Tip of the Week

September 12, 2005

Validating O_2 and CO_2 Readings

You're at a coal-fired boiler and you tell the client that your latest values for stack O_2 and CO_2 are 9% and 7.5%, respectively. He storms off muttering something about idiots and no-good stack testers under his breath. Why?

We measure O_2 and CO_2 almost every day of the week. In fact, it is so routine, we sometimes forget how important these measurements are. More often than not, they are just as important as the pollutant concentrations that we measure. Their influence on such calculations as ppm@7%O_2 and lb/MMBtu can mean the difference between a source passing and failing a compliance test.

Did you know that there are a couple of quick checks to verify that your O_2 and CO_2 numbers make sense? These checks should ALWAYS be done in the field, and IMMEDIATELY upon measurement of the O_2 and CO_2 values.

The easiest check is to just look at the sum of the O_2 and CO_2 values. Depending on the fuel being burned, this sum should fall within a fairly tight range, as shown below:

Fuel Type	Range	Average
Anthracite Coal	19.3 - 19.8	19.6
Semianthracite Coal	19.1 - 19.2	19.2
Bituminous Coal	17.7 - 19.3	18.5
Subbituminous Coal	19.1 - 19.2	19.2
Lignite Coal	19.2 - 19.5	19.4
Natural Gas	11.6 - 12.7	12.2
Municipal Waste	18.0 - 20.0	19.0
Fuel Oil	14.3 - 16.4	15.3
Coke Oven Gas	9.2 - 10.6	9.9
Blast Furnace Gas	24.6 - 25.3	25.0
Wood	20.1 - 20.5	20.3

Another way to check is to calculate something called a fuel factor, or Fo, against tabulated values for the fuel being combusted. The calculation for the Fo value is defined in EPA Method 3B as:

$$F_o = \frac{20.9 - \%O_2}{\%CO_2}$$

Once again, the values for the fuel factor are predictable within a narrow range for each type of fuel.

If either check is outside the range of expected values, then you should immediately investigate possible problems that could lead to erroneous O_2 and/or CO_2 values. For example, check the calibration of the analyzers (or freshness of the solutions if using an Orsat), or investigate the sampling system for possible leaks or pressure issues. Validating the O_2 and CO_2 results is one of the best diagnostic tools we have for assessing our work in real time. Bad O_2/CO_2 readings are always indicative of either a sampling system problem or an analytical (or instrumentation) problem.

There are a few cases where these checks will not work; most notably non-combustion processes, some combustion processes that also involve non-combustion related chemical reactions, boilers that use oxygen enrichment to aid combustion, or processes such as cement kilns that generate CO_2 from non-combustion activities.

Fo Ranges for Common Fuels

Fuel Type	Fo Range
Anthracite and Lignite Coal	1.016 - 1.130
Bituminous Coal	1.083 - 1.230
Distillate Oil	1.260 - 1.413
Residual Oil	1.210 - 1.370
Natural Gas	1.600 - 1.836
Propane	1.434 - 1.586
Butane	1.405 - 1.553
Wood	1.000 - 1.120
Wood bark	1.003 - 1.130
Paper and Wood Waste	0.998 – 1.094
Municipal Solid Waste	1.048 – 1.172