

Integrate water, steam sampling with chemical feed

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Owners of many gas-turbine-based combined-cycle and cogeneration plants are increasingly parsimonious when it comes to capital expenditures and plant staff. At the same time, turbine manufacturers are tightening the water/steam purity requirements for their units.

The contradiction: Increased manpower is needed to monitor and control to the tighter specifications at a time when there are fewer personnel onsite. One solution to this dilemma is to integrate water/steam sampling with chemical feed systems. This article focuses on one set of criteria that has been used to develop such an integrated system for heat-recovery steam generators (HRSG).

Sample panels are among the last items considered in the design of a powerplant and among the lowest in priority for capital upgrades (Figs 1, 2). It is difficult to quantify the cost benefit of avoiding a failure that may not happen for 10 years. Simple fact is that very few chemistry upsets will have an immediate, catastrophic impact on powerplant equipment.



1, 2. Sample panels are among the last items considered in the design of a powerplant and among the lowest in priority for capital upgrades

Sampling systems almost always are designed for the lowest capital cost to meet the engineer/constructor's specifications—perhaps because there is little appreciation for the positive impact that timely and accurate steam/water analysis can have on the owner's goal of reliable operation and top performance. It is the rare engineering firm that has on-staff personnel with substantial, practical experience in water treatment. The result: Sample panels generally are not capable of meeting today's exacting standards.

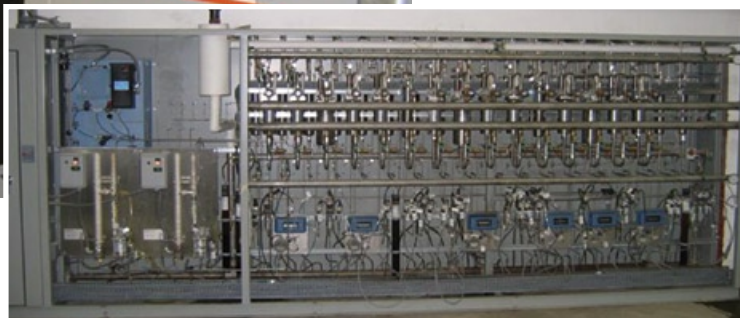
Panel design begins with proper sizing of the sample line. Because sample lines are field-run piping, there is no true design of the line. The size of the line at the sample panel typically becomes the size of the line to the source. However, sample-line size is extremely important and it should be part of the specification given to the panel manufacturer.

Line size should reflect the lag time of the sample and its velocity in the line, as well as the pressure drop from the source to the panel. For your system, consider limiting lag time to less than five minutes. Longer periods make tuning of the control system progressively more difficult. As for velocity, it must be high enough to prevent sedimentation of particulates—extremely important in a cycling plant—yet low enough to ensure that the pressure drop is not so great to prevent the sample from passing all the way through the analyzer. This translates to a sample pressure of 30 to 40 psig at the panel, depending on the exact configuration of the panel.

Ensuring adequate sample flow is extremely important. Instrument manufacturers say most analyzers are capable of operating with a sample flow as low as 50 cc/min. But such a low flow is extremely difficult to control when it is one of several streams. Minor fluctuations in pressure may stop the flow completely, losing the ability to monitor a given parameter and control chemical feed based

on that reading. Average flows of from 150 to 200 cc/min per analyzer *and* the grab sample allow for consistent monitoring and control.

For example, the HRSG's high-pressure drum sample is used as both a grab sample and to test for specific conductivity, pH, silica, and sodium—five samples at





3. Blowdown lines at top of panel are provided to flush sample lines at the beginning of each startup

200 cc/min totals 1 liter/min. Flow impacts the size of the sample coolers and chiller, so keep your estimates realistic to avoid installing unnecessary cooling capacity.

Sample conditioning

A common design failure is omission of secondary coolers and a chiller for precise temperature control. Samples above 100F, for example, cannot be cooled with cooling tower water in the summer because most cooling towers are designed to provide about 100F circulating water at maximum ambient temperature. Although manufacturers say their analyzers will “work” at temperatures up to 120F, a close look at the curves used to compensate for temperature reveal inconsistency in high-purity water over 100F. Instrument drift at high temperature can mask a developing chemistry problem. The optimum temperature for analysis is 77F.

The cooling capability installed should be sufficient to satisfy the 77F requirement at maximum sample flow to all analyzers simultaneously. This ensures reliable use of the sample panel and automation of control under all conditions.

Also important is temperature protection to guard analyzers against improper operation of sample coolers. The potential for extremely high-temperature samples reaching the analyzer is very real. Scaling and an interruption of cooling-water flow are two causes. Thermal valves or switches properly located offer very inexpensive insurance.

Analyzer selection is impacted by system chemistry and HRSG operation. To illustrate: A cycling plant on a phosphate program should not use phosphate analyzers. Hideout during rapid load swings makes this constituent problematic for control. Phosphate analyzers also are expensive to buy and maintain. Phosphate feed based on existing steam flowmeters is sufficiently accurate for reliable con-

trol without adding additional flowmeters to the system.

Dissolved oxygen (DO) analyzers traditionally have been cumbersome to maintain and, therefore, unreliable in the field. They are improving in quality; however, the jury is still out on the latest models. The Electric Power Research Institute, Palo Alto, Calif, recommends the use of ORP analyzers for controlling DO in oxygenated systems. Recall that oxygenated treatment is suggested only for large, tight, base-load plants.

ORP analyzers provide better response for control of oxygen scavengers and are less expensive than DO instruments. Correlating the ORP reading to a specific DO level allows the ORP analyzer to control scavenger feed. But since DO normally fluctuates rapidly, it is not recommended as the primary parameter for control. Feedwater or steam flow is suggested for feeding a base level of scavenger and then using the ORP output to trim about 10% of the pump control signal.

One of the most significant changes to steam-turbine warranties is a decrease in cation conductivity to from 0.25 to 0.30 microSiemens/cm. It is relatively easy to achieve water quality of that purity, but steam samples are influenced by the amine and CO₂ that exist in steam. Therefore, to demonstrate that chlorides and sulfates are not the source of conductivity in your steam—these being the constituents of greatest concern to the turbine OEM—degassed cation conductivity should be monitored. This requires addition of a reboiler to the sampling system—a worthwhile investment to confirm that you are within warranty specifications on major equipment.

Operational considerations

It is important to understand how plant personnel will use the sample panel and to factor this into the design. Operators are time-challenged and cannot baby-sit instruments. They must work consistently and reliably. Panels planned with the operator in mind will be used and maintained as intended. The plant owner is the beneficiary here. Some of the questions you should ask:

- Can the panel accommodate crud bursts associated with cycling HRSGs?
- Does it adequately protect the analyzers from plugging?
- Are the probes configured to ensure consistency even after periods of lay-up?

Crud burst is becoming a common term in cycling plants. It refers to the release of hematite

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that coats metal surfaces as HRSGs flex in going from cold to hot to cold. Often this particulate matter will be sufficiently concentrated to turn sample water black. This would overwhelm any inline filter. The solution: Install a blowdown valve (Fig 3) in the sample line upstream of the panel and flush the line for 10 to 15 minutes at the beginning of each startup. If this is not sufficient, extend the blowdown period. It is important to blow down to a flash tank, not the waste drain header. Reason: Drains flashing in the latter can back up into and damage sensitive equipment.

After the sample lines are properly drained, inline filters can deal with the occasional particulate matter that would plug analyzers. Quality filters are important, particularly on all lines with high-pressure samples and also those serving sodium and silica analyzers because of their orifices and small capillary tubes.

Lowest cost is not always the best price. To minimize cost, panel designers often opt for polyacrylate rotometers in place of glass. They save \$1000-\$2000 for the entire panel. Poly rotometers stain easily and generally require replacement by the end of the plant's commissioning. But they're often not replaced, in the name of cost-cutting. Eventually operators can't read the flow and balancing flows becomes an issue. Glass rotometers are easily cleaned with a cotton swab in less than a minute.

Vent entrained air. Air affects conductivity and pH readings. Positive venting eliminates air as a potential source of erroneous readings. You can do this by installing probes at a 45-deg angle (Fig 4) and ensuring that sample flow is up. However, be sure that the probe's discharge line is not elevated above the probe—this to prevent the siphoning of water from the fitting and leaving the probe dry. A dry pH probe will be irreparably damaged.

Patch panel. Incorporating a so-called patch panel is a simple design enhancement that greatly facilitates troubleshooting. It is a set of female quick-disconnects mounted between the wet and dry sections of the sample panel. Every sample stream that does not already pass through the shared analyzers has a connection. There also is a connection for each shared analyzer.

This configuration allows for a connection between any stream and the shared analyzers (silica and sodium). By including a sequencing module, a sample can be tested immediately or placed in the sequence queue for long-term troubleshooting—for example, testing for sodium or silica in the condensate. Such additional capabilities can be available without adding a single analyzer.

Layout is another problem found in sample panels. What this means is that there is no pattern

to the layout of the sample lines and/or the analyzer monitors, making it difficult to learn a panel and quickly monitor readings. During periods of system upset, wrong readings can lead to poor decisions.

Good ideas reduce costs

Some cost-cutting ideas discussed previously were not well thought out, marginal at best. Here are two ideas that can reduce initial cost and not compromise operations:

■ Sequencing sample streams can save about \$10,000 each on sodium and silica analyzers. Limiting the sequencing to four samples per analyzer still maintains two to four samples per hour—sufficient to adequately monitor trends. If a particular stream is suspected of being “bad,” the sequencer can be programmed to monitor that stream continuously. One of the sample points should be reserved for the patch panel to provide superior troubleshooting capabilities. Additional savings from sequencing come from reducing the physical size of the panel.

■ Standardizing on a single manufacturer for “dry” analyzers may bring a quantity discount and beget better service. Multi-channel monitors can contribute by reducing panel size and by providing an installed spare to serve the entire panel. Latter eliminates multiple spares (one spare per analyzer) and helps reduce cost without compromising analysis capabilities.

Substantial savings can be had in sample panels when

generating companies standardize on a particular design for all their plants. The benefits of fleet-wide standardization include these:

■ Less time and effort is required to prepare quotations. Estimated component and labor costs have a sound historical basis.

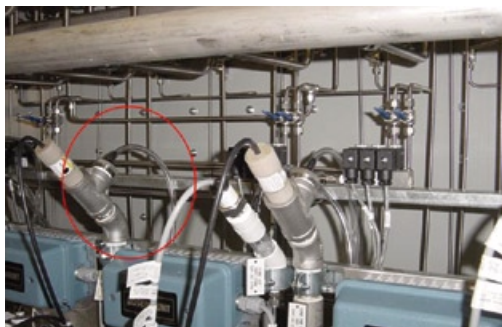
■ Engineering cost is lower. Updating of an existing drawing typically is all that's required.

■ Shop labor costs are less. Project is one of replication not a first-time event.

■ Vendor evaluation is simplified. Panel suppliers know what is expected in their quotations and generally take far fewer exceptions.

■ Engineering review is simplified. Ambiguity between vendor drawings and requirements is minimal. Drawings follow a standardized format, making them easier to review.

Proof of a standard design's benefit is offered by way of example. Quotes to one owner based on a draft version of its specification varied by up to 100% during the vendor qualification phase of the project. After qualifying three vendors to bid on a final specification, quotes are now within 5%, first to last. For some sample panels based on a standard design, the top two bidders can be within a few hundred dollars. CCJ



4. Positive venting achieved by installing probes on a 45-deg angle eliminates air as a potential source of erroneous readings