ALLOWING FOGGING ON 7FA

SUPPLIERS CARVE OUT APPLICATIONS IN F-CLASS SYTEMS DESPITE EARLY NEGATIVE PUBLICITY

A lot has changed since that spring day in 1988 when Jim Nolan and Vernon Twombley fired up the world's first turbine inlet fogging system at the American Atlas Cogeneration plant in Rifle, Colorado. Fogging is now a standard method of cooling down the air and increasing air mass flow in order to improve efficiency and boost output.

Despite early concerns about potential blade damage, most turbine manufacturers today offer their own fogging systems. Several third-party firms retrofit existing units. Mee Industries, for instance, has installed fogging units on the Midland Cogeneration as well as in Unit One at Coyote Springs described below.

In 2009, when Midland Cogeneration, the largest cogen facility in the U.S., wanted to install inlet fogging systems on all 12 of its ABB 11N gas turbines, "The OEM had no concerns," says Brian Vokal, Midland's Performance Engineer.

This is not to say that there is no chance of incurring blade erosion. But with a properly designed and operated turbine and fogging system, the risk can be minimized, observers say, and point out that fogging provides significant advantages in terms of increasing power when required.

The Rolls-Royce Trent 60 WLE, for example, uses a fogging array downstream of the inlet filters and spray rails in the bell mouth to provide overspray into the Low Pressure compressor. The Trent 60 WLE also injects water into the combustor for flame quenching and to reduce NOx formation. Using the water boosts power output by 15% - 30% and cuts the heat rate by 3% - 6%.

"We have hard-faced the blades with laser peening, which increases the erosion protection level by four to five times compared to the normal hard metal of blades," says Scott Nolen, product director for the Trent. "In addition, since the erosion rate is related to the cube of the water droplet size, we keep the droplet small, which greatly reduces the risk.

One model, however, that may be problematic is the GE F Class. Since 2001, GE has issued a series of warnings in Technical Information Letters (TILs) about using online water washing, evaporative cooling systems or fogging systems on its units. It has issued limitations on the number of hours owners can run cooling systems or even how often they can perform online compressor washing.

This has been prompted by one instance where a blade broke loose on a 9FA, fogging suppliers say. They are questioning whether the root cause is really fogging, since there have been reports of blade damage in units not fitted with fogging systems.

A Case of hydrophobia

In the summer of 2001, GE issued TIL 1303 Compressor Rotor R-0 Blade Erosion which stated, "Recent inspection of a 9FA unit revealed distress on 4 rotor 0 (R0) blades, with one blade liberated. Significant erosion was found on the leading edge of the distressed blades, and on all other R0 blades in this unit and other units on this site." The TIL did not mention fogging, but said to inspect the blades after 100 hours of water washing.

While it is true that large water droplets can potentially damage the blades, fog system suppliers say that what has not been established is any link between such damage and a correctly designed and operated fogging system

This was followed with TIL 1323 "Isolating Inner On-Line Water Wash (OLWW) System Nozzle for F-Class Units," which said, "After R0 blade erosion was established as the root cause for a GE 9FA Gas Turbine suffering a blade liberation event, GE began looking for ways to improve its OLWW system."

It recommended only using the outer OLWW manifold, since "Testing done by GE shows the inner (forward) OLWW manifold performs minimal compressor cleaning and may cause increased erosion rates on the R0 blade leading edge. The erosion appears to be caused by water stratification on the bell mouth struts wall, which then impacts the root of the R0 blade." GE also advised owners to lower the pressure on the outer manifold to 40 psig.

In February 2003, TIL 1389 Compressor Rotor Blade Erosion From Water Ingestion Used in Power Augmentation, extended the concern about R0 blade erosion to inlet fogging systems and evaporative coolers, in addition to any OLWW systems that had not been modified in compliance with TIL 1323.

With both types of inlet cooling systems, the problem was said to be unevaporated water striking the blades. "Blade erosion varies but is dependent on how the fogger is maintained and operated. Specifically, the higher the spray ratio, the higher the water carryover into the compressor, and therefore, the higher the erosion on the R0 blade leading edge."

This was followed with TIL 1400-1 F-Class R0 Erosion Inspection Limits for Units with Evaporative Coolers, which found that, as long TIL 1323 recommendations were implemented, "if the evaporative cooler is properly commissioned and operated, there is low risk of R0 erosion." Immediately thereafter, TIL 1401-1 (A) Blade Erosion from GE SPRINT Foggers stated that blades needed to be inspected after 100 hours of OLWW operation, and "Any unit dispositioned with 10 mils or more of R0 leading edge blade erosion should cease all OLWW, inlet fogging and evaporative cooler operation until the R0 blades can be properly repaired or replaced by GE qualified personnel."

Finally in June 2008, GE issued TIL 1603 R0 Erosion and Water Ingestion Recommendations, which supersedes the above TILS, except for 1323, and applies to all F-class GTs. The TIL covers any type of water ingested into the compressor including "online water wash, fogging/Sprint system output, and evaporative cooling system carry-over" as well as "unintended sources such as the leakage of rainwater through compromised inlet ducting seals or malfunctioning accessory equipment." It includes a chart detailing usage guidelines for how long OLWWs, foggers and evaporative coolers can be run when inspections are needed.

Restricting water use

While it is true that large water droplets can potentially damage the blades, fog system suppliers say that what has not been established is any link between such damage and a correctly designed and operated fogging system. The fog suppliers are peeved that

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the blade failure that set off the whole train of events involved OLWW, not foggers or evaporative coolers, yet inlet cooling was lumped in as a water source.

"The original OLWW system provided by GE had nozzles on the inner cone of the inlet and on the outside of the bell mouth," says Dan Turley, an engineer at Portland General Electric's Coyote Springs plant in Boardman, Oregon. "It injected huge volumes of water into the machine, and the nozzles on the inner cone would spray right at the root of the blade. The root of the blade is the highest stress zone due to centrifugal force and bending moments, so any compromise to the root would lead, if it was significant enough, to a failure."

The Coyote Springs plant has two GE Frame 7FAs, and Turley does not buy the idea that fogging is causing the blade problems. Unit 1 went commercial in 1995 and had a fogging system installed in 1997. The plant ran the OLWW for half an hour every day when the temperature was above 50°F, and the fogger whenever the temperature was above 60°F. He estimates that he had 1,000 hours of OLWW and about 10,000 hours of fogging by the time GE inspected Unit 1 following the 2003 TIL.

The blades showed pitting of up to 12 mils on the leading edge of the blades. GE had developed the P-cut blade, which was designed to relieve the stress at the root so it would not shear. Turbines with the original blades that had more than 10 mils of erosion were prohibited from using OLWW or fogging until the pits were repaired. Those with the P-cut blades, however, were permitted unlimited wet operation, so PGE installed these blades on Unit 1.

However, a P-cut blade liberated in 2006, leading GE to come up with an enhanced P-cut blade design. GE inspected Unit 1's P-cut blades and said they were cracked, so Coyote Springs put the original blades back in Unit 1. Because of the latest restrictions imposed by GE, the unit requires inspection after 25 hours of OLWW or fogging, even though there have not been problems.

A proper design

Turley says that GE is missing the real problem by targeting fogging systems. "With the unit that liberated a non-P-cut blade back in 2003, there had to be some foreign object damage or there had to be some chlorides," he says. "The blades are just a high-strength carbon alloy so they are susceptible to corrosion and if they get salt in those pits, it would have led to stress corrosion cracking."

To the extent that water is the cause, it would have to be due to actual water droplets, not fog, says Mee. GE was correct to modify its system so it does not direct large amounts of water at the blade roots.

Poorly designed fogging or drainage systems can also cause water build up on the duct floor and walls which gets sucked en masse into the turbine, adds Mee. But with a proper design, the droplets will fully evaporate before entering the turbine. Even when used for wet compression, the droplets are too small to damage the blades, according to Mee.

Coyote Springs Unit 1 has a fog nozzle array installed right after the filters, allowing more time for the droplets to evaporate before entering the bell mouth. It also uses 6 mil nozzles that produce a finer mist of fog.

Plant staff inform that the fogging system that came with Unit 2 was designed by a different firm. It was installed downstream of the inlet silencer, closer to the compressor bellmouth. It uses approximately half the number nozzles as Unit 1. The nozzles also had larger 8 mil orifices that produced significantly bigger droplets and have less time to evaporate before impacting the R0 blades. "On Unit 2, we had lots of problems," says Turley.

Unit 2, since it has the new enhanced P-cut blades, is allowed to fog without restriction. However, since Unit 1 has the original blades, GE severely restricts the amount of wet operation. Turley says that after the second major inspection occurs at 96,000 hours, they will probably replace the R0 blades with ones that GE allows unlimited fogging. "Fogging is an integral part of our economics; in a normal year, the fogger will generate $350,000 in net profit," says Turley. TI

7FA USER GROUP FOCUSES ON MAINTENANCE INSTRUCTIONS FROM OEM

The GE 7FA User Group met in May in Atlanta for its annual convention. "The big takeaway from this year was a greater emphasis on the maintenance instructions for 7F turbines as contained in a GE document known as GER3620," said Sam Graham, chairman of the 7FA User Group steering committee. "This provides detailed technical information on how to maintain the turbine for optimum results."

"This is the second year we have held vendor presentations and they seem to be popular," Graham said. "It gives vendors the chance to present technical issues and solutions for an hour with interested users."

Day One began with a keynote from Richard Dennis, turbine technology manager at U.S. Department of Energy. The rest of the day's program featured various GE speakers addressing the audience over the course of the day. The OEM talked about such topics as maintenance factors, control enhancements, and extended life intervals for 7F turbine components.

"GE discussed an enhanced compressor as well as covering upgrade packages for the 7F," said Graham. "GE also held a product fair where they showcased various tools that could be of benefit to the user community."

Rotor life management was another area to come under scrutiny as a key element of maintaining the 7F. Graham explained that the 7F is an aging fleet. In addition, a large number of models were deployed soon after the turbines initial release. "We are just starting to see the oldest and hardest run machines beginning to reach the end of their lives," he said. "We are having to collectively deal with an end of life bubble."

Day Two saw the spotlight go back to the users. Each day going forward, the meetings largely consisted of two primary elements: a user presentation on a 7F technology element followed by a round table discussion, which is essentially a Q & A period. "The first user session dealt with compressors and addressed areas such as changing zero blades and R1 tip loss," said Graham.

Day Three looked into the turbine itself including advice regarding major inspections. Over the course of the day, users presented on combustion matters and exchanged tips and advice during the round table.

"Every year, I show up with various 7F maintenance problems on my mind and find people who have already solved those issues," said Graham. "I get most benefit from questions raised at the roundtables and then I follow up with the people who seem to have the experience I need."

Day Four moved on to generators and auxiliary systems. Topics included fire suppression and water washing. Later that day, vendor presentation began. Users were provided with a total of 15 sessions. A vendor fair ended the day's proceedings. On the last day, attention shifted over to steam turbines. The GE D11 and A10 steam turbines are those most commonly paired with the 7F, so user sessions concentrated on them.

Next year's user group conference will be held in Houston, TX in May. While the basic format will probably remain the same, Graham noted that an extra night for the vendor fair might be added. But he stressed that the primary purpose of the event is on 7F O&M, not products.