User's Guide...

Realtime PAH Monitor

PAS 2000

EcoChem Analytics

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CUSTOMER SERVICE

We at EcoChem want to provide you with the very best customer service possible. If you have any questions, problems or comments about the PAS 2000, we would like to hear from you. In addition, it is recommended that all maintenance and repair work on the PAS 2000 should only be done by customer service or appropriately trained personnel. You can reach us at:

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SAFETY INSTRUCTIONS

In this User's Guide we will try to indicate explicitly hazardous situations that may result in potential personal injury or damage to the instrument.

Please read this User's Guide carefully before installing and using the instrument. In particular, please pay attention to paragraphs that refer to possible hazardous situations.

Warnings and references are presented as follows:

! **Warning**	Indicates that non-compliance with the instructions can lead to potential personal injury.

Attention	Indicates that the instructions must be followed explicitly to avoid damage to the instrument.

! **Warning**

Voltage

Danger of potential injury

- Always run the instrument with a ground connection (earthing).
- Under no circumstances remove or open the internal ground connection.
- If the instrument is switched on, the electrical connections are charged. Hence do not attempt to touch internal components when the instrument is switched on. Internal components should only be touched or removed when the monitor has been switched off.
- **The lamp power supply is operated at high voltage. Do not attempt to touch the lamp power supply when the instrument is switched on.**

The following general guidance should be followed during operation of the PAS 2000:

- Do not touch the interior components of the instrument when it is switched on.
- Never operate the instrument if the cover or any other parts the instruments are removed.
- Customer service or appropriately trained personnel should only do maintenance and repair work.
- If you observe that the instrument has insufficient grounding or that the grounding connection is damaged, please take the instrument out of operation and prevent unauthorized use of the instrument.

Some situations leading to insufficient instrument grounding include:

- Instrument has visible physical damage.

- Instrument was stored for a long time under unfavorable conditions (e.g. high humidity environments).
- Instrument was handled improperly during transportation and shipping.

⚠ **Warning**	Explosive gases in the operating environment The instrument should never be operated in an explosive environment.

Some other environments that can lead to operating problems and should be avoided include:

- Outdoor environments where the instrument is not appropriately protected from nature's elements (sun, rain and snow).
- Excessively high humidity environments.

1 INTRODUCTION

This User's Guide describes the PAS 2000. Special configurations such as housings and the Sampling System are described in separate documents.

Chapter 2 provides information regarding the **Measuring Principle** of the PAH monitor. Chapter 3 describes **Installation and Start Up** of the instrument. Chapter 4 presents **Operating Procedures.**

Appendix A is a **General Overview of Polycyclic Aromatic Hydrocarbons**. It contains a discussion of PAH compounds, their formation, sources of PAHs, human exposure, toxicity and associated regulations. Appendix B describes **Data Acquisition** from the monitor and the associated PAS 2000 Data Acquisition Software. Appendix C provides information regarding the **Dilution System** supplied with the stack version of the PAH monitor. Appendix D provides instructions regarding **Replacement of the Excimer Lamp**.

The User's Guide contains no Service or Maintenance related instructions. Appropriately trained personnel should only perform these tasks.

2 MEASURING PRINCIPLE

2.1 Physical Phenomena

The photoelectric aerosol sensor is based on the photoelectric ionization of particles. If one irradiates ultrafine particles with light having energy hν and if this energy is larger than the photoelectric threshold function, the particle emits a photoelectron. After photoemission, the original donor particle becomes a positively charged particle.

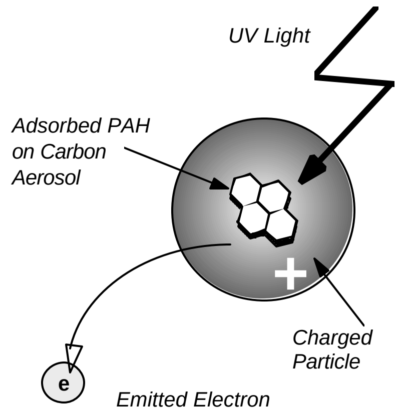


Fig. 1: Principle of the Photoelectric Aerosol Sensor

By themselves, the particles are not capable of photoemission. However the particles frequently have a layer of PAH, which are condensed or adsorbed on the surface. These surface bound PAH molecules can be easily photoionized.

A free gas molecule or another charged particle can capture the photoelectron emitted from a particle. The recapture probability (i.e. chance that the photoelectron meets a charged particle or encounters a neutral gas molecule) is high for large particles. From this it follows that photoemission is especially effective for small particles in the ultrafine region. This group of ultrafine particles is however of particular interest, because these particles are capable of reaching the lower respiratory tract and pose maximum health risk concerns.

The charge created by photoemission can be modeled as:

$$dN^+ / dt = f\{ \Phi_{UV}, \pi (r_p)^2, Y(h\nu), F, N \}$$

where

N^+	= Number of positive charged particles
t	= Time
Φ_{UV}	= Light intensity
$\pi (r_p)^2$	= Illuminated cross section of the particles
$Y(h\nu)$	= Photoelectric yield (depending on the light energy)
F	= Fraction of particle surface capable of photoemission

N = Number of particles

With Φ_{UV}, $\pi(rp)^2$, $Y(h\nu)$, N being constant, the charge rate is a direct measure of the PAH concentration. This charge is measured by the PAH sensor. For a reproducible measurement it is most important that the lamp energy, particle geometry and chemical composition remain essentially constant. From previous scientific studies, it has been observed that most combustion sources have a unique “PAH-signature“, i.e. within a specific operating range, a combustion source will consistently produce similar PAH along with a specific particle size distribution.

The dependence of the charge production on the lamp intensity is non-linear and varies between different applications. Therefore all instruments are delivered with a normalized lamp intensity. The lamp intensity is automatically controlled internally to avoid a drift of the sensitivity during the lifetime of the lamp. In addition the flowrate of the instrument is also controlled at a constant value of 2 liters/min.

2.2 Measuring Principle

The measuring principle of the instrument is illustrated in Fig. 2. The particle-loaded flow is passed through a quartz tube. Around the quartz tube an excimer lamp is mounted. The excimer lamp is a hollow double-wall quartz tube. The hollow space (2 mm thickness) between the concentric walls is filled with Krypton (approx. 300 mbar) and traces of Chlorine. The electrodes are external to the lamp. The outer electrode of the lamp is a metallic reflecting tube. The inner electrode is transparent to the light. The lamp is operated at high frequency and at high voltage. The lamp radiation occurs at 222 nm with an approximate half-bandwidth of 2%. A silicon detector measures the intensity of the radiation. This signal is used for controlling the intensity of the lamp. The intensity control is achieved by adjusting the lamp frequency.

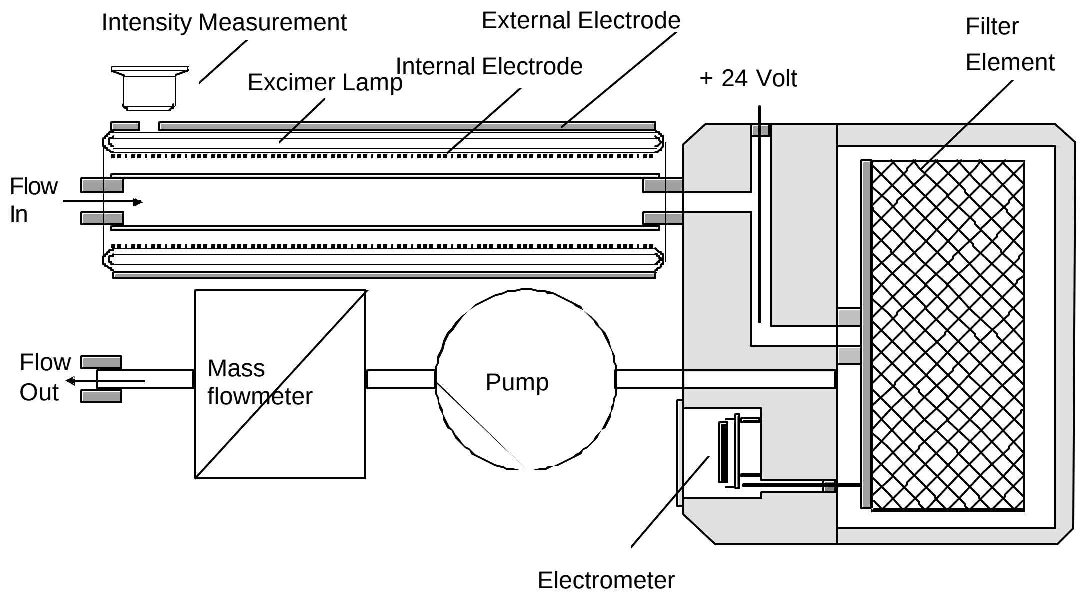


Fig. 2: Process Schematic for the Photoelectric Aerosol Sensor

The charged particles then flow through a short tube before entering a filter component. Within this tube a small voltage is applied to remove all negatively charged particles safely. Subsequently the charged particles are collected on a filter element, which is mounted in a Faraday cage. The electrical current associated with the ion current is shunted over an electrometer and measured.

PAH-sensors manufactured in the past used a mercury lamp, which was operated on a continuous basis. The mercury lamp requires a warm-up time and hence always had to be switched on. The advantage of the excimer lamps is that they can be switched on and off without any delay. The use of the excimer lamp in a pulsed mode suggests itself. The measurement signal is obtained by integration over the current pulse produced during the time of exposure. The advantage of this pulsed-mode operation is that any background interference of the signal by precharged particles is avoided. In addition any drift of the baseline is suppressed.

The pump behind the filter is operated at constant flow in order to eliminate the dependence of the measuring current on the total flowrate. This is achieved by the use of a mass flowmeter. The optimum flowrate is 2 liters/min.

3 INSTALLATION AND START-UP

For the installation and start-up the following has to be done:

1. Set up of the PAS 2000.
2. Make the electrical connections.
3. Introduce the gas to be measured into the gas inlet.
4. Switch on the PAS 2000.

3.1 Set Up

The standard version of the PAS 2000 is delivered as a desktop configuration. There are no special requirements concerning the position of the instrument.

You can operate the PAS 2000 in an environment where the ambient temperature ranges between 40 to 104 °F (5 to 40 °C).

Attention

Always avoid exposing the instrument to excessive vibration and high humidity environments.

3.2 Electrical Connections

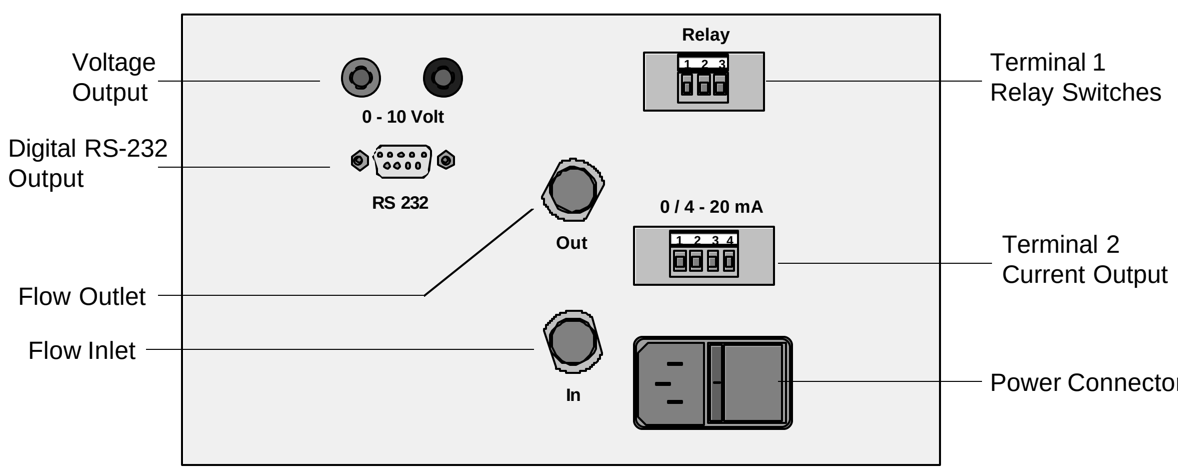


Fig. 3: Back panel with electrical connections

3.2.1 Power Connection

The PAS 2000 can be operated with 50 or 60 Hz and 230 volts as well as 115 volt. A switch for the different voltages is not necessary. The power connection is located on the back panel of the instrument. The power switch is integrated into the power connection.

3.2.2 Signal Output

The PAS 2000 has the following signal outputs located on the back panel :

Current Output 1 :	Pins 1 and 2 located on Terminal 2
	0 / 4 - 20 mA with a load factor of 500 Ohm
	This output signal can be used for monitoring the concentration signal within the actual measuring range.
Current Output 2 :	Pins 3 and 4 located on Terminal 2
	0 / 4 - 20 mA with a load factor of 500 Ohm
	This output signal can be used to monitor the lamp intensity (20 mA corresponds to a display of 100 on the LCD)
Voltage Output	0 - 10 Volt
	This output signal can be used for monitoring the concentration signal within the actual measuring range.
Maintenance Relays	On Terminal 1 we have two possible relay switches :
	(Pins 1 and 2) or (Pins 2 and 3)
	Pins 2 and 3 are open if no maintenance situation is selected.
Serial Interface	Baud rate : 9600 Baud
	Data bit : 8 Bit
	Parity : No
	Stop bit : 1

3.3 Gas Inlet

The connection for gas inlet and outlet comprises of a 1/4“ NPT female thread. Any standard fittings can be used with this connector.

Attention

While mounting the fitting on the connector, hold the external connector tightly with a wrench. Failure to do so can lead to damaged screw threading inside the instrument.

3.4 On Switch

Power on the instrument using the switch on the back panel. The instrument’s front display will show measured values. When first powered on (“cold start”), the instrument may require a few minutes of warm-up time (4 measuring cycles). With the keyboard on the front panel you can then make adjustments regarding the operation of the instrument.

4 OPERATING PROCEDURES

4.1 Front Panel

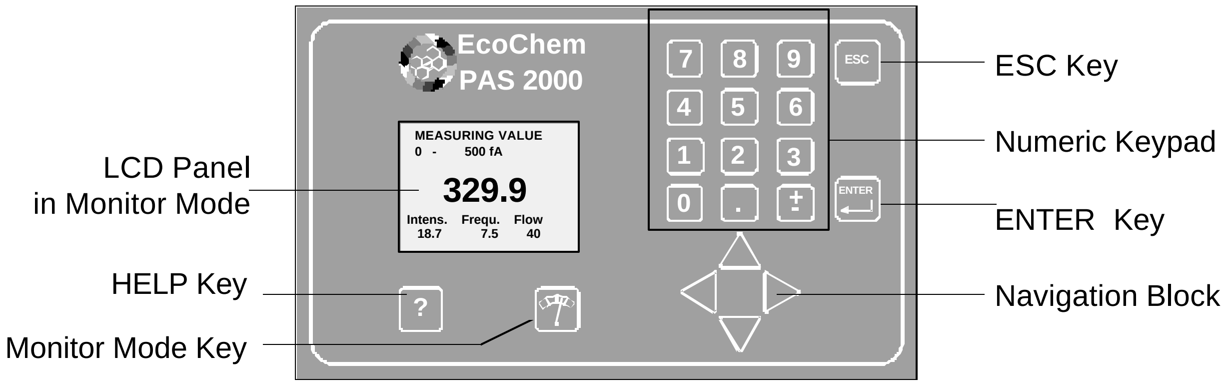
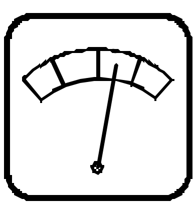


Fig. 4: Front Panel of the PAS 2000

The User Interface of the PAS 2000 uses a familiar input screen methodology. Screens appearing on the LCD panel have been logically designed and have been arranged in a hierarchical scheme (i.e. input screens can be accessed at different levels). On certain screens, it is possible to enter numerical values for input variables. Data entered on the input screens can be saved by moving the cursor to the **SAVE** selection on the screen using **the Navigation Block keys**. The **SAVE** selection must be confirmed by pressing the **ENTER key**.

Figure 6 illustrates the screen in the monitoring mode of the instrument. This screen will appear when the instrument is initially powered on. Input screens for modifying operating parameters can be accessed from this initial display by pressing the **ESC key**.

On the front panel you will find a numeric keypad. In addition there are five special keys:



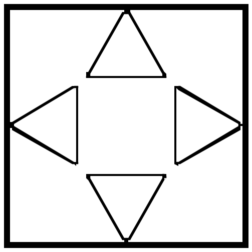
Monitoring Mode

This is a “hot” key which enables you to go directly to the Monitoring mode screen (depicted in Fig. 4) from any other screen.

Caution : If you are on an input screen, please use the SAVE and ENTER commands to save input values before you select the Monitor mode key --- otherwise you will lose the input values which you have entered.

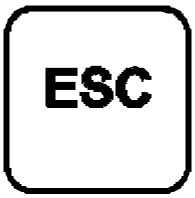
Help

This selection provides context sensitive help regarding the input screen. In the Section 4.3.8 we provide the text associated with the individual Help screens.



Navigation Block

These keys are used for navigating (Up, Down, Left, Right) on an input screen. The selected entry fields are usually highlighted. The selectable input items are shown in brackets (for example < 4 - 20 mA >). Some inputs do not require the input of numbers but comprise of a choice between different alternatives. You can toggle between and select alternative selections by using the **ENTER key**.

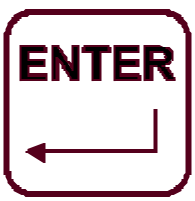


ESC Key

When the display is in monitoring mode, pressing the **ESC key** initiates input mode, starting with the Main Menu screen.

The **ESC key** always leads back to next higher level input screen.

The **ESC key** can be useful if you do not want to save changes made to an input screen. If you have entered input values and you do not want to save them, simply press the **ESC key** and old values will be restored.



ENTER Key

This key has several functions :

- Enables you to select an input screen
- For a particular input variable with fixed choices, the **ENTER key** enables you to toggle between different alternatives.
- While entering the numerical value of an input variable, the **ENTER key** confirms the input and the cursor automatically jumps to the next input item.
- The **ENTER key** is also used to confirm the **SAVE** command. In this case after pressing the **ENTER key** you will leave the input screen and go back to the appropriate higher level screen.

4.2 Input and Help Screens

In this section we will discuss the input screens associated with the PAS 2000. Help screens are available for every input screen and provide context sensitive help. The Help screen associated with the various input screens are also discussed in this section.

To initiate input mode from the monitoring mode display, press the **ESC key**. As discussed previously, the Input screens are arranged in an hierarchical scheme. The overall flowchart of the input screens is as follows :

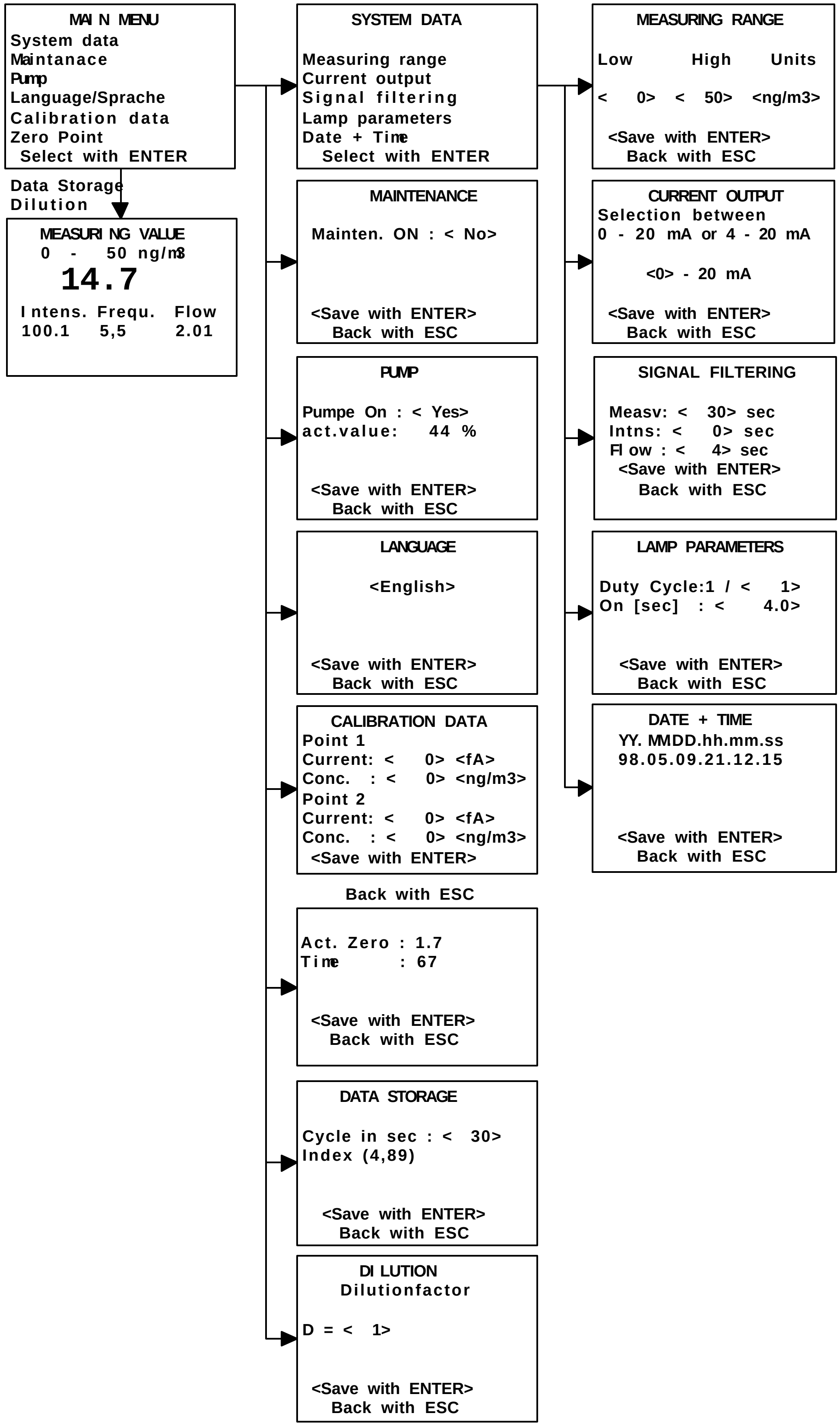


Fig. 5 : Overall Flowchart of the Screens in the User Interface

4.2.1 Becoming Familiar with the User Interface

Before explaining to you in detail the contents of each screen, we want you to become comfortable with the User Interface of the PAS 2000. In this section we will provide you hints as to how to use the User Interface efficiently. We will also walk you through two examples. By following explicitly the steps which we outline you will become familiar with the User Interface.

4.2.1.1 Tips, Tricks and Pitfalls

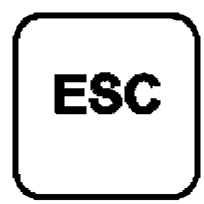
- On most screens you will observe the selection **<Save with ENTER>**. Use this selection to save the values which you have entered on the screen. When you select **<Save with ENTER>** the user interface will also **automatically exit** from the screen and take you to the next appropriate screen. Thus you should use the **<Save with ENTER>** after you have entered all selections on the screen.

LANGUAGE
< English >
<Save with ENTER>
Back with ESC

- On most screens you will also observe the selection **Back with ESC**. This means that at any time you can press the **ESC key** to exit a screen.

  ***A word of caution* --- when you press the ESC key the entries on the screen will NOT BE SAVED.** Thus you should use this key if you do not want to save the changes which you have made to a screen.

LANGUAGE
< English >
<Save with ENTER>
Back with ESC



- If you are lost in the Menu scheme, do not worry !!! Simply press the **ESC** key a couple of times and you will finally end up on the **MAIN MENU** screen. This is the topmost selection. Refer to Fig. 5 which provides you with an overall flowchart of the screens.

- On several screens you will have the capability to enter a **precise number** for a variable. In order to enter the number use the **Numeric Keypad**.

  For example, suppose you want the **On [sec]** to be 7 seconds. Then you can use the Numeric Keypad to enter 7 for the value of this variable.

LAMP PARAMETERS
Duty Cycle : 1 / < 1 >
On [sec] : < 4.0>
<Save with ENTER>
Back with ESC

- On other screens you will encounter a variable which has a definite list of selections. In order to toggle between the selections, place the cursor on the entry using the **Navigation Block Keys** and then use the **ENTER key** to cycle through the list of selections.

  For example, in this case the language selection can be English or German. Using the **ENTER key** you can toggle

LANGUAGE
< English >

between the selections.

Next, use the **Navigation Block keys**, position the cursor on the **<Save with ENTER>** selection and press **ENTER** to save the setting.

<Save with ENTER>
Back with ESC

4.2.1.2 Walkthrough Exercise 1 --- Turning Off the Pump

For this example we want to use the user interface to turn off the pump. Here are the steps :

1 If the current screen display differs from the one at the right, press the **ESC** key several times until you reach the **MAIN MENU** screen.

MAIN MENU
System Data
Maintenance
Pump
Language
Calibration Data
Zero Point
Select with ENTER

2 Using the **Navigation Block keys**, move the cursor until you are on the **Pump** entry.

MAIN MENU
System Data
Maintenance
Pump
Language
Calibration Data
Zero Point
Select with ENTER

3 Press **ENTER** to select the entry and then the **PUMP** screen will be displayed.

PUMP
Pump On : <Yes>
Act. Value : 44 %
<Save with ENTER>
Back with ESC

4 Using the **Navigation Block keys**, move the cursor until it is on the **<Yes>** selection for the **Pump On** entry.

PUMP
Pump On : <Yes>
Act. Value : 44 %
<Save with ENTER>
Back with ESC

5 Press the **ENTER key** to toggle between **<Yes>** and **<No>** for this selection. Since we want the pump to be off, make sure that the final value of this entry is **<No>**.

PUMP
Pump On : <No>
Act. Value : 44 %

<Save with ENTER>
Back with ESC

6 Using the **Naviagation Block keys**, position the cursor on the **<Save with ENTER>** selection. Press **ENTER** to save the Pump setting. The pump should now be off.

PUMP
Pump On : <No>
Act. Value : 44 %
<Save with ENTER>
Back with ESC

4.2.1.3 Walkthrough Exercise 2 --- Defining the Measuring Range

For this example we want to use the user interface to define the **Measuring Range**. We want the PAS 2000 to display values between 0 to 10 picoamp. Here are the steps :

1 If the current display on your monitor does not match the one at the right, press the **ESC key** several times until you reach the **MAIN MENU**.

Using the **Navigation Block keys**, move the cursor until you are on the **System Data** entry.

MAIN MENU
System Data
Maintenance
Pump
Language
Calibration Data
Zero Point
Select with ENTER

2 Press **ENTER** to select the entry and the display will change to the **SYSTEM DATA** screen.

Using the **Navigation Block keys**, move the cursor until you are on the **Measuring Range** entry.

Press **ENTER** to select the entry and the display will show the **Measuring Range** screen.

SYSTEM DATA
Measuring Range
Current Output
Signal Filtering
Lamp Parameters
Select with ENTER

3 Using the **Navigation Block keys**, move the cursor until it is on the **Low Value** selection.

Using the **Numeric Keypad** enter 0000 *(note, the user interface requires you to enter four digits for this selection).*

Press **Enter** to save the selection.

MEASURING RANGE
Low High Units
< 0 > < 50 > < ng/m3 >
<Save with ENTER>
Back with ESC

4 Using the **Navigation Block keys**, move the cursor until it is on the **High Value** selection.

Using the **Numeric Keypad** enter 0010 *(note, the user interface requires you to enter four digits for this selection and hence you have to enter leading zero).*

Press **Enter** to save the selection.

MEASURING RANGE
Low High Units
< 0 > < 10 > < ng/m3 >
<Save with ENTER>
Back with ESC

5 Using the **Navigation Block keys**, move the cursor until it is on the **Units** selection.

Now use the **ENTER key** to toggle between various

MEASURING RANGE
Low High Units

selections. Select **femtoamp (fA)** from the list.

```
< 0 >   < 10 >  < fA >

<Save with ENTER>
Back with ESC
```

6 Using the **Navigation Block keys**, position the cursor on the **<Save with ENTER>** selection. Press **ENTER** to save the settings. The instrument will now display values in the range of 1 to 10 microgm/m3.

```
MEASURING RANGE

Low     High    Units
< 0 >   < 10 >  < fA >

<Save with ENTER>
Back with ESC
```

4.3 Explanation of Each Screen

For the rest of this Chapter we will provide you with a detailed explanation of every screen that is part of the User Interface. For each screen, we explain its purpose, its variables, and how to enter and exit the screen. We will also highlight special issues that are associated with variables on the screen.

4.3.1 Measuring Value

Purpose :	On this screen you can observe the measured values. You can also obtain a summary of important operating parameters (lamp intensity, lamp frequency and flowrate).
How to Reach this Screen :	Save the selections which you are making on any screen. Press the **Monitoring Mode** key on the Front Panel
How to Exit this Screen :	Press the **ESC key** on the Front Panel. You will reach the **MAIN MENU** screen

Screen Layout :

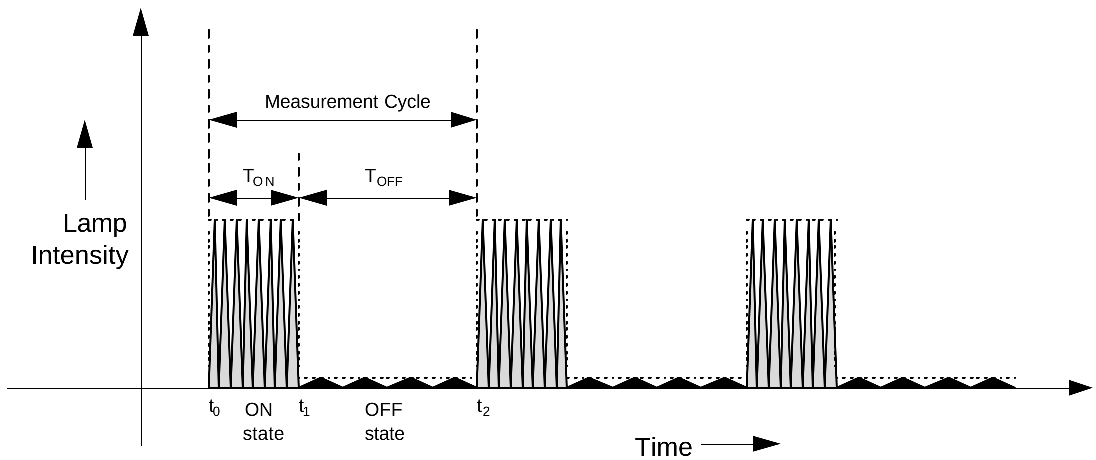
```
        MEASURING VALUE
      0    -   50   ng / m3

             14.7
  Intens.     Frequ.      Flow
  99.6        5.5         1.95
```

Notes :

On this screen you will observe the numerical values of several variables :

- The measured value is displayed in big digits. The range and units of the measured value are indicated on the second line of the screen. The units and range can be modified by using the **System Data / Measuring Range** input screens.
- The actual light intensity, actual lamp frequency and the gas flowrate values appear towards the bottom of the screen:
  - The light intensity is displayed as percentage of the nominal value of the instrument. A value of 100 indicates that the instrument is operating at the exact nominal value. Slight deviations can be tolerated since the final output of the reading is corrected using the deviation.
  - The lamp frequency is displayed in kilohertz (kHz). The frequency increases during the lifetime of the lamp. The maximum frequency value is 21 kHz. <u>If the frequency value exceeds 15 kHz it is recommended that you order a new lamp.</u>
  - The flow is displayed as liters/min. The nominal value is 2.0 l/min. Here again deviations from the nominal value are taken into account to correct the final reading of the concentration output.

- The last line of this screen is reserved for failure messages and warnings. Under normal operation of the instrument this line is usually blank.



One measurment cycle comprises of an ON period (duration = t_1 - t_0 = T_{ON}) along with an OFF period (duration = t_2 - t_1 = T_{OFF}).

The frequency during the ON period is displayed on the MEASURING VALUE screen. The frequency during the OFF period is fixed at a constant value around 0.3 kHz. The light intensity variable displayed on the MEASURING VALUE screen is a normalized value of the actual intensity.

4.3.2 Main Menu

Purpose : This screen provides you with a selection of other input screens.

How to Reach this Screen : Save the selections which you are making on any screen. Press the **ESC key** on the Front Panel a couple of times.

How to Exit this Screen : Press the **ENTER key** on the Front Panel. You will reach the screen relevant to your selection.

Screen Layout :

```
              MAIN MENU
System Data
Maintenance
Pump
Language
Calibration Data
Zero Point
Data Storage
Dilution
           Select with ENTER
```

Notes :

This input screen is used to select other input screens:

1. System data
2. Maintenance
3. Pump
4. Language
5. Calibration data
6. Zero Point
7. Data Storage
8. Dilution

In order to make a selection on this screen, place the cursor on the corresponding entry using the **Navigation Block keys** and press the **ENTER key**.

To jump back to the display of the measuring value, use the **Monitoring Mode key** .

Hint

<u>Due to the limited vertical dimensions of the display screen, some entries may not appear on the first screen. Use the Down Navigation key to access entries that do not appear on the display screen.</u>

4.3.3 System Data

Purpose : This screen provides you with a selection of other input screens which control the operation of the instrument.

How to Reach this Screen : Select **System Data** on the **MAIN MENU**.

How to Exit this Screen : Press the **ENTER key** on the Front Panel. You will reach the screen relevant to your selection.

Screen Layout :

```
                SYSTEM DATA

Measuring range
Current output
Signal filtering
Lamp parameters

          Select with ENTER
```

Notes :

You can arrive at this screen by selecting the **System Data** entry on the Main menu screen. On this screen you have four selections :

1. Measuring range
2. Current output
3. Signal filtering
4. Lamp parameters

In order to make a selection on this screen, place the cursor on the corresponding entry using the **Navigation Block keys** and press the **ENTER key**.

4.3.3.1 Measuring Range

Purpose : This screen allows you to define the measuring range and the units of the variable to be measured.

How to Reach this Screen : Select **Measuring Range** on the **SYSTEM DATA** menu.

How to Exit this Screen : Select the **<Save with ENTER>** entry and press the **ENTER key**. You will reach the **SYSTEM DATA** screen.

Screen Layout :

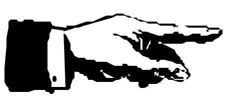
```
              MEASURING RANGE

Low              High            Units

<   0 >         < 50 >         < ng/m3 >

             < Save with ENTER >
                Back with ESC
```

Notes :

On this screen you can enter the following variables:

- Low value of the measuring range
- High value of the measuring range
- Units for the measuring range. If you have site specific calibration data, you can select between ng/m^3 and $\mu g/m^3$. If you do not have calibration data, you can simply monitor the instrument signal as an electric current in fA (femtoampere) or pA (picoampere).

For the Low and High values, you can enter a maximum of 4 digits (without the decimal point).



Hint

Please note the following for all entry fields:

1. **For Entry Fields where you have to input numbers all digits must be entered. If the length of the number is shorter than the Entry field, you should enter <u>leading zeros</u>.**

For example, the entry fields for Low and High values require 4 (four) digits. In order to input a value of **4**, you should enter **0004**; in order to input a value of **78**, you should enter **0078**.

2. **Every input has to be saved with the ENTER key.**
3. **For Entry Fields where you have to toggle between selections you should use the ENTER key.**

   For example, the selection related to Units on this input screen allows you to choose between ng/m^3 , $\mu g/m^3$, fA or pA. You can use the **ENTER key** to toggle between these selections.

4.3.3.2 Current Output

Purpose : On this screen you can define the analog current output signal.

How to Reach this Screen : Select **Current Output** on the **SYSTEM DATA** menu.

How to Exit this Screen : Select the **<Save with ENTER>** entry and press the **ENTER key**. You will reach the **SYSTEM DATA** screen.

Screen Layout :

```
          CURRENT OUTPUT
Selection between
0 - 20 mA or 4 - 20 mA

             < 0 >  - 20 mA


          < Save with ENTER >
             Back with ESC
```

Notes :

On this screen you can choose between 0 - 20 mA or 4 - 20 mA.

Hint

As discussed previously in Section 3.2.2 Signal Output, we have two current outputs (measuring value and lamp intensity) from Terminal 2 on the back panel. The selection made on this Current Output screen will apply towards both current output signals.

4.3.3.3 Signal Filtering

Purpose : This screen enables you to define parameters which control the signal filtering algorithm. You can define the time intervals associated with signal filtering of the Measured Value, the Lamp Intensity and the Flowrate.

How to Reach this Screen : Select **Signal Filtering** on the **SYSTEM DATA** menu.

How to Exit this Screen : Select the **<Save with ENTER>** entry and press the **ENTER key**. You will reach the **SYSTEM DATA** screen.

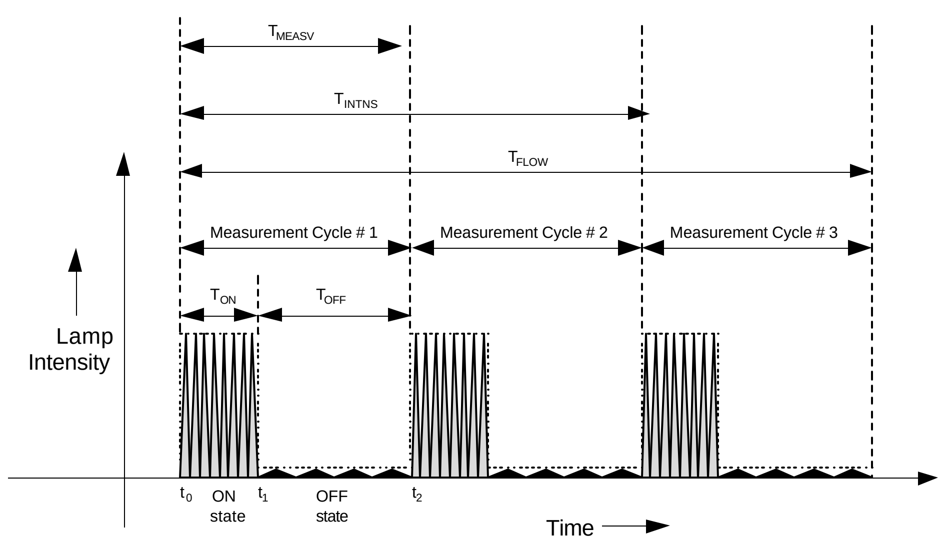
Screen Layout :

```
           SIGNAL FILTERING

Measv  :   < 8 > sec
Intns  :   <  16 > sec
Flow   :   <  24 > sec

         < Save with ENTER >
            Back with ESC
```

Notes :

The time interval associated with signal filtering can be entered here in seconds. The instrument will calculate the average value of the parameter over the selected time interval. It is possible to enter a time interval for the concentration signal, the lamp intensity and the flow.

Suppose one measurement cycle is 8 seconds duration (this is accomplished by choosing 4 seconds as the ON time and 1 / 1 as the DUTY CYCLE on the LAMP PARAMETERS screen). Suppose we want the concentration signal to be averaged over one measuring cycle, the lamp intensity signal to be averaged over two measurement cycles and the Flow signal to be averaged over three measurement cycles. We should then enter 8 seconds for the Measv selection, 16 seconds for the Intns selection and 24 seconds for the Flow selection.



Hint

The **Lamp Parameters** screen (On-time of the lamp and duty-cycle) determines the time required by the instrument to make one measurement. The instrument will automatically reset values entered on the **Signal Filtering** screen so that they are not in conflict with values on the **Lamp Parameters** screen. The PAS 2000 corrects the entries on the Signal Filtering screen such that they are a multiple of the on-time and duty cycle plus one.

Select 0 if you do not want any Signal Filtering.

4.3.3.4 Lamp Parameters

Purpose : On this screen you can define parameters related to the operation of the excimer lamp. You can define the Duty Cycle and the time duration of the pulse during which the lamp is switched on.

How to Reach this Screen : Select **Lamp Parameters** on the **SYSTEM DATA** menu.

How to Exit this Screen : Select the **<Save with ENTER>** entry and press the **ENTER key**. You will reach the **SYSTEM DATA** screen.

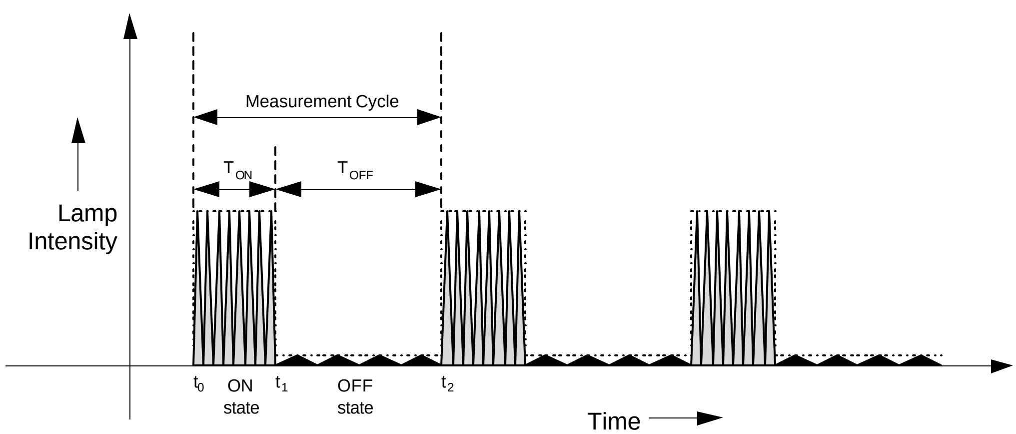
Screen Layout :

```
          LAMP PARAMETERS

Duty Cycle : 1 / <  1 >
On [sec]   :  <  4.0 >


          < Save with ENTER >
             Back with ESC
```

Notes :

Two lamp parameters can be entered.

1. **Duty Cycle : Choose** the ON / OFF time ratio for the lamp. The maximum value of the duty cycle is 1 / 1. From the below figure we have Duty Cycle = $T_{ON} / T_{OFF} = (t_1 - t_0) / (t_2 - t_1)$. Please note that you cannot enter any numerical value for this selection, the program allows you to choose between 1/1, 1/2, 1/5, 1/10, 1/15 and 1/20 (use the ENTER key to toggle between selections).
2. **On - Time :** Enter the duration of the light pulse in seconds. From the below figure we have On - Time = $T_{ON} = t_1 - t_0$.



Large values for the Duty Cycle shorten the life time of the lamp.

It is recommended that you use the smallest Duty Cycle, which produces an acceptable signal.

Attention

4.3.3.4 Date + Time

Purpose : On this screen you can input the actual date and the time. This information is used for the internal data storage of the PAS 2000.

How to Reach this Screen : Select **Date + Time** on the **SYSTEM DATA** menu.

How to Exit this Screen : Select the **<Save with ENTER>** entry and press the **ENTER key**. You will reach the **SYSTEM DATA** screen.

Screen Layout :

```
          DATE + TIME

       YY.MM.DD.hh.mm.ss
       98.05.09.21.13.00




     < Save with ENTER >
         Back with ESC
```

Notes :

The hours have to entered in the 24 hours mode format.

4.3.4 Maintenance

Purpose : This screen enables you to put the instrument either in a Maintenance Mode or the normal Monitoring Mode.

How to Reach this Screen : Select **Maintenance** on the **MAIN MENU** screen.

How to Exit this Screen : Select the **<Save with ENTER>** entry and press the **ENTER key**. You will reach the **MAIN MENU** screen.

Screen Layout :

```
              MAINTENANCE

Mainten.  ON : < No >




          < Save with ENTER >
             Back with ESC
```

Notes :

On this screen the relay switches can be activated. This triggers the message **System in Maintenance** to an external data logger. As a result the datalogger should recognize that all measuring values are invalid.

You can toggle between **Yes** or **No** on this screen by using the **ENTER key**.

4.3.5 Pump

Purpose : On this screen you can switch the pump ON or OFF.

How to Reach this Screen : Select **Pump** on the **MAIN MENU** screen.

How to Exit this Screen : Select the **<Save with ENTER>** entry and press the **ENTER key**. You will reach the **MAIN MENU** screen.

Screen Layout :

```
                 PUMP

Pump On    :  < Yes >
Act. Value :  44 %



          < Save with ENTER >
             Back with ESC
```

Notes :

On this screen you can switch the pump **On** or **Off**. When the pump has been switched **Off**, no flow passes through the instrument and consequently the measuring value should be zero.

Hint

Because of the inherent design of the PAS 2000 (excimer lamp operated in a chopped mode with extremely sensitive electronics) the instrument has an extremely stable baseline. A tool to adjust the zero offset is not necessary.

If you observe an offset when the pump has been switched off, the instrument is malfunctioning. You should call for service.

On this screen you will also observe a variable called “ Act. Value : xx %”. This variable is an indicator of the power consumption by the pump. **Typical values of this variable range between 40 to 55%. Higher values indicate that the pump should be checked.**

4.3.6 Language

Purpose : This screen enables you to select the language which is used by the various user interface screens

How to Reach this Screen : Select **Language** on the **MAIN MENU** screen.

How to Exit this Screen : Select the **<Save with ENTER>** entry and press the **ENTER key**. You will reach the **MAIN MENU** screen.

Screen Layout :

```
              LANGUAGE

            < English >



        < Save with ENTER >
           Back with ESC
```

Notes :

On this screen you can select between **English** and **German**.

Hint

If by mistake, you select the German language mode or if through some mishap your PAH monitor is displaying text in German language, please do not panic. Press the **ESC** key several times till you reach the **MAIN MENU** (called **HAUPTMENU**). Select the fourth selection from the top (called **Sprache**). You are then in the Language screen. Change **Deutsche** to **English** !

4.3.7 Calibration Data

Purpose : On this screen you can define inputs related to the calibration data function.

How to Reach this Screen : Select **Calibration Data** on the **MAIN MENU** screen.

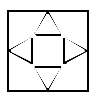
How to Exit this Screen : Select the **<Save with ENTER>** entry and press the **ENTER key**. You will reach the **MAIN MENU** screen.

Screen Layout :

```
        CALIBRATION DATA
Point 1
Current :  <     0 > < fA >
Conc.   :  <     0 > < ng/m3 >
Point 2
Current :  <     0 > < fA >
Conc.   :  <     0 > < ng/m3 >
          < Save with ENTER >
             Back with ESC
```

Notes :

On this input screen you have the capability of defining your own calibration function:

1. Use the **Navigation Block**  to move between selections.
2. You have to define the numerical values and units associated with two coordinate points (requiring a total of 4 numerical inputs and 4 inputs regarding units).
3. For each coordinate point you must enter the current and matching concentration value. For the units associated with current you can select between fA (femtoampere) and pA (picoampere). For the units associated with concentration you can select between ng/m³ and µg/m³.

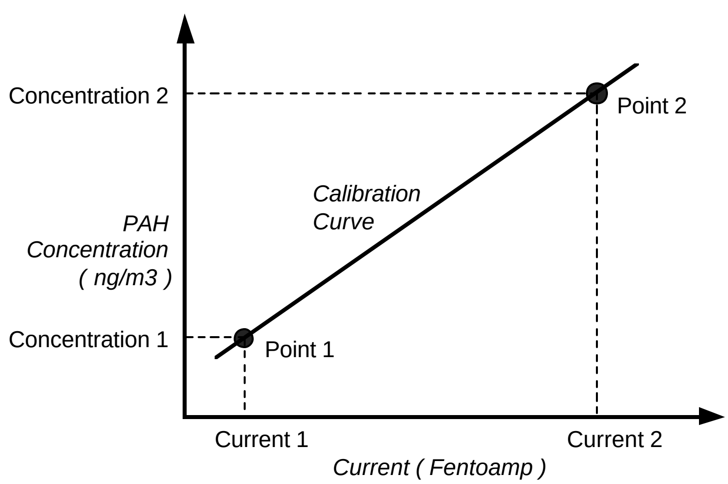


Fig. 6: Defining a calibration function for the PAH Monitor

4. Usually you should use Point 1 to define the zero offset in your calibration function (i.e. zero current does not correspond to zero concentration). If your calibration function does not have a zero offset then enter 0 for both entries associated with Point 1.
5. If you enter the value 0 for all numerical inputs (Point 1 and Point 2) on this screen, the instrument assumes that you do not have a calibration function and displayed values are in picoamperes or femtoamperes.

4.3.8 Zero Point

Purpose : On this screen you can reset the zero point for your system

How to Reach this Screen : Select Zero Point on the **MAIN MENU** screen.

How to Exit this Screen : Select the **<Save with ENTER>** entry and press the **ENTER key**. You will reach the **MAIN MENU** screen.

Screen Layout :

```
                ZERO POINT

Act. zero :    0.8
Time :         95



          < Save with ENTER >
             Back with ESC
```

Notes :

On this input screen you have the capability to reset the zero point for the system.

1. Simply leave the system in this Zero Point screen untouched for a short period of time (approximately 5 minutes). Observe the value displayed for Act. zero. Once this value stabilizes use the Navigation Block keys to select the **<Save with Enter>** selection. This will reset the zero point for the PAH monitor.
2. After you have reset the Zero Point, the internal calculations have to be reset. This may take a couple of measurement cycles. Please ignore the first few values displayed by the instrument in the monitoring mode. After a couple of measurement cycles have elapsed proper values will be displayed by the PAH monitor.
3. The Act. Zero value displayed by the instrument is a relative number. It is a zero, which is defined relative to the previous setting of the zero value.

4.3.9 Data Storage

Purpose : This screen is used for the input of the parameters for data storage on the PAH monitor.

How to Reach this Screen : Select **Data Storage** on the **MAIN MENU** screen.

How to Exit this Screen : Select the **<Save with ENTER>** entry and press the **ENTER key**. You will reach the **MAIN MENU** screen.

Screen Layout:

```
              DATA STORAGE

Cycle in sec:  <   30>
Index (4,89)



          < Save with ENTER >
             Back with ESC
```

Notes:

In the example shown every thirty seconds an average value is stored in the memory of the analyzer. To get a ½ hour averages to be stored on the PAH monitor you have to overwrite the input line with 1800 seconds.

Hint

To extract the data, EcoChem provides you with software, which runs under Windows 95/98 and Windows NT. This software extracts the data to a formatted text file readable by Microsoft Excel or any other spreadsheet software.

You can also download the data with terminal emulation software. You have to connect the PC with a standard serial cable. To start the download, you send **Ctrl E (05 hex)** to the analyzer. To erase all data, you send **Ctrl F (06 hex).**

The data are stored in 32 sections. Every section has a header. The format of the extracted data section is as follows:

:	Start of the section
98.03.05*	Date YY.MM.DD at the start of the data storage
19.25.44*	Time hh.mm.ss at the start of the data storage
30*	Cycle time in sec
fA*	Dimension selected
2.425*	First value
.	.
2.280*	Last value
;	End of transmission

On this screen you will also observe a variable called " Index (xx,yyy) ". xx is the actual section. yyy is the actual index of the last stored value in this section. A maximum of 14,000 data points can be stored.

4.3.10 Dilution

Purpose : On this screen you can select the dilution factor if the analyzer is equipped with a dilution system.

How to Reach this Screen : Select **Dilution** on the **MAIN MENU** screen.

How to Exit this Screen : Select the **<Save with ENTER>** entry and press the **ENTER key**. You will reach the **MAIN MENU** screen.

Screen Layout:

```
                DILUTION
Dilutionfactor
D  =  < 1 >



          < Save with ENTER >
             Back with ESC
```

Notes:

On this screen you can the settings for the dilution system if incorporated. The selections are 1(No dilution), 10, 20, 50 and 100.

Hint

If your system is not equipped with a dilution system, the selection must be 1 = No dilution. Otherwise you will get error messages.

The dilution system and the dilution probe are described in APPENDIX C.

4.4 Continuous ON Mode Operation

In the normal mode of operation, the PAH monitor usually runs in the ON/OFF mode. This mode prolongs the lamp lifetime and at the same time there is a continuous check of the background signal during the OFF mode. However there may be some conditions under which you may want to operate the instrument in a continuous ON mode. An example of such a situation is when you want to measure a rapidly changing transient signal. Here are the steps you need to perform to put the analyzer in the continuous ON mode.

Reset Lamp Parameters

- Go to the **Main Menu**. Choose **System Data**.
- From the System Data menu choose **Lamp Parameters**.
- Make your **Duty Cycle** as 1/<0>.
- Save the selection and return to the **Main Menu**.

Reset Lamp Frequency and Intensity

- Press 3262436 to enter the **Diagnostic** mode.
- Wait for about a minute for the lamp frequency and intensity to stabilize.
- Save entries and go back to the Main Menu.

Reset Zero Point

- From the Main Menu select the **Zero Point** selection.
- Wait for a couple of minutes for the ZERO OFFSET to stabilize.

After doing the above procedures, the lamp will run in a continuous ON mode and you will get a reading approximately every 2 seconds.

Hint

How to go back to the normal ON/OFF mode of operation…

Repeat the above three steps of resetting the lamp parameters, lamp frequency and intensity and zero point. Make sure that your duty cycle is set to 1/<1>.

Attention

When you run the instrument in the continuous ON mode, the lifetime of the excimer lamp is decreased. Thus you should only operate the instrument in the continuous ON mode for short periods of time when it is absolutely necessary to measure a rapidly changing transient signal.

5 DATA ACQUISITION

5.1 Introduction

Real-time measurements are displayed on the front panel of the PAH monitor and they can be collected through outlets on the back panel of the instrument. There is an RS-232 serial port through which a digital signal may be transmitted. This data can then be processed using PAS 2000 Data Acquisition software (Appendix B). In addition, the measurement data can be accessed as a current or voltage analog signal. These outlets can be connected to datalogger or stripchart devices. In principle, you can get three outputs simultaneously -- the digital RS232, the analog voltage and the analog current.

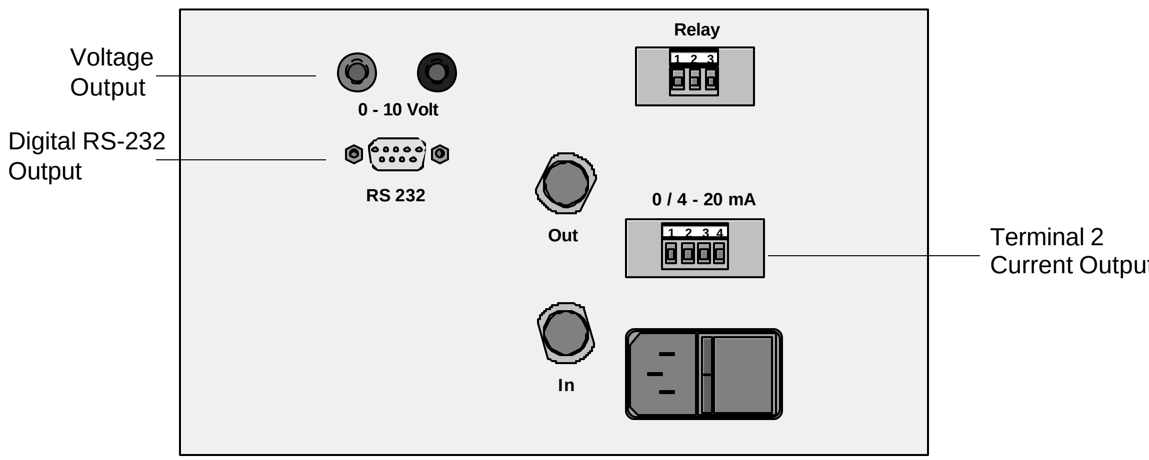


Fig 8: Back panel with digital and analog output signals

5.2 Analog Output from the PAH Monitor

Analog output from the PAH monitor is available from in the form of a voltage or current. Each type of analog output can be connected to any device, such as a datalogger or a strip-chart recorder.

Current output is accessed through Pins 1 and 2 located on Terminal 2. The measuring ranges of 0 to 20 mA or 0 to 20 mA can be selected through the **Current Output** screen (see section 4.3.3.2). The current output has an associated load factor of 500 Ohm. This current output signal is directly proportional to the Measuring Range which is specified on **Measuring Range** screen (see section 4.3.3.1).

Example 1

On the **Current Output** screen we select 0 to 20 mA.

On the **Measuring Range** screen we select 0 to 100 ng/m^3.

For this set of values we have :

- A measured current of 0 mA corresponds to 0 ng/m3 of total particle-bound PAH.
- A measured current of 20 mA corresponds to 100 ng/m3 of total particle bound PAH.
- A measured current of 7 mA corresponds to :

  Slope = (100 - 0)/ (20 - 0) = 5 ng/(m^3-mA)

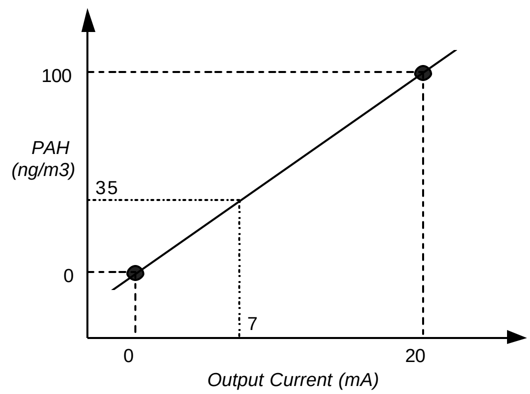
  Y Initial = 0 ng/m^3

  Delta X = 7 - 0 = 7 mA

  Thus (Y value) = [(Slope) x (Delta X)] + (Y Initial)

  = [(5) x (7)] + 0

  = 35 ng/m^3 of total particle-bound PAH



Example 2

On the **Current Output** screen we select 4 to 20 mA.

On the **Measuring Range** screen we select 10 to 25 µg/m^3.

For this particular set of values we have :

- A measured current of 4 mA corresponds to 10 µg/m3 of total particle-bound PAH.
- A measured current of 20 mA corresponds to 25 µg/m3 of total particle bound PAH.
- A measured current of 7 mA corresponds to :

  Slope = (25 - 10)/ (20 - 4) = 0.94 µg/(m^3-mA)

  Y Initial = 10 µg/m^3

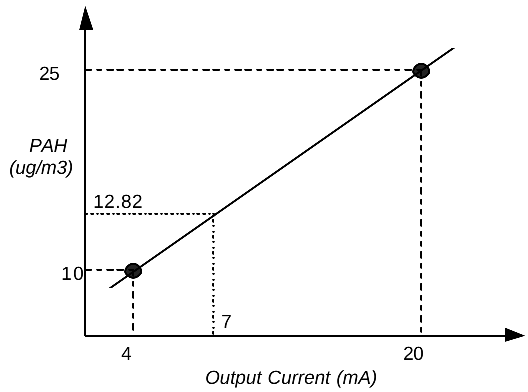
  Delta X = 7 - 4 = 3 mA

  Thus (Y value) = [(Slope) x (Delta X)] + (Y Initial)

  = [(0.94) x (3)] + 10

  = 12.82 µg/m^3 of total particle-bound PAH

An additional analog output which can be obtained from the PAH monitor is the voltage output. This output is always in the range of 0 to 10 volts. Similar to the analog current output, the analog voltage out is directly proportional to the selecctions made on the **Measuring Range** screen.



Example 3

On the **Measuring Range** screen we select 0 to 500 ng/m^3.

For this set of values we have :

- A measured voltage of 0 v corresponds to 0 ng/m3 of total particle-bound PAH.
- A measured voltage of 10 v corresponds to 500 ng/m3 of total particle bound PAH.
- A measured current of 5.6 v corresponds to :

  Slope = (500 - 0)/ (10 - 0) = 50 ng/(m^3-v)

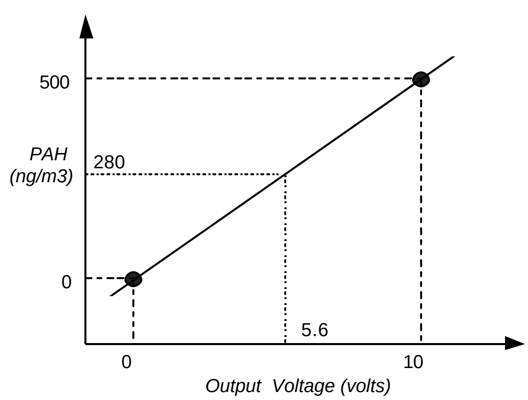
  Y Initial = 0 ng/m^3

  Delta X = 5.6 - 0 = 5.6 v

  Thus (Y value) = [(Slope) x (Delta X)] + (Y Initial)

  = [(50) x (5.6)] + 0

  = 280 ng/m^3 of total particle-bound PAH



5.3 Digital Output from the PAH Monitor

Digital output can be obtained through the RS-232 serial port located on the back panel of the monitor. The attributes of the port are: 9600 baud, 8 bit, no parity and 1 stop bit. An RS-232 cable can provide a connection between this port on the PAH monitor and a computer. The PAS 2000 Data Acquisition Software (PAHDAS) should be used to display and store the real time measurements from the monitor. Appendix B provides detailed information regarding the installation and operation of PAHDAS.

6 TECHNICAL SPECIFICATIONS

DISPLAY	LCD Panel with 128 by 64 pixel resolution
POWER	115 volts AC / 60 Hz & 220 volts AC / 50 Hz, Maximum power consumption 35VA
RANGE	0 to 100 picoamp (user selectable)
SENSITIVITY	~ 0.3 - 1 µg /m^3 PAH per picoamp (actual calibration is site-specific)
LOWER THRESHOLD	~ 3 ng / m^3 total particle-bound PAH
RESPONSE TIME	< 10 seconds (adjustable)
ANALOG OUTPUT	(0 to 10 volt) and (0 to 20 mA or 4 to 20mA)
DIGITAL OUTPUT	RS - 232
SAMPLE GAS	Built-in pump with flowrate controlled at 2 L/min
OPERATING TEMP	40 to 104 ºF (5 to 40ºC)
DIMENSIONS	Standard Desktop Unit (Height x Width x Depth)
	4.5in x 9.3in x 12.5in (133mm x 236mm x 317mm)
WEIGHT	20 lb. (9 kg)
DATA STORAGE	14000 Data Points (each data point consisting of : Date, Time, Value)
SOFTWARE	User-friendly PC-compatible graphical software collects data from PAS 2000. The software displays real-time strip charts and calculates averages. Data is stored in a variety or formats. Flat ASCII file output can also be generated for further analysis in standard spreadsheet programs (e.g. Microsoft Excel).

Appendix A -- POLYCYCLIC AROMATIC HYDROCARBONS

A.1 Introduction

Polycyclic aromatic hydrocarbons (PAH) are associated with the incomplete burning of fossil fuels, wood, garbage, tobacco, charbroiled meat or other organic materials. They are usually found in complex mixtures, such as soot or tar. There are over 100 different PAH molecules.

PAH are organic molecules made up of carbon and hydrogen atoms having at least two fused aromatic rings; that is, two benzene rings which share a common border. These compounds are solids with generally high melting and boiling points (see Fig. A.1). They are planar and nonpolar and are extremely insoluble in water. Vapor pressures for pure PAH vary and this factor can greatly affect the amount that can be adsorbed onto particulate matter.

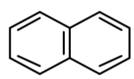
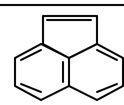
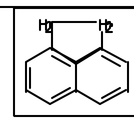
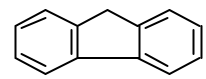
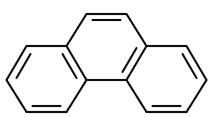
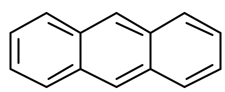
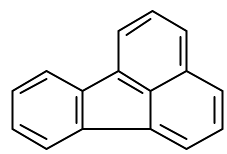
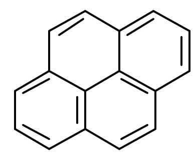
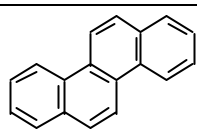
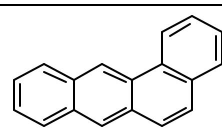
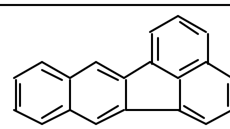
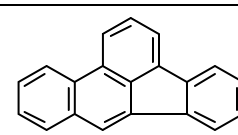
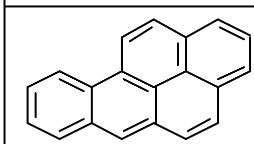
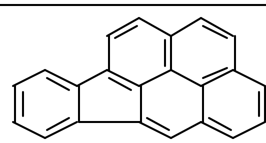
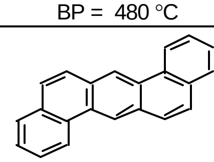
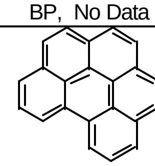
 Naphthalene MW = 128.2 MP = 80.2 °C BP = 217.9 °C	 Acenaphthylene MW = 152.2 MP = 92 - 93 °C BP = 265 - 275 °C	 Acenaphthene MW = 154.2 MP = 95 °C BP = 279 °C	 Fluorene MW = 166.2 MP = 116.5 °C BP = 295 °C
 Phenanthrene MW = 178.2 MP = 100 °C BP = 340 °C	 Anthracene MW = 178.2 MP = 218 °C BP = 342 °C	 Fluoranthene MW = 202.3 MP = 110.8 °C BP = 393 °C	 Pyrene MW = 202.3 MP = 156 °C BP = 393 °C
 Chrysene MW = 228.3 MP = 255 °C BP = 448 °C	 Benzo(a)anthracene MW = 228.3 MP = 160 °C BP = 435 °C	 Benzo(k)fluoranthene MW = 252.3 MP = 215.7 °C BP = 480 °C	 Benzo(b)fluoranthene MW = 252.3 MP = 168.3 °C BP, No Data
 Benzo(a)pyrene MW = 252.3 MP = 178.5 °C BP = 311 °C (at 10 torr)	 Indeno(1,2,3-c,d)pyrene MW = 276.3 MP = 163.6 °C BP = 530 °C	 Dibenzo(a,h)anthracene MW = 278.4 MP = 262 °C BP, No Data	 Benzo(g,h,i)perylene MW = 276.3 MP = 273 °C BP = 550 °C

Fig. A.1: Typical PAH compounds and physical properties (MW - Molecular Weight, MP - Melting Point, BP - Boiling Point)

A.2 PAH Formation

PAH present in the environment are a result of incomplete combustion rather than commercial production. In fact, only three PAH: acenaphthene, acenaphthylene and anthracene, are produced in significant quantities for use in chemical manufacturing processes. Waste products containing PAH are considered hazardous wastes and their generation, treatment, storage and disposal are all regulated. They are commonly destroyed by incineration or bioremediation. Degradation by landfarming processes and bioreactors are innovative techniques which have been successful.

The amount of PAH formed due to incomplete burning will depend upon the raw material and the combustion efficiency of the source. The formation mechanism occurs in the gas phase with subsequent transition to the particulate form generally found in the atmosphere. It is theorized that PAH are created both by the degradation of large fuel molecules and by polymerization of small organic molecules within the hydrocarbon flames.

While PAH compounds are found in the gas phase, those in the atmosphere are primarily associated with particulate matter. Vapor phase material adsorbs on particles as the gas stream cools through hydrogen bonding. Condensation may also be a mechanism for particle formation, but apparently PAH vapor pressures are not high enough in most combustion sources for this to occur.

A large mass fraction of the PAH can be associated with ultrafine particles. Ninety to ninety-five percent of particulate PAH are associated with particle diamters less than 3.3 µm and the peak distributions are localized between 0.4 and 1.1 µm (Baek, 1991). In the presence of high particulate concentrations nearly complete adsorption of PAH onto particles may be expected. Temperature is another factor affecting particle-bound versus vapor states. Experiments involving fly ash samples taken from the same release stream show that considerably more particulate PAH is associated with fly ash at a lower temperature (5 °C) than at a high temperature (290 °C).

The particle to gas phase concentrations for PAHs have been modeled as (EPA 1996) :

$$K_p = \frac{F / TSP}{A}$$

where

K_p	Partitioning constant ($m^3\ \mu g^{-1}$)
TSP	Concentration of total suspended particulate matter ($\mu g\ m^{-3}$)
F	Particle - bound concentration ($\mu g\ m^{-3}$)
A	Gas phase concentration ($\mu g\ m^{-3}$)

Using the above formulation, we now define

$$\varphi = \frac{F}{A + F} = \frac{K_p\ TSP}{K_p\ TSP + 1}$$

where

φ Fraction of the total compound that is on the particle phase

Several references (EPA 1996, Pankow 1991, Yamasaki 1982 and Baek 1991) provide further information regarding the evaluation of K_p for different compounds and enumerate values obtained at different locations.

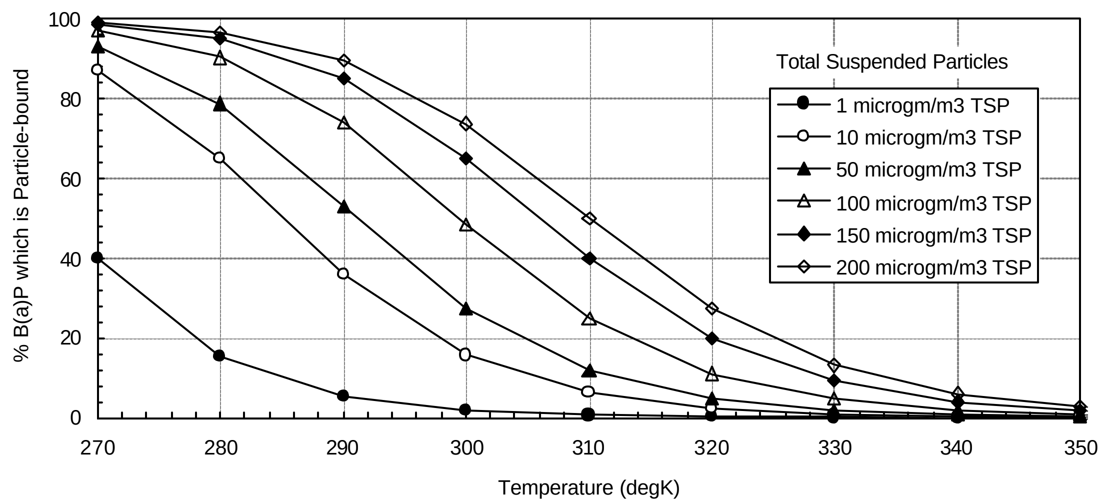


Fig. A.2: Particle-bound PAH as a function of Temperature and Total Suspended Particulate Matter (graph created using data from Baek, 1991)

A.3 Sources of PAH

PAH are released into the atmosphere through natural and anthropogenic processes. Natural sources include emissions from volcanoes and forest fires. Anthropogenic sources produce greater amounts of PAH by far. They can be released into surface water through discharges from industrial plants and waste water treatment plants and soils at hazardous waste sites if they escape storage containers.

The single largest source of PAH emissions to the air is the burning of wood in homes due to inefficient combustion and lack of emission controls (Baek, 1991; Ramdahl, 1982). Cars and trucks are also major contributors. Stationary sources account for 80% of annual PAH emissions with the rest attributed to mobile sources. For indoor air, tobacco smoke, gas cooking and heating appliances and kerosene space heaters can increase PAH levels.

Many of the current combustion processes and certain industrial processes such as coke production or petroleum refining have led to the widespread presence of PAH in industrial and ambient atmospheres. Combustion is a major source of PAH pollutants, encompassing industrial operations and power plants using fossil fuels, waste incinerators, domestic heaters and vehicles powered by gasoline or diesel fuels. Emissions of PAH from fossil fuel combustion can vary over several orders of magnitude depending upon the particular fuel and combustion conditions.

Emissions of PAH from burning coal or wood for residential space heating are several orders of magnitude greater than those from gas or oil burning. Urban and highly industrialized environments contain higher levels of PAH than do rural locations. Industrial and commercial sources of PAH can be categorized according to processes associated with a certain fuel type or combustion unit.

Annual emissions of polycyclic organic matter, a category encompassing PAH, have been broken down as follows (NRC, 1983):

- 39% Open burning
- 38% Residential heating
- 22% Automobiles and trucks
- 1% Industrial boilers

The fate of PAH in the environment depends on how easily they dissolve in water and how easily they evaporate into the air. In general, PAH do not dissolve easily in water. PAH released into the atmosphere can be transported long distances. For particle-bound PAH atmospheric residence time and transport distance will depend upon the size of the particles to which they are adsorbed. They are removed by wet and dry deposition onto soil, water and vegetation. In water they can volatilize, photolyze, oxidize, biodegrade, bind into suspended particles or sediments or accumulate in aquatic organisms. In sediments, they can biodegrade or accumlate in aquatic organisms. PAH in soil can volatilize, degrade or accumulate in plants. They can also migrate into the groundwater and be transported within an aquifer.

Stationary External Combustion	Residential Heating, Industrial and Commercial Heat and Steam Generation
Stationary Internal Combustion	Reciprocating Engines, Gas Turbines
Waste Incineration	Municipal, Industrial, Commercial, Medical, Landfill Gas, Hazardous, Scrap Tire, Sewage Sludge
Metals Industry	Aluminum, Iron and Steel, Secondary Lead Smelting
Petroleum Refining	Catalytic Cracking, Other
Asphalt Products	Asphalt Roofing Manufacturing, Hot Mix Asphalt Production
Coke Production	Coke Ovens, Byproduct Recovery Plants
Cement Manufacturing	Portland Cement Manufacture
Pulp and Paper Industry	Furnaces and Kilns
Open Burning	Wildfires, Scrap Tire Burns, Agricultural Plastic Film Burning, Coal Refuse Burning, Other
Mobile Sources	On-road Vehicles, Aircraft, Locomotives, Marine Vessels
Miscellaneous	Carbon Black Manufacture, Wood Treatment, Carbon Regeneration, Cigarette Smoke, Wood Charcoal Production, Crematories, Gasoline Distribution, Rayon Fiber Manufacture, Commercial Charbroilers

Table A.1: Common sources of PAH

A.4 Human Exposure to PAH

A.4.1 Exposure of the General Population

People are exposed to mixtures of PAH at home, outdoors and at work. The greatest sources of exposure to the general population include inhalation of tobacco smoke, wood smoke, contaminated air and ingestion of food. Exposure pathways can be characterized as follows:

- ***Respiration:*** The most likely exposure pathway is breathing in PAH attached to dust or other particles in the air. Non-occupational respiratory exposure is mainly to tobacco smoke and urban air. It has been estimated that smoking one pack of cigarettes a day results in exposure of up to 5 µg/day of carginogenic PAH (Menzie, 1992). Urban air pollution is from various sources, including vehicle exhausts and combustion products from residential and industrial heating. Background levels of PAH in ambient air are reported to be 0.02 to 1.2 nanograms/m^3 in rural areas and 0.15 to 19.3 nanograms/m^3 in urban areas (DHHS, 1995).

- ***Ingestion:*** PAH have been found in some drinking water supplies due to contamination with pollution, runoff from asphalt and used motor oil. PAH levels in drinking water range from 4 to 24 nanograms/liter.

  Major sources of PAH in foods include curing smokes, contaminated soil, polluted air and water and cooking at high temperatures. PAH in a typical U.S. diet is estimated at less than 2 micrograms/kilogram of food or 1 to 5 µg/day.

- ***Skin Contact:*** Exposure can also occur via contact with contaminated soil, soot or tar. Mineral oils and refined petroleum products used in cosmetics and medicinal products have also been shown to contain PAH.

It has been estimated that the general population is exposed to total PAH levels of 0.207 µg/day from air, 0.027 µg/day from water and 1.6 to 16 µg/day from food (Santodonato, 1981). It should be noted that the uncertainty in measurement of PAH in food is greater than that from air or water. However, the estimates are thought to be accurate within one order of magnitude, so that food was predominant among exposure sources. Another factor to consider is the fact that PAH which are swallowed are generally absorbed more slowly by the body than those inhaled.

PAH can enter all the body tissues containing fat. This is because PAH are nonpolar so they tend to dissolve readily in and cross the lipoprotein membranes of mammalian cells. Once PAH are injected into the bloodstream they are rapidly and widely distributed. The demonstrated toxicity of many PAH in organs remote from the site of their administration confirms this. They tend to be stored mostly in the kidneys, liver and fat. Smaller amounts are stored in the spleen, adrenal glands and ovaries. Animal studies show that PAH do not tend to be stored in the body for long periods of time. Most of them leave the body within a few days, primarily in the feces and urine.

A.4.2 PAH Levels in the Environment

While PAH air levels have been monitored at many locations, it is important to understand sampling complexities before making any comparisons between studies. As mentioned before, three-ring PAH compounds generally exist in the vapor phase in the atmosphere, where as five- and six-ringed PAH are predominantly found in the particle phase and four-ringed compounds exist in both phases. Thus, to measure total PAH levels both particulate and gaseous samples must be taken. However, early studies used filter sampling methods, which only measured particle-phase PAH, underestimating total PAH concentrations.

Trends suggested by studies indicate that urban PAH levels are higher than rural ones and concentrations in the winter exceed those in the summer:

- Pucknat (1981) summarized 1970 data from the U.S. National Air Surveilance Network reporting benzo[a]pyrene concentrations at 120 U.S. cities ranged from 0.2 - 19.3 ng/ m^3 whereas nonurban levels were 0.1 - 1.2 ng/ m^3.

- Greenberg (1985) evaluated particle-phase PAH levels in New Jersey. The geometric mean concentrations of tn PAH compounds were 0.03 to 0.62 ng/ m^3 in urban areas and 0.01 to 0.12 ng/ m^3 in rural areas during the summer. In the winter, these values ranged from 0.40 to 11.15 ng/ m^3 in urban areas and 0.08 to 1.32 ng/ m^3 in rural areas.

A.4.3 Occupational Exposures

Occupational exposures to PAH are prevalent in petroleum refining, metalworking, coke production, anode manufacture and aluminum production. They also associated with manufacturing processes involving the use of coal tar, pitch, asphalt, creosote, soot and anthracene oil. Engine exhausts containing PAH emissions are found in a wide variety of occupational settings. Some levels measured in various workplaces appear below (DHHS, 1995):

Petroleum Refinery, Fluid Catalytic Cracking and Delayed Coker Units	10 µg /m^3 total PAH
Petroleum Refinery, Bitumen Processing Units	1 - 40 µg /m^3 total PAH
Petroleum Refinery, De-asphalting Unit	2.5 - 49.8 µg /m^3 total PAH
Metalworks, Cutting Area	66 ng/ m^3 total PAH
Metalworks, Hardening Area	90 ng/ m^3 total PAH
Metalworks, Extruding Oilshave Area	106 ng/ m^3 total PAH
Aluminium Reduction Plant	0.03 - 53 µg /m^3 benzo[a]pyrene
Coke Plant, Oven Operations	0.15 - 6.72 µg /m^3 benzo[a]pyrene
Roofing, Removing Coal Tar Pitch Roof and Applying Asphalt Roof	10.2 µg /m^3 total PAH

Table A.2: Workplace exposure to PAH for various occupation (DHHS, 1995)

A.5 PAH Toxicity

The linkage between PAH and cancer can be traced back to observation in London in the 1700's that scrotal cancer in chimney sweeps was due to their occupational exposure to soot. A century later, occupational skin cancers in the coal tar industry of Germany were noted. By the early 1900's it was widely recognized that soot, coal tar and pitch are all carcinogenic for man. Soon after it was discovered that the carcinogenic activity in coal tar resided in the benzo[a] pyrene it contains. In addition to the skin cancers which were noted initially, there have also been several reports indicating that higher incidences of respiratory tract and upper gastrointestinal tract tumors are associated with occupational exposures to PAH.

Many PAH are recognized as potent carcinogens. Epidemiological studies have reported an increase in lung cancer in humans exposed to coke oven emissions, roofing tar emissions and cigarette smoke. Each of these mixtures contains a number of PAH. Cancer associated with exposure to PAH-containing mixtures in humans occurs predominantly in the lungs due to inhalation and skin due to dermal contact. Animal studies have reported respiratory tract tumors from inhalation exposure to benzo[a] pyrene; forestomach tumors, leukemia and lung tumors from oral exposures; and skin tumors from dermal exposures (DHHS, 1995).

Chronic non-cancer effects to long-term exposure to benzo[a]pyrene in humans has resulted in dermatitis, photosensitization in sunlight, irritation of the eyes and cataracts. People exposed to PAH and respirable particles in a rubber plant reported bloody vomit, breathing problems, chest pains, throat irritation and abnormalities in chest X-rays. Studies have shown that human lung cells can metabolize PAH into reactive intermediates, meaning inhalation exposure can result in toxicity to the respiratory tract. Animal studies have reported effects on the blood and liver from oral exposure to benzo[a] pyrene and effects on the immune system from dermal exposure to benzo[a] pyrene (DHHS, 1995).

No information is available on the reproductive or developmental effects of PAH in humans. Animal studies have indicated that benzo[a] pyrene, via oral exposure, induces reproductive toxicity, including a reduced incidence of pregnancy and decreased fertility. Developmental effects, such as a reduced viability of litters and reduced mean pup weight, have also been noted from oral exposure to benzo[a] pyrene in animals (DHHS, 1995).

A recent technical publication (Denissenko et al, 1996) provides a direct link between a defined cigarette smoke carcinogen (Benzo[a]pyrene) and human cancer mutations. Using techniques of molecular biology, the authors explcitly show how Benzo[a]pyrene brings about mutations resulting in human lung cancer.

A.6 Regulations and Advisories in USA

The U.S. EPA has categorized PAH as Hazardous Air Pollutants and has proposed regulations governing major sources. It has also developed reference doses for anthracene (0.3 mg/kg/day), acenaphthene(0.06 mg/kg/day), fluoranthene (0.04 mg/kg/day), fluorene(0.04 mg/kg/day) and pyrene (0.03 mg/kg/day). However, no reference concentrations exist for any PAH (DHHS, 1995).

OSHA regulates the benzene-soluable fraction of coal tar pitch volatiles and mineral oil mists, which contain several PAH compounds. Engineering controls and work practices must be used to reduce occupational exposures below and 8-hour time weighted average of 0.2 mg/m^3 for coal tar pitch volatiles and 5 mg/m^3 for mineral oil mist. The ACGIH classifies PAH as confirmed human carcinogens and specifies the same limits as OSHA (DHHS, 1995).

U.S. EPA has set an ambient water quality criteria for protection of human health at 0.0028 ug/L for PAH exposure due to ingestion of water and organisms. PAHs are regulated by the Clean Water Effluent Guidelines in the Code of Federal Regulations. They are classified as Total Toxic Organics for electorplating and metal molding and casting sources. They have specific regulatory limitations for point source categories including organic chemicals, plastics, synthetic fibers, cokemaking and nonferrous metals manufacturing (DHHS, 1995).

The Emergency Planning and Community Right-to Know standards (EPCRA) regulate PAH by requiring owners and operators of certain facilities to report the release of those chemicals into the environment each year (DHHS, 1995).

Under the Resource Conservation and Recovery Act (RCRA), several PAH are considered hazardous wastes when they are discarded commercial chemical products, off-specification species, container residues and spill residues (DHHS,1995).

A.7 References

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Appendix B -- DATA ACQUISITION USING THE PAHDAS 6 SOFTWARE

B.1 Introduction

PAHDAS 6 is a special data acquisition program for collection the data from the PAH monitor. This software runs on IBM-PC and compatibles and requires the Windows 95, Windows 98 or Windows NT operating system. In the following sections, we will describe the installation of the software, user interface and post processing of the collected data.

B.2 Installation of the Software

In the following discussion we will assume that your floppy disk drive is called **A**. In case your floppy drive is called **B**, please substitute **A:** with **B:** in the following instructions:

From the Windows **Desktop**...

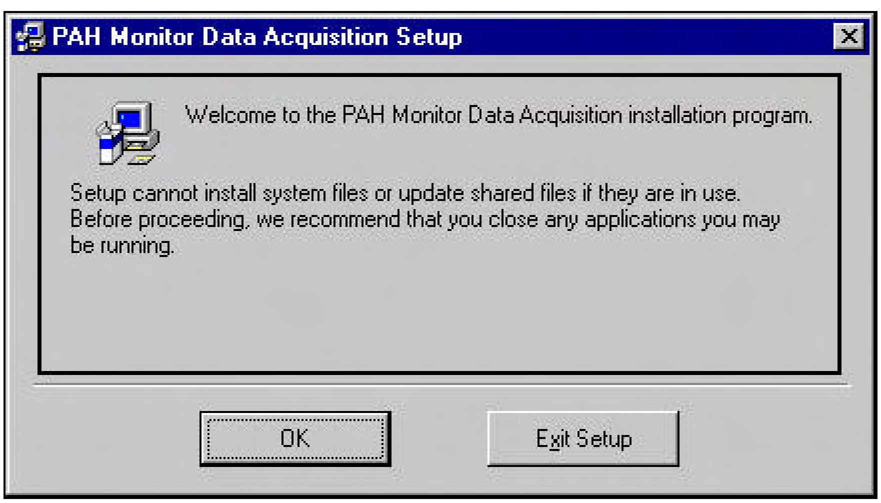
- Press the **Start** section of the status bar at the bottom of the screen.
- Choose **Run** from the **Start** Menu. The **Run** dialog will appear.
- In the dialog type:

  A:\SETUP
- Press the **OK** button.

After activating the SETUP program, only one input regarding the installation directory may be required. Let us walk through the complete installation process.

Step 1

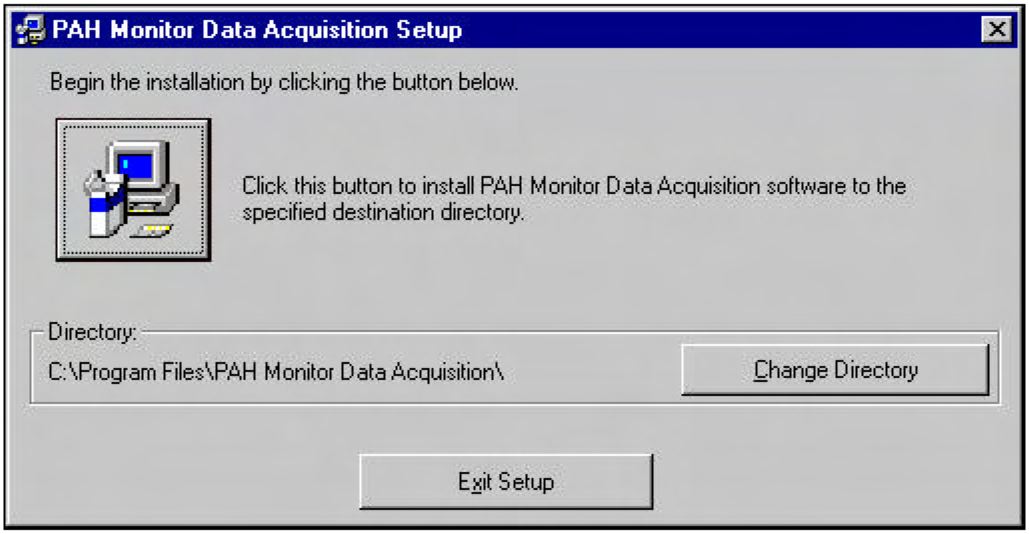
The first screen that appears is the title window. Press OK to continue.



Step 2

Within a short period of time, the installation screen will appear within the initial window. The default directory for the data acquisition software is displayed.

- Press the **Large Square Button** to continue installation.
- Press **Change Directory** if you prefer another directory name or disk drive.
- Press **Exit Setup** if you wish to abort the installation procedure.



Step 3

Windows displaying the progress of the installation process will appear as files are decompressed and placed in the proper directory. The installation process will create an entry called:

PAH Monitor Data Acquisition

which can be used to start the data acquisition program.

B.3 Program Operation

The PAS 2000 Data Acquisition program consists of several user friendly screens. Through them you can view real-time data as it is measured by the PAH monitor and also download data stored on the PAH monitor. You also have complete control over how the data is displayed, what values are collected and where they are stored. The program also tests the link between the computer and the instrument, providing diagnostic information if there is a problem.

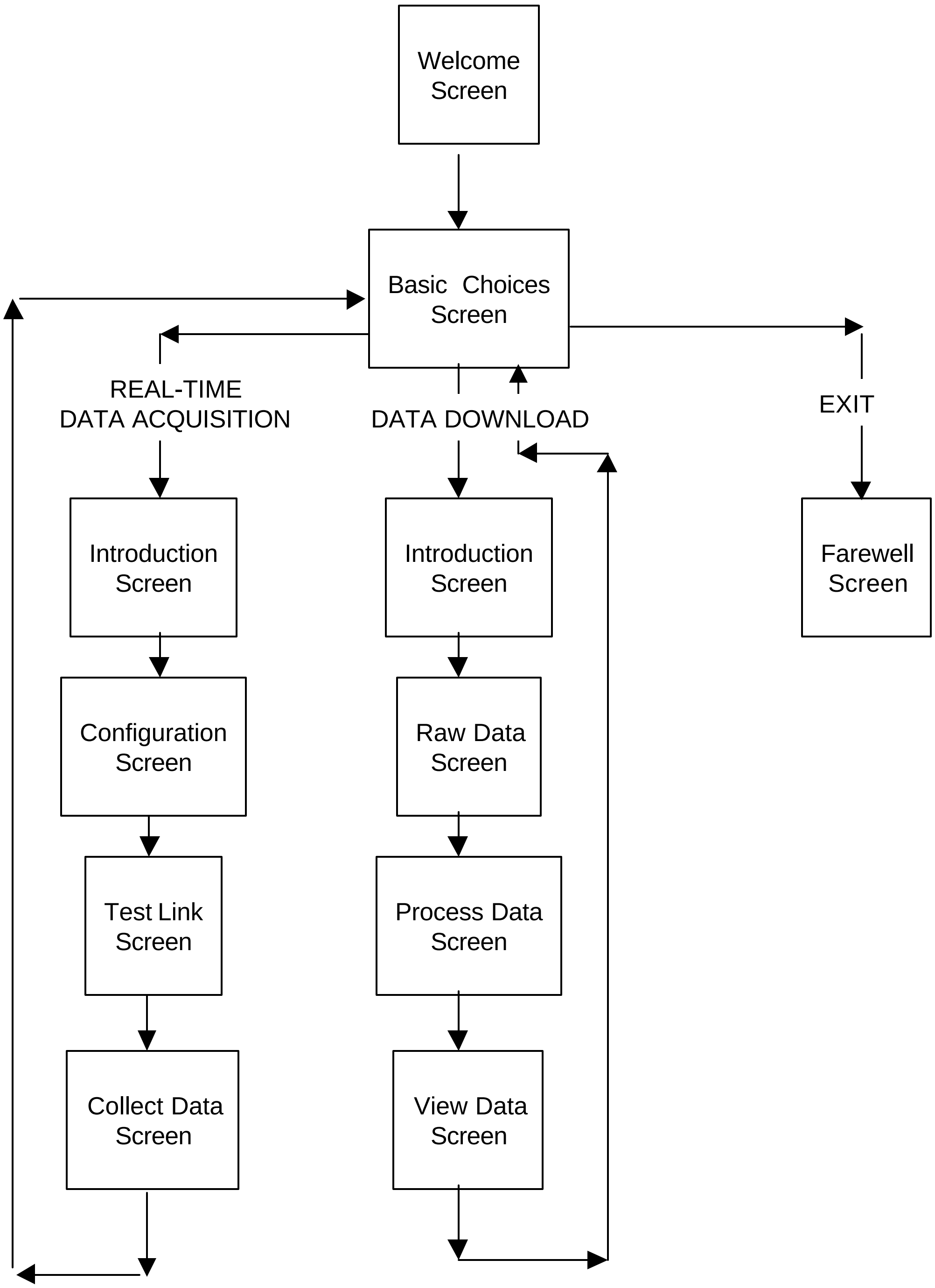
At this point, we will walk through the program providing general information:

Welcome Screen This is a starting point for the program. We press the **Next>** button and proceed to the **Basic Choices (Common)** screen.

Basic Choices (Common) Screen On this screen you will decide whether you want real-time dat acquisition, download data or exit the program. You will also be able to choose the serial port connecting the PC to the PAH monitor.

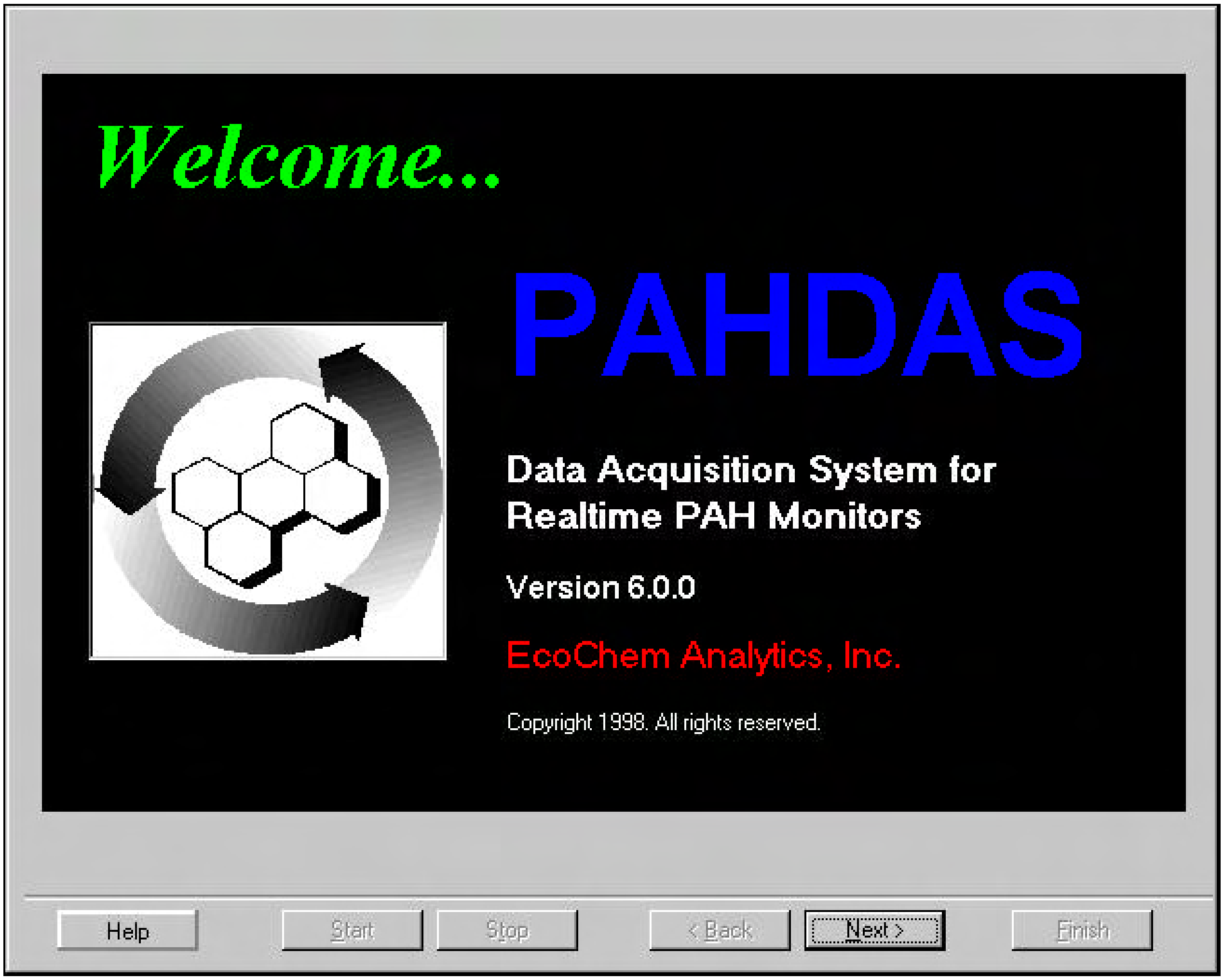
Real-Time Data Acquisition	Data Download	Exit
Introduction Screen On this screen you will see a summary of the steps required to do real-time data acquisition.	**Introduction Screen** On this screen you will see a summary of the steps required to do data downloading from the PAH monitor.	**Farewell Screen** You will be given an option to exit or return to the main program.
Configuration Screen On this screen you will be able to configure the manner in which the PAH monitor data will be obtained, stored and displayed.	**Raw Data Screen** On this screen you will be able to download raw data from the PAH monitor to your PC.	
Test Link Screen Once we've configured the program, it is time to test the link between the PC and PAH monitor. The program automatically checks the RS-232 port and tries to collect some data points. It lets us know whether we should proceed or reconfigure the system.	**Process Data Screen** Once the raw data has been downloaded, it needs to be processed. In this step you will choose the data format and then process the raw data.	
Collect Data Screen This screen shows us our data. It plots data on a stripchart as it is collected and a text data listing. It also shows us the data file where the measurements are being stored and status messages as they are generated	**View Data Screen** This screen will enable you to view the processed data.	

B.3.1 Program Flowchart



B.3.2 Welcome Screen

Purpose This screen is displayed when the PAHDAS program begins.

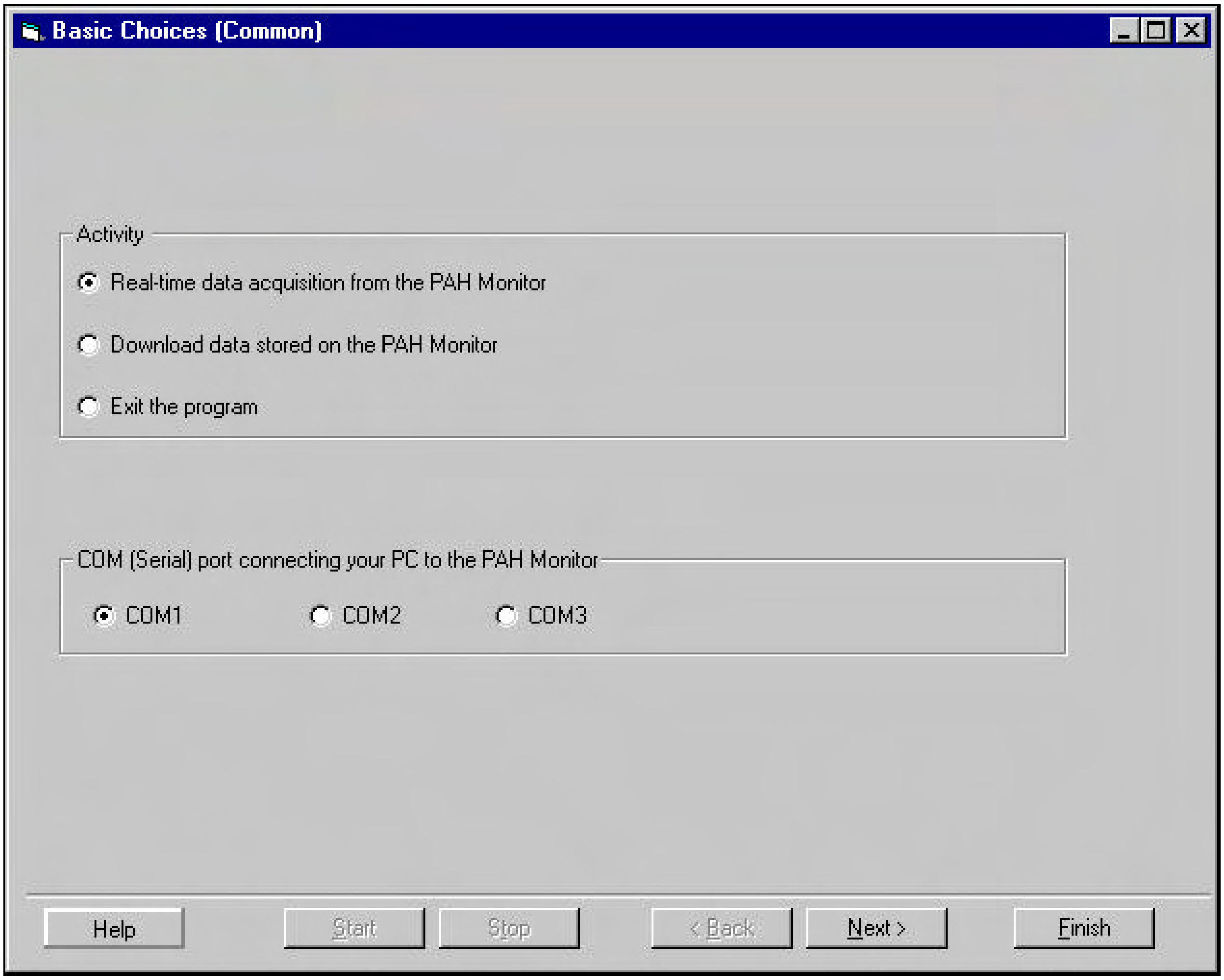


Navigation Buttons

Help	Press this button to obtain context-sensitive help regarding this screen.
Start	Disabled
Stop	Disabled
<Back	Disabled
Next>	Press this button to proceed to the **Basic Choices (Common)** Screen.
Finish	Disabled

B.3.3 Basic Choices (Common) Screen

Purpose This screen enables you to define the activity (real-time data acquisition, data download or exit) and the serial port connecting your PC to the PAH monitor.



Selectors

Activity Choose one of the following:

- Real-time data acquisition from the PAH monitor
- Download data stored on the PAH monitor
- Exit the PAHDAS program

COM Port This specifies which serial port on the computer is being used by the RS-232 cable to connect to the PAH monitor.

Navigation Buttons

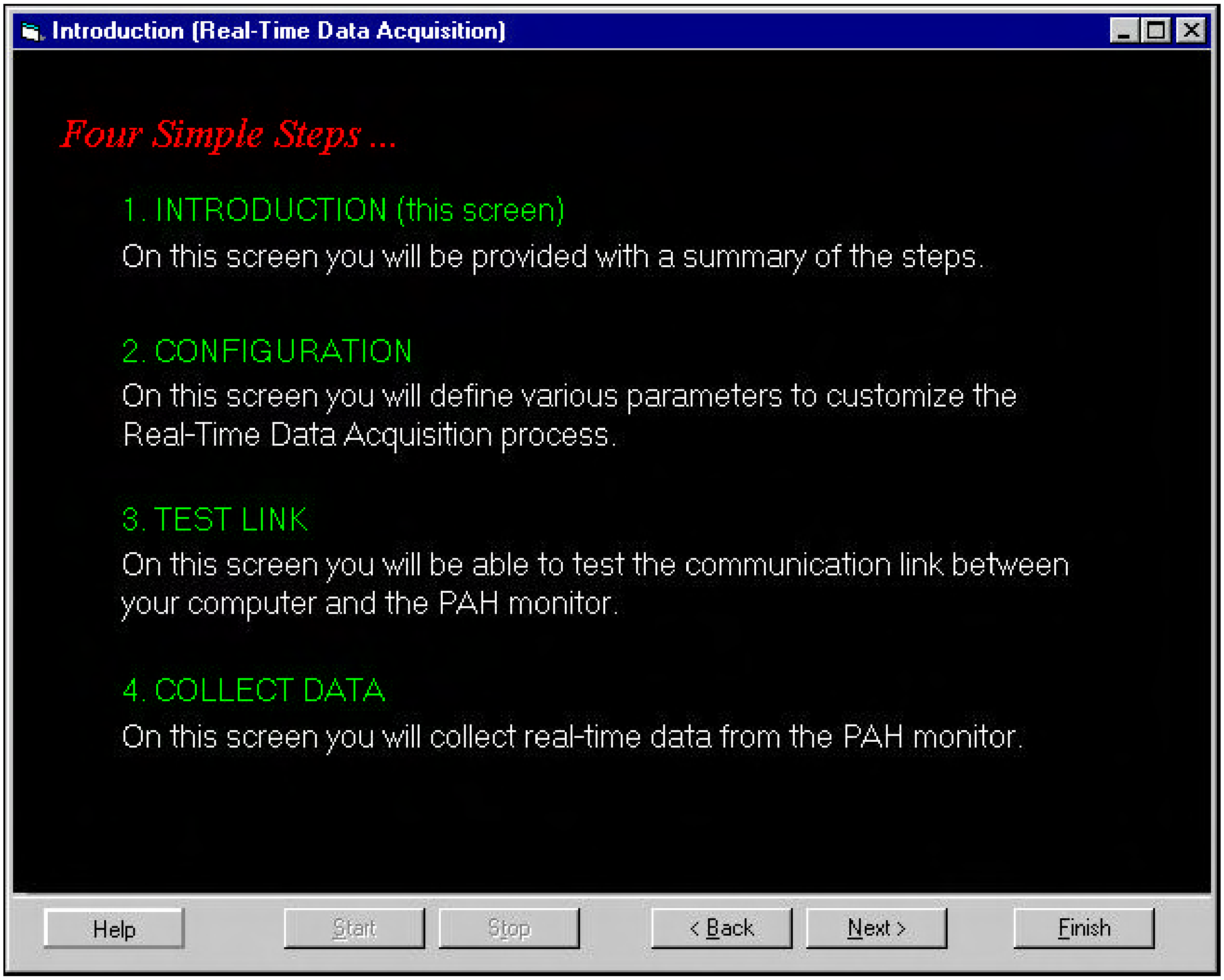
Help Press this button to obtain context-sensitive help regarding this screen.

Start Disabled

Stop	Disabled
<Back	Disabled
Next>	Press this button to proceed to the **Introduction (Real-Time Data Acquisition)** or **Introduction (Data Download)** screen.
Finish	Quit the PAHDAS program

B.3.4 Introduction (Real-Time Data Acquisition) Screen

Purpose This screen provides you with a summary of the steps required to do real-time data acquisition.

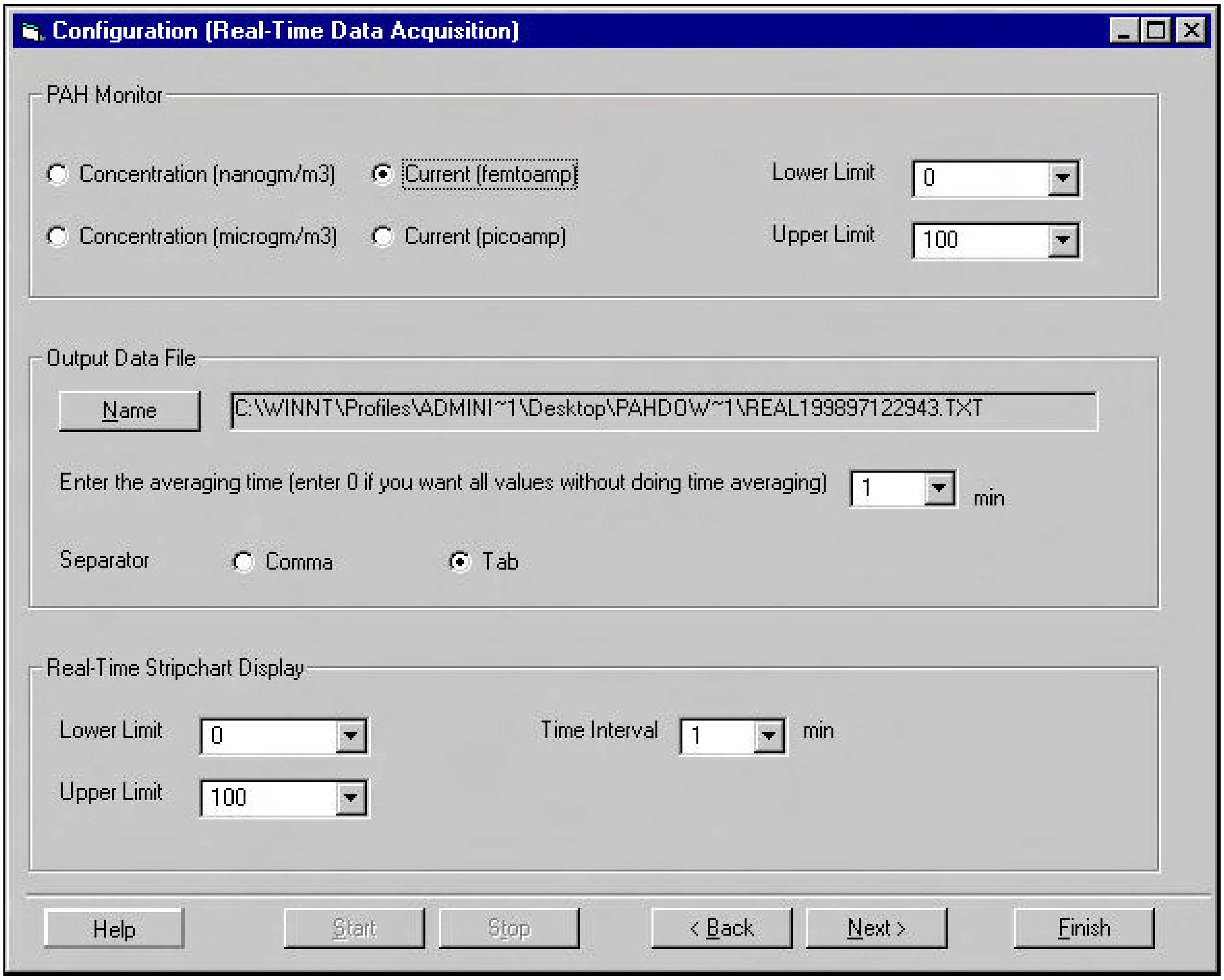


Navigation Buttons

Help	Press this button to obtain context-sensitive help regarding this screen.
Start	Disabled
Stop	Disabled
<Back	Press this button to return to the **Basic Choices (Common)** screen.
Next>	Press this button to proceed to the **Configuration (Real-Time Data Acquisition)** screen.
Finish	Quit the PAHDAS program

B.3.5 Configuration (Real-Time Data Acquisition) Screen

Purpose This screen affects how the data is collected and how it is displayed. It allows the user to specify the output file name, PC data port, plotting variable and operation mode.



Data Entry

Plotting Variable This determines which value is actually plotted on the stripchart when data is displayed on the Collect Data screen.

(See note 3 at the end).

Lower Limit

(PAH Monitor) Specify the lower limit of the measuring range chosen on the PAH monitor.

(See note 3 at the end)

Upper Limit

(PAH Monitor) Specify the upper limit of the measuring range chosen on the PAH monitor.

(See note 3 at the end)

File Name — This is a file name into which all of the data points are to be collected.

(See notes 1 and 2 at the end.)

Averaging Time — This is the averaging time used for processing the signal values. Choose a time period and data values will be averaged over this time period.

Separator — This is the character (either COMMA or TAB) that will be used to separate field values in the data file.

Lower Limit (Stripchart Display) — Specify the lower limit of the display range for the stripchart.

Upper Limit (Stripchart Display) — Specify the upper limit of the display range for the stripchart.

Time Interval — Specify the time interval (range on the x-axis) for the stripchart.

Navigation Buttons

Help — Press this button to obtain context-sensitive help regarding this screen.

Start — Disabled

Stop — Disabled

<Back — Press this button to return to the **Introduction (Real-Time Data Acquisition)** screen.

Next> — Press this button to proceed to the **Test Link (Real-Time Data Acquisition)** screen.

Finish — Quit the PAHDAS program

Notes

1) You cannot enter a name directly in this Output File data field. You should press the Output File button which will create a File Open dialog screen. On this screen you can enter a new file name or select an existing file. On the File Open dialog screen you will also be able to select the directory in which the file resides.

2)By default every time you run PAHDAS, the program will generate a new file name. This file name is created by taking into account the current month, minute and second which are extracted from your computer. If you want to use the default file name, you simply do not have to do anything. However if you would like to assign a file name relevant to your activity (e.g. TEST1.PAH, INDOOR1.PAH etc...) you are free to do so.

Attention

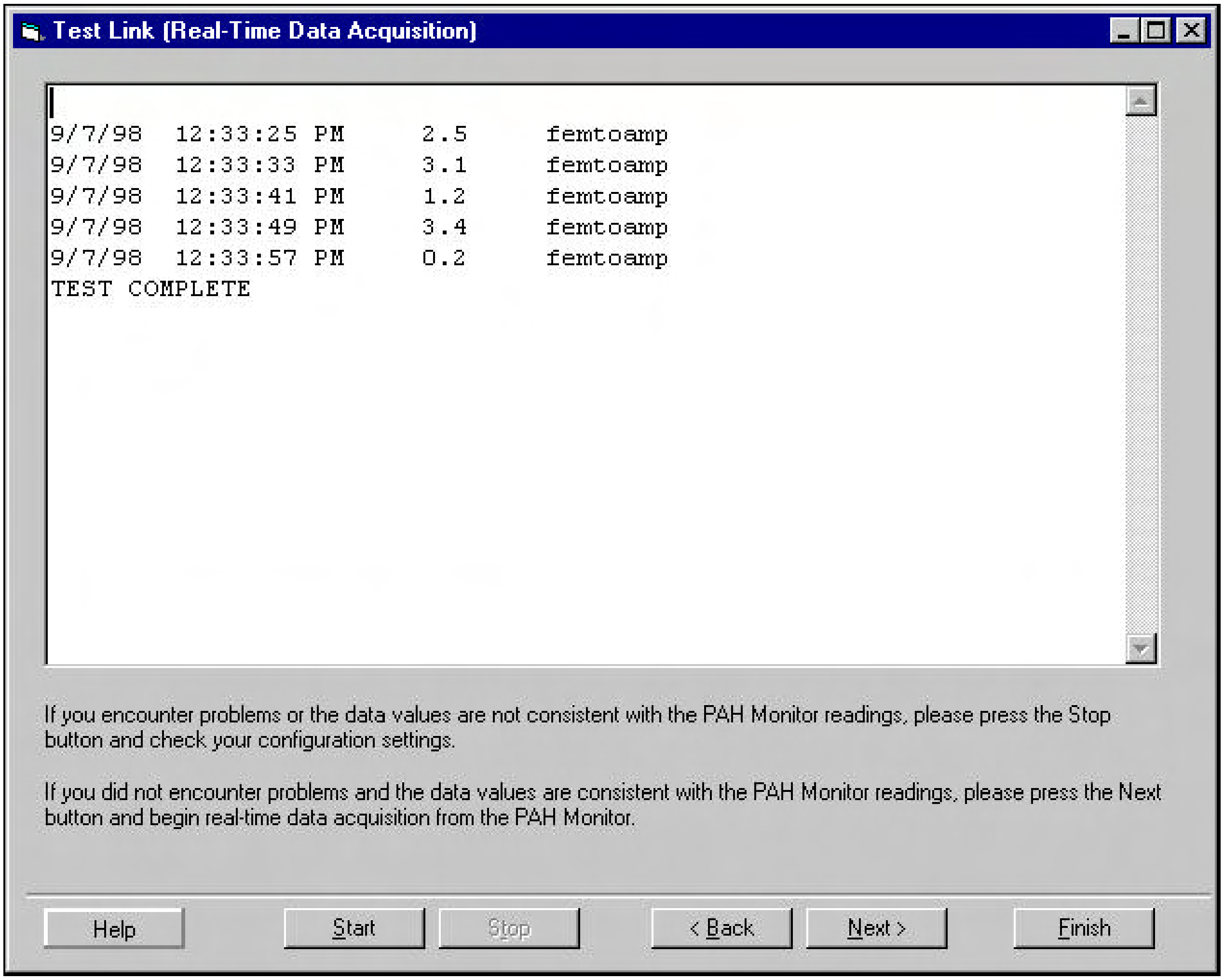
3)**PAHDAS Version 6.0 does not obtain the setting variables automatically from the PAH monitor.** Thus you should be consistent in choosing the same parameter as the plotting variable between the PAH monitor and the data acquisition software. If you have chose to display concentration in ng/m^3 on the PAH Monitor, you should also choose concentration in ng/m^3 on the Configure screen.

In addition it is important to define the same **measuring range** for the

PAH monitor and the PAHDAS software. Thus values chosen for the **measuring range** on the PAH monitor should be identical to those entered for the **Lower** and **Upper Limit** on the PAHDAS software. **The software uses the limits for internal calculations and inconsistent entries will result in erroneous data acquisition.**

B.3.6 Test Link (Real-Time Data Acquisition) Screen

Purpose This screen tests the linkage and data flow between the PAH monitor and the computer. It displays status messages regarding the test results.



Displays

Status Window This window displays messages as the PAHDAS program performs some tests regarding the PC-Monitor connection and data flow. Once the tests are completed, it will advise the user as to the status of the data acquisition process.

Navigation Buttons

Help Press this button to obtain context-sensitive help regarding this screen.

Start Press this button to initiate the Test Link process.

Stop Press this button to terminate the Test Link process.

<Back Press this button to return to the **Configuration (Real-Time Data Acquisition)** screen.

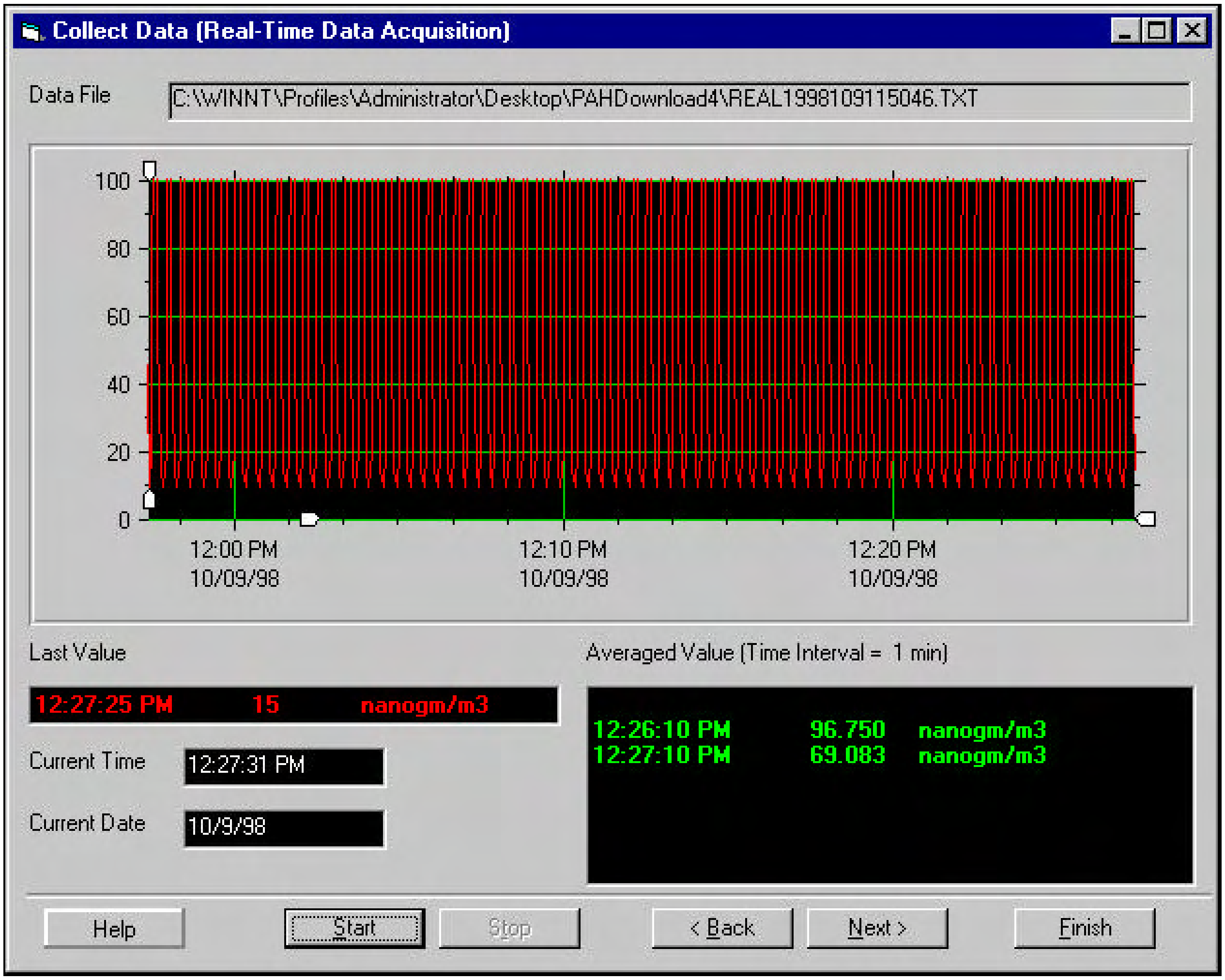
Next> Press this button to proceed to the **Collect Data (Real-Time Data Acquisition)** screen.

Finish Quit the PAHDAS program

Notes The PAHDAS program will open the port which you have specified on your Configure screen. The program will then attempt to collect data points which are sent by the PAH monitor. Depending upon the time interval which is defiined on your PAH monitor, you may have to wait some time (seconds to minutes) before this test is completed.

B.3.7 Collect Data (Real-Time Data Acquisition) Screen

Purpose This screen displays the data values obtained from the PAH monitor on a stripchart and in a data window.



Displays

Data File	This is the data file into which the data points are being archived.
Stripchart	This plots the data points as they are collected.
Last Value	This window displays the last data point collected from the PAH monitor.
Averaged Value	This window displays the average values. The time, average value and data units appear for each data point.
Current Time	This is the current time.
Current Date	This is the current date.

Navigation Buttons

Help	Press this button to obtain context-sensitive help regarding this screen.
Start	Press this button to initiate collecting data from the PAH monitor.
Stop	Press this button to terminate collecting data from the PAH monitor.
<Back	Press this button to return to the **Test Link (Real-Time Data Acquisition)** screen.
Next>	Press this button to proceed to the **Basic Choices (Common)** screen.
Finish	Quit the PAHDAS program

Note

Attention

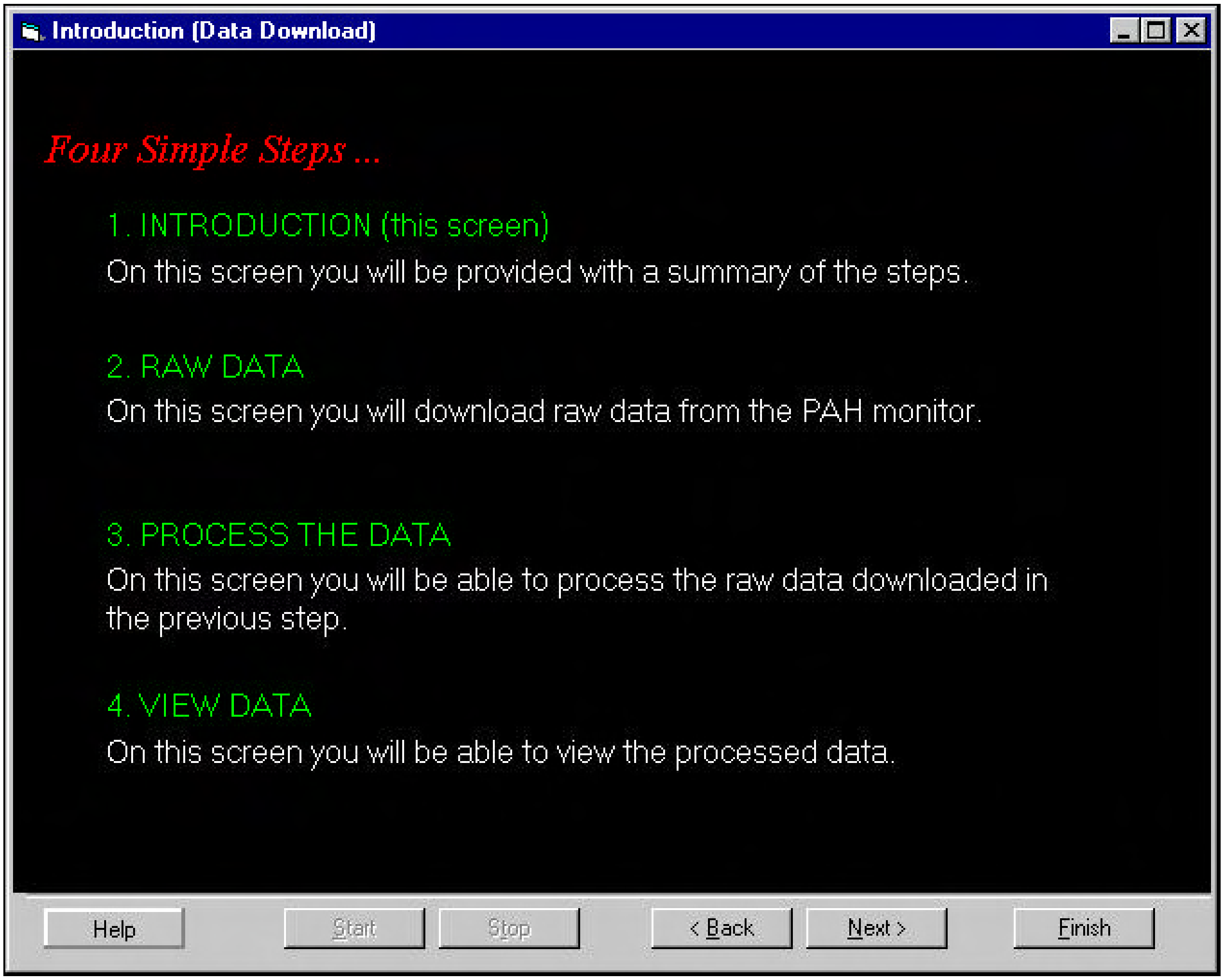
1) The frequency with which the data is collected by PAHDAS depends upon the parameter settings which you have defined on the PAH monitor. On the **SYSTEM DATA** (see 4.3.3) menu you have selections for **Lamp Parameters** (section 4.3.3.4). The time variables which you have defined on this screen will determine the frequency at which the PAH monitor transmits data.

2)On the X and Y axes of the stripchart you will observes „handles“ (white arrow pointers). You can move the handles along the axes and focus your attention on any particular portion of the strip chart.

3)If you choose an extremely large time span on the x-axes, you will observe a „red band“ being developed. The stripchart is designed to have a memory buffer of several thousand data points. However due to the pixel resolution of the screen, more than one data point may be plotted at the same location on the screen resulting in the „red band“. Do not despair – you can use the handles described above to focus on any particular portion of the red band and see the fine details within occurred for a short period of time.

B.3.8 Introduction (Data Download) Screen

Purpose This screen provides you with a summary of the steps required to download data stored on the PAH monitor.

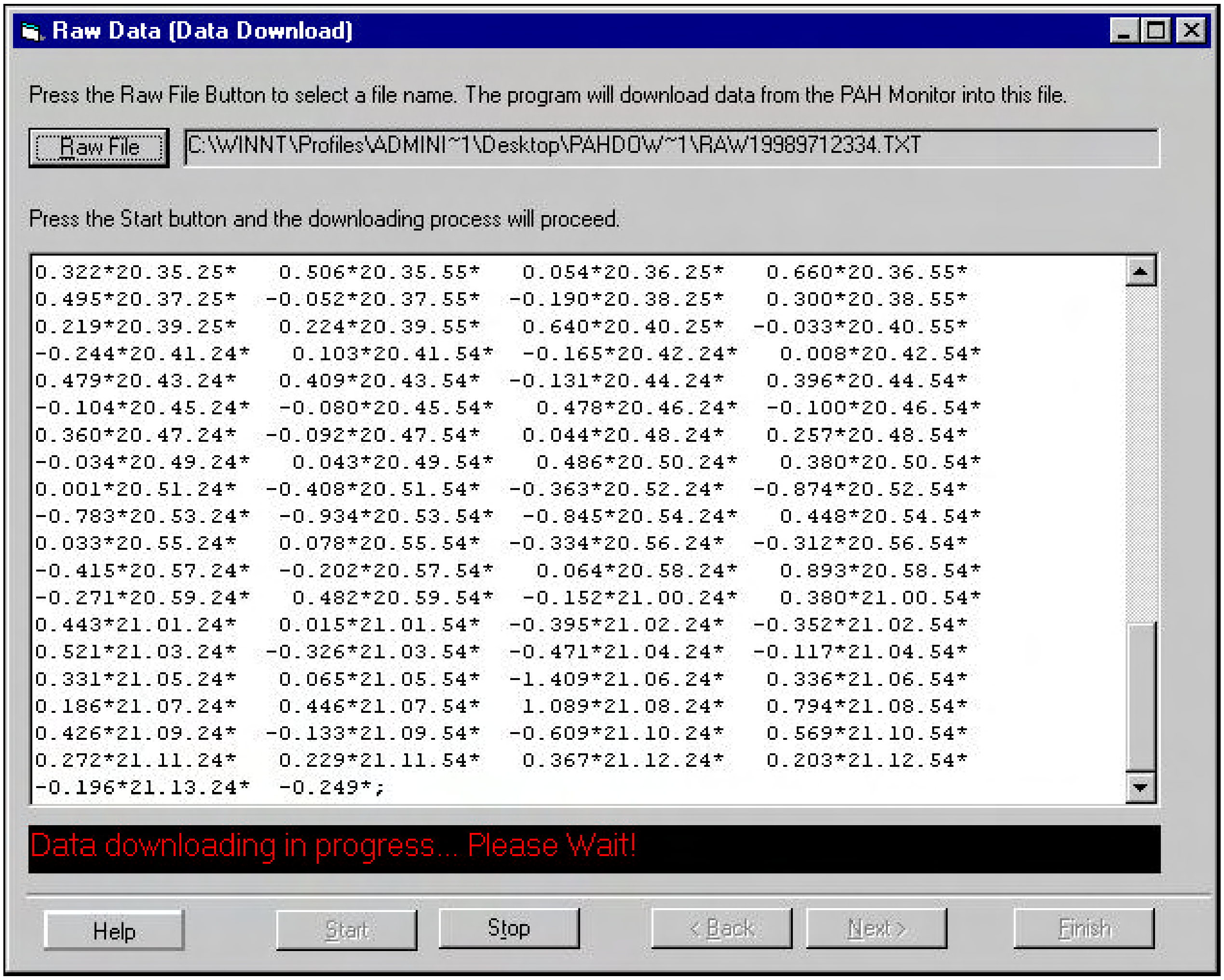


Navigation Buttons

Help	Press this button to obtain context-sensitive help regarding this screen.
Start	Disabled
Stop	Disabled
<Back	Press this button to return to the **Basic Choices (Common)** screen.
Next>	Press this button to proceed to the **Raw Data (Data Download)** screen.
Finish	Quit the PAHDAS program

B.3.9 Raw Data (Data Download) Screen

Purpose This screen enables you to download raw data stored by the PAH monitor.



Displays

Raw File Press this button to obtain a File Open dialog. You will be able to choose the file name and directory within which the raw data is to be downloaded.

Status Window This window displays raw data as the PAHDAS program performs the data download process. Once the process is completed, it will advise the user as to the status.

Navigation Buttons

Help Press this button to obtain context-sensitive help regarding this screen.

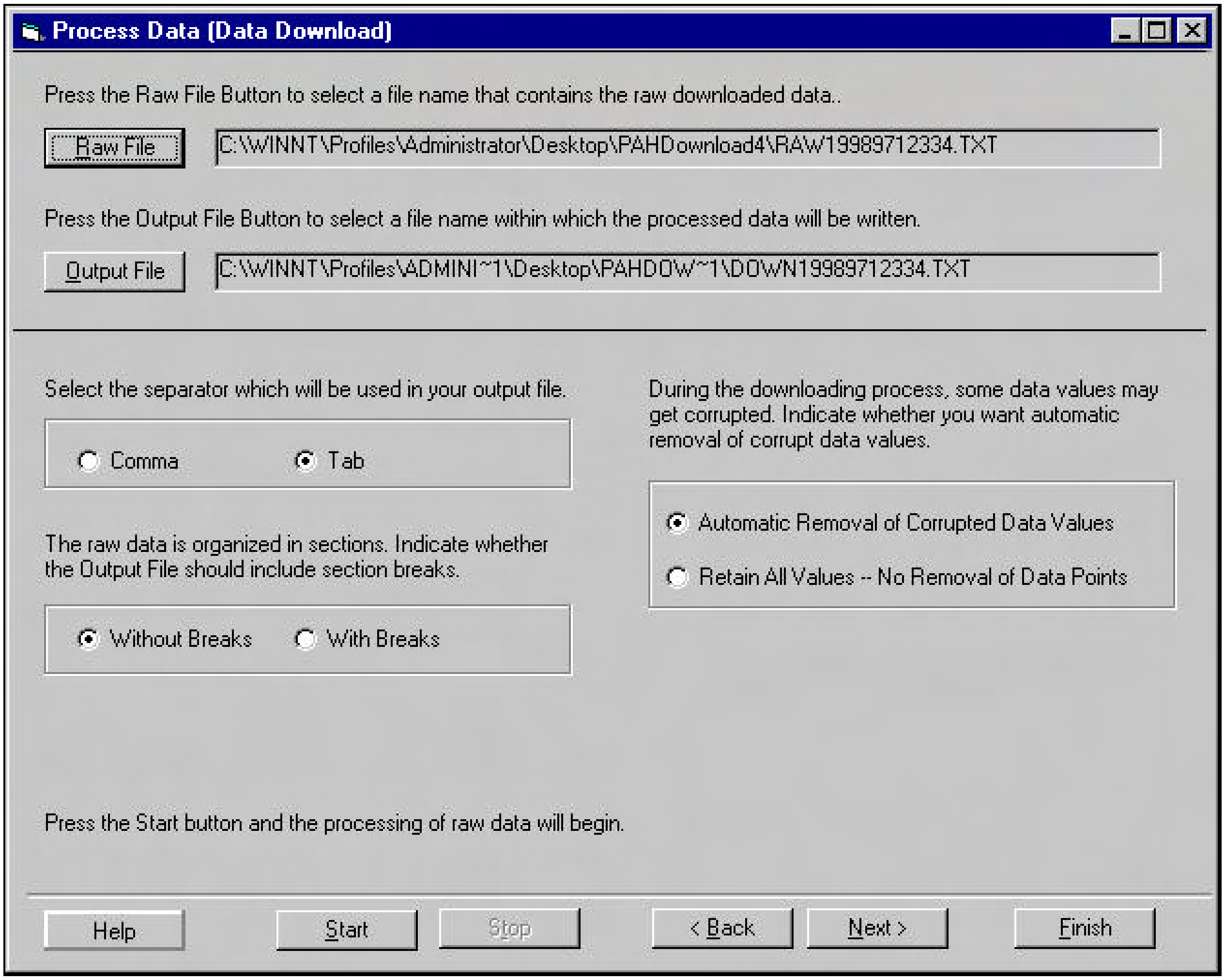
Start Press this button to initiate the Data Download process.

Stop Press this button to terminate the Data Download process.

<Back	Press this button to return to the **Introduction (Data Download)** screen.
Next>	Press this button to proceed to the **Process Data (Data Download)** screen.
Finish	Quit the PAHDAS program

B.3.10 Process Data (Data Download) Screen

Purpose This screen enables you to process raw data downloaded from the PAH monitor.



Displays

Raw File Press this button to obtain a File Open dialog. You will be able to choose the name and location of this file.

Output File Press this button to obtain a File Open dialog. You will be able to choose the name and location of the output file. **NOTE, the ouput file will contain data processed from the Raw Data file.**

Separator This is the character (either COMMA or TAB) that will be used to separate field values in the Output file.

Sections The data stored on the PAH monitor comprises of multiple sections. Indicate whether you want the section breaks to appear within your Output file.

Corrupted Data Ocassionally, there maybe coruption of data during the download process. Indicate whether you want automatic removal of corrupted data

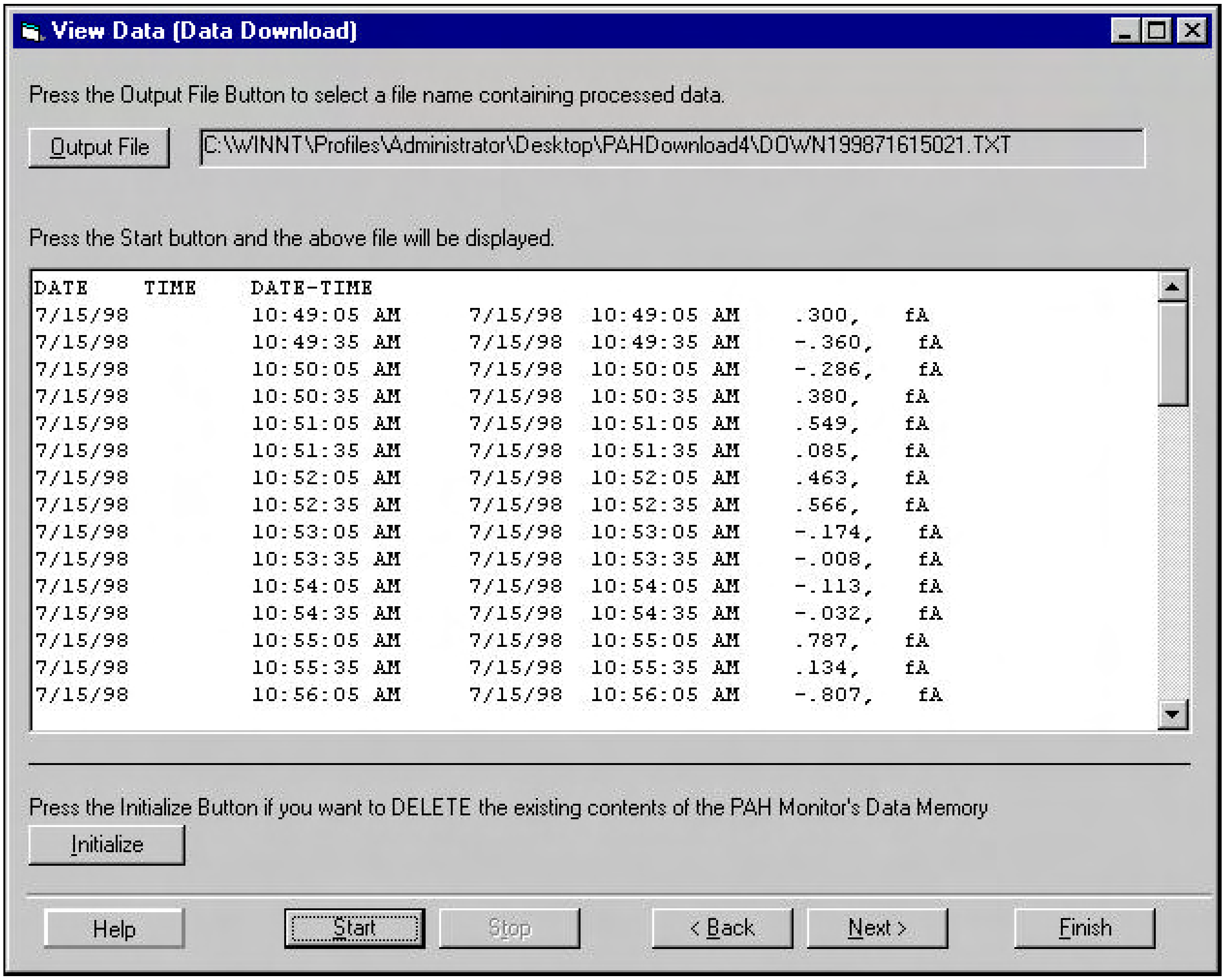
Removal	process. Indicate whether you want automatic removal of corrupted data or whether you would like to retain all values.

Navigation Buttons

<u>H</u>elp	Press this button to obtain context-sensitive help regarding this screen.
<u>S</u>tart	Press this button to initiate the processing raw data.
S<u>t</u>op	Press this button to terminate the processing raw data.
<<u>B</u>ack	Press this button to return to the **Raw Data (Data Download)** screen.
<u>N</u>ext>	Press this button to proceed to the **View Data (Data Download)** screen.
<u>F</u>inish	Quit the PAHDAS program

B.3.11 View Data (Data Download) Screen

Purpose This screen enables you to view processed data downloaded from the PAH monitor.



Displays

Output File Press this button to obtain a File Open dialog. You will be able to choose the name and location of the output file. **NOTE, the ouput file will contain data processed from the Raw Data file.**

Display Window In this window the program will display the processed data file.

Initialize Press this button if you want to initialize the memory of the PAH monitor. All previous data stored on the monitor will be blanked out.

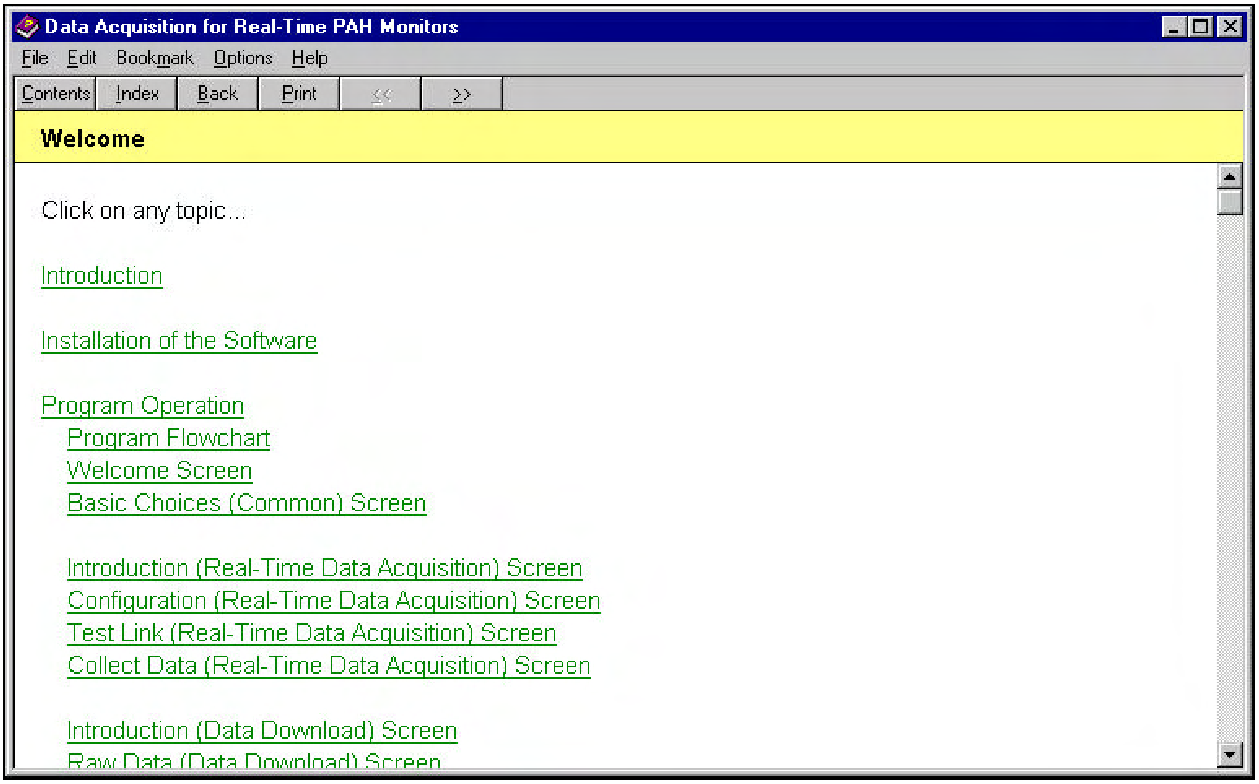
Navigation Buttons

Help Press this button to obtain context-sensitive help regarding this screen.

Start	Press this button to display the contents of the output file.
Stop	Disabled
<Back	Press this button to return to the **Process Data (Data Download)** screen.
Next>	Press this button to proceed to the **Basic Choices (Common)** screen.
Finish	Quit the PAHDAS program

B.3.12 Help Screen

Purpose This screen is displayed whenever the user presses the Help button on any screen. It provides helpful information pertaining to the currently displayed screen. It also provides access to other help topics.



Menu

File	Menu for printing help topics and exiting the Help facility.
Edit	Menu containing editing commands for help text.
Bookmark	Menu to define or go to bookmarks within the Help facility.
Help	Menu to obtain help pertaining the Help facility itself.

Push Buttons

Contents	Display a Table of Contents for the on-line Help facility.
Index	Display a list of items.
Back	Return to the last help screen displayed.
Print	Prints the current Help subject.
<<	Proceed to the previous help topic in the Table of Contents.
>>	Proceed to the next help topic in the Table of Contents.

B.4 Post- Processing of Collected Data

As data is collected from the monitor it is plotted on the strip chart and displayed on the Monitor screen of the PAS 2000 Data Acquisition Program. At the same time, it is written to a data file on the computer hard disk. The name of this output file is specified on the Configure screen. What is written to the data file will depend upon which data value is chosen on the Configure screen (current in picoamps or femtoamps, concentration in micrograms/m^3 or nanograms/m^3). In the following example file, concentration values with units of nanograms/m^3 have been written:

```
File name :, JAN1036.PAH
Stored Variable is Conc in nanogm/m3
Date, Time, Concentration
DY:MT:YR, HH:MM:SS, nanogm/m3
 22-JAN-1997, 11:16:10,  907,
 22-JAN-1997, 11:16:11,  644,
 22-JAN-1997, 11:16:12,  165,
 22-JAN-1997, 11:16:13,  301,
 22-JAN-1997, 11:16:14,  166,
 22-JAN-1997, 11:16:15,  285,
```

The first line of the file contains the data file name within the PAS2000 directory. The next line specifies whether the stored values are concentration or current. It also indicates the units associated with the values: nanogram/m^3, microgram/m^3, femtoamp or picoamp. Two header lines then appear and finally the date, time and value for each measurement appear.

This data can be imported into a spreadsheet program such as Microsoft Excel or Lotus 1-2-3 by opening the file as comma separated value (CSV) data text file. This is accomplished by importing the file in your spreadsheet program and indicating that the comma character (" , ") is a delimiter. Once this data is imported in your spreadsheet you can perform statistical operations (e.g. averaging), create graphs and/or export the data to other applications.

B.5 Trouble-Shooting

Here are a couple of things which you can do to try and resolve commonly-encountered problems :

- **The data acquisition program does not seem to collect any data from the PAH monitor**

  Check the settings on the CONFIGURE screen. Make sure that you have selected the right COM port (RS232 port) on your computer. Frequently a computer will have more than one COM port and devices like a mouse or external modem may occupy one COM port. Make sure that you specify the correct COM port which is linked to the PAH monitor.

  Check the cable and the adapter used for linking the PAH monitor to the computer. Along with the program we supply you a serial cable and an adapter. In case you are using another cable and/or adapter make sure that this cable is "straight" and not cross-linked.

- **The data acquisition program seems to report data values which are different from the PAH monitor**

  Check the range values (High and Low) on the data acquisition program. Make sure that the range specified on the PAH monitor matches in numerical value and units as that chosen on the CONFIGURE screen of the data acquisition program.

- **All data values collected by the data acquisition program have a numerical value of zero**

  Frequently "rounding problems" may result in the loss of accuracy between data transmitted from the PAH monitor. For example, suppose you have specified a range of 0 to 1000 picoamp on the PAH monitor. Suppose you are operating in a clean environment and your measured signal is low (for example 0.010 picoamp or 10 femtoamp). The PAH monitor will display a value of 0.010 femtoamp. However the data acquisition program displays a value of 0.

  To rectify this situation choose a more appropriate range on PAH monitor. For example in this scenario you may want to reduce the measuring range to 0 and 1 picoamp or even select 0 to 1000 femtoamp. Selecting an appropriate range on the PAH monitor will enable you to collect identical values on the computer as those displayed on the PAH monitor.

APPENDIX C - THE DILUTION SYSTEM

C.1 Operating Principle

The dilution system consists of dilution electronics and the probe. The whole system is delivered in a 19” rack-mounted unit. On the left side of the rack is the analyzer itself. The dilution electronics is inserted on the right side of the rack.

The operating principle is shown in Figure C.1. The dilution air passes a pressure regulator and a critical orifice with stable flow of approx. 3.2 l/min. This dilution air is transported to the probe and mixed with a small quantity of the stack gas. The mixture is pumped back to the dilution electronics. A massflow meter measures the total flow. The total flow is set by the pump, which is controlled by the software of the PAS 2000.

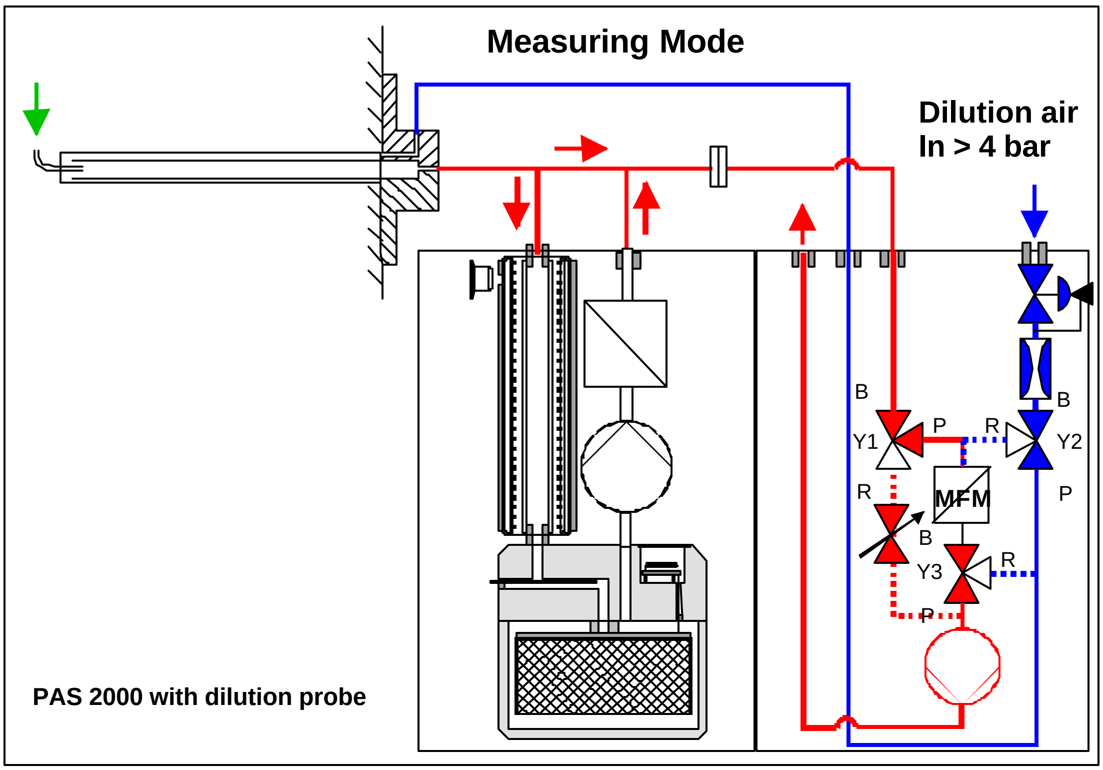


Figure C.1

To eliminate the drift of the massflow meter and orifice both units are calibrated repeatedly. In the calibration mode the flow of the orifice is passed through the massflow meter. The actual flow is measured during 2 minutes and the measured value is stored in the PAS 2000. This calibration value is used for the control of the pump. During the calibration mode the flow through the pump is kept constant.

The cycle time of the calibration mode depends on the dilution factor, which has been selected. The cycle times are:

D = 10 4 hours

D = 20 2 hours

D = 50 1 hour

D = 100 ½ hour

During the measurement the measuring value is multiplied with the actual dilution factor.

This dilution factor is shown in the display of the PAS 2000 in the measuring mode. With a dilution different from 1 the display looks as follows:

Screen Layout :

```
           MEASURING VALUE
           0   -   50   ng / m3

                14.7
      Intens.     Frequ.      Flow
      99.6        5.5         1.95
D = 46.5          3.2698       3.2010
```

Notes :

In the last line of this screen you observe the numerical values of three variables:

1. The first variable (D = 46.5) is the actual dilution factor.
2. The second variable is the actual flow through the massflow meter
3. The third value is the last calibration value of the orifice.

During the calibration mode the third value is the actual value measured at the orifice. This means value 2 und 3 are equal.

C.2 The Dilution Probe

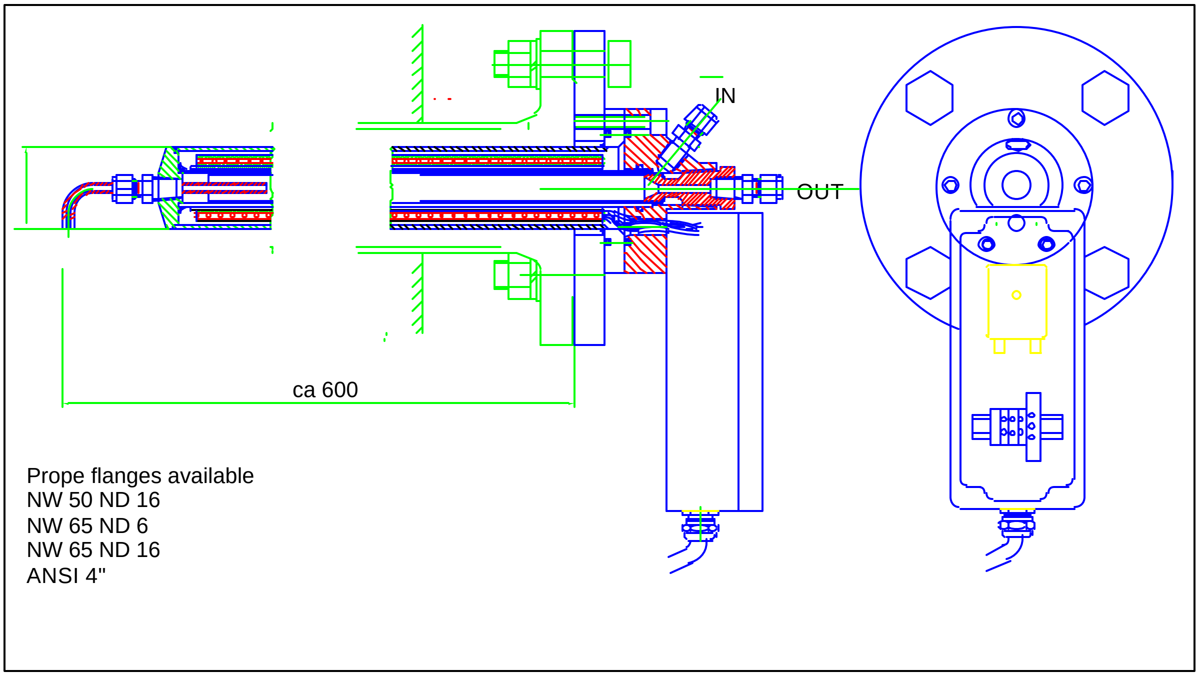


Figure C.2

The dilution probe is heated to a fixed temperature of 100 °C. Higher temperatures are not recommended since the PAH on the surface of the particles would vaporize.

For the same reason the installation should be done in a way that the temperature of the probe flange never exceeds 100 °C. Otherwise losses of PAH might occur.

C. 3 Set Up

The system is delivered ready for installation. You simply have to connect the dilution air inlet, the dilution air outlet at the dilution unit. The measuring gas inlet has to be connected to the analyzer itself.

The massflow meter needs a warm up since it is a thermostated unit. **For a dilution factor of 50 the warm-up time is up to 3 hours until the measuring signal is stable. Therefore we recommend to run the system after start-up at least 2 hours with a dilution factor of 1.** During this time the pump in the dilution unit is switched of and no stack gas is extracted. This mode avoids the introduction of humidity by malfunctioning of the unit during warm-up.

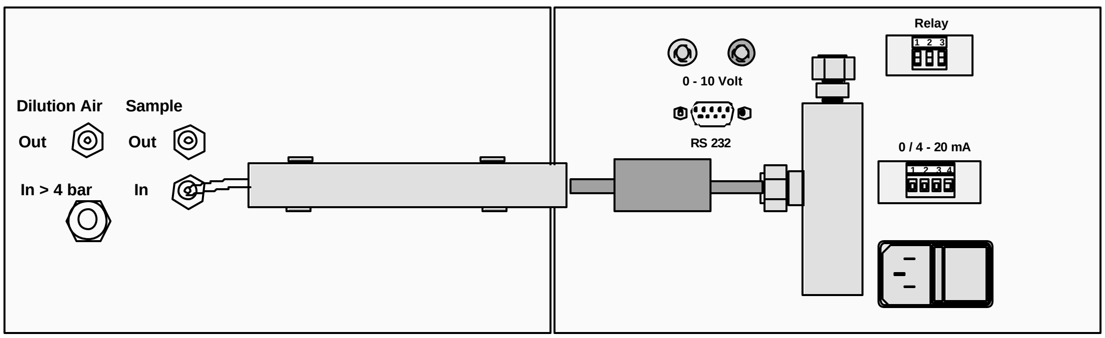


Figure C.3 Backplate of the PAH Monitor (Source Version)

APPENDIX D - EXCIMER LAMP EXCHANGE PROCEDURE

D.1 Overview

In order to exchange the excimer lamp you have the accomplish the following tasks:

- Remove the analyzer module from the housing
- Remove the ionization tube
- Remove the old excimer lamp
- Place the new excimer lamp
- Place back the ionization tube
- Place back the analyzer module within the housing
- Make software adjustments

D.2 Tools you will need to accomplish the job

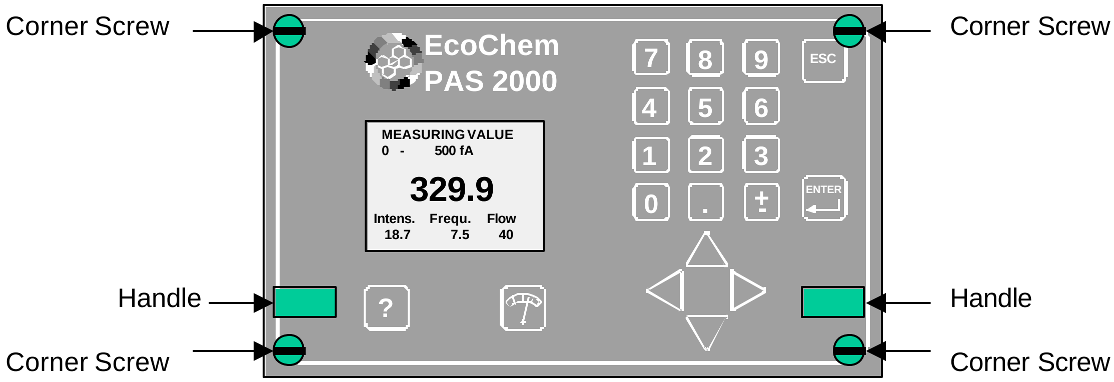
1. Tools for removing screws and nuts
2. Two pieces of string to hold on to the electrical connectors

D.3 Warnings

Warning

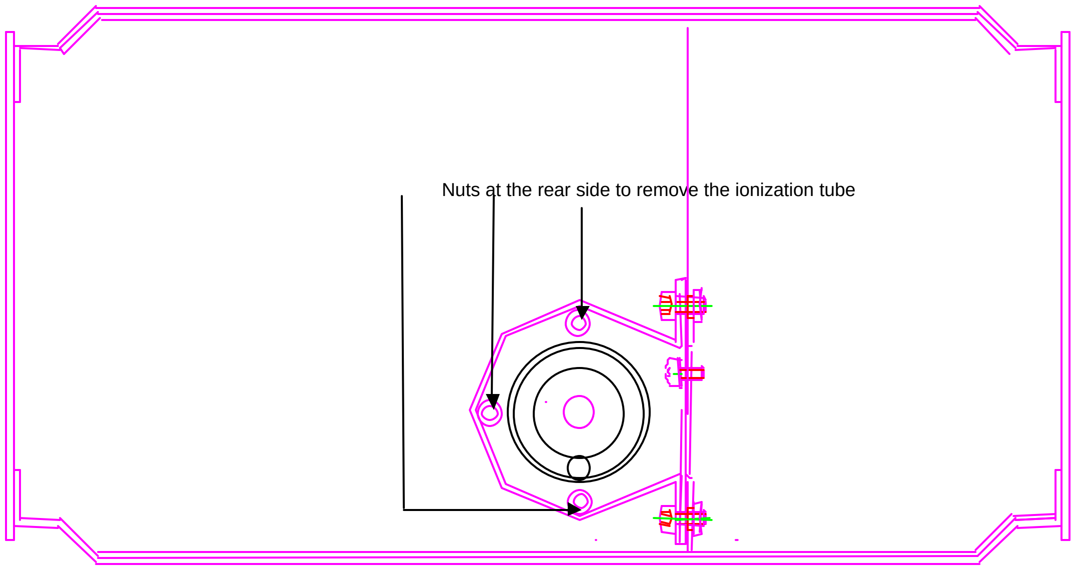
- Before attempting to exchange an excimer lamp, read carefully the instructions. If you do not understand anything, please call technical support.
- After reading the instructions, if you do not feel comfortable exchanging the excimer lamp, please feel free to contact us. At a nominal cost we will replace the lamp for you at our facility.
- The PAH monitor utilizes high internal voltage. Hence please make sure that no screws or other mechanical components fall within the interior of the analyzer. If a component falls inside, gently remove it.
- **Before attempting to exchange the excimer lamp, disconnect the analyzer from the power mains.**

D.4 Removal of the analyzer module from the housing



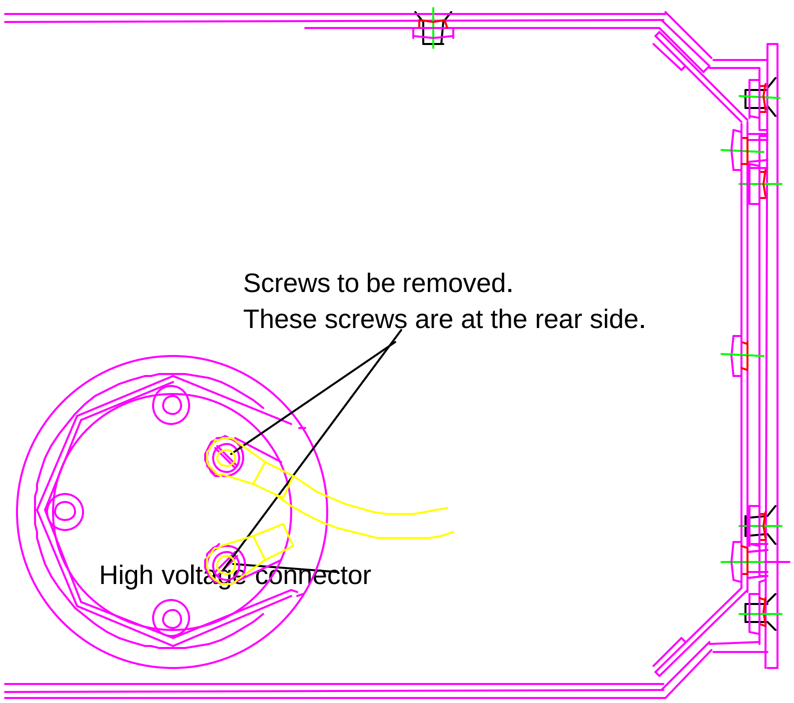
- On the front panel of the PAS2000 you will find screws located at the four corners. Remove these screws.
- Using the two handles on the front panel, firmly pull out the analyzer module from the housing.

D.5 Removal of the ionization tube

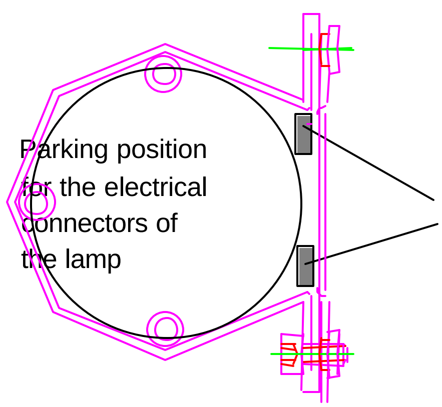


- The ionization tube is attached to the rear panel of the analyzer module by three nuts. Remove these nuts and carefully place them aside.
- Gently pull out the ionization tube from the analyzer. The ionization tube is spring mounted and hence this should not require the use of excessive force.
- Place aside the ionization tube.

D.6 Removal of the old excimer lamp



- Once the ionization tube has been removed, you are ready to remove the excimer lamp. Look at the back panel and you will observe two electrical connections. Also observe that one connector has a SLIGHTLTY BIGGER DIAMETER AND HAS A STRIPE MARKED ACROSS IT. THIS IS THE HIGH VOLTAGE CONNECTOR. Clearly mark this connector and note where it is connected to the excimer lamp assembly.
- Remove the two screws connecting the electrical leads to the excimer lamp.
- Gently pull the electrical connectors and place them on the side of the old excimer lamp.

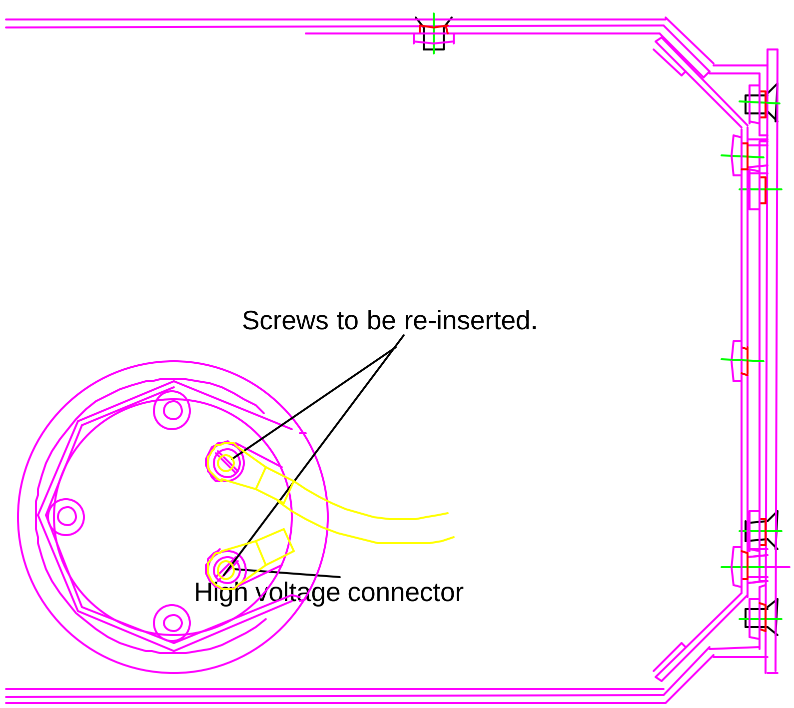


- Gently pull out the old excimer lamp. IT IS IMPORTANT THAT YOU AVOID SCRATCHING THE ELECTRICAL LEADS TO THE SHEET METAL IN THE HOUSING.

- Tie small pieces of string to the electrical connectors. This will ensure that the connectors will not slip into the housing when you try to put in a new lamp.

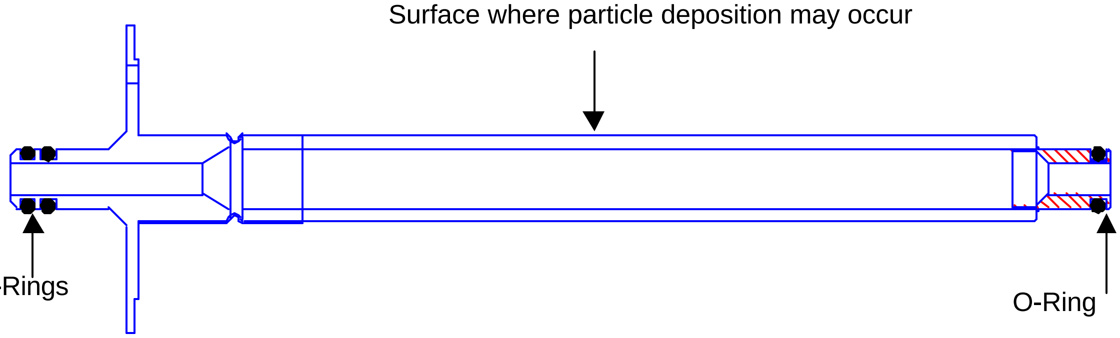
D.7 Placing back the excimer lamp

- Gently insert the new excimer lamp within the cavity. Center the lamp if necessary. If done correctly this should fit snugly. AVOID SCRATCHING THE TERMINAL LEADS WITH THE SHEET METAL.
- Reconnect the electrical terminal screws on the rear panel. MAKE SURE THAT THE HIGH VOLTAGE CONNECTOR (THE ONE WITH LARGER DIAMETER AND STRIPE MARKING) IS CONNECTED TO THE LOWER SCREW.



D.8 Placing back the ionization tube

- Check your ionization tube for contamination or excessive deposition of particles. If the ionization tube appears dirty, use an ultrasonic device for cleaning. The solvent should be isopropanol.



- Check the ionization tube assembly for the three O-rings. If necessary you can replace them. Use Vaseline grease to slide in the new O-rings.
- After the ionization tube assembly is cleaned and mounted with fresh O-rings, gently re-insert the tube with the excimer lamp. IT IS EXTREMELY IMPORTANT THAT YOU SLIDE THE IONIZATION TUBE CONCENTRICALLY ALONG THE CENTERLINE. IF DONE CORRECTLY THE IONIZATION TUBE WILL FIT SNUGLY IN THE ASSEMBLY. USE OF FORCE WILL MISALIGN THE TUBE RESULTING IN POSSIBLE BREAKAGE OF THE IONIZATION TUBE.
- Place back the three nuts that connect the ionization tube to the analyzer module.

D.9 Placing back the analyzer module in the housing

- Slide back the analyzer module in the housing. Please do not use excessive force --- if done correctly the rail sidings on the housing will allow a smooth re-entry into the housing.
- After the analyzer module has almost reached completely inside, you should use the front handles to “snap-fit” the analyzer module. This ensures that electrical connections are established between the analyzer module and the back panel of the housing cabinet.
- Tighten the four screws located at the corners of the front panel.

D.10 Software adjustments after Lamp Exchange

- Start the PAH monitor and let it run for a short period of time.
- Press **3262436** on the numeric keypad.
- A Service Menu screen will appear.
- Enter **07.5** for the lamp frequency and press **ENTER**.
- Stay in the Service Menu screen for a minute so that the intensity stabilizes.
- Go to the **<Save with Enter>** selection and press **ENTER**.
- You will now be returned to the Measuring Value screen. Your lamp frequency reading should be approximately 7.5 and the intensity reading should be around 100.