Real-time Formaldehyde Monitoring from Natural Gas-Fired Turbines

Background

Natural gas-fired turbine engines are a source of formaldehyde, which has been recognized as a known human carcinogen by the International Agency for Research on Cancer as well as the U.S. Department of Health and Human Services. As such, these sources need to be periodically monitored by emission testing firms. The EPA Stationary Combustion Turbine Regulation [40 CFR Part 63 Subpart YYYY] requires this type of turbine to limit formaldehyde emissions to 91 ppbvd or less at 15% O_2. Gas turbine manufacturers go to great lengths in their combustion "hot section" design to minimize these formaldehyde emissions, and the formaldehyde concentration levels continuously emitted from these sources are generally low, on the order of 0.1 ppmv. However, the volume of exhaust gas from gas turbines is quite large, which can cause the total mass of the pollutant to be significant.

Problem

Source testing professionals require an analytical technology that can measure < 91 ppbv formaldehyde precisely from a natural gas-fired turbine in real-time. FTIR gas analyzers following EPA Method 320 in some configurations can reach this low level, but often don't have the precision to accurately predict the formaldehyde emission. EPA Method 0011 is also utilized, which requires the use of collection impingers, a derivatizing reagent [2,4-dinitrophenylhydrazine (DNPH)], followed by high pressure liquid chromatography with UV/Vis detection which lacks precision and is also not a real-time measurement. A real-time analysis methodology with single digit ppb detection limits is required for this application.

Solution

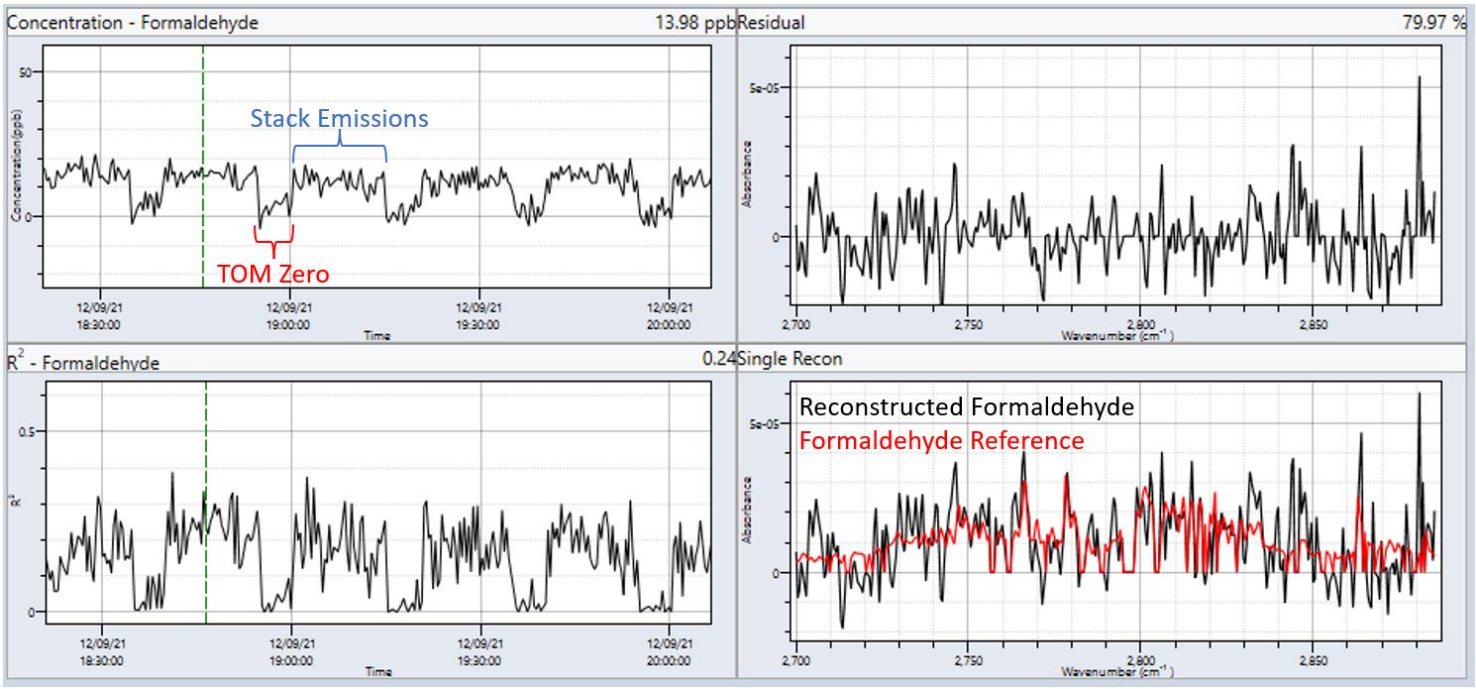
Max Analytical has released its new MAX-iR FTIR gas analyzer with an optical enhancement technology called StarBoost™, which significantly increases the sensitivity, detector linearity and dynamic range of the analyzer. **This breakthrough technology allows for single digit ppbv detection of hazardous air pollutants (HAPs) such as formaldehyde in real-time.** At typical gas sampling flows of ~5LPM, rapid turn-over of the sample occurs and real-time results can be observed.

A MAX-iR with StarBoost™ utilizes a longpass pass optical filter that allows the measurement of compounds from 1,900 – 3,300 cm^{-1}. This technology can simultaneously measure hydrocarbons and other oxygenates including CO, CO_2, CH_4, and H_2O.

In addition to the MAX-iR with StarBoost™, Max Analytical has developed a novel technique for zeroing the analyzer using stack emissions. The Thermal Oxidizer Module (TOM) selectively removes the target analyte from the sample matrix without reducing the concentrations of atmospheric interferences, such as H_2O, CH_4, and CO_2. This allows for the collection of an "Interference Spectrum", which can be added to the regression in real time to improve the IR residual and formaldehyde data quality. Even if the Interference Spectrum is not used in the regression, it is a powerful tool for data validation.

Results

To demonstrate the ability of the MAX-iR with StarBoost™ technology to measure formaldehyde emissions, data were collected from a natural gas-fired turbine. Data were periodically zeroed using the TOM. Results from the field test are shown below.



The plot in the upper left panel shows the concentration of formaldehyde (ppb) over the run. For the selected sample spectrum, indicated by the green hashed line, the formaldehyde concentration was 13.98 ppb. This application utilized a Thermal Oxidizer Module (TOM) to periodically remove the formaldehyde from the sample and collect Interference Spectra, as shown in the concentration plot. When these spectra are added to the regression matrix, the formaldehyde concentration can be easily validated down to 10 ppb. This technique minimizes bias in the formaldehyde measurement due to spectral interferences, which is critical for measuring compounds on a 10-ppb scale.

The standard deviation on the formaldehyde measurement was 1.37 ppb, meaning the minimum detection limit for this test was 4.11 ppb. At a concentration of 13.98ppb, the formaldehyde is visible in the regression reconstruction.

Conclusion

These data show that the MAX-iR with StarBoost™ can measure low ppb levels of formaldehyde from a gas-fired turbine. The ease of sampling and data flow allow for increased efficiency for this measurement compared with EPA Method 0011. Whereas it previously could take hours for a result, it now can be performed in minutes, saving the source tester time, aggravation and money. In addition, the heightened precision assures the tester and the client that the result will truly reflect the actual formaldehyde levels sampled during the test.