Electro-Chemical Devices

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Introduction

A manufacturer of wireless handset chips in the United States, whose products include power amplifiers, front-end modules and RF products for handsets and wireless infrastructure equipment, needed to treat its fabrication facility's acidic wastewater prior to disposal. As part of the chip manufacturing process, highly caustic hydrofluoric acid (HF) was used to etch its gallium arsenide (GaAs) chip wafers and that left it with a wastewater issue to address.

Hydrofluoric acid is a high-volume chemical that is extremely corrosive. HF is a significant health and safety hazard as a liquid, even in diluted quantities. HF vapor, or hydrogen fluoride gas, can cause severe injury through contact, inhalation or ingestion. Free fluoride ions will destroy soft tissue and damage bones. The use of HF is heavily regulated by both the U.S. Occupational Health & Safety (OSHA) and Environmental Protection Agency (EPA).

After the chip wafer etching process is completed, the HF becomes waste acid and needs to be treated and removed before disposal into the wastewater system. In the past, the company treated the HF wastewater by creating a gaseous compound that was safe to release into the atmosphere. To better comply with air quality regulations, the company decided to install a fluoride removal system.

The Problem

The company's fluoride removal system consisted of a programmable logic controller (PLC) with a dosing pump to inject milk of lime solution Ca $(OH)_2$ into the process and precipitate the fluorides out as calcium fluoride (CaF) salt. If the HF concentration was a constant flow, then the PLC could direct a constant dosing level of the milk of lime solution into the HF waste acid to neutralize it.

Unfortunately, the concentration of HF was variable dependent on the required quantity of chips being manufactured and so neutralization through this method was not possible to meet the wastewater treatment system requirements. The PLC could inject more of milk of lime than necessary to resolve this issue, but this would have been a waste of milk of lime solution.

To be successful, the company's new wastewater treatment system needed to measure the incoming and the outgoing fluoride levels to determine the correct dosing of the milk of lime solution in the acid wastewater. The use of a fluoride colorimetric analyzer was initially considered as necessary to determine the incoming and outgoing fluoride levels, but the plant's manufacturing team was concerned that the high cost of the chemical reagents required by this type of analyzer made this solution expensive and unattractive.

Solution

The plant team then contacted the applications group engineers at Electro-Chemical Devices (ECD) to discuss its dilemma. They recommended a different solution to the plant's wastewater treatment problem and suggested installing two dual-channel analyzers with a fluoride ion sensor and a pH sensor on the acid wastewater inlet and on the treated water outlet of the fluoride removal system (Figure 1).

Fig 1. Fluoride removal system with installed T80-S80 Analyzer

The first analyzer is placed on the acid wastewater inlet side of the process to measure the incoming fluoride concentration level, which helps determines the proper $Ca(OH)_2$ dosing rate to neutralize the HF wastewater. The second analyzer was installed on the outlet side of the process to ensure that the fluoride ions were removed from outgoing treated water flow prior to effluent discharge.

ECD's T80 Universal Transmitter is a single or dual channel digital device designed for the continuous measurement of fluoride and other ions, pH, ORP, DO, turbidity, conductivity or resistivity in a general purpose industrial environment. The T80 transmitter communicates with any S80 Sensor, automatically configuring the transmitter's menus and display screens to the fluoride sensors or any of many other measured parameters. Together the transmitter and sensor provide a complete analyzer system.

The ECD S80 Ion Selective Sensors convert the analog signals from their electrode cartridge into a digital protocol that allows two way communications with the T80 Transmitter. The identity of the sensor, measurement type and serial number, are stored in the sensor's memory along with three calibration registers. When connected to the digital transmitter the sensor's information is uploaded to the

analyzer. This configures the displays and outputs of the transmitter to the values appropriate to the sensor's measured parameter.

Benefits

The advantages of the T80-S80 Fluoride Analyzer for the electronics plant team are that it is a reagent-less system that continuously monitors for the presence of the fluoride ions and pH level. Its ion detection sensor design eliminates any need for a reagent-type fluoride analyzer, which can cost four to eight times more. There is a significant cost saving achieved both in the initial purchase of the analyzer equipment and then eliminating the ongoing costs of replacement chemical reagents.

Very easy to maintain versus a colorimetric analyzer, the new installed fluoride ion analyzer system requires only periodic re-calibration and cleaning (of which the frequency depends on the process conditions). The only consumable items are the replacement fluoride and pH electrodes for the sensors, calibration solutions and polishing powder.

Results

In addition to the fluoride ion analyzers installed on the fluoride removal system, the company also installed a second fluoride analyzer on its final wastewater discharge line along with the cooling water blowdown water and reverse osmosis (RO) reject water line because the water is fluorinated by the local municipality (Figure 2 and 3).

Fig 2. S80 Sensor for pH and F- ion on RO reject water line

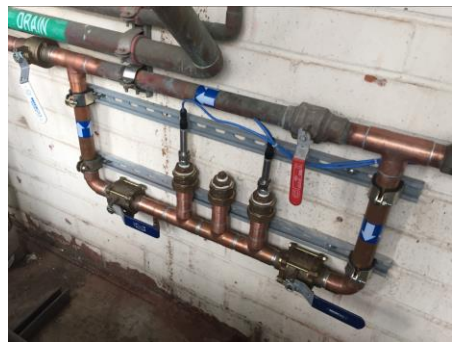

Fig 3. S80 Sensor for pH and F- ion on cooling tower blowdown water line

The fluoride ion analyzer transmitters on the final discharge line, the RO reject and the cooling water blowdown are connected to a circular chart recorder so that they can log the amount of fluoride being discharge into the sewers (Fig 4).

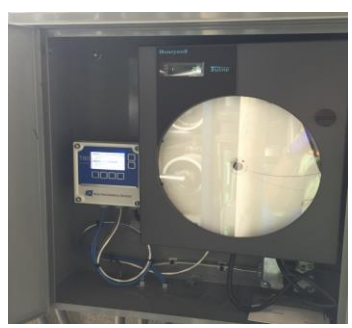

Fig 4. T80 Transmitter connected to chart recorder

This ensures that the company compiles with federal and state water quality regulations covering the discharge limit of fluoride into the sewer system. The fluoride ion analyzer system has been in continuous operation for over a year without any problems or incidents to report.