PQ100
Air Sampler

INSTRUCTION MANUAL
Firmware Version 5.X and lower

PM$_{10}$ REFERENCE SAMPLER

DESIGNATION NO. RFPS-1298-124

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PREFACE

The purpose of this manual is to provide complete operational, calibration and maintenance details for the BGI PQ100 air sampler. This instrument has been specifically designed to meet or exceed the operational requirements of a Reference Method sampling device under 40 CFR Part 50, Appendix J ("Reference Method For The Determination of Particulate Matter as PM-10 in the Atmosphere") and was designated a Federal Reference Method Sampler Number RFPS-1298-124 in December 1998.

SAFETY

The PQ100 should only be operated as described and for its intended use. Because the PQ100 runs primarily from battery power, all of the typical hazards associated with high voltages and internal A.C. wiring have been reduced or eliminated. Personal injury, damage to the instrument, or fire can occur if the following electrical precautions are not observed:

- Caution should always be given when attaching the A.C. mains power connection. Do not attempt to connect main power if the plug or wire are cracked or frayed.
- Do not attempt to connect main power if the power cord, leads, or outlet are wet. Do not immerse power cords in water or other liquids.
- Place power cords away from traffic and do not allow anything to rest on them during operation.
- Do not overload AC outlets.
- Do not attach improperly wired external batteries, solar panels or power sources.
- Do not open the control panel or handle any other of the electrical parts while power is applied to the PQ100. Always disconnect the power supply first.

In addition, personal injury or damage to the instrument could occur if the following precautions are not observed:

- Always operate the PQ100 in a normal, upright position. The legs should be bolted down to prevent tipping in conditions of high winds.
- Do not operate the PQ100 if any of the parts are defective, damaged, or missing.

TABLE OF CONTENTS

1.0   INTRODUCTION

The BGI PQ100 is an "Intelligent Air Pump" that can monitor it's own airflow rate and thereby adjust the pump speed to compensate for changes in load pressure and/or other forces which would otherwise hamper the flow of air through a filter (or sample collector). The PQ100 can be programmed to begin it's sampling job at a specific date and time and stop sampling after the user defined run time is depleted. A 24 character by 2 line Liquid Crystal Display provides the operator with a readout of flow rate, and other useful information.

Events such as the flow being restricted by blocking the inlet, batteries depleted (power failure), pump unable to regulate flow (excess resistance), etc. all force the pump into a shutdown mode which consumes no battery power until the problem causing the shutdown is corrected.

The PQ100 was designed to operate from 1 standard liter per minute (1000 cc per minute) to 25.0 standard liters per minute and is unaffected by changes in ambient temperature and barometric pressure. The flow rate precision is guaranteed 2% of the calibration set point. Standard conditions, for some forms of air sampling, being 20°C, 760 mm of Mercury barometric pressure.

Certain default values in this instrument have been selected to reflect EPA style air sampling procedures. The default "Run Time" is 24 hours. The default "Start Date and Time" is midnight tomorrow.

Principle of Operation

The operating principle of the PQ100 can be appreciated by referring to the block diagram below. Air is drawn by the pump through a size selective inlet device and/or filter. It then passes inside the instrument housing to a Mass Flow Sensor. The signal generated by the sensor is then routed to a microprocessor which determines if the flow is at the set value and adjusts the pump speed to maintain the correct flow rate. Because the flow sensor is extremely sensitive and all pumps produce pulsation to some degree, a pulsation damping volume has been introduced to control this effect. The microprocessor not only controls the flow rate accurately and precisely to the set point but also performs several other functions. These include turning the instrument on at a preselected time and running it for a selected interval. The flow is maintained by the processor to a designated pressure and temperature value. A pulse width modulated signal is configured and sent to the pump motor in a constantly updated manner based on signal information received from the Mass Flow Sensor. The microprocessor also stores all parametric information generated during the run period and configures it for presentation on the visual display and downloading to the software provided with the instrument.

The system is completed by it's 12 volt battery and external battery charger/A.C. power supply. The power supply function permits operation if desired with no battery whatsoever.

SIZE SELECTIVE
INLET OR FILTER

MASS FLOW
SENSOR

PULSATION DAMPING
VOLUME

PUMP

EX

MICRO PROCESSOR

VISUAL DATA DISPLAY

BATTERY

BATTERY CHARGER
A.C. POWER SUPPLY
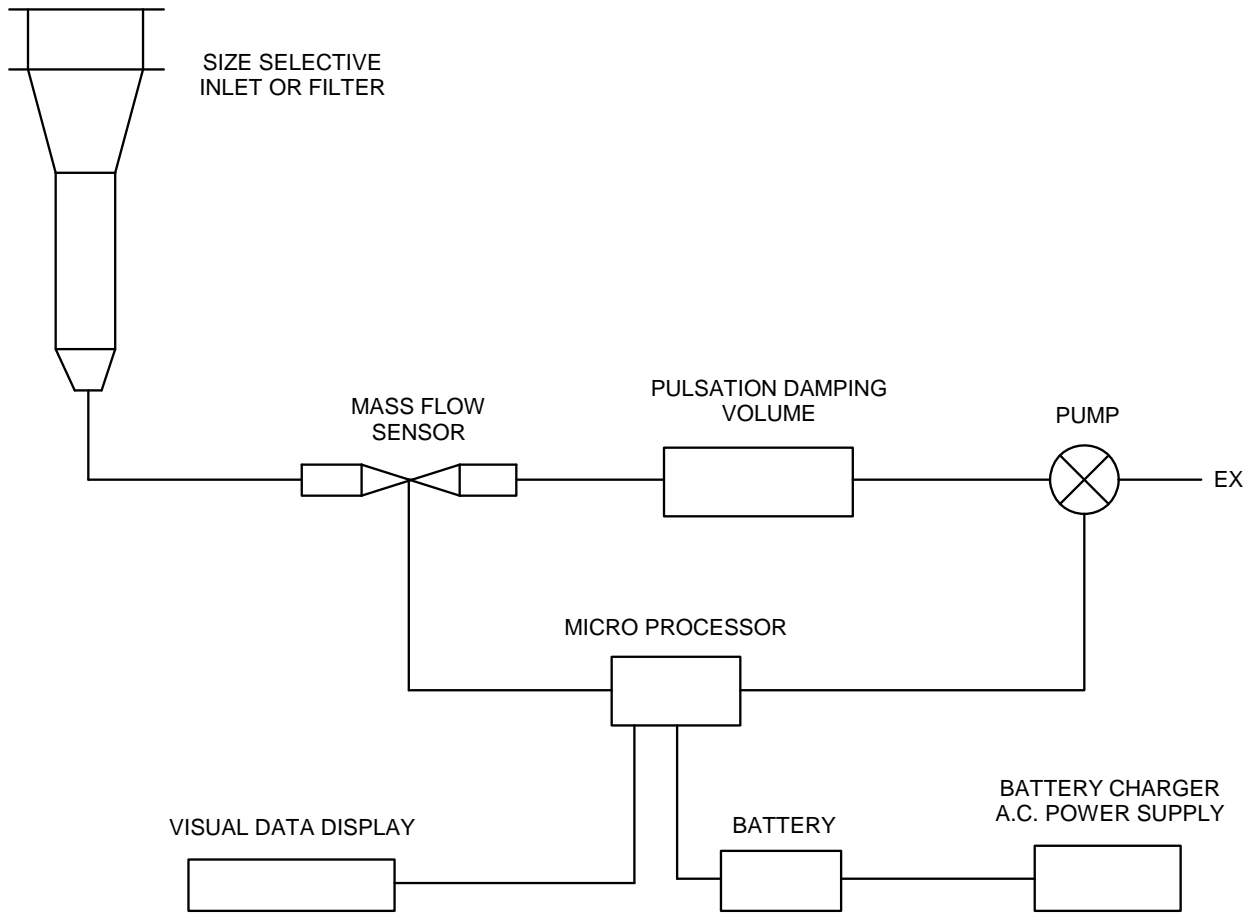
SCHEMATIC DIAGRAM OF PQ 100 SYSTEM

1910

2.0   GETTING STARTED CHECKLIST

2.1   Included with the PQ100

1.   PQ100 Main Unit
2.   PQ101 Battery Charger (120 VAC or 240 VAC)
3.   CQ2 PC Communication Adapter Cable
4.   PC Software Diskettes - 3 ½", 1.44K
5.   PQMAN Manual
6.   PQ102 Hose Adapter

2.2   Optional Accessories Available (See Section 5)

1.   PQ103 Replacement Battery
2.   CQ3 External Battery Adapter Cable
3.   SSI-10 Size Selective Inlet (SSI) Kit
4.   TP100R Dicot Inlet Rigid Tripod Assembly
5.   F20 47mm Filter Holder for BGI16.7
6.   F21 Filter Cassette (for use with F20 above)
7.   TSP CAP Total Suspended Particulate Inlet

2.3   User Supplied Items

1.   A DeltaCal, TetraCal (formally triCal) or Bubble Meter/Calibrator.
      Note: Dry Calibrators and Rotameters are not recommended!
2.   A length of rubber hose (about a half meter).
3.   A Pinch Clamp or Valve (helpful but not required).
4.   Ambient Temperature and Local Barometric Pressure Readings.
5.   A Magnehelic Pressure Gauge (helpful but not required).
6.   Filter Holder (F20) with Filter Cassettes (F21/2) to collect sample (also protects the PQ100 from damage).

Note: Permanent damage can occur if the PQ100 is operated without a filter in series with the Inlet. If the unit is operated without a SSI head with filter and holder, a suitable filter must be used to prevent damage to the pump and sensors.

3.0 HOW TO USE THE PQ100 IMMEDIATELY
3.1 What the Buttons do

"ON/OFF"   Turns the PQ100 On or Off.

"RESET"   Press after a sampling job to clear all the counters in preparation for the next sampling job.

"RUN/STOP"   Use when the PQ100 has been reset and programmed for another run and you now wish to start the pump.

"+"   Increase

"-"   Decrease

"SETUP"   Traveling from screen to screen and entering the information set on the screen.

"ENTER"   Accepts new setting within the screen.

3.2 Running the PQ100 at 16.7 Liters per Minute

1.   Turn the PQ-100 on (Push the "ON/OFF" button). If a message is blinking on the display, press "ENTER" to proceed to the "MAIN IDLE DISPLAY".

2.   Before you change any setups and to delete the last run push the "RESET" button. Screen display should be:

ET0000Min TS00.00M (Date)
Q(Flow)Lpm T(Time) Bty(Capacity)%

(Date) - today's date in military type notation; e.g., 01JAN= January 1st
(Flow) - the current flow rate selected to be regulated.
(Time) - military time; e.g., 13:08= 13 Hours 8 Minutes or 1:08 PM
(Capacity) - remaining charge in the internal battery.

3.   Press "SETUP"
        Screen reads; "Select FLOW RATE"

        To change TARGET FLOW RATE;
                * Press ENTER (Whole number value will remain on constant while the
                tenths still blink); use "+" or "-" to increase or decrease until 16 is
                displayed.
                * Press ENTER (Tenths value will now remain constant while whole
                number blinks); use "+" or "-" to increase or decrease until .7 is displayed.

Note: If the flow rate displayed is followed by Lpm then the selected flow rate is
calibrated and recalibration is not required. If CAL is displayed then calibration should
be performed as described in section 7.0.

4.   Press "SETUP"
        Screen reads; "Set DATE and TIME"

        To change the Date and Time;
        a. DAY: Press ENTER and change by pressing the + or - key.
                       When the day is correct, press ENTER.
        b. MONTH: To change, press + or - key. When correct, press ENTER.
        c. YEAR: To change, press + or - key. When correct, press ENTER.
        d. TIME (hrs): To change, press + or - key. When correct, press ENTER.
        e. TIME (min): To change, press + or - key. When correct, press ENTER.

5.   Press "SETUP"
        Screen reads; "Set START DATE and TIME"

        This determines when you wish to start a sample job. It always defaults to
        midnight the next day. Should you wish to change it;
        a. DAY: Press ENTER and change by pressing the + or - key.
                       When the day is correct, press ENTER.
        b. MONTH: To change, press + or - key. When correct, press ENTER.
        c. YEAR: To change, press + or - key. When correct, press ENTER.
        d. TIME (hrs): To change, press + or - key. When correct, press ENTER.
        e. TIME (min): To change, press + or - key. When correct, press ENTER.
        f. (enable):   This is to turn this function On or Off. If "Off" then a sample job
                       (pump starts running) is initiated as soon as the "RUN/STOP" key
                       is pressed from the "MAIN IDLE DISPLAY". If "On" then the
                       sample job is initiated when the start date and time are achieved.
                       SET THIS FUNCTION TO "OFF" IF YOU WISH TO START
                       SAMPLING NOW. Change by pressing + or - key. When correct,
                       press ENTER. FOR THE PURPOSE OF THIS TUTORIAL, SET
                       TO "OFF".

6.   Press "SETUP"
      Screen reads; "Set RUN TIME"

      This is for when you wish to set the length of time that the pump will run for.
      (Other than for 24 hrs). It always defaults to 24 hrs 0 min. To change;
      a. HOURS: Press ENTER and change by pressing the + or - key. When the
                    hours are correct, press ENTER.
      b. MINUTES: To change, press + or - key. When correct, press ENTER.
      c. (enable): This is to turn this function On or Off. If "On" then the pump will
                    run for the amount of time specified and then power itself off.
                    SET THIS FUNCTION TO "OFF" IF YOU WISH TO RUN
                    UNTIL THE BATTERIES RUN DOWN. Change by pressing +
                    or - key. When correct, press ENTER. FOR THE PURPOSE OF
                    THIS TUTORIAL, SET TO "OFF".

7.   Press "SETUP"
      Screen returns to the "MAIN IDLE DISPLAY"

      DO NOT PRESS THE RESET BUTTON AT THIS TIME AS THE START
      TIME AND RUN TIME WILL DEFAULT.

8.   Press "RUN/STOP"
      If the START TIME ENABLE is set to "OFF" then the pump will begin to run
      immediately and will run until one of the shutdown causes (explained in
      APPENDIX E) force the unit to terminate the sample job. During the initial time
      that the PQ100 requires to stabilize its flow rate, flow will be displayed as
      --.-Lpm. If the START TIME ENABLE is set to "ON" then the message "Alarm
      Triggered Run..." followed by "PQ100 Powering Down.." will appear briefly.
      The PQ100 is now waiting for the internal real time clock to achieve the
      designated start time and will then power itself on and begin the Air Sample Job.

3.3   Downloading (A Quick Start Overview)

1.   Insert the "PQ" software diskette in the "A:" drive of your PC or notebook and
      type INSTALLC at the A:\> prompt. This will create a subdirectory on your hard
      drive called PQ and will copy all files from the floppy disk to this subdirectory.
      After the installation is complete, type PQ at the A:\> prompt to run the program
      (see section 8.0).

2. From the PQ MAIN MENU, select "b" to begin a job and answer the questions provided or simply press enter for each of the entries.

3. From the PQ MAIN MENU, select "I" to import (download) the data from the PQ100.

4. Connect the cable provided from your computer to the UTILITY ADAPTER port on the front of the PQ100. NOTE: THE PQ100 MUST BE AT THE "MAIN IDLE DISPLAY" FOR THE DOWNLOAD TO WORK.

5. When the download is complete you may then select "s" from the "PQ MAIN MENU" to view the file data.

4.0 SPECIFICATIONS

4.1 Flow Rate Precision, Accuracy and Pulsation

Flow Rate Selections: 1.0 to 25.0 Lpm in .1 Lpm increments

Flow Rate Accuracy: .5%
(When calibrated with a DeltaCal or TetraCal (formally tetraCal))

Flow Rate Precision: 2%

Pulsation for various applications as measured downstream from the filter:

Flow Rate	Media Type	Pulsation
16.7 Lpm	47mm Quartz	4.56%
10.0 Lpm	47mm Quartz	3.84%
10.0 Lpm	47mm Teflo	7.38%
7.0 Lpm	47mm Quartz	5.06%
5.0 Lpm	47mm Quartz	6.13%
4.0 Lpm	47mm Quartz	7.94%
2.2 Lpm	37mm MCE w/BGI-4 Cyclone	4.70%

4.2 Run Times for Various Applications

Flow Rate	Media Type	Pressure Drop	Run Time
25.0 Lpm	47mm Teflo	28.0cm H2O	11.6 Hours
25.0 Lpm	47mm Fiberglass	37.0cm H2O	7.4 Hours
16.7 Lpm	47mm Teflo	10.8cm H2O	33.6 Hours
16.7 Lpm	47mm Fiberglass	25.4cm H2O	32.4 Hours
16.7 Lpm	47mm Quartz	33.0cm H2O	28.4 Hours
14.0 Lpm	37mm MCE .8	112.0cm H2O	13.0 Hours
12.0 Lpm	37mm MCE .8	94.0cm H2O	13.5 Hours
12.0 Lpm	25mm MCE .8	170.0cm H2O	11.6 Hours
10.0 Lpm	37mm MCE .8	66.0cm H2O	19.8 Hours
2.2 Lpm	37mm w/BGI-4 Cyclone	5.0cm H20	67.0 Hours

4.3 Dimensions and Weights (PQ100 Main Unit Only)

Dimensions:

Height:	5.3" (13.46cm)
Width:	9.9" (25.15cm)
Depth:	9.7" (24.64cm)
Weight:	19 Lbs. (8.63Kg)

4.4 Electrical Specifications

Main Battery-	12V 12Ah Short Circuit Protected
Clock Battery-	3.6V Lithium Cell
Clock Battery Life-	2 Years
Motor Drive-	High Efficiency Pulse Width Modulator
Flow Rate Measurement-	Mass Flow Sensor
Serial Data Signals:	

Outputs-   9V Nom.
Inputs- 30V Max.

Charging System-   120VAC (60 Hz) or 240VAC (50 Hz)

Note: The PQ100 can run from the Charger.

4.5 Hardware Requirements for PQ Software

IBM XT, AT or 100% Compatible Clone
MS-DOS Operating System version 2.1 or greater
Minimum one 3.5, 5.25, Low or High Density Floppy Drive
COM1 or COM2 RS232 Serial Port for Downloading
        (Not required for Correction Calculator)
Any Video Adapter Configuration
Hard Disk is preferred but not required

For Printouts: All printouts are directed to LPT1 as generic ASCII text with no special printer functions. This means that redirection can be accomplished using the MS-DOS function "MODE" and that any printer will work.

4.6   Dimensions, Weights and Flow Specifications for SSI

SSI-10 Inlet Kit (Including Rigid Tripod Assembly)

Flow Rate:	16.7 Lpm 5%
Weight:	16 Lbs. (7.3Kg)
Tripod Diameter Footprint:	51" (1.29M)
Tripod/Inlet Overall Height:	76" (1.93M)

5.0   ACCESSORIES

5.1   Cables

CQ2
Communication
Adapter Cable

Connects the PQ100 to a computer for downloading

CQ4
External High
Capacity Battery
Cable

Use to connect the PQ100 to a large external battery, typically 80 Amp Hour for greater than 48 hour run time

5.2   Inlets, Adapters and Filter Holders

PQ102
Hose Adapter

For attachment of a rubber hose to the PQ100.

SSI-10
Inlet Kit

PM10 Size Selective Inlet for separation and collection of particles with an aerodynamic equivalent of 10 micrometers or less.

F20
47mm Filter Holder

Connects to Dicot Inlet and holds Filter Media, also used as TSP Inlet when used with TSP CAP.

F21/2
Filter Cassette
(for use with F20 above)

Plastic Cassette containing a screen and filter media

TSP
100 Micrometer Inlet

(for use with F20 above)

5.3   Batteries and Chargers

PQ101 Battery Charger
Auxiliary Power Supply

Used to Recharge system batteries and to power the PQ100 for long run times when AC Power is available.

PQ103
Replacement Battery

5.4   Miscellaneous

TP100R
Rigid Tripod Assembly

Supports Dicot Inlet at EPA recommended height

6.0   OPERATION DETAILS

6.1   Basic Operation

To operate the PQ100 Air Sampler, press the Power "On/Off" pushbutton keyswitch. The unit will beep a few times and display;

<div style="text-align:center">BGI PQ100 Air Sampler</div>

and briefly, the unit serial number and firmware revision;

<div style="text-align:center">SN:1234   Version 5.23</div>

and then;

<div style="text-align:center">Initializing!</div>

During the power-up sequence if it has been determined that the unit had previously shutdown due to one of the shutdown conditions, i.e. "Flow Rate Error", "Low Batteries", "Sample Run Completed" etc. the unit will then flash one of these messages at the display and requires that the user press the "Enter" key to continue on to the MAIN IDLE DISPLAY (See APPENDIX E for a description of all shutdown codes). If the unit was powered down normally, i.e. the power "On/Off" key was previously pressed while at the MAIN IDLE DISPLAY, then it will jump from the above initialization messages directly to the MAIN IDLE DISPLAY and will not display a flashing error message.

6.2   Main Idle Display

ET0000Min TS00.00M 28oct   (or similar)
Q10.0 Lpm T01:00 Bty99%

Where;

ET   is the Elapsed Time of the previous run in minutes.
TS   is the Total Sample of the previous run in cubic meters.
Q   is the selected TARGET flow rate in liters per minute.
Bty   is the percentage of charge stored in the battery.
T   is Time (24:00 hour system)
28oct   is Day Month (year is displayed only on Setup and
                    download).

For power conservation purposes, the PQ100 is equipped with an algorithm which detects inactivity. If the front panel pushbutton switches or the RS232 port are not used within 3 minutes the unit will power itself off.

6.3   What to Do Next

Pressing the "Setup" key steps through the various Menu Selections. Each of the selections are explained in detail, in the order they will be encountered, on the following pages.

6.4   Setting a New Target Flow Rate

From the "MAIN IDLE DISPLAY" press the "Setup" key once until the message below appears;

>   Select FLOW RATE
>   Target Q...   xx.yLpm

where;

>   xx = Liters per minute
>   y = tenths of a Liter per minute

The target flow rate is that which the PQ100 will draw air through the inlet at when a run is initiated.

If the displayed flow rate is acceptable and you do not wish to change it, press the "Setup" key. This action will change nothing and will step the menu to the next selection. If a change is required, press the "Enter" key. You will notice that the whole number value (the value preceding the decimal point) will then remain on while the tenths value continues to flash. The value that remains on is the one that will change when the "+/-" keys are pressed. When the proper value has been reached, pressing the "Enter" key will then select the tenths value (the digit after the decimal point) for editing. After the values have been entered, pressing the "Setup" key will then store the new values in memory and step to the next menu selection.

6.5   Setting the Date and Time

From the "MAIN IDLE DISPLAY" press the "Setup" key twice until the message below appears;

> Set DATE and TIME
> dd mmm yyyy hh:mm

where;

> dd = day of the month
> mmm = month
> yyyy = year
> hh = hour (0-24, 24 hour system) mm = minutes (0-59)

The date and time are read from the real time clock just prior to entering this screen. This action copies the precise date and time data at that instant to temporary memory locations. Once the values have been established in these temporary locations they are then modifiable by the user and will then be flashing on the display.

If all is correct pressing the "Setup" key will change nothing and will step the menu to the next selection. If a change is required, press the "Enter" key. You will notice that the day will then remain on while the rest of the values continue flashing. The value that remains on is the one that will change when the "+/-" keys are pressed. When the proper value has been reached, pressing the "Enter" key will then select the next value for editing. After all the values have been entered, pressing the "Setup" key will then write the new values to the real time clock and step to the next menu selection.

Notes:
1.   Seconds will always default to zero. Therefore, if you wish to synchronize the clock exactly, press the "Setup" key at zero seconds.
2.   Once the Set Time menu selection is entered, the clock is not read again during this screen. Don't expect the date or time to change while this menu selection is engaged. However, the clock is not halted, and is still keeping time. If the "Enter" key is never pressed while this menu selection is being displayed no changes are made to the date or time even though the time does not appear to change.
3.   Century will only change on 12/31/1999 at midnight. Century will then become 2000.

6.6   Setting the Start Date and Time

From the "MAIN IDLE DISPLAY" press the "Setup" key three times until the message below appears;

> Set START DATE and TIME
> dd mmm   hh:mm   eee

Where;

> dd = day of the month
> mmm = month
> hh = hour (0-24, 24 hour system) mm = minutes (0-59)
> eee = enable "On" or "Off"

Note: If "On" is enabled see the next section for further description of run procedure.

This sets the date and time that the sampler will begin running the pump. If all is acceptable pressing the "Setup" key will change nothing and will step the menu to the next selection. If a change is required, press the "Enter" key. You will notice that the day will then remain on while the rest of the values continue flashing. The value that remains on is the one that will change when the "+/-" keys are pressed. When the proper value has been reached, pressing the "Enter" key will then select the next value for editing. After all the values have been entered, pressing the "Setup" key will then write the new values to the real time clock alarm registers and step to the next menu selection. This function can be disabled. This means that if the Enable (eee) is set to "Off", the PQ100 will begin to run the pump immediately when the "Run/Stop" key is pressed from the "MAIN IDLE DISPLAY" regardless of the start time and date.

IF YOU SIMPLY WANT THE PUMP TO START RUNNING WHEN YOU PRESS THE "RUN/STOP" KEY, THE LOWER RIGHT OF THE DISPLAY SHOULD INDICATE OFF.

Note: When the reset key is pressed to clear the counters this setup will automatically default to Midnight (00:00) of the next day. If some other Date and Time are required you must reset the run first before using this menu selection (See Resetting the Counters).

RESET DOES NOT AFFECT THE ENABLE AND WILL REMAIN UNCHANGED!

6.7   Setting the Run Time

From the "MAIN IDLE DISPLAY" press the "Setup" key four times until the message below appears;

> Set RUN TIME
> Hours:hh Min:mm   eee

Where;

> hh = hour (0-99 hours)
> mm = minutes (0-59)
> eee = enable "On" or "Off"

This sets the length of time that the sampler will run the pump for. If the setting is acceptable, pressing the "Setup" key will change nothing and will step the menu to the next selection. If a change is required, press the "Enter" key. You will notice that the hours will then remain on while the other values continue flashing. The NON-FLASHING value will now change when the "+/-" keys are pressed. When the proper value has been achieved, pressing the "Enter" key will then select the next value for editing. After all the values have been entered, pressing the "Setup" key will then store the new values and step to the "MAIN IDLE DISPLAY".

This function can be disabled thereby allowing the pump to run until some other shutdown such as Low Batteries etc. if the Enable (eee) is off.

IF YOU SIMPLY WANT THE PUMP TO RUN UNTIL SOME OTHER CONDITION SUCH AS BATTERIES TOO LOW CAUSES A SHUTDOWN, THE LOWER RIGHT OF THE DISPLAY SHOULD INDICATE OFF.

Note: When the reset key is pressed to clear the counters this setup will automatically default to 24 Hours. If some other Run Time is required you must reset the run first before using this Mode (See Resetting the Counters).

RESET DOES NOT AFFECT THE ENABLE AND WILL REMAIN UNCHANGED!

Note: If START TIME was enabled, after RUN TIME screen, the unit will not step the screen to the "MAIN IDLE DISPLAY". Instead, the next screen that appears will state;

> To initiate a run,
> Press Run/Stop

At this time pressing "Run/Stop" will power the unit off and sampling will commence at the programmed run time. If you simply wish to go to the main idle screen (bypass this function) press "Setup". This will return you to the "MAIN IDLE DISPLAY". At this point you can also press "Run/Stop" to initiate the run.

6.8   Running the Pump

6.8.1   Start Time Disabled

To initiate a run, from the "MAIN IDLE DISPLAY", press the "Run/Stop" key. If the START ALARM is disabled (See setting the Start Time and Date) the pump will immediately begin running and the "Q" in the display window will start to flash. This indicates normal operation and the pump will run at the specified Flow Rate until a stop condition is encountered (i.e. Batteries depleted, excess Flow Restriction etc.). If "CAL" is displayed after the Flow Rate in the lower left corner of the display, this target is not calibrated and therefore the Flow Rate indicated is a coarse approximation and is somewhere 10% of that displayed. Use the Calibration Mode to set this to 2%.

During the initial time that the PQ100 requires to stabilize its flow rate, flow will be displayed as --.-Lpm.

6.8.2   Start Time Enabled

To initiate a run, from the "MAIN IDLE DISPLAY", press the "Run/Stop" key. If the Alarm values are correctly set and Enabled, the PQ100 will power itself off (or GO TO SLEEP) until the start date and time have been reached. When the Alarm triggers the PQ100 to "Wake-Up", after the Initialization and diagnostics, the pump will begin to run until a shutdown condition occurs.

6.8.3   Run Time

If the RUN TIME is Enabled ("On"), the pump will run until this shutdown condition occurs. Successful completion is indicated by the following message flashing on the screen when the unit is powered on;

> SAMPLE RUN COMPLETED!
> Key "Enter" to Continue!

6.8.4   Acoustic Phenomena at High Negative Pressure

When running the PQ100 at very high load pressures (i.e. 150 centimeters of water or better), a metal popping sound may be heard by the user. This is merely the internal pulsation dampner (Plenum) adjusting its chamber area. The PQ100 will alert you as to the nature of any problems via the shutdown messages as described in APPENDIX E.

6.9   Verifying the Flow Rate

To verify the Flow Rate while the Pump is running, a DeltaCal or TetraCal (formally triCal) is highly recommended for Calibration and Verification of the true Actual Flow Rate. Use section 8.7; Appendix A, Equation 2; or the "CORRECT" utility provided on floppy diskette to calculate the corrected flow rate as shown on the Calibration/Verification Standard.

If the flow rate is not within 2% of the "Corrected Flow Rate" a leak in the system is the probable cause and should be inspected.

More information on the DeltaCal or TetraCal (formally triCal) may be found at www.bgiusa.com/cal/index.htm

6.10   Resetting the Run

When a Run has been completed, and all the information from it either recorded or downloaded via the Communications Software, the "Reset" key can be pressed to clear all of the "Run-Time Variables". This action causes the "Elapsed Time" (ET) and the "Total Sample" (TS) to Clear (all zero's) and also causes the Start Time Alarm Clock to default to the next occurrence of Midnight (00:00) and the Run Time to 24 Hours. The Reset Function does not affect the Enables for the Start Time or Run Time. Also, all "Flow Calibrations" remain in memory.

NOTE: IF YOU SIMPLY WISH TO START A NEW RUN WITH NO CHANGES (DEFAULT START TIME, RUN TIME, AND CALIBRATION VALUES ARE ALL ACCEPTABLE) THEN THE ONLY ACTIONS NECESSARY AFTER RECORDING OR DOWNLOADING THE PREVIOUS RUN DATA IS TO PRESS THE "RESET" KEY (CLEARS ALL COUNTERS AND DEFAULTS THE RUN TIME AND START TIME) AND PRESS "RUN/STOP" FROM THE "MAIN IDLE DISPLAY". THIS WILL CAUSE THE PQ100 TO BEGIN A SAMPLING JOB IDENTICAL TO THE PREVIOUS JOB.

7.0   CALIBRATION

7.1   Entering and Using Calibration Mode

From the "MAIN IDLE DISPLAY" press the "Setup" key once until the message below appears;

>   Select FLOW RATE
>   Target Q...   xx.yLpm

(See Section 6.4 to select a new target Flow Rate.)

From the "Select FLOW RATE" message screen you must press both the "Reset" key and the "Run/Stop" key simultaneously to enter the calibration mode and the message below will appear;

>   CALIBRATE Target=qq.qLpm

where;
>   qq.q = Target Flow Rate to be Calibrated

CAUTION: BE CAREFUL WHEN USING CALIBRATION MODE. IT IS NOT USED TO CHECK CALIBRATION FLOW RATE. INCORRECT USE CAN ERASE A PREVIOUSLY STORED CALIBRATION. IF YOU SIMPLY WISH TO CHECK THE FLOW RATE ACCURACY FOR THE SELECTED TARGET, GO TO THE MAIN IDLE DISPLAY AND PRESS "RUN/STOP". BE CERTAIN THAT THE START DATE ENABLE IS SET TO "OFF" (SECTION 6.9).

This mode is used to Calibrate the PQ100 at a target flow rate. It should be noted here that each individual target has it's own independent calibration storage area and is non-volatile. That means that each and every flow rate from 1.0 LPM to 25.0 LPM can have its own discrete tolerances without approximation and will remain programmed in the instrument even in the event of total battery discharge. Pump speed values are also stored with the calibration data.

Assuming that a typical filter for a target was in place at the time of the calibration, the filter load is compensated for causing the pump to initialize to the proper speed. Once a target has been calibrated it should never have to be re-calibrated unless extreme conditions are expected.

To use this mode, Press the "Run/Stop" key to turn on the pump (pump will start to draw at somewhere in the range of the target flowrate depending on the resistance presented by the filter and calibrating device) and the following message will appear;

Reference Q.. rr.r

Where;

rr.r   is an approximate flow rate used only as a visual aid in finding the corrected flow on the calibration device. This value may indicate 5 to 15% error. Don't be concerned! This is for reference only!

Use the "+/-" keys to move the pump speed up or down until the calibration device indicates the "Corrected Flow Rate" value as determined by the Calibration Equations given on the following pages.

HOLDING DOWN THE "RESET" KEY WHILE PRESSING THE "+" OR "-" KEY WILL ALLOW FOR COARSE ADJUSTMENT OF THE PUMP SPEED. WHEN THE PUMP SPEED WILL SEEM TO GO NO HIGHER OR LOWER, THE UPPER AND LOWER LIMITS HAVE BEEN REACHED.

When a good stable reading has been achieved, pressing the "Enter" key will store both the "Actual Sensed Flow Rate" and the pump speed data into the table of non- volatile calibrations where they will remain as "Constants" until a change is required (Only under "Extreme Ambient Conditions" as it should be impervious to moderate changes) and will then exit the Setup menu and return to the "MAIN IDLE DISPLAY".

CALIBRATIONS ARE NOT AFFECTED UNTIL THE ENTER KEY IS PRESSED AND THE PUMP IS RUNNING.

7.2   Using a DeltaCal or TetraCal (formally triCal)

The use of a DeltaCal or TetraCal (formally triCal) is highly recommended for calibration of the PQ100. Connect either unit to the PQ100 just before the filter holder and read the actual flow on the display. More information on the DeltaCal or TetraCal (formally triCal) may be found at www.bgiusa.com/cal/index.htm

7.3 Using a Rotameter

Calibrating the PQ100 Air Sampler with a Rotameter is to be avoided for two reasons. The PQ100 is more accurate (.5% of the expected flow rate) than the typical rotameter (within 3% of Full Scale). Secondly, the rotameter, unlike the bubble meter, has a reference condition calibration and requires a correction for ambient conditions.

The procedure for using a rotameter is best illustrated by example.

Example 4:
Referring to the conditions cited in example 1 (Appendix A), the required set point is 9.74 Lpm. If a rotameter is used, they are typically calibrated at 760 millimeters of Mercury and 70 degrees Fahrenheit (21.11 degrees Celsius or 294.29 degrees Kelvin). The room conditions in Example 1 were 19 degrees Celsius and 765 millimeters of Mercury. The equation for the rotameter correction is;

$$QI = QT \left(\frac{PT}{PI} \times \frac{TI}{TT} \right)^{\frac{1}{2}} \quad \text{Equation \#4}$$

$$QI = 9.74 \left(\frac{760}{765} \times \frac{292.18}{294.93} \right)^{\frac{1}{2}} = 9.66 \text{ Lpm}$$

where;

QT is the Rotameter Calibration Condition flow rate in Liters per minute (Lpm)

QI is the calibrator reading (Lpm) at a given Time, Temperature and Barometric Pressure

PT is the Rotameter Calibration Condition Barometric Pressure (760) in millimeters of mercury (mm of Hg)

PI is the Indicated Barometric Pressure reading (mm of Hg.) at the time of the calibrator flow reading

TT is the Rotameter Calibration Condition Temperature (21.11) in degrees Celsius.

TI is the Indicated Temperature reading (degrees Celsius) at the time of the calibrator flow reading.

However, a 3% accurate rotameter, suitable for reading 10 Lpm, usually reads 2 to 20 Lpm. That means 9.66 Lpm could actually vary from 9.06 to 10.26 Lpm! Therefore, if a rotameter must be used with the PQ100, the corrections are pointless and a straight 10 Lpm read from the rotameter should be utilized. The accuracy of the PQ100 is now degraded to 5%.

7.4   Calibration Notes

1. After a Calibration has been entered, it should be "Run" 15 minutes or so for verification. If the measured flow appears to be offset, determine the amount of offset and jot this number down. Next, Re-enter the Calibration mode and this time, set the calibration high or low depending on the observed offset.

2. If the "Run/Stop" key is pressed to stop the pump for any reason during calibration, the Target location becomes Un-Calibrated. If the "Setup" key is then pressed to exit, the location remains Un-Calibrated.

    THE ONLY WAY TO "ACCEPT" THE VALUE IS TO PRESS THE "ENTER" KEY WHILE THE PUMP IS RUNNING.

3. EACH TARGET FLOW RATE THAT IS TO BE USED SHOULD BE CALIBRATED WITH A FILTER WHOSE PRESSURE DROP IS SIMILAR TO THE TYPE ACTUALLY INTENDED FOR USE.

Failure to follow this procedure will result in an extended time period for the Flow Control System to Equilibrate (1-3 min.)

8.0   INSTALLATION AND USE OF THE PC SOFTWARE

8.1   Supported Hardware

Any IBM PC or compatible running MS-DOS 2.1 or higher with 1 floppy drive and at least 512K of memory. Any video adapter, Color or Monochrome, may be used. A hard drive is useful but not required. One serial communication port must also be available if you intend to use the communication software but is not required for the correction calculator program. For printouts, any printer attached to or redirected from LPT1 will work. All data sent to print are ASCII characters with no special printer functions called out.

8.2   Installation on a Hard Disk System

To install the software onto your C drive (typical installation), insert the supplied floppy disk into drive A of your PC, select drive A and run the "INSTALLC.bat" batch program. The installation utility will then create a subdirectory called "PQ" on the C drive and copy all files to it. Those wishing to install to another Drive such as D, E or F can use the "INSTALL.bat" batch program and specify the drive you want to install on as an argument, e.g., "INSTALL D:".

8.3   Advanced Installation

For those users who wish to install to other directories from any other floppy drive, the only file supplied on the disk of real importance is "PQ.EXE". You may create any directory you wish and copy this file to it. All files managed by PQ.EXE are, by default, placed in the directory where PQ.EXE resides unless full path names are specified.

8.4   Floppy Based Systems (No Hard Drive)

The Executable program supplied "PQ.EXE" can be run directly from either floppy drive by simply invoking the program from the drive prompt.

A:\>PQ

8.5   Program Overview

PQ.exe is a menu driven program that utilizes the serial communication port of the PC to download sample data from the PQ Series of Air Sampling Systems and to provide Data logging, Concentration Equations, export to Database, and Chain of Custody applications. PQ allows the user to communicate with the PQ100 Air Sampler and

downloads Run Data from the PQ100 to your PC. The data may then at a later time be appended with the measured final filter weight, printed and stored for later use.

The Correction Calculator is also available from the PQ Main Menu and allows the user to determine corrections for calibration and verification of flow rate.

8.6   Running the Program

From the MS-DOS prompt (typically "C:\PQ>") type;

> PQ [ENTER]

if COM1 is to be used or,

> PQ -2 [ENTER]

if COM2.

where;
> [ENTER] is the enter key on the PC Keyboard

The "PQ" Main Menu will then be displayed.

Note: "Ctrl-C" refers to the simultaneous depression of two keys at once on the computer console. To produce a "Ctrl-C", press and hold down the "Ctrl" key on the keyboard. While this key is held down press the "C" key. This action will most always halt the program and return you to the MS-DOS prompt.

8.7   Correct Utility

CORRECT is a utility that will perform the calculations outlined in the CALIBRATION EQUATIONS. From the PQ Main Menu press "c". The resulting screen will present a message that describes this utilities function. You must have the present local barometric pressure reading and the ambient temperature reading of the calibration area. To correct to Engineering Standards answer "y" to the first two questions presented by the utility (See Appendix A for other than Engineering Standard Conditions). Then enter the "Target Flow Rate" in liters per minute. The target flow rate is that which the PQ100 is set to operate at. Then enter your barometric pressure and temperature readings. The results from the correction equations will then be displayed. The Corrected Flow Rate value is that which must be observed on the calibration standard (Bubble Meter) for the given target flow rate. A Printout can then be obtained for reference.

8.8   Beginning a Sample Job

To initiate a run and manage the data generated by the PQ100, a file must be opened at the beginning of a job to store site and other background data along with "Initial Filter Weight". Initial weight is used when the job is complete to determine delta weight (final weight, minus initial weight) and when combined with sample time is used to compute concentration.

From the PQ Main Menu press "b" to Begin a Job File for a Run. The resulting screen requires that you adopt a Job File naming convention.

a. Default method   By pressing enter at the prompt, a unique name will be given to the file based on today's date and run number.
b. Custom method   Type in anything you wish.

Once a file name has been entered, a number of other fields are presented such as Site Name, Station Code, Job Code, Operator, Filter Number, and Initial Filter Weight. You may press enter for each field which will leave it blank. The job file editor provides the means to enter the data later if you wish, however, it is recommended that the fields be filled when beginning the job to avoid confusion and to maintain chain of custody.

8.9   Downloading

When a sample job has been completed, the data pertaining to the run is stored in the PQ100 until it is reset by the user. Prior to resetting the PQ100 for its next run, the data should be downloaded using the PQ software to provide information such as run time, total sample accumulated, cause of the shutdown etc. All of this data is important in determining the particulate concentration and conditions during the prior run.

From the PQ Main Menu press "I" to import data from the PQ100. The resulting screen will prompt you for a file to append the download to. This should be the file that was begun in the previous step to insure file integrity. If you do not remember the name of the file, go back to the MAIN MENU and select "d" to view a directory of current files. If you try to select a file that was already appended with a download, the system will let you know. When the proper file has been selected you are ready to download.

THE CQ2 COMMUNICATION CABLE SHOULD NOW BE ATTACHED TO THE PQ100 AND TO THE PC "COM1" or "COM2" PORT. THE PQ100 MUST BE POWERED ON AND AT THE MAIN IDLE DISPLAY FOR THE DOWNLOAD TO WORK!

8.10   Adding the Final Filter Weight

Upon completion of the sample job, the final filter weight must be determined and this final weight entered in order to compute concentration. From the PQ Main Menu press "a" to Add the final filter weight. Again you are asked for the appropriate file name and again you must be careful to select the proper file. When the file is selected the resulting screen will show the initial weight, final weight, delta weight (difference) and standard concentration. All except for initial weight should display zero. When a final weight is entered, concentration is dynamically computed and displayed. This is to allow for re-entry of the final weight in case concentration computes unbelievable results indicating an error during entry. When the results are as expected press "n" for no new filter weight and the program will exit normally.

8.11   Data Displays

Showing the data on the screen is accomplished by pressing "s" at the MAIN MENU. You can alternately obtain a printout if a printer is attached to your computer. Simply press 'Y' when prompted with "Would you like a printout (y) or (n)?". If a printer is not attached pressing 'Y' will result in the DOS message;

"Write fault error writing device PRN" "Abort, Retry, Ignore, Fail?"

You must then press 'a' to abort and you will be sent back to the DOS prompt.

8.12   Managing Data Files

Job files can be easily erased when no longer required using the "e"rase function or can be "r"enamed to allow reuse of a particular Job File name while retaining the old data if required. All Job files from the PQ software have the extension ".run" and can be copied to floppy disk using standard MS-DOS functions for archive purposes.

8.13   Spreadsheet Support

Job Files can be exported to a coma delimited file called database.txt. This format is readable by most database programs allowing reports and graphs to be generated for presentation. This function is provided as a tool for users of database programs that are experienced enough with their database program to import from this type of file format.

From the PQ Main Menu press "x" to export the run data to a file. You will be prompted to enter a file name. After entering the file name you will be asked if this is a new database you are generating or appending an old one. If this is a new report that you are

generating based on a particular site etc. select "n"ew. If you want to add records to build a database, press "a"ppend.

This is used to combine a number of run files into a multi record database with each job file as a record. For a more detailed description of the use of this type of file refer to the users manual of your database program. If you do not already have a database program, Borland Paradox is recommended as it is the most user friendly and simplest to use.

9.0   A.C. POWER SUPPLY/CHARGER

The PQ100 should be Recharged before use to allow for the greatest available Run Time. Connect the Charger to the PQ100 Utility Adapter socket located on the front panel. Plug the Charger into an appropriate power source. BE SURE TO CHECK CHARGER SPECIFICATIONS FOR CORRECT POWER SOURCE INPUT.

Charging is activated only when AC power is actually applied to the charger. This allows the system to be used in a long run time application where the battery is to be used for power loss protection. While the Charger is engaged the PQ100 will display [DCin] in the lower right corner of the display.

When the battery has reached full charge (16 hours typically), the PQ100 will then display "Charged" in the lower right display.

THE PQ100 SHOULD ALWAYS BE CONNECTED TO THE CHARGER WHEN NOT IN USE! THIS WILL PROVIDE MAXIMUM RUN TIME WHENEVER NEEDED AND WILL NOT HARM THE INTERNAL BATTERY.

10.0   MAINTENANCE AND SERVICE

10.1   Replacement Component List

The following is a list of components for replacement and/or servicing the PQ100 and may be ordered from the factory (Refer to drawing figures 1 thru 7 for identification by Item#);

Item#	Fig.	PN	Description
1	5	SSI-10	Dicot Inlet
3	5	CT16.7	Coupler Tube - Old Model
4	5,4,8	A1752	Filter Holder Top
5	4,8	BUNA135	O-Rings
6	4,8	A1727-L27	Cassette Top - New Model
7	4,8	F1/U	Screen
8	4,8	A1729-L29	Cassette Bottom - New Model
9	5,4,8	B1425	Filter Holder Bottom
10	5	A1446	Holder Hose Adapter - Old Model
11	5,6	TP100	Tripod Assembly
11a	5,6	B1453	Leg Extensions - Old Model
69	5	P1001	Pull Pin
12	5	HS4	1 Meter of Rubber Hose - Old Model
13	5,6	CRPQ1	Cradle Assembly - Old Model
14	5,6,8	PQ100	Main Unit
18	1	PQ103	Main Battery
19a	1	SC0101	#6-32x1/4" Screw w/ washer
19b	1	WS0100	#6x.372 Flat Washer
20	1	B1412	Pulsation Dampner/Plenum
21	1	HS3	Hose
22	1	PM3026	Pump Assembly
23	1	B1413	Chassis
24	3	SC0107	#4-40 x 1/4" Phillips Pan Head Screws
25a	1	SC0103	#4-40x1 ½" Pan Head Screws
25b	1	WS0101	#4x.372 Flat Washer
26	1	HS2	Hose
27	1	A1416	Sensor tube adapters

Item#	Fig.	PN	Description
28	1	Buna 113	O Rings
29	1	CB1	Clock Battery
30	1	MFS1	Mass Flow Sensor
31	1	HS1	Hose
32	1	PQFP	Front Panel Assembly
33	1	SC0104	#6-32 x 3/8" Flat Head Screws
71	1	BP001	Rubber Bumper
72	1	BATT.PCA	P.C. Ass'y, Battery
34	5	PQ102	Hose Adapter
35	2	B1292	Valve Upper Plate
36	2	B1293	Valve Lower Plate
37	2	A1288	Diaphragm Retainer
38	2	A1281	Diaphragm
39	2	A1289	Diaphragm Retainer Bushing
40	2	B1283	Pump Housing
41	2	A1287	Follower Yoke
42	2	DDRI-6632	Bearing \ as assembly only
43	2	A1294	Eccentric /
44	2	SC0105	Set Screw
45	2	SC0106	#2.5x8mm CheeseHead Screw
46	2	A1290	Motor Mount
47	2	PQMOTOR	Motor
48	2	BUNA010	O-Rings
49	2	A1402	Locating Pins
50	2	B1408	Valves
51	3	SC4014	#4-40x1/2" Phillips Pan Head
52	3	Nt3006	#4-40 Hex Nut w/ Captive Washer
53	3	SC2001	#4-40x3/8" Screw w/ Washer
54a	3	SC3014	#8-32 Phillips Pan Head
54b	3	LW4001	#8 Internal Tooth Lock Washer
55	3	SC3028	#10-32x3/8" Slotted
56	3	NT3027	7/16" Panel Nut
57	3	ICA001	Utility Connector/Cable Assembly
58	3	DSP001	Display Assembly
59	3	PQ100PC	P.C. Assembly
60	3	B1417	Front Panel
61	3	B1409	Graphic Faceplate
62	3	H9111B	Handle
63	3	A1419,A1420	Exhaust Port
64	3	A1418	Inlet Receptacle
65	3	CCC001	Cap and Chain

```
Item#   Fig.   PN          Description
-------  ----   -----       ---------------------------------
66       3      A1483       Connector Gasket
67       3,5    BUNA116     O-Ring
86       2      SC1014      #8x1" Sheet Metal Screws
87       2      A1403       Inlet/Outlet Tube
88       2      SC1013      #8x5/8" Sheet Metal Screws
146      7      SC3030      #6-32 x 3/8" Philips pan head screw
147      7      1705-L5     10 micron inlet top
148      7      1709-L9     Spacer
149      7      1709-L8     Screen
150      7      1711-L11    10 micron inlet sub top
151      7      1712-L12    10 micron inlet body
152      7      Viton-036   O-ring
153      7      DI1013      10 micron inlet tube
154      7      SC3031      1/4 x 3/8 NPT adapter (Old Style)
155      7      SC3032      1/4 NPT nipple (Old Style)
156      7      JC3033      Jar top
157      7      SC3034      1/4 NPT plug (Old Style)
158      7      JR3035      Glass jar
159      7      Buna-026    O-ring
--       -      ICA002      Internal Battery Cable Assembly
--       -      ICA003      Flow Sensor Cable Assembly
164      7      SC3036      1/4" NPT Hex Nipple
```

10.2 Rebuilding the Pump after 5000 Hours

To determine "Pump Cumulative Time" you must use the PQ software to obtain a download from the PQ100 (See Section 8.9). Pump Cumulative time is the number of actual service hours of the dual diaphragm pump and is shown when either printing or screen viewing a download. When this time exceeds 5000 hours the pump should be rebuilt. The rebuild is a relatively easy task and requires the replacement of the diaphragms, valves, and bearing. A kit of parts is available from the factory and includes instructions. Service can also be performed by the factory.

Kit #   Description

X014   Pump Rebuild Kit (Includes valves, diaphragms and "o" rings)

X015   Advanced Pump Rebuild Kit (Includes X014 with bearing)

X016   Total Pump Rebuild Kit (Includes X014 with bearing and motor)

X017   Pump Diaphragms Only

10.3 Replacement of the Mass Flow Sensor

As each mass flow sensor is unique and will present variations in operation, all stored calibrations are obsolete when the sensor is replaced. Each flow sensor replacement kit contains an 8 pin DIP Integrated Circuit (I.C.) that must be replaced (socketed) on the main printed circuit board. This will clear all calibrations and will require that a new set of calibrations must be entered for the new sensor.

11.0   OPERATIONAL THEORY

When first powered on, the micro controller runs through some initialization and diagnostic routines. When completed, data stored as "Run-Time information" is then read from the non-volatile (EEPROM) memory device. Amongst this data is a single byte flag called the "shutdown code". If this code indicates that the system was shutdown normally (i.e. power-off button was pressed) it will proceed to the "IDLE MODE" display screen which contains all the pertinent run-time information such as Elapsed Time, Total Sample, Battery condition, last known Flow Rate when halted etc. If the shutdown code indicates that some other event has caused the system to power down such as Flow Restricted, Excess Flow Resistance, Batteries Too Low, Sample run time Completed, an appropriate message will be displayed to the operator indicating the cause of the stoppage and requires operator intervention to proceed to the "IDLE MODE" display. From the "IDLE MODE" display the active keys are "Reset" (all run parameters to their default conditions), "Run/Stop"- runs the pump at the last selected flow rate and continues the previously setup run (if a start time was programmed then the pump will not begin to run until the start time has been achieved), and "Setup" allows for programming the user definable run parameters such as target Flow Rate, Start time, Run time, Date & Time, and also provides a calibration mode. If Run/Stop is pressed at this time the pump will begin to run and attempt to match the target, pre-programmed Flow Rate.

12.0 WARRANTY INFORMATION

BGI Incorporated warrants equipment of its manufacture and bearing its nameplate to be free from defects in workmanship and material. We make no warranty, express or implied, except as set forth herein. BGI's liability under this warranty extends for a period of one (1) year from the date of BGI's shipment. It is expressly limited to repairing or replacing at the factory during this period and at BGI's option, any device or part which shall within one year of delivery to the original purchaser, be returned to the factory, transportation prepaid and which on examination shall in fact be proved defective.

BGI assumes no liability for consequential damages of any kind. The purchaser, by acceptance of this equipment, shall assume all liability for consequences of its misuse by the purchaser, his employees or others. This warranty will be void if the equipment is not handled, installed, or operated in accordance with our instructions. If damage occurs during transportation to the purchaser, BGI must be notified immediately upon arrival of the equipment. The Equipment will be returned via collect shipment.

A defective part in the meaning of this warranty shall not, when such part is capable of being repaired or replaced, constitute a reason for considering the complete equipment defective. Acknowledgment and approval must be received from BGI prior to returning parts or equipment for credit. BGI Incorporated makes engineering changes and improvements from time to time on instruments of its manufacture. We are under no obligation to retrofit these improvements and/or changes into instruments which have already been purchased.

No representative of ours has the authority to change or modify this warranty in any respect.

APPENDIX A. CALIBRATION EQUATIONS

Because the PQ100 uses a "Through Stream" mass flow sensor, the mass flow is not affected by pressure and temperature. However, the velocity (flow rate) through a fixed area nozzle will vary with atmospheric conditions. When work is carried out in an area with conditions other than Engineering Standard Conditions the "Corrected Flow Rate" is that which is measured on the calibration device for these new conditions.

The following equations are used to determine the "Corrected Flow Rate" that should be set on the PQ100 for atmospheric conditions other than "Engineering Standard Conditions" of 20 degrees Celsius (293.18 degrees Kelvin) and 760 millimeters of Mercury. They are provided for users who do not have access to an IBM PC or Compatible and can not use the "CORRECT" utility provided on the floppy disk.

These equations and recommendations have been prepared for Investigators with an advanced understanding of atmospheric sampling procedures. It is not our intention to justify every equation and procedure set down below to the uninitiated. For this reason, the "Correct" program supplied with the instrument is highly recommended.

To set up a calibration on the PQ100 to "Engineering Standard Conditions" the following applies;

$$QI = QS \left(\frac{PS}{PI} \times \frac{TI}{TS} \right) \text{ Equation \#1}$$

where;

QS   is the Standard Condition (PQ100 Target) flow rate in Liters per minute (Lpm)

QI   is the calibrator reading (Lpm) at a given Time, Temperature and Barometric Pressure

PS   is the Standard Condition Barometric Pressure (760) in millimeters of mercury (mm of Hg) (Equal to 1013.25 HectoPascals)

PI   is the Indicated Barometric Pressure reading (mm of Hg.) at the time of the calibrator flow reading

TS   is the Standard Condition Temperature (20) in degrees Celsius

TI   is the Indicated Temperature reading (degrees Celsius) at the time of the calibrator flow reading

Therefore, for Standard Conditions;

$$QI = QS \left(\frac{760}{PI} \times \frac{TI}{293.18} \right)$$

$$QI = 2.592 \; QS \left(\frac{TI}{PI} \right) \quad \text{Equation \#2}$$

Example 1:
The instrument is being set up to run at 10 Lpm at Standard Conditions with a flow meter. The ambient conditions in the set up location are 19 degrees Celsius (292.18 degrees Kelvin) and 765 millimeters of Mercury.

Then;

$$QI = 2.592 \; 10.0 \left(\frac{292.18}{765} \right) = 9.899 \text{ Liters per minute}$$

Therefore, if you set a Target Flow of 10.0 Lpm on the PQ100 and 9.90 Lpm on the flow meter, you will always be sampling at 10.0 Lpm to Standard Conditions regardless of changes in the weather (i.e. regardless of changes in air density). At a later date when you wish to check the calibration, Equation #2 still applies as in Example 2.

Example 2:
The instrument was set as detailed in Example 1. You are now out of doors at a sampling site. The conditions are TI = 27 degrees Celsius (300.18 degrees Kelvin) and PI = 750 millimeters of Mercury.

From Equation #2;

$$QI = 2.549 \; 10.0 \left(\frac{300.18}{750} \right) = 10.37 \text{ Liters per minute}$$

Therefore, if the PQ100 reads 10.00 Lpm and the bubble meter reads 10.37 Lpm the PQ100 is still in calibration and is sampling 10.0 Lpm at Standard Conditions.

On July 18, 1997, U.S. EPA changed the regulations for the operation of mass flow controlled instruments (e.g., the PQ100). Previously, EPA specified a set of "EPA Standard Conditions", which were 25 degrees C and 760 mm of Hg.

Now, mass flow controlled instruments are to be run in "volumetric mode". The details of EPA's recommended calibration procedure may be found in general form 40 CFR Part 50, Appendix M, 8.2.4 July 18, 1997. When applying these instructions to the PQ100, the following steps are suggested:

1.   Place a clean filter of the type to be used for the sampling in the PQ100 filter holder.

2.   Remove the PM10 inlet and connect a bubble meter to the filter holder. BGI adaptor (P/N L-30) is convenient for this purpose.

3.   Enter the calibration mode and adjust the flow up or down until the flow meter reads 16.67 LPM and lock the flow rate.

4.   Record the barometric pressure and temperature at the time of calibration.

5.   This procedure provides volumetric flow rate control as long as there are no shifts in temperature. EPA recommends the use of seasonal average values. In the case of the PQ100, this requires calibration for each season of intended use. Since it is not practical to be out of doors to perform the calibration, a facility has been provided in the calculation section of our software supplied with the PQ100.

6.   In software, selection the correction calculator. Then select (C) "EPA volumetric or user defined conditions".

> For T insert average seasonal local temperature
> For P insert average seasonal local barometric pressure
> For sample target flow rate enter 16.67 lpm
> Enter Pstd at calibration location (local)
> Enter Tstd at calibration location (local)

The program will return the flow rate which is to be observed on the flow meter in order to be running in the field at 16.67 lpm.

EPA regulations require that you calibrate at 3 flow rates. The other two flow rates selected are generally in the range of 15 lpm and 18.4 lpm ($\pm$ 10%). This procedure serves no particular purpose with the PQ100 which is microprocessor controlled. However, it is a statutory requirement and must be performed for concentration measurements to be compliant. An example of the calibration procedure is illustrative:

Tstd = 10°C, outdoor location, seasonal average

Pstd = 720 mm of Hg
Target flow rate = 16.67 lpm (desired volumetric flow at above conditions)
Tlab = 22°C (conditions in calibration location)
Plab = 760 mm of Hg

Corrected flow rate = 16.95 lpm (flow in calibration location)

In the event that a computer is unavailable, the above example may be calculated manually:


```
                          Plab        Tstd
Corrected Q  =   Qtarget  (   ------    x   ------ )
                          Pstd        Tlab
```

APPENDIX B. TROUBLESHOOTING

Problem: Pressing the "Run/Stop" key causes the unit to shutdown.

Answer: This indicates that the PQ100 is now powered off and ready to begin a sample run at the designated Start Date and Time. It means that the enable for the Start Date and Time is set to "On" (See Section 6.1). Be sure that the Start Date and Time are set correctly.

Problem: The Actual Flow Rate is not what is indicated in the Display.

Answer: Variations in Atmospheric Conditions (B.P. and Temp.) will cause slight variations in flow as displayed on the Calibration Device however the PQ100 will be displaying "True Flow Rate". If large variations exist, or if the variation is different from that of the calculated "Corrected Flow Rate" as described in the Calibration Equations Section of this manual then, the unit requires service.

Problem: I hear a popping metal sound as the PQ100 load pressure increases.

Answer: When running the PQ100 at very high load pressures (i.e. 150 centimeters of water or better), a strange metal popping sound may be heard by the user. Do not be concerned! This is merely the internal pulsation dampner (Plenum) adjusting its chamber area. The PQ100 will alert you as to the nature of any problems via the shutdown messages as described in APPENDIX E.

Problem: The flow rate does not seem to hold when additional pressure is added to the load (usually tested using a pinch clamp).

Answer: This is usually caused by a leak somewhere between the PQ100 Inlet and the calibration measuring device. Make sure that the hose adapter is firmly tightened in the PQ100 inlet, check the inlet mechanism and filter holder. You can usually isolate the suspect device by starting at the PQ100 inlet and working your way out.

APPENDIX C. SYSTEM BATTERIES

MAIN INTERNAL BATTERY
If the Internal Battery should ever require replacement, use ONLY the proper BGI Battery (PQ103).

EXTERNAL BATTERY
The External Battery is used to provide double the Run Time Capacity of the PQ100.

CAUTION: REVERSAL OF THE BATTERY LEADS CAN CAUSE IRREPARABLE DAMAGE TO THE PQ100.

CLOCK BATTERY
The Real Time Clock/Calender is backed-up by a Lithium Cell that will require changing once every 2 years. It also provides power to the Alarm Clock wake-up circuit. The PQ100 will let you know when this battery requires changing by providing a warning just prior to shutdown or when powered on and must be acknowledged by the user. You can temporarily ignore the warnings but a replacement should be acquired from the factory immediately. If the battery is allowed to get too low (ignoring the warnings) you may not be able to power off the PQ100 (It will keep waking up after a shutdown).

IF "REPLACE CLOCK BATTERY" MESSAGE IS ENCOUNTERED YOU MUST REPLACE THE CLOCK BATTERY IMMEDIATELY FOR CONTINUED OPERATION. IGNORING THIS MESSAGE MAY PRODUCE ERRATIC OPERATION.

APPENDIX D. MILITARY TIME CHART

The following chart is supplied for users who are unfamiliar with a 24 hour Military type time system.

```
00:00   12:00 Midnight
01:00   1:00 AM
02:00   2:00 AM
03:00   3:00 AM
04:00   4:00 AM
05:00   5:00 AM
06:00   6:00 AM
07:00   7:00 AM
08:00   8:00 AM
09:00   9:00 AM
10:00   10:00 AM
11:00   11:00 AM
12:00   12:00 Noon
13:00   1:00 PM
14:00   2:00 PM
15:00   3:00 PM
16:00   4:00 PM
17:00   5:00 PM
18:00   6:00 PM
19:00   7:00 PM
20:00   8:00 PM
21:00   9:00 PM
22:00   10:00 PM
23:00   11:00 PM
```

APPENDIX E. SHUTDOWN MESSAGES

The following is a description of the various messages that can be displayed by the PQ100 or the PQ Software to indicate the reason for sample job termination or current status of the PQ100;

00   Download not yet Appended! PQ Software

        * Indicates that a previously created job file has yet to receive a download from a PQ100 Sampler.

01   LOW BATTERY SHUTDOWN!   PQ100
        Low Batteries!   PQ Software

        * Indicates that the sample job was terminated when the battery power had been depleted and should now be recharged.

02   SAMPLE RUN COMPLETED!   PQ100
        Run Completed!   PQ Software

        * Indicates that the sample job was terminated when the RUN TIME had been depleted (See Section 6.7 or Section 6.8.3).

03,04   FLOW RESTRICTED!   PQ100
        Flow Restricted!   PQ Software

        * Indicates that the sample job was terminated due to a flow rate transient of 50% of the target flow rate and is usually caused by a kinked or broken hose, filter load removal etc.

        During the initial time that the PQ100 requires to stabilize its flow rate, flow will be displayed as --.-Lpm. During this stabilization period, flow rate is allowed to vary more than 50% for a maximum of one minute. After one minute the flow is considered restricted causing the above shutdown. Once the flow rate has stabilized, the flow rate will appear and response to transients greater than 50% is instantaneous.

05   Counters Reset, Awaiting new Run! PQ Software

        * Indicates that the PQ100 has been "Reset" and is now ready for a new sample job.

06   Powered Off Normally!   PQ Software

* Indicates that the PQ100 had last been powered off by pressing the "ON/OFF" button. If you simply allow the PQ100 to power itself off (automatic after approximately 3 minutes of no user activity such as key presses or downloads) then the last Shutdown code is retained.

07   Waiting for Alarm Event!   PQ Software

* Indicates that the PQ100 has been programmed to start a sampling job at some future time and is waiting for this occurrence.

08   MAXIMUM LOAD EXCEEDED!   PQ100
          Maximum Load Exceeded!   PQ Software

* Indicates that the sample job was terminated because the PQ100 could not force the pump to run any faster to regulate flow rate. This can happen when a large load pressure is developed and the battery voltage drops. To eliminate this problem you can run from the charger, recharge the batteries or try a different filter media.

09   Run Terminated by Operator! PQ Software

* Indicates that the sample job was terminated when an operator has pressed the "RUN/STOP" button while a sample job was in progress.

10   RUN TIME EXCEEDED!   PQ100

* Indicates that the PQ100 can not initiate a run as the RUN TIME (See Section 6.7) has not been reset.

11   REPLACE CLOCK BATTERY!   PQ100

* Indicates that the internal clock battery now requires replacement (See Appendix C).

APPENDIX F. ASSEMBLING THE PQ167 PM10 AIR SAMPLING SYSTEM

Included with your PQ167 PM10 Air Sampler System are the following items (Item#'s are indicated on the appended drawings);

Item#	Qty..	PN	Description
14	1	PQ100	Air Sampler Main Unit
*	1	PQ101	Battery Charger (specify 120 VAC or 240 VAC)
34	1	PQ102	Hose Adapter
*	1	CQ2	PC Communication Adapter Cable
*	1	*	Manual and Software CD
12	1	HS4	1 Meter of Rubber Hose
11	1	TP100	Tripod Frame
*	3	B1453	Leg Extensions
13	1	CRPQ1	PQ Series Sampler Cradle
01	1	SSI-10	Inlet
2,3	1	JR3035	Water Jar w/ 2.5" Coupler
4,5,9,10	1	F20	Filter Holder (Requires F21/2 Cassette)
6,7,8	2	F21/2	47mm Filter Adapter Cassette w/Screen

FOR COMPLETE SYSTEM ASSEMBLY PLEASE REFER TO FIGURES 4, 5 AND 6.

APPENDIX G. ASSEMBLING THE BGITSP AIR SAMPLING SYSTEM

Included with your PQTSP Air Sampler System are the following items (Item#'s are indicated on the appended drawings);

Item#	Qty.	PN	Description
14	1	PQ100	Air Sampler Main Unit
*	1	PQ101	Battery Charger (specify 120 VAC or 240 VAC)
34	1	PQ102	Hose Adapter
*	1	CQ2	PC Communication Adapter Cable
*	1	*	Manual and Software CD
4,5,9,10	1	F20	Filter Holder (Requires F21 Cassette)
6,7,8	2	F21/2	47mm Filter Adapter Cassette w/Screen

FOR COMPLETE SYSTEM ASSEMBLY PLEASE REFER TO FIGURES 4, AND 8.

APPENDIX H. INSTALLING FILTER MEDIA

Referring to Figure 4, the filter media is placed on screen (7) and placed on the inner lip of cassette base (8). Cassette top (6) is then inserted into cassette base when pin of base is aligned with locating hole on cassette top. Holder base (9) and holder top (4) are supplied with O-Rings (5) already installed. Loaded cassette is then inserted into base (9) with the screen side down and holder top (4) is then screwed into base (9) firmly as to insure against leaks.

APPENDIX I. CONCENTRATION EQUATION

For reference, the following is the formula for Concentration used by the PQ Software;

$$\frac{\text{CONTAMINANT WEIGHT (mg) x 1000}}{\text{TOTAL SAMPLE VOLUME (m}^3\text{)}} = \text{CONCENTRATION} \left(\frac{\text{micrograms}}{\text{m}^3} \right)$$

Where;

(CONTAMINANT WEIGHT)	is the difference between initial filter weight and final filter weight
(TOTAL SAMPLE VOLUME)	is the Volume of air passed through the filter in cubic meters
(CONCENTRATION)	is the quantity of particulate matter in micrograms per cubic meter

APPENDIX J. FLOW RATE STABILITY

EPA Regulations 40 CFR part 53.43 (July 1987) require measurement of flow rate stability during the testing of an instrument for reference or equivalency. This test is permanently incorporated into the PQ100 firmware. The flow rate through the instrument is measured and stored automatically while the run is in progress. The initial flow rate is measured one minute after the instrument has stabilized the flow rate (The flow rate is stable when the PQ100 visual display shows the actual flow rate instead of "Q--.-"). The flow rate is then sampled once every hour thereafter until the completion of the run with a maximum capability of 30 readings after the initial.

NOTE: THE RUN MUST BE CONTINUOUS IN ORDER FOR THE READINGS TO BE TRUE. IN OTHER WORDS, IF A RUN IS HALTED FOR ANY REASON THE PQ100 MUST BE RESET TO INSURE THAT THE READINGS ARE STORED IN THE PROPER SEQUENCE.

The Flow Rate Stability Report is generated after a run is completed and the data has been downloaded as previously described by the PQ Software. The report is shown as a second page after a run has been "Screened".   The option of obtaining a printout is given for each screen after viewing the data.

The following is a description of the equations used to calculate flow rate stability as shown in the report;

$$\overline{F} = \frac{F(1) + F(2) + F(3) + ... F(n)}{n}$$

where;

$\overline{F} =$	Average Flow Rate in Liters per Minute
$n =$	Total number of readings taken
$F(1) =$	Initial Flow Rate reading 1 minute after flow has stabilized
$F(2) =$	Flow Rate 1 Hour after Initial Flow Rate reading
$F(n) =$	Flow Rate (n-1) Hours after Initial reading

The first EPA indicator of flow rate stability is the percent of difference between average flow rate and initial flow rate.

$$= \frac{\overline{F} - F(1)}{F(1)} \times 100$$

48

where;

 % difference between average and initial flow rate.
 This may be a plus or minus value and may not exceed 5% (EPA).

The second EPA indicator of flow rate stability is the percent of difference between each hourly flow rate reading and the initial flow rate.

$$(t) = \frac{F(t) - F(1)}{F(1)}$$

where;

 F(t) = hourly flow rate readings   F(2), F(3), F(4) etc.
 (t) =   % difference between individual hourly readings and initial flow rate.
 This may be a plus or minus value and no value may exceed 10%.

In reality all displayed values should be expected to be typically less than 1% and should not exceed 2%. Values more than 2% should be investigated. A blocked or restricted inlet, hose, etc. at precisely the time the PQ100 takes a reading internally should be suspected.
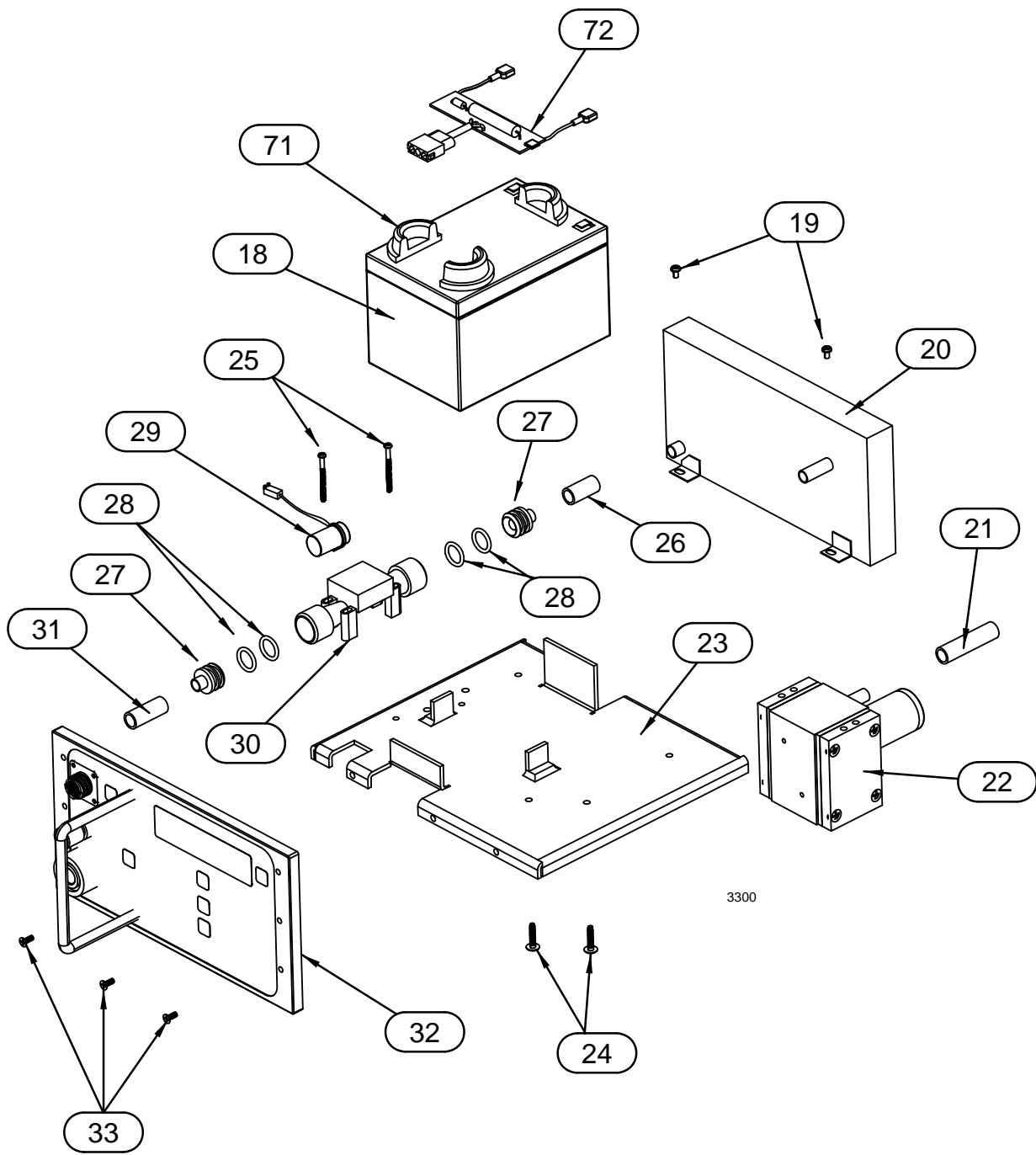
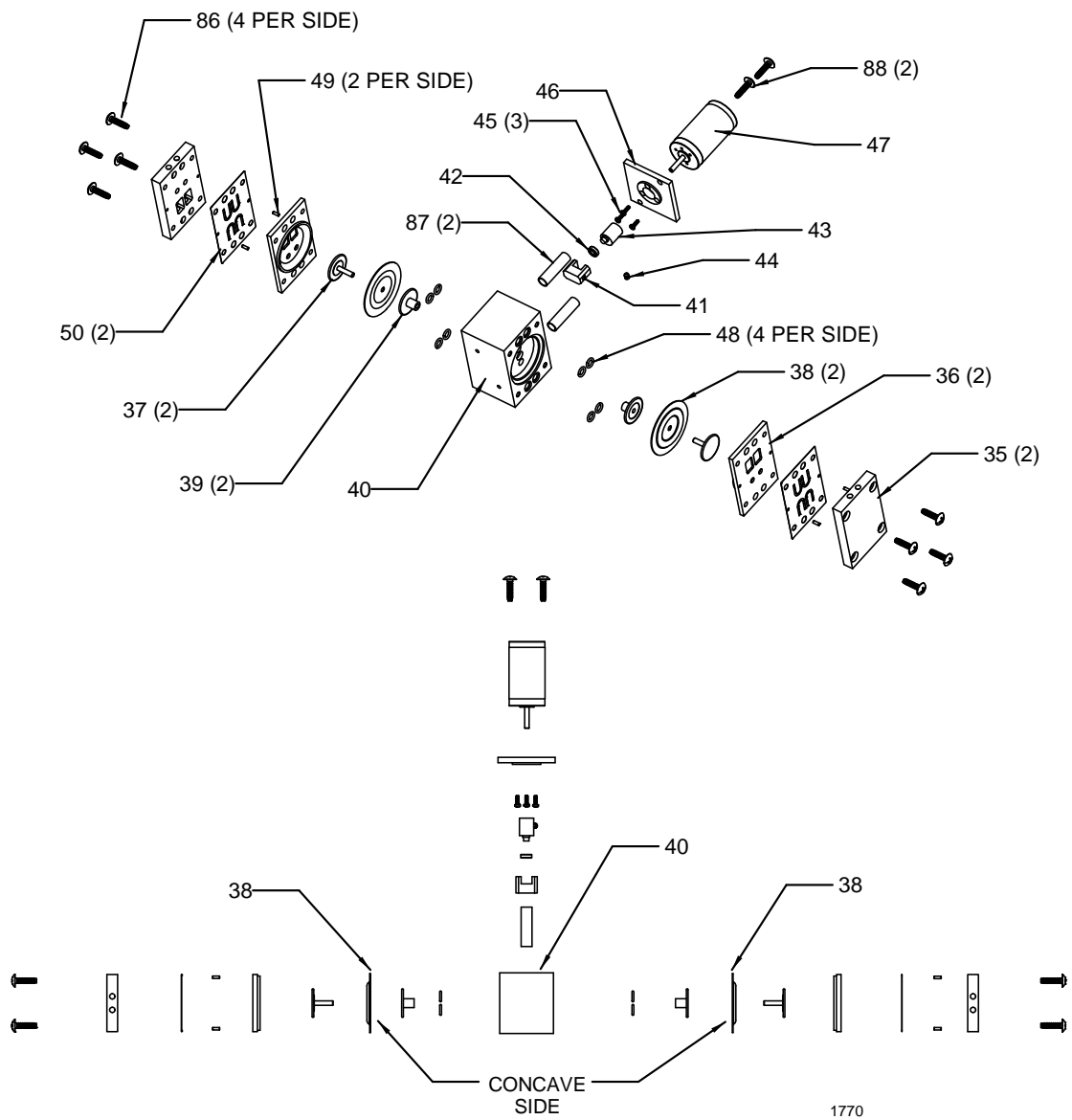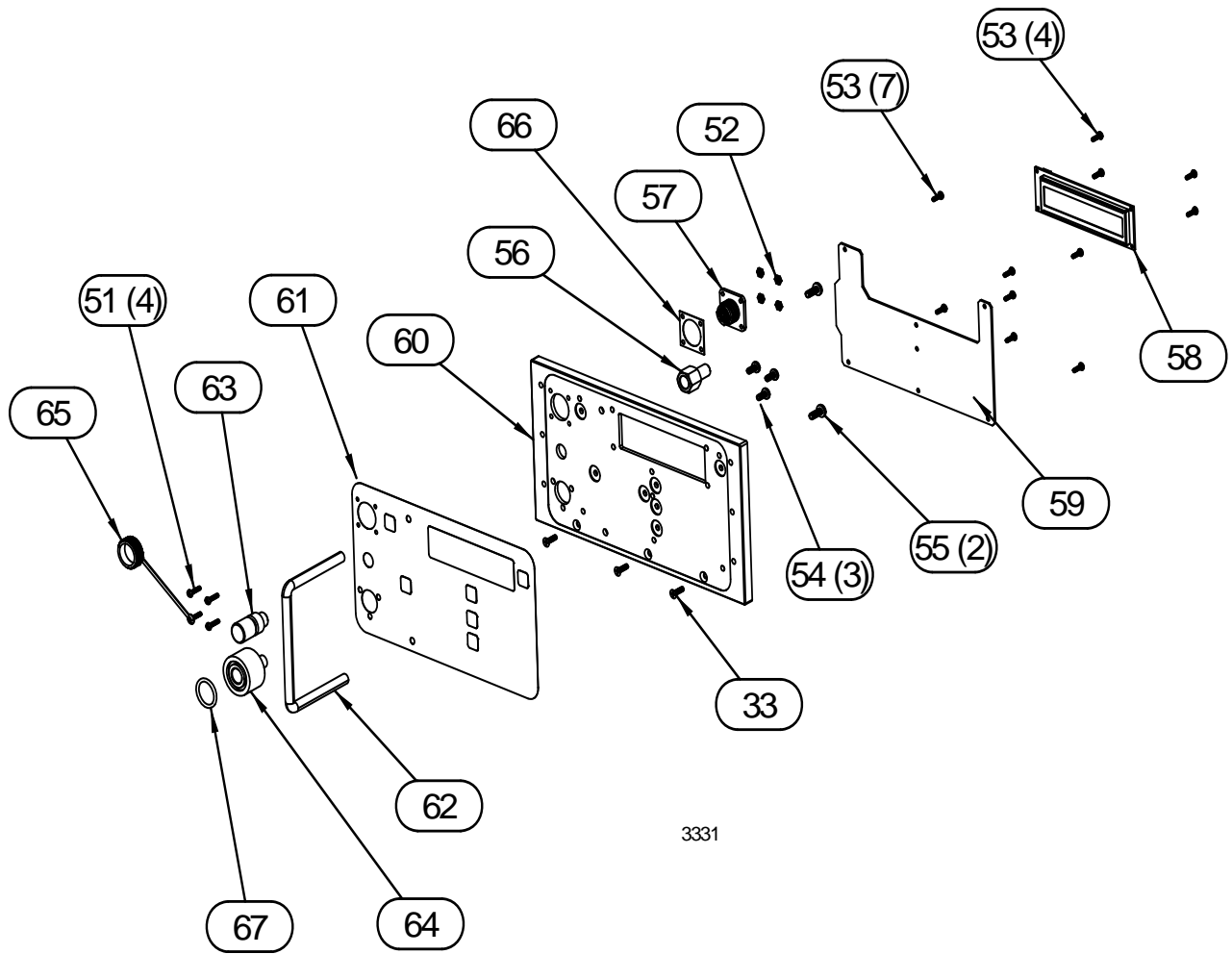**APPENDIX K. FIGURES**

Figure 1. Exploded Assembly View

86 (4 PER SIDE)

49 (2 PER SIDE)

46

45 (3)

42

87 (2)

88 (2)

47

43

44

50 (2)

37 (2)

41

48 (4 PER SIDE)

38 (2)

36 (2)

35 (2)

39 (2)

40

40

38

38

CONCAVE
SIDE

1770

Figure 2. Exploded View of Pump

52

Figure 3. Exploded View of Front of PQ100

3331

04

05

06

FILTER MEDIA

CASSETTE ASSEMBLY

07

08

05

09

2418
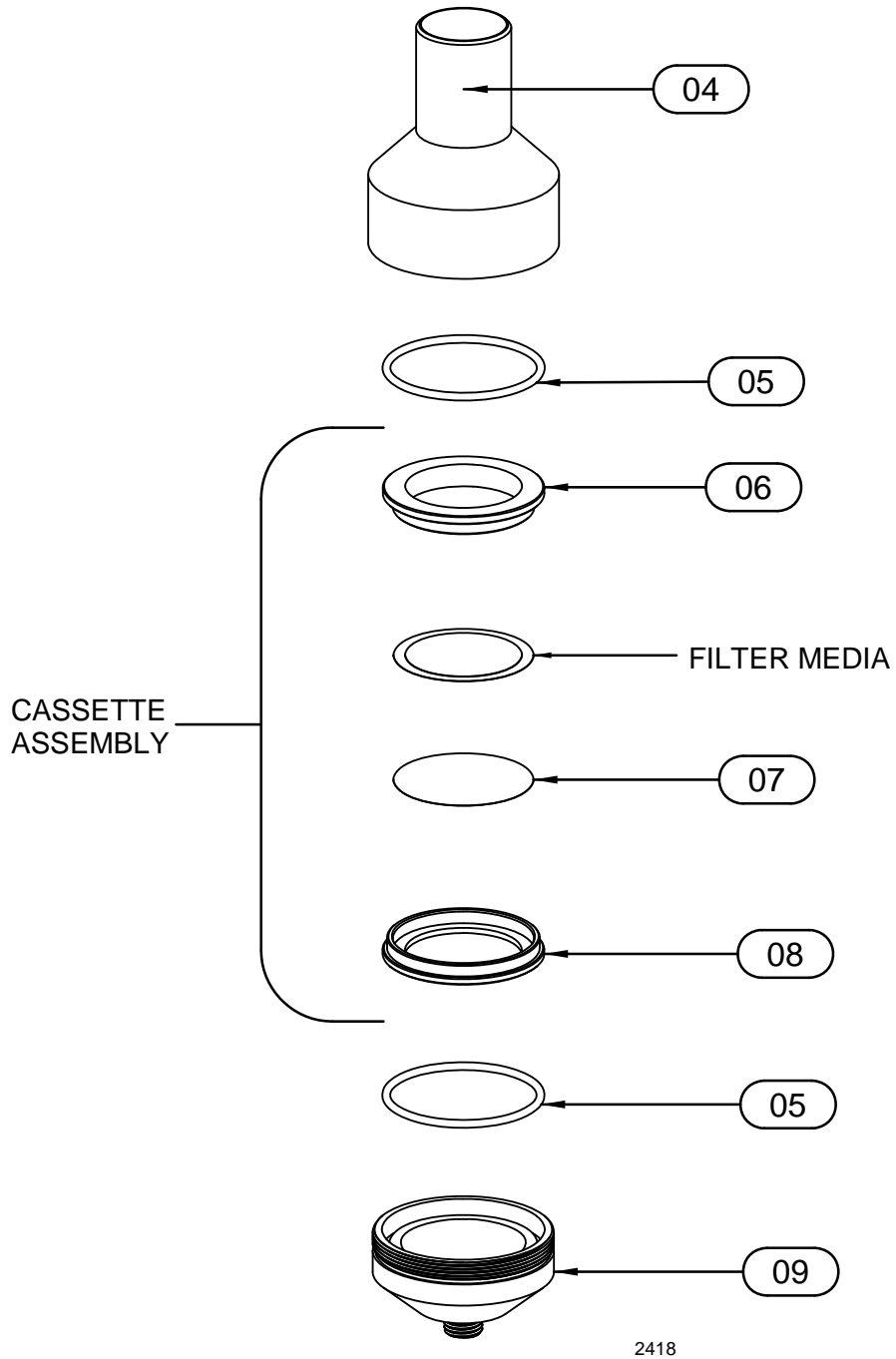
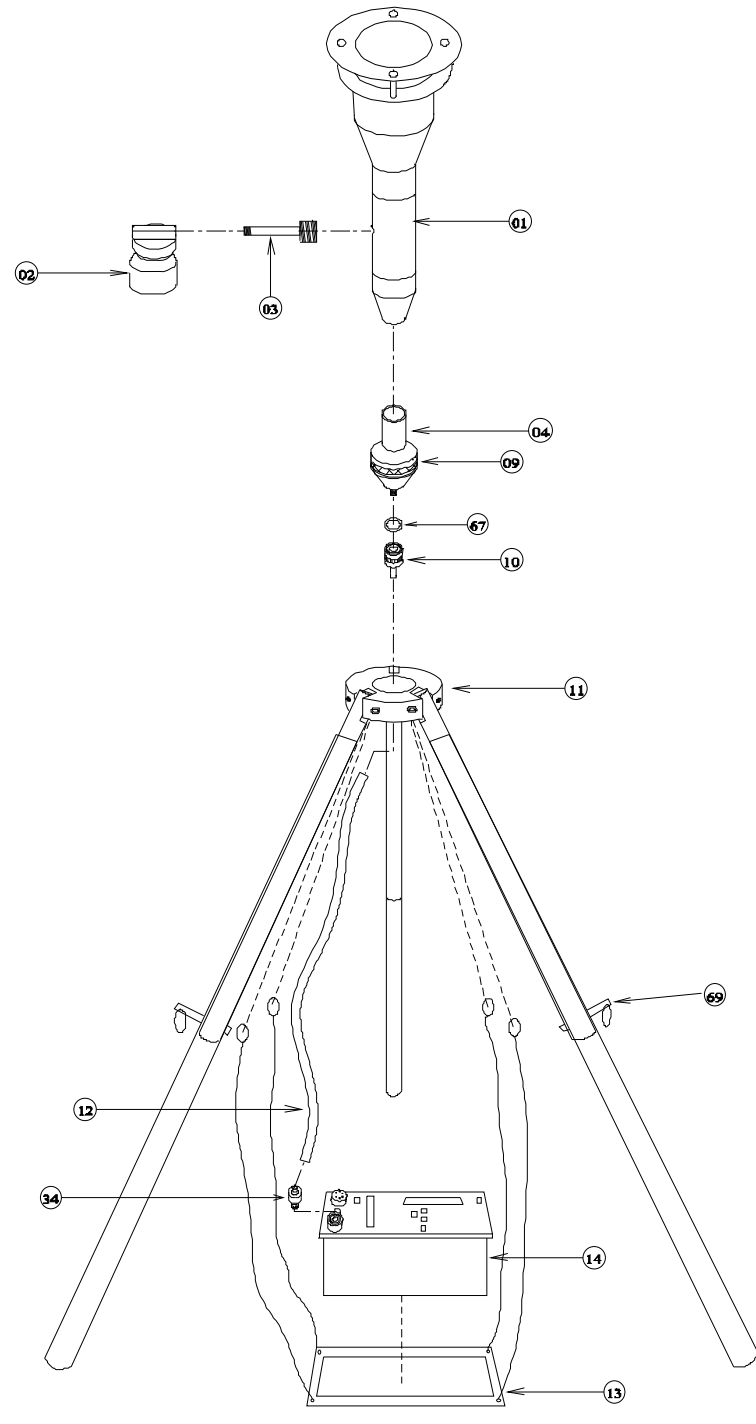Figure 4. Exploded View of Filter Cassette and Filter Holder

Figure 5. Exploded Assembly with Inlet and tripod

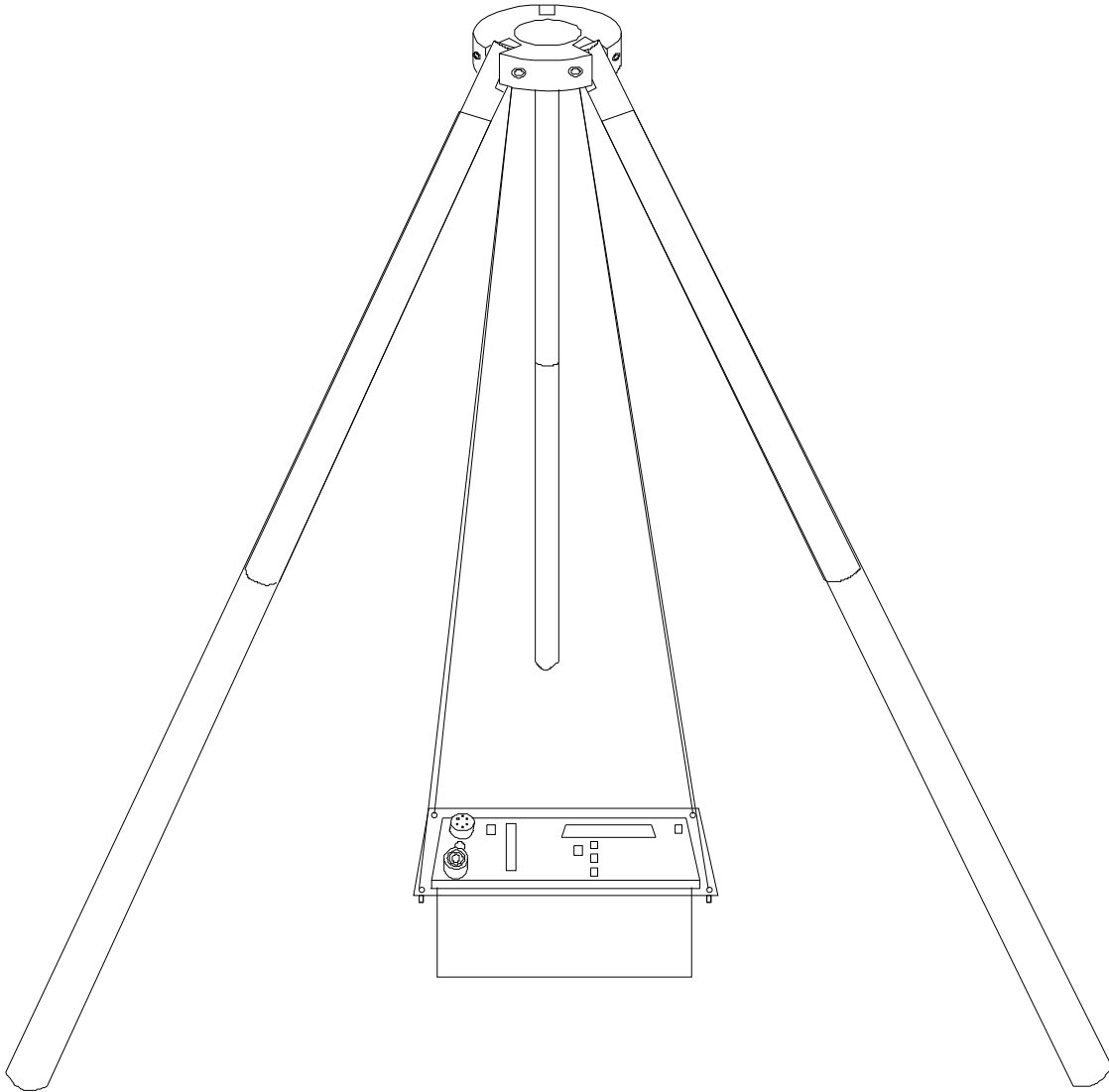*(January 2000: OBSOLETE> Parts subject to stock on hand. See Appendix O)*

Figure 6. assembled PQ100 Tripod.

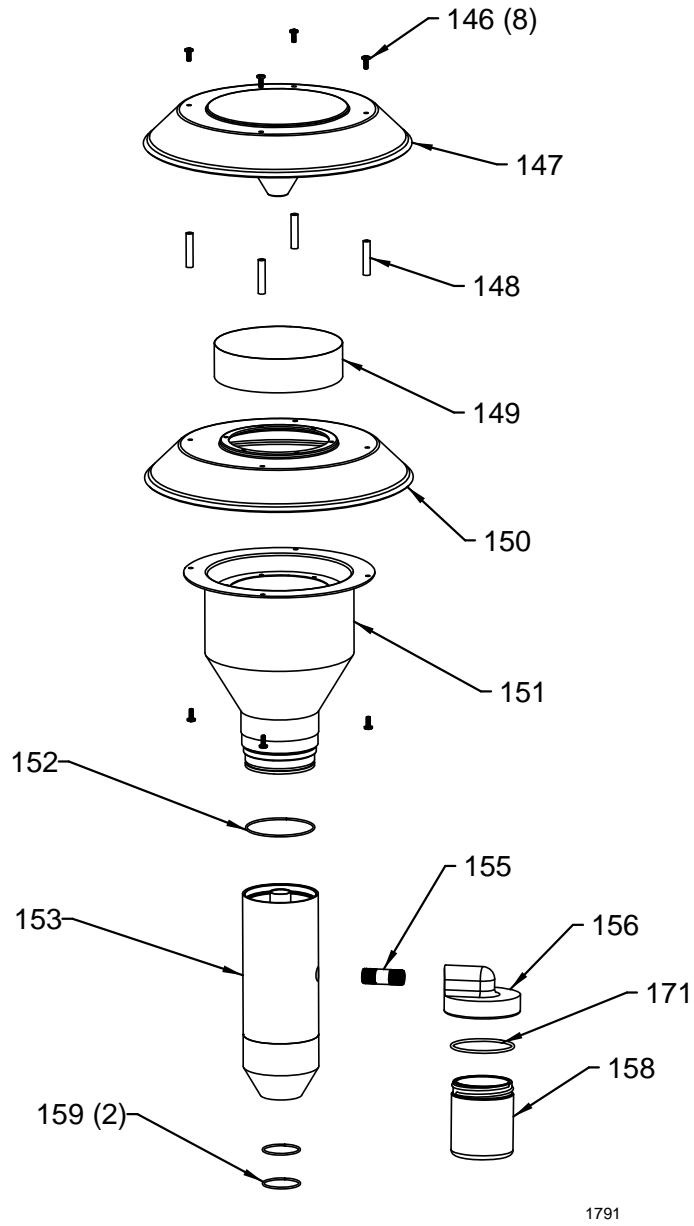*(January 2000: OBSOLETE> Parts subject to stock on hand. See Appendix O)*
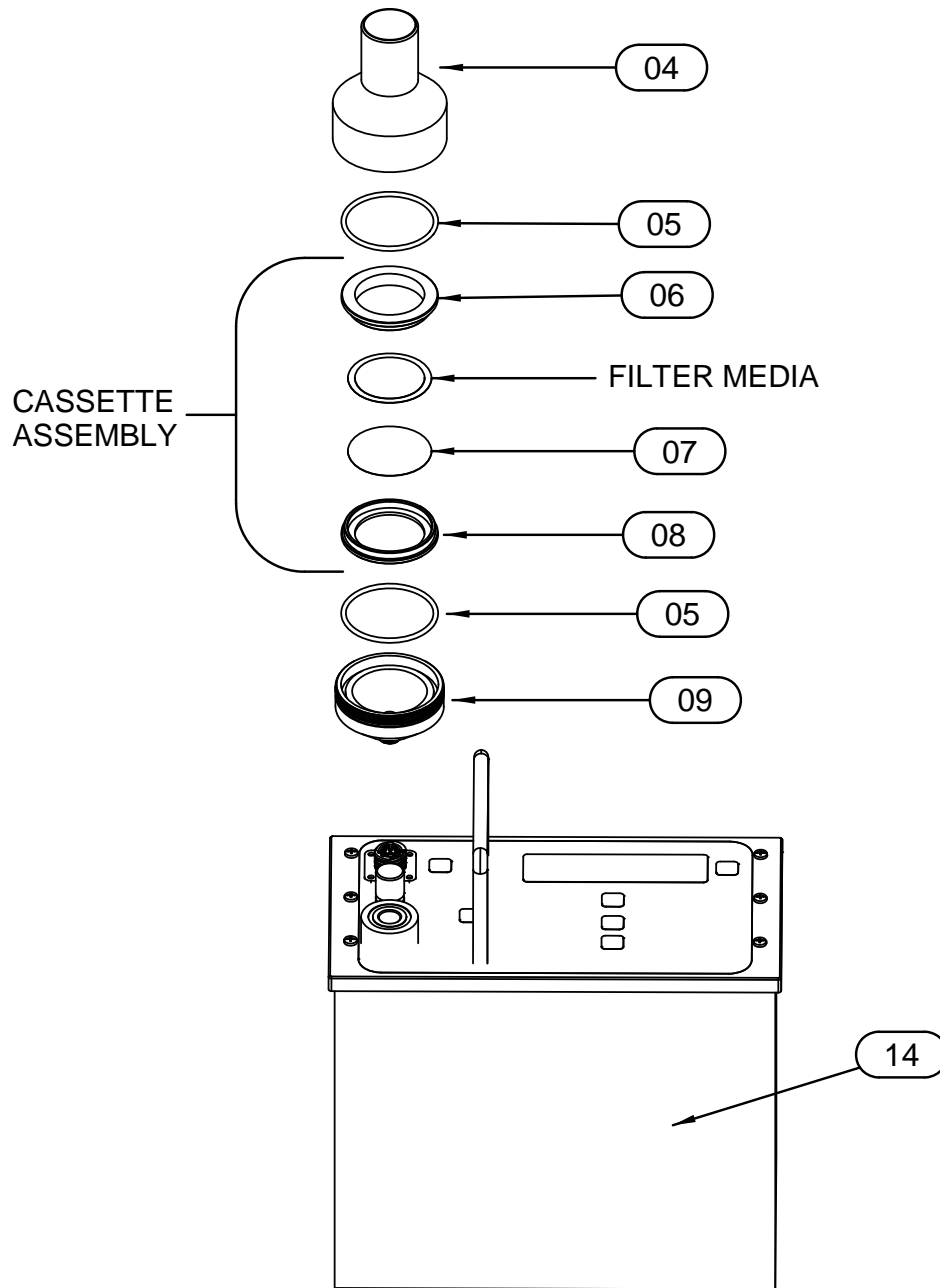
Figure 7. Exploded View of PM10 Inlet

04

05

06

FILTER MEDIA

07

08

05

09

CASSETTE
ASSEMBLY

14

2419

Figure 8. PQ100 Front with Filter Assembly

APPENDIX L. FILTER HANDLING AND WEIGHING

Note: The following guidelines are based on the regulations developed for sampling PM2.5. It is recommended that these guidelines be followed for PM$_{10}$ sampling using the PQ100.

Filter Specifications

For exact compliance with EPA procedures for PM2.5, refer to 40 CFR Part 50, Appendix L, and Section 2.12 of EPA's Quality Assurance Handbook.

In brief, the filter should have the following characteristics:

Size: Circular, 46.2 mm diameter ± 0.25 mm. Medium. Polytetrafluoroethylene (PTFE Teflon), with integral support ring.

Support ring: Polymethylpentene (PMP) or equivalent inert material, 0.38 ± 0.04 mm thick, outer diameter 46.2 mm ± 0.25 mm, and a width of 3.68 mm (+0.00 mm, -0.51mm).

Pore size: 2μm as measured by ASTM F316.94.

Filter thickness: 30 to 50 μm.

Maximum pressure drop (clean filter): 30 cm H$_2$O column @ 16.67 Lpm clean air flow.

Maximum moisture pickup: Not more than 10 μg weight increase after 24-hour exposure to air of 40 percent relative humidity, relative to weight after 24-hour exposure to air of 35 percent relative humidity.

Collection efficiency: Greater than 99.7 percent, as measured by the DOP test (ASTM D 2986-91) with 0.3 μm particles at the sampler's operating face velocity.

Alkalinity: Less than 25 microequivalents/gram of filter, as measured by the guidance given in reference 2 in section 13.0 of this appendix.

One current source of these filters is Pallflex Products Corp. Of Putnam, CT, USA; Type TK15-S3M.

Filter Handling

Filters should be handled delicately using non-serrated forceps, never using fingers (even in laboratory gloves) to touch any part of the filter. When not in use, filters should be stored in protective cartons in conditions of moderated temperature and relative humidity. Filters should from the always be transported from the laboratory to the sampling location in the filter cassette, which should be protected within a metal canister. These canisters may be ordered directly from BGI.

Filter Cassette Handling

The filter cassettes provided for use with the PQ100 have been designed with an interference fit to prevent the cassette from coming apart easily, therefore some care must be exercised when opening and closing the cassette, especially when a filter is inside. Always maintain the cassette in an upright position, especially if the filter has already been used to collect particles. To open, place a clean, flat blade device (knife edge, screwdriver blade) against the outside edge of the cassette between the upper and lower halves and gently wedge them apart. DO NOT TWIST THEM APART, this could tear the filter. Set the upper half of the cassette aside.

To close the cassette, place it the upper and lower halves together and gently press them together, being careful not to twist them. When closed, the two halves should seat snugly together with the backing screen securely held in place between the two halves.

Filter Weighing

Because of the small amounts of material collected, an extremely high quality microbalance and carefully, temperature and humidity controlled filter weighing room are recommended. For complete EPA recommended details, consult 40 CFR 50 Appendix L8.0, Federal Register, July 18, 1997, and Section 2.12 of EPA's Quality Assurance Handbook.

The analytical balance used to weigh filters must be suitable for weighing the type and size of filters specified and have a readability of $\pm 1 \mu g$. The balance should be calibrated as specified by the manufacturer at installation and should be recalibrated immediately prior to each weighing session.

APPENDIX M. EXTERNAL DATALOGGER

The BGI Datatrans is a "Download Data Collector" designed to extract the "Data Download" from a PQ100 at the end of its sample period and store it until it can be uploaded to a personal computer running BGI PQ software, for more permanent storage. This device facilitates rapid "Filter and Data" collection in the field while providing trouble free data collection at extended temperature range (-30° to +60°C). The Datatrans was designed specifically to address the problem of field data collection at these extended temperatures where notebook, laptop or palmtop computers are not designed to operate below 0°C.

To use the Datatrans

1. Turn the unit on with the power switch on the front panel (See Figure M1).
2. The following light sequence should be observed: red, yellow then green.
3. The green light will remain on (This indicates a ready condition). If the yellow light is also illuminated, one or more runs are currently stored in the Datatrans and it should either be downloaded or erased as described below.

    NOTE: The Datatrans should be fitted with a fresh, new 9-Volt battery prior to each field use.

Downloading the PQ100

1. Place the connection switch, located on the front panel of the Datatrans, in the "Samp" (sampler) position.
2. Insure the PQ100 Sampler is powered on and at the Main Idle Screen.
3. Attach the PQ100 Adapter to the Datatrans (See Figure M2) and plug the other end of the adapter into the Utility Port on the front panel of the PQ100.
4. Press and hold the pushbutton on the front of the Datatrans.
5. The red light will turn on, the green light will turn off and if communication is successful the yellow light will flash for each line of data received. When the download is complete, the yellow light will remain on, the red light will stop flashing and turn off and the green light will turn on.

    Note that the PQ100 takes less than 5 seconds to download.

6. Repeat the above steps for each sample run that is to be collected (multiple samplers) realizing that the "Runs" are stacked up using **First In, Last Out methodology**.

NOTE: You must remember how many runs that you've stored in the Datatrans. 20 is the maximum. If you try to store 21 runs, the Datatrans will not accept the 21st run. You will notice that the yellow light flashes while data is transferring. When memory becomes full, the red light will not flash indicating that the run was not accepted.

7. It is now safe to turn the unit off.

NOTE: The data will be retained in the Datatrans, even if the 9-Volt battery fails, until it has been uploaded into a computer and the unit is erased using the data deletion procedure described below.

To upload to the Computer

1. Plug the Datatrans into the RS232 serial port of the computer.
2. Turn on the power switch and observe the following light sequence: red, yellow then green. (Green light indicates unit is ready and yellow on indicates Runs are stored). Red light turns off.
3. Place the connection switch, located on the front panel, in the **(Comp)** computer position.
4. Insure the computer is running BGI PQ Software for DOS. (B)egin a new job, then import data from the sampler should be selected and should be ready to receive data as if it were attached directly to the sampler.
5. Press any key on the computer keyboard to initiate the transfer.
6. Green light will turn off, Red Light will turn on and "Run Data" will be stored in the Datatrans.
7. When the transfer is complete, the software will step to the next screen indicating that the "Run" has been transferred.
8. If multiple runs have been stored in the Datatrans, the last run captured is the current resident run. While a run is resident, the Datatrans retains the characteristics of the sampler type it was captured from. To step the Datatrans to the next run, you must first download the current run and then press the pushbutton. Repeat for multiple runs pushing the Datatrans button after each sample is uploaded. You must "Begin"
   a   new run for each sample run to be uploaded to the computer. When all runs have been uploaded, the yellow light will remain off.
9.   To use the device again for new runs from the field, you must erase it as described below:

NOTE: TO RECYCLE SAMPLE RUNS:

If after all runs have been downloaded, a lost file, mistake or a problem is discovered and you must download a run again, the Datatrans allows the runs to be recycled as long as it has not yet been erased as described in the Erasure Procedure below.

AFTER GREEN LIGHT GOES OFF, INDICATING ALL RUNS HAVE BEEN DOWNLOADED, PRESSING BUTTON WILL RETRIEVE THE SERIES OF

RUNS AND REMAIN UNTIL DELETED.

THIS IS HELPFUL IF YOU ARE UNSURE OF AN UPLOADED RUN.

DATA DELETION PROCEDURE
(TO ERASE THE DATATRANS AFTER ALL RUNS HAVE BEEN TRANSFERRED)

1. Turn the power switch off.
2. Hold down the pushbutton.
3. While holding the pushbutton down, turn the power switch On.
4. The Red light will turn on, now release the button.
5. When erased, all three lights will flash <u>2 times in unison and 1 time in series</u>.
6. Unit is now cleared and ready for new downloads.

Maintenance

The Datatrans requires no maintenance except for replacement of the 9-volt battery. A spare, fresh battery should always be taken to the field.

Troubleshooting

Most of the problems that occur with the device can be traced to a bad 9-Volt battery. It is recommended that the user purchase Duracell Alkaline Batteries which come packaged with a cell tester. Follow the instructions given on the box or cell and determine if the cell requires replacement or not. It is highly recommended that the user install a brand new, fresh cell before each field use (If you forget to turn the unit off for some reason, you will have about 18 full hours of battery use).

GREEN

YELLOW

RED

S
A
M
P

C
O
M
P

O
N

O
F
F

GO   CONNECT   POWER

BGI INCORPORATED
WALTHAM, MA. 02451
(781) 891-9380
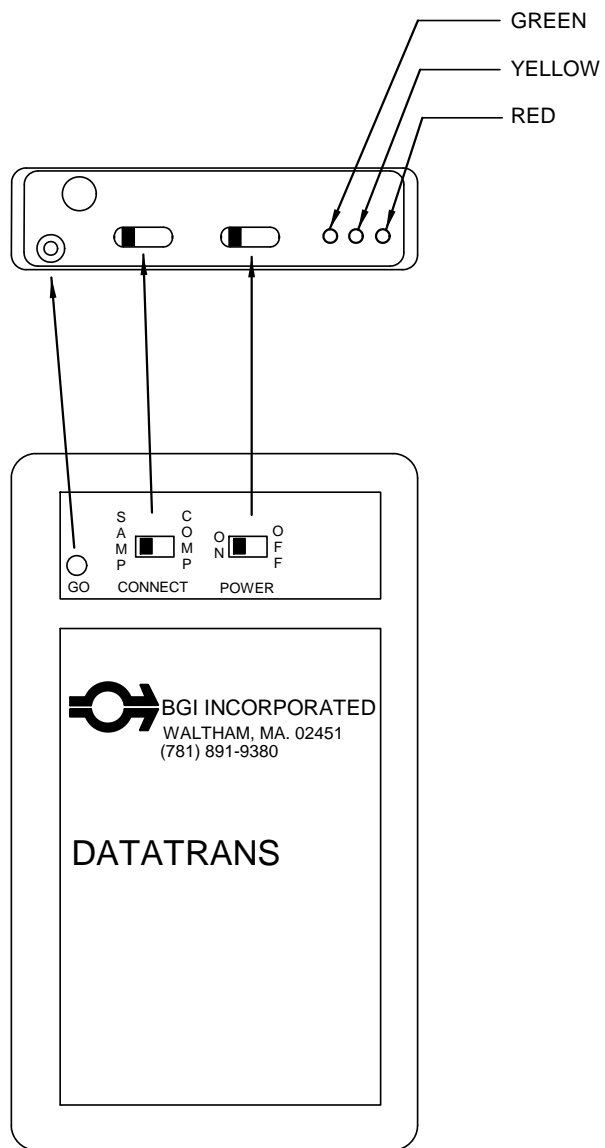
DATATRANS

Figure M1. Schematic Diagram of Datatrans

DATATRANS

DB-9F

DB-9M

PQ 100
ADAPTER

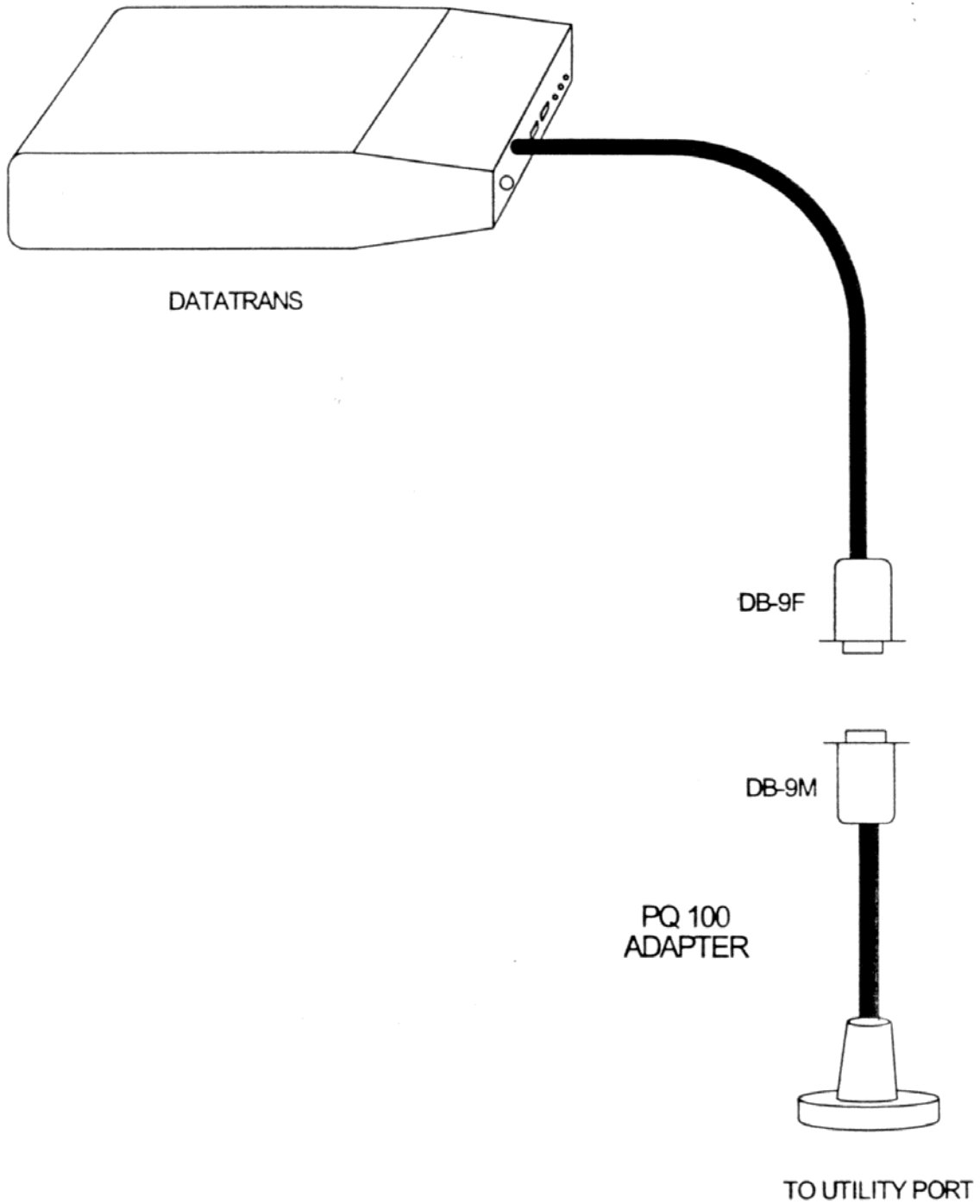TO UTILITY PORT

Figure M2. Datatrans with Adapter for use with PQ100

APPENDIX N. SOLAR PANEL POWER SUPPLY

Introduction

The SP32, solar panel kit is intended to permit the PQ100 to run for extended or, indefinite periods of time depending on the available sunlight (solar radiation) at a given location. The solar panel may only be used as the sole source of power for a U.S. EPA-designated instrument if sampling is not being performed every day (i.e., continuously).

Because of the low current draw of the instruments they are highly amenable to this technique. Given sufficient sunlight, they may be deployed in locations where no line power is available. The basic components of the solar kit are:

1. 32-watt solar panel with mounting brackets.
2. Built in voltage regulator.
3. 100+ amp hour (approx.) ballast battery. (User supplied).

The purpose of the external high capacity battery is to provide back up power on days when there is little or no sunlight. The recommended battery capacity will provide 7-8 days run time with little or no sunlight. It will recharge, almost completely, after one days' use during a day of full sunlight while the instrument is non-operational. Complete recharging of a fully depleted system would require 10 days.

This type of system should not be considered for latitudes higher than 45-50° N or S, or particularly overcast regions.

Operational Considerations

While the use of solar power is highly desirable from the standard of utilizing a renewable energy source and being freed from the need to locate a source of power in difficult situations, there are some preliminary considerations. Clearly, the PQ100 is not operating directly from the received energy of the sun but rather from a battery, which has been charged by that energy. If a PQ100 were to be run continuously from the internal and (recommended) external battery, 7 to 8 days run time could be achieved. However, considering only EPA designated sampling conditions, i.e. sampling from midnight to midnight, then it would be possible to run on alternate days yielding one day to replenish the energy used. Given that this is accomplished in full sunlight while the instrument is running, the extra day recovery reduces the need for full sunlight by 50%. If the popular, one in 3 days, or one is 6 days schedule is utilized, the probability of complete replenishment is greatly increased.

Experience has shown that on cloudless days in the Boston area, 5 Kwh/M^2 insolation will replenish the energy used by a PQ100. In order to determine the suitability of the PQ100 solar system for a given location, Appendix A of the cited reference gives the insolation index for 54 locations in the US and other places throughout the world. Given a one in 6 day sampling schedule; only Fairbanks Alaska is unsuitable for solar application in the months

of November, December and January. These are clear sky tables and seasonal overcast must be considered in individual locals. Table N1 comprises locations at various US latitudes and indicates operational months vs. sampling schedules.

There are other factors which will reduce the energy replenishment of the system and make accurate performance predictions difficult. Amongst these are:

1. Dirt on the solar panel.
2. Extreme cold weather affecting battery performance.
3. Extremely high particulate loadings causing high filter resistance and consequent high current drain.
4. Old "used up" batteries -- more than two years old.

While all the preceding factors are to be considered in the deployment of a solar powered PQ100. They are not easy to quantitate. The effect of too little sunlight will be noticed on the "percent charge remaining" on the PQ100's main screen. Given perfect replenishment, it will always read 99%. If at any time it falls below 50% it is well to consider replacing the large battery with a fully charged one. At a minimum, given winter gloom, a fully charged battery and an every other day sampling schedule, a one month operating period is achievable at any location below 45° latitude.

Setting up

Subsequent to unpacking a new unit, it is attached to the rear leg of the PQ100 as shown in Figure N1. It is important that the board provided be located as shown in the figure with the battery placed on top of it. This serves to anchor the lower end of the panel to prevent its lifting during high winds. Failure to do so could result in damage to the solar panel and the PQ100. **NOTE:** In due consideration of weight, shipping expense and ready, local availability, a battery is not furnished with the solar panel kit.

However, the recommended battery is known as a "trolling motor" battery. This is a marine type battery used for low speed, electric outboard motors. They are equipped with handles and 5/16 inch binding posts with wing nuts. Because of their marine specifications, they are a "deep discharge" battery, which is also the type recommended for solar panel applications[1].

Direction

The direction of the solar panel will be with its long axis from the north to south, with the foot (low) end of the panel to the south. Inasmuch as the cell will be attached to the rear leg of the PQ100, this means that the back of the PQ100 is pointing due south and the front of the instrument is due North as illustrated in Figure N2.

Tilt Angle

The tilt angle is defined as the angle of inclination of a solar collector measured from the horizontal. The reason for tilt angle is because of the suns' elevation will vary over a range of 47° from winter solstice to summer solstice [1].

For the greatest <u>annual</u> energy production, the tilt angle should equal the latitude at the location of deployment. For best energy production, the wintertime the angle should be the latitude plus 15°. The maximum summertime production is obtained at latitude minus 15°. The tilt angle and one method of setting is shown in Figure N3.

It may also be set with a user supplied protractor/bubble level.

<u>Wiring Connections</u>

On the back of the solar panel is a rectangular box from which two cables exit as shown if Figure N4. The cable with 5/16 inch ring terminals is intended to connect to the external battery described in section N 2. The white wire is positive (+). The black wire is negative (-) and the green wire, with the tinned end is ground. A 12-inch ground spike and terminal is provided.

The other wire emanating from the box is equipped with a CPC connector. This wire is installed on the PQ100 panel normally used for the power supply cable. This wire is installed in place of the power supply cable when running on solar power.

Overall Operation and Troubleshooting

Prior to deploying a PQ100 with solar panel, it is prudent to ensure that the internal battery is fully charged. This is accomplished by plugging the PQ100's power supply into a source of line current for 16 hours. Full internal battery charge will be indicated on the main menu display as 99% or charged when the battery is full charged and the power supply is disconnected.

The external solar panel battery may be initially charged from any automotive battery charger. Alternatively, the PQ100 may simply set in a sunny location or the actual field sampling site and not run for 10 days. The solar panel will fully charge both batteries.

<u>Troubleshooting</u>

Battery is not maintaining at least 50% charge – caused by inclement weather or excessive current drain. Excessive current drain is caused by an excessively dirty filter or a worn out pump. After installing a new filter, if problem persists, check for worn pump valves or diaphragms.

If either battery is in excess of two years old – replace.

Reference

(1)   Stand-Alone Photovoltaic Systems, A Handbook of Recommended Design Practice. Available from National Technical Information Service
US Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
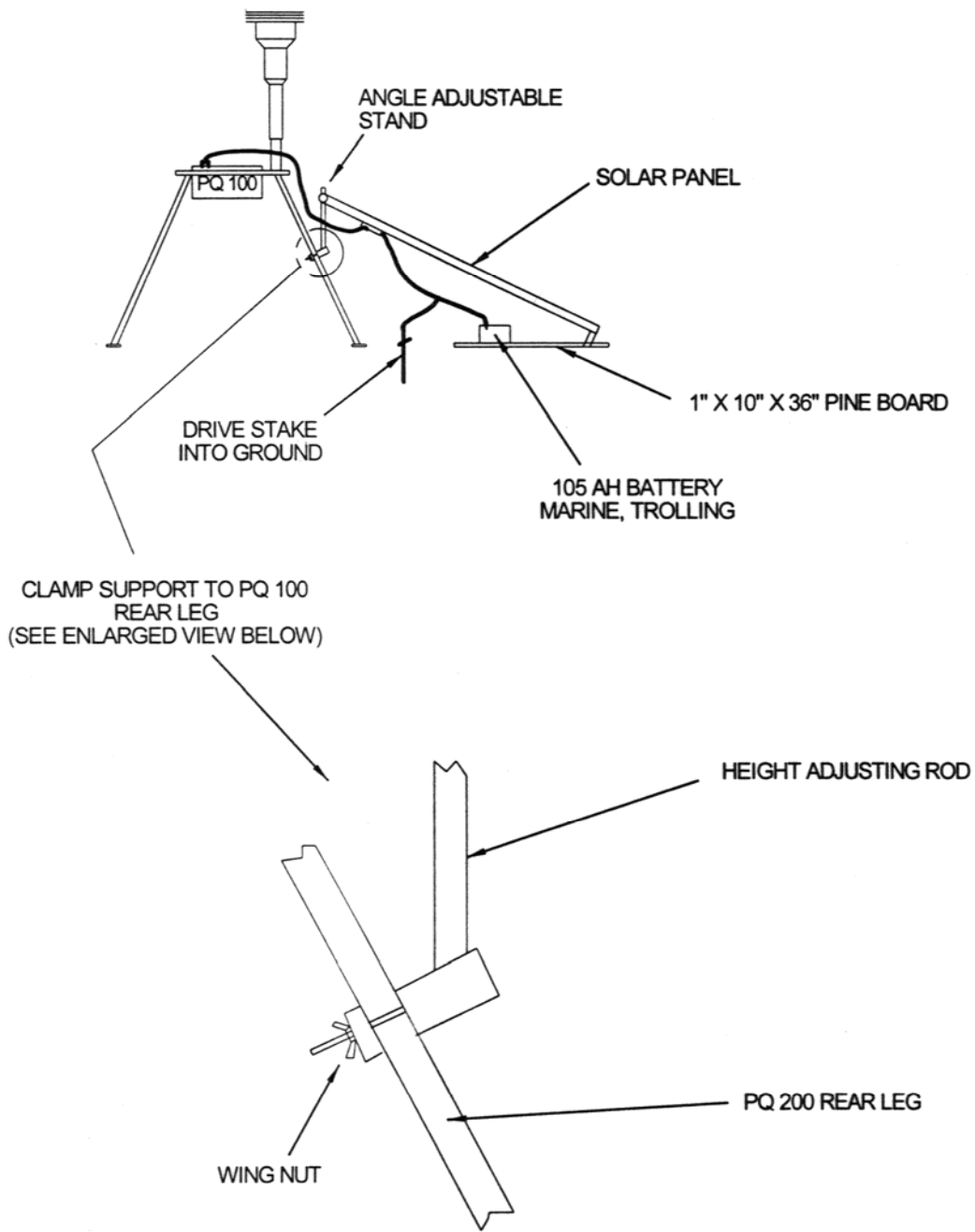Document No. SAND87-7023

Solar Panel Parts List

Quantity	Figure	Part Number	Description
1	N 1	SP-21	Solar panel assembly
1	N 4	A1920	PQ100 adapter cable

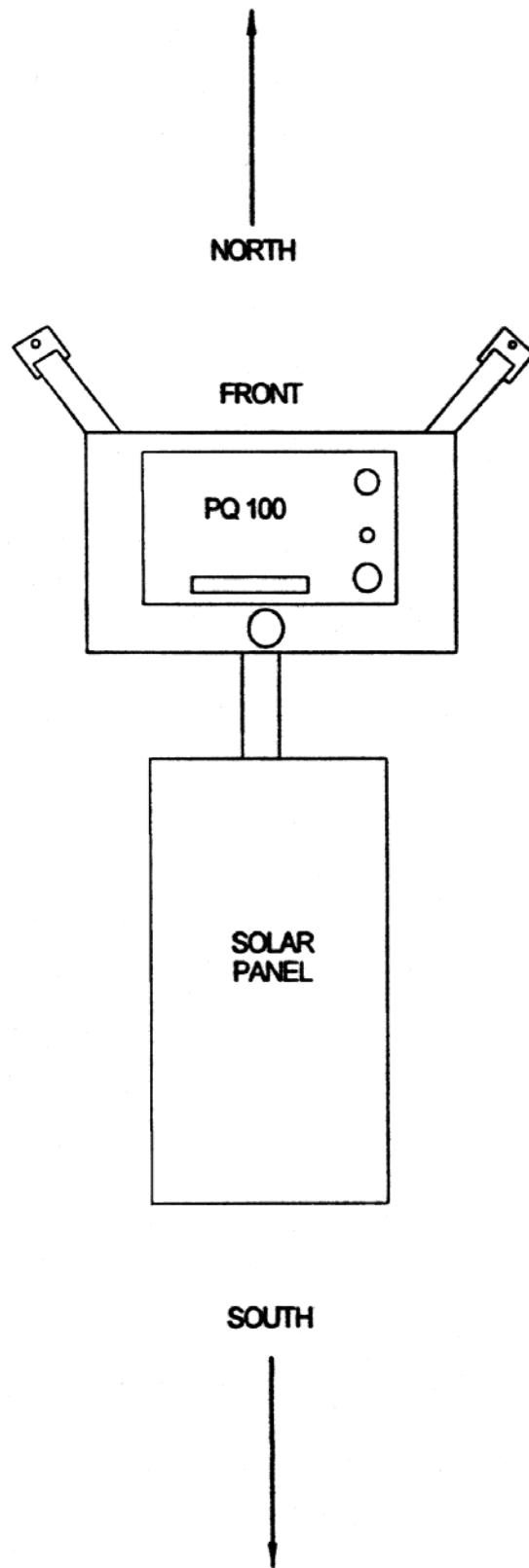TABLE N1.   Clear Sky Insolation Data from Northernmost to Southernmost U.S. cities[1].

Months wherein full charge can be maintained.

City	N. Latitude	Continuous Sampling	Every other day Sampling	Third day Sampling	Sixth day Sampling
Caribou, ME	46° 52'	Mar-Aug	Jan-Oct	Jan-Dec	Jan-Dec
Boston, MA	41° 40'	May-Sept	Jan-Nov	Jan-Dec	Jan-Dec
Raleigh-Durham, NC	35° 52'	Apr-Aug	Jan-Dec	Jan-Dec	Jan-Dec
Miami, FL	25° 48'	Feb-Sep	Jan-Dec	Jan-Dec	Jan-Dec

NOTE: This approximation is based upon 5 Kwh/M^2 received, as being necessary to fully restore the PQ100 system whilst drawing 500 MA (typical).

ANGLE ADJUSTABLE STAND

SOLAR PANEL

PQ 100

1" X 10" X 36" PINE BOARD

DRIVE STAKE INTO GROUND

105 AH BATTERY MARINE, TROLLING

CLAMP SUPPORT TO PQ 100 REAR LEG (SEE ENLARGED VIEW BELOW)

HEIGHT ADJUSTING ROD

PQ 200 REAR LEG

WING NUT

Figure N1. Setup of Solar Panel

Figure N2. Orientation

VERTICAL
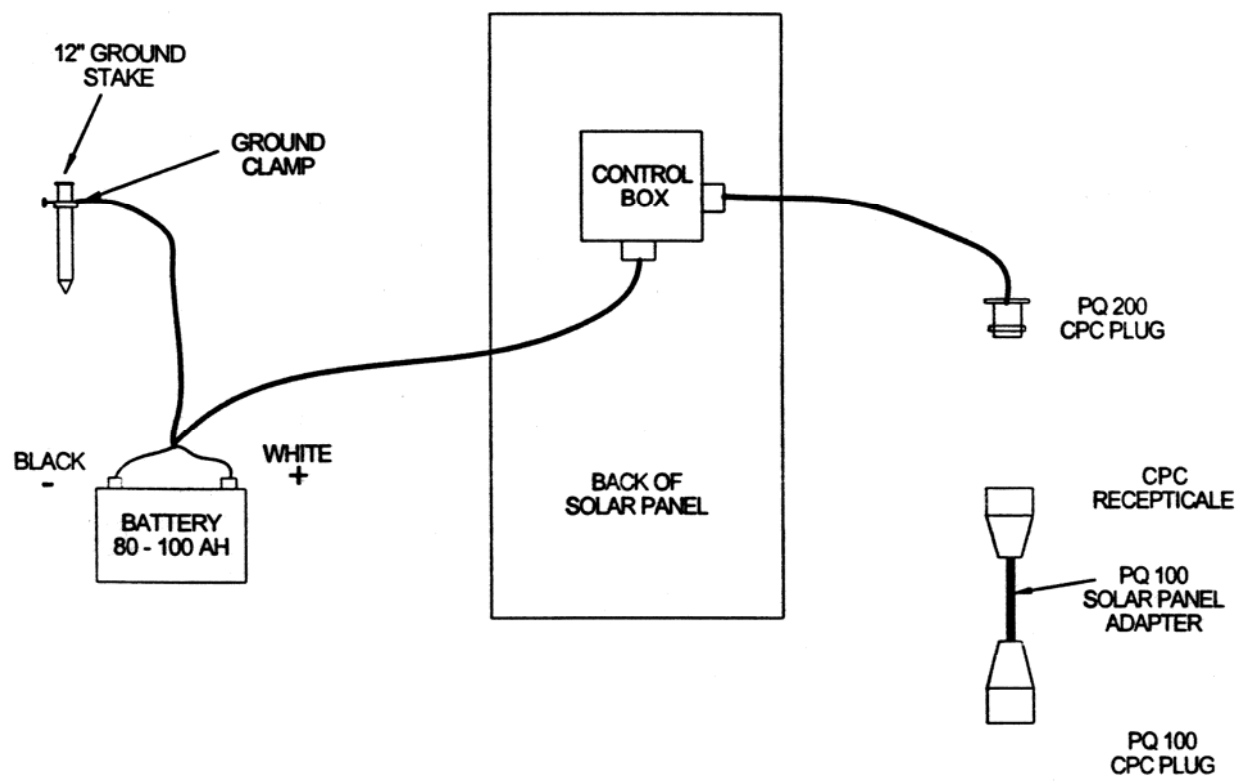MEASUREMENT
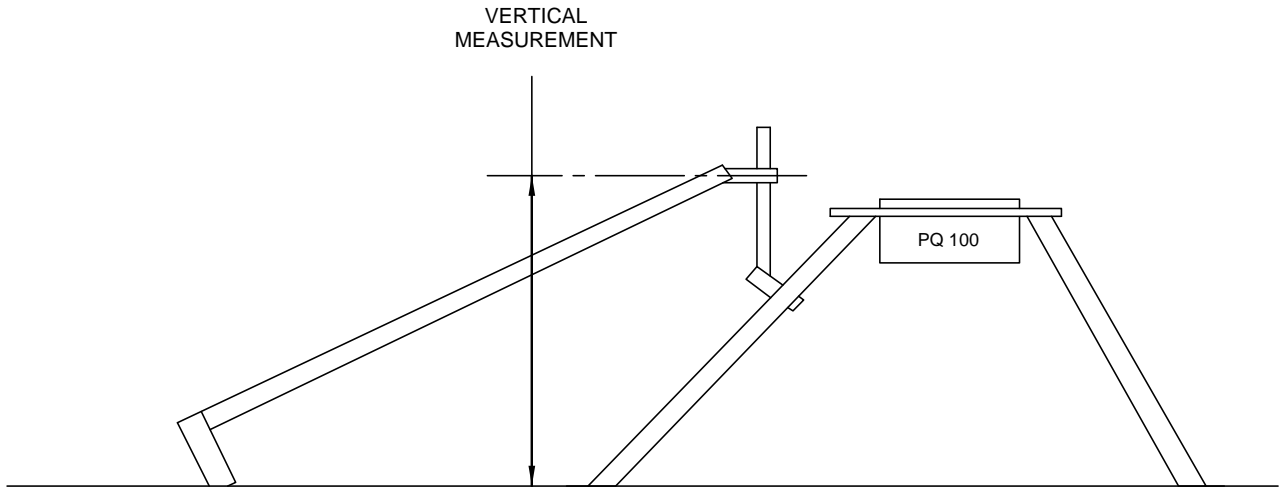
BEFORE USING THE CHART BELOW DETERMINE WHETHER YOU HAVE THE
LONG STYLE (13" WIDE x 51" LONG) OR THE SHORT STYLE (21" WIDE x 25" LONG)
SOLAR PANEL

| VERTICAL MEASUREMENT | | | | TILT ANGLE |
| SHORT STYLE (21"x25") | | LONG STYLE (13"x51") | | |
INCHES	CM	INCHES	CM	DEGREES
12.2	30.0	18.7	47.5	15
16.1	40.9	27.5	69.8	25
19.8	50.3	35.2	89.4	35
22.3	56.6	42.2	107.2	45
24.5	62.2	48.0	121.9	55
25.5	64.8	51.8	131.6	65

Figure N3. Setting Tilt Angle

12" GROUND
STAKE

GROUND
CLAMP

CONTROL
BOX

BACK OF
SOLAR PANEL

PQ 200
CPC PLUG

BLACK
−

WHITE
+

BATTERY
80 - 100 AH

CPC
RECEPTICALE

PQ 100
SOLAR PANEL
ADAPTER

PQ 100
CPC PLUG

FIGURE N4 WIRING CONNECTIONS

APPENDIX O. RIGID MOUNTING ASSEMBLY

Introduction

The original PQ167 utilized a tripod assembly, which held the PQ100 pump in a swinging cradle. This assembly, now designated PQ167S, is detailed in Figures 4, 5, and 6. A new, improved rigid assembly is available designated PQ167R. Details of this new assembly are shown in Figures O.1 and O.2. *(January 2000: Only PQ167R is now in production.)*

Description

The inlet is still maintained at a height of two meters above the ground, with the filter holder plugged directly into the bottom of the PM10 inlet, as previously done.

An outlet cap for the bottom of the filter holder has been designed which is similar to the EPA L30 component with the addition of an "O" ring. This allows the filter holder to be placed onto a down tube which is a longer version of the EPA designed L19 component. Inasmuch as particulate matter is removed from the air stream prior to passage through the tube its increased length is not a consideration.

The downtube slips over a support member welded into a plate, which serves multiple functions. The support member serves as a water trap and is fitted with the same drain valve as is used in the PQ200 water trap. The support plate has a rectangular slot into which the PQ100 pump module can be placed, this supports the PQ100 at waist height for ease of use. Three stub legs are welded to the bottom of the support plate, which permits the attachment of 3 legs, which are interchangeable with the legs on the PQ200.

ASSEMBLING THE PQ167R PM10 AIR SAMPLING SYSTEM

Included with your PQ167R PM10 Air Sampler System are the following items. Item #'s are indicated on the appended drawings.

Item #	Quantity	Part Number	Description
14	1	PQ100	Air Sampler Main Unit
*	1	PQ101	Battery Charger/Auxiliary Power Supply
34	1	PQ102	Hose Adapter
*	1	CQ1	Charger/External Battery Cable
*	1	CQ2	PC Communication Adapter Cable
*	1	*	Manual and Software CD
12	1	HS5	1 foot; Rubber Hose
11A	1	TP100R	Tripod Frame
*	3	A1634	Legs
01	1	SSI-2.5	Inlet
3	1	JR3035	Water Jar
165	1	F20	Filter Holder (Requires F21 Cassette)
*	1	F21	47mm Filter Adapter Cassette w/Screen
162	1	A1751	Long Down Tube
161	1	A1904	Filter Adapter
163	1	2245	Stabilizer
160	3	1634	Legs

For complete system assembly refer to Figures 4, 5, 6, O.1 and O.2.
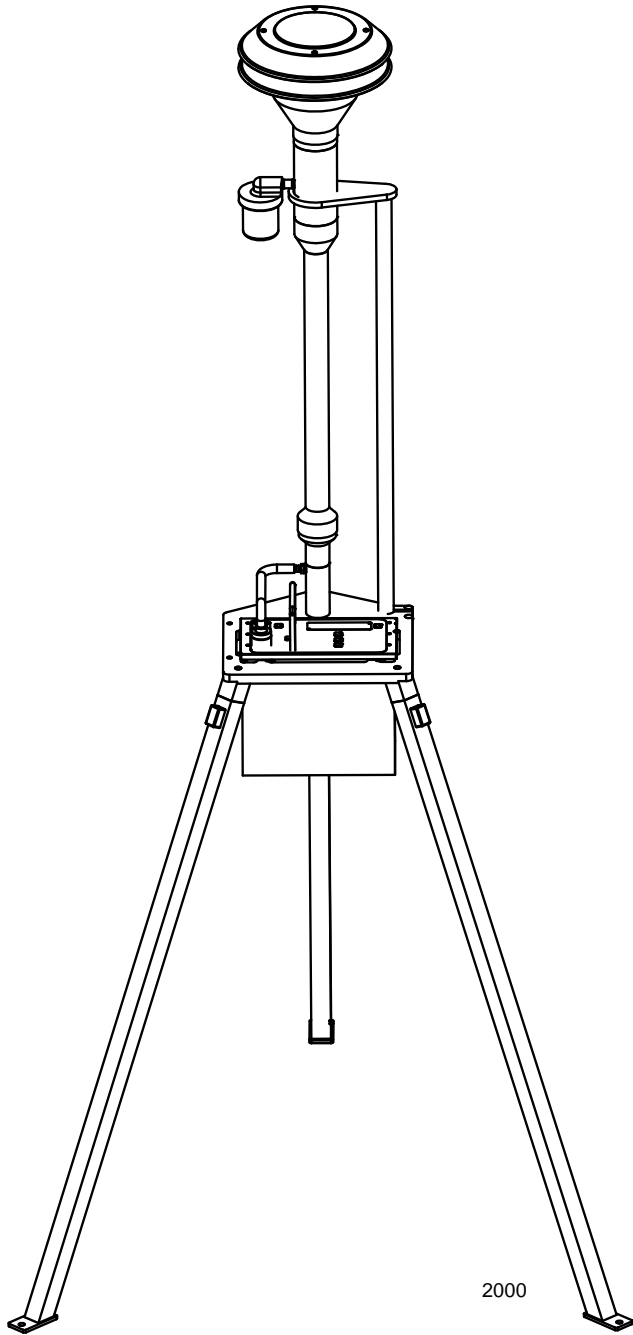
2000

Figure 0.1 PQ167R Rigid Mounting Stand

01

03

162

34

165

163

161

12

11A

160

1999
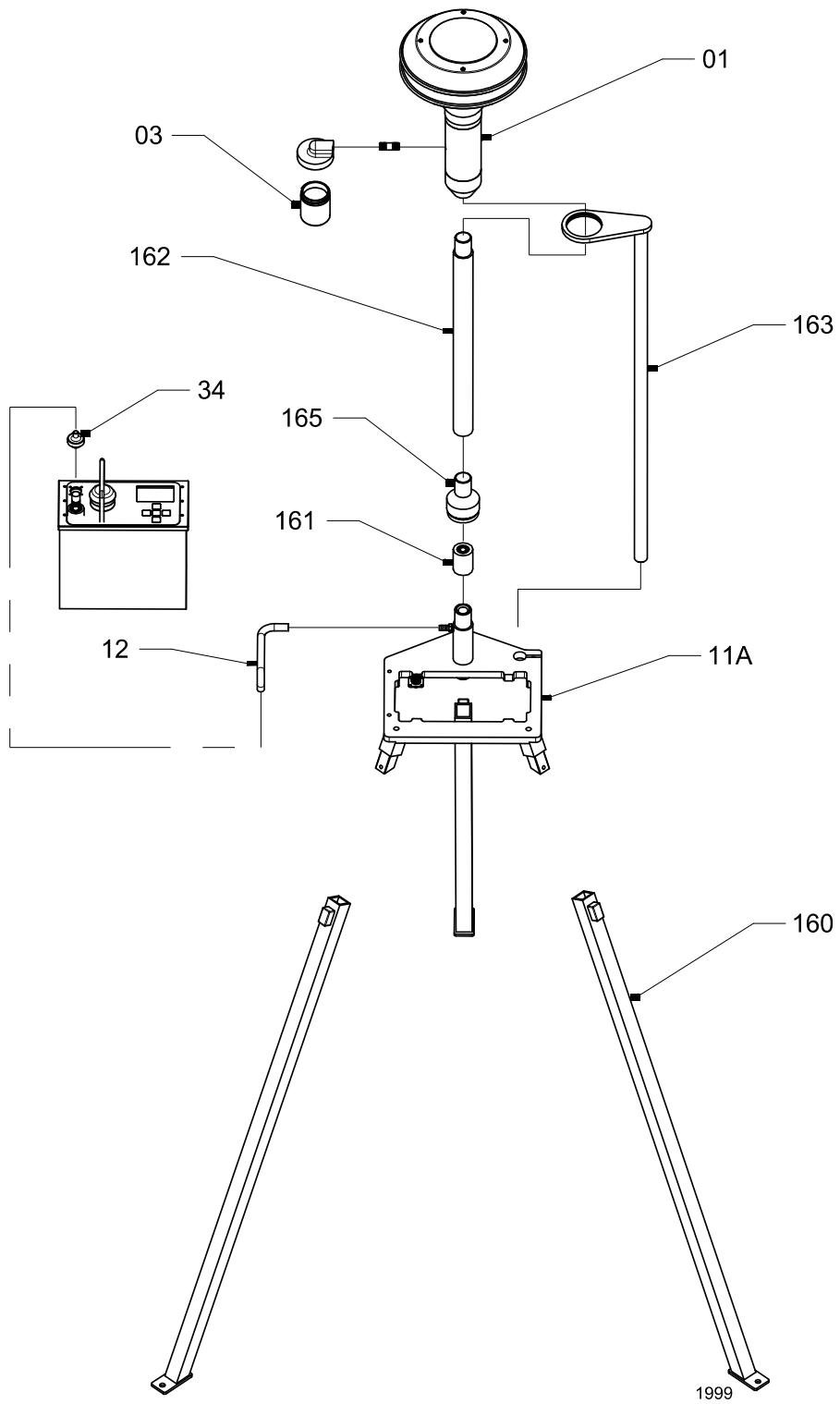
Figure 0.2 Exploded View of PQ167R Stand

APPENDIX P. PQ167 High Altitude (*mini*PM Inlet)

IMPORTANT: FLOW RATE MUST BE SET FOR 5 lpm

1.0 Size selective inlet

The size selective inlet will be familiar to all who have had experience with the Standard EPA Louvered Inlet in its original 16.7 lpm configuration. The only two differences are that it has been scaled down to 1/3 its original dimensions and the acceleration jet in the impactor is changeable over five size ranges. An exploded diagram of the inlet is shown in Figure 9 with all parts identified.

2.0 Jet Differential

If a Size Selective Jet (SSJ) other than PM10 was ordered/furnished with your instrument it was furnished as a separate item. The individual jets are hand detachable and removed/installed by screwing in and out. A light grease should be applied to the threads to prevent seizure. Jets manufactured prior to May,2005 were not marked. As a guide to their functional size refer to the table of approximate internal dimensions below. Later jets were color coded and their functional size can also be found in the following table.

Function	P/N	I.D. (In.)	I.D. (mm)	Color
TSP	2599	0.38	9.6	Clear
PM 10	2616	0.26	6.6	Blue
PM 4.0	2741	0.14	3.6	Green
PM 2.5	2617	0.11	2.8	Red
PM 1.0	2618	2 holes	2 holes	Black

3.0 Maintenance

Items which require cleaning and maintenance are common to all ambient air sampling devices fitted with size selective inlets. The inlet and the sampler may be considered two separate items for cleaning and maintenance purposes.

Cleaning should occur once every 90 days or sooner in highly polluted environments. Until such time as sufficient experience has been gathered, the unit should be inspected once a month. In order to perform an inspection it is only necessary, after removing the inlet from the top of the filter holder to unscrew the top from the bullet as shown in Figure 10.

Normal cleaning of air sampling inlets is generally, best done with clean water and lint free wiping cloths. If an ultrasonic cleaner is available it is the preferred device as it will remove dirt from deep corners and pockets, avoiding the need for further disassembly. After ultrasonic, or any liquid cleaning, be certain to dry thoroughly before reassembling and placing in service.

Summary of Maintenance Items:

Frequency*	Maintenance item
Every 5 sampling days	1. Service water collector bottle
Monthly	1. Clean inlet surfaces 2. Check inlet screen for any clogging
Quarterly (every 3 months)	1. Inspect O-rings. Remove and lightly coat them with Vacuum grease. 2. Clean impaction surface.

*Frequency may vary depending on climate, amount of particulate matter in the air, weather, and so on.
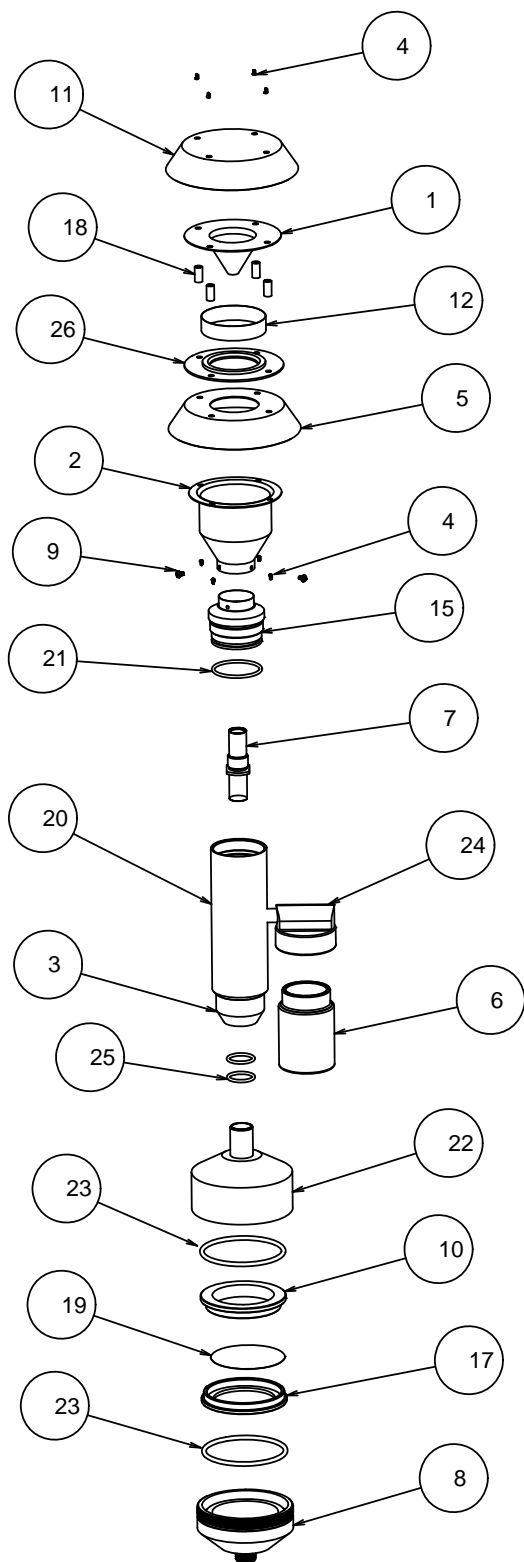
Detail #	Part #	Qty.	Description
1	2585	1	2585 WIND DEFLECTOR
2	2583	1	2583 NOZZLE ENTRY
3	2602	1	2602 EXIT ADAPTER
4	10002	8	4-40 x 1-4 PAN HEAD
5	2586	1	2586 LOWER PLATE
6	OC13	1	JAR
7	2617	1	2617 NOZZLE INSERT, PM 2.5
8	1425	1	1425 FILTER HOLDER
9	OM10124	3	2-56 x 1-8 PAN HEAD
10	1727-L27	1	1727-L27 CASSETTE UPPER SEC.
11	2584	1	2584 TOP
12	2589	1	2589 SCREEN
13	2596	3	2596 RECEIVER TUBE
14	2595	1	2595 TARGET PLATE
15	2598	1	2598 IMPACTOR NOZZLE
16	OM10123	1	NIPPLE
17	1729-L29	1	1729-L29 CASSETTE LOWER SEC.
18	2588	4	2588 SPACER
19	1728-L28	1	1728-L28 FILTER SCREEN
20	2597	1	2597 OUTER TUBE
21	024 BUNA	1	024 ORING
22	2672	1	2672 UPPER FILTER HOLDER
23	135 BUNA	2	135 ORING
24	OM10120	1	JAR TOP
25	015 BUNA	2	015 ORING
26	2587	1	2587 RAIN DEFLECTOR

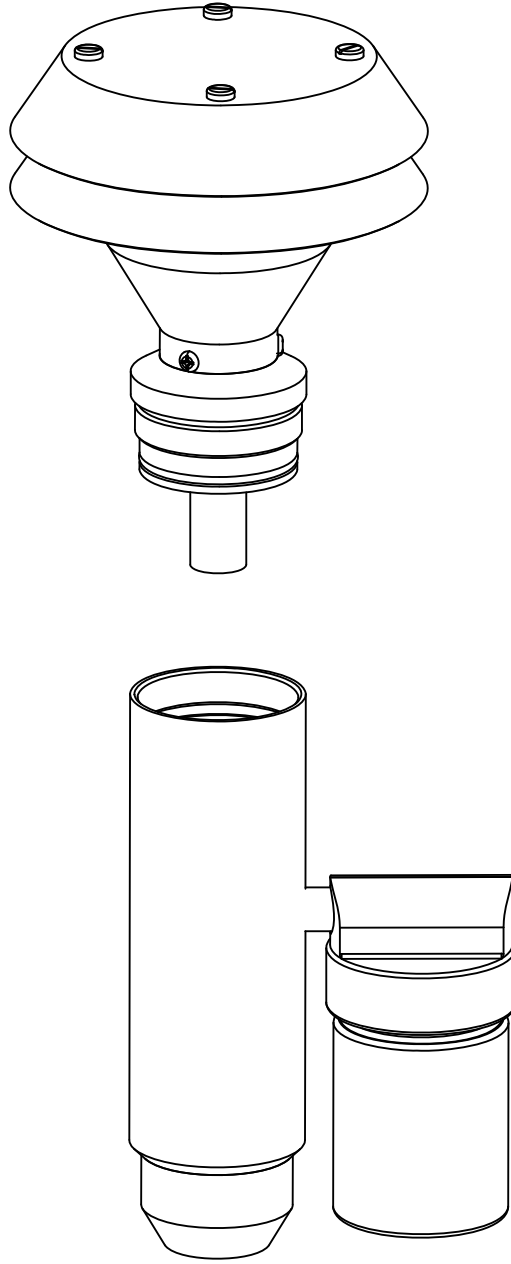Fig. 9 Exploded Diagram of Inlet with Filter Holder

Figure 10: Photo of Initial Disassembly of Inlet

The jet may also be removed from the top of the inlet as shown in Figure 11.
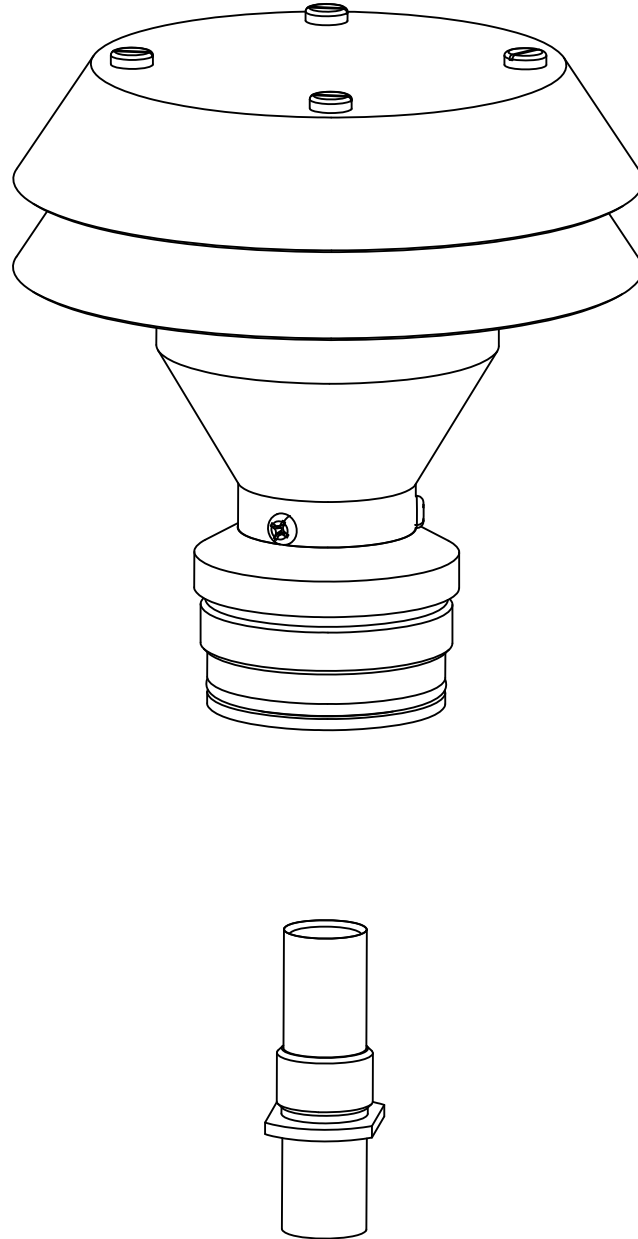

Figure 11: Photo of Jet Removed for Cleaning or Size Change

PQ100 Instruction Manual Revision History

Version 5.0   Updated to WP6.0 format   March 1998

Version 6.0   Added Preface, Safety, Appendix L, M, N, and O   December 1998
              Added Designation Information

Version 6.01 Corrections to Replacement Component List   February 1999

Version 6.02 Corrections to Appendix M   April 1999

Version 6.03 Corrections to Appendix N   January 2000

Version 6.1   Miscellaneous corrections   January 2000

Version 6.2   Miscellaneous corrections   May 2002

Version 6.21 Added note to Appendix M   October 2003

Version 6.22 Added Appendix P   September, 2005

Version 6.23 Ch'd tetraCal to TetraCal   May, 2007

Version 6.24 Added firmware version to Cover   November, 2008