Performance Auditing of a Human Air Pollution Exposure System for PM2.5

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CAUTION

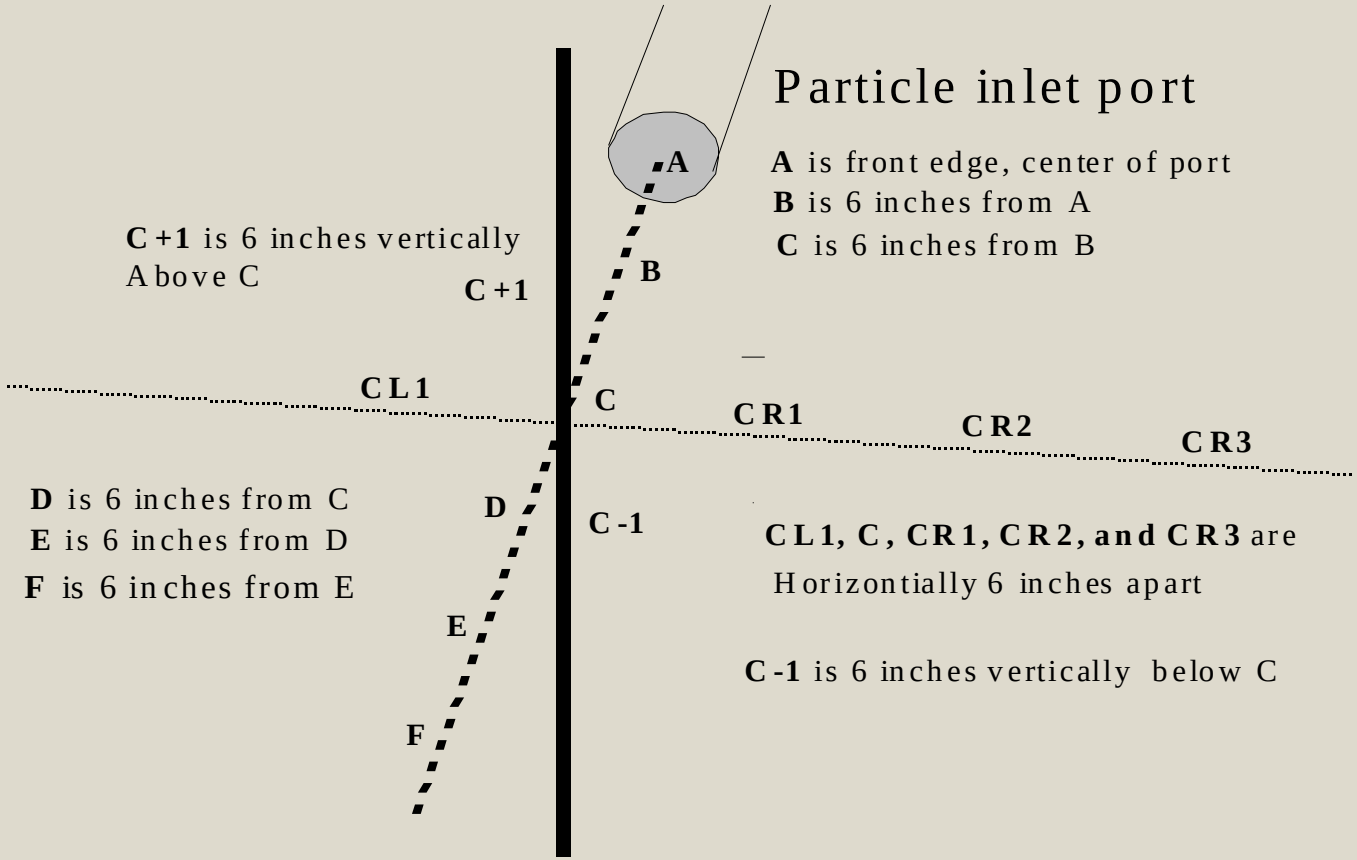
Exposure System Characteristics

- 0.1-2.5 micrometer ambient PM particles concentrated 6-8x
- Concentrated PM mixed with temperature and RH conditioned air is drawn through 4 ft. x 7 ft. x 6 ft. chamber @ 200 L/min

Critical Operating Parameters

- PM2.5 Concentration
- Size Distribution of PM
- Spatial Distribution of PM
- Temperature
- Relative Humidity

Diagram of sampling locations for the aerosol concentrator chamber



Audit Methods

Temp/RH	Digital NIST traceable sensors	Location C
PM spatial distribution	Matched portable light-scattering monitors	Locations C & B, CR1, CL1 & D
PM2.5 concentration	Anderson RAAS2.5-100 PM2.5 monitor	Location C
Total PM concentration	47 mm filter sampler	Location C
PM size distribution	MOUDI sampler	Location C

Table 1. Temperature Audit Results

Audit Date	Time Interval (min)	DAS Mean Temperature (°C)	Audit Mean Temperature (°C)	Difference (°C)
5/18/98	60	21.7	19.7	2.0
10/29/98	60	22.8	23.0	-0.2
7/19/99	60	19.9	18.9	1.0
10/27/99	60	23.8	24.2	-0.4
1/20/00	60	23.0	23.4	-0.4
4/13/00	60	22.9	23.7	-0.8
7/20/00	40	18.9	17.5	1.4
10/26/00	60	23.3	23.9	-0.6
1/10/01	60	23.4	23.7	-0.3
7/23/01	60	22.1	22.8	-0.7
10/25/01	60	22.0	22.6	-0.6
1/11/02	60	21.1	21.3	-0.2

DAS = Exposure chamber data acquisition system
Difference = DAS mean temperature - Audit mean temperature

Table 1. Temperature Audit Results

Audit Date	Time Interval (min)	DAS Mean Temperature (°C)	Audit Mean Temperature (°C)	Difference (°C)
4/18/02	60	19.2	17.7	1.5
6/5/02	60	20.8	18.7	2.1
10/23/02	45	22.4	22.3	0.1
12/23/02	60	22.7	23.1	-0.4
4/6/04	60	19.1	19.0	0.1
6/29/04	60	19.7	19.1	0.6
9/1/04	55	22.4	22.4	0.0
1/12/05	55	22.1	21.8	0.3
4/21/05	60	22.1	22.8	-0.7
5/24/05	55	21.5	21.3	0.2
8/23/05	60	23.0	23.3	-0.3
1/18/06	60	16.9	16.0	0.9

DAS = Exposure chamber data acquisition system
Difference = DAS mean temperature - Audit mean temperature

Table 2. Humidity Audit Results

Audit Date	Time Interval (min)	DAS Mean RH (%)	Audit Mean RH (%)	Difference (% RH)
5/18/98	60	39.5	68.5	-29.0
10/29/98	60	40.3	43.0	-2.7
7/19/99	60	50.4	50.7	-0.3
10/27/99	60	20.3	20.7	-0.4
1/20/00	60	26.3	28.2	-1.9
4/13/00	60	32.1	30.7	1.4
7/20/00	40	40.7	45.2	-4.5
10/26/00	60	24.3	24.9	-0.6
1/10/01	60	6.0	6.7	-0.7
7/23/01	60	16.0	15.4	0.6
10/25/01	60	8.4	9.9	-1.5
1/11/02	60	12.9	13.0	-0.1

DAS = Exposure chamber data acquisition system
Difference = DAS mean relative humidity - Audit mean relative humidity
The DAS RH sensor was adjusted after the 5/18/98 audit.

Table 2. Humidity Audit Results

Audit date	Time Interval (min)	DAS Mean RH (%)	Audit Mean RH (%)	Difference (% RH)
4/18/02	60	46.7	54.0	-7.3
6/5/02	60	50.2	55.3	-5.1
10/23/02	45	38.0	40.3	-2.3
12/23/02	60	7.6	9.8	-2.2
4/6/04	60	57.7	55.2	2.5
6/29/04	60	49.3	48.0	1.3
9/1/04	55	46.4	46.7	-0.3
1/12/05	55	21.9	22.9	-1.0
4/21/05	60	47.1	45.2	1.9
5/24/05	55	43.6	41.2	2.4
8/23/05	60	35.5	33.2	2.3
1/18/06	60	31.1	32.1	-1.0

DAS = Exposure chamber data acquisition system
Difference = DAS mean relative humidity - Audit mean relative humidity

Table 3. End-to- End Total Particulate Matter Audit Results

Audit Date	Time Interval (min)	DAS Corrected Total PM ($\mu g/m^3$)	Audit Total PM ($\mu g/m^3$)	Difference ($\mu g/m^3$)	Difference (%)
9/3/98	300	19.0	12.0	7.0	58.3
10/21/98	270	11.0	7.0	4.0	57.1
3/11/99	360	11.0	8.3	2.7	32.5
4/8/99	360	22.9	17.1	5.8	33.9
7/1/99	360	27.2	19.1	8.1	42.4
8/19/99	360	46.0	34.0	12.0	35.3
1/20/00	300	41.2	29.0	12.2	42.1
3/9/00	360	157.4	117.4	40.0	34.1
7/6/00	307	165.5	144.6	20.9	14.5
9/15/00	180	97.7	99.7	-2.0	-2.0
1/10/01	240	23.1	15.3	7.8	51.0

DAS = Exposure chamber data acquisition system
DAS corrected total PM = Total PM measured above chamber x 0.7.
% Difference = ((DAS corrected total PM - Audit total PM) / Audit total PM) x 100

Table 3. End-to- End Total Particulate Matter Audit Results

Audit Date	Time Interval (min)	DAS Corrected Total PM ($\mu g/m^3$)	Audit Total PM ($\mu g/m^3$)	Difference ($\mu g/m^3$)	Difference (%)
4/9/02	120	32.7	27.8	4.9	17.6
6/5/02	120	116.2	115.4	0.8	0.7
10/23/02	120	43.7	40.5	3.2	7.9
12/23/02	120	11.3	10.3	1.0	9.7
4/16/04	360	56.8	55.8	1.0	1.8
6/14/04	270	100.7	70.2	30.5	43.4
8/18/04	240	124.1	119.6	4.5	3.8
7/1/05	180	88.3	81.6	6.7	8.2
9/13/05	211	60.1	63.4	-3.3	-5.2
11/14/05	240	47.9	50.6	-2.7	-5.3

DAS = Exposure chamber data acquisition system
DAS corrected total PM = Total PM measured above chamber x 0.7.
% Difference = ((DAS corrected total PM - Audit total PM) / Audit total PM) x 100

Table 4. End-to- End PM2.5 Audit Results

Audit Date	Time Interval (min)	DAS Corrected Total PM ($\mu g/m^3$)	Audit PM2.5 ($\mu g/m^3$)	Difference ($\mu g/m^3$)	Difference (%)
3/11/99	360	11.0	11.8	-0.8	-6.8
4/8/99	360	22.9	27.0	-4.1	-15.2
7/1/99	360	27.2	20.7	6.5	31.4
8/19/99	360	46.0	38.0	8.0	21.0
1/20/00	302	41.2	28.0	13.2	47.1
3/9/00	346	157.4	124.3	33.1	26.6
7/6/00	307	165.5	146.6	18.9	12.9
10/26/00	120	130.8	143.0	-12.2	-8.5
1/10/01	240	23.1	14.2	8.9	62.7
10/31/01	120	131.9	117.0	14.9	12.7
1/11/02	120	12.0	10.0	2.0	20.0

DAS = Exposure chamber data acquisition system
DAS corrected total PM = Total PM measured above chamber x 0.7.
% Difference = ((DAS corrected total PM - Audit PM2.5) / Audit PM2.5) x 100

Table 4. End-to- End PM2.5 Audit Results

Audit Date	Time Interval (min)	DAS Corrected Total PM ($\mu g/m^3$)	Audit PM2.5 ($\mu g/m^3$)	Difference ($\mu g/m^3$)	Difference (%)
4/9/02	120	32.7	30.5	2.2	7.2
6/15/02	120	116.2	124.5	-8.3	-6.7
10/23/02	120	43.7	44.5	-0.8	-1.8
12/23/02	120	11.3	11.0	0.3	2.7
6/29/04	180	136.4	174.6	-38.2	-21.9
8/17/04	240	88.6	99.2	-10.6	-10.7
3/24/05	210	29.5	36.3	-6.8	-18.7
6/9/05	240	74.8	82.5	-7.7	-9.3
8/26/05	240	50.8	49.2	1.6	3.3
11/15/05	240	31.2	32.7	-1.5	-4.6

DAS = Exposure chamber data acquisition system
DAS corrected total PM = Total PM measured above chamber x 0.7.
% Difference = ((DAS corrected total PM - Audit PM2.5) / Audit PM2.5) x 100

Table 5. Particulate Matter Spatial Distribution Audit Results

Audit Date	Concentration at Location C ($\mu g/m^3$)	Maximum Difference (%)	Location of Maximum Difference
9/7/00	13 - 16	15.8	B
1/11/01	27 - 38	12.4	B
8/30/01	289 - 337	-6.8	CR-1
1/29/02	76 - 89	1.8	D
4/11/02	56 - 86	6.3	B
6/13/02	211 - 238	1.9	B
10/24/02	78 - 85	-7.4	CR-1

Table 6. Particulate Matter Size Distribution Audit Results

Audit Date	Time Interval (min)	Audit PM Mass Median Diameter (μm)	< = 2.5 μm (%)
1/13/00	360	0.91	91
4/27/00	360	0.57	91
7/20/00	330	0.55	95
9/15/00	180	0.54	91
12/5/00	120	0.52	98

Table 6. Particulate Matter Size Distribution Audit Results

Audit Date	Time Interval (min)	Audit PM Mass Median Diameter (μm)	< = 2.5 μm (%)
1/11/02	120	0.57	91
5/14/02	120	0.48	98
4/21/04	307	0.41	95
7/22/04	150	0.59	92

Table 6. Particulate Matter Size Distribution Audit Results

Audit Date	Time Interval (min)	Audit PM Mass Median Diameter (μm)	< = 2.5 μm (%)
8/23/04	240	0.45	92
4/5/05	240	0.30	96
6/21/05	240	0.44	95
8/25/05	240	0.56	94
12/1/05	280	0.45	91

Conclusions

- QA limits can be established
- Preliminary limits
  - Temp +/-2.2^{0}C
  - RH +/-5%
  - PM spatial distribution +/-25%
  - Total PM concentration +/-25%
  - PM2.5 concentration +/-25%
  - PM size distribution > 90% < = 2.5µm