HF Monitoring for Aluminum Smelters

Products: Tiger-i 2000

Tiger Optics Overview
Tiger Optics introduced the world's first commercial "Continuous Wave Cavity Ring-Down Spectroscopy" (CW-CRDS) analyzer in 2001. Today, our instruments monitor thousands of critical points for industrial and scientific applications. They also serve the world's national metrology institutes, where they function as transfer standards for the qualification of calibration and zero gases, as well as research tools for such critical issues as global warming and urban air quality.

CW-CRDS is ideally suited to the requirements of numerous environmental measurement applications, including the monitoring of hydrogen fluoride (HF) inside and at the boundary fence of aluminum smelter facilities. Here, factors such as accuracy, sensitivity, low detection limits, speed of response, long-term stability, and low maintenance are all essential attributes. This application note details the use of our Tiger-i 2000 HF unit for aluminum smelter facility monitoring.

Tiger-i 2000 HF

Hydrogen Fluoride – Hazardous Pollutant
HF is extremely harmful to both personnel working within smelter facilities and to the wider environment surrounding such operations. HF is a very strong acid that can be inhaled directly causing respiratory problems and irritation at low concentrations or at higher concentrations more serious lung and heart damage that could prove fatal. In addition to the gas phase, HF will also dissolve in water vapor or adhere to particulate matter, where it can again make its way into the environment and affect human health. Dissolved in water and in the gas phase, prolonged dermal contact with HF will result in skin irritation and damage, with prolonged exposure harming internal organs potentially to the point of failure.

Moreover, prolonged exposure to HF in the atmosphere can have an adverse effect on the infrastructure and the natural surroundings of a smelter facility. Dissolved HF will cause damage to building materials, such as limestone, concrete, and metals. In significant quantities, it will also affect animals and agriculture, resulting in significant economic cost. It is therefore critical that health and safety measures be implemented to minimize the risk of accidental release of HF and to monitor atmospheric concentrations of the gas inside and at the boundary fence of smelter facilities.

Source of HF from Aluminum Smelting
Aluminum is produced almost exclusively using the Hall-Héroult process. This electrolytic process uses prodigious amounts of electricity to extract aluminum from purified bauxite (aluminum oxide) as depicted in Figure 1 below.

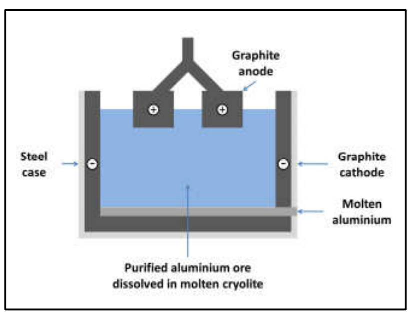

Figure 1. Schematic of aluminum smelter pot

Smelter facilities may consist of several hundred pots, each of which is capable of producing over one metric tonne of aluminum per day. Fluorine present in the molten cryolite (Na_3AlF_6) reacts to generate several gaseous by-products, including HF. This is captured and recycled into the process as aluminium fluoride (AlF_3), but monitoring is required to ensure minimal releases to atmosphere. In the US, emissions of HF are subject to EPA regulations under the Primary Aluminum maximum achievable control technology (MACT) standards.

Analytical Technologies
HF was traditionally monitored using instruments based on ion mobility spectrometry (IMS), a cumbersome technique requiring regular maintenance, calibration, and consumables. More recently, IMS has given way to a range of laser-based techniques, including CW-CRDS, tunable diode laser absorption spectroscopy (TDLAS), and other cavity-enhanced methods. As a direct absorption technique, TDLAS instruments can lack sensitivity. Cavity enhancement overcomes this limitation by increasing the effective path-length of the sample cell, with such technologies finding a firm foothold in industrial monitoring applications. Tiger Optics now has over thousands of measurement points worldwide, serving demanding industrial applications, including continuous emissions monitoring and process control.

CW-CRDS for Aluminum Smelter HF Monitoring
Tiger Optics Tiger-i range has been developed for the measurement of trace level gases in samples at ambient pressure via the use of a vacuum pump to introduce the sample to the analyzer. All Tiger Optics instruments are based on CW-CRDS, as shown in Figure 2 below.

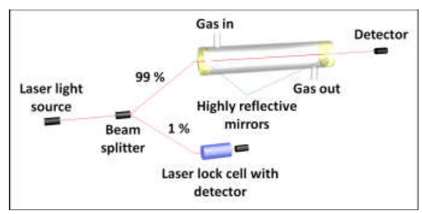

Figure 2. Schematic of CW-CRDS Analyzer

CW-CRDS works by tuning light rays to a unique molecular fingerprint of the sample species. By measuring the time it takes the light to expire or "ring-down", you receive an accurate molecular count in milliseconds. The time of light decay, in essence, provides an exact, non-invasive, and rapid means to detect contaminants.

CW-CRDS Operation
Tiger Optics Tiger-i 2000 HF delivers optimum performance for ambient monitoring applications:

- 200 parts per trillion (ppt) detection limit,
- 0-1 parts per million (ppm) range
- Accuracy traceable to the world's major national reference labs
- Freedom from interference
- No zero or span required
- No periodic sensor replacement/maintenance

CW-CRDS delivers the sensitivity and response time to ensure safer smelter operations and a cleaner environment.