

Source Testing Methods for Particulate Matter: A Comparative Review of Measurement Methods

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Particulate Matter

- Particulate Matter (PM) is defined as a mixture of solid particles and liquid droplets in air
- PM exists in a variety of sizes as ultra-fine particles (10 to 500 nanometers), fine particles (ranging from 1 micron to 2.5 microns) and coarse particulate matter (2.5 microns to 10 microns)
- PM less than 2.5 microns ($PM_{2.5}$) are expected to mostly form in the atmosphere due to secondary processes
- Coarse PM less than 10 microns in size (PM_{10}) occur from primary emissions
- PM_{10} and $PM_{2.5}$ emissions, as defined by US EPA, include filterable and condensable emissions.



Source Testing

- Measurement of air pollutant concentration and/or quantity at a source or stack.
- In most cases, it is conducted as a one-time or snapshot basis measurement; as opposed to continuous ambient monitoring.
- Continuous Emissions Monitors (CEMS) systems also are available, usually Nitrogen Oxides (NO_x), Carbon Monoxide (CO) and Sulfur Dioxides (SO₂) are measured using CEMS.
- Source testing may be performed to provide design data or to measure performance of a process
- Performed on a periodic basis to demonstrate compliance with air permit emissions limitations
- As all measurements and monitoring methods, this requires labor to set up the test, collect samples, and to analyze the results

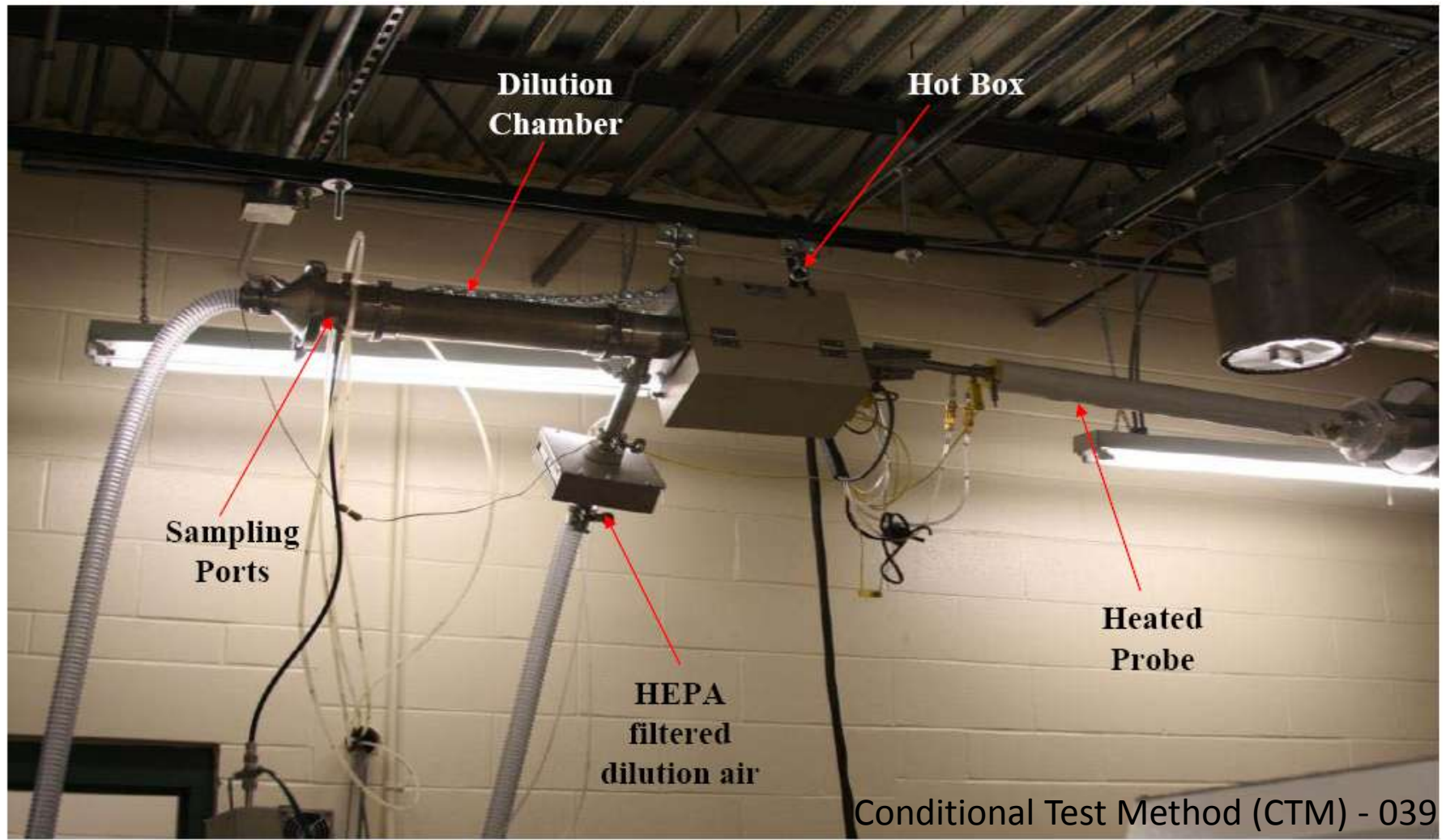
Condensable and Filterable PM

- Filterable emissions are emissions that exit the stack in either solid or liquid state and are referred to as "front-half" emissions or non-condensable emissions
- Condensable emissions, collected separately, are usually referred to as "back-half" emissions, due to the standard method of measurement that captures the PM in the back half of the sampling train.

Source Sampling Methods for PM

- EPA Method 5
- Alternative to the traditional EPA methods:
Dilution sampling such Conditional Test
Method – 039

Dilution Sampling System



From Laing, J.L. et al., Biofuel combustion, NERM 2010

Combined U.S. EPA METHODS 5 & 6

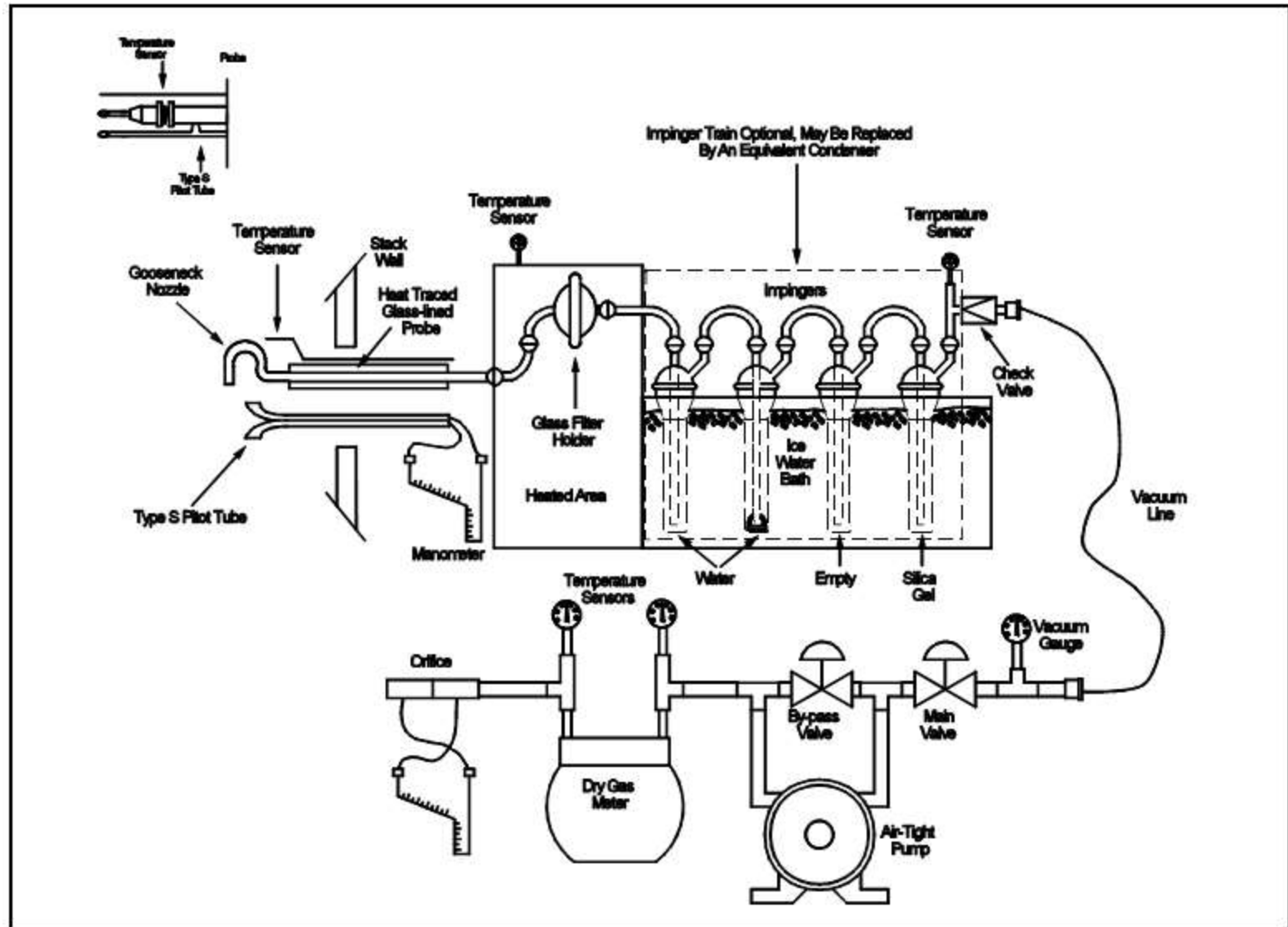


Figure obtained from: <http://www.epa.gov/ttn/emc/promgate/m-05.pdf>

Determination of Particulate (PM) and Sulfur Dioxide (SO₂) Emissions from Stationary Source

Advanced Wood Combustion Boiler

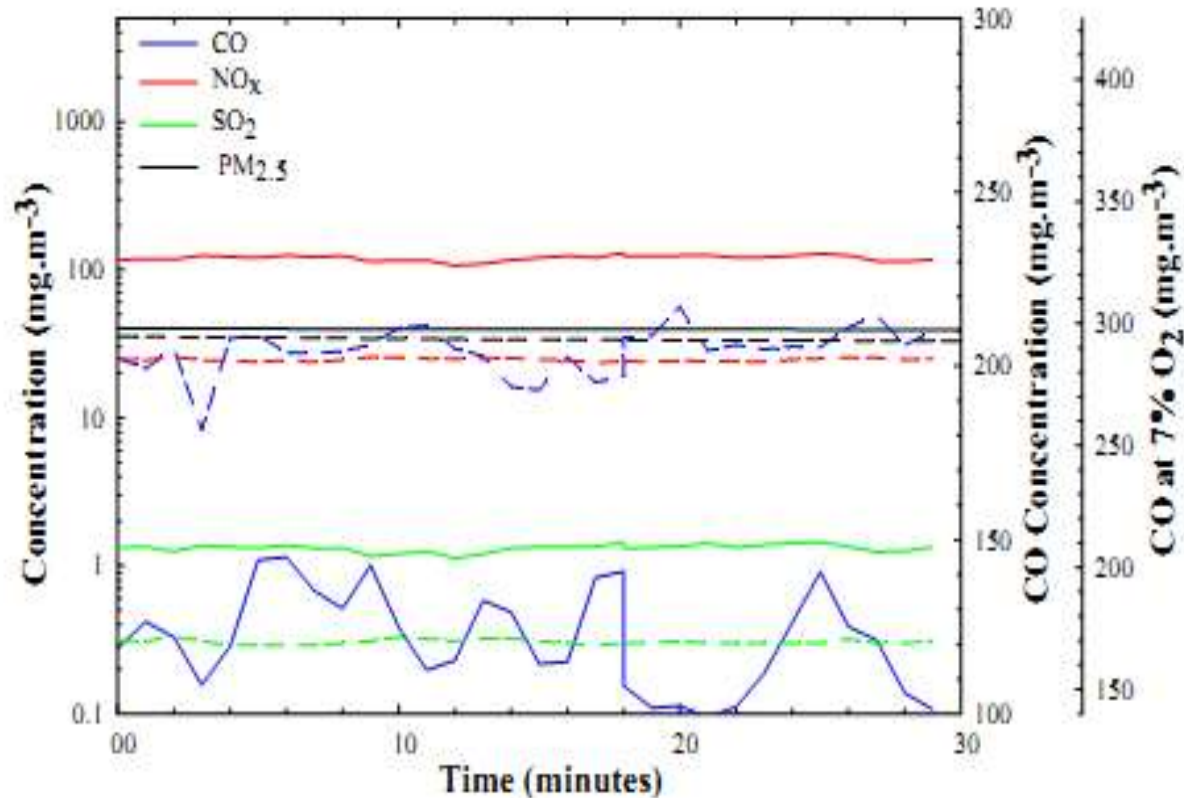


From Laing, J.L. et al., Biofuel combustion, NERM 2010



From Laing, J.L. et al., Biofuel combustion, NERM 2010

Concentration of Criteria Pollutants during Steady State Operation of 150 kW Boiler



Dashed lines indicate data for wood pellets and solid line indicate data for wood chips.

Comparison of Measurements with Dilution Tunnel CTM-039 and EPA Method 5

Pollutant	CTM-039 ¹			EPA Method 5 ²
	150 kW (Pellets)	150 kW (Woodchips)	500 kW (Pellets)	500 kW (Pellets)
PM (mg.m-3)	37	38	56	108
PM (lb/mmBTU)	0.06	0.11	0.07	0.07
CO (mg.m-3)	168	138	1182	-
CO @ 7% O2(ppm)	224	168	1015.29	-
NOx (mg.m-3)	26	119	72	-

1 - CTM-039 measurements are averages of at least eight hours of measurements
 2 - EPA Method 5 are averages of about two hour aggregated filter measurements

Comparison of PM measurements by EPA Method 5 and Dilution Method CTM-039

Sampling Date/Time	FPM (mg.m ⁻³)	PM _{2.5} (mg.m ⁻³)		FPM (lb.MMBTU ⁻¹)	PM _{2.5} (lb.MMBTU ⁻¹)	
	Method 5	CTM-039		Method 5	CTM-039	
4/20/10 09:23 – 11:20	123.0	109.01(1)	91.50(2)	0.07	0.07(1)	0.06(2)
4/20/10 13:23 – 14:29	121.6*	57.29(1)	45.30(2)	0.11	0.06(1)	0.05(2)
4/21/10 8:52 – 11:12	93.8	38.34(1)	58.04(2)	0.10	0.06(1)	0.08(2)

FPM – Filterable particulate matter, PM_{2.5} – particulate matter with particles less than 2.5µm aerodynamic diameter.

*-Data collected using an in-stack PM_{2.5} cyclone.

(1) – data collected using Teflon filter, averaging time was typically about one hour

(2) – data collected using TEOM FDMS system

CONCLUSIONS

- EPA Method 5 clearly fails to capture the dynamics of a process system operation.
- Dilution method (CTM-039) has the additional flexibility to measure all criteria pollutants, while the EPA method 5 can measure only particulate matter.
- EPA Method 5 is less bulky and easier to handle in the field, unlike the CTM-039 measurement system.

Questions?

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References

[1] Chandrasekaran, S.R., Laing, J.L., Holsen, T.M., Raja, S., Hopke, P.K., “Emission Characterization and Efficiency Measurements of High Efficiency Wood Boilers”, Energy and Fuels, in press (2011).

[2] NYSERDA, 2010, “Evaluation of the energy and emissions performance of commercial scale advanced wood combustion systems”, Final Report 10-15, August 2010.

URL: http://www.nyserda.org/publications/10_15_eval_energy_emissions_performance.pdf

[3] Raja, S., Laing, J., Hopke, P.K., Holsen, T. 2009. Organic Composition of Stack Emissions from a High Efficiency Wood Boiler. AAAR 28th Annual Conference, Orlando, FL.