OPERATION PROCEDURES

PSAP
Particle Soot/Absorption Photometer

Rom Version 1.01

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PSAP DESCRIPTION

General Information

The Particle Soot/Absorption Photometer (PSAP) is used to measure in near real time the optical extinction coefficient for absorption which can be used to estimate the corresponding concentration of fine particle soot. The method is based on the generally accepted integrating plate technique (IP) in which the change in optical transmission of a filter caused by particle deposition is related to the optical absorption coefficient using Beer's law and a calibration transfer coefficient. The difference between the PSAP measurement and the standard IP method is that the PSAP measurement is continuous as particles are being deposited rather than a single , time integrated measurement. Therefore, a continuous, time resolved measurement of absorption can be obtained. Measurement time resolution can be as short as a few seconds to 5 minutes depending on aerosol soot concentration. The calibration transfer coefficient was determined from measurements on aerosol with know absorption and is filter type dependent.

The optical absorption coefficient is calculated in real time and is available as both analog and serial data. Data also is displayed on an alpha/numeric display which additionally serves as a menu driven control panel for changing operation parameters. An embedded controller located in the instrument case is used to process optical and flow data, provide engineering calculations, and generate serial and analog outputs.

The principle features of the PSAP are:

- The instrument is self contained and requires only an external vacuum source to provide a sample flow of 1 to 2 lpm.

- Operating parameters are menu driven using front panel switches and the 4x20 alpha/numeric panel display. Averaging periods, minimum sensitivity and time clock can be modified from the front panel.

- Optical absorption coefficient, flow rate and lamp reference are available as both analog and serial data. Outputs update once each second.

System Specifications

Measurement

Parameter	Optical absorption coefficient, @ λ = 565 nm
Sensitivity	< 10^{-6} m^{-1} for 1 min averages.
Outputs	4 Analog (0 to 5VDC), 1 Serial (9600 baud, 8 bits, 1 stop, No parity). Baud rate can be set from 1200 to 9600.
Time Resolution	10 seconds to 300 seconds - user set

Measurement Characteristics

Principle	Integrating Plate method - dual path optical measurement
Electronics	68HC11 cpu, 21 bit AtoD conversions
Flow Rate	1-2 lpm @ 2"Hg
Lamp	Green, 565 nm LED

Physical Characteristics

Size	HxWxD (5.25"x19"x9.5") 19 inch rack size
Weight	Approximately 2 kg

Power

Operating Voltage	115/220 VAC
Power Usage	Approx. 10 watts

Measurement: Optical Absorption Coefficient, bap, in units of m^{-1}.

Assuming a specific absorption of 10 m^2/g for black carbon (soot),
[soot] = bap/10m^2/g = bap x 10^5 $\mu g/m^3$, where bap is in units m^{-1}.

Outputs: 4 analog, 1 serial, and alpha/numeric lcd panel display

bap calc:` Based on change in filter transmission (I/I_0) for given volume of sample air.

Without correction for filter type and loading:

$$bap = Area/Vol \times \ln_e(I_0/I)$$

where Area is area of sample spot = 1.783 x 10^{-5} m^2
Vol is volume of air sampled in ave. period in m^3.
I_0 is average filter transmittance in ave. per. *i*
I is average filter transmittance in ave. per. *i+1*

With correction for filter nonlinearity:

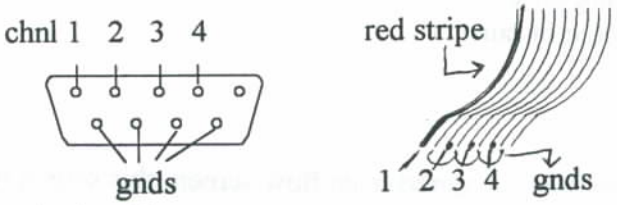
$$bap(corrected) = bap \times f(Tr)$$

where f(Tr) is the transfer function based on filter loading (Tr) for Pallflex filters. The transfer function is incorporated in software.

OUTPUTS

Analog: 4 channels, 0 to 10vdc, DB9p connector

Chnl #	Output	Range	example
1	$\log_{10}$ bap	10^{-7} to 10^{-2} m^{-1}	4 vdc is 10^{-5} m^{-1}
2	linear bap	0 to 5 x 10^{-5} m^{-1}	4 vdc is 2 x 10^{-5} m^{-1}
3	filter trans.	0 to 1.25	8 vdc is 100% trans. relative to clean filter
4	flow rate	0 to 5 lpm	4 vdc is 2 lpm flow



Analog Connector

Serial: 1 ascii data string per second, DP9s connector, 9600, 8, 1, N (baud rate adjustable)

Format:

YY	MM	DD	hh	mm	ss	Ave Per	Bap	Filtr Trans	Flow Rate	Signal	Reference
95	10	10	14	22	38	60	1.2	.821	1.95	303478	257157

col 1-6 Date and time
col 7 Averaging period in seconds
col 8 Bap, Absorption coefficient (units 10^{-6} m^{-1})
col 9 Filter transmittance relative to clean filter (set to 1.000 with new filter)
col 10 Flow rate in liters per minute (lpm)
col 11 Signal path A/D conversion
col 12 Reference path A/D conversion

note: magnitude of col 11,12 are determined from setting of maximum photodetector current. Maximum signal conversion is 800000. If signal or reference is much higher than 800000 the indicated output defaults to a fixed value of 33840. If over ranged, maximum PD current should be raised (see pg 6)

FRONT PANEL SWITCHES

Function: Steps through menu screens, 'up' or 'down' determines the order of screens displayed.
Item: Operates on the currently displayed screen only. Enables adjustable parameters to be changed.
Reset: Sets the filter transmittance to 1.000 when a new filter is installed (up position only; down position does nothing at this time).

SCREENS: Screens are accessed with 'function Switch'

ba = 0.2 E-6	10/10/95
	14:12:30
Tr 0.996	Ave 60 s
lvl 30 25	flow 1.91

MAIN

1. Computed bap units $10^{-6}m^{-1}$. Updates at end of each averaging period. e.g. every 60 secs
2. Filter transmittance relative to clean filter
3. Signal & reference levels from A/D's; 80 is max. Just under 1/2 scale is good operating range (changed by changing maximum detector current on 'level screen'.
4. Date and time
5. Averaging period in seconds.
6. Measured flow rate in lpm. If false flow is entered from flow screen, this screen will print 'fake flow' on screen.

LOGO SCREEN

Radiance Research etc
ROM checksum 1F2D
ADC mode F010

1. EPROM checksum, indicates installed program
2. ADC mode, indicates software settings for converters

FLOW SET SCREEN

Set Fixed Airflow
Zero = Actual
.0 lpm
Item to Set

1. A fixed, false flow rate can be entered on this screen in steps of 0.5 lpm up to 5 lpm. When set to 0.0, which is the normal operating condition, flow is determined directly from the mass flow meter. Defaults to '0' on power-up.

If the instrument is operating with no sample flow (and fixed flow set to 0.0 - normal operating condition) the software forces the volume calculation to assume a flow of 0.1 lpm to avoid dividing by zero. The indicated bap on the panel will have perhaps 20 times the noise associated with detector drift or noise because of this low volume assumption. If testing detector stability or whatever, a faked flow can be entered from this screen to get noise measurements comparable to sampling conditions. When power is turned off and back on, this value is set back to 0.0, the normal operating condition.

If a faked flow of 0.5, 1.5, 2.5, 3.5 or 4.5 are entered, an additional line of serial data is printed each second that contains the intermediate steps in the bap calculation.

TIME SET SCREEN

1. Current time and date.

```
YY MM DD hh mm ss
95  10  09  14 32  00
^

Item  Set-Select to change
```

Time and date settings are changed with the Item switch. The select position (up) moves cursor to digit to be changed; the set position (down) changes value of that digit.

AVERAGING PERIOD SET SCREEN

1. Current averaging period

```
Xmsn Sample Period

Item  to set
          Secs = 60
```

Item switch changes sample integration period, 10 secs is good for heavy smoke, 60 to 120 secs is standard for lower aerosol concentrations.

SERIAL BAUD RATE SET SCREEN

1. Current baud rate setting
   Item switch changes setting

```
Serial Port Speed

    Item   to change
      Bps = 9600
```

Possible settings are 9600, 4800, 2400 and 1200 baud.
Output format is B.rate, 8 bits, 1 stop, no parity. Data strings are output once per second.

PHOTODETECTOR MAXIMUM CURRENT SET SCREEN

1. Maximum A/D signal for a given maximum photodetector current (always 800000) - represents maximum digital resolution.
2. Digitized signal path photodetector current. (relative to maximum PD current setting)
3. Digitized reference path photodetector current.

```
Xmsn Lvl
                  Max  800000
                  Sig   304903
                  Ref  257938
Item
to set range          47 nA
```

4. Maximum photodetector current that can be digitized in nanoamps. This value is adjustable with the Item switch. It determines the length of time the converters spend digitizing the photodetector current. Should be set so that the signal and reference values are in the 200000 to 600000 range (that is approximately 1/4 to 3/4 full scale). For these pallflex filters 47 na or 71 na is good and shouldn't have to be changed. If light levels over range (e.g. no filter installed or highly transparent filter) the sig and ref values both default to a value of 33840. They can be brought on scale by increasing the max. PD current setting up to 1 μa (1000 na).

OPERATION

Note: When the instrument has been off for some time, it may take 15 min or so for internal temperatures to stabilize. Keep in mind that to measure bap near 10^{-7} m^{-1} requires stability in the ratio of the signal and reference currents to about 1 part in 70,000.

The unit is calibrated for use with Pallflex type E70.2075W 47 mm filters. The filters can be cut in half so that two measurement periods can be obtained from one filter. The filters should be loaded, sample-side up, in the holder (o-rings up) such that the o-rings will seal over the filter.

1. Close and secure holder - sample side up, o'rings sealing from the top.

2. Turn power on and start sample flow. The signal level screen will show for about 10 secs, then the main screen will be displayed automatically and data will begin the accumulate. Set flow in the range of 1.5 to 2.0 lpm using the flow control valve.

3. The averaging period can be changed at any time using the 'Averaging Period Set Screen'; 30 sec to 60 sec are good for most situations. The first few averaging periods will be noisy until the filter position stabilizes and the data registers get valid transmission measurements. The averaging period and signal levels are displayed on the main screen.

4. The 'lvl' values shown on the main screen are the same values shown on the photodetector current screen divided by 10,000. So, maximum is 80 instead of 800000. Values in the 20 to 60 range are acceptable for good digitizing. If the lamp is out or there is a hole in the filter it should be apparent from these values.

5. If a new filter was loaded, wait at least 1 averaging period then press and hold the 'Reset' switch up until 'Tr' on the front panel resets to 1.000. This sets the relative filter transmission to 1 in software. The 'Tr' value is updated after each sampling period and will decrease as the filter loads with particles. 'Tr' is used by the software to correct for filter loading as well as indicate when the filter should be changed.

6. The filter should be changed prior to the filter transmittance, 'Tr', going to far below 0.5.

Parameters can be changed at any time, however, the first averaging periods after changing the sample period or maximum photodetector current may be not be valid.

Notes:

1. Serial data is transmitted once each second.

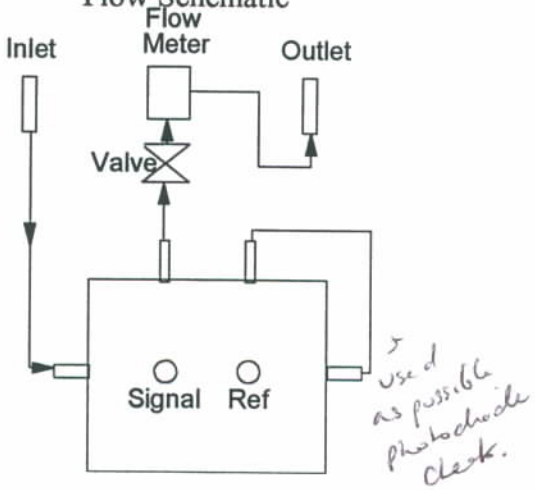
2. Absorption data is updated at the end of each averaging period and held at that value until the end of the next period.

3. If power is lost then restored, the 'Tr' value will indicate 0.0 for 1 averaging cycle then return to its previous value.

4. If the o'rings in the holder come loose or need to be replaced the grooves should be cleaned and a small amount of silicone adhesive used to secured the o'rings. The grooves are slightly too wide and the glue is necessary. The o'rings are standard 3/8 x 1/16 inch.

5. The lamp is an ultra-brite green LED and should have a long lifetime. If it is necessary to change it, a spare is taped to the inside of the of the instrument case. Remove the rubber cap, and cut or desolder the leads from the lamp. The lamp is press fit with a small amount of glue to hold it in place. You should be able to break it loose with a pair of pliers. Install the new lamp and solder power leads to the lamp leads. The long lead on the LED is positive and should connect to the center lead of the shielded wire. The shield connects to the short LED lead.

Flow Schematic



Filter Holder