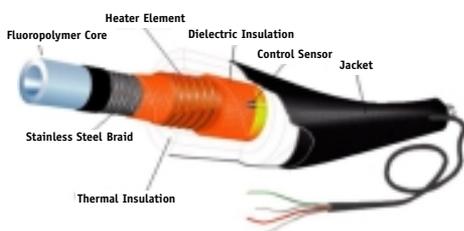


Sources of Background CO In Heated Sample Lines

Continuous emissions monitoring (CEM) systems traditionally use heated fluoropolymer sample lines because they are inexpensive and the fluoropolymer tubing is resistant to the acids that are present in most stack gas. The disadvantage with fluoropolymer sample lines is that fluoropolymer is a porous material. In fact fluoropolymers are often used to manufacture permeation membranes. One of the components measured in stack gas emission systems is CO. Since CEM samples are transported through the sample line under a slight vacuum the problem is that the heated sample line generates CO, which migrates into the sample tube giving a false reading for the stack emissions.

We designed a set of tests to determine the conditions under which background CO is generated, the source of the CO, and finally to test possible solutions. The testing of sample line contamination proved to offer a number of technical challenges.

A carbon monoxide analyzer was used for testing. A total of six separate test procedures were performed with a number of different sample line configurations. Each of the tests used a different approach in an attempt to isolate the mechanism of CO production and/or migration. Theories were formulated using the results of previous tests, new tests were designed and run to validate or disprove the theory. It must be understood that the tests were performed to identify carbon monoxide only and the results may not apply to other gasses.



Background CO, roughly 4 ppm on average, was found in ambient air at room temperature. When ambient air was heated the CO level was found to increase. Variable CO readings within the air created a challenge for test procedure and interpretation due to the fact that CO contamination from different sources had to be separated. Pure nitrogen was used in some tests to eliminate the background CO. Using nitrogen would isolate the CO source

to only those generated by the heated sample line. However, the nitrogen source was pressurized, which impeded CO permeation into the sample tube.

The heated sample lines tested had a stainless steel braided fluoropolymer tube with stainless steel fittings. Fiberglass, silicone, and kapton were used for dielectric insulation. A nichrome element served as the series resistive heater circuit with fiberglass and polyester thermal insulation. An extruded polyurethane jacket covered the entire assembly. A thermocouple was installed on the core tube and a PID controller controlled the temperature of the test bundles.

CO level was recorded at room temperature and then the test bundles were heated. As the temperature of the bundle was increased the CO level increased. The major contributors of CO were the high temperature fiberglass insulation and fiberglass tape, with the kapton tape producing lower levels. We found no detectable levels emitted from the fluoropolymer tubing, metal sheath, or silicone. As the temperature is increased CO is formed from the materials mentioned above. The CO then travels through the silicone, the metal mesh, and the fluoropolymer tube into the process gas.

The amount of CO rose at a dramatic rate when the temperature reached 385°F. Taken and held at 400F the CO level continued to rise, peak, then begin a gradual decrease. This confirmed field observations that a "burn in" period reduces the background CO levels over time. "Burn in" refers to the procedure of heating the sample line for an extended period of time prior to service in an effort to deplete the contamination source. The testing did not show a significant reduction in contamination for a "burn in" time of 53 hours. Field reports indicate that a successful "burn in" period is from 5 to 7 days.

The results show that CO was generated from the construction materials of the heated sample line and migrate into the sample tube causing inflated readings. We found the CO levels were constant over a 48 - 72 hour period if the flow rate and temperature were held constant. We also found that CO levels were reproducible in

any given hose when conditions are returned to previous levels. Considering that the contamination reading is repeatable and consistent calibration of the analyzer to zero out the background CO provides an accurate method to measure the sample content. For example, if the hose provides a reading of 12 ppm when sampling atmospheric gas and 18 ppm when reading sample gas the sample gas CO content would be determined to be (18ppm-12ppm) 6 ppm. The calibration offset would have to be periodically checked due to the possibility of a reduction in sample line contamination over time.

Several methods were investigated in an attempt to reduce or eliminate the influence of background CO in the sample tube. Reducing the operating temperature below 300F has a dramatic affect as to the amount of CO introduced. Testing repeatedly showed a marked increase in CO levels as the temperature of the bundle was heated above 300F. There was a marked increase in CO above 385F. Increasing the wall thickness of the fluoropolymer tube reduces the amount of CO permeation. Doubling the wall thickness reduces the permeation by one half. Wrapping the core with a foil mylar was found to be ineffective. The applied barrier is not gas tight and only slowed the rate of change, not the rate of permeation. It took longer to reach the maximum CO content but the foil mylar did not reduce the maximum level. This would have the effect of increasing the needed 'burn in' time.

CO RELATED TO TEMPERATURE

