Technical Publication

Project Report and Data Summary

Evaluation of On-Line Analyzer System for Potable Water Chloramination Monitoring and Control

City of Milwaukee
Howard Avenue WTP

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ChemScan®

Chloramination Analysis
Demonstration Summary
Howard Ave. WTP Milwaukee WI

The City of Milwaukee's Howard Ave. Water Treatment Plant has a need to monitor the chloramination process to insure optimal chlorine and ammonia feed rates. Within this process, chlorine is added prior to a large wet well, and then ammonia is added as the final treatment. It is essential that the chlorine is controlled to a certain concentration and the ammonia be added to combine with the chlorine to produce a final product with a tightly controlled chlorine to ammonia ratio. The essential parameters to measure for this process are monochloramine, total chlorine, free ammonia and total ammonia. The plant currently has a Hach APA-6000 plus several W&T Micro 2000 total chlorine analyzers to monitor their process. ASA was invited to demonstrate a ChemScan analyzer for this application.

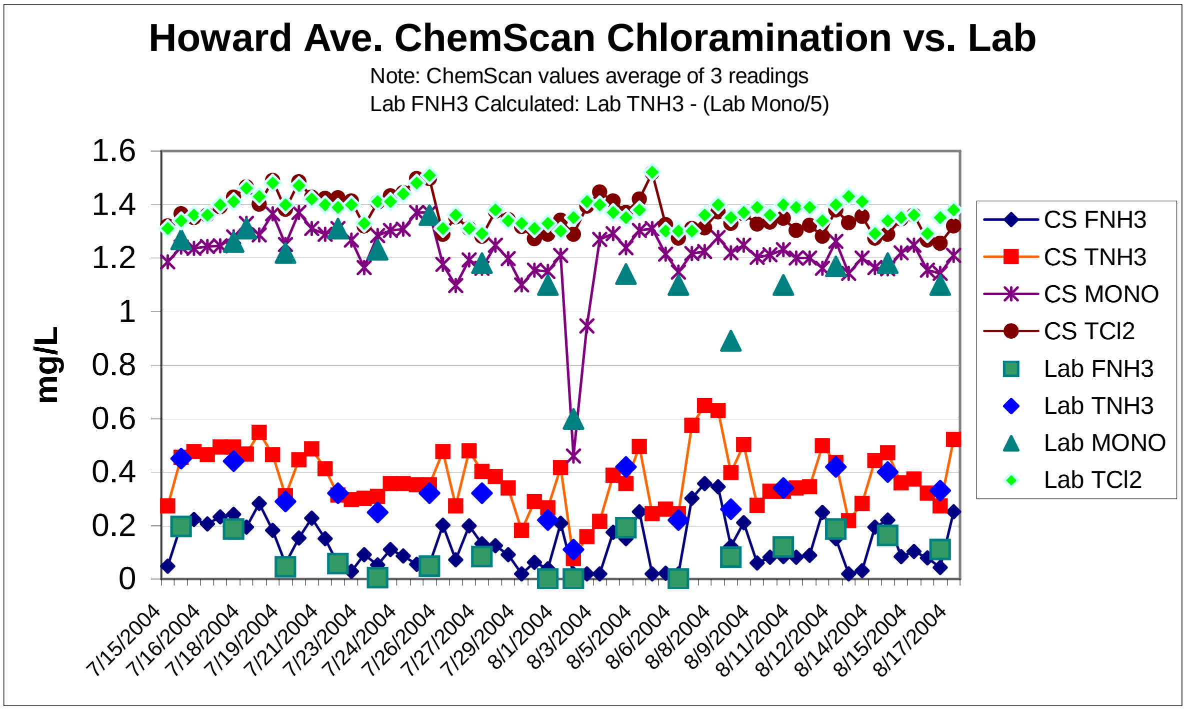
Typically a UV-2150/S Chloramine Analyzer is used for this application however, because of demo availability, a UV-6101 was installed in July of 2004 for a 5 week period. One of the two process trains were monitored for all four parameters on a 15 minute cycle. The plant collected samples twice per day for laboratory analysis of total chlorine and every fourth sample was also analyzed for monochloramine and total ammonia. The lab results along with the ChemScan readings were logged.

The selected sample point shared the sample with existing an ammonia analyzer and a total chlorine analyzer. The chlorine was added prior to a large wet well and it was fully mixed and very stable. However, this sample point was very close to the ammonia feed, resulting in ammonia fluctuations due to incomplete mixing and/or insufficient reaction time prior to sample extraction. The existing ammonia analyzer required a "bubble arrestor" and "sample heater" prior to the analyzer. This sample conditioning equipment dampened the ammonia variation but also greatly reduced the response time to actual ammonia changes. Two weeks into the data collection a "sample integrator" was installed on the ChemScan analyzer sample line. This device greatly reduced the ammonia variation without substantially reducing the response time.

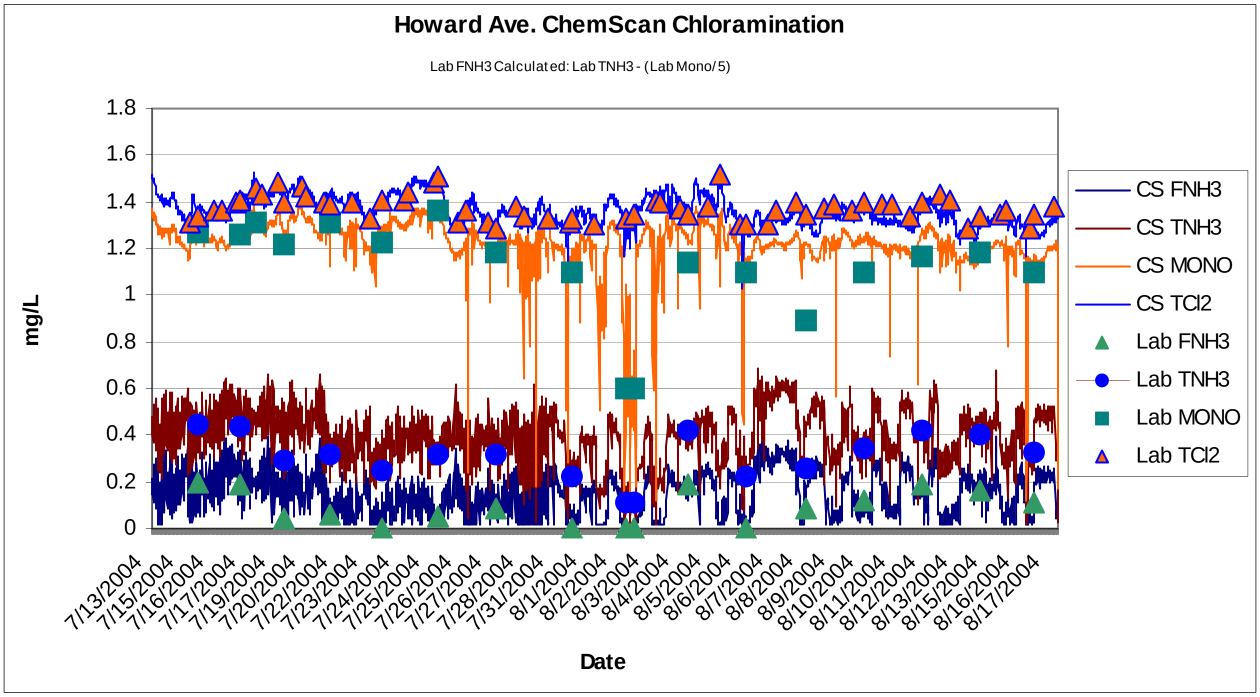
Data Results:

The lab results have been plotted along with the corresponding analyzer values (Graph 1). The lab free ammonia was determined using break-point chlorine theory that the free ammonia is equal to the total ammonia minus monochloramine divided by 5 (F-NH3-N = T-NH3-N – (Mono/5)). In practice this calculation technique produces a good estimate of the free ammonia in the absence of a specific free ammonia analysis. Given the ammonia variation in the sample related to insufficient mixing and reaction time, there was an unusual degree of variation in the analyzer ammonia results. Therefore, three data log results were averaged for comparison purposes. The analyzer data log value corresponding to the recorded grab sample time was extracted, along with one value immediately before and one immediately after the recorded time. In general, the averaged analyzer data agreed very well with the lab data. After the sample integrator was added, there was no longer any need to average the analyzer data and a good correlation with the grab sample was observed.

The analyzer data log has been plotted along with the lab results (Graph 2). All of the analyzer data tracks the lab data closely. The sample integrator was installed two weeks into the data collection to simulate the effects of better mixing or more reaction time had the sample point been further downstream. This can be clearly seen in the reduction of the variation in the ammonia data.



Graph 1: Lab vs ChemScan Grab Samples



Graph 2: Lab Data with ChemScan Data Log Data

While not typical, the data indicates some instances where the chlorine to ammonia ratio was outside of the ideal 4:1 to 5:1. Since the chlorine concentration was very stable, the ammonia must have been either over or under fed. While not an immediate concern, overfeed of ammonia (ratio below 4:1) will cause excess free ammonia in the distribution system potentially leading to future development of nitrifying bacteria. Figure 1 shows an approximate break-point curve and location of operation for the sample collected on July 15^{th}. This sample has a chlorine-to-ammonia ratio of 3:1 and free ammonia was 0.2 mg/L.

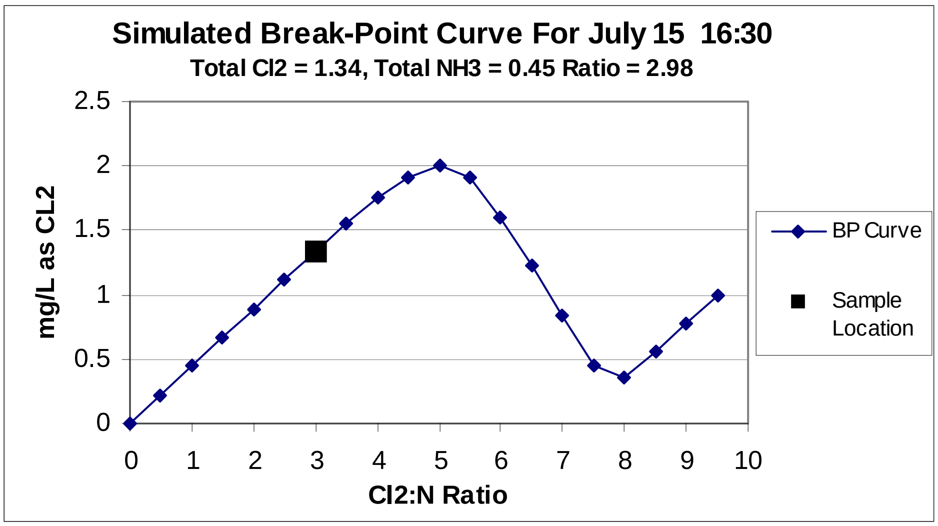


Figure 1: Breakpoint Curve for July 15^{th} at 16:30

A more immediate water quality concern is when the chlorine to ammonia ratio gets above 5:1. During this time, dichloramine can form which has a foul taste and odor. Figure 2 shows an approximate break-point curve and location of operation for the sample collected on July 31^{st}. This sample has a chlorine-to-ammonia ratio of 6:1. During this period, the free ammonia dropped to detection limit (<0.02), the total ammonia dropped and the monochloramine concentration dropped (see graph 2). This is an indication of the dichloramine formation.

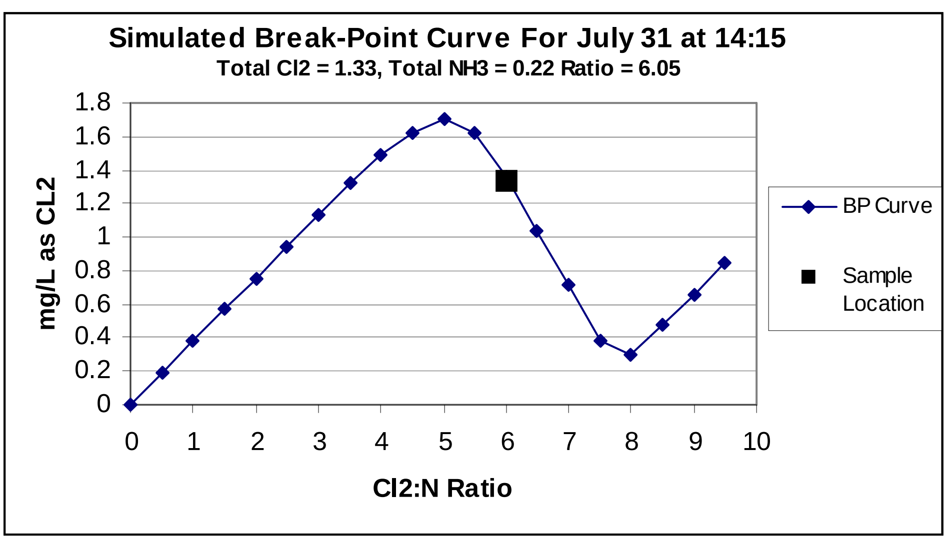


Figure 2: Breakpoint Curve for July 31st at 14:15

Conclusion:

While the chlorine-to-ammonia imbalance occurrences are occasional, they do indicate the need for accurate, reliable online analysis to facilitate prompt operational adjustments. While less expensive to initially purchase, the existing equipment requires more maintenance and a series of costly repairs every few weeks to keep operating. The addition of external sample conditioning equipment such as bubble arrestors and sample heaters for each sample line increases the installation cost and adds to the maintenance requirements. The existing analyzer's small sample tubing makes sample filtration necessary and the requirement of a sample heater indicates the process sample does not respond the same as the internal calibration standard. The external communication modules along with the sample conditioning devices requires a wall full of equipment to produce only the free ammonia, total ammonia and monochloramine values. Then an external total chlorine analyzer is required for each sample line to complete the necessary measurements.

The ChemScan analyzer provides all four parameters in the same device with multiple sample line capability. It uses large ¼ inch I.D. tubing to eliminate the need for pre-filtration of the water. The only regular maintenance requirement is replacing reagents and since all new chloramination analyzers are fabricated with a diaphragm pump, the pump tube replacement has been eliminated.

A key advantage is the sequential analysis of the monochloramine and total chlorine. During plant operation when the chlorine to ammonia ratio is less than 5:1, these two parameters should be close to the same concentration and track together. As the ratio increases above 5:1 the total chlorine and monochloramine will begin to separate indicating the formation of foul tasting and smelling dichloramine.

The accurate and reliable analysis of free ammonia at concentrations as low as 0.02 mg/l allows the plant to tightly control the ammonia feed and minimize excess ammonia in the distribution system. This greatly reduces the potential development of nitrifying bacteria in the reservoirs and distribution system.

Even though the ChemScan analyzer appears to be initially more expensive, it is a complete system that does not require additional sample conditioning equipment or supplemental sensors for a complete analysis suite. The reliable and accurate operation of the system with minimal O&M expense makes the ChemScan a better value with the lowest cost of ownership over the long term.