Intermission control: Reducing downtime risk to HRSGs

By Steven C Stultz, Consulting Editor

The trend from baseload to cycling service (and short- or long-term layup) in the "renewables era" seems inevitable and universal. Regardless of original HRSG design, the physical stresses and atmospheric impacts become more hostile with age. It is all too common to overlook these forces until significant damage is done. For older units (Fig 1), it can be even more troubling.

1. Frederickson 1 is a 249-MW 7F-powered combined cycle with a vintage HRSG

2. Typical stack balloon slopes toward the access for moisture drainage

The need for caution

Any amount of downtime can hurt most equipment. At last year's Australasian HRSG Users Group (AHUG 2015) meeting, while discussing layup at Stanwell Corp's 375-MW Swanbank E power station in Queensland, Dr Barry Dooley of Structural Integrity Associates Inc, San Jose, Calif, added a post-presentation comment: "Any storage above three days poses a critical risk to the LP steam turbine." The topic was corrosion (see CCJ 4Q/2015, "Deep dive on HRSG and cycle chemistry make this meeting special," p 8).

For most attendees, three days seemed a short time for critical risk. And what about the HRSG? Industry experts generally recommend maintaining relative humidity in both the LP turbine and on the gas side of the HRSG at less than 40%. So even a short cooling of HRSG components calls for caution.

Consider also the temperature differences between night and day. Metal temperatures lag, so tubes cooled overnight condense the warmer daytime humid air, leading to corrosion. In this reverse-draft scenario, air enters the stack and exits through the gas turbine.

Corrosion, in turn, adversely affects HRSG performance and can soon increase backpressure and de-rate or trip the plant. Air likes to move. Tube, fin, header, casing, piping, and hanger corrosion all are probable outcomes.

Ambient conditions (whether seasonal or geographic) compound the need for protection. In most locations, spring and fall coincide with higher ambient humidity and precipitation. The important point is that as temperature and humidity cycle, HRSG system components can attract condensation. This can be considered another form of dewpoint corrosion, but now entire sections are at risk.

And if not removed, corrosion products compound their damage and can become particulate emissions at restart.

Thumb rules

A recent industry event offered some rules of thumb, along with definitions, for both gas-side and water-side components in cycling service:

- Short-term wet storage, less than seven days.
- Long-term wet storage, seven to 30 days.
- Dry storage, more than 30 days.

Some units, like the one discussed below, exceed the 30-day shift to dry

3. The GT exhaust-duct balloon, a multi-purpose isolation barrier, was installed first at Frederickson (left)

4. Desiccant dehumidifier maintains humidity at less than 40% on the gas side of the HRSG (above)

storage with nitrogen capping, pH checks, and by circulating water and filling as required.

Each time period has specific requirements, but the fundamental owner/operator goals are the same:

- Reduce the potential for gas-side and water-side corrosion.
- Allow restart as quickly as possible (and achieve proper chemistry on the water side).
- Retain maintenance access (and attention).

Isolation barriers

Whether short term (bottling up) or longer term, the first rule is to impede draft. One such strategy, either partnered with or as an alternative to stack dampers, is custom-manufactured balloons (Fig 2). When also used at the HRSG's turbine exhaust inlet (Fig 3), these become the first line of defense against corrosion (CCJ 1Q/2010, "Preservation program works for outages from one month to several years," p 92).

According to Gary Werth of G R Werth and Associates Inc, North Riverside, Ill, "stack and duct balloons are increasingly common and highly effective methods of creating isolation barriers to reduce offline corrosion issues in both HRSGs and gas turbines. For various reasons, primarily high dewpoint and high humidity, corrosion can become significant within days of a shutdown. Potential corrosion carryover at next startup complicates the issue and adds to potential system damage."

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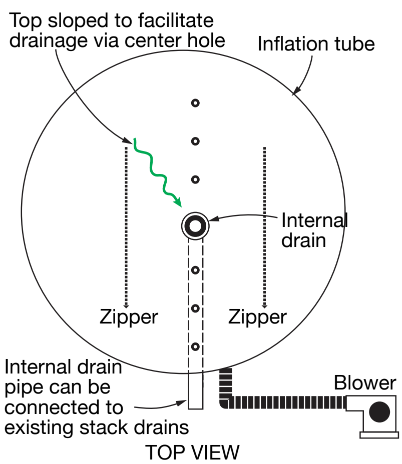
Balloon drain enhancement

In the stack balloon design used successfully at Frederickson 1, the top balloon surface is tilted toward the access door opening to permit water runoff. Collected rainwater then runs down the outside of the stack. It does the job; there are more than 100 installations of this type operating around the world.

Although effective, designers have developed an improvement applied recently in Thailand. This latest design (drawing) lets the plant connect the new stack balloon drain line to the existing stack drains. The balloon's top surface is pitched toward the middle to funnel rain water towards the center drain hole. Once the water is collected, it is transported through the internal PVC drain line to the perimeter edge and the stack drain system.



The standard stack balloon has two basic objectives:

- Prevent precipitation (rain, snow, ice) from traveling down the stack and affecting the HRSG.
- Block the natural air flow that would occur because of the pressure differential between the GT inlet and top of stack.

And there are more, all related, including but not limited to:

- Eliminate daytime condensation on HRSG components whose temperatures lag behind those of warmer ambient air (by reverse draft).
- Maintain HRSG heat for more efficient startup. Formerly wet-storage cold starts can become warm starts and formerly wet-storage warm starts can become hot starts.

Example. Use of balloons in, for example, a combined cycle during a weekend shutdown in cold weather can, according to published reports:

- Retain residual heat in the HRSG and prevent freeze-ups.
- Hold temperature below the balloon at 100F when the outside temperature is 20F.
- Reduce or eliminate sparging requirements.
- Reduce offline corrosion potential, fuel use on warm startups, equipment stress fatigue attributed to cold starts, opacity at startup, and/or tube and fin cleaning needs before startup.

Case history

Frederickson 1 Generating Station is a 7FA-powered, natural-gas-fired 1 × 1 combined cycle located near Tacoma, Wash. This rejuvenated and upgraded

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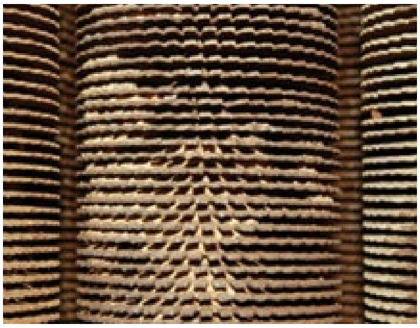
facility began commercial operation in 2002 and can produce up to 275 MW with supplemental duct firing. A nearby peaking unit, similarly named, can provide an additional 147 MW.

The refurbished plant features a 1992-vintage HRSG packed with finned tubes in the back end, originally meant to compete with coal-plant steam capacity and heat rate. Maintenance was secondary. Although somewhat unique in its age, Frederickson typifies many of the risks that all owner/operators need to target in their inspection, maintenance, and planning cycles.

Frederickson LP, part of Atlantic Power, holds power-purchase agreements (PPAs) with three public utility districts in the state. The area's power-generation environment (Puget Sound Energy, which owns just under half of the plant's output) lists, in order of preference for its "diversified portfolio strategy," hydroelectric, wind, natural gas, and imported coal-fired power from Montana. Hydroelectric is dominant (with seasonal peaks); gas-fired power is about 20%.

Therefore, Frederickson is faced with both short- and long-term cyclic operation.

Ric Chernesky, plant manager, explains the benefits of the stack balloon added in 2013, "We first looked at installing stack dampers, mainly because of all the rain in this area. Instead, we bought two balloons—one for the stack and one for the turbine exhaust. This made our HRSG a nice enclosed vestibule."



5. The tightly packed LP tubes are subject to both corrosion and fouling by ammonia salts

The plant also modified the roof penetrations to avoid standing water and moisture seepage. As Chernesky explains, "If moisture hits the ammonia deposits you get a change in pH right away and it turns into stalagmites; it's ugly." The changes have also reduced moisture damage to the SCR catalyst.

In late 2014, Frederickson worked with Applied Systems Northwest to design and purchase a Munters desiccant dehumidification system to use when offline, controlling humidity to 40% or less (Fig 4). This part of the program included the dehumidifier, a new motor control-center breaker, conduit and wring runs, supply and return ductwork, and HRSG access doors.

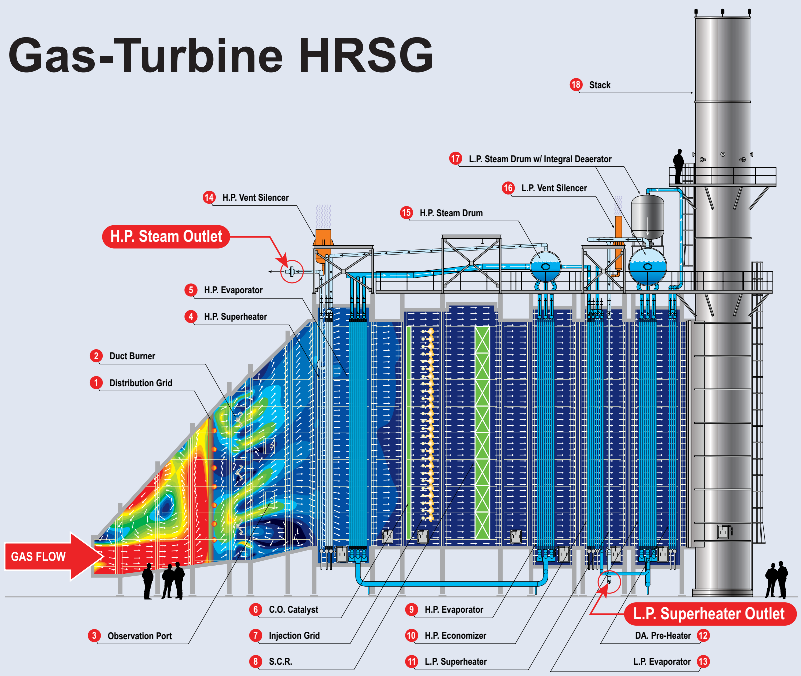
With the HRSG's congested back end (Fig 5), the plant had experienced severe buildup of ammonia salts beyond the SCR. "Now that we can close off the HRSG and control humidity," explains Chernesky, "the tensile strength of these ammonia salts has gone down and they're more brittle (less moisture). They come off a lot easier."

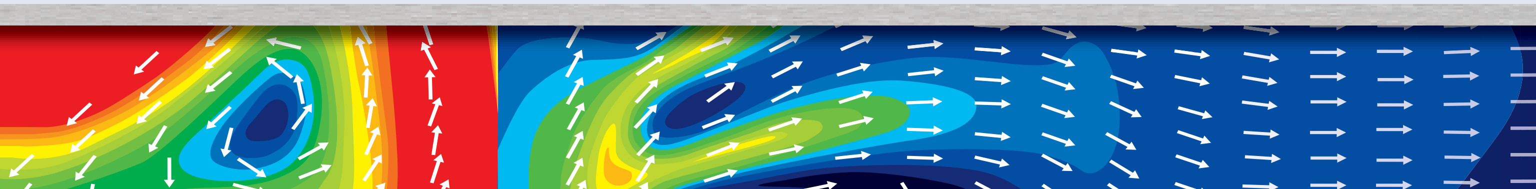
Balloon handling

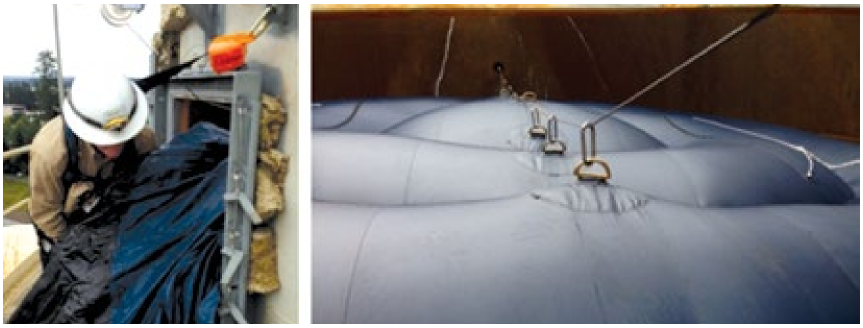
Chernesky notes that "'Freddie' normally averages 35% to 50% capacity factor depending on the amount of rain. We usually get nine to 12 starts per year, some with short downtime, and we'll run anywhere from one week to three months. We put the balloons in six or seven times each year."

Inflated, the duct balloon is slightly larger than 18 ft in diameter and 5 ft deep. The stack is 18 ft in diameter and required a new stack door and platform at elevation (Fig 6).

"Balloon installation is much faster than we thought it would be," he states. "We can generally have them both installed within about two hours, with a crew of two."







6. Access door and platform were added to accommodate the stack balloon (left); guy wire (right) holds the balloon during placement and is retracted during plant operation

"We've learned a lot over the last 10 years or so," he continues. "We know a great deal now about corrosion control of the carbon steel, including the casing. These balloons, along with the dehumidifier, have helped us immensely."

Tube cleaning improves

The overall HRSG protection program has shown good benefits over time, says Chernesky. "We did our own cleaning for a few years, and even had special hoses and nozzles. But our LP sections are 14 rows deep, and we could only get four or five rows in," he explains.

Working with Precision Iceblast Corp, Peshtigo, Wisc, which was supported by HRST Inc, Eden Prairie, Minn, Frederickson can now get eight rows in from the access lanes. Chernesky notes that this progress results from tube-spreading techniques—including staging, improved media nozzle designs, and improved mixing of ice and air (at the nozzle) for maximum cleaning efficiency. Pressure has increased from 250- to 350-psig air at the nozzle.

"This has reduced backpressure by a couple of inches," he notes, "primarily from our LP preheater and evaporator."

His use of the term "protection program" is appropriate. In Frederickson's case, it is taking on older unit and applying attention and technology improvements to make it operate extremely well, even by new-unit standards.

Continual improvement

During its 2016 outage, Frederickson 1 continued its technical move forward by replacing the SCR catalyst bed and adding a sampling grid for fine tuning. This work was done by Groome Industrial Service Group Inc, Waldwick, NJ, within an 11-day outage window and included the removal and disposal of the existing catalyst plus installation of new Haldor Topsoe A/S catalyst.

"Flow through the SCR is not laminar," explains Chernesky, "and we can now sample across the catalyst bed, not just at the sampling blocks. We can add ammonia to specific areas. This way we have less unreacted ammonia slipping through the SCR." In a further advancement, Frederickson can now back-blow the catalyst at low pressure to extend its life.

Frederickson 1 continues to improve because Chernesky and the lean staff continually look for opportunities. He sums it up perfectly: "You've got to share information and learn from others. I'm interested in anything that can help make us better here. Every little bit helps." CCJ