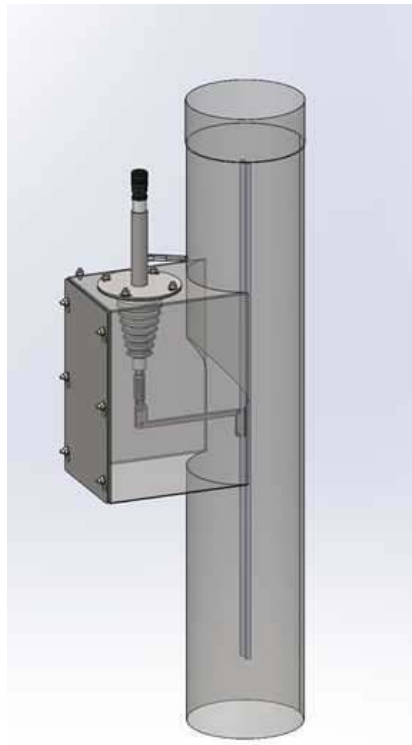


OekoTube Inside Testing Protocol

Wood stove type	Englander NC-13 (60,000 BTU)
Filter	OekoTube Inside 6"
Location	Washington National Mall, 2018 Wood Stove Design Challenge Washington, D.C.
Date	Friday, November 9, 2018
Tester	Norbert Senf Chair of Technical Committee Masonry Heater Association of North America



OekoTube Inside (OTi)

1 Summary

The OekoTube inside is an electrostatic precipitator (ESP) which is designed to remove fine particulates from wood burners. The device used in this experiment with a 6" flue and an 800mm (31.5") electrode was tested with a Condar portable dilution tunnel to determine the effectiveness of its particulate reduction capacity for wood smoke.

Gravimetric tests were performed in one test, sampling 4 times at 6 minutes each with the ESP on and 4 times at 6 minutes with the ESP off. The test indicated a removal of 0.3233g or 55.6% of total particulates (PM) from a sample of 275 liters of raw flue gas, diluted 10:1 with ambient air. The removal efficiency of total PM-2.5 was not recorded separately. The visual appearance of the filters (Pic. 4) indicates, from previous experience with the Condar sampler, that a large fraction of the PM from this test run consisted of organic carbon (OC), with only a small fraction of elemental carbon (EC).

2 Experimental Set-up

- Wood stove rating: 17 kW (60,000 BTU)
- Actual energy output during testing: N/A
- Year of manufacture: N/A
- Fuel type: cord wood
- Specification of filter:
 - Whatman grade 691, glass fiber, 1.5 um.
 - OTi- 180
 - D: 180 mm
 - L_{electrode} 800 mm
- wood stove ignition: manual

2.1 Measuring Points

- flue diameter to OekoTube filter: 7" (180 mm)
- measuring point for unfiltered flue gas: 8 ft. (240 cm) above floor
- measuring point for filtered flue gas: 8 ft. (240 cm) above floor

3 Measuring Devices

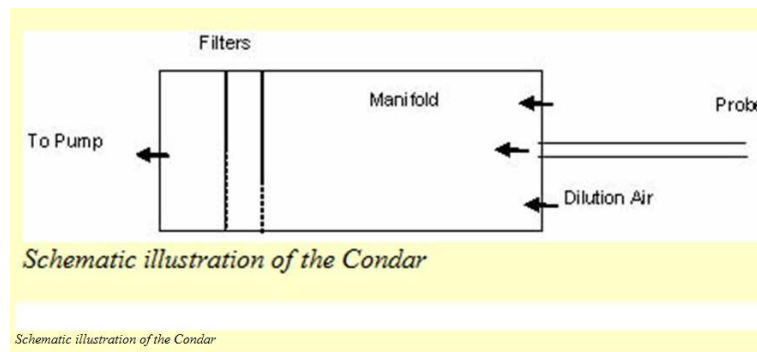
3.1 Gravimetric PM Measurement

The gravimetric measurements were performed by using two Condar portable dilution tunnels. The measuring device draws flue gas to be tested at the rate of

0.2 raw liters per second and dilutes them with ambient air at a 10:1 ratio before depositing them on dual glass fiber filters (primary filter plus backup). A second probe at the same height sampled the flue gases with a Testo 330-2 gas analyzer which gives flue gas temperature, O₂ and CO concentration. This normally allows calculation of a PM emissions factor in grams of PM per kg of dry fuel burned. There was a malfunction with the Testo system, and insufficient flue gas data was obtained. Therefore, the results are reported as the filter catch of particulates. The PM weights can be compared directly, due to the methodology of alternating samplers at short intervals.



Pic. 1: Condor dilution tunnel



Pic. 2 Schematic illustration of the Condor

4 Measuring Procedure

The testing was performed at the same height above the woodstove at opposing sides of the flue. To ensure equal testing conditions, the Condar filters were alternatively switched on with or without the OekoTube filter.

4.1 Gravimetric Measurement

- Condar
- Simultaneous particulate (PM), oxygen (O₂), carbon monoxide (CO) and stack temperature measurements
- No cleaning of the OekoTube Inside during the testing procedure
- Measuring intervals: alternating 4 times ESP on for 6 min and 4 times ESP off for 6 min, respectively.



Pic.3 Testing of the Englander NC-13 using 2 Codars

5 Results

The two filters were weighed before and after the tests. The difference in weight for each filter was recorded which reflected the total weight of the particulate emissions captured.

	OekoTube ESP	net weight:
Filter 1	OFF	0.5814g
Filter 2	ON	0.2581 g
Difference in weight		0.3233g
% PM removal		55.6%



Pic. 4 Gravimetric measurements: left without OekoTube inside (0.5814 g), right with OekoTube inside. (0.2581 g)