SOP #3

FILTER CARTRIDGE SHIPPING, RECEIVING, PROCESSING, AND CYCLONE SIZE-CUT

Various precautions are taken throughout cartridge assembly, shipment, and disassembly to protect the filters from contamination. This section describes shipping procedures, proper handling of sampled cartridges once received at Dalhousie, and determination of air volume sampled.

REVISION HISTORY			
Revision No.	Change Description	Date	Authorization
2.0	Updated cartridge assembly to reflect the elimination of stacked filters from experimental design	July 11, 2018	Paul Bissonnette

1.1 Cartridge Assembly

Each cartridge is assembled within 2 weeks of when it is required by the site operator. This provides enough time to allow for shipment time to any site, even if unexpected delays arise. The tools needed for the cartridge assembly process are:

- Hex key (opening cartridge)
- Two pairs of clean tweezers
- Custom-made plug remover (see Figure 5)
- Methanol (for wiping tweezers, cleaning parts)
- Milli-Q water (for cleaning parts)

Figure 3 describes the order of operations for assembly of a cartridge. For example, for the thick half of the cartridge that is split into 2 2x2 blocks as shown in Figure 5, a metal grid is inserted into the cartridge, followed by the filter, plastic washer, and o-rings. It is important to place the filters in the proper slot according to the filter label. For example, a filter labelled with a “1T”, must go in the number one slot on the PTFE side of the cartridge.

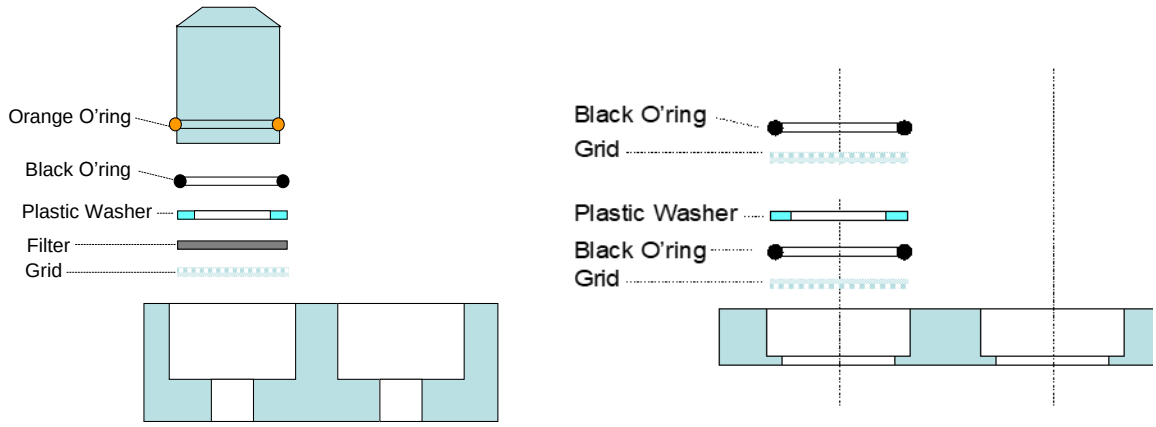


Figure 1. Cartridge assembly scheme. Left is TOP half containing the Teflon filters

Once the cartridge is assembled, a log sheet for the cartridge must be prepared. The log sheet with the cartridge number (e.g. CHTS-024) is recorded on the log sheet. One of the two small labels on each of the filter petri-dishes must be transferred to the appropriate column and row on the log sheet.

2.2 Cartridge Shipping

After a cartridge is successfully assembled and the log sheet prepared, the cartridge is placed inside three sealable plastic bags. The log sheet is placed inside the outermost bag to ensure it remains with the cartridge. Next, the cartridge is placed inside a box and transport to the Dunn building to be shipped to the sampling site. The box containing the cartridge is then wrapped in bubble-wrap and then placed inside a bubble-wrap envelope. Finally, the cartridge is shipped to the sampling site by way of a courier (e.g. UPS or FedEx).

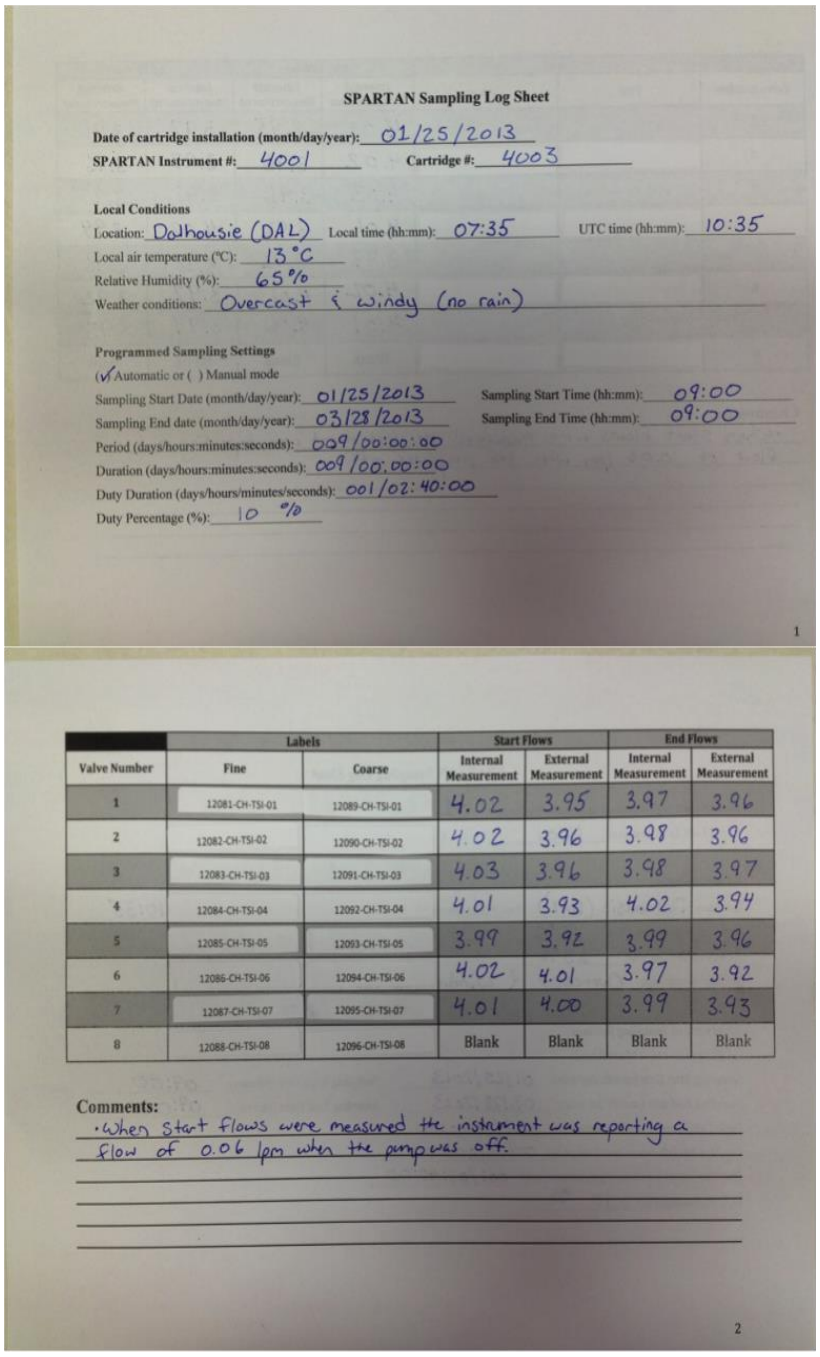
Once the tracking information is obtained it is forwarded on to the site operator so they know to expect the cartridge. After a cartridge finishes sampling, it is returned to Dalhousie in the

same manner it was shipped out: triple-bagged, inside a box, bubble-wrapped, and including a copy of the log sheet.

2.3 Cartridge Receiving

Upon receiving a sampled cartridge from a site operator, ensure that a copy of the sampling log sheet (e.g. Figure 4) is included. If no log sheet is included, contact the site operator to provide a scanned copy of the log sheet. Original log sheets are not necessary, but a copy must be obtained for data processing and SPARTAN records.

Note that the log sheet shown in Figure 4 has all the necessary information provided, however for some sampled cartridges this will not be the case. It is imperative to request more detailed information from site operators if data is missing. If flow measurements are missing and the site operator is unable to provide written record of measured flow rates, the sample volume cannot be accurately calculated and the conversion from mass to concentration is not possible. Therefore, it is important to stress the need to record flow rates to site operators.



SPARTAN Sampling Log Sheet

Date of cartridge installation (month/day/year): 01/25/2013
SPARTAN Instrument #: 4001 Cartridge #: 4003

Local Conditions
Location: Dalhousie (DAL) Local time (hh:mm): 07:35 UTC time (hh:mm): 10:35
Local air temperature (°C): 13°C
Relative Humidity (%): 65%
Weather conditions: Overcast & windy (no rain)

Programmed Sampling Settings
(✓ Automatic or ( ) Manual mode
Sampling Start Date (month/day/year): 01/25/2013 Sampling Start Time (hh:mm): 09:00
Sampling End date (month/day/year): 03/28/2013 Sampling End Time (hh:mm): 09:00
Period (days/hours:minutes:seconds): 009/00:00:00
Duration (days/hours:minutes:seconds): 009/00:00:00
Duty Duration (days/hours/minutes/seconds): 001/02:40:00
Duty Percentage (%): 10 %

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	Labels		Start Flows		End Flows	
Valve Number	Fine	Coarse	Internal Measurement	External Measurement	Internal Measurement	External Measurement
1	12081-CH-TSI-01	12089-CH-TSI-01	4.02	3.95	3.97	3.96
2	12082-CH-TSI-02	12090-CH-TSI-02	4.02	3.96	3.98	3.96
3	12083-CH-TSI-03	12091-CH-TSI-03	4.03	3.96	3.98	3.97
4	12084-CH-TSI-04	12092-CH-TSI-04	4.01	3.93	4.02	3.94
5	12085-CH-TSI-05	12093-CH-TSI-05	3.99	3.92	3.99	3.96
6	12086-CH-TSI-06	12094-CH-TSI-06	4.02	4.01	3.97	3.92
7	12087-CH-TSI-07	12095-CH-TSI-07	4.01	4.00	3.99	3.93
8	12088-CH-TSI-08	12096-CH-TSI-08	Blank	Blank	Blank	Blank

Comments:
• When start flows were measured the instrument was reporting a flow of 0.06 lpm when the pump was off.

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Figure 2. Properly completed SPARTAN sampling log sheet.

After the date of receiving the cartridge is recorded in the SPARTAN shipping and receiving log, the cartridge is transported to the chemical analysis lab on Dalhousie's Sexton campus to be disassembled.

Figure 3. Foreground: a disassembled SPARTAN cartridge showing the two top 2x2 blocks as well as the bottom 2x8 block.

Once received, the cartridge is taken to Dalhousie University Sexton campus, room N310, where all chemical analysis is completed. There you will find a drawer labeled “IN FIELD”, which contains filter petri dishes labeled [Site Code]-[Cartridge #] (e.g. INKA-004). Individual filters are then labeled, e.g. 13161-INKA-1T. All filters from a given cartridge are grouped and transported together.

Disassemble and unload the cartridge in the HEPA-filtered hood, being sure to turn off the blower. Leaving the blower on often results in filters blowing out of the clean environment onto an unclean surface where contamination renders them unusable for chemical analysis. First place a fresh large Kim-wipe in the HEPA hood before disassembling to provide a guaranteed clean working area. The tools needed for cartridge disassembly are the same as those for cartridge assembly, described in section 2.1. Remove all 8 screws with hex key. Separate cartridge halves by flipping over the two 2x2 top halves containing the PTFE filters. Wipe tweezers with methanol and proceed to place filters in the appropriately labeled petri-dishes being sure to only grab the edge of the filters. Teflon filters (opaque white) go in dishes labeled 1T, 2T, etc., corresponding to the slots

they were placed in the cartridge. Note: If any anomalies are observed, a photo of the filter in the petri-dish (so that the filter label is apparent) should be taken and sent to a SPARTAN site manager.

When cartridge disassembly is complete, the filters are transported (inside three sealed plastic bags) to the HERC clean room facility where post-weighing and black carbon analysis are completed. Refer to section 1.0 for the filter weighing procedure and section 3.0 for the BC analysis procedure.

2.4 Converting Mass Measurements to Mass Concentrations

Each cartridge has its own digital "Cartridge Analysis" Excel spreadsheet like that shown below in Figure 6.

ARCB-001

Duty minutes 111 **scaling factor 1**
correction factor 0

PM2.5 Sampling Date Range	Filter ID	PM mass (ug)	PM Error	Average Flow (lpm)	Volume (m3)	PM2.5 conc. (ug/m3)	PM2.5 corrected	Error
10/02/2014 - 10/11/2014	13001-ARCB-1T	35.83	3.45	4.11	4.108	**8.72**	**8.72**	0.84
10/11/2014 - 10/20/2014	13002-ARCB-2T	31.70	4.89	3.91	3.907	**8.115**	**8.11**	1.25
10/20/2014 - 10/29/2014	13003-ARCB-3T	33.50	6.89	3.84	3.839	**8.73**	**8.73**	1.79
10/29/2014 - 11/07/2014	13004-ARCB-4T	27.40	1.90	4.10	4.093	**6.70**	**6.70**	0.46
11/07/2014 - 11/16/2014	13005-ARCB-5T	50.50	5.09	3.84	3.839	**13.16**	**13.16**	1.33
11/16/2014 - 11/25/2014	13006-ARCB-6T	34.47	3.90	3.89	3.89	**8.86**	**8.86**	1.00
11/25/2014 - 12/04/2012	13007-ARCB-7T	48.60	6.05	3.92	3.918	**12.40**	**12.40**	1.54
Blank	13008-ARCB-8T	7.20	1.51		0.000			
					Average: 9.08		**9.53**	1.17

PMcoarse Sampling Date Range	Filter ID	PM mass (ug)	PM Error	Average Flow (lpm)	Volume (m3)	Pmcoarse conc. (ug/m3)	Error
10/02/2014 - 10/11/2014	13009-ARCB-1N	27.07	2.55	4.11	4.108	**6.59**	0.62
10/11/2014 - 10/20/2014	13010-ARCB-2N	67.67	7.78	3.91	3.907	**17.32**	1.99
10/20/2014 - 10/29/2014	13011-ARCB-3N	56.70	7.92	3.84	3.839	**14.77**	2.06
10/29/2014 - 11/07/2014	13012-ARCB-4N	40.33	6.53	4.10	4.093	**9.86**	1.60
11/07/2014 - 11/16/2014	13013-ARCB-5N	65.87	3.41	3.84	3.839	**17.16**	0.89
11/16/2014 - 11/25/2014	13014-ARCB-6N	44.33	11.75	3.89	3.891	**11.39**	3.02
11/25/2014 - 12/04/2012	13015-ARCB-7N	86.93	1.91	3.92	3.918	**22.19**	0.49
Blank	13016-ARCB-8N	4.77	12.17	0.00	0.000		
					Average: 13.14		1.52

Figure 4. Raw mass data (micrograms) combined with flow rates (lpm) and sampling time determine the mass concentration during each sampling period. Total volume sampled is provided in cubic meters (m^3).

Digital log sheets should follow the above template for standardization where:

- PM mass (μg) is the raw post-weighed mass from gravimetric analysis
- PM error is 1 standard deviation from the triplicate pre- and post-weighing: $\Delta PM_{tot} = \sqrt{(\Delta PM_{pre})^2 + (\Delta PM_{post})^2}$
- Average flow is the mean of the pre- and post-measured external flow

- Volume sampled is calculated as: (flow rate x time sampled) / 1000
- PM mass concentration is PM mass divided by the sampled volume

1.0 Using a Cyclone Inlet to Induce a Sampling Size-cut

As both the nephelometer and sampling stations are sampling ambient air that contains particulate matter with a distribution of different diameters, a method is needed to introduce a size-cut above which PM is not collected or measured. The method employed by SPARTAN is a cyclone inlet which uses variable inlet flow speeds to separate larger and smaller particles due to the inertia of particles of a critical diameter being too great to follow the curved cyclone trajectory and so they collide with the walls and are removed. Particles below the critical diameter are able to follow the curved trajectory and are thus collected.

A flow rate of 5.0 lpm is able to create a size-cut to sample only $PM_{2.5}$ and a flow rate of 1.5 lpm is able to induce a size-cut for sampling PM_{10}.

The selected flow rates and the performance at those flow rates is based off data from the Size-cut validation reported by the manufacturer shown below in figure 5.

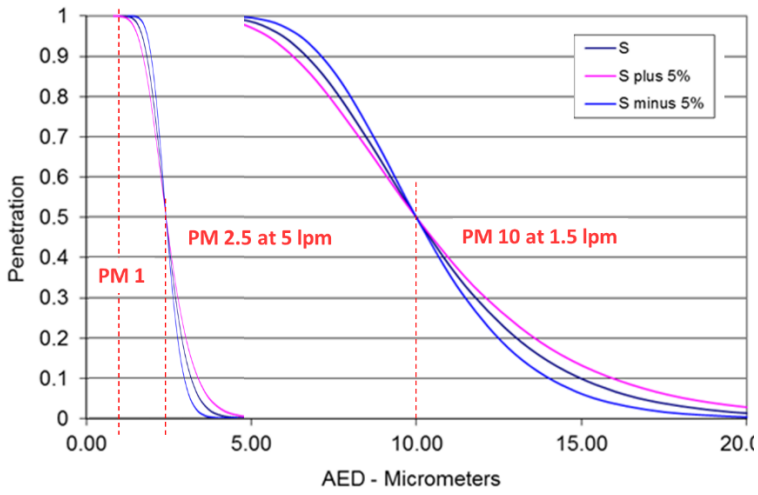

Figure 5: Cyclone inlet performance at 1.5 and 5.0 lpm, where penetration refers to the fraction of PM at a given size that is able to pass through the cyclone inlet.