



PM_{2.5} PEP Collocation Study of WINS Impactors and Very Sharp Cut Cyclones



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Sorry I can't be here...





Background

On April 2, 2002, EPA designated the BGI PQ200 using a Very Sharp Cut Cyclone (VSCC) as a Manual Reference Method: RFPS-0498-116 or Manual Equivalent Method: EQPM-0202-142

The VSCC is a low maintenance separator that cuts the particulate to the $PM_{2.5}$ size fraction

- ✓ Less frequent cleaning than WINS
- ✓ Optimized for continuous monitors
- ✓ No oils or filters required



Has since been approved for all other $PM_{2.5}$ reference methods

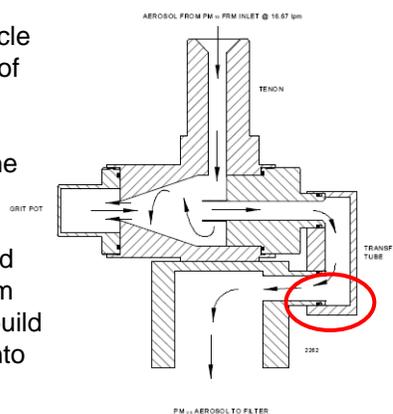


VSCC Cleaning Frequency

Recommendations:

- BGI indicates 30 days of continuous 24-hr sampling can be tolerated by the VSCC.
- PEP specifies cleaning on a 10-day cycle (or quarterly) to minimize any likelihood of excess contamination.
- Also, clean if unusual circumstance warrants such action (e.g., local fire in the vicinity).

Note: PEP field scientists have observed that particulate may deposit in the bottom corner of the transfer tube. As such, a build up of particulate could be re-entrained into the air stream in subsequent sampling events if the VSCC is not maintained properly.



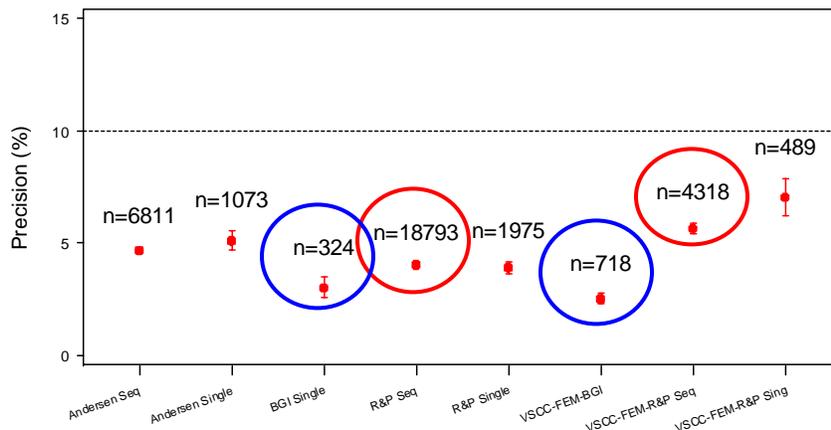


OAQPS 3-Year Quality Assurance Report Calendar Years 2005, 2006, and 2007 The SLAMS PM_{2.5} Ambient Air Monitoring Program

"[The following figure] provides 3-year precision estimates and 95% confidence intervals for all 8 federal reference methods that operated in 2005-2007. The last three methods (far right) are method designations that were previously accepted but switched to the use of the very sharp cut cyclone instead of the WINS impactor. The values above the whisker indicate the number of paired collocated values that were used in the precision estimates. The precision estimates are fairly similar and below the DQO. Although we can not attribute the increased variability directly to the use of the very sharp cut cyclone, there does appear to be more variability with R&P samplers using the cyclones."



95% Confidence Intervals for the 3-Year National Precision Estimates
By Method Designation *



* Points are labeled with the number of observations in each quarter
* Only values > 3 ug/m3 used



Study Design Summary

- 20 BGI PQ200A samplers
- Initial 3-day collocation of study samplers for precision testing (WINS only)
- 10-day comparison study using 18 most consistent samplers
 - 9 with VSCC
 - 9 with WINS
 - Rotated randomly (coin flip!)
- 24-hour runs
- Flow, temperature, pressure verifications every run
- One field operator; One gravimetric lab analyst; One gravimetric microbalance to reduce bias
- Weather conditions varied during study



Initial Comparison of Samplers, WINS ONLY

- No samplers measured consistently high or low
- BGI0595 measured high on two days but not on the third
- 4 samplers experienced invalid sampling runs for several reasons
- Differences between daily high and low values are 2 $\mu\text{g}/\text{m}^3$ or less

	12/9/2008	12/12/2008	12/14/2008
PE Serial No	PE Conc. (ug/m3)	PE Conc. (ug/m3)	PE Conc. (ug/m3)
BGI0587	10.6	4.5	10.0
BGI0590	10.7	4.2	10.2
BGI0591	10.4	4.0	Invalid sample
BGI0592	10.9	4.1	10.4
BGI0594	10.4	3.8	9.7
BGI0595	11.6	4.5	9.9
BGI0596	10.7	3.8	9.8
BGI0597	10.3	3.9	9.8
BGI0627	Invalid sample	3.8	9.1
BGI0628	10.2	3.5	9.8
BGI0629	9.6	Invalid sample	9.9
BGI0630	10.2	3.7	9.6
BGI0631	10.2	3.7	9.8
BGI0632	10.2	4.0	9.5
BGI0633	10.4	3.8	9.7
BGI0634	10.4	3.7	9.4
BGI0635	9.9	4.0	9.3
BGI0636	10.0	Invalid sample	9.7
BGI0637	10.1	3.9	9.7
BGI0638	10.3	4.0	9.7
High and Low Diff	2.0	0.8	1.3

Highlighted values indicate highest and lowest concentrations



WINS vs. VSCC Min-Max Difference Comparison

V=VSCC; W=WINS

Day	V Avg Conc	Max	Min	Min Max Diff	W Avg Con	Max	Min	Min Max Diff
1	7.71	8.07	6.95	1.12	7.47	7.91	7.16	0.75
2	7.92	8.57	7.24	1.33	7.98	8.57	7.36	1.21
3	14.73	15.73	12.27	3.46	15.22	15.73	14.90	0.83
4	9.80	10.19	9.45	0.75	9.86	10.53	8.36	2.17
5	16.32	17.77	15.86	1.91	16.09	17.55	15.27	2.28
6	24.42	24.89	23.59	1.30	24.22	25.26	23.63	1.62
7	7.17	7.95	6.24	1.71	6.51	7.53	5.74	1.79
8	9.06	9.32	8.82	0.50	9.22	9.61	8.78	0.83
9	3.91	8.57	7.24	1.33	4.25	4.58	3.87	0.71
10	8.91	9.45	8.61	0.83	9.00	9.36	8.32	1.04
				1.42				1.32

- Average difference of the totals over the course of the study is 0.10 ug/m3 with the VSCC measuring higher.
- Historical data indicates that the difference between Min and Max should be no more than 2 ug/m3



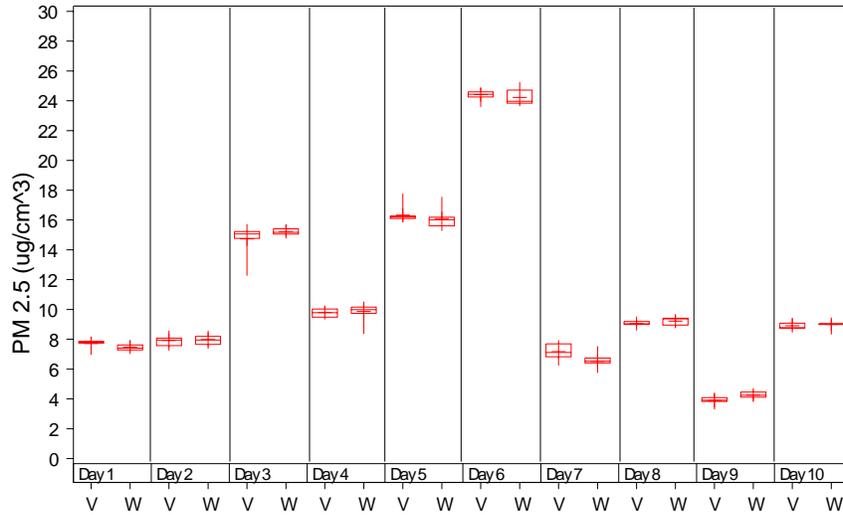
WINS vs VSCC Average Difference Comparison

V=VSCC; W=WINS

Day	V Avg Conc (mg/m3)	W Avg Conc (mg/m3)	Difference (mg/m3)
1	7.71	7.47	0.24
2	7.92	7.98	-0.06
3	14.73	15.22	-0.48
4	9.80	9.86	-0.06
5	16.32	16.09	0.23
6	24.42	24.22	0.20
7	7.17	6.51	0.66
8	9.06	9.22	-0.16
9	3.91	4.25	-0.35
10	8.91	9.00	-0.08
		Avg Diff	0.01



Box and Whisker Plots — Samplers with VSCCs vs. WINS



Collocation Study Evaluation

- *Historical methods used to evaluate “parking lot” collocation study data involved classical statistics of hypothesis testing.*
- *Drawbacks: Tools required SAS software to run, results could be difficult to interpret, and results could provide conflicting answers.*



Collocation Study Evaluation

- *In 2008, EPA began developing a new tiered decision framework for collocation study data.*
- *Benefits: Good combination of statistics and engineering judgment, enables consistent interpretation, equations are easily programmed into most software systems.*



Four Basic Steps

- **Step 1. Reasonable measured concentrations (screen for high concentrations)** – The maximum concentration limit is 200 $\mu\text{g}/\text{m}^3$.
- **Step 2. Notable differences** – Normalized percent differences $\leq 15\%$ will be accepted as within the expected normal range of within-sampler precision historically observed within the PEP. Normalized percent differences $> 15\%$ will be flagged as “notable differences.”



Four Basic Steps

- **Step 3. Relevance of notable differences (screen for low concentrations)** – EPA has determined that the lowest ambient concentration that can be used for calculating within-sampler precision and network bias relative to the PEP audit sampler is $3 \mu\text{g}/\text{m}^3$. Differences based on concentrations $\geq 3 \mu\text{g}/\text{m}^3$ are considered “relevant notable differences”. If concentrations from both samplers in the comparison measure $< 3 \mu\text{g}/\text{m}^3$, then the normalized percent difference from the pair will not be used to identify the sampler for further investigation.



Four Basic Steps

- **Step 4. Samplers requiring further evaluation** – Random variability will produce expected differences in sampler results. However, to identify an inconsistently performing sampler for further investigation, the sampler must be involved with at least 50% of the relevant notable differences computed over the entire collocation study.



For the equation lovers out there

Normalized paired differences for all valid parking lot studies were calculated using the following equation:

$$N_{i,j,d} = \frac{abs(D_{i,j})}{\bar{x}_d}$$

$$\text{where, } D_{i,j} = \sum_{i=1}^{n-1} \sum_{j=i+1}^n x_i - x_j$$

There are n samplers evaluated for a specific day, d , during the testing period. The absolute value of the differences ($D_{i,j}$) for all available pairings (i, j) among samplers are computed for each day during the study. For each day of a testing period, these differences are then normalized and turned into a percentage ($N_{i,j,d} * 100$) by dividing each i, j pair by the daily mean, \bar{x}_d , and multiplying by 100. After normalization, the differences are considered comparable among individual studies conducted under differing atmospheric conditions. Normalization also serves to dampen the effects of lower concentrations on the percent difference.



Simple Data Set (4-Day Study, 4 Samplers)

Sampling Date	Sampler 1	Sampler 1 Concentration	Sampler 2	Sampler 2 Concentration	Daily Mean	Difference Between Pairs	Normalized Percent Difference	Notable Diff. (>15%)	Relevant Notable Diff. (exclude if both < 3 ug/m3)
4/4/2000	BGI0214	5.449	BGI0191	5.915	5.52	0.47	8.44		
4/4/2000	BGI0214	5.449	BGI0189	5.199	5.52	0.25	4.53		
4/4/2000	BGI0191	5.915	BGI0189	5.199	5.52	0.72	12.97		
4/5/2000	BGI0214	3.246	BGI0191	3.126	2.69	0.12	4.47		
4/5/2000	BGI0214	3.246	BGI0189	2.038	2.69	1.21	44.98	Yes	Yes
4/5/2000	BGI0214	3.246	AND00011	2.333	2.69	0.91	33.99	Yes	Yes
4/5/2000	BGI0191	3.126	BGI0189	2.038	2.69	1.09	40.51	Yes	Yes
4/5/2000	BGI0191	3.126	AND00011	2.333	2.69	0.79	29.53	Yes	Yes
4/5/2000	BGI0189	2.038	AND00011	2.333	2.69	0.30	10.98		
4/7/2000	BGI0214	10.82	BGI0191	8.493	8.95	2.33	26.00	Yes	Yes
4/7/2000	BGI0214	10.82	BGI0189	8.028	8.95	2.79	31.19	Yes	Yes
4/7/2000	BGI0214	10.82	AND00011	8.462	8.95	2.36	26.34	Yes	Yes
4/7/2000	BGI0191	8.493	BGI0189	8.028	8.95	0.47	5.20		
4/7/2000	BGI0191	8.493	AND00011	8.462	8.95	0.03	0.35		
4/7/2000	BGI0189	8.028	AND00011	8.462	8.95	0.43	4.85		
4/8/2000	BGI0214	9.527	BGI0191	9.295	9.60	0.23	2.42		
4/8/2000	BGI0214	9.527	BGI0189	9.526	9.60	0.00	0.01		
4/8/2000	BGI0214	9.527	AND00011	10.042	9.60	0.52	5.37		
4/8/2000	BGI0191	9.295	BGI0189	9.526	9.60	0.23	2.41		
4/8/2000	BGI0191	9.295	AND00011	10.042	9.60	0.75	7.78		
4/8/2000	BGI0189	9.526	AND00011	10.042	9.60	0.52	5.38		



A Look at the Notable Differences

Sampling Date	Sampler 1		Sampler 2		Daily Mean	Difference Between Pairs	Normalized Percent Difference	Notable Diffs (>15%)	Relevant Notable Diffs. (exclude if both < 3 ug/m3)
	Sampler 1	Concentration	Sampler 2	Concentration					
4/5/2000	BGI0214	3.246	BGI0191	3.126	2.69	0.12	4.47		
4/5/2000	BGI0214	3.246	BGI0189	2.038	2.69	1.21	44.98	Yes	Yes
4/5/2000	BGI0214	3.246	AND00011	2.333	2.69	0.91	33.99	Yes	Yes
4/5/2000	BGI0191	3.126	BGI0189	2.038	2.69	1.09	40.51	Yes	Yes
4/5/2000	BGI0191	3.126	AND00011	2.333	2.69	0.79	29.53	Yes	Yes
4/5/2000	BGI0189	2.038	AND00011	2.333	2.69	0.30	10.98		
4/7/2000	BGI0214	10.82	BGI0191	8.493	8.95	2.33	26.00	Yes	Yes
4/7/2000	BGI0214	10.82	BGI0189	8.028	8.95	2.79	31.19	Yes	Yes
4/7/2000	BGI0214	10.82	AND00011	8.462	8.95	2.36	26.34	Yes	Yes
4/7/2000	BGI0191	8.493	BGI0189	8.028	8.95	0.47	5.20		
4/7/2000	BGI0191	8.493	AND00011	8.462	8.95	0.03	0.35		
4/7/2000	BGI0189	8.028	AND00011	8.462	8.95	0.43	4.85		

Sampler ID	Notable differences per monitor	Differences based on concentrations < 3 ug/m3 per monitor	Relevant notable differences per monitor	Relevant notable differences per study	Percentage of relevant notable differences per study	Further evaluation required
AND00011	3	1	2	7	0.29	No
BGI0189	3	1	2	7	0.29	No
BGI0191	3	0	3	7	0.43	No
BGI0214	5	0	5	7	0.71	Yes



After the Study

- *Samplers identified as displaying inconsistent measurements will be investigated further. For example, verification records will be reviewed and the field scientist will be contacted if necessary. Previous audits involving that sampler (up to the last successful collocation study) may also be reviewed.*
- *If the overall collocation study results show a high number of notable differences, EPA will investigate not only the samplers, but the filter handling process for all personnel involved in the collocation study.*
- *EPA will take proactive steps to correct or replace those samplers which exhibit repetitive exceedances.*



WINS vs. VSCC Study Evaluation

- The new decision framework was applied to the WINS vs. VSCC special collocation study
- 1015 paired differences over 10 days
- No concentrations < 3 ug/m³
- 104 notable differences across entire study
- 21 notable differences (maximum) for one sampler = 20.2%
- No samplers warranted further evaluation

- Also looked at data by separator type and by individual VSCC units – No observable trends were identified



WINS vs. VSCC Study Evaluation

Site	Sampler ID	Notable differences per monitor	Differences based on concentrations < 3 ug/m ³ per monitor	Relevant notable differences per monitor	Relevant notable differences per study	Percentage of relevant notable differences per study	Further evaluation required
13Region4	BGI0597	4	0	4	104	3.8%	No
13Region4	BGI0592	6	0	6	104	5.8%	No
13Region4	BGI0587	7	0	7	104	6.7%	No
13Region4	BGI0590	8	0	8	104	7.7%	No
13Region4	BGI0594	8	0	8	104	7.7%	No
13Region4	BGI0633	8	0	8	104	7.7%	No
13Region4	BGI0638	8	0	8	104	7.7%	No
13Region4	BGI0628	9	0	9	104	8.7%	No
13Region4	BGI0634	9	0	9	104	8.7%	No
13Region4	BGI0629	11	0	11	104	10.6%	No
13Region4	BGI0630	11	0	11	104	10.6%	No
13Region4	BGI0631	13	0	13	104	12.5%	No
13Region4	BGI0636	14	0	14	104	13.5%	No
13Region4	BGI0637	14	0	14	104	13.5%	No
13Region4	BGI0595	16	0	16	104	15.4%	No
13Region4	BGI0596	17	0	17	104	16.3%	No
13Region4	BGI0632	18	0	18	104	17.3%	No
13Region4	BGI0635	21	0	21	104	20.2%	No



Study Results – **GOOD NEWS!!**

Observations:

- ✓ WINS and VSCC compare well in the BGI PQ200A audit sampler
- ✓ Variability seems small, consistent, and random between the WINS and VSCC
- ✓ There appears to be little bias in either direction between WINS and VSCC separators in the PEP study

Further evaluation:

- ✓ PEP audit samplers operating in other Regions are performing collocation studies with WINS and VSCC to provide more data
- ✓ EPA will continue to assess collocated results as more samplers are switched from WINS to VSCC
- ✓ EPA will continue to evaluate decision framework for collocation studies (may tighten up 50% cut-off).



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Questions??

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