Technical Publication

Project Report and Data Summary

Chloramination Analyzer On-site Trial at F.J. Horgan Water Treatment Plant, City of Toronto

F.J. Horgan WTP
Toronto

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Summary of
ChemScan Chloramination Analyzer On-site Trial at
F. J. Horgan Water Treatment Plant, City of Toronto

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Acknowledgment
We appreciate the generous support on laboratory analysis and maintenance assistance from F. J. Horgan Water Treatment Plant. A special appreciation goes to Liza Ballantyne, for her effort to organize the trial and technical leadership of the entire program.

Project Background and Product Information
The ChemScan Model UV-2150/S is an on-line analyzer manufactured by Applied Spectrometry Associates, Inc. (ASA). It is designed for control and monitoring of the chloramination process. It is capable of monitoring multiple parameters and multiple sample streams in one centralized analyzer. Many water treatment plants have successful experience for chloramination ratio control with this analyzer. The four parameters offered are free ammonia, total ammonia, mono-chloramine and total chlorine. 4-20 mA outputs signal for each parameter are sent from the analyzer to the plant central control system (SCADA), where control decisions are made based on the ammonia to chlorine ratio. It takes approximately 8 minutes for the analyzer to complete analysis of all four parameters. If analyzer is set up to monitor two sample streams, it sends 8 signal outputs (4 signals at each sample location) every 16 minutes. Another feature is the internal storage capacity: If there is a power outage; ChemScan analyzer stores the last 1,000 sets of data. For a two sample stream operation (4 parameters for the finished water and ammonia for the raw influent), it stores approximately 7 days of data.

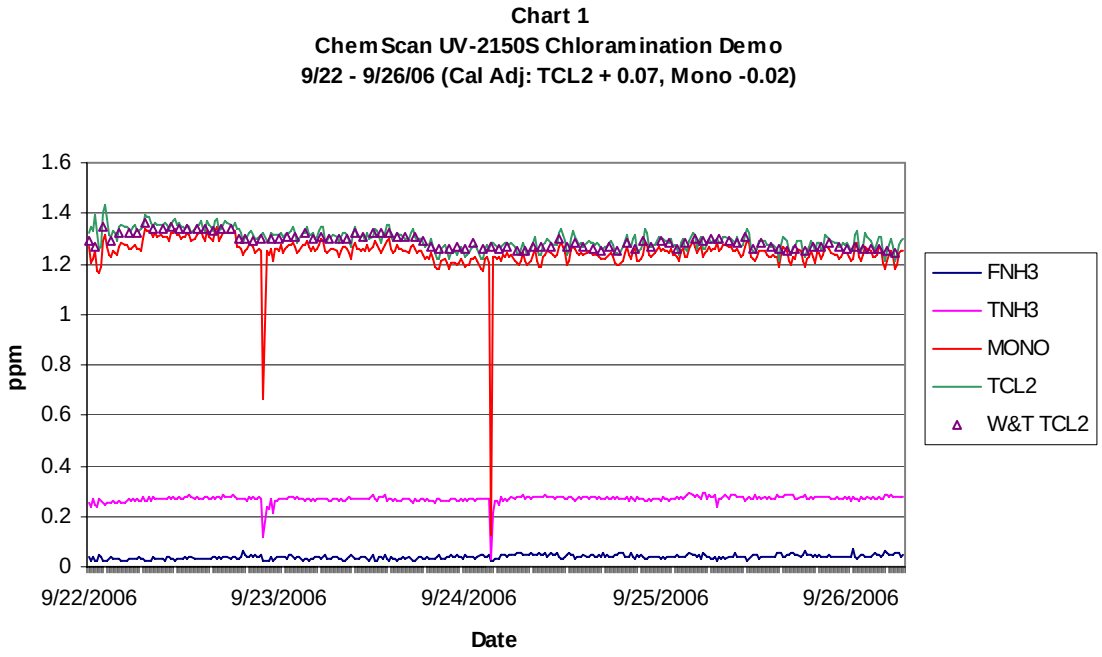
A UV-2150/S was installed at the F. J. Horgan Water Treatment Plant, City of Toronto, for an evaluation test from mid August 2006 to mid Oct 2006. Four parameters were monitored at the treated water suction channel (after ammonia addition and mixing). These parameters are: free ammonia, total ammonia, mono-chloramine and total chlorine. The purpose of the demonstration was to demonstrate the reliability of the instrument and to evaluate the maintenance requirements. The goal is to eventually use an on-line multiple-parameter analyzer for chloramination process control and assess the performance of this analyzer for the purpose of process control.

Test Results
1. Stable Operation.

The demonstration program had a slow start because of a couple issues. First, a continuous flow of sample could not be maintained because the internal sample pump in the analyzer was damaged in shipping; ASA replaced the pump promptly. The ChemScan analyzer then showed the stable operation plotted below.

A second issue was initial calibration. The purpose of initial calibration is to make sure good correlation is established between the ChemScan reading and the plant's lab reading. If the ChemScan's internal Master Data Set does not reflect fully the characteristics of the water chemistry specific to the plant, simple steps of initial calibration adjustment can be made. ChemScan analyzer was initially calibrated against another on-line chlorine analyzer, but this analyzer needed to be re-calibrated once each week. Because values from this chlorine analyzer might be a moving target, it was decided at a meeting in late September between the Horgan water plant and ASA to calibrate the ChemScan using split samples analyzed using the laboratory titration method.

Chart 1 shows comparison data between the ChemScan and the W&T total chlorine analyzer during stable operation. The results indicate good agreement between the two analyzers on total chlorine.



2. Performance when calibrated against titration method.

Charts 2 - 4 show the ChemScan values along with those from the laboratory titration method. The time when titration sample is collected is recorded each time. Then, the results will be used to compare with on-line data read from ChemScan in the same time. This procedure is called "Split Sample". Several split samples are prepared using water from the sampling site. One set of samples is assayed by the laboratory titration method and the other set is run on the ChemScan. Based on the comparison sample, the internal Calibration File in the ChemScan was adjusted so that the ChemScan values agree with the reference (titration) method. The charts show the agreement of the ChemScan values (after initial adjustment) with the laboratory titration values over a three-week period with no further adjustment of the ChemScan calibration. If it is necessary, the calibration

of the ChemScan can be further adjusted by using the Calibration Adjustment feature that can be accessed from the front panel of the instrument. This further adjustment is only rarely required.

There are no split samples on free chlorine available during the period of October 5 to October 11 (Chart 2). But they are available during the rest of the trial (Chart 3 and 4).

Chart 2
Comparison of ChemScan Data with Lab Titration
10-05-06 to 10-11-06

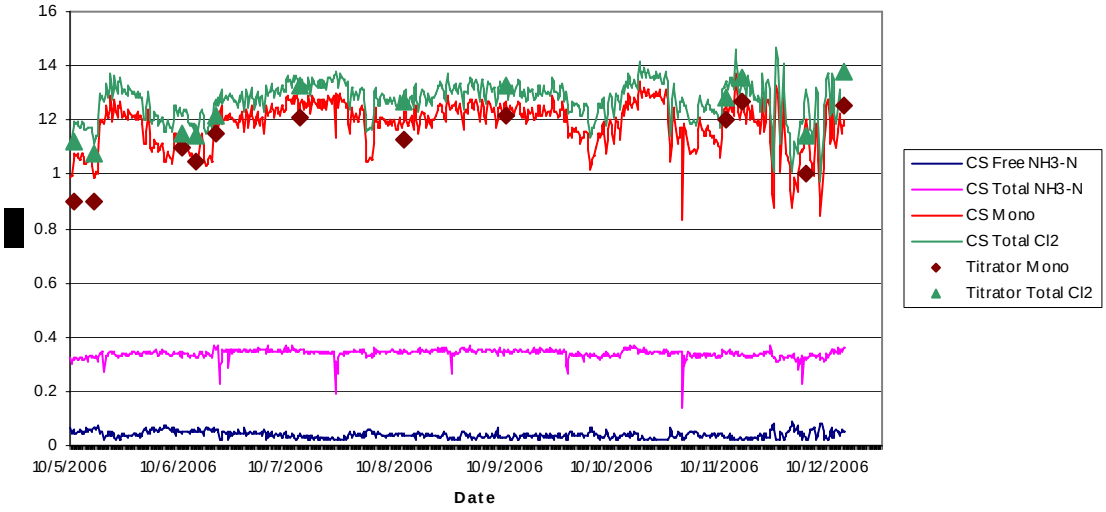


Chart 3
Comparison of ChemScan Data with Lab Titration
10-12-06 to 10-19-06

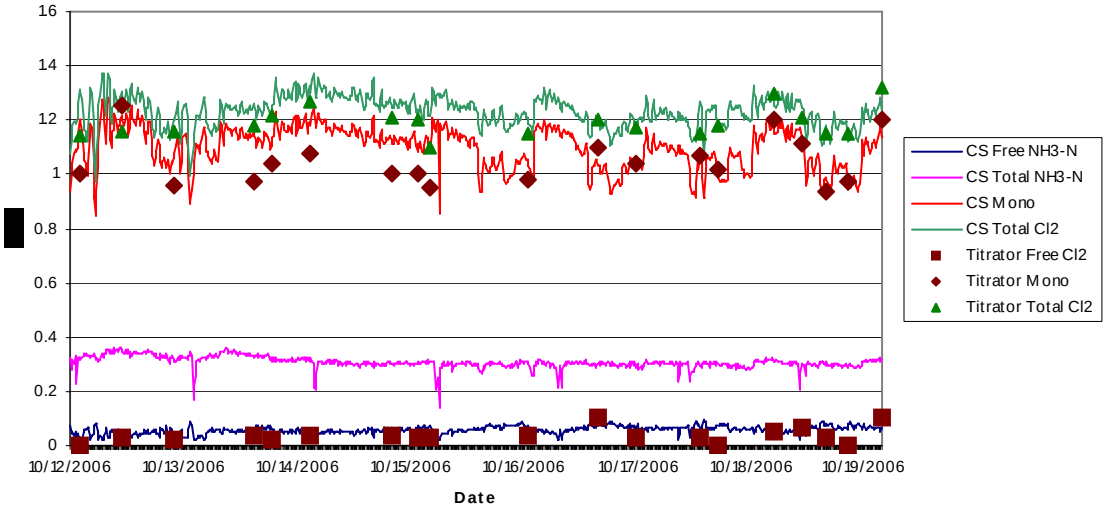
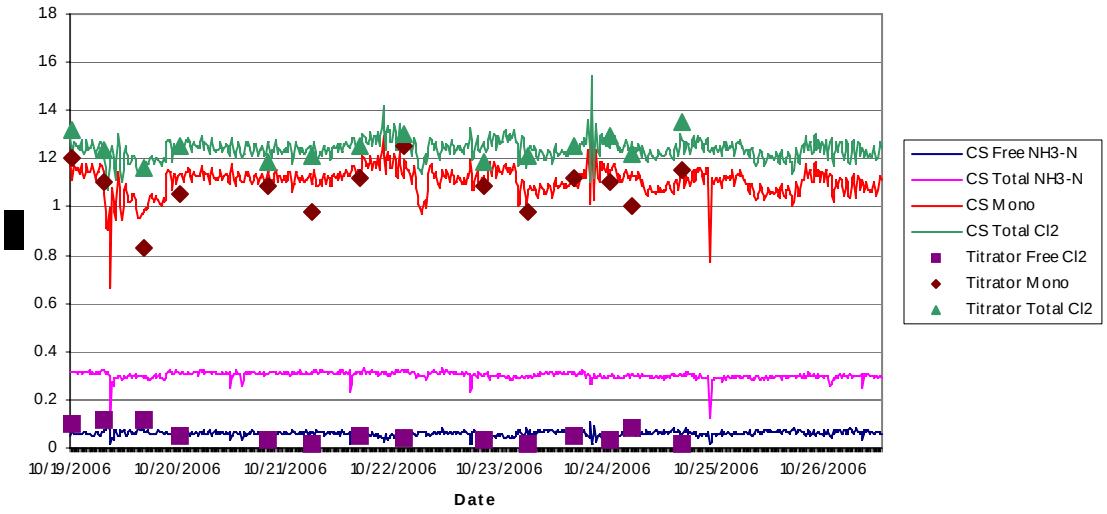


Chart 4
Comparison of ChemScan Data with Lab Titration
10-20-06 to 10-27-06



Observations on the Recorded Data:

Total Chlorine

ChemScan readings consistently agree with the results from laboratory titration method within approximately ±0.05 mg/l range. Under normally operation condition, re-calibration is suggested if the difference is greater than 0.1 mg/l.

Mono-Chloramine

Generally, the ChemScan readings agree well with the results from the laboratory titration method. There are two days when the laboratory titration results are about 0.1 mg/l lower than the ChemScan results, although the difference does seem to disappear after a few days. No calibration adjustments were made on the ChemScan during this time, so it is possible that the titration process or sample age be the cause. Mono-chloramine values are consistently 0.1 to 0.2 mg/l lower than total chlorine values, and this indicates good control of the chlorine to ammonia ratio at the plant, and minimal formation of di- and tri-chloramine.

Free Ammonia

It is important in chloramination process to keep free ammonia from entering the distribution system. Free ammonia in the distribution system can cause many problems, such as nitrification, algae growth, DO deficiency and corrosion control, etc. There were no free ammonia test results from the Horgan laboratory, so we cannot make any comparisons. However, the ChemScan readings for this parameter show a good stable pattern. Free ammonia values are constantly below 0.05 mg/l, which indicates good control of the chloramination ratio and very little free ammonia "leak" to the distribution system. However, free ammonia at the finished water location should be controlled as close to zero as possible. This concept can be explained by the "Break-Point

Chlorination Curve." For optimum control, the plant should be operated as close to the peak of the curve as possible. At this point, free ammonia is close to zero and di-chloramine will be close to zero also. If the plant is operated on the left side of the "peak", there will be free ammonia left in the water as it enters distribution system. Controlling free ammonia near zero is one of the key control objectives. However, because free ammonia is also zero on the right side of the "peak" where di-chloramine forms, it is not only key parameter.

The most common practice for optimizing chloramination is referred to as the "ratio-metric control strategy", in which both free ammonia and di-chloramine are monitored. Another method being used in a few plants is called the "free ammonia residual control strategy", in which the plant operates (1) on left side of the peak of break-point curve, to ensure no formation of di-chloramine; and (2) as close to the peak of the curve as possible, to ensure minimum free ammonia entering the distribution system. Therefore, a low detection range for free ammonia is critical for the residual control strategy. The detection range for free ammonia using the ChemScan is 0.02 – 1.00 mg/l. Some plants using the residual control strategy have taken advantage of this low detection range and successfully set up their protocol to adjust chemical feed when free ammonia is higher than 0.05 mg/l.

Total Ammonia

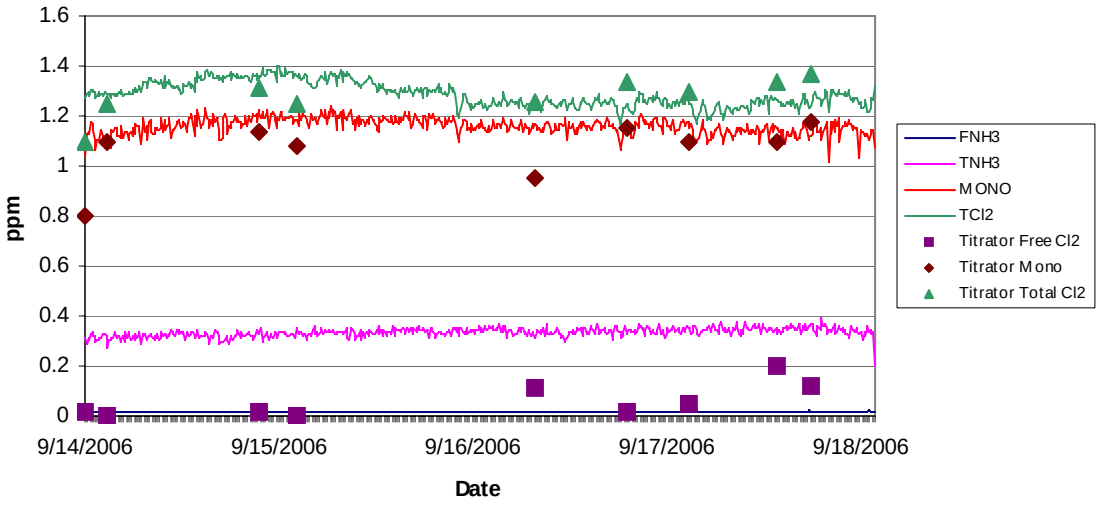
Again, we have no total ammonia test data from the Horgan laboratory, so we cannot make any comparisons. However, the readings on the ChemScan for this parameter are quite stable.

Discussion

Process Control using the Analyzer Data

The analyzer gave an early indication of an ammonia feed control problem. After losing ammonia feed early in September, it was reintroduced on September 12th. Shortly after ammonia was added, the analyzer gave an indication the ammonia was being underfed resulting a ratio of chlorine to ammonia greater than 5:1. See Chart 5. It was evident in two ways: (1) the free ammonia was constantly at the detection limit of 0.02 mg/l, and (2) the difference between the total chlorine and monochloramine was greater than 0.1 mg/L indicating the formation of dichloramine. It can be noted that during other period of trial, the difference is below 0.1 mg/l (an optimized control target is to operate at this value as close to zero as possible). This was verified in the operator titration log sheet as an occasional presents of free chlorine and the regular difference between the total and mono chloramine greater than 0.1 mg/L.

Chart 5
Comparison of ChemScan Data with Lab Titration
09-14-06 to 09-18-06



Calibration on ChemScan

Initial calibration was not performed during start up. However, slope and offset have been adjusted a few times to make the ChemScan agree with another online analyzer. Finally, agreement was reached to calibrate ChemScan using only laboratory titration samples. Once this was done, the results showed very good correlation and no calibration were necessary since then.

The normal procedure of ChemScan calibration is that ChemScan is calibrated against laboratory data once at startup by factory personnel to assure agreement between the analyzer and the on-site laboratory. After initial calibration, the ChemScan data should agree well with laboratory values. Only occasional (once every few months) split comparison samples are needed to check the agreement with the laboratory values. Using simple slope and offset adjustments should be sufficient to maintain agreement. No extensive recalibration is needed. The procedure of performing the adjustment can be found in ChemScan O&M manual.

Reliability and Maintenance

ChemScan analyzers use daily automatic analysis of a zero standard to maintain a stable optical baseline. An optical analyzer such as ChemScan uses a beam of light for analysis and therefore has no contact between a "sensor" and the sample. The automatic zeroing procedure used by the analyzer maintains optical stability, subtracts out any effects of deposits on cell windows and triggers automatic cleaning if the deposits exceed allowable set points. The reagent-assisted methods used by the ChemScan for analysis of the sample always subtract the full spectrum of a sample blank from the full spectrum of the reacted sample, thus removing background chemistry variations from the resulting spectrum prior to the analysis calculations.

All reagent and cleaning solutions used in the ChemScan analyzer are commercially available. ChemScan also provides the chemical composition of these reagents. The chemical cost for the ChemScan chloramination analyzer is less than $40 per month. There is no need to purchase proprietary reagents.

Operator maintenance is limited to topping off of reagents, zero standard and cleaning solution, as well as taking an occasional comparison sample. Replacement of solutions is typically required only once a month, so the amount work involved is only a few minutes per month.

Summary

1. Values from ChemScan on-line analyzer agree well with those from the laboratory titration method.
2. ChemScan online analyzer can be easily calibrated using values from the laboratory titration method.
3. ChemScan can be used to coordinate with plant SCADA for chloramination ratio control.
4. ChemScan requires little maintenance during operation.

Prepared by Applied Spectrometry Associates, Inc.