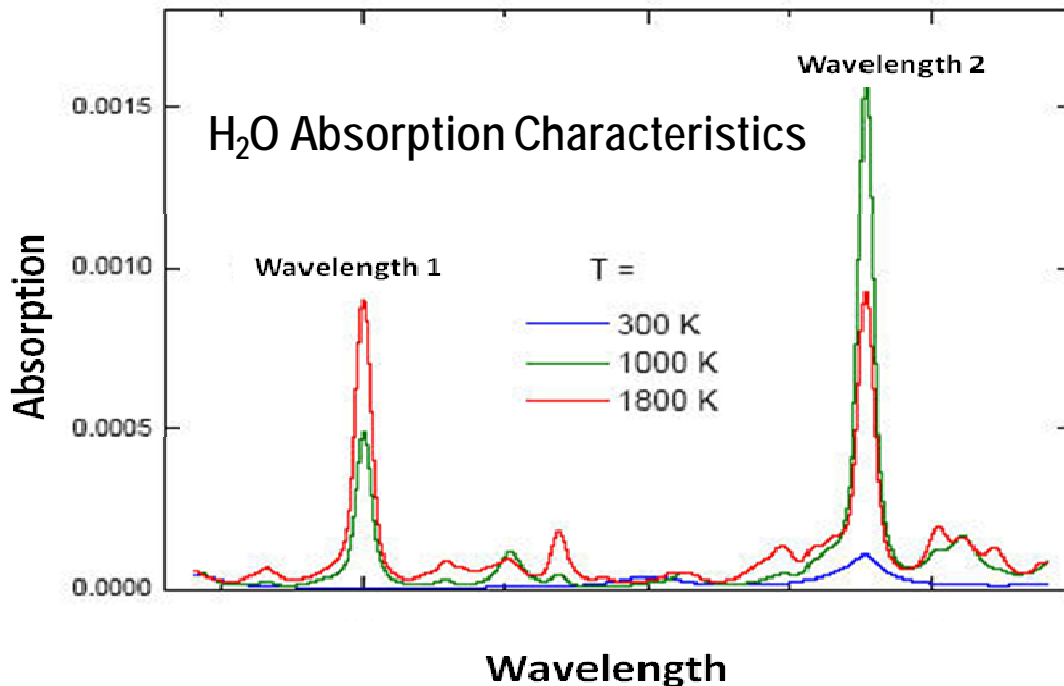


## Determination of Temperature from H<sub>2</sub>O measurements using Tunable Diode Laser Absorption Spectroscopy (TDLAS)

The ZoloBOSS system uses Tunable Diode Laser Spectroscopy (TDLAS) to determine the concentration of certain molecules, such as H<sub>2</sub>O, CO and O<sub>2</sub>, in the combustion gases of a coal-fired boiler. The concentration of the constituent can be calculated from the amount of laser light absorbed in a very narrow and carefully chosen wavelength range if the gas temperature is known.

Generally, the temperature is not known, and in fact, needs to be measured to provide useful information for boiler operators (such as furnace exit gas temperature) and to accurately quantify absorption measurements and therefore constituent concentrations. However, if the light absorption is measured at two different, carefully chosen wavelengths for a single constituent (for example H<sub>2</sub>O), the temperature can be determined. For example, the absorption spectrum for H<sub>2</sub>O is shown below in a particular wavelength region and at three different temperatures (300, 1000 and 1800 °K). This portion of the absorption spectrum contains two absorption features for H<sub>2</sub>O which are highly temperature sensitive. Note how the absorption characteristics vary with temperature and at the different wavelengths.



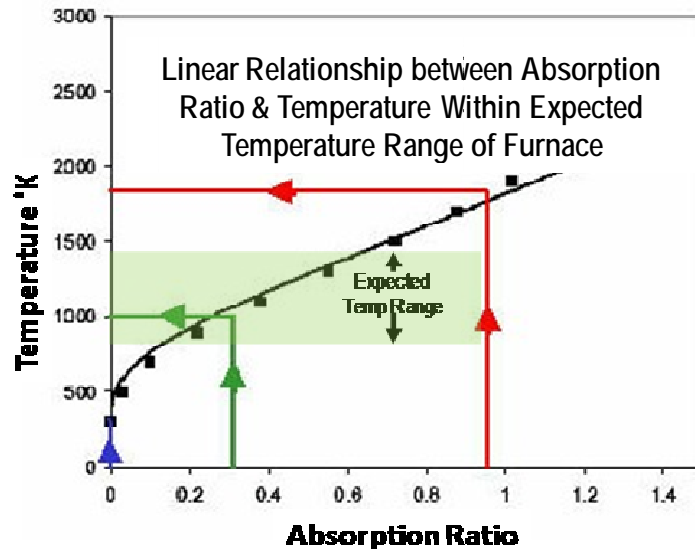
**Better measurements, better results**

## H<sub>2</sub>O Absorption and Absorption Ratio as a Function of Temperature

Degree °K	Temperature		Absorption at Wavelength 1	Absorption at Wavelength 2	Absorption Ratio
	Degree °F	Degree °C			
300	1063	573	0	.000111	0.000
1000	2323	1273	.000499	.001590	0.314
1800	3763	2073	.000894	.000930	0.960

The ratio of the measured integrated absorption at Wavelength 1 divided by the measured integrated absorption at Wavelength 2 is known as the Absorption Ratio. The table above shows the absorption at each combination of wavelength and temperature and the resulting Absorption Ratio for this sample data.

If the Absorption Ratio is then plotted against the gas temperature as shown in the graph below, a clearly defined, linear relationship exists over the expected temperature range of the combustion gases, in this case about 800-1375°K (1900-3000°F or 1075-1650°C).



The relationship between Absorption Ratio and temperature has been established for H<sub>2</sub>O through extensive research at Stanford University and validation in the Zolo test facility. Zolo utilizes these proven relationships to accurately determine the temperature from the Absorption Ratio computed from the actual H<sub>2</sub>O absorption measurements at different wavelengths as measured by the ZoloBOSS system.

**Better measurements, better results**