

Sampling Manifold Effects On Through The Probe Audit Gas Concentrations

By

Avraham Teitz and Mustafa Mustafa, US EPA Region 2
Edison, NJ

George Froehlich, NYSDEC
Albany, NY

Mark Shanis, EPA/OAQPS
Research Triangle Park, NC



In this paper, a manifold is defined as the flow path from the air monitoring station sample intake to the ambient air analyzer.



Causes of Manifold Effects on Gas Concentration

- Obstructions
- Leaks
- Absorption to contaminants on flow path surfaces
- Photoactivity
- Manifold design
 - Surface area relative to internal volume
 - number and degree of turns in flow path
 - residence time

Manifold Types

- Glass – 1”-4” in diameter
- Teflon ¼” – 1” diameter
- Shielded vs. exposed to sunlight
- Bends/Connections vs. Straight Run
- Water Traps/Heated Lines vs. Straight Run

Manifold Tour – Sample Intakes

glass tubing + u bend + screen



Manifold Tour - Sample Intakes

glass tubing + u bend + small funnel + screen



Sample Intakes - Glass

glass tubing + u bend + large funnel + screen



Manifold Tour - Sample Intakes

glass tubing + hat



Manifold Tour - Sample Intakes

glass tubing + solar shielding + hat



Manifold Tour - Sample Intakes

glass or Teflon tubing + solar shielding + Teflon lined hat



Manifold Tour - Sample Intakes

individual Teflon tubes + glass funnel



Manifold Tour - Sample Intakes

Individual Teflon tubes + filter



2009 National Ambient Air Monitoring Conference Nashville, TN



Manifold Tour - Sample Intakes

individual Teflon tubes + solar shielding + u bend + funnel



2009 National Ambient Air Monitoring Conference Nashville, TN



Manifold Tour – Connections

outdoor glass cross + horizontal run



Manifold Tour – Connections indoor glass cross + horizontal run



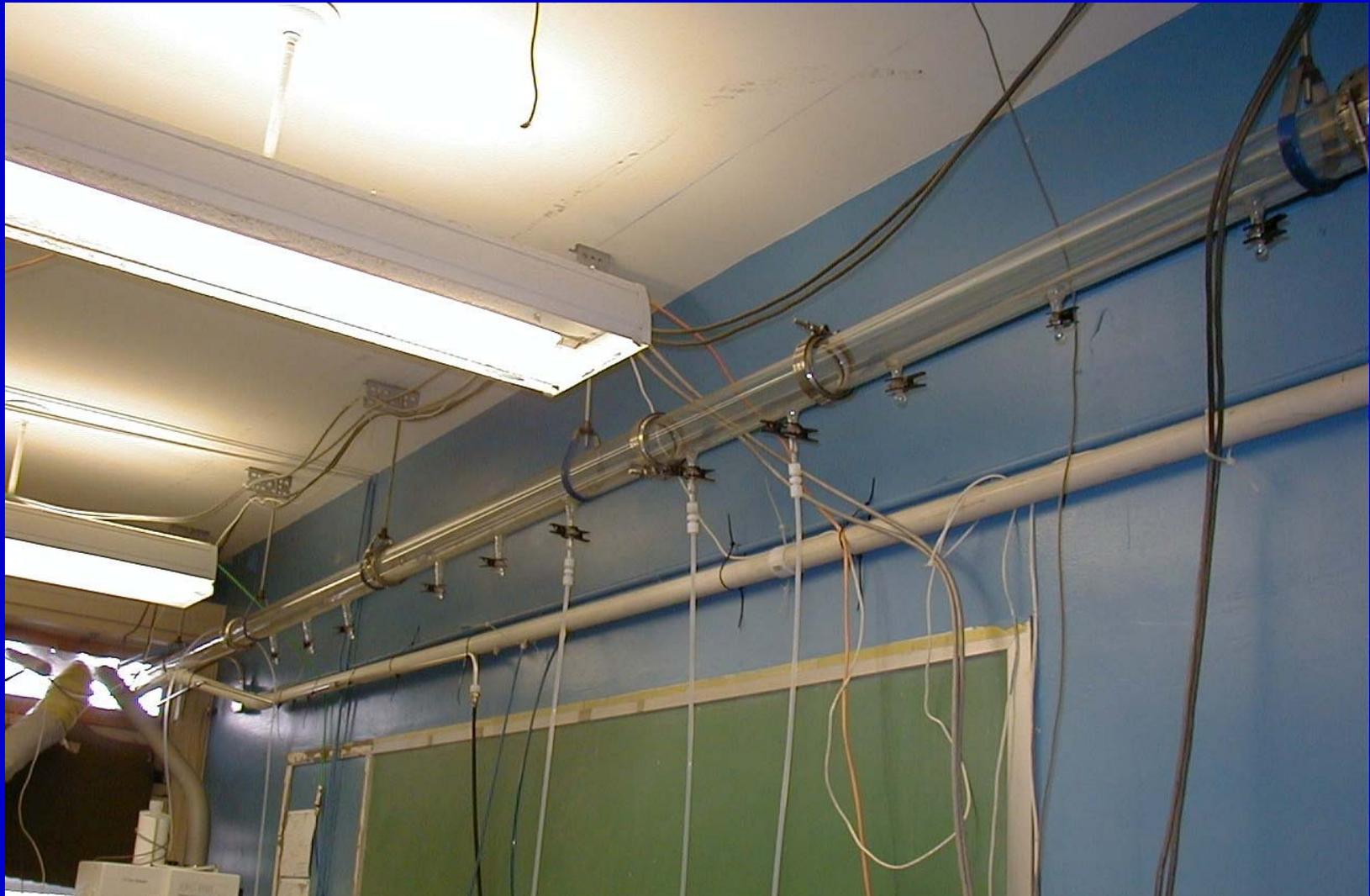
Manifold Tour – Connections

glass tee + water trap + horizontal run + heating



Manifold Tour – Connections

long horizontal run



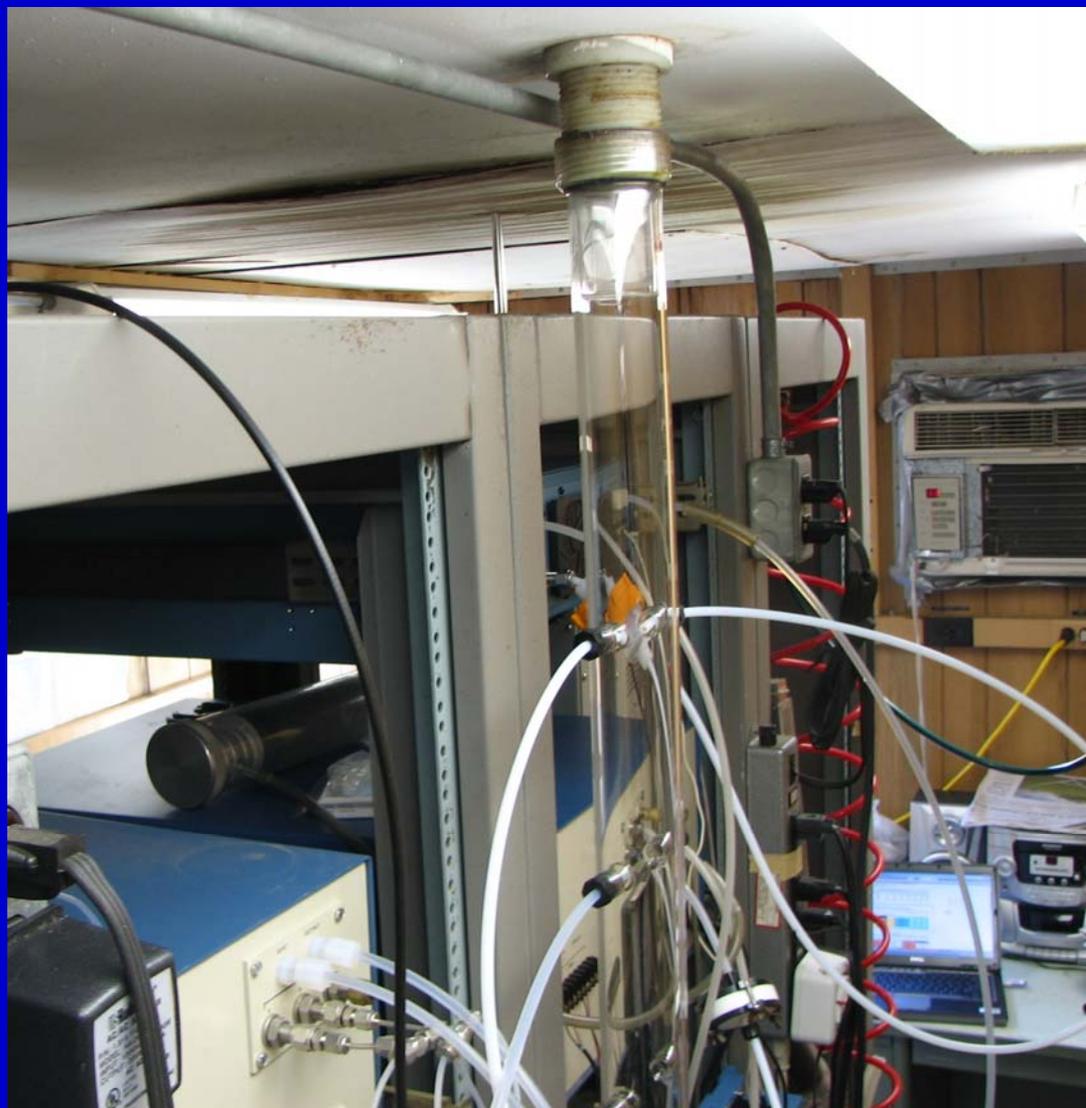
Manifold Tour – Connections

short horizontal run



Manifold Tour – Connections

straight glass tubing + vertical run



2009 National Ambient Air Monitoring Conference Nashville, TN

Manifold Tour – Connections

Teflon straight tube + vertical run + glass distribution manifold



Manifold Effects - Obstructions

Characterized by:

Low sample flow

Back Pressure

Reduction in gas concentration reported by station



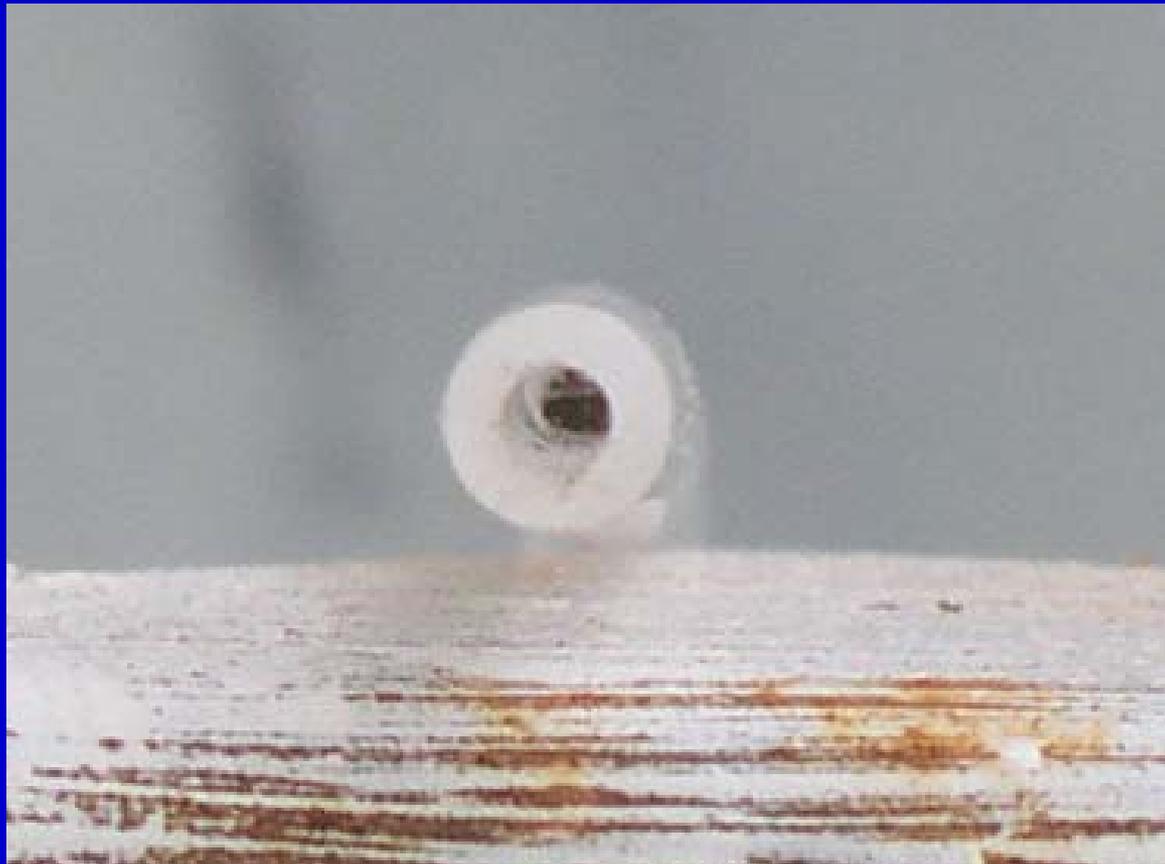
Manifold Effects - Obstructions

spider web in line



Manifold Effects - Obstructions

cross section of spider web in line



Manifold Effects - Leaks

Characterized by:

Wave like data trace, and/or

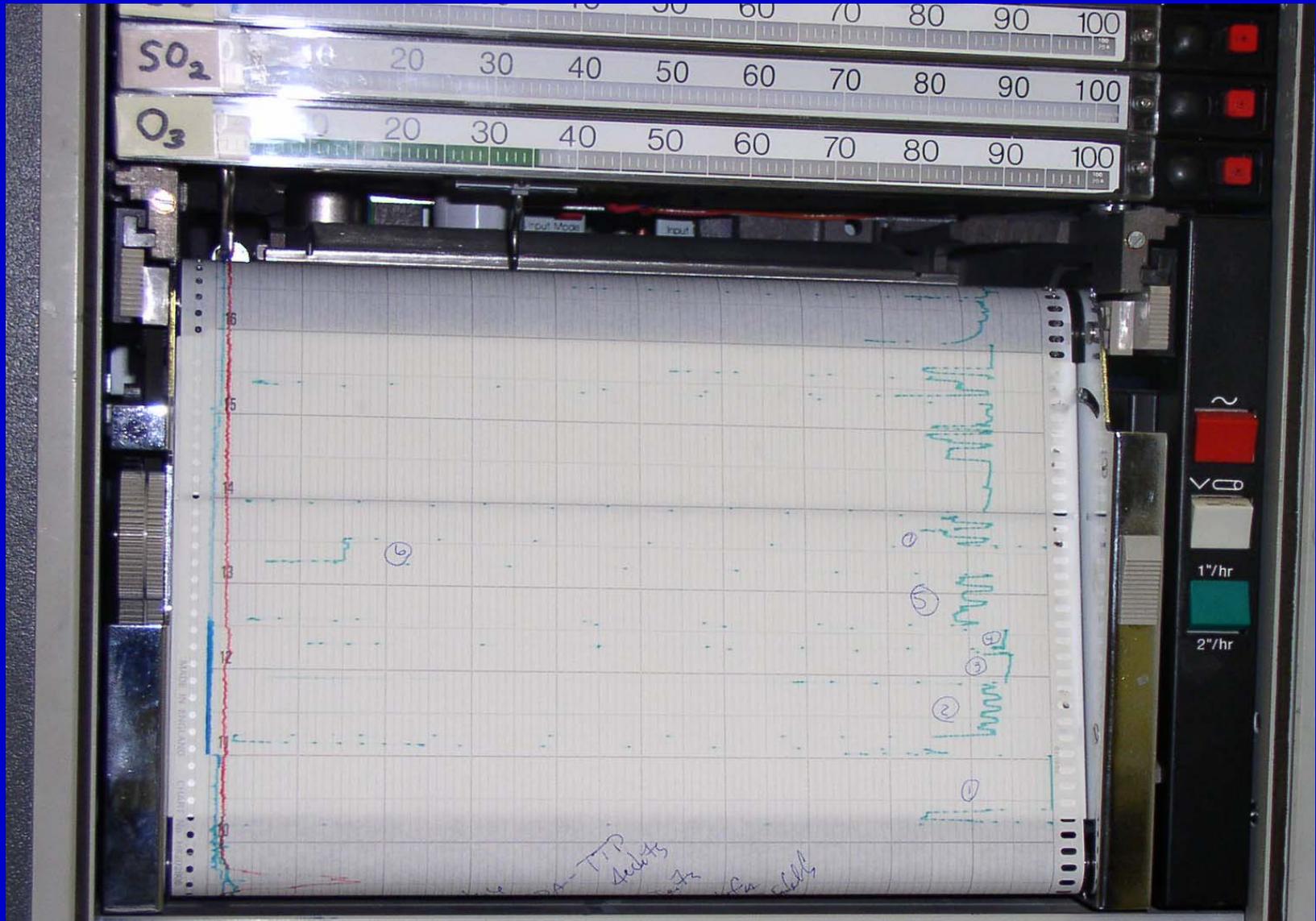
Long equilibration times (hours)
at all concentrations

Low flow at manifold vent to atmosphere



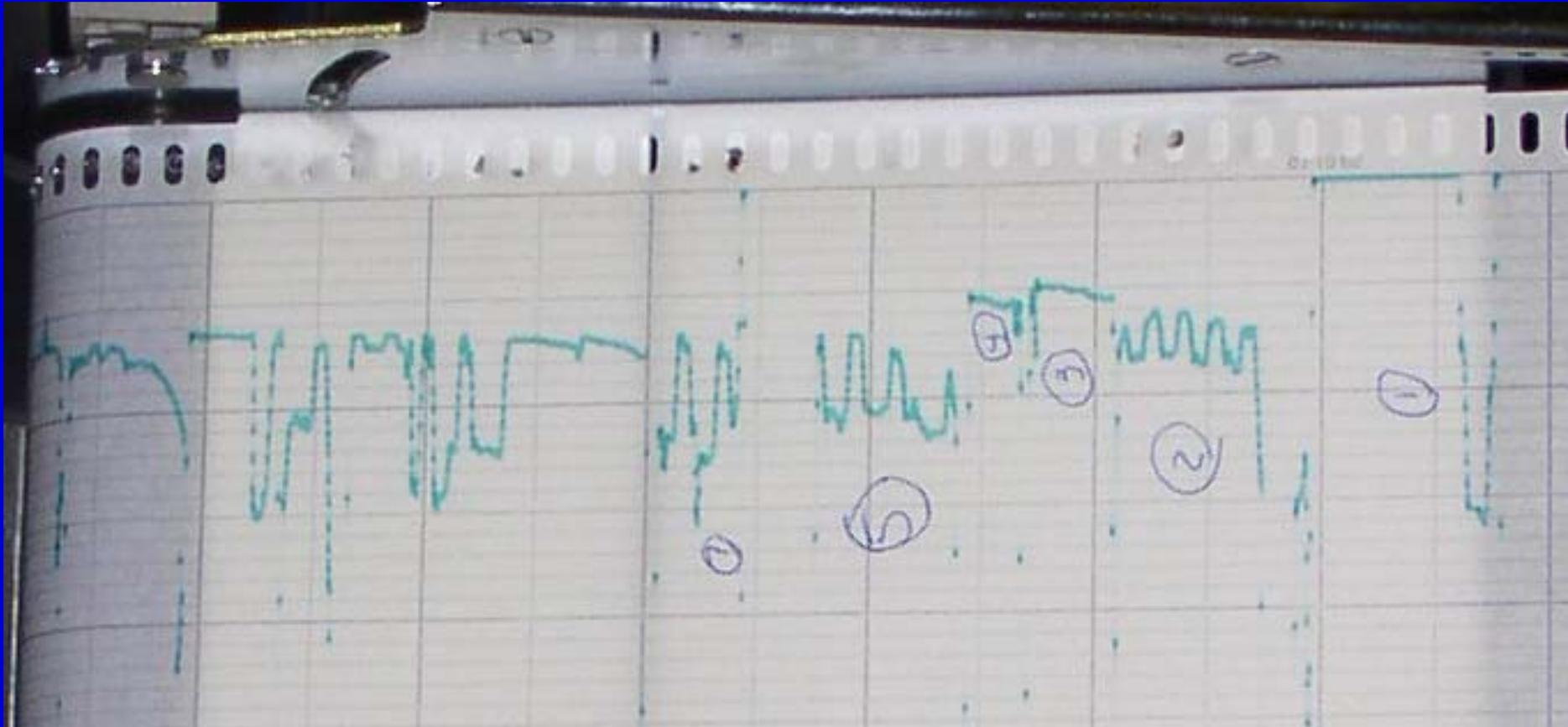
Manifold effects - Leaks

Wave like data trace @ 400 ppb O₃



Manifold Effects - Leaks

Close up of data trace – chart rate @ 1"/hour



Manifold Effects - Leaks

Bad gasket seal



Manifold Effects - Leaks

Bad gasket seal close up



Manifold Effects - Leaks

Out of round gasket (and dirty)



Manifold Effects - Adsorption

Characterized by:

Reduction in gas concentration reported by
station



Manifold Effects – Absorption

SO₂ Through The Probe @ Alcoa # 1

July 28, 2009

Audit Concentration (ppm)	Station Concentration (ppm)	% Difference
0.000	0.000	n/a
0.413	0.320	-22.4



Manifold Effects – Absorption

SO₂ Through The Probe @ Alcoa # 1

July 28, 2009



2009 National Ambient Air Monitoring Conference Nashville, TN



Manifold Effects – Absorption

SO₂ Through The Probe @ Alcoa # 1

July 28, 2009



Manifold Effects – Absorption

SO₂ Through The Probe @ Alcoa # 1

July 28, 2009



2009 National Ambient Air Monitoring Conference Nashville, TN

Manifold Effects – Absorption

SO₂ Through The Probe @ Alcoa # 1

Manifold typically covered in insulation & heat tape



Manifold Effects – Absorption

SO₂ Through The Probe @ Alcoa # 1

Close up of bend in manifold



Manifold Effects – Absorption

SO₂ Through The Probe @ Alcoa # 1

Close up of bend in manifold



Manifold Effects – Absorption

SO₂ Through The Probe @ Alcoa # 1

Close up of tee in manifold



Manifold Effects – Absorption

SO₂ Through The Probe @ Alcoa # 1

Manifold Cleanup



Manifold Effects – Absorption

SO₂ Through The Probe @ Alcoa # 1

After cleanup



Manifold Effects – Absorption

SO₂ Through The Probe @ Alcoa # 1

Post Cleanup - July 28, 2009

Audit Concentration (ppm)	Station Concentration (ppm)	% Difference
0.000	0.000	n/a
0.413	0.405	-1.8
0.161	0.159	-1.1
0.068	0.067	-1.2



Manifold Effects – Photoactivity

Characterized by:

Manifold system exposed to sunlight

Increase in NO_2 independent of sample concentration

Sunlight can interact with contaminants on surfaces and decrease O_3 concentrations



Manifold Effects – NO_x Photoactivity

NO_x Through The Probe @ Buffalo, NY

June 5, 2006

Audit Concentration (ppm)		Station Concentration (ppm)		NO _x	NO % Difference
NO	NO₂	NO	NO₂	NO _x	
0.000	0.000	0.001	0.002	0.002	n/a
0.451	0.000	0.440	0.008	0.447	-3.3
0.281	0.000	0.262	0.011	0.272	-6.8
0.177	0.000	0.164	0.010	0.173	-7.8
0.076	0.000	0.066	0.010	0.074	-13.7

- Manifold and presentation line uncovered
- With only manifold uncovered, NO₂ was increased by 0.003 ppm



Manifold Effects – NO_x Photoactivity

NO_x Through The Probe @ Buffalo, NY

Installation of full aluminum foil jacket



2009 National Ambient Air Monitoring Conference Nashville, TN

Manifold Effects – NO_x Photoactivity

NO_x Through The Probe @ Buffalo, NY

With full aluminum jacket – June 6, 2006

Audit Concentration (ppm)		Station Concentration (ppm)		NO _x	NO % Difference
NO	NO₂	NO	NO₂	NO _x	
0.000	0.000	0.000	0.002	0.001	n/a
0.449	0.000	0.450	0.003	0.452	-0.7
0.278	0.000	0.276	0.002	0.278	-1.4
0.175	0.000	0.175	0.002	0.176	-0.6
0.074	0.000	0.076	0.002	0.076	-0.8



Manifold Effects – Photoactivity

Improved jacketing materials



Manifold Effects – Photoactivity

Improved jacketing materials



2009 National Ambient Air Monitoring Conference Nashville, TN

Manifold Effects – O₃ Photoactivity

O₃ Through The Probe @ Loudonville, NY

April 23, 2009

TTP system (ppm)	un-covered manifold (ppm / %d)	covered manifold (ppm / %d)
.393	.3840 / -2.3	.3920 / 0.3
.259	.2500 / -3.5	.2610 / 0.8
.177	.1660 / -6.2	.1780 / 0.6
.073	.0660 / -9.6 *	.0730 / 0.0
.031	.0240 / -22.6 **	.0317 / 2.3
.000	.0008 / <u>-</u>	.0006 / <u>-</u>

* exceeds warning limit (+/- 7%)

** exceeds failure limit (+/- 10%)

note: the manifold at this site was thoroughly cleaned 6 days prior to the audit



Manifold Effects – O₃ Photoactivity

O₃ Through The Probe @ Loudonville, NY

April 23, 2009



2009 National Ambient Air Monitoring Conference Nashville, TN

Manifold Effects – O₃ Photoactivity

O₃ Through The Probe @ Loudonville, NY

April 23, 2009



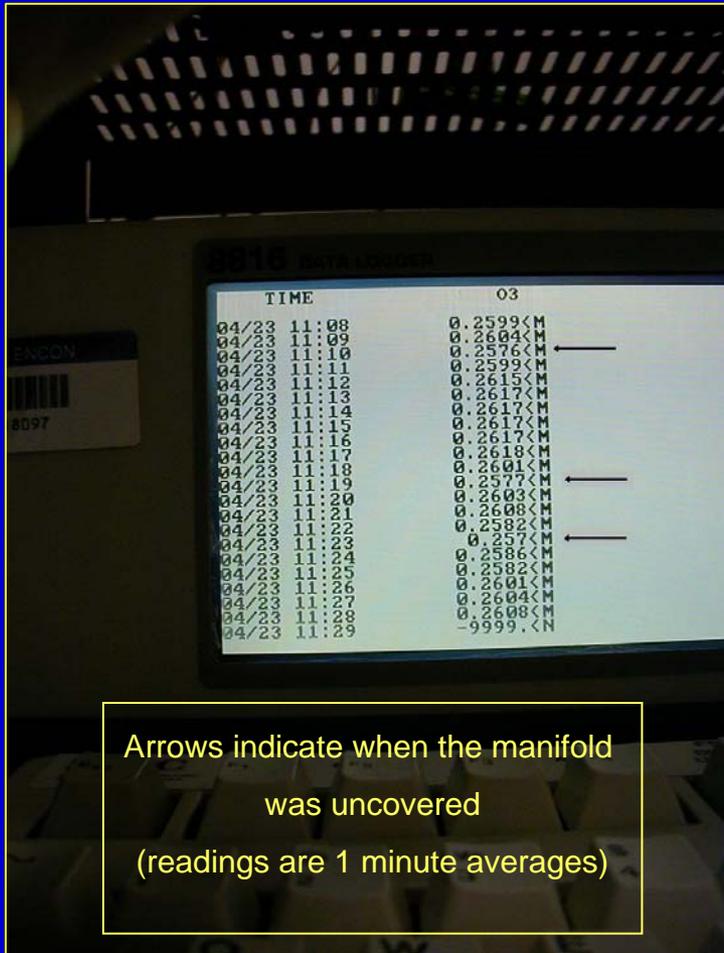
Light entering the shelter through the door and window were sufficient to affect the readings and therefore had to be covered.



Manifold Effects – O₃ Photoactivity

O₃ Through The Probe @ Loudonville, NY

April 23, 2009



The photo to the left shows how the O₃ response changed by simply covering and uncovering the window!

The 0.262 covered vs. 0.257 uncovered difference is a 2% change in instrument Response.

Manifold Effects – O₃ Photoactivity

O₃ Through The Probe @ Loudonville, NY

April 23, 2009

Immediately after the initial TTP audit:

- The manifold was taken down and cleaned with a clean dry cotton cloth through the glass portions.
- The connectors were cleaned with isopropyl alcohol on the cotton cloth followed by distilled water on Kimwipes
- Air dried before the manifold was reassembled and re-audited.



Manifold Effects – O₃ Photoactivity

O₃ Through The Probe @ Loudonville, NY

April 23, 2009

The Kimwipes used to wipe the joints



Joint before cleaning



The horizontal and vertical sections of the glass manifold were cleaned while in place

Cleaned joints and U-bend prior to re-installing manifold



Vertical manifold

Horizontal manifold

Cleaning cloth inside manifold



Manifold Effects – O₃ Photoactivity

O₃ Through The Probe @ Loudonville, NY

Air Drying the manifold rings



Manifold Effects – O₃ Photoactivity

O₃ Through The Probe @ Loudonville, NY

April 23, 2009

Immediately After Cleaning

TTP O ₃ reading (ppm)	Station O ₃ reading (ppm)	% Difference
0.391	0.350	-10.5

After conditioning manifold with 0.800 ppm O₃ for 15 minutes

TTP O ₃ reading (ppm)	Station O ₃ reading (ppm)	% Difference
0.391	0.386	-1.3



Manifold Effects – O₃ Photoactivity

O₃ Through The Probe @ Loudonville, NY

Full Audit After Cleaning

TTP system (ppm)	un-covered manifold (ppm / %d)	covered manifold (ppm / %d)
0.391	0.3860 / -1.3	0.3880 / -0.5
0.261	0.2580 / -1.1	0.2610 / 0.0
0.180	0.1774 / -1.4	0.1795 / -0.3
0.075	0.0733 / -2.3	0.0753 / 0.0
0.033	0.0332 / 0.7	0.0337 / 2.0
0.000	0.000 / <u>-</u>	.0006 / <u>-</u>



Manifold Effects – Conclusions

- Manifold effects can be prevented by good manifold design
 - Straight Runs
 - Minimal or no bends
 - Minimal number of connections
 - Solar shielding
 - Easy Cleaning
 - Vertical manifold alignment
 - Easy/inexpensive replacements of wetted parts
- Trouble shooting requires patience
 - One idea tested at a time
 - Sufficient equilibration time at each point tested