

The Avogadro Group, LLC

Source Emissions Testing and Emissions Specialists

PM2.5 Emissions: Do the New Test Methods Improve the Results?

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McIlvaine Hot Topic Hour, December 2010

EPA's PM2.5 Implementation Rule

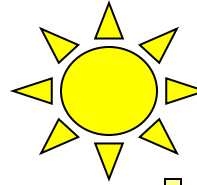
- May 2008 Promulgation
 - applies NSR to sources in PM2.5 non-attainment areas
 - and to plants in some PSD areas
- Measure emissions of pollutants that contribute to PM2.5:
 - Directly emitted PM2.5
Filterable and Condensable (CPM)
 - Gaseous Precursors to Secondary PM2.5
(SO₂, NO_x, VOC, NH₃) measured by separate methods
- EPA had to develop a new, better methods, especially for CPM – results from existing methods were

What are we trying to measure?

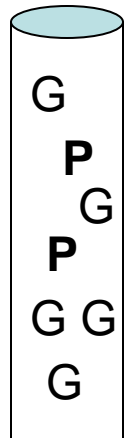
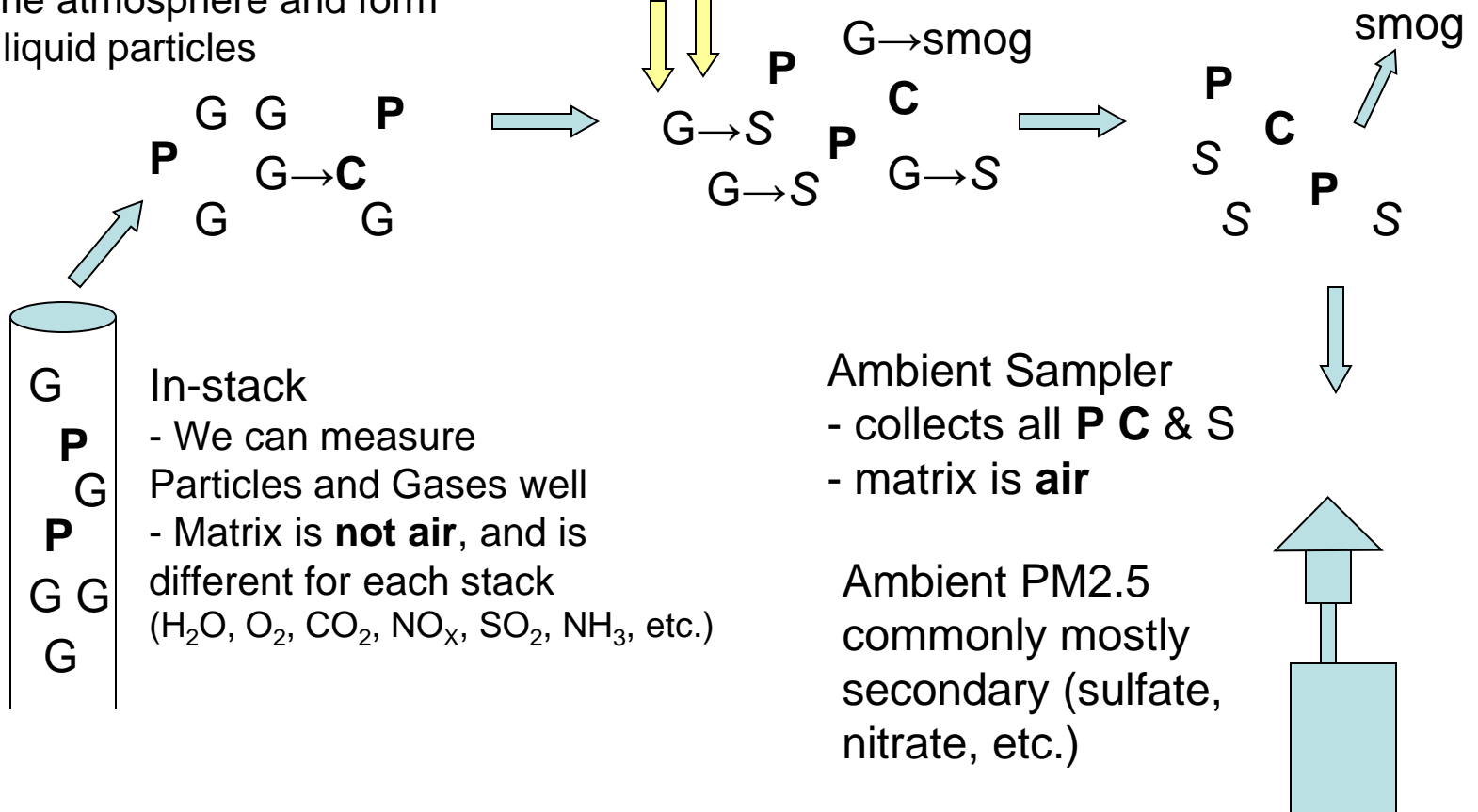
Primary Particulate Matter less than 2.5 μm

Measure **Primary** PM2.5 Emissions

- **P**articles from stack
- **C**ondensable PM - some Gases cool in the atmosphere and form solid or liquid particles



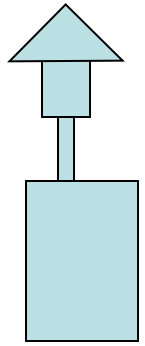
Photochemistry – other Gases (precursors) form **Secondary** PM2.5 and gaseous smog (ozone, etc.)



In-stack
 - We can measure Particles and Gases well
 - Matrix is **not air**, and is different for each stack (H₂O, O₂, CO₂, NO_x, SO₂, NH₃, etc.)

Ambient Sampler
 - collects all **P C & S**
 - matrix is **air**

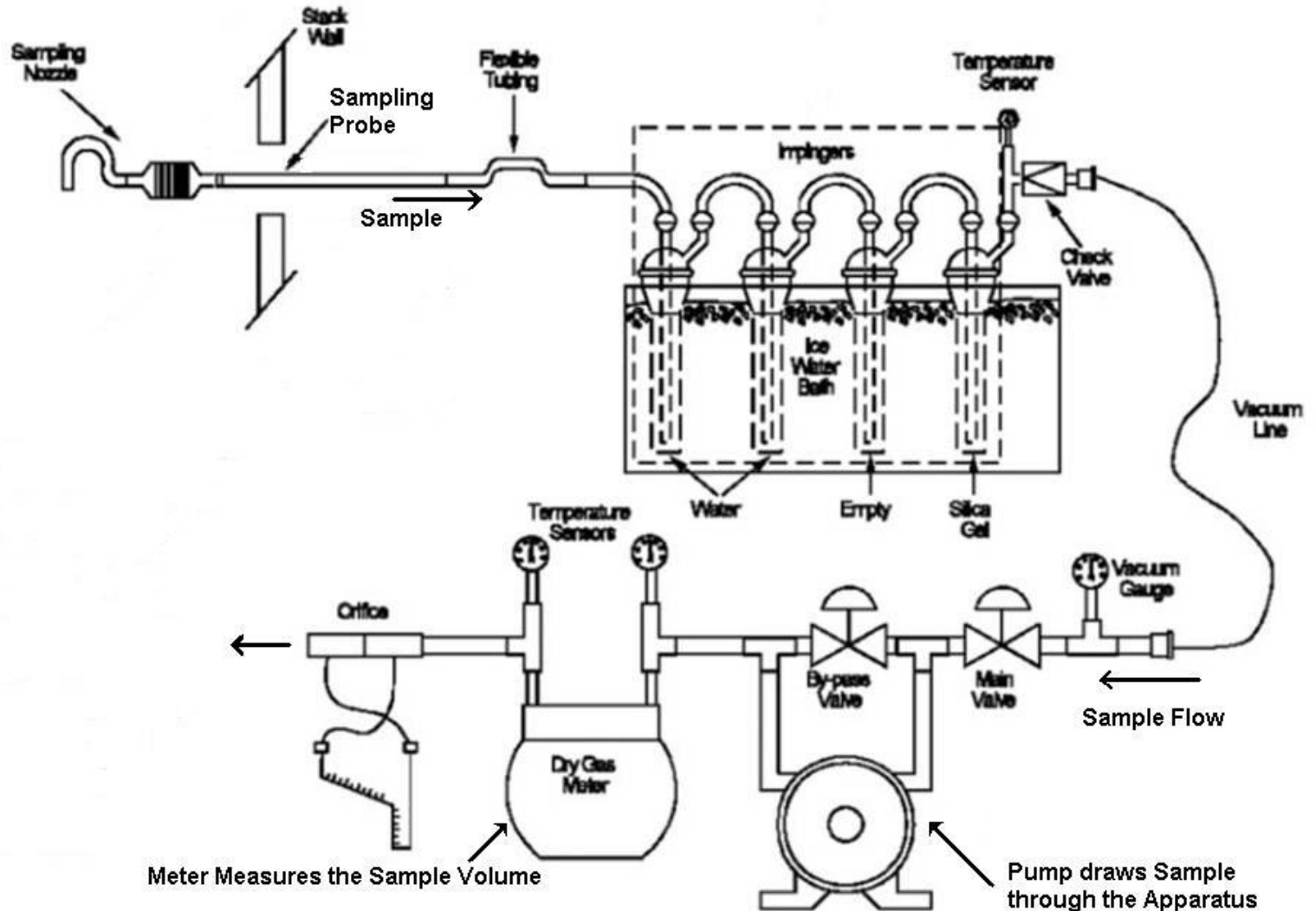
Ambient PM2.5
 commonly mostly secondary (sulfate, nitrate, etc.)



Available “traditional” methods

- CARB 5, SCAQMD 5.2 or 5.3,
- Oregon DEQ 5 or 7, Washington DOE 8, etc.
- “Old” EPA 202 from 1990
(with EPA 5 or EPA 201A for filterable)
- All collect filterable PM in similar ways;
the filter is **similar** to ambient sampling
- All collect condensable PM by bubbling through water in impingers to cool the sample
 - this is **different** from what happens in the atmosphere
- Samples are collected, dried to residue and weighed
 - results are in weight per volume of stack gas sampled

Diagram, Typical Traditional Test Method



Example of Traditional Method

- Sample bubbled through impingers

Impingers stand about 18 inches tall. The photo shows a typical set of impingers, the first three with water and the 4th containing silica gel to dry the sample gas.

The next slide shows impingers “in action” with sample bubbling through them.





MAXIMIZED GAS-LIQUID CONTACT

Confusion

Between what is Primary and what is Secondary

- Some of the precursor gases get double-counted:
 - as if they were Primary CPM
 - and also measured separately as gases, and computer models calculate how much forms Secondary PM2.5
- Gases bubbled through water go into solution
- The impinger contents are dried to residue and the residue is weighed to determine the mass of CPM
- Salts form from dissolved gases – The salts become part of the CPM residue that we measure
- Example: Ammonia and SO₂ dissolve to form ammonium sulfate (NH₄)₂SO₄ which becomes part of the measured CPM total
- Some of this may be actual CPM - Primary PM2.5 emissions - but much can be an **Artifact** of the method

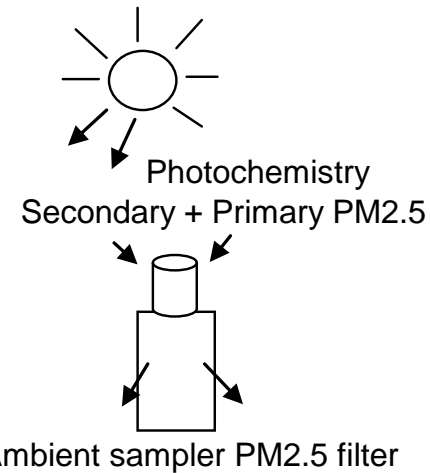
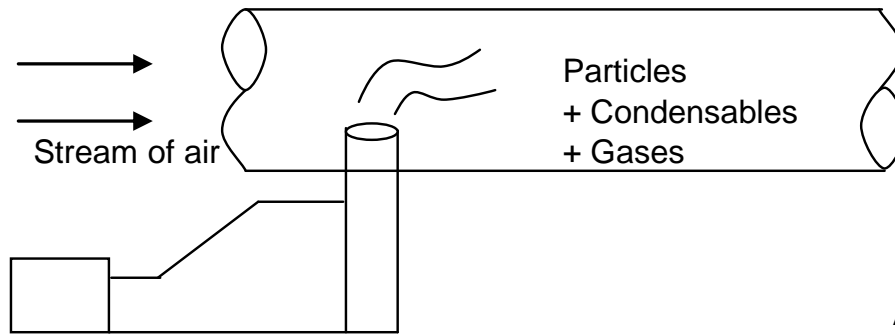
Dilution methods are being developed

– like those long used for mobile sources

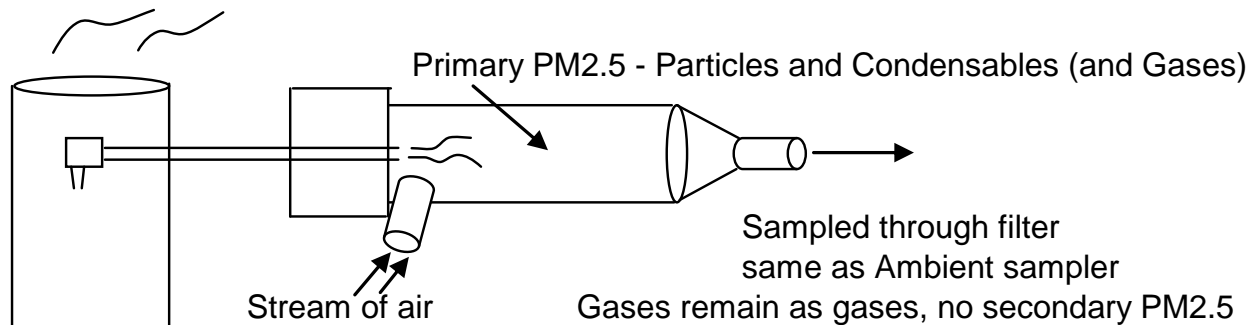
- Sized for handling on a stack platform; examples:
 - EPA “conditional test method” CTM-039
 - GE Energy compact dilution sampler
 - ASTM standard for dilution method
- Designed to emulate cooling and dilution of stack emissions in ambient air
- Condensables form in the same way as in actual emissions
- Primary PM_{2.5} – particles and CPM, all sampled together, *similar* to ambient sampling but without the secondary PM_{2.5}
– **Great!**
- Shows promise **but**
 - Measurement can be below the lab detection limit for some sources
 - Uses new, expensive equipment
 - Difficult to implement on the large scale necessary to test stacks everywhere in the time frame necessary

Dilution Sampler Concept

Stack emissions of Primary PM2.5
Emissions into a "virtual" stream of air

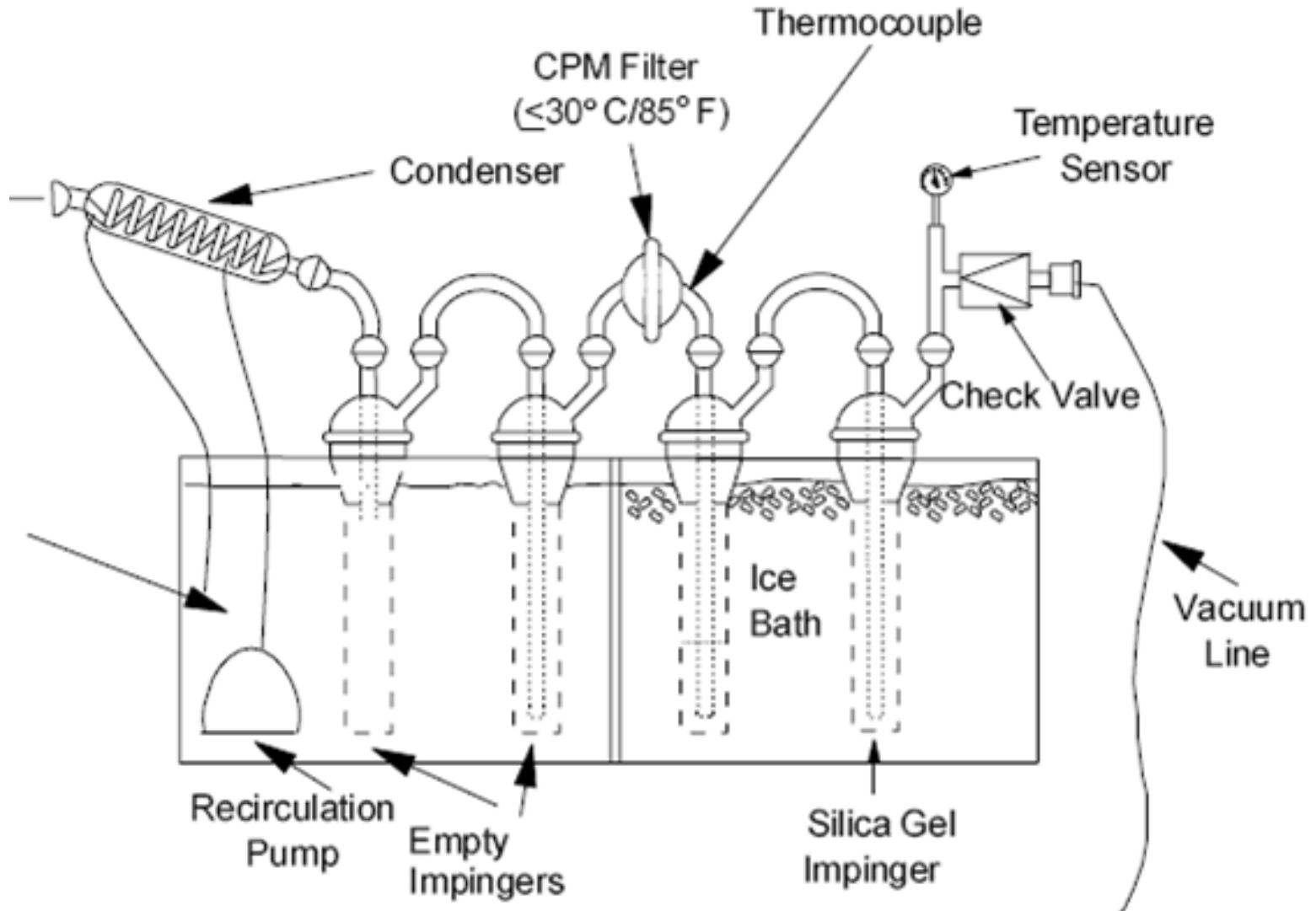


Stack sampling of Primary PM2.5 by CTM-039
Sample "emitted" into a stream of air



New 202 (formerly called "OTM-028")

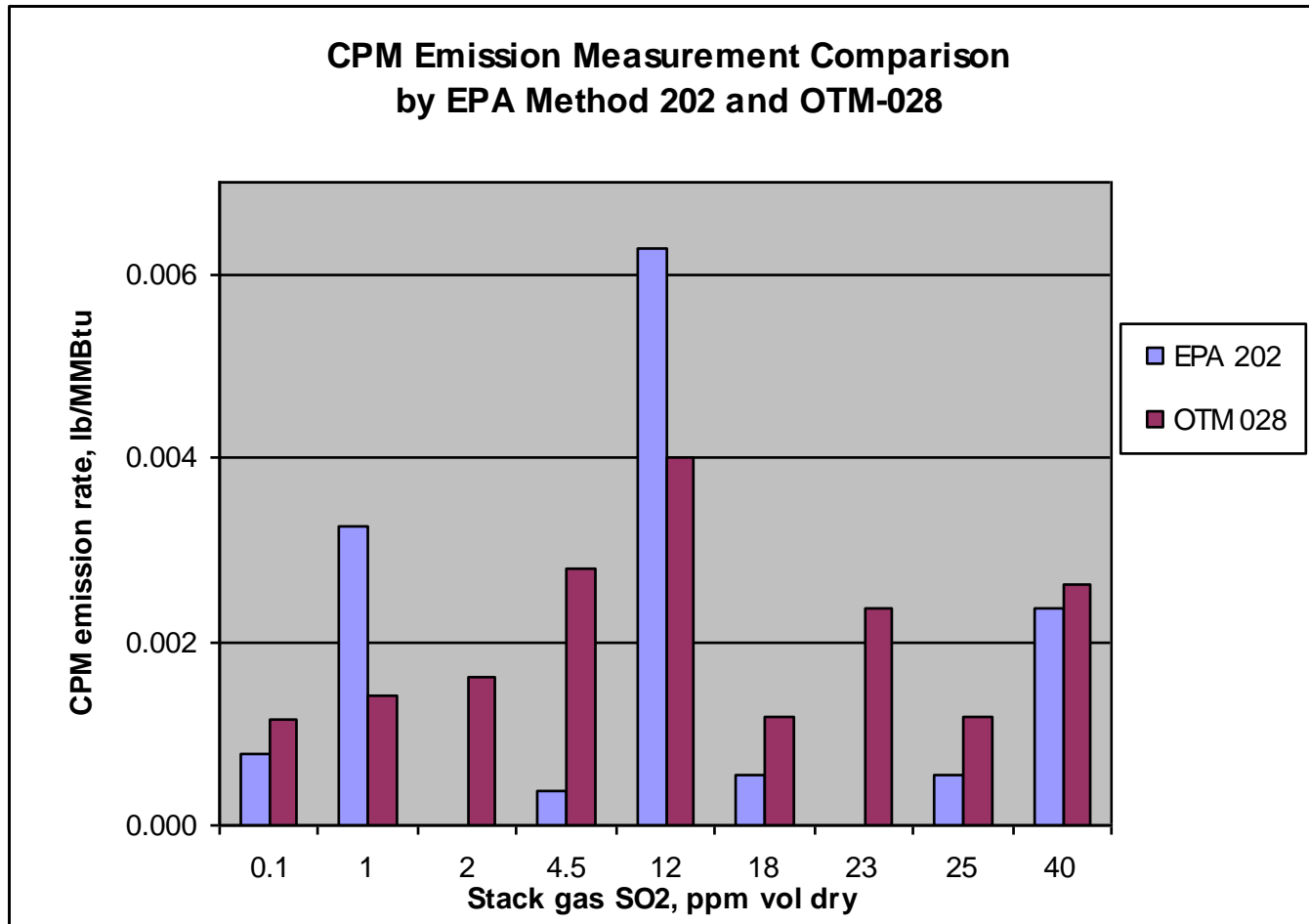
- EPA's more easily implemented solution
- uses condenser and dry impingers with backup filter



New 202 (formerly called “OTM-028”)

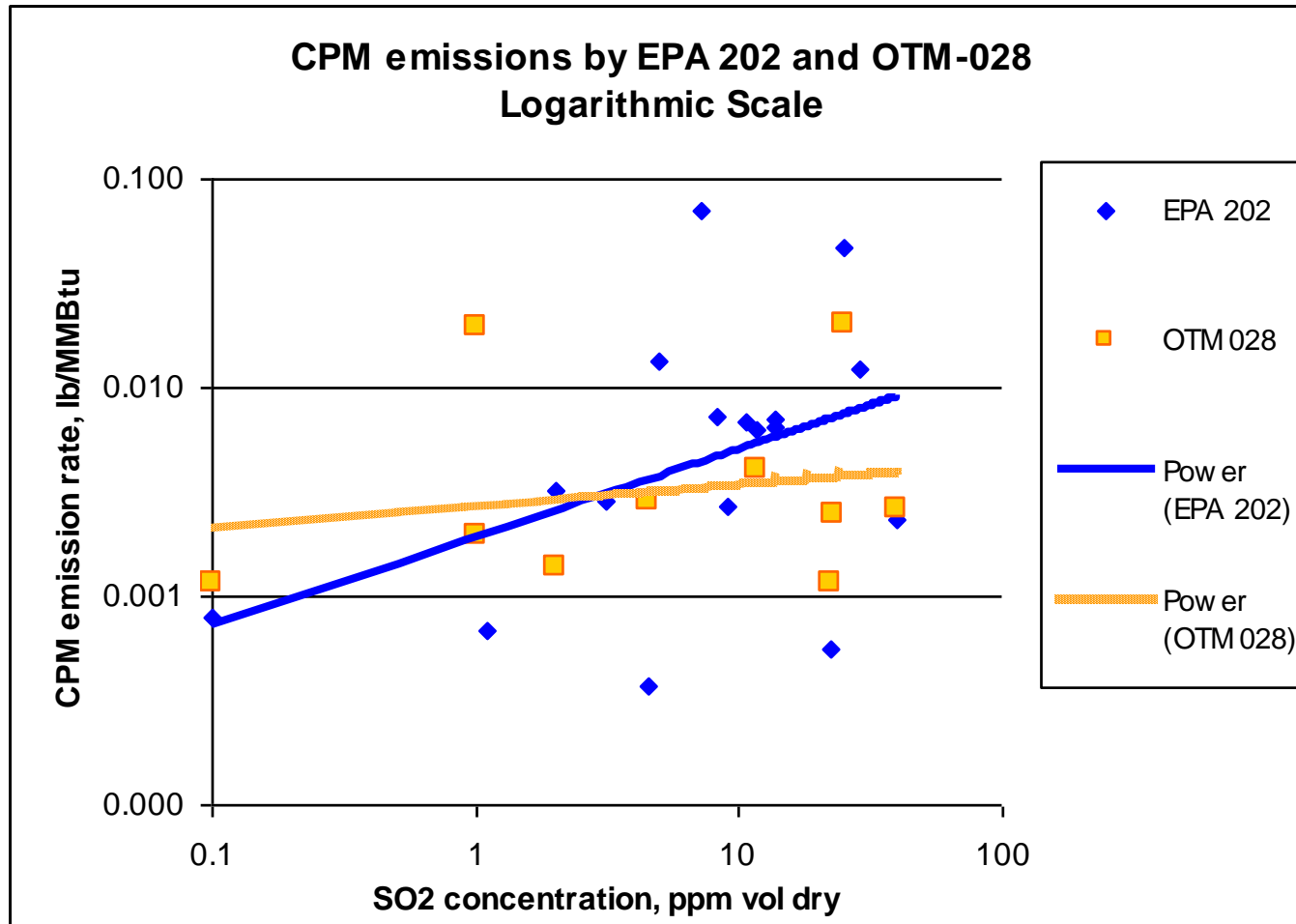
- EPA’s **objectives**: Less artifact, Less variable results
- First two impingers are **dry** at beginning of test run; condenser and impingers cool the sample to 85°F or lower
- Condensed aerosols or particles are collected in impingers and backup filter – recovered with rinses after sampling, dried to residue and weighed similar to “old” Method 202
- Condensate forms (water from stack gas, CPM) but there is **no bubbling** of gases through water or condensate
 - this **minimizes** gas-liquid contact
 - some, but **much less** of precursor gases are dissolved or collected as artifact
 - still ***different*** from ambient sampling because there is no dilution into air
- Lab studies indicate 40 to 80% less sulfate artifact (as much as 85 to 95% for some high-SO₂ sources)
- Our **hypothesis** – less artifact (especially from SO₂ forming sulfate)
 - Results should be lower than those from the “old” 202
- **Does it really improve results in the field?**

Comparison of new 202 (OTM-028) and EPA “old” 202



Results are arranged according to SO₂ concentration, X-axis is **not linear**. Data include 2 cases of OTM-028 only; others are from concurrent tests with both methods; all are the average of 3 test runs. These are from a variety of sources with more variables than just the SO₂ concentration, and include organic CPM that is very different from one source to another. OTM-028 results were often higher than “old” 202 but seem to be less variable or scattered.

Results of new 202 (OTM-028) and EPA "old" 202 Comparison with Trend Lines



These are the same results as the previous slide, plus other non-concurrent runs, with trend lines for each of the two methods. Scales are logarithmic. OTM-028 results were higher than "old" 202 at low SO₂ but seem less scattered.

- **Did EPA meet its objectives?**

Yes, results seem less variable.

Maybe there is less artifact, it's hard to tell from these results

- there are other variables in the field from such a variety of sources.

- **Was our hypothesis true?**

The hypothesis seems not true – the results from the new 202 may be higher than from the “old” Method 202 at low SO₂ – future studies and developments may help.

- **Does the new method improve the results?**

- The results seem improved by lower variability; perhaps they will be more predictable than the old, more variable method.

- The higher results for some sources do not seem to be an “improvement”

- **As always, the results are defined by the method used, so this method will define PM_{2.5} emissions**

- Some sources may have “actual” emissions lower than either method can measure.

- There may be a “floor” or some “background” or blank value that can be lowered as testers practice and experiment within the limits of the method's procedures.

- We improved nuances of technique to get better, lower results from the “old” 202, so this new method will likely benefit from similar developments.

- There may be technical reasons for higher results at some sources – for example, the laboratory evaporation temperature is lower than for the old method.

Conclusion – choose your tester and method carefully – good science and technique may be the keys to the best test results

Questions ???

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