Sample Stream Switching versus Dedicated Analyzers in Online Process Water Monitoring

Reducing analytical equipment costs by sharing analyzers across several sample streams is an attractive notion which can yield some technical benefits. To ensure meaningful measurements however, care must be taken to apply a sample sequencing solution to appropriate test points and with the necessary precautions in the process being analyzed. This article describes the pros and cons of using sample stream sequencers (aka "switchers" or "selectors") as well as proposes some basic guidelines for their use.

Background

The sharing of an analyzer among several sample streams was introduced in gas chromatography where using these devices on a dedicated basis is generally cost prohibitive. For process water analysis, this concept is of increasing interest especially where operational cost savings are sought such as in the Power industry. The key issue that arises is how to apply it to realize the cost benefit without introducing unnecessary risk.

Continuous versus Batch Analyzers

There are different modes of operation for online analyzers – batch and continuous. Electrochemical analyzers such as those for sodium and chloride are capable of delivering a continuous, uninterrupted measurement. The use of electrodes in constant contact with the sample flow produce a continuous voltage measurement that corresponds to a chemical concentration.

Colorimetric analyzers such as those that measure silica or phosphate provide intermittent (aka "batch") measurements. This class of analyzers typically involve a chemical reaction of the sample with reagents to produce a specific measurable color that is in proportion to the chemical species of interest. Because this technique requires time for the reaction to complete, measurements are performed in batches and are therefore provided on a periodic basis.

With continuous-mode analyzers, early detection benefit can be lost with sample switching – both the instantaneous reading and any data-logging associated with a given sample stream are lost as soon as the sample is switched.

In contrast, with batch-mode analyzers, a single measurement data point may only be generated once every 15 minutes. As such, an argument can be made that there is sufficient time, and no disadvantage to, switching samples.

Figure 1: Batch Analyzers such as those for silica require time to mix the sample with reagent to produce a measurement

Figure 2: Continuous-mode analyzers such as electrochemical sodium monitors use electrodes (indicated by red arrows) in constant communication with a flowing sample

Sample Integrity

Intermittent measurements made through sample stream switching may be considered acceptable on the basis of the level of understanding of the process to be analyzed and the criticality of its sample points. When this is the case, it is crucial that the sample integrity be maintained to achieve an accurate measurement.

According to ASTM D3370 (Standard Practices for Sampling Water from Closed Conduits), samples shall flow continuously even where analyses are performed on a batch basis. Continuous flow helps ensure that the sample conditions (temperature, pressure, cleanliness, flow rate) are maintained by minimizing the possibility for spikes in concentration of the chemical species being measured. Interrupted flow can lead to unwanted effects such as stratification, reactions and sorption on tube walls.

For a sample sequencing system, this means a valve arrangement that allows offline streams to continually flow. In addition, dead volumes must be minimized and samples with similar concentration and chemistry used so as not to influence concentration measurements when switching between streams. As an illustrative example, it would not be good practice to switch between samples from the inlet of a cation exchange column and its outlet.

Absolute or Relative Measurement?

Even the most carefully designed sample sequencer adds complexity to the overall flow path from sample point to analyzer. Consequently, for the most critical of measurements, dedicated sample lines will always provide the highest likelihood of achieving absolute accuracy. Here "absolute" refers to the true actual value of the parameter.

In particular for a low reading approaching zero, however, there is a case to be made for cycling multiple sample streams through the same analyzer. Measurements obtained this way provide an accurate relative comparison to one another since sources of error that can arise by using different analyzers are eliminated. These sources of error may be related to differences in calibration, reagents, or electrode life.

To highlight the relative differences between sample points quickly and accurately requires careful attention to the fluidics design of the sample sequencer. The main onus is on the sample sequencer design to ensure the flow path has minimal dead volume and that channels are sized for maximum flow velocity while keeping pressure drop reasonable. Using conductivity pull-down, Figure 3 shows subtle changes in fluidics design have a material impact on required flush time.

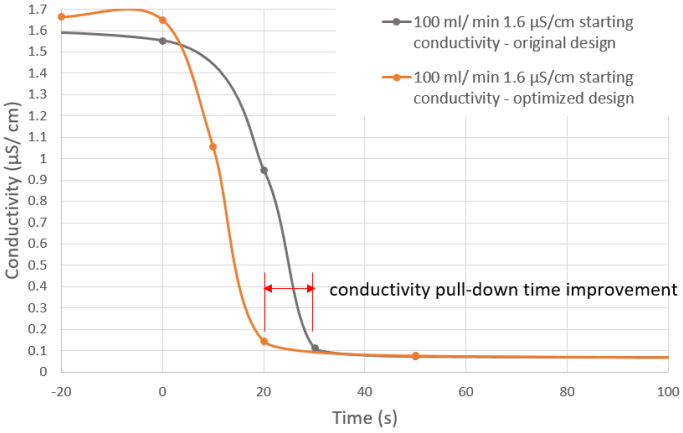

Figure 3: Effect of Fluidics Optimization on Sample Stream Stabilization

The operator also plays a role to ensure that the sample sequencer is configured to provide adequate flushing time between samples. Here, a balance needs to be struck between ensuring the system is thoroughly flushed and maximizing the amount of time available for sampling. This may require historical data analysis as well as some testing to achieve. For continuous-mode analyzers, a sample sequencer with a trend chart feature can be used to visually confirm that a measurement has leveled out to determine when to transition from flushing to sampling. In addition, the operator can influence flush times by varying sample flow rate. Higher flow rates significantly reduce flush time since they not only transport the old sample out quicker but also increase shear rate in flow channels.

Automated Sample Sequencing

Sample sequencing can be done on a manual or automated basis. While manual sample switching may be appropriate for a lab environment, automated switching is the likely choice for production environments.

When switching samples, no longer is there a one-to-one relationship between the sample point and the analyzer display. It becomes important for the sample sequencer to provide a clear indication of the current measurement and its source but also the status of sample streams not being sampled at that moment (see Figure 4).

A default set of configuration parameters to establish a starting point for further optimization will help commission systems as quickly as possible. As such, a sample sequencer should be equipped with an analyzer library from which an operator can select the model they are using to load the corresponding operating parameters.

Conclusions

Sample Sequencing, and in particular the automated variety, can deliver benefits in a production environment such as reduced capital costs and precise relative comparisons between sample points. Clearly, replacing a number of online analyzers with a less costly sample sequencing device will provide a savings on equipment costs.

Where it is important to know the accurate absolute value of a particular measurement or have the earliest possible detection for an out-of-tolerance parameter, dedicated analyzers have a distinct advantage. By simple virtue of the fact that adding a switching device before an analyzer increases sample circuit complexity, it is impossible for absolute accuracy to be enhanced.

The decision to deploy sample sequencing will depend on the specific process and sample points being analyzed. In the example of a power generating plant, the guidelines and specifications of the turbine manufacturer and technical organizations such as the EPRI (Electric Power Research Institute) and IAPWS (International Association for the Properties of Water and Steam) should be followed.

Figure 4: Clear User Interface Design is Essential in Deciphering Status Across Several Sample Streams

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