Application Note

# ULR CL17sc Success at a Microelectronics Manufacturing Facility

## Introduction

Ultrapure water for semiconductor, chemical, or beverage production has strict limits on presence of oxidants or reducers. Incoming water is usually chlorinated and undergoes dechlorination with either granulated activated carbon (GAC) or chemicals such as sodium bisulfite (SBS). Dechlorinated water flows through additional treatment frequently involving RO filtration when the operators should maintain low levels of chlorine, while not allow excess of oxidants to damage the membranes. It has been shown that prolonged exposure of RO filters to chlorine above 38 ppb (based on 1000 ppm-hr over 3 years) is detrimental to the membrane structure and integrity, while absence of the disinfectant promotes biofouling and causes loss of recovery. To maintain this delicate balance, the operators must be able to accurately monitor oxidant concentration and addition of dechlorinating chemicals.

### Problem

GAC is used in the UPW preparation cycle for electronics or pharmaceutical manufacturing, as well as in beverage production, to name just a few industries. The effect of channeling and the issues related to underfeeding/overfeeding dechlorinating agents are well-known in the industry. The channeling and underfeeding SBS will manifest in creating an excess of chlorine attacking the RO membrane's polymeric structure and causing irreversible damage. The overfeeding SBS leads to increase in biofilm formation due to the lack of disinfectant in the water. Besides the added cost and increase in biofouling, excess of sulfite leads to depletion of dissolved oxygen and proliferation of sulfur-reducing bacteria (SRB) in the water. SRB can cause microbially influenced corrosion, rotten egg smell due to formation of hydrogen sulfide ($H_2S$), slimy coatings, and brown foaming. All these factors creating either excess or lack of chlorine will diminish the RO membranes performance (flux) necessitating better monitoring and process optimization. Currently, RO feedwater monitoring and proportional addition of SBS is done with either grab sample analysis alone, or in its combination with continuous measurement of redox potential (ORP). Well known deficiencies of this approach do not make it the method of choice and such monitoring cannot provide effective optimization. There is a need for a simple and reliable instrumentation measuring chlorine directly, accurately and in a substantially continuous manner; able to monitor the exposure of the RO filters to chlorine to understand its impact on the membrane efficiency and life span.

### Solution

The need to maintain disinfectant residual to keep biofilm from growing excessively but at/below 38 ppb to ensure life expectancy of the RO membranes, dictates the necessity to monitor residual chlorine accurately at such low levels. The Ultra-Low Range (ULR) CL17sc chlorine analyzer uses colorimetric method to measure total chlorine residual with unparalleled accuracy provided by the low limit of detection (LOD) of 8 ppb. Accurate chlorine readings provided by the analyzer every 150 seconds will show a complete picture of the dechlorination process, detect any excursions of chlorine above the set limit, and help to manage RO membranes properly. The Cumulative Chlorine Counter function of the analyzer calculates and shows on screen how much chlorine has passed through the membrane at any given time. All this helps to ensure specified quality of RO feedwater, of produced UPW, and by extension the quality of the manufactured products ranging from semiconductors to drinking water.

## Case Study

A test was conducted at a semiconductor manufacturing facility with primary objectives to improve the efficiency of their dechlorination process while reducing the risk of chlorine damage to the first stage RO membranes. The plant has several RO racks containing over 200 individual cartridges with GAC pretreatment and addition of metabisulfite (MBS) to destroy extra chlorine residual in the RO feedwater should chlorine to break through the GAC beds. Around 30 membrane cartridges are replaced during a typical year, which is approximately $10,000, including the costs of membranes, labor, and lost revenue. Every three years on average, the RO membrane users must run an autopsy of failed membranes, which is usually done by contractors, and it can cost a few thousand dollars extra. Therefore, any premature failure of RO membranes due to chlorine breakthrough is a costly problem, amounting to about $5,000 annually, not even considering the final product losses.

The facility monitored chlorine using grab sample analysis before ULR CL17sc analyzer was installed at the first pass RO system influent line, after the GAC beds and MBS injection point, with the source water (city tap water) containing 3–4 ppm total chlorine before GAC. The analyzer had been tested at the facility for several weeks to validate its performance, including MBS response time, Figure 1.

Once the personnel gained confidence in the ULR CL17sc, the analyzer was put through a long-term test during which it detected an event related to a GAC tank failure, Figure 2.

The RO feed comprised the combined effluent from four carbon beds/tanks. Two out of four tanks account for ~20 % of the total flow each and the other two for ~30 % each. The event presented in Figure 1 happened after the MBS feed was deemed unnecessary and stopped. It was discovered that one GAC tank's effluent was contributing 150 ppb of chlorine to the combined sample. This contribution was immediately detected and recorded by the analyzer, while was missed by the personnel during the holiday week. Once the exhausted media was replaced, the chlorine concentration came down to the desired level of < 30 ppb as was confirmed by the grab sample analysis, Figure 2. The test demonstrated that GAC media can be exhausted or develop channels passing chlorine through.

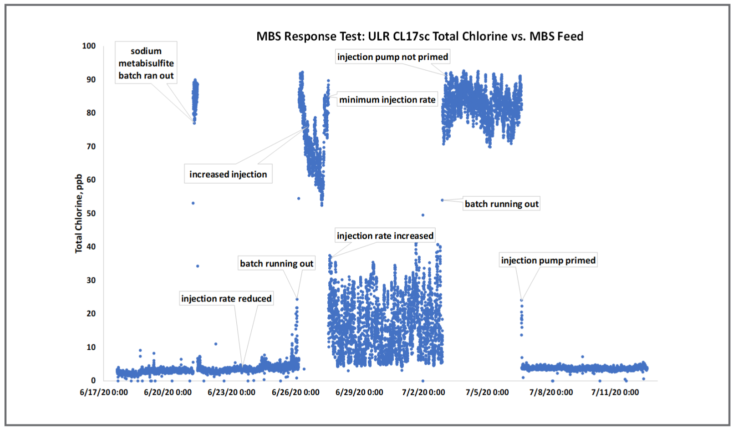


**Figure 1. Metabisulfite (MBS) feed response test: the analyzer responded fast to all changes in the dechlorination process.**

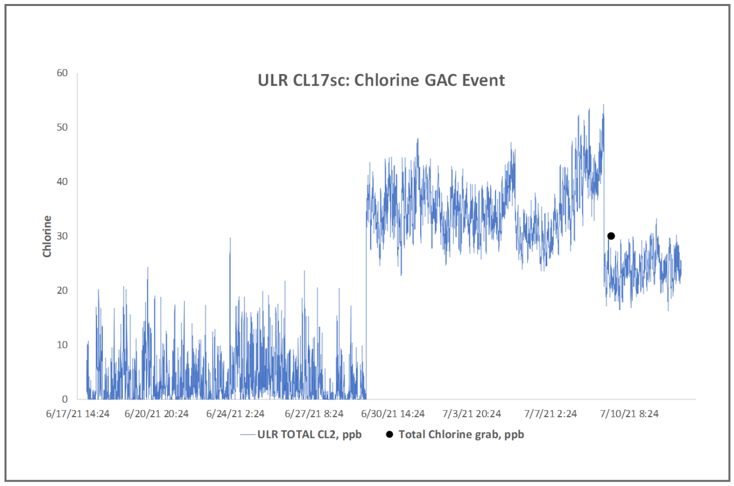


**Figure 2. GAC failure detected by the tested ULR CL17sc and verified with a reference analysis after the root cause was found and eliminated.**

## Outcomes

During the ULR CL17sc testing at this and many other municipal and industrial facilities, the analyzer demonstrated expected sensitivity to sulfite feed rate changes and showed good accuracy against grab sample analyses (e.g. Method 8167, DR3900).

The results of this and many other case studies revealed the value of highly accurate direct chlorine measurements at minimal maintenance efforts supporting all chemical and labor cost savings elucidated by the instrument and projecting the full ROI in two years on average.

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