

HRSG Gas-side Cleaning

The dollars and sense of clean boiler tubes

Fouled finned-tube bundles in heat-recovery steam generators (HRSGs) can penalize your bottom line by hundreds of thousands of dollars on an annual basis, so it makes good sense to call in a qualified cleaning contractor—periodically (every year or two) or when pressure drop reaches what you decide is the “action-required” level.

According to Keith Boye of Precision Iceblast Corp (PIC), Wallace, Mich, every additional one-half inch (water column) of pressure drop through a typical F-class HRSG reduces your bottom line by about \$100,000 per annum—depending on the price of fuel. There are no guarantees on how much a given cleaning will reduce your backpressure, but a rule of thumb is that a proper cleaning can recover half of the increase in pressure drop over the as-designed value.

An informal poll by the editors of users attending a recent industry meeting revealed that owner/operators were most likely to contract for cleaning when the pressure drop reaches about 3 in. H₂O above the as-new delta p. Payback on the investment should be three or four months at that point, they said, and typically acceptable to management.

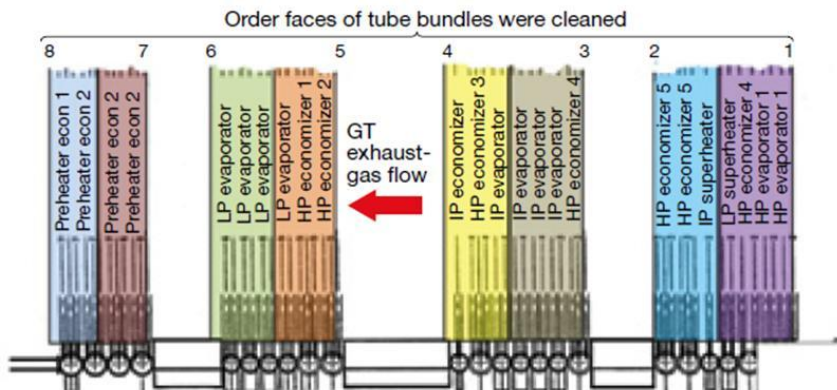
The users generally agreed that corrosion products are relatively easy to remove from finned-tube panels, provided there’s sufficient access space. By comparison, ammonia salts are difficult. The biggest challenges typically are found at plants not regulated on slip, where there may be a temptation to overfeed ammonia as a way to assure that NO_x emissions are maintained within permit limits. Plants burning gas with above-average levels of sulfur also run the risk of severe fouling.

What cleaning medium? Contractors often rely on dry ice to remove deposits, sometimes high-pressure air, water, or grit blasting. A few plants have installed sonic horns to extend cleaning intervals, but they have not been successful in all cases. Several users warned against the use of water because it can turn otherwise manageable deposits into “concrete.” Plus, water can contribute to corrosion of the HRSG floor, damage insulation, and shorten the lives of penetration seals.

Identifying the proper cleaning medium for your plant requires some research. Two variables particularly important to decision-making are foulant tenacity and the extent of fouling, Patrick Walker of HRST Inc, Eden Prairie, Minn, told the editors. You want to know how tough it is to remove and how deep the fouling penetrates each heat-transfer section. Then you can develop a procedure for its removal and an operating plan that would slow the deposition rate. A recommended first step is foulant characterization.

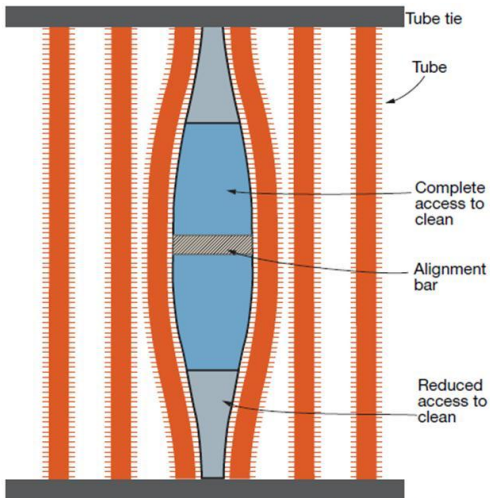
Not all foulants are created equal, Walker reminded. A thorough gas-side inspection and pressure-drop

evaluation are an important part of your research. Comparing the latter to the delta p after cleaning will put hard numbers on the value of “clean” tubes. A before/after analysis also will help you predict the optimal time for the next cleaning.

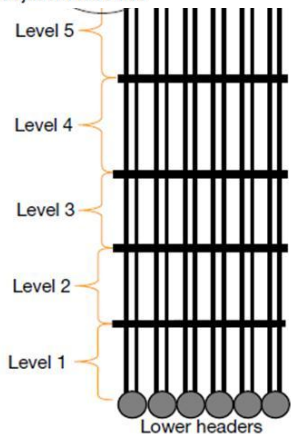


1. Tube bundles with the eight coolest faces in this HRSG were scheduled for cleaning using both dry ice and air, in sequence. Note the order of cleaning in the direction of exhaust-gas flow. Upstream face of HP evaporator 1 was cleaned first, the downstream face of HP economizer 5, was second, and so on

Like foulants, not all cleaning contractors are created equal. There is some technology and engineering, in addition to fouling science, that you should know about before selecting a contractor (sidebar). For example, tube spreaders—so-called alignment bars—developed and patented by

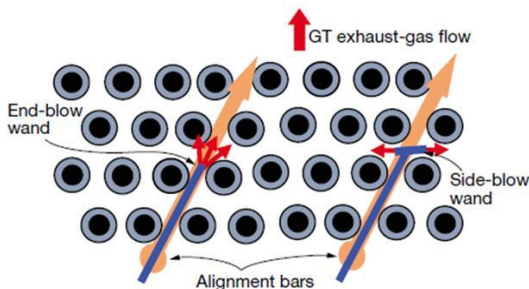


4. Shape of the cleaning lane is roughly elliptical. As sketch shows, access for cleaning is not uniform between adjacent tube ties



2. F-class HRSG had six cleaning levels separated by tube ties

The design of this HRSG is characterized by staggered 1.5- and 2-in.-diam tubes with varying fin heights. Tube length nominally is 70 ft. The tube bundle closest to the stack is 12 rows deep, the next box is 14 tube rows deep, and the final two are 15 tube rows deep. According to previous inspections, the majority of the debris present is rust flakes.



3. Alignment bars open tube lanes and permit relatively easy access by both end- and side-blow wands for most of the tube length between tube ties

a technical advisor (TA) checks cleaning effectiveness, making changes in procedure, air pressure, and/or cleaning heads as necessary. Then the remaining sections of the HP evaporator 1's upstream face are deep-cleaned. There's another TA check at this point, before moving equipment to the next downstream access lane. The procedure is repeated for each of the remaining seven faces.

Alignment bars are inserted into the face of tube bundle being cleaned, level by level, at a location roughly equidistant between the tube tie above and the one below. The technique is illustrated in Figs 3 and 4.

HRST enable deep penetration of cleaning wands into a tube bundle to access as much heat-transfer surface as possible. Tube spreading is not for amateurs. You need boiler design experience to calculate tube stresses associated with spreading. Get too aggressive opening up cleaning lanes and you can have real problems.

HRST also designs its own compressed-air nozzles to maximize cleaning effectiveness. It is not unusual for the company to customize cleaning heads to accommodate a boiler's idiosyncrasies.

A team approach to cleaning may beget best results, agreed Boye and Walker. When their companies work together, PIC brings to the table the cleaning know-how, HRST the engineered solutions. For simple jobs involving shallow tube banks—that is, four tube rows deep or less—most traditional "surface blasting" methods provide favorable results, unless the foulant is particularly tenacious. Walker described surface blasting as a cleaning method where the lance doesn't penetrate the "surface" or plane of the tube field. What you can see, you should be able to clean, Walker said.

In tube banks that are deep or have very close tube spacing, it is important to have tools to assure success—like those described above. A step-by-step plan is important for achieving top results. The information required to develop a plan might come from photos taken by HRST during a recent unit inspection. If those are not available, PIC will do a gas-side walkdown to determine the degree of fouling, to decide where spreading is necessary, etc. HRST gets design details from boiler drawings to customize cleaning heads and provide input to procedure development.

Cleaning procedure

The procedure HRST and PIC prepared for cleaning a 10-yr-old, F-class, double-wide HRSG in the Southeast illustrates the level of planning required for success. The tube bundles downstream of the SCR's ammonia injection point were scheduled for cleaning (Fig 1). The assessment by HRST/PIC indicated that a combination of CO2 blasting and deep cleaning with high-pressure air would accomplish the owner's objectives.

CO2 blasting is relatively straightforward. The cleaning cycle begins in the stack and works opposite of gas flow towards the HP evaporator 1 face at the extreme right in Fig 1. Work begins at Level 1 and proceeds to Level 6 and back down to Level 1 (Fig 2)—two passes of dry-ice blasting for each of the eight tube-bundle faces. Then the process is repeated moving by blasting each face in turn from the HP evaporator to the stack.

Best practice: When blasting, follow a standard cleaning pattern to be sure debris is removed from each tube. Do not randomly move the cleaning wand all over the tube face.

Deep cleaning takes more time than blasting. It begins on the upstream face of HP evaporator 1 at Levels 6 and 5. When done,

Once tubes are spread on one level, the side wand uses high-pressure air to clean above and below each alignment bar as it is moved deeper into the tube field. Penetration of the tube bundles should be five or six tubes deep from either side, meaning foulant will be removed from most tubes.

Next, the end-blow wand is used in areas tough to reach with the side-blow wand—such as near tube ties, around any physical interference, etc. When a given level is finished, alignment bars are removed and moved down to the next level. At the end of the job, be sure to go up and down the face of each tube bundle to verify cleanliness. Bring along a borescope to look deep into the tube bundles.

The editors spoke with the plant supervisor responsible for overseeing the tube cleaning project to learn more about the benefits accrued. Unfortunately, with other work going on, including change-out of the control software, as well as inconsistent run time, definitive performance numbers couldn't be compiled.



5. Tube bundle is fouled with rust and other deposits



6. First cleaning pass using CO₂ eliminates most deposition on tubes near the face of the tube bundle



7. Alignment bars are inserted by protected technician to spread tubes and allow deeper penetration of the cleaning wands

A photo record of another cleaning project illustrates the qualitative effectiveness of a combination CO₂ blast and HP-air deep cleaning program. Fig 5 presents the challenge, Fig 6 shows how CO₂ eliminates debris at the face, Fig 7 shows stakes in place to enable deep cleaning, Fig 8 confirms the effectiveness of deep cleaning, and Fig 9 shows debris at the bottom of the unit piled more than 18 in. deep in places. Upwards of 7 tons of rust and other debris were carted away from this HRSG.

You can do back-of-the-envelope calculations on the economic value of tube cleaning using the following information from GE report GER-3567H, which states that for a 7EA a 4 in. H₂O exhaust pressure drop over design translates to:

- * Power output loss of 0.42%.
- * Heat-rate increase of 0.42.
- * Stack temperature rise of about 2 deg F.

The maintenance manager for a 7FA-powered combined cycle said he believed the numbers were about the same for his unit. He added that the backpressure alarm is set at 20 in. H₂O on his turbines and that they trip at 24 in. CCJ



8. Effectiveness of tube spreading is evident by comparing this photo with Fig 6



9. Foreign material removed from finned tubes must be collected and sent to a landfill

Qualifying candidate cleaning services

Important to the success of any HRSG gas-side cleaning project is selecting a contractor with the technology and experience to deliver the expected results. Consider seriously a face-to-face interview with each candidate, at a job site if possible.

You often learn more from seeing than from listening. Here are a few ideas to help you begin compiling the list of questions for your interviews:

- What's the prospective contractor's experience? Ask for references, including at least one from a plant with the same HRSG you have, and at least one from an OEM.
- How much repeat business does the prospective contractor have? How many long-term contracts?
- What's the experience of the prin-

cipals who will be running your job? Ask for resumes.

- Will the personnel assigned to your project be employees of the contractor of record or will they be local hires with little or no relevant experience?
- How many people will be on the cleaning team, how many nozzles will be operated simultaneously?
- How many passes will be made on each face? How much time will be dedicated to cleaning each face?
- What cleaning medium would the contractor use on your job? What pressure? High pressures may be needed for severely fouled tubes. Keep in mind that if the cleaning pressure is too low to remove a particular deposit, there is the chance

of debris being packed into downstream tubes, making the deposit even more difficult to remove. Can the contractor work at pressures up to 350 psig, or higher?

- Does the contractor have the know-how to spread tube rows (without damaging them) to facilitate access to fouled heat-transfer surfaces and assure a proper cleaning? Note that HRST's patented tools and tube-spreading procedure for deep cleaning have been licensed only to Precision Iceblast Corp and Master Lee Industrial Services.
- Will the contractor's supervisor escort you on a full inspection up and down the faces of accessible bundles to assure your satisfaction with the job?