



## Basic Emissions Testing for Residential Appliances

**Purpose:** The purpose of this publication is to describe basic emissions testing equipment and procedures for on-site evaluation of grass pellet combustion.

### Emissions Regulations

Biomass heating can be energy efficient and effective for greenhouse gas reduction, but there are concerns over the emissions from these appliances. Current residential-scale emissions regulations, if they exist at all, focus on combustion efficiency estimates using CO emissions, and on coarse particulate emissions.

A fully equipped emissions analysis laboratory can evaluate particle size distribution, including PM2.5 particles. Volatile organic compounds, speciated organics, trace metals, and a variety of other compounds can be quantified. Total amounts over time can be quantified by determining stack gas velocity, volumetric flow rate and other parameters. Portable equipment, however, can provide compliance level accuracy for on-site testing.



Fig. 1. Testo 350 Portable Emission Analyzer.

### Portable equipment

A variety of analyzers are available that may be similar in accuracy; the Testo 350 unit is described here. This instrument has plug-and-play sensors for measuring O<sub>2</sub>, CO, NO, NO<sub>2</sub>, SO<sub>2</sub>, CO<sub>2</sub>, and H<sub>2</sub>, and also measures stack temperature. Up to 6 gases can be measured simultaneously. Readings can be recorded every second and can be transferred to a

spreadsheet. The length of a sampling session depends on gas concentrations, overloading of detection cells must be avoided.

### Sampling Protocol

For a circular duct, a sampling port should be 8 stack inner diameters downstream, and 2 stack diameters upstream from any flow disturbance (bends). For double walled ducts, a small pipe can be inserted as a sampling port, secured with heat-resistant glue and a brace (Fig. 2). During winter, a heated sampling line will maintain exhaust in a gaseous state prior to entering the instrument (Fig. 3). The sampling probe tip filter should be inserted to the center of the duct.



Fig. 2. Construction of a sampling port for a double-walled stack pipe.



Fig. 3. Heated sampling line for outdoor emissions sampling.

## Test for Coarse Particulates

A smoke spot test utilizes a hand pump and a white filter, with 10 complete intake strokes generating one spot test (Fig. 4). A smoke number is estimated by comparing the smoke spot to the smoke number scale. Pellet stoves can vary greatly in smoke number with consecutive spot tests (Fig. 5).

The smoke spot test appears to work well for wood pellet combustion, but it is not clear if the test is generating comparable results when evaluating grass pellet combustion. Depending on the specific type of grass pellet, smoke spots vary in their color, as well as intensity.



Fig. 4. Testo Smoke Pump for smoke spot test.

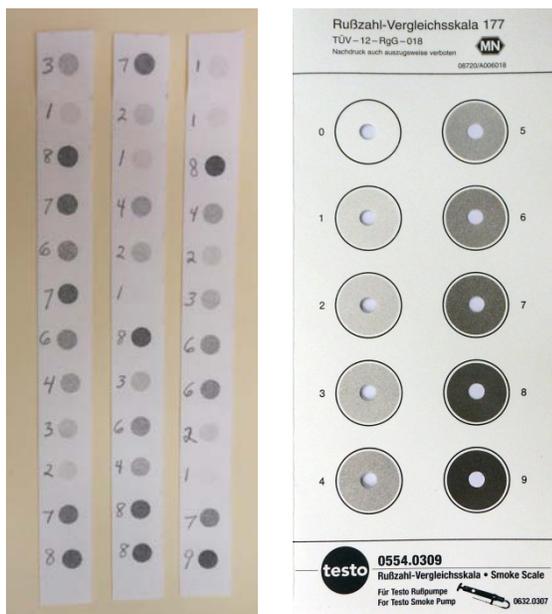


Fig. 5. Smoke spots scored using a smoke number scale.

## Efficiency Estimates

Thermal efficiency for boilers can be calculated on-site, depending on the feasibility of emptying the pellet hopper. Some units are problematic. Once boiler temperature is stabilized, in and out water temperatures can be recorded. Weighing pellets in and out of the

hopper over a specific time period can generate a pellet feed rate. Knowing BTU content of the pellets, water temperature, and water flow rate, it is possible to estimate the percent of fuel BTU delivered to a water/water heat exchanger (thermal efficiency).

## Maintenance

The Testo analyzer requires regular maintenance and recalibration, seasonally or every 6 months, depending on usage. Instrument filters need regular replacement, and the sample probe tip filter requires cleaning after each use when testing grass pellets. The smoke pump requires regular disassembly and cleaning/greasing.

## Summary

Regulations focus on CO and particulates, however, these regulations will most likely be expanded in the future, to better characterize particulates and gaseous compounds. A properly calibrated portable emission testing system can produce accurate results; the Testo 350 is acceptable for compliance testing under many state and local protocols.

Exhaust must be maintained in a gaseous phase to the analyzer, a heated sampling line is required for outside testing in winter. Smoke spot tests may or may not be meaningful measurements for grass combustion. When evaluating grass pellets, it is best to compare grass emission results directly with wood combustion emissions in the same appliance.

## Additional Resources

Testo 350 Portable Emission Analyzer  
<http://www.testo350.com/350.html>

## Acknowledgments

Equipment purchase was supported by the Cornell Univ. Agricultural Experiment Station.

For more information



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