

ChemScan[®] Process Analyzers

Demonstration Project Summary

Instrument Test Association
Ammonia Analyzer Test
Houston Beltway Plant
Houston Texas

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Project Summary

The Instrument Test Association organized a test project for analysis of ammonia in aeration basin mixed liquor at the City of Houston Beltway WWTP starting in July 2000. ASA was among the several manufacturers invited to participate in this test, which is the subject of a copyrighted report published by the ITA in May 2001.

The ITA intended to supply a tap from a shared sample line to all instruments, but ASA and a number of other suppliers did not have confidence that ITA's sample system could provide a reliable sample flow that was suitable for analysis. The original ITA sample system used a simple transfer pump and did not provide any debris protection or filtration of suspended solids. Because of these conditions, ASA elected to take responsibility for its own sample supply and filtration.

The ChemScan UV-4100 system provided by ASA for the test used a new experimental cyclic filter rather than the customary cross flow filter normally used for wastewater mixed liquor applications. The standard cross flow filter uses a positive displacement pump, which would have delivered some of the debris present at the Beltway site to the ultrafilter. (The alternative was to use a grinder pump, which would produce a reliable sample flow in the Beltway mixed liquor, but could not be properly installed prior to the required start date. ASA also believed that the nature of the debris at Beltway was such that a grinder pump might pass ground glass and metal that could physically damage a membrane type ultrafilter.) The cyclic filter uses a special filter element that is directly immersed in the mixed liquor and connected to a diaphragm pump at the analyzer, using a dedicated small diameter sample line. The analyzer is programmed to flush a filtered sample from the sample point through the analyzer for a short period of time, analyze the sample for ammonia, then reverse the flow and flush the reacted sample back through the sample line, followed by a blast of compressed air. Because the ChemScan analyzer uses reagents for ammonia analysis, the reacted sample has the effect of cleaning the sample line and filter after every analysis cycle. The air tends to clear any particulates and debris from the filter after the reverse sample flush.

Test Project Issues

ASA has four major issues with the ITA test. We believe that any of these four issues are sufficient reason for recipients of the ITA report to interpret the results with caution:

1. The mixed liquor sample conditions at Beltway may not be representative of the conditions at most plants.
2. The physical location for the analyzer did not meet our minimum requirements.
3. Field calibration and start-up procedures were not typical for a process analyzer installation.
4. A faulty analog recorder supplied by the Instrument Test Association at the test site invalidated several weeks of ChemScan test data.

Mixed Liquor Contents.

Although the Houston Beltway WWTP is a very well operated and maintained facility, it is not a representative municipal facility for wastewater process analysis of ammonia. This plant has no influent screening, no grit removal, no flow equalization and no primary clarifier. Thus, not only are the mixed liquor suspended solids higher in concentration than the typical facility, there is also a heavy accumulation of trash, rags and debris in the mixed liquor. In addition, the plant has no aeration rate control capability. The blowers are operated at maximum, regardless of the process load. Thus, much of the time effluent ammonia is at or close to zero. This resulted in a change from the original sample point location in the aeration basin effluent to a sample point near the middle of the basin in order to obtain some measurable ammonia. ASA has years of experience in the supply of chemical analysis systems for wastewater process monitoring applications and therefore recognized that a project such as the one organized by the ITA at the Beltway plant was as much a test of sample handling systems as it was a test of the ammonia analyzers.

The new ChemScan cyclic filter system did provide very reliable performance during the test period, although power outages and uneven maintenance did reduce the effectiveness of the system compared to design capability.

Analyzer Location

The original plan by ITA for the Beltway test site was to locate all instruments under test in a trailer or enclosed shelter located next to the aeration tank. The actual installation used a partially enclosed shelter for the instruments that relied on the ITA sample line. Instruments that used a dedicated sample system, such as ChemScan were located in the open air on another side of the tank. A temporary sunscreen was fabricated for this location by ASA, using materials from the ChemScan packing crate. An installation that is open to the sun is not recommended because ChemScan needs to maintain a controlled internal temperature at 105° F within the analyzer electronics cabinet for optical stability. Ambient temperatures during the test period at Houston exceeded 110° F in the sun for several consecutive days. ASA would not normally consent to an outdoor installation where ambient temperatures could exceed our temperature stability set point. An air conditioned shelter or an indoor location would normally be required for a site with conditions like Houston in the summer.

Calibration and Start-Up

Unlike other analyzers, ChemScan is not calibrated to absolute standards but is, rather, calibrated relative to laboratory values at each site. In order to accomplish this, an initial calibration is performed by factory personnel at startup, then adjusted based on comparison values obtained over a period of time. Prior to startup, ASA requested that our internal data logs be provided during the test period and that comparison values be provided, at least for an initial operating period. ITA denied this request. At the time of start-up, operators were requested by ASA to perform periodic “manual zeros” and also

requested to compute and enter offset adjustments based on comparison with the initial laboratory results. Although this comparison is a normal and necessary field calibration and start-up procedure for ChemScan, it was not performed at Houston. ASA was permitted to review a few lab results for the initial set-up at the end of tank sample point while the factory technician was on site. No comparison data was made available after the test point was changed to the aeration tank midpoint. The result is that this test was performed using procedures that are substantially different than those normally used by ASA (or any other manufacturer) to startup, calibrate and adjust a process analyzer. Once ASA had an opportunity to review the data gathered during the Houston test, we determined that an offset of +1.0 ppm should have been added to every ammonia analysis value provided by ChemScan. The analyzer has a feature that allows standard offset values to be entered at the keypad. Had this offset been calculated and entered, as we had instructed the operators during startup, conformance with lab results would have been greatly improved.

Faulty Analog Recorder

By far, the most serious problem observed by ASA during the test involved a faulty analog output recorder used to collect data by ITA. Operator field notes made available to ASA after the test clearly show an analog output “mismatch” was observed by operators as early as July 27, but was not discussed at all with ASA until October 3 and was not corrected until October 4. The cause of the so-called mismatch was the result of a faulty channel on a multi-channel data recorder used by ITA for the test. Despite a valid and properly scaled 4-20 mA signal from ChemScan, the faulty channel was recording erratic results for the ammonia values communicated by ChemScan. Once the problem was discovered, a new input channel was assigned to ChemScan. ASA objected to any data obtained from the faulty analog recorder prior to October 4 being used by ITA for evaluation of the ChemScan system or reported to others by ITA. Inspection of the data very clearly shows better correlation between laboratory and analyzer results following correction of the analog recorder problems. Unfortunately, this was too late to provide very much valid data for the test report.

Because of the analog recorder problems, some of the signals to noise tests by ITA prior to October 4 are invalid for ChemScan. Another signal to noise test performed on 10-30-00 was after a new input channel had been assigned to ChemScan and show steady output results. However, the ChemScan analyzer was setup to perform an analysis every 10 minutes and hold the analog output value until a new analysis is performed. The period of time sampled during the output stability test on 10-30-00 covered a period of time that straddled two of these 10-minute periods, making it appear as though the analog output deviated from standard in the middle of the test.

Despite the objections of ASA, the ITA chose to present the faulty data with the notation “Data acquisition problems during this period. Data unsuitable for analysis.” However, graphic presentation of the faulty data in the ITA report creates the incorrect impression that the analyzer was inaccurate.

Test Results

Even though there were numerous problems with the design and execution of this test, ChemScan was among the best performing analyzers at Beltway (during the short time when valid data was being recorded for the ChemScan system). The well-traveled demonstration analyzer furnished by ASA for the test did experience a reagent injector pump failure and an inlet valve failure prior to the official start of the test. ASA and the local ChemScan representative corrected both problems before the test period started. During the test, the average ChemScan error was -1.06 mg/l. This error would have been very close to zero if the normal calibration adjustment had been performed as requested, but the uncorrected ChemScan values were still among the lowest average errors for any of the test instruments. ChemScan was able to accurately track the process trend during the test period and provided very good correlation with grab sample laboratory values. Our standard error of 0.11 mg/l and standard deviation of 0.74 mg/l were the lowest of any of the eight analyzers to complete the test. (ChemScan, Bran + Luebbe, Danfoss, FPM, Hach, Waltron, WTW and Zellweger) Among the eight analyzers, ChemScan had the best (highest) coefficient of correlation between analyzer results and lab data. The ChemScan analyzer and sample handling system provided reliable service under very poor conditions with only minimal bi-weekly maintenance required to replenish expendable items and change filter elements.

ITA Ammonia Analyzer Comparison

ITA Ammonia Analyzer Statistical Comparison

| | ChemScan | Bran & Luebbe | Danfoss | FPM | Hach | Waltron (ABB) | WTW |
|--------------------|----------|------------------|---------|-------|-------|------------------|-------|
| Mean | -1.06 | -1.63 | 7.14 | 0.02 | 0.82 | -1.08 | -0.86 |
| Standard Error | 0.11 | 0.30 | 0.39 | 0.16 | 0.29 | 0.24 | 0.18 |
| Median | -1.09 | -0.98 | 9.33 | -0.11 | 0.49 | -1.19 | -0.76 |
| Standard Deviation | 0.74 | 3.20 | 4.50 | 1.85 | 3.34 | 2.76 | 2.11 |
| Sample Variance | 0.54 | 10.25 | 20.24 | 3.42 | 11.13 | 7.63 | 4.46 |
| Data Points | 44 | 112 | 134 | 132 | 128 | 128 | 132 |