Analyzer Specifications Technical Bulletin

1. Introduction

At Tiger Optics, we provide comprehensive specifications to give a detailed understanding of our instruments' performance. Each analyzer goes through a rigorous qualification procedure to ensure compliance with these highly stringent requirements. In this way, we guarantee product uniformity in keeping with our most exacting customers' expectations.

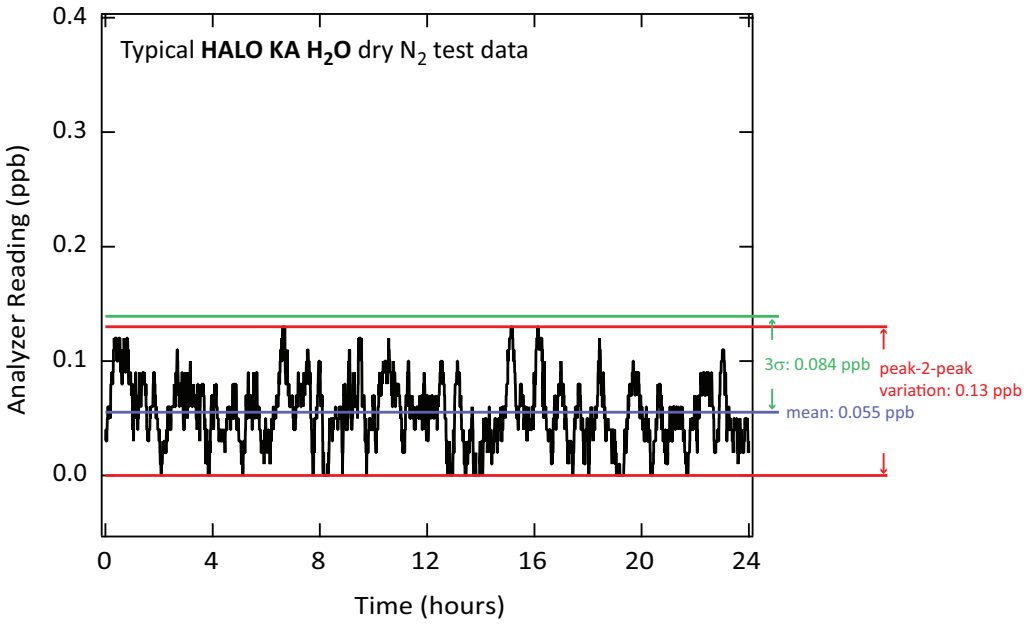
2. Specifications

Lowest detection limit (LDL)	Peak-2-peak variation over 24 hours of zero gas data*
Sensitivity	3σ (3 standard deviations) over 24 hours of zero gas data*
*Accuracy***	Relative deviation of mean reading from nominal intrusion level
*Precision***	±1σ (1 standard deviation) of intrusion data (not smaller than 1σ of zero gas data)
Range	The minimum and maximum measurable concentration of the analyte (lowest reading limited by LDL)

*includes any instrument drift over the 24-hour period

**for general definitions, see http://en.wikipedia.org/wiki/Accuracy_and_precision

3. Testing with zero gas

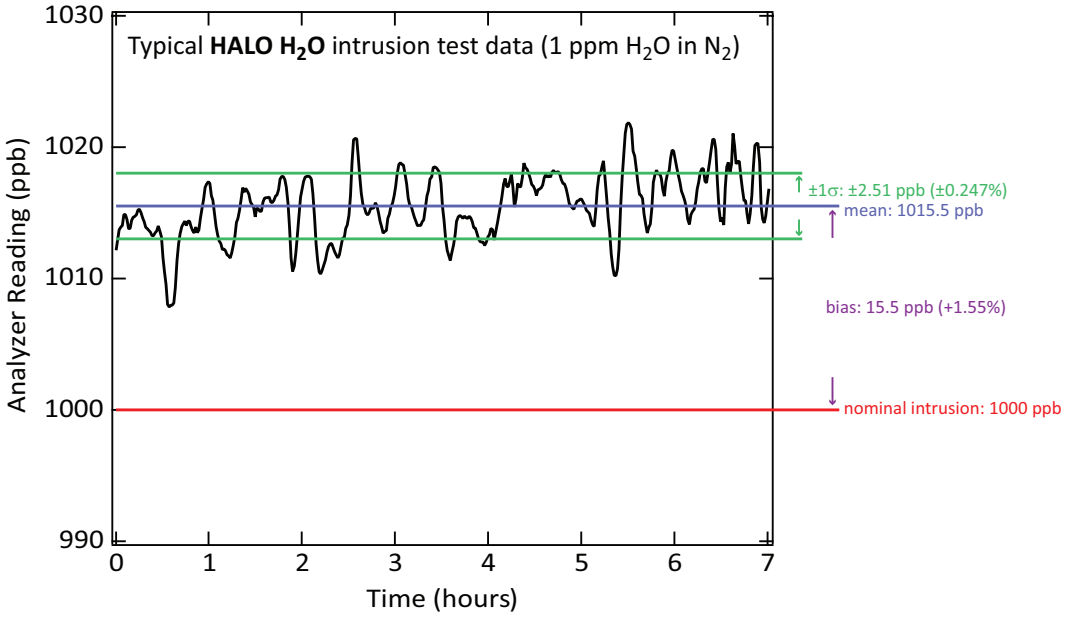


Qualification criteria:

Peak-2-peak variation***	Must be lower than *LDL*
Mean reading***	Must be lower than *LDL*
3σ variation***	Must be lower than *Sensitivity*

***24h testing is only performed to derive specifications; qualification tests may be less than 24h; qualification criteria may vary for non-standard matrices

4. Testing with analyte intrusion



Qualification criteria:

Bias of reading	Bias relative to mean reading must be within *Accuracy*
1σ variation	±1 standard deviation relative to mean reading must be within *Precision*

5. Examples

Lowest detection limit (LDL):

A process control engineer needs to monitor moisture levels of dry nitrogen used in a semiconductor factory and employs a LaserTrace 3 H_2O for this purpose. The instrument is expected to read "zero" most of the time, but it will trigger an alarm if an increase in moisture is detected. Due to ubiquitous optical and electronic noise, the analyzer reading will not stay at zero, but fluctuate around small numbers.

Also, moisture tends to stick to surfaces and gas line, which typically causes the analyzer to display a small H_2O reading even if the N_2 is (theoretically) completely dry. The LDL of the LT3 H_2O for N_2 is specified as 250 ppt, defined as the peak-to-peak variation of the reading over a 24-hour period on dry gas (including drift). This means that within one day, the difference between the maximum and minimum reading is less than or equal to 250 ppt.

If the gas is completely dry, the analyzer will read below 250 ppt over the same period. Consequently, any detected moisture level above 250 ppt indicates an increased H_2O concentration. Please note, however, that during long-term operation, there is a chance for outliers above the LDL to occur; this should be taken into account when setting alarm levels.

Sensitivity:

An environmental control engineer in a chemical plant has to monitor a vent line of a process for occasional spikes of toxic hydrogen chloride. A Tiger-i 2000 HCl is installed on the vent line for this purpose. In this case, the Sensitivity of the instrument is important to distinguish between an actual spike in HCl concentration and random spikes in the nominally zero reading caused by instrument. The Tiger-i 2000 HCl has a specified Sensitivity of 3 ppb, which is given by 3σ, i.e. three standard deviations of the average point-to-point fluctuation of the instruments reading when no analyte is present. 3σ is a typical level of significance used in practice because it means that for a random (Gaussian) distribution of measurements, 99.8% of data points will be within ±3σ. In this example, when a concentration spike in excess of 3 ppb is detected, there is a 99.8% chance that it is "real" and not a fluctuation caused by instrument noise. Please note that users may consider different levels of statistical significance, e.g. 2σ or 5σ; however, the relevant concentrations can be easily calculated from the specified 3σ-Sensitivity.

Accuracy:

A metrology laboratory uses a HALO KA H_2O to measure a moisture standard, which has exactly 1000 ppb of H_2O in N_2. The instrument has a specified Accuracy of ±4% of the reading or 1/2 of the LDL, whichever is greater. Since 4% of 1000 ppb is larger than 200 ppt (1/2 LDL in N_2), here the expected accuracy is 40 ppb. During the measurement, the mean reading of the analyzer may not be exactly 1000 ppb. Due to systematic errors, the instrument will experience a measurement bias (i.e. a deviation from the true value). The Accuracy spec means that this bias is not more than 4% of the reading, i.e. for 1000 ppb of moisture the mean reading will be within 960 ppb and 1040 ppb.

Precision:

A research institute uses a Tiger-i 2000 CH_4 to monitor the fluctuation of ambient concentrations of the greenhouse gas methane. The concentration reading will not only fluctuate in response to changing CH_4 levels, but also from instrument noise. Therefore, it is important to know the average variation of the instrument reading from point to point. The Tiger-i specifies a Precision of ±0.75% of the reading or 1/3 of the Sensitivity, whichever is greater. The Precision is defined as 1σ, i.e. one standard deviation of a set of data. At typical ambient methane levels of ≈1000 ppb, 0.75% of the reading is greater than 1/3 of the Sensitivity. Therefore the expected precision is 7.5 ppb. This means that the instrument's point-to-point variation during the measurement will have a standard deviation of less than or equal to 7.5 ppb. From this number, the researchers can calculate what change in reading will constitute an actually significant change in CH_4 reading. For instance, for many meteorological applications, 2σ is considered a statistical significant change, which would correspond to a concentration change of 15 ppb.