STANDARD OPERATING PROCEDURE (SOP)
FOR FIELD OPERATION OF THE
SEQUENTIAL CYCLONE SAMPLER (SCS)

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1. APPLICATION

The SCS is designed to collect PM2.5 on Teflon filters for the determination of (list of trace elements) at six hour intervals in the urban environment. To provide sufficient mass for the accurate determination of these elements in most samples, the sampler uses a commercial cyclone manufactured by URG (model 2000-30ED) cyclone operated at 42 slpm to remove particulate matter > 2.5 μm. Thus each sample represents the PM2.5 in 15 m³ of air. A schematic of the sampler is shown in Figure 1. The cyclone and gooseneck (URG) are Teflon coated to minimize losses. An Al cone holds a nylon screen to eliminate bugs. The PM2.5 is collected on 47 mm Teflon filters using the URG model 2000 filter packs. To limit operator interaction to once per day four filter holders are connected through a URG Teflon coated manifold to the cyclone inlet. Electrical solenoid valves controlled by a Grasslin timer (Appendix 2) connect the filter holders to the vacuum pump. An AALBORG mass flow controller maintains the flow rate. The controller automatically compensates for temperature and mass variations and has an accuracy of ± 1 slpm. As a control check on the air flow, the output of the mass flow controller is connected to a data logger that records the flow rate every 5 minutes.
Figure 1

The data logger can hold over 50 days of data and will be downloaded at the end of the sampling session. A relief valve is teed in below the mass flow controller to allow the pump to operate on
free air while the filters are being changed.2.

SAMPLE HANDLING

URG Teflon filter packs (Figures 2 and 3) are used to collect the PM2.5 aerosols on 47 mm Zefluor filters (2: m pore size). The Filter packs should be loaded and unloaded in a clean dry area and the filters should be handled with gloved hands and Teflon tweezers.

If there is a filter already in the filter Pack rotate the unit by 180 degs. relative to Figure 3 prior to opening. Unscrew the dust cap and the Delrin screw sleeve. Lift off the Filter Housing inlet. The filter should be placed in a clear plastic petri holder with the aerosol loaded side up. Mark filter identifications with Sharpie directly on the petri dish. The fresh Zefluor filter should be placed on top of the collection screen. The filter orientation matters and should be placed on the screen in the same orientation as it is in the box. Carefully reseal the filter housing inlet and tighten the Delrin screw sleeve. Check the o-ring on the end of filter housing inlet and cap both ends of the filter pack.
3. SAMPLING PROTOCOL
Samples start at 6:00 AM, 12:00 PM, 6:00 PM and 12:00 AM. This protocol is designed for one sample change per day at 12:00 noon. The Grasslin 4 circuit timer controls the sampling. The basic operations are outlined in section 5 and the complete manual is attached as Appendix 1. It has an internal battery so the program will not be lost during power failure. The normal operating program is pre-loaded. Specific step for operators are given in section 6.

The four sampling ports are numbered 1 - 4 and color coded (reg, blue, green and orange respectively). Each sampling leg has an elapsed time indicator (minutes) that should be recorded and reset during each sample change. The timer program is set so that the start of the first sample and the end of the last sample is manually controlled by the operator so the length of these samples may be slightly different than 360 minutes. The manual control permits the operator some flexibility in changing the filters, however 12:00 PM ± 15 minutes is preferred. There are 2 set of four filter holders A (1-4) and B(1-4).

4. CAUTIONS AND NOTES:
   If a problem does arise and delay the sample change, the first sample should be shorten but still end at the normal time. One short sample is better than having the schedule for all sample start and stops changed.

   Always check the o-ring in the filter holder prior to screwing the sample holder into the sampling port.

   Tighten and loosen the sample holder by the metal base and not the Delrin body.

   The elapsed timers record the time the valve is open. For the first sample the timer should be zeroed after the pump is turned on.

   The relief valve should only be opened when all four sampling ports are closed. This allow some free air to pass through the pump prior to shutting it off.

   Always double check that the relief valve is close before leaving.
5. Basics of the Grasslin Timer

Full operating instructions from Grasslin for circuit Timer are attached as Appendix 1. A concise description is given here. The control screen of the timer is shown in Figure 4. The display panel is the lightly shaded area in the upper left. The status of the four circuits is indicated on the right hand side of the display panel (on or off is indicated by 1 or O, respectively). In addition each circuit has three modes indicated by small icons [timed(clock face), manual override (hand), and fixed]. Pressing the elongated buttons on the upper right cycles through the various modes. The Reset button clears everything and you must proceed to the cold start procedures (6.5). The R button reviews the program steps sequentially as pressed. If there are any errors, they can be corrected at this time. When a step is displayed, the CL button removes that step. The clock button is used to set the clock and to return to the normal display screen shown in Figure 4. When a step is complete, the N button records that step and opens a new program step. The S button MUST BE PRESSED TO SAVE THE PROGRAM AFTER ANY CHANGES ARE MADE.

![Figure 4]

Figure 4
6. STEP BY STEP PROCEDURES

6.1 FIRST START
   Simply load sampling ports with fresh filters and run start sequence

6.2 START SEQUENCE
   Pump          off
   Relief valve  closed
   Elapsed timers zeroed
   Valve 1       on (override mode, hand 1)
   Pump          on
   Elapsed timer 1 zeroed
   Record program times

6.3 DAILY FILTER CHANGE
   Record flow rate on mass flow controller
   Manually close the valve for the sample 4 (hand 0)
   Open relief valve
   Record elapsed timer data
   Change filters
   RUN START SEQUENCE

6.4 COLLECTING FIELD BLANKS (EVERY 5th DAY)
   Sample 1 is used for blanks.
   By collecting sample 2 for 12 hours no changes in the program steps are required.
   **Simply run the START SEQUENCE with sample 2 instead of 1.**
   Normal programing will shut 2 off at midnight yielding a 12 hour sample
   Samples 3 and 4 are collected at their normal times so no changes in the program is
required. At the end of the run momentarily turn sampler 1 on and then off.
Continue with normal filter change.

6.5 COLD START (use in case of timer reset)

Set the current Day/Date/Time -- While pressing the clock button ( )

- Press “Year” until you reach current year.
- Press “Month” until you reach current month
- Press “Day” buttons to clear all but current day
- Press “h+” or “h-“ until you reach current hour.
- Repeat for current minute with “m+” and “m-“.

Program timer for 6 hour samples (six program steps are needed):

1. Circuit 1 to turn off at 6:00 PM.
   - Push “h+” button. The screen will look like Fig 5a.
   - Press the “i/o” button for Circuit 1 until the ”0 “ is next to the number.
   - Use the h ± and m ± buttons to set the time for 6:00 PM.
   - Leave all day active so the timer will activate each day (Fig. 5b)
   - Press the “N” button to indicate that this step has been completed.

2. Circuit 2 on at 6:00 PM (Fig. 5c)
3. Circuit 2 off at 12:00 AM (Fig 5d)
4. Circuit 3 on at 12:00 AM (Fig 5e)
5. Circuit 3 off at 6:00 AM (Fig. 5f)
6. Circuit 4 on at 6:00 AM (Fig. 5g)

Press “S” button to save the program.

Press the clock button.
Fig. 5
## APPENDIX 2
Sequential Cyclone Sampler Log

<table>
<thead>
<tr>
<th>Date</th>
<th>Sampler</th>
<th>Time</th>
<th>Elapsed Time (min)</th>
<th>Sample Name</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Start</td>
<td>Stop</td>
<td></td>
</tr>
</tbody>
</table>

**Flow Rate (liters)**

- Comments: 

- Comments: 

- Comments: 

- Comments: 

**START SEQUENCE**

- Pump: off
- Relief valve: closed
- Elapsed timers: zered
- Valve 1: on (override mode, hand 1)

**START SEQUENCE FOR FIELD BLANK**

- Pump: off
- Relief valve: closed
- Elapsed timers: zered
- Valve 2: on (override mode, hand 1)

- Pump: on
- Elapsed timer 2: on
- Record program times: zered