibration coefficients are saved a complete record of the results are stored in the cal data subdirectory. The file name is generated automatically by the program as a unique identifying number based on the date and time the file was saved. This record contains all of the data displayed on the regressions screen and is generated for record keeping purposes.

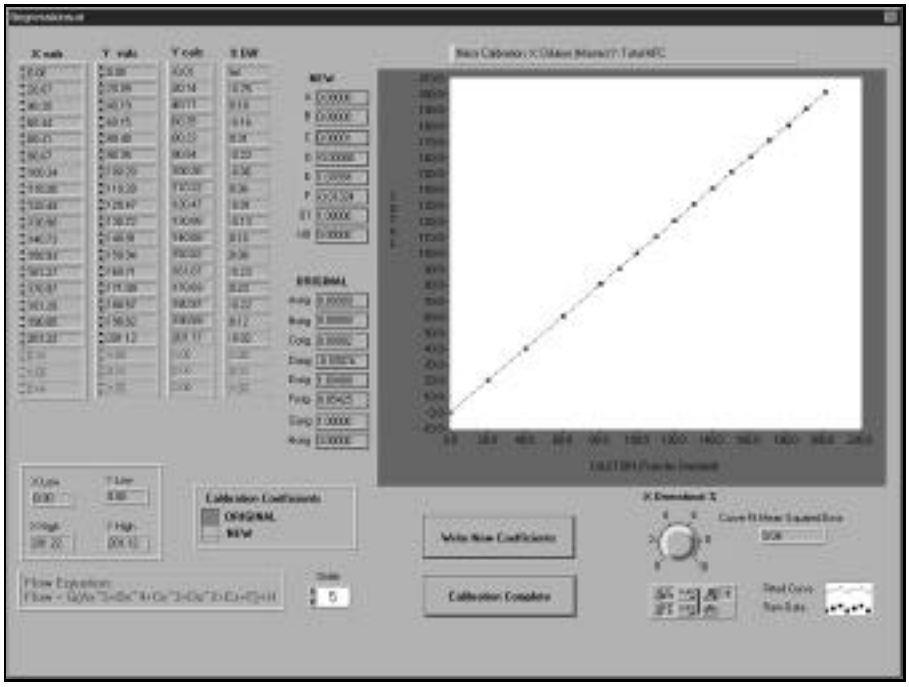


Figure 3-11. Regression Screen in Calibrate Mode

BG-1 Diagnostic Functions

BG-1 diagnostic functions are helpful when troubleshooting the system or adjusting MFC setpoints. There are three options available in diagnostics:

- Enable Manual Valve Switching
- Perform Leak Test
- Perform Autobalance

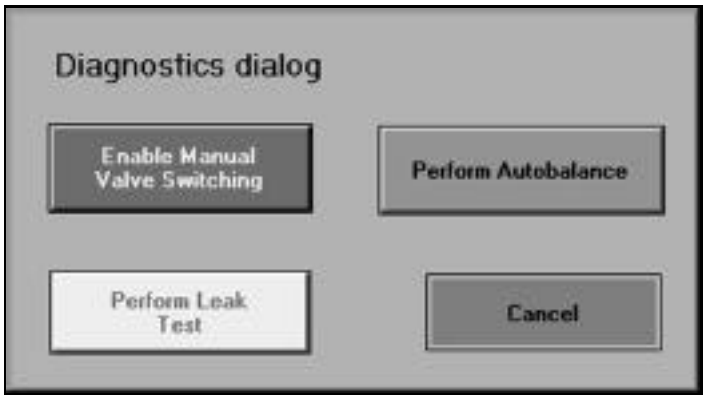


Figure 3-12. Diagnostic Dialog Screen

Perform Leak Test

To perform a leak test of the system, the BG-1 opens all necessary valves and pressurizes the flow path of the system. During the leak check, valves 3 and 7 open along with the dilute mass flow control valve and valve 0. After pressurizing, the inlet air valve, 0, closes. The leak check tests for leaks in the plumbing of the BG-1 system.

To pass the leak test, the system to cannot exceed a loss of three psi in three minutes. If the pressure loss is greater than allowed, the system automatically isolates different areas of the flow path and performs another leak test on that area.

When the system passes the leak test, the program displays the measured pressure loss and the time used for the test. If the leak test fails, the system indicates the failure and suggests the general location of the leak.

Factory-set leak test values are stored in the Setup Options subscreen. The default values can be modified by entering a password and then selecting new values.

Enable Manual Valve Switching

Enable Manual Switching allows manual simulation all BG-1 operations. This is useful in diagnosing problems with the system, during the installation of the BG-1, or evaluating sampling techniques.

When Enable Manual Switching is selected, each valve is operated independently by clicking on the numbered boxes or valves on the BG-1 Main screen. After clicking on a device, the indicator changes color from red to green indicating that the device is on or, in the case of a valve, open.

Caution!
To prevent damage to the pump when using manual switching mode, always ensure an open flow path.

When the inlet valve opens, this also activates the dilute MFC. Similarly, when the pump is turned on, the total MFC is activated. Before starting the pump in manual switching mode, always open valve number 2 or other values to ensure an open flow path.

Adjusting the MFC Setpoints

The flow setpoints for the two MFCs can be adjusted from the BG-1 Main screen while in a manual switching mode. To change setpoints, either highlight the current setpoint and type in a new value, or use the arrows to scroll the value to the desired setpoint.

When a setpoint is selected, the setpoint indicated on screen may not be the exact setpoint desired. Because the MFC is a digital device, there are a number of discrete setpoints possible. To ensure proper operation, the BG-1 program writes the desired setpoint to the MFC and then reads back the actual setpoint and displays this on screen. The displayed setpoint is the actual setpoint used by the system.

Perform Autobalance

Perform Autobalance is one of the mass flow controller's most powerful features. A sensor can be affected by numerous uncontrolled variables such as extreme changes in the operating temperature. The net effect of these variables on the sensor is to cause the transducer's "zero" to drift. This "zero" is the reference point on which the transducer calibration is based. If the "zero" drifts, so will the calibration. Thus, in order to maintain long term repeatable and accurate calibration, it is necessary to neutralize the effect of "zero" drift on the sensor.

The autobalance feature solves the "zero" drift problem at the source. If the output signal drifts beyond (±).15% of its initial calibrated "zero," autobalance will sense this drift and automatically re-zero the MFC within the bridge circuit of the sensor itself. In this manner, the "zero" drift is corrected at its point of origin, the actual bridge circuit and any calibration drifts are eliminated.

Chapter 4 Preventive Maintenance

Warning!
All maintenance procedures must be performed with the power off.

BG-1 system maintenance involves replacing consumables and returning the Series 860 Mass Flow Controllers to Sierra for annual recalibration.

To obtain sample filters contact Pallflex Products Corporation, Kennedy Drive, Putnam, CT, 06260, (203) 928-7761, Size 90 mm, Type T60.A.20. Contact the Sierra factory for desiccant and filter elements.

Component locations are shown on the next page and also in Chapter 5. The BG-1 preventive maintenance schedule is as follows.

Daily Maintenance

Sample filter assembly quick release connectors: use silicon grease to lightly lubricate the rubber O-rings and bearings inside the quick release connectors on each end of the sample filter holder.

Weekly Maintenance

Drierrite desiccant: visually monitor for liquid in the window. Replace with Sierra P/N 39-0217 when moisture is apparent.

Annual Maintenance

Mass flow controllers: return to Sierra for recalibration every twelve months.

Particle filter element: monitor visually looking for liquid in the glass. Drain if necessary. Replace with Sierra P/N 39-0219 annually or when dirty.

Coalescing filter element: monitor visually looking for liquid in the glass. Drain if necessary. Replace with Sierra P/N 39-0220 annually or when dirty.

Particulate filter element: monitor visually. Replace with Sierra P/N 39-0221 annually or when dirty.

Absorption filter element: monitor visually. Replace with Sierra P/N 39-0222 annually or when dirty.

Return line filter: replace the filter element annually. See Figure 5-3 for location.

Bi-Annual Maintenance

Vacuum pump: inspect vanes for wear after 24 months. Replace with Sierra P/N 39-0240 if vane width is less than 32 mm.

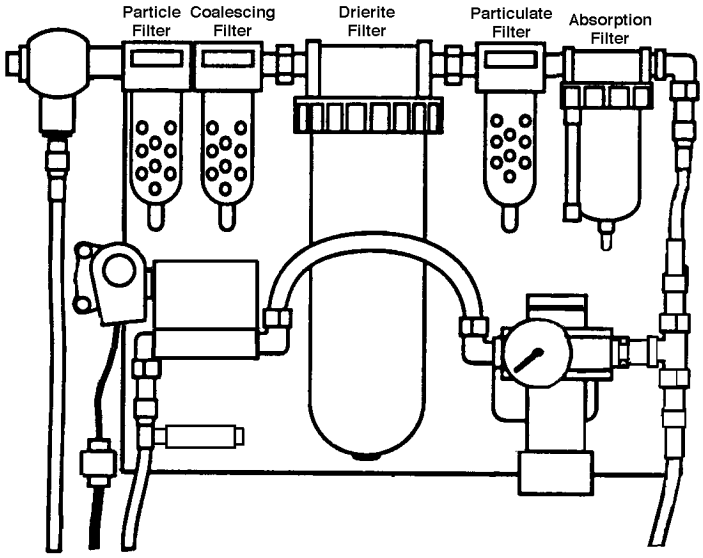


Figure 4-1. BG-1 Air Preparation Filters

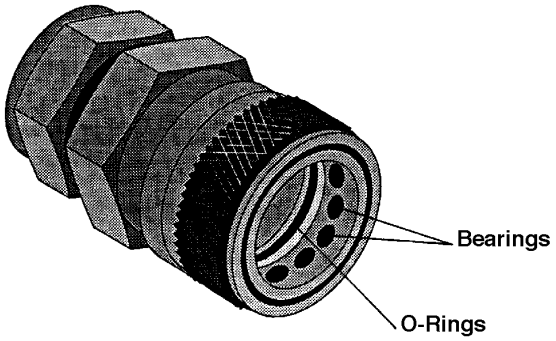


Figure 4-2. Lubrication of Filter Assembly Connectors

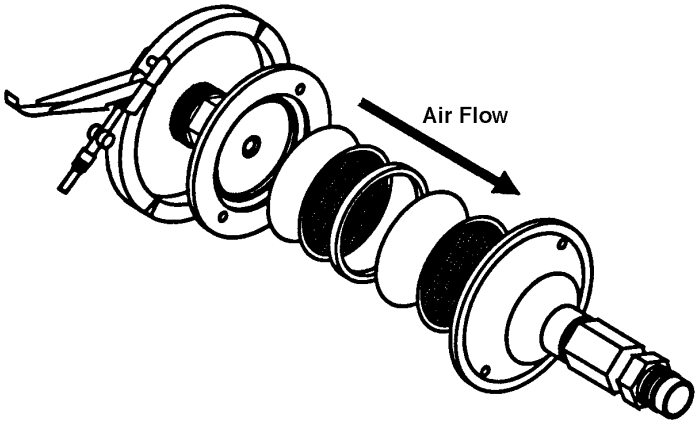


Figure 4-3. Filter Assembly

Obtaining a Return Material Authorization

Before returning any component or subassembly of the BG-1 to the factory, you must obtain a Return Material Authorization (RMA) from Sierra Instruments Customer Service. Have your model number and serial number available when you call. To contact Customer Service call:

(800) 866-0200 or (831) 373-0200 in the US, or
30 (0) 20-6145810 in Europe.

Return shipments to:

USA Headquarters
Sierra Instruments Service Department
5 Harris Court, Building W
Monterey, CA 93940
Attn: RMA #_____

European Headquarters
Sierra Instruments b.v. Service Department
Bolstoen 30A
1046 AV Amsterdam, The Netherlands
Attn: RMA #_____

When returning a component, include this information:

- a note describing the problem
- the model and serial number and the RMA number
- corrective action to be accomplished at the factory
- the purchase order number used to buy the component
- a contact name and phone number
- complete return shipping instructions (components cannot be delivered to a post office box)

Chapter 5 Troubleshooting and Repair

Warning!
To avoid potential electric shock, follow National Electric Code or your local electrical code when troubleshooting or repairing the BG-1 system. A hazard of personal injury and/or equipment damage exists if codes are ignored. Only qualified persons should perform service on the BG-1.

This chapter covers basic troubleshooting procedures along with BG-1 repair procedures. The repair procedures describe how to remove field replaceable units or subassemblies. Replacement procedures, unless specifically provided, are the reverse of the removal procedure.

The repair procedures do not describe why a particular subassembly may need to be replaced, nor do they describe how to repair subassemblies. In most instances of component failure, Sierra recommends that you return the subassembly to the factory for repair or replacement.

Begin hardware troubleshooting by verifying the following facilities issues are correct. These areas impact BG-1 operation and must be corrected prior to performing any system level inspections.

1. Verify that incoming power to the BG-1 is present and of the correct voltage.

2. Check that the compressed air line is connected to the BG-1. Verify pressure is 80 psi minimum to 100 psi maximum.

3. Make sure the sample line is not kinked, damaged or bent in a radius tighter than 18 inches.

4. Verify the sample probe location meets the installation guidelines shown on page 2-1.

After verifying the factors above, follow the troubleshooting procedures outlined on the following pages. If you need to return any component or subassembly to the factory, see Chapter 4 for RMA and shipping instructions.

Problem	Possible Cause	Solution
After weighting sample filters, you find that results are inaccurate.	Improperly prepared sample filters.	When using filter papers in a micro-dilution process, they must be suitably prepared for soluble fraction extraction protocol; for example, using a methylene chloride rinse or vacuum sublimation. Verify that your sample filters are suitable for use in a micro-dilution system where vacuum pressures are much higher.
Flow readings are erroneous.	The air heater controller has not had time to stabilize or the 5 amp fuse is open.	Check the air heater controller display panels on the MFC subassembly. They should read 29°C. If not, wait five minutes for the temperature to stabilize. If there is no display at all, check the 5 amp fuse. (See Figure B-8 for location.)
The system will not calibrate.	Pressurized air is not connected to the BG-1.	Connect pressurized air to the BG-1 chassis.
Sample flow is less than requested.	The adjustment knob on the vacuum pump may be loosening and allowing air leakage or there is leakage somewhere else in the vacuum line.	Check the vacuum pump adjustment knob. Check all the fittings in the vacuum line.
The dilution air temperature is too high.	The air is being heated by a solenoid.	Do nothing. The problem will correct itself during operation.

Problem	Possible Cause	Solution
The ΔP transducer reads zero during sampling.	A hole has melted through the plastic tubing.	Check the spaghetti tubing over its entire length for melted spots. Replace with new.
The vacuum pump will not start.	There is no power output from the I/O box.	Verify power to and from the I/O box.
	The pump is not plugged in.	Verify that the vacuum pump is plugged into the side of I/O box.
There is little or no dilution air at the sample probe.	The valve at the dilution probe air inlet is defective.	Replace the valve.
	The cooling air control valve in the dilution chamber needs adjustment.	Turn the valve clockwise to close, then open 3/4 turn.
The dilution air at the probe is not being cooled.	The chiller is not providing air that is sufficiently cold.	Purge system between samples.
The filters are ruptured after a test run.	There may be fluctuations in the exhaust stack pressure.	Use a fiberglass-backed filter.
	The sample is too hot.	Relocate the probe downstream further from the engine.
	Compressed air pressure to BG-1 is too low.	Increase pressure to maintain at least 90 psi.

BG-1 Repair Procedures

Warning!
All repair procedures must be performed with the power off.

The first five BG-1 repair procedures describe how to remove the three doors and two side panels of the cabinet, thereby completely exposing the chassis frame and all subassemblies inside the BG-1.

If you plan to work on a particular portion of the system, it may be unnecessary to remove all the doors and panels. However, we recommend door and panel removal as a general practice because it allows easier access to mounting bolts, components, adjustment screws, filters, etc.

The repair procedures include:

page
1. Removing the display door.....5-5
2. Removing the front door 5-6
3. Removing the rear door.....5-6
4. Removing the left side panel.....5-7
5. Removing the right side panel 5-8

Procedures 6 through 14 assume you have removed the doors and panels.

6. Removing the video display.....5-9
7. Removing the air preparation assembly.....5-10
8. Removing the inlet air pressure gauge and regulator.....5-11
9. Removing the air preparation assembly solenoid-activated valve 5-11
10. Removing the I/O assembly.....5-12
11. Removing the computer assembly.....5-12
12. Removing the MFC assembly 5-13
13. Removing the vacuum pump assembly.....5-14
14. Removing the chiller assembly 5-15

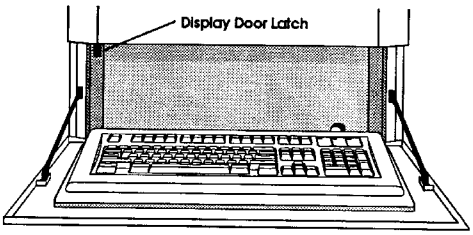
Unless otherwise indicated, the designation of left, right, front and back of the BG-1 chassis are made with respect to someone who is facing the video display and keyboard. Unless otherwise indicated, screw and nut fittings are tightened clockwise and loosened counterclockwise.

Removing the Display Door

Remove the display door to allow video display access or removal.

1. Rotate the key on the keyboard door 1/4 turn clockwise and lower the keyboard to its normal operating position.

2. Locate the 1/4 inch shaft on the upper left, inside corner of the keyboard well. This shaft, which protrudes down from the corner of the well is the display door latch.



3. Press up on the display door latch and open the door.

4. Locate the hinge assemblies at the bottom and top of the door.

5. Use a medium, flat-blade screwdriver to lift up (or pull down) the hinge pin approximately 1/2 inch until the hinge assembly mounted on the door is no longer captured by the hinge pins. *Do not remove the hinge pins entirely from the hinge assembly*.

6. Remove the door from the BG-1 cabinet.

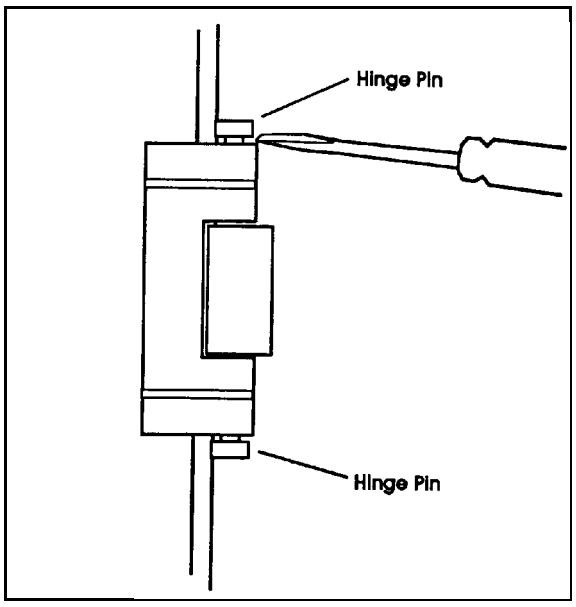


Figure 5-1. Hinge Assembly Detail

Removing the Front Door

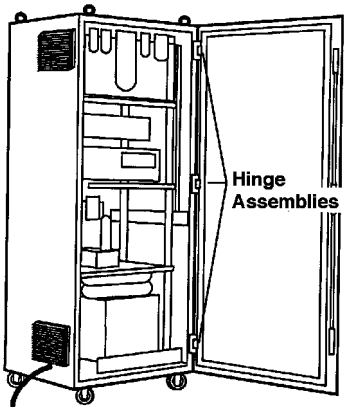
Remove the front door to allow access to or removal of all major assemblies.

1. Locate the front door lock cover. Slide up the lock cover to expose the door lock.
2. Use the cabinet key located inside the keyboard well to open the front door.
3. Locate and disconnect the in-line AC power connector to the front door air intake fan.
4. Locate the hinge assemblies at the bottom and top of the door.
5. Use a medium, flat-blade screwdriver to lift up (or pull down) the hinge pins approximately 1/2 inch until the hinge assembly mounted on the door is no longer captured by the hinge pins. *Do not entirely remove the hinge pins from the hinge assembly.* See Figure 5-1.
6. Remove the front door from the BG-1 cabinet.

Removing the Rear Door

Remove the rear door to allow access to or removal of all major assemblies.

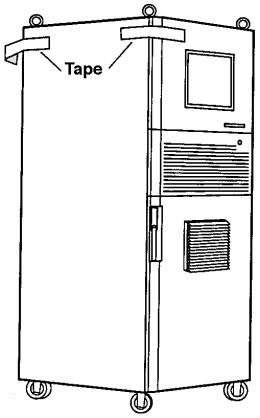
1. Use the cabinet key located inside the keyboard well to open the rear door.
2. Locate the hinge assemblies at the bottom, middle and the top of the door.
3. Use a medium flat-blade screwdriver to lift up (or pull down) the hinge pins approximately 1/2 inch until the hinge assembly mounted on the door is no longer captured by the hinge pins. *Do not entirely remove the hinge pins from the hinge assembly.* See Figure 5-1.



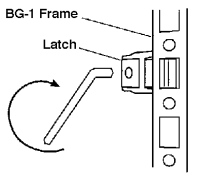
4. Remove the rear door from the BG-1 cabinet.

Removing the Left Side Panel

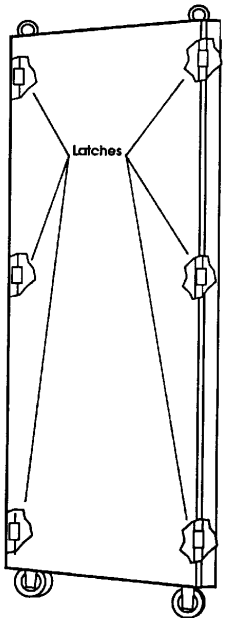
Remove the left side panel to allow access to or removal of all major assemblies. You must remove the display door and the front and rear doors before removing the side panels. *The figure below shows the display door and front door in place for orientation purposes only. You must remove these doors before beginning this procedure.*



1. Cut two strips of tape (masking, electrical, duct, etc.) about 12 inches long.
2. Tape the corners of the side panels to the corners of the top panel. (The tape prevents the side panel from falling off as you remove the panel latches in the next step.)
3. Locate the six latches that hold the left side panel in place. See the latch detail shown below.
4. Use a 5/32 inch Allen wrench to turn the latch adjusting screws clockwise to loosen and remove the latches from the chassis frame.
5. When the six side panel latches are completely removed, remove the tape from the top corners. Grasp the left panel by its sides and lift it up and away from the BG-1 chassis.



Side Panel Latch Detail



Removing the Right Side Panel

Remove the left side panel to allow access to or removal of all major assemblies. You must remove the display door and the front and rear doors before removing the side panels.

1. Cut two strips of tape (masking, electrical or duct) about 12 inches long.

2. Tape the top corners of the side panel to the corners of the top panel. See figure on previous page. (The tape prevents the side panel from falling off as you remove the panel latches in the next step.)

3. Locate the six latches that hold the right side panel in place. (See figure on previous page.)

4. Use a 5/32 inch Allen wrench to turn the latch adjusting screws clockwise to loosen and remove the latches from the chassis frame.

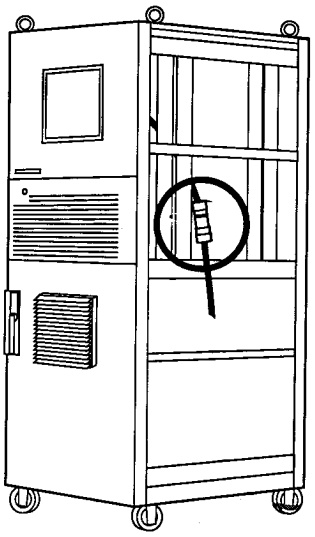
5. When the six side panel latches are completely removed, remove the tape from the top corners. Grasp the right panel by its sides and set the panel alongside the chassis.

6. Locate the AC distribution box mounted above the video display.

7. Locate and disconnect the 30 amp, in-line, AC power connector to the BG-1. See the circled component at right.

8. Feed the AC line cable back through the BG-1 chassis frame. Coil this cable with the external power cable to the BG-1.

9. Lift the right side panel up and away from the chassis and carefully lean it up against a wall to prevent damage to the fan.



Removing the Video Display

We recommend removing the display door, rear door and right side panel before continuing with this procedure. Verify the the 30 amp, in-line AC power connector to the BG-1 is disconnected.

1. Locate and disconnect the display's AC power cord plugged into the rear panel of the computer.

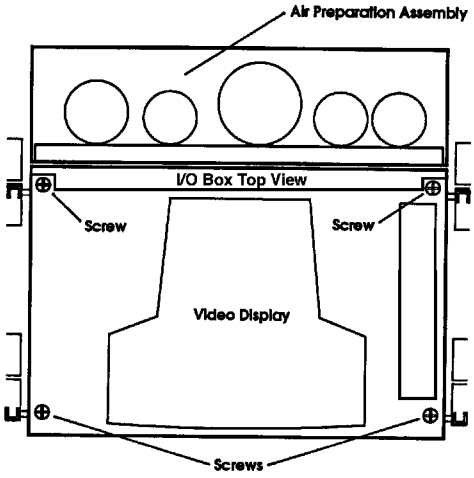
2. Feed the power cord out through the front of the chassis alongside the display.

3. Locate and disconnect the video interface cable from the display adapter at the rear panel of the computer.

4. Feed the video interface cable out through the front of the chassis alongside the display.

5. Use a medium Phillips screwdriver to remove the four screws that lock the display support panel in position on its support posts. (If the screws do not come out when turned, push up on them from beneath the panel.)

6. Hold the display by its sides and slide it and its attached support panel toward the front of the chassis for removal.



Removing the Air Preparation Assembly

We recommend removing the rear door and both side panels before continuing with this procedure. Verify the the 30 amp, in-line AC power connector to the BG-1 is disconnected. In this procedure, you will be facing the rear of the BG-1 chassis. All designation of left and right are made with respect to this position.

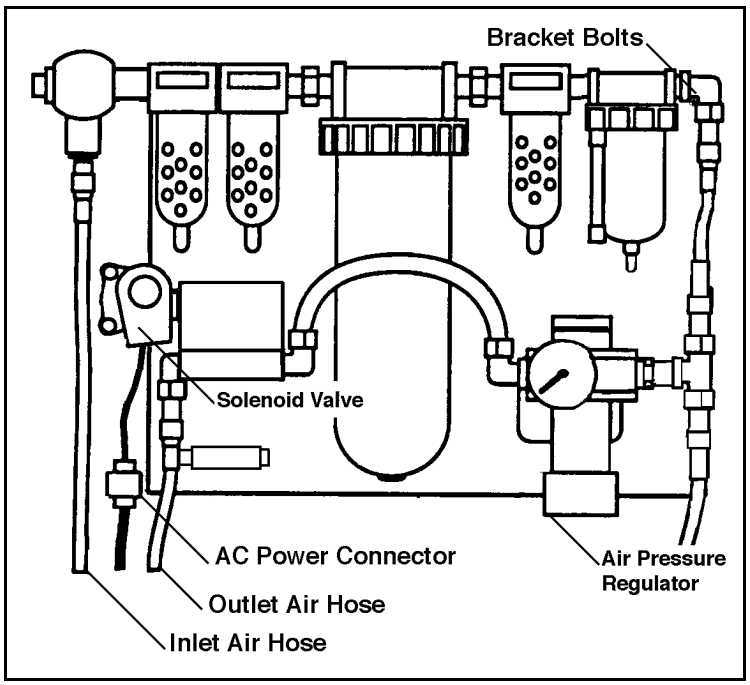


Figure 5-2. Air Preparation Assembly

1. Locate and disconnect the in-line AC power connector to the air preparation assembly solenoid.

2. Disconnect the inlet air hose to the air preparation assembly.

3. Use a 7/8-inch open ended wrench to loosen and disconnect the air preparation assembly outlet air hose from the solenoid.

4. Use a 10 to 12 inch long, 6 mm hex balldriver to remove the mounting bracket bolts from the upper left and right corners of the air preparation assembly support panel. The panel is supported by and rotates on the bottom bracket bolts.

5. Slide the assembly support panel to the right as far as it will go .

6. Rotate the top of the assembly support panel toward you (about one inch).

7. Lift the left side of the assembly support panel up and off the lower left mounting bracket bolt.

8. Rotate the top of the assembly support panel up–back to its original position.

9. Lift the right side of the assembly support panel up and off the right mounting bracket bolt.

10. Grasp the body of the large desiccant chamber and the body of the air pressure regulator and lower the air preparation assembly straight down–dropping the right side slightly as you do so.

Removing the Inlet Air Pressure Gauge and Regulator

We recommend removing the rear door and both side panels before continuing with this procedure. Verify the the 30 amp, in-line AC power connector to the BG-1 is disconnected.

1. Use a 7/8 inch open ended wrench to disconnect the inlet hose to the air pressure/regulator (see Figure 5-2 for locations).

2. Use a 7/8 inch open ended wrench to disconnect the outlet hose from the air pressure gauge/regulator.

3. Use two 7/16 inch open ended wrenches to remove the nuts and bolts fastening the air pressure gauge/regulator bracket to the air preparation assembly panel.

4. Remove the air pressure gauge/regulator from the air preparation assembly panel.

Removing the Air Preparation Assembly Solenoid-Activated Valve

We recommend removing the rear door and both side panels before continuing with this procedure. Verify the the 30 amp, in-line AC power connector to the BG-1 is disconnected.

1. Use a 7/8 inch open ended wrench to disconnect the inlet hose to the valve (see Figure 5-2 for locations).

2. Use a 7/8 inch open ended wrench to disconnect the outlet hose to the valve.

3. Use a 7/16 inch open ended wrench to remove the nuts and star washers that fasten the valve to the air preparation assembly panel.

4. Remove the valve from the air preparation assembly panel.

Removing the I/O Assembly

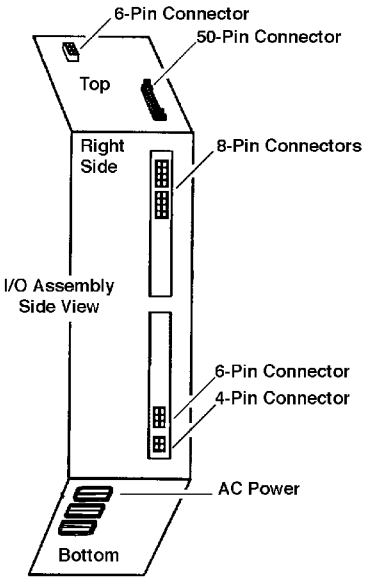
We recommend removing all doors and panels before continuing with this procedure. Verify the the 30 amp, in-line AC power connector to the BG-1 is disconnected.

1. Disconnect the 50-pin connector (that comes from the computer) from the top of the I/O assembly.

2. Disconnect the 6-pin connector (that comes from the MFC assembly) from the top of the I/O assembly.

3. Disconnect the 4-pin, 6-pin and two 8-pin connectors from the right side of the I/O assembly.

4. Use a medium Phillips screwdriver to remove the four screws that lock the I/O assembly support panel in position on its support posts. (If the screws do not come out when turned, push up on them from beneath the panel.)



5. Slide the I/O support panel toward you and lift it up and out of the BG-1 chassis.

Removing the Computer Assembly

We recommend removing all doors and panels before continuing with this procedure. Verify the the 30 amp, in-line AC power connector to the BG-1 is disconnected.

1. Disconnect all the cables from the back of the computer including:
   - AC power (input)
   - AC power (output to video display)
   - keyboard
   - 9-pin D-shell to I/O assembly
   - 15-pin D shell to video display

2. Use a medium Phillips screwdriver to remove the four screws that lock the computer support panel in position on its support posts. (If the screws do not come out when turned, push up on them from beneath the panel.)

3. Slide the computer support panel toward you and lift it up and out of the BG-1 chassis.

Removing the MFC Assembly

We recommend removing all doors and panels before continuing with this procedure. Verify the the 30 amp, in-line AC power connector to the BG-1 is disconnected. Refer to Figures 5-3 and B-_, *Mono-Block Flow Control Sub-Assembly*, while performing the following steps.

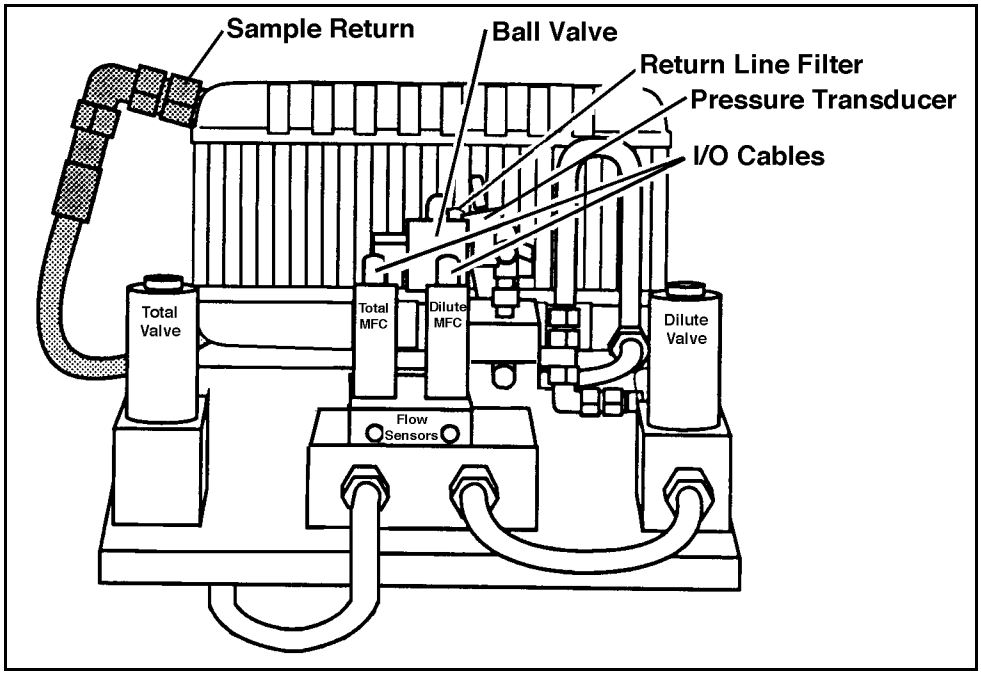
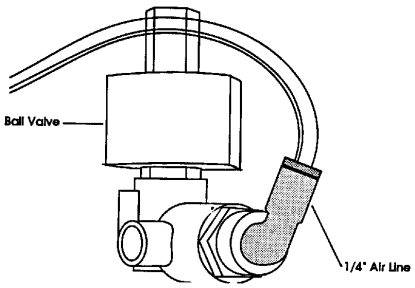


Figure 5-3. Connections to the MFC Assembly

1. Turn off AC power to the BG-1. Disconnect the pressurized air to the chassis.

2. Disconnect the 115 VAC in-line power connector to the air heater controller assembly.

3. Disconnect the in-line power connector to the calibration ball valve.



4. Disconnect the leads to the pressure transducer.

5. Disconnect the two I/O cables from the tops of the MFCs.

6. Use a large adjustable wrench to disconnect the inlet air to the radiator.

7. Use a 7/8 inch open ended wrench to disconnect the chilled air input line to the MFC assembly.

8. Use a 1-1/8 inch open ended or larger adjustable wrench to disconnect both ends of the vacuum line between the MFC assembly and the vacuum pump.

9. Disconnect the air line between the MFC assembly and the air preparation assembly.

10. Disconnect the 1/4 inch plastic air line from the calibration ball valve.

11. Slide the MFC assembly support panel toward the rear of the BG-1 chassis, then lift it up and out of the chassis.

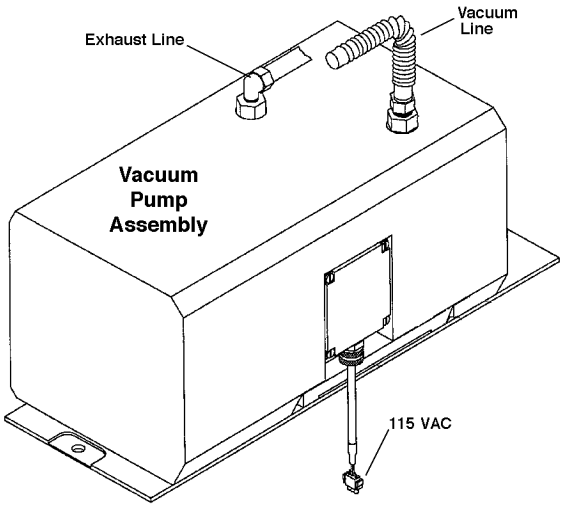
Removing the Vacuum Pump Assembly

We recommend removing all doors and panels before continuing with this procedure.

1. Turn off AC Power to the BG-1. Locate and disconnect the in-line AC power connector to the vacuum pump.

2. Use a 1-1/8 inch open ended or large adjustable wrench to disconnect and remove the vacuum line between the MFC assembly and the vacuum pump.

3. Use a 1-1/8 inch open ended or large adjustable wrench to disconnect and remove the exhaust line from the vacuum pump.



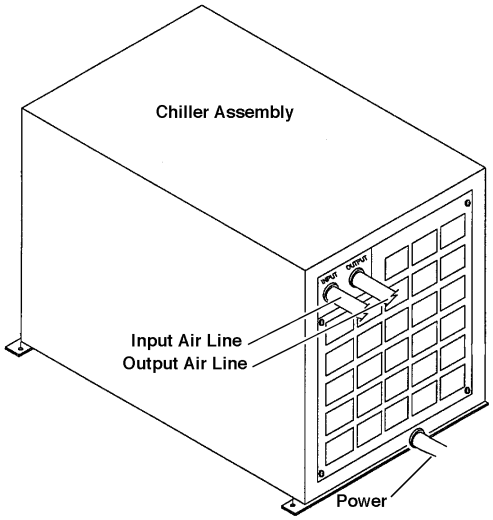
4. Use a 3/4 inch open ended wrench to loosen the two nuts at opposite ends of the vacuum pump support plate. Loosen the nuts several turns until the T-bolts to which they are attached can rotate 90° in the support tracks. (The shoulders of the T-bolts should clear the sides of the support tracks.)

5. Lift the vacuum pump assembly straight up and out of the chassis.

Removing the Chiller Assembly

We recommend removing all doors and panels before continuing with this procedure.

1. Turn off AC Power to the BG-1. Locate and disconnect the in-line AC power connector to the chiller assembly.



2. Use a 11/16 inch open ended wrench to disconnect the output and input air lines from the chiller.

3. Use a 3/4 inch open ended wrench to loosen the two nuts at opposite ends of the chiller support rails. Loosen the two nuts several turns until the T-bolts to which they are attached can rotate 90° in the support tracks. (The shoulders of the T-bolts should clear the sides of the support tracks.)

4. Slide the chiller assembly part way out of the chassis until you can tilt it clear of obstructions.

5. Lift the chiller assembly out of the chassis.

Appendix A Configuration Files

BG-1 configuration files may be changed manually using a text editor such as Windows Notepad. However, to reduce the possibility of errors Sierra recommends that all changes to the configurations be made from within the program.

BGUSER.CFG File

This file contains the user settings that can be adjusted from the Setup screen as described in Chapter 3. For example, to convert the flow rate from slpm to g/min, change the value on line 12 from 0 to 3 since g/min is the 4th units option in the list. To convert the accumulated flow or mass from liters to grams, change the value in line 14 from 3 to 0.

```
;----< CONFIG BGUSER.CFG FILE FOR BG1 REV 3.0>-------------------------------+
;----< SOFTWARE CONFIGURATIONS >-----------------------------------------------+
FALSE                              ;003-B) Dil Ratio Input on(T)/off(F).(TRUE)
TRUE                               ;004-B) Trip Mode True=Time, False=Pressure
TRUE                               ;005-B) Purge=True, Standby=False
TRUE                               ;006-B) Not Used at this time        (TRUE)
0.00                               ;007-I) Not Used at this time        (0.00)
0.00                               ;008-R) Not used at this time        (0.00)
12.00                              ;009-I) Purge time in mins.             (4)
147.96                             ;010-R) Purge Set Point (SLPM)        (190)
;----< DEFAULT SYSTEM UNITS >-------------------------------------------------+
0                                  ;012-I) Flow rate    (SLPM,SCFM,lb/m,g/min)
0                                  ;013-I) Temperature               (C,F,K,R)
3                                  ;014-I) Mass              (gr,kg,lb,liters)
5                                  ;015-I) Press(inH2O,cmH2O,mmHG,inHG,kPa,psig)
0                                  ;014-I) DelP (inH2O,cmH2O,mmHG,inHG,kPa)
1.20                               ;016-R) Gas Density in grams/liter  (1.200)
17.65                              ;017-R) Max Target Delta P             (90)
8.10                               ;020-R) Maximum Sampling Time         (100)
1.00                               ;021-R) Time Mult delays demo = 1      (60
sec                                ;022-S) Time units descriptor         (min)
```

BGSYSTEM.CFG File

This file contains system settings that govern the hardware and software operation of the system. These are preset at the factory and should not be changed without direction from Sierra.

```
;----< BGSYSTEM.CFG FILE FOR BG1 REV 3.0>-----------------------------------+
;----< SOFTWARE REVISION & CUSTOMER INFO. >---------------------------------+
SIERRA INSTRUMENTS CORP.           ;002-S) Customer name
97-2035                            ;003-S) System serial #
;----< HARDWARE CONFIGURATIONS >-------------------------------------------+
1                                  ;005-I) Com Port Number for RS-485      (2)
2                                  ;006-I) Address of Total MFC            (1)
1                                  ;007-I) Address of Dilution MFC         (2)
3                                  ;008-I) Com Port Number for SLAVE       (1)
TRUE                               ;009-B) Check PC-LPM16               (TRUE)
;----< SOFTWARE CONFIGURATIONS >-------------------------------------------+
200.00                             ;011-R) 860 Max flow rate in SLPM. (250.00)
25                                 ;012-I) Comm retries                   (25)
200                                ;013-I) Comm() timeout time in msec.  (200)
;----< SYSTEM FILENAMES & DIRECTORIES >------------------------------------+
SI860.EXE                          ;015-S) 860     (SI860.EXE or RSSIERRA.EXE)
;----< Limits >------------------------------------------------------------+
0.25                          ;017-R) Zero Setting
```

BGOPTION.CFG File

This file contains system settings which can affect sample integrity. Do not modify without direction from the Sierra factory or the system supervisor.

```
;----< BGOPTION.CFG FILE FOR BG1 REV 3.0>-----------------------------------+
;----< SOFTWARE CONFIGURATIONS >-------------------------------------------+
1200.00                              ;003-I) WamUpTime in mins.           (20)
3.00                                 ;004-R) Leaktest Range in PSIG     (3.00)
180                                  ;005-I) Leaktest Duration in mins.    (3)
OPTIONS                              ;006-S) Options Password        (OPTIONS)
Allow Autobalancing                  ;007-S) Zero Options
```

BGFILTER.CFG File

This file contains the user adjustable inlet filter reminder and the current elapsed time for inlet conditioning filter usage.

```
;----< CONFIG BGUSER.CFG FILE FOR BG1 REV 3.0>------------------------------+
;----< SOFTWARE CONFIGURATIONS >-------------------------------------------+
36000.00                           ;003-R) Maxfilter usage              (600)
14346.00                           ;002-R) Filter used time               (0)
```

BGCOEFFS.CFG File

This file contains the calibration coefficients for the pressure and temperature transmitters that are used by the program. If the transmitters are changed, these coefficients may need to be changed. By setting the values for A, B and C to 0, 1, and 0 for any of the sets of coefficients, the on screen display will provide the direct voltage output for the transmitter.

```
;----< BGCOEFFS.CFG FILE FOR BG1 REV 3.0>-----------------------------------+
;----< FILTER PRESS GAUGE COEFFS >-------------------------------------------+
TRUE                              ;003-B) Use on board P if TRUE       (TRUE)
0.00                              ;004-R) A                             (0.00)
83.10                             ;005-R) B                            (83.10)
-183.10                           ;006-R) C                         (-183.10)
;----< INLET PRESSURE GAUGE COEFFS >----------------------------------------+
TRUE                              ;007-B) Use on board P if TRUE       (TRUE)
0.00                              ;008-R) A                             (0.00)
20.00                             ;009-R) B                            (32.00)
0.00                              ;010-R) C                           (-30.40)
;----< FILTER TEMP GAUGE COEFFS >-------------------------------------------+
TRUE                              ;012-B) Use on board T if TRUE       (TRUE)
-0.21                             ;013-R) A                            (-0.21)
26.35                             ;014-R) B                            (26.35)
-26.17                            ;015-R) C                           (-26.17)
;----< DIL AIR TEMP GAUGE COEFFS >------------------------------------------+
TRUE                              ;017-B) Use on board T if TRUE       (TRUE)
-0.21                             ;018-R) A                            (-0.21)
26.35                             ;019-R) B                            (26.35)
-26.17                            ;020-R) C                           (-26.17)
```

BGCAL1.CFG File

This file contains the calibration coefficients for the two Model 860 Mass Flow Controllers used in the BG-1. The first section of the file contains the calibration date information, both the original Sierra calibration date and the last calibration or mirror date for each individual controller. If the current date has exceeded one year past the original calibration date, you will be prompted to perform a thorough calibration of the two controllers. The system will also prompt you to perform a daily mirror of the total controller when the current date is greater than 24 hours past the last mirror.

Each controller is originally factory calibrated and the calibration coefficients for each controller are set to indicate the direct MFC output in the program. When a calibration or mirror is performed these calibration coefficients are changed to reflect the new calibration. To reset the calibration coefficients to once again yield the original MFC outputs, set the coefficients as shown in the example on the next page.

```
;----< BGCAL.CFG FILE FOR BG1 REV 3.0>---------------------------------------+
;----< date format: mm-dd-year (mm: 2 digits for month, dd: 2digits for day
;----<                          year: 4 digits for year)
;----< time format: hr:mn:sc (hr: 2 digits for hour in 24 hr format,
;----<                        mn: 2 digits for minutes, sc: 2 digits for secs)
;----< LAST MFC CALIBRATION INFORMATIONS >-----------------------------------+
TRUE                            ;007-B) System Calibration Auto=True
03-25-1997                      ;008-S) DIL - MFC's last 1 yr calib date
10:27:05                        ;009-S)       MFC's last 1 yr calib time
03-25-1997                      ;010-S)       last 24 hour calib date
10:27:05                        ;011-S)       last 24 hour calib time
03-25-1997                      ;012-S) TOT - MFC's last 1 yr calib date
10:27:05                        ;013-S)       MFC's last 1 yr calib time
02-28-1997                      ;014-S)       last 24 hour calib date
09:37:40                        ;015-S)       last 24 hour calib time
;----< SOFTWARE CONFIGURATIONS >-------------------------------------------+
200.00                          ;017-R) Calib. settle rate in SLPM.(200.00)
1                               ;018-I) Calib. settle time in mins.     (1)
1                               ;019-I) AutoBal wait period in mins.    (1)
2                               ;020-I) # of failures allowed           (2)
;----< DILUTION FLOW METER COEFFS >----------------------------------------+
0.000000E+0                     ;022-R) A  AX^5  OF FIFTH ORDER      (0.00)
0.000000E+0                     ;023-R) B  BX^4  OF FIFTH ORDER      (0.00)
0.000000E+0                     ;024-R) C  CX^3  OF FIFTH ORDER      (0.00)
0.000000E+0                     ;025-R) D  DX^2  OF FIFTH ORDER      (0.00)
1.000000E+0                     ;026-R) E  EX^   OF FIFTH ORDER      (0.00)
0.000000E+0                     ;027-R) F  F     OF FIFTH ORDER      (0.00)
1.000000E+0                     ;028-R) G  SPAN VALUE                (0.00)
0.000000E+0                     ;029-R) H  ZZERO VALUE               (0.00)
1.000000E+0                     ;030-R) TOTALIZER SCALE              (1.00)
;----< TOTAL FLOW METER COEFFS >-------------------------------------------+
2.757027E-10                    ;031-R) A  AX^5  OF FIFTH ORDER      (0.00)
-1.205868E-7                    ;032-R) B  BX^4  OF FIFTH ORDER      (0.00)
1.667683E-5                     ;033-R) C  CX^3  OF FIFTH ORDER      (0.00)
-7.395267E-4                    ;034-R) D  DX^2  OF FIFTH ORDER      (0.00)
1.004081E+0                     ;035-R) E  EX^   OF FIFTH ORDER      (0.00)
5.425207E-2                     ;036-R) F  F     OF FIFTH ORDER      (0.00)
1.000000E+0                     ;037-R) G  SPAN VALUE                (0.00)
0.000000E+0                     ;038-R) H  ZZERO VALUE               (0.00)
1.000000E+0                     ;039-R) TOTALIZER SCALE              (1.00)
```

BGCAL2.CFG File

This file contains the calibration settings used during the calibration and mirroring procedures in the BG-1. Whenever these are changed for a calibration, this file is updated to reflect this change. The example below shows the factory default settings.

```
;----< BGCAL.CFG FILE FOR BG1 REV 3.0>----------------------------------------+
;----< CALIBRATION MODE CONSTANTS >-------------------------------------------+
17.00                               ;003-I) Calib: # of setpoints          (15)
30.00                               ;004-I) Calib: delay seconds           (30)
30.00                               ;005-I) Calib: # of samples            (50)
20.00                              ;006-R) Setpoint # 0 - MAX. %ERROR    (0.0)
40.00                              ;007-R) Setpoint # 1                  (7.5)
60.00                              ;008-R) Setpoint # 2                  (3.4)
80.00                              ;009-R) Setpoint # 3                  (2.3)
90.00                              ;010-R) Setpoint # 4                  (1.7)
100.00                             ;011-R) Setpoint # 5                  (1.3)
110.00                             ;012-R) Setpoint # 6                  (0.9)
120.00                             ;013-R) Setpoint # 7                  (0.6)
130.00                             ;014-R) Setpoint # 8                  (0.3)
140.00                             ;015-R) Setpoint # 9                  (0.3)
150.00                             ;016-R) Setpoint #10                  (0.3)
160.00                             ;017-R) Setpoint #11                  (0.3)
170.00                             ;018-R) Setpoint #12                  (0.3)
180.00                             ;019-R) Setpoint #13                  (0.3)
190.00                             ;020-R) Setpoint #14                  (0.3)
200.00                             ;021-R) Setpoint #15                  (1.0)
Autobalance                       ;022-S) Zero Setting
```

Input Data File

If you select to input sample setpoint data using an input data file, you will be prompted to enter the name of the file containing the sample setpoints. These files are easily created on the BG-1 or another computer using Windows Notepad or other text editing program. The input data file can be prepared to collect any number of predetermined sample points. The example below contains setpoints for five samples.

```
;----< SAMPLE.DAT   FILE FOR BG1 REV 3.0>-----------------------------------+
;----< HEADER   CONFIGURATION  >-------------------------------------------+
5                                ;003-I) NUMBER OF SAMPLES IN SEQUENCE   (4)
FALSE                            ;004-B) DILUTION RATIO T=DR/F=DIL   (FALSE)
TRUE                             ;005-B) TRIP DEL P T=TIME F=PRESS    (TRUE)
TRUE                             ;006-B) STANDBY T=STANDBY            (TRUE)
0                                ;007-I) FLOW UNITS INDEX DEFAULT        (0)
0                                ;008-I) PRESS UNITS INDEX DEFAULT       (0)
;----< SAMPLE NUMBER 1 CONFIGURATION  >-------------------------------------+
180.0                            ;010-R) TOTAL FLOW                  (180.3)
160.0                            ;011-R) DILUTION FLOW OR DR IF 4=T  (152.6)
180                              ;012-R) SAMPLE TIME                   (4.0)
60                               ;013-R) STANDBY TIME                  (1.0)
25                               ;014-R) MAX DELTA P TO TRIP          (20.0)
600                              ;015-R) MAX SAMPLING TIME             (8.0)
;----< SAMPLE NUMBER 2 CONFIGURATION  >-------------------------------------+
180                              ;010-R) TOTAL FLOW                  (180.3)
160                              ;011-R) DILUTION FLOW OR DR IF 4=T  (152.6)
240                              ;012-R) SAMPLE TIME MINS              (4.0)
60                               ;013-R) STANDBY TIME                  (1.0)
25                               ;014-R) MAX DELTA P TO TRIP          (20.0)
600                              ;015-R) MAX SAMPLING TIME             (8.0)
;----< SAMPLE NUMBER 3 CONFIGURATION  >-------------------------------------+
200                              ;010-R) TOTAL FLOW                  (180.3)
180                              ;011-R) DILUTION FLOW OR DR IF 4=T  (152.6)
300                              ;012-R) SAMPLE TIME MINS              (4.0)
60                               ;013-R) STANDBY TIME                  (1.0)
40                               ;014-R) MAX DELTA P TO TRIP          (20.0)
600                              ;015-R) MAX SAMPLING TIME             (8.0)
;----< SAMPLE NUMBER 4 CONFIGURATION  >-------------------------------------+
200                              ;010-R) TOTAL FLOW                  (180.3)
160                              ;011-R) DILUTION FLOW OR DR IF 4=T  (152.6)
180                              ;012-R) SAMPLE TIME MINS              (4.0)
60                               ;013-R) STANDBY TIME                  (1.0)
40                               ;014-R) MAX DELTA P TO TRIP          (20.0)
600                              ;015-R) MAX SAMPLING TIME             (8.0)
;----< SAMPLE NUMBER 5 CONFIGURATION  >-------------------------------------+
180                              ;010-R) TOTAL FLOW                  (180.3)
160                              ;011-R) DILUTION FLOW OR DR IF 4=T  (152.6)
300                              ;012-R) SAMPLE TIME MINS              (4.0)
60                               ;013-R) STANDBY TIME                  (1.0)
40                               ;014-R) MAX DELTA P TO TRIP          (20.0)
600                              ;015-R) MAX SAMPLING TIME             (8.0)
```

Appendix B Drawings

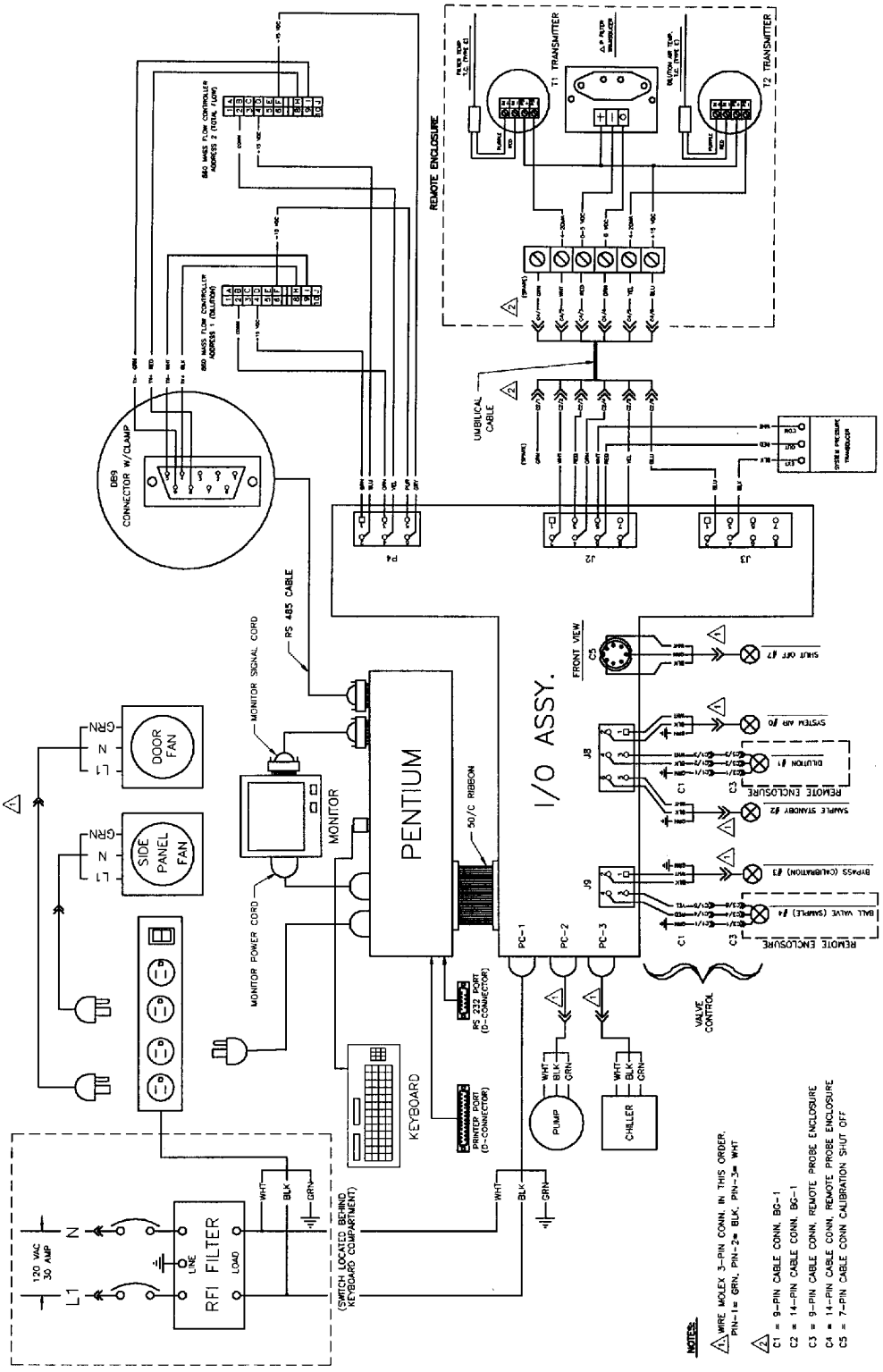
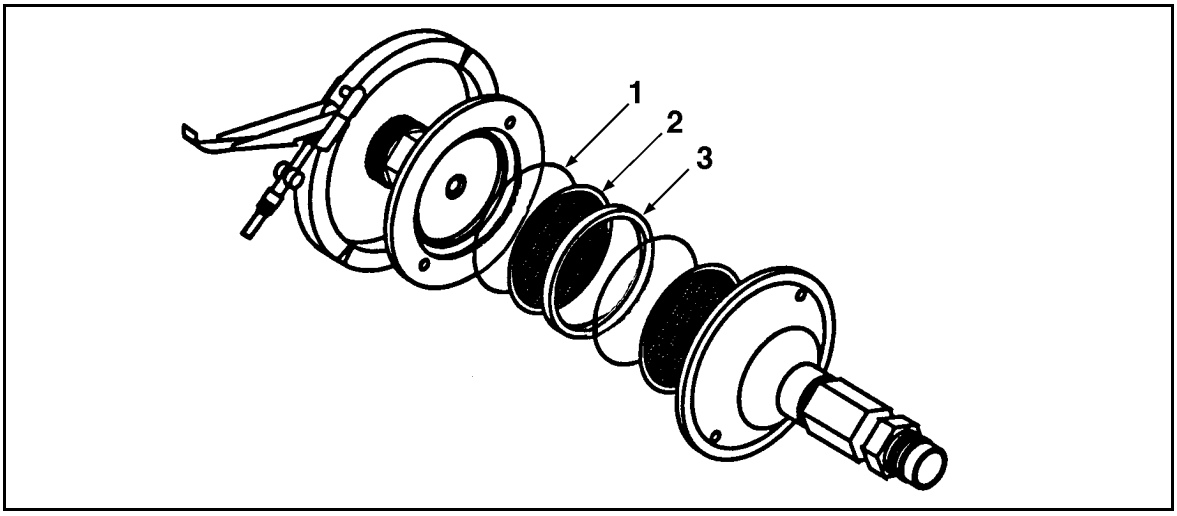
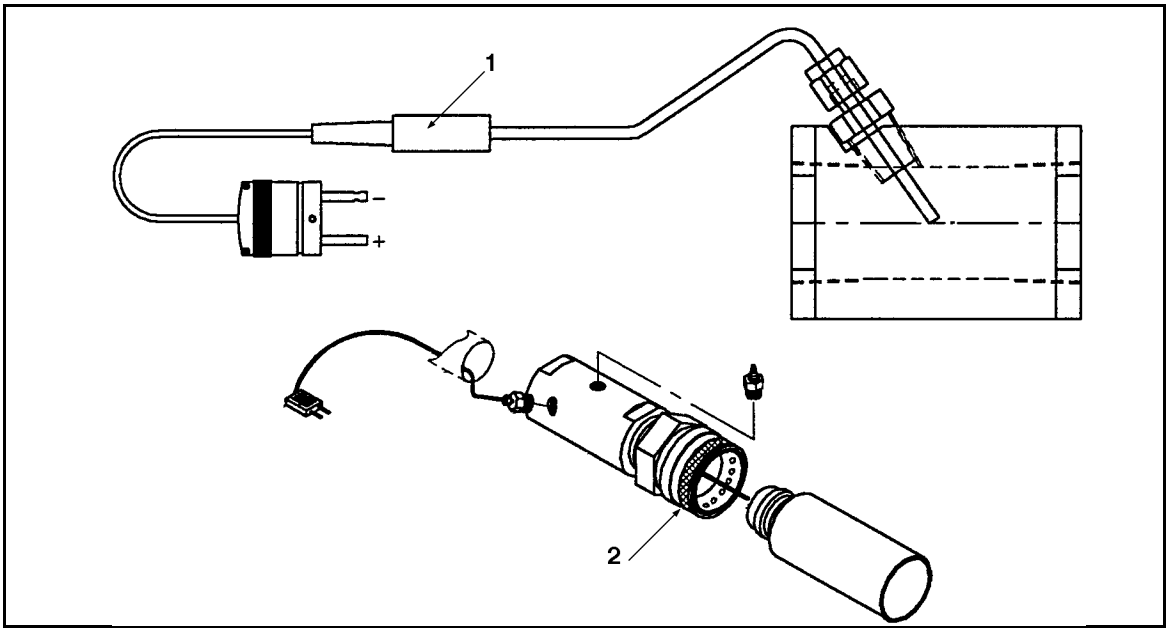


Figure B-1. BG-1 Wiring Diagram



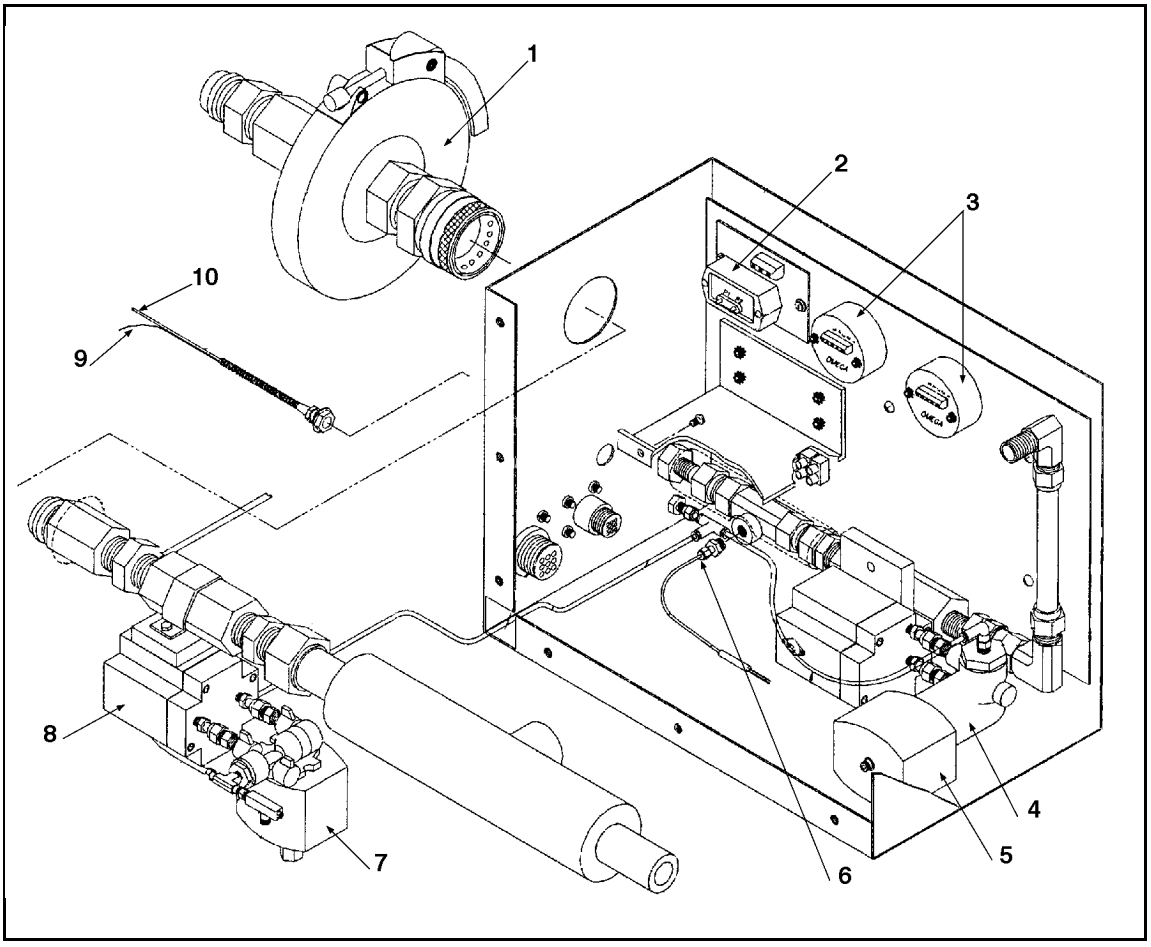
Item No.	Part No.	Description	Quantity
1	31-0047	O-ring, TFE	4
2	39-0244	Screen, 90 mm	2
3	35-0552	Insert, spacer seal	1

Figure B-2. Filter Assembly



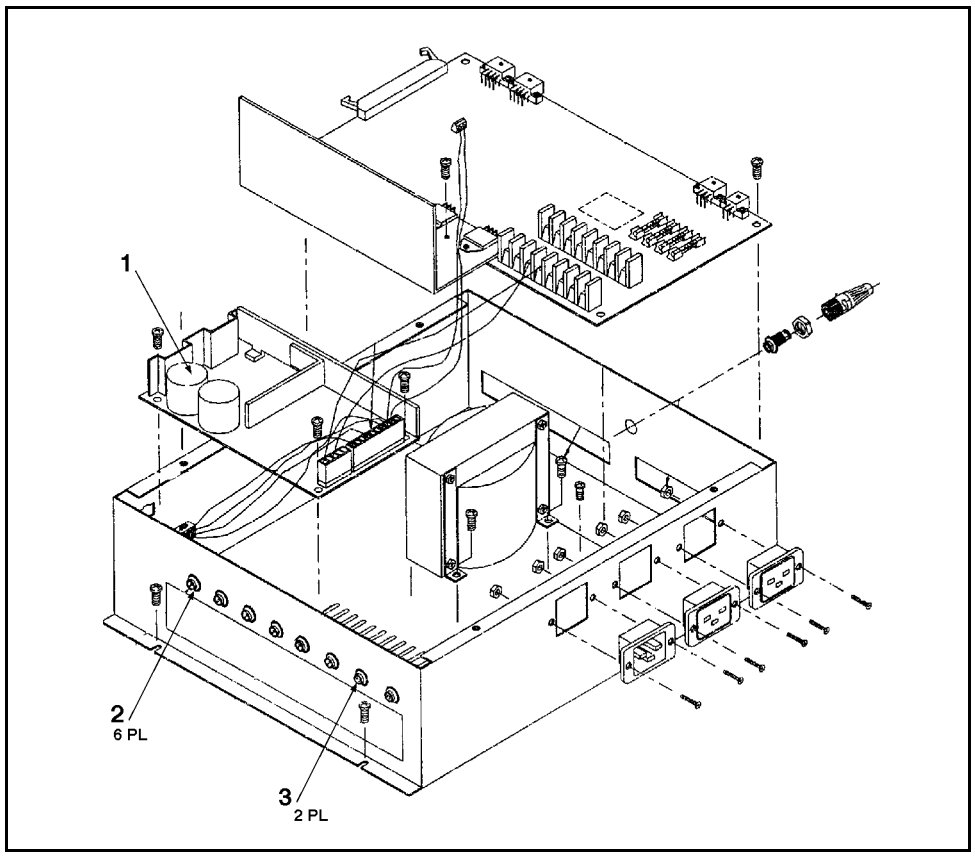
Item No.	Part No.	Description	Quantity
1	43-0143	Thermocouple, Type J, 1/16 x 12.00	1
2	30-0377	Quick connect body, female 1’ body x 1” NPT	1

Figure B-3. Hose Assembly



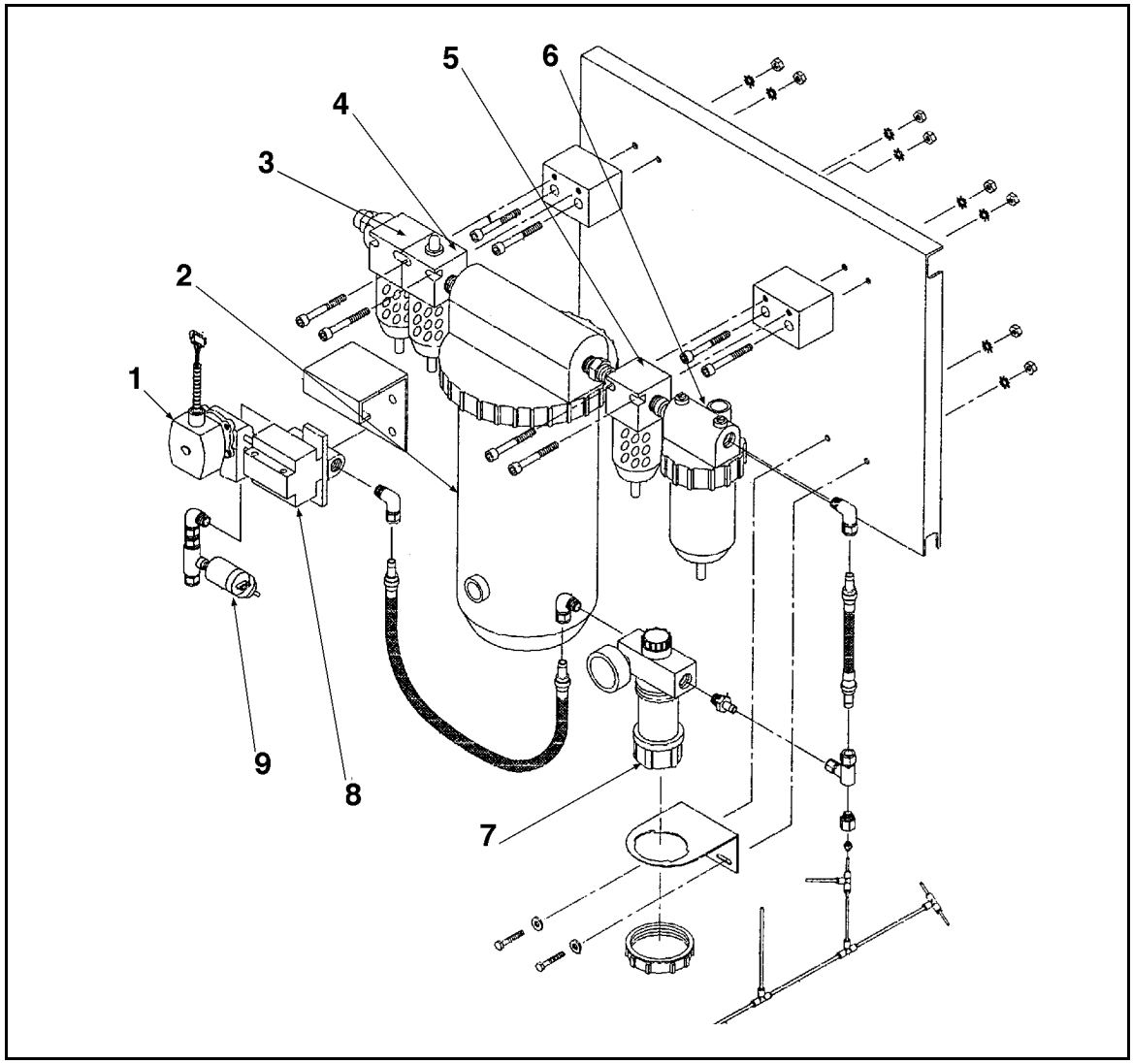
Item No.	Part No.	Description	Quantity
1	93-0025	Filter housing, 90mm assembly	1
2	52-0083	Pressure transducer mounting board assy	1
3	39-0205	Transmitter, Thermoucouple Type J	2
4	30-0421	Valve, ball, F, 1/2 NPT x 1/2 NPT w/sol., 24 VAC	1
5	30-0325	Valve, solenoid, 24 VAC	1
6	43-0133	Thermocouple, Type J, 1/8 x 6.00	1
7	30-0325	Valve, solenoid, 24 VAC	1
8	30-0326	Valve, 1” ball doubleacting actuator with pilot	1
9	23-0096	Wire, thermoucouple type E, 20 ga	1
10	30-0012	Tubing	1

Figure B-4. Probe/Filter Box Assembly



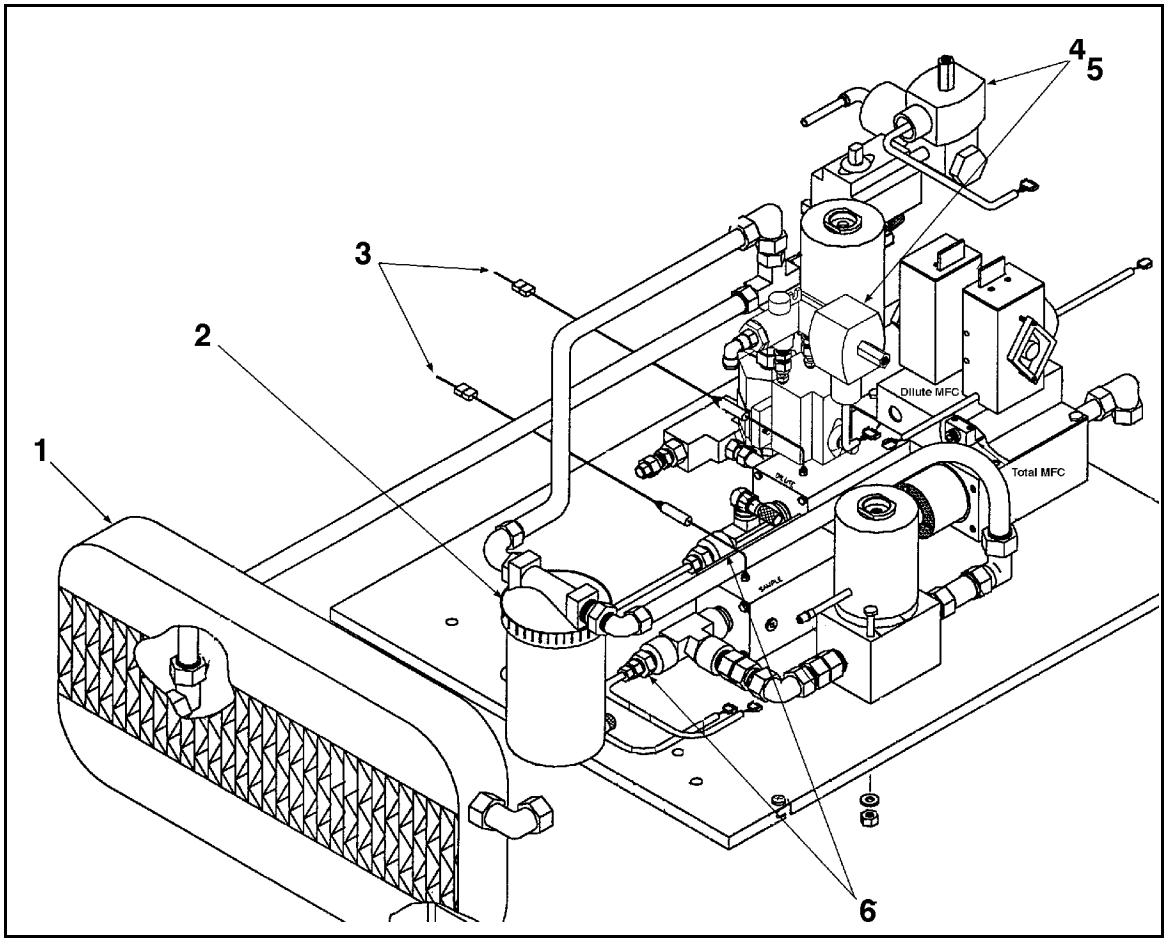
Item No.	Part No.	Description	Quantity
1	21-0044	Power supply, switching 115 input +15 VDC @ 5A	1
2	29-0192	Circuit breaker, 3 A	6
3	29-0193	Circuit breaker, 15 A	2

Figure B-5. I/O Assembly



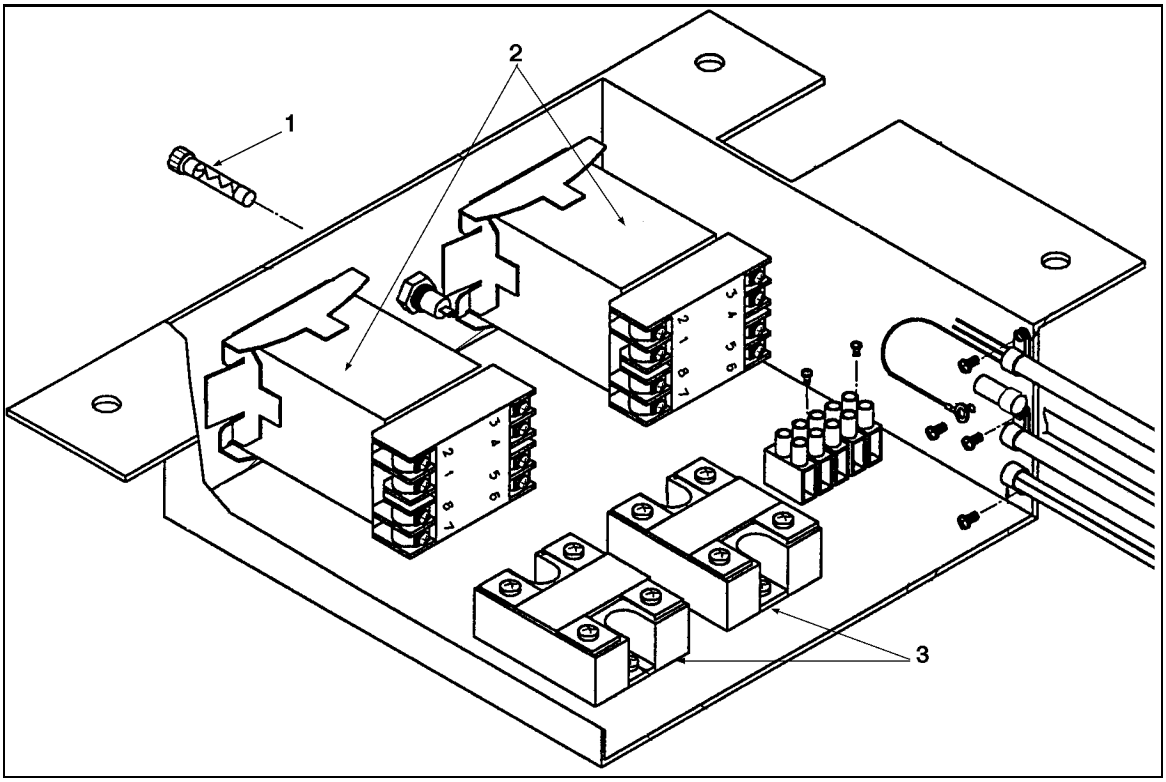
Item No.	Part No.	Description	
1	30-0325	Valve, solenoid, 24 VAC	1
2	39-0219	Particle filter element	1
3	39-0217	Desiccant, 25 lb	1
4	39-0220	Coalescing filter element	1
5	39-0221	Particulate filter element	1
6	39-0222	Absorption filter element	1
7	30-0495	Precision regulator, 1/2 NPT, high flow	1
8	30-0421	Valve, ball, F, 1/2 NPT x 1/2 NPT w sol, 24 VAC	1
9	39-0193	Transducer, pressure, 0-100 psig, 0-5 VDC	1

Figure B-6. Air Preparation Assembly



Item No.	Part No.	Description	Quantity
1	41-0954	Air cooler radiator	1
2	39-0242	Filter particulate	1
3	43-0151	Thermocouple, Type J, 1/16 x 6.00	2
4	30-0326	Valve, 1” ball doubleacting actuator with pilot	2
5	30-0325	Valve, solenoid, 24 VAC	2
6	20-0038	Heater, 1/15 x 24.00, 120 VAC	2

Figure B-7. Flow Control Assembly



Item No.	Part No.	Description	Quantity
1	29-0167	Fuse, 5 A, fast blow	1
2	21-0044	Power supply, switching 115 input+15 VDC @ 5A	2
3	20-0039	Relay, SSR Input 4-20mA	2

Figure B-8. Air Heater Control Sub-Assembly