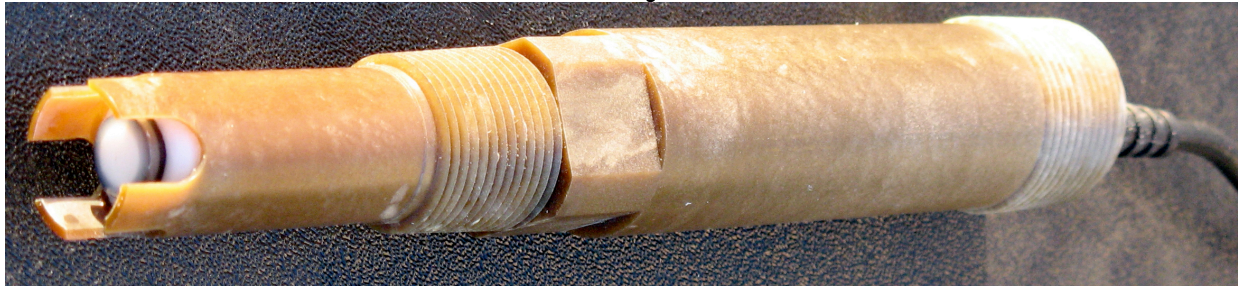


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## Case Study No. 19



### **Ammonia Sensor and Nitrate Sensor with Significantly Improved Selectivity Over Respective Interfering Ions Potassium & Chloride**

- ✦ Capability to measure below 1ppm ammonium (total ammonia or NH<sub>3</sub>-N) in presence of common levels of potassium for secondary WWTP
- ✦ Capability to measure nitrate (NO<sub>3</sub>-N) even in the presence of high levels of chloride or nitrite ions without loss of linearity or stability
- ✦ Ammonia and nitrate measurements can be performed using just one analyzer
- ✦ Support for dual ammonia/ammonia, nitrate/nitrate configurations and ammonium/nitrate configurations to minimize cost per channel as well as triple channel ISE, pH and ORP measurement configurations
- ✦ No potassium ion "compensation" required for ammonium ion selective sensors and no chloride ion "compensation" required for nitrate ion selective sensors for most common WWTP applications, due to substantial improvements using novel proprietary technology developed from ASTI research and extensive field trials to ensure performance in actual measurement conditions of interest
- ✦ Support for dual ammonium/pH systems to determine total ammonia at any given pH for any given temperature within the permissible range

#### The Problem

The measurement of ammonium ions (commonly referred to as "total free ammonia") at low levels, such as below 1 ppm, can be difficult with many competing sensor technologies. Competitors using older traditional ISE membrane technology grapple with a well-known problem due to the effects of the interfering ion potassium at the concentration in which they are commonly present. The "solution" that is promoted by many competitors is to employ a second ion selective sensor to measure the interfering potassium ion activity and then to "compensate" for the effects of the potassium ion error upon the ammonium sensor. This approach is fundamentally faulty, and does not work, for at least three reasons:

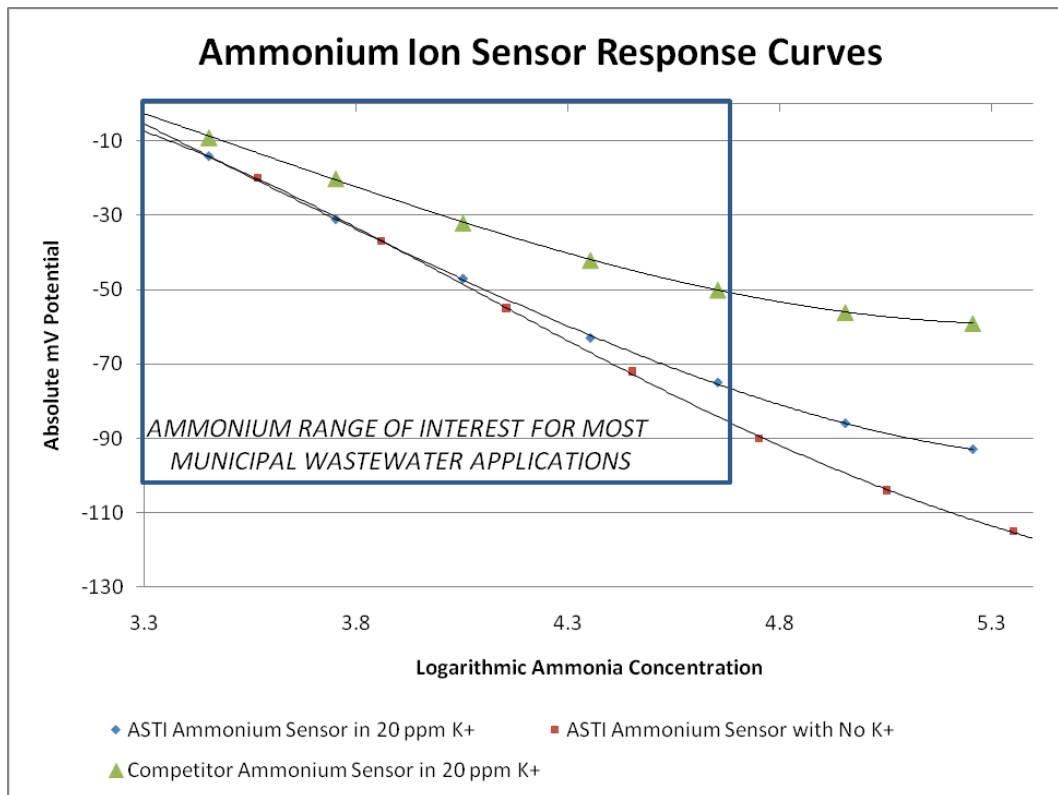
- 1) There is no well-accepted scientific basis for using a second ion selective sensor to "compensate" for the effects of an interfering ion upon the primary measured analyte of another ion selective sensor in continuous field measurements. Whereas single (static) laboratory samples might lend themselves to extensive corrections and data manipulation with cumbersome customized calibration schemes, online measurements have constantly changing samples with variance in both analyte and potential interfering ion levels, sample background, and temperature. Interference is a degenerative process when the sensor is continuously exposed to levels of interfering ions beyond the performance limitations of that given sensor, meaning that the interference effects cannot be described as a simple mathematical correction for online systems. Interference exposure beyond the sensor capabilities causes the sensor to eventually become altogether unresponsive to sensing the primary measured ion. Even under ideal laboratory settings "compensating" for the effects of interfering ion is extraordinarily tedious and difficult procedure even for single sample tests.

- 2) In addition to lacking scientific basis, the competitors' approach of adding a second ion selective sensor to "compensate" for the error caused by such an interfering ion to "correct" the measured ion of interest (in this case either ammonium or nitrate) increases up-front procurement costs (extra sensor/channel in the analyzer) and total cost of ownership (extra sensor to maintain and replace).
- 3) The uncertainties and errors of ion selective sensors when used to find a third computed characteristic (in this case allegedly "compensated" ammonium or "compensated" nitrate ion activity supposedly free from the interfering ion errors) are compounding rather than offsetting. The uncertainty introduced by the "compensating" ion selective sensor (typically potassium for ammonium and chloride for nitrate) is often greater than the interfering ion error itself.

These three problems are naturally never discussed by any competitors in a rigorous nor scientific manner when attempting to sell their systems to perform ammonium (total free ammonia) or nitrate measurements in municipal water or wastewater applications, as it would highlight their flawed approach.

The Solution

Measurements should be attempted only with a sound scientific basis as to its feasibility and reliability, and with due consideration to the potential sources of uncertainty and error. For most municipal wastewater treatment applications, an ammonium ion selective sensor must have a selectivity over potassium that is sufficient so that you can measure down below 1 ppm in the presence of 20 to 30 ppm potassium. The issues of potassium selectivity for ammonium ion selective sensors are illustrated in the graph below for ASTI ammonium ion selective sensors and those of a leading competitor. The ideal response (with no potassium ions present) is shown with red squares. The response in the presence of 20 ppm potassium is shown for the ASTI ammonium ion sensor with the blue diamonds, and that of a leading competitor is shown by green triangles.



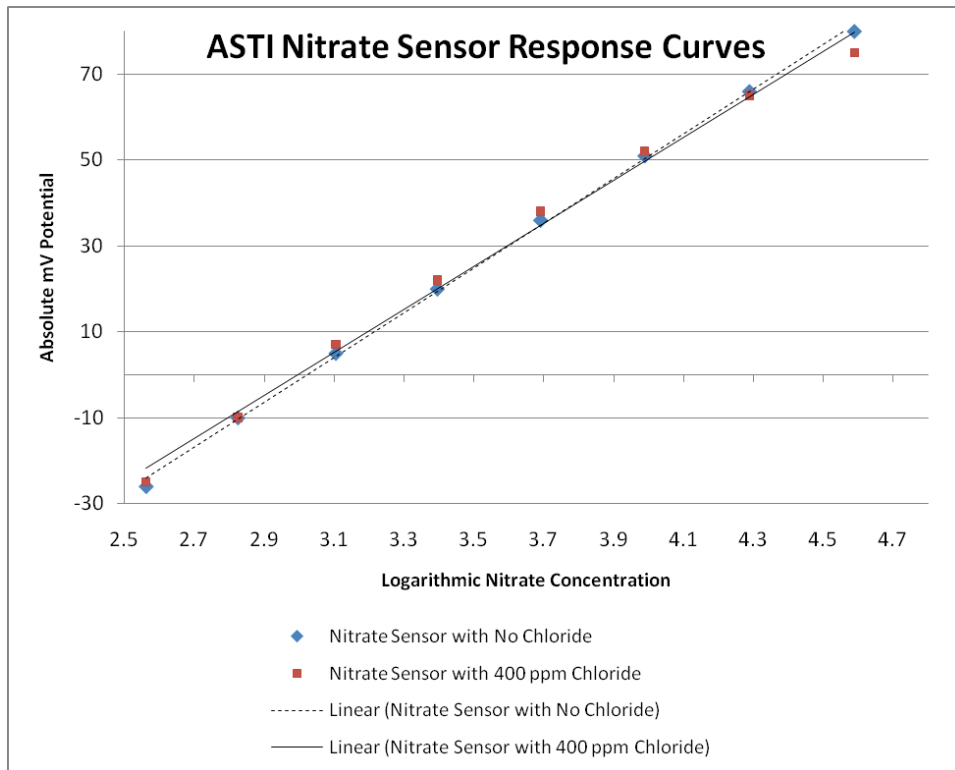
Conversion Table for  
Logarithmic Ammonia  
pNH4 to ppm Ammonia

3.3	9.041 ppm
3.8	2.859 ppm
4.3	0.904 ppm
4.8	0.286 ppm
5.3	0.090 ppm

The Solution (Continued)

As can be clearly seen from the graph on the previous page, the ASTI sensor performs nearly identical to the ideal response (as shown with the no potassium ions present plot with red squares) in the presence of the 20 ppm potassium even at low levels of ammonium. For the primary range of interest (as shown in blue square bracketed area) the deviation from ideal response for the ASTI sensor even in the presence of 20 ppm potassium is altogether negligible whereas the deviation from the competitor sensor in this same area is quite prominent, with poor linearity and large deviations from the ideal response. Even in the lowest concentration range, the only real effect for the ASTI sensor will be a slightly lower sensor slope which can be readily accounted for in the analyzer configuration or via a standard addition slope determination procedure. For the leading competitor's sensor, the deviation from the ideal response in the presence of the 20 ppm interfering potassium concentration are quite significant even at higher ammonium concentrations, and they become much more pronounced at lower ammonium concentrations. The final result for the competitor's sensor is that it will be a completely non-responsive unit if it is subjected to these conditions for a prolonged period of time, as will be the case for continuous measurement applications. Since the ASTI ammonium sensor slope does not "flatten out" (unlike how the competitor's sensor does) and remains responsive to changes in ammonium ion activity even in the presence of potassium ions at the typical level found at most municipal WWTP facilities (~20 ppm), it is quite possible to reliably measure total free ammonia in these conditions with the ASTI online ISE systems.

Nitrate ion measurement with our ion selective sensors is possible as low as 1 ppm even in the presence of the common level of 400 ppm chloride ion background (see graph below). Such a high selectivity over chloride is necessary in many secondary municipal wastewater applications to make nitrate measurement useful.



Conversion Table for Logarithmic  
pNO<sub>3</sub> Nitrate to ppm Nitrate

2.5	196.1 ppm
2.7	123.7 ppm
2.9	78.05 ppm
3.1	49.25 ppm
3.3	31.07 ppm
3.5	19.61 ppm
3.7	12.37 ppm
3.9	7.805 ppm
4.1	4.925 ppm
4.3	3.107 ppm
4.5	1.961 ppm
4.7	1.237 ppm

The graph above shows that the linear response plot of our nitrate sensors in the presence of chloride at such concentrations and in the complete absence of chloride at such concentrations is statistically identical both from an absolute response and slope (sensitivity) standpoint. This means that chloride ion interference can be



neglected for the measurement of nitrate under the most common conditions found for nitrification and denitrification monitoring processes. These sensors are available to support a variety of installation types including submersible, inline or low-flow setups, and can be configured in numerous mating analyzer configurations. Some typical examples for sensors and analyzers configurations are provided below, although many more configurations are possible and can be customized to best suit each facility's needs. External preamplifiers with waterproof enclosures are available for all ion selective sensors, allowing them to be installed up to 300 feet away from the analyzer. These external preamplifiers can be useful to take advantage of the very low per channel costs that can be attained with the dual 1056 and triple 1057 analyzer configurations.

### Typical Sensors Used for These Measurements

*Sensors for Tank Installations with 1" NPT Standpipe for Immersion or Submersion*

**Model:** AB 6410-1000-25-TL-WPB-ULTRALOW Ammonium ( $\text{NH}_4^+$  /  $\text{NH}_3\text{-N}$ ) ISE Sensor

**Description:** Ultralow Level Ammonium Ion Selective Sensor with 1000 Ohm Platinum TC Element; 25 feet cable; Waterproofing "B" to support fully submersible installs

**Model:** AB 6810-1000-25-TL-WPB Nitrate ( $\text{NO}_3^-$  /  $\text{NO}_3\text{-N}$ ) Ion Selective Sensor

**Description:** Nitrate Ion Selective Sensor with 1000 Ohm Platinum Temperature Compensation Element; 25 feet cable; Waterproofing "B" to support fully submersible installs

**Model:** PN 6052-1000-25-TL-WPB pH Sensor

**Description:** Industrial pH Sensor with 1000 Ohm Platinum Temperature Compensation Element; 25 feet cable; Waterproofing "B" to support fully submersible installs

**Model:** PNB 6852-1000-25-TL-WPB pH Sensor

**Description:** Industrial ORP Sensor with 1000 Ohm Platinum Temperature Compensation Element; 25 feet cable; Waterproofing "B" to support fully submersible installs

*Sensors for 1" NPT Inline Installations with Quick Disconnect Bayonet Style Fittings*

**Model:** ABX 8410-1000-10-TL-WPIT-LOW Ammonium ( $\text{NH}_4^+$  /  $\text{NH}_3\text{-N}$ ) Ion Selective Sensor

**Description:** Low Level Ammonium Ion Selective Sensor with ACCU-TEMP Fast Response PT1000 TC Element; 10 feet cable; Minimal Waterproofing "IT" Option for Weatherproofing

**Model:** ABX 8810-1000-10-TL-WPIT ( $\text{NO}_3^-$  /  $\text{NO}_3\text{-N}$ ) Ion Selective Sensor

**Description:** Nitrate Ion Selective Sensor with ACCU-TEMP Fast Response PT1000 TC Element ; 10 feet cable; Minimal Waterproofing "IT" Option for Weatherproofing

**Model:** PNX 8052-1000-10-TL-WPIT pH Sensor

**Description:** Industrial pH Sensor with ACCU-TEMP Fast Response PT1000 TC Element; 10 feet cable; Minimal Waterproofing "IT" Option for Weatherproofing

### Typical Analyzer Configurations Used for these Measurements

Model: 1056-XX-22ISE-38-YY (Single Channel Ammonium OR Fluoride OR Nitrate)

Description: Single Channel Ammonium OR Fluoride OR Nitrate Analyzer, Transmitter and Controller

Model: 1056-XX-22ISE-32-YY (Ammonium / pH)

Description: Dual Channel Ammonium & pH Analyzer, Transmitter and Controller

Model: 1056-XX-22ISED-32ISED-YY (Ammonium / Nitrate)

Description: Dual Channel Ammonium and Nitrate Analyzer, Transmitter and Controller

Model: 1057-XX-22ISED-32ISED-42 (Ammonium / Nitrate / pH or ORP)

Description: Triple Channel Ammonium, Nitrate and third channel as pH or ORP Analyzer, Transmitter and Controller

*XX is the power supply option and YY is the output option. ISE configuration must be specified at time of order.*

*Complete ISE systems only available directly from ASTI as complete systems. Ion selective sensors NOT available for sale without ISE analyzer as provided complete by ASTI. Applications must be validated by ASTI factory prior to sale.*

*References are available upon request.*

Last Revised April 25, 2011