PROTON
THE LEADER IN ON SITE GAS GENERATION.

Proton OnSite Case Study Series

Best Practices Awards: Proper Layup Reduces Corrosion, Enables Faster Startups

Challenge

The cycling nature of this facility posed an array of problems related to corrosion, operating and layup chemistry, and layup procedures. Oxygen pitting and general corrosion that occurred in plant equipment during shutdowns were traced to less-than-ideal layup practices and to the initial system design, which allowed air-saturated makeup water to enter the HRSGs.

This resulted in elevated iron levels in the evaporator water during operation which could lead to deposition— undesirable because of efficiency loss and potential for underdeposit corrosion. Oxygen pits could lead to leaks, corrosion fatigue (CF), or stress corrosion cracking (SCC).

Also, it took a long time to achieve the permissible main-steam cation conductivity (CC) limit during startups because of air-saturated makeup; the condensate-pump discharge (CPD) CC limit rarely was achieved, even after several hours of full-load operation. Additionally, CPD dissolved oxygen (DO) levels were as much as two to 10 times higher than recommended during operation and were near saturation when makeup was supplied to the HRSGs during shutdown. A reducing agent (oxygen scavenger) could not be used to remove the DO because of singlephase FAC concerns.

Finally, capping a wet HRSG with nitrogen from industrial-type cylinders became cost-prohibitive. A comprehensive improvement program was needed to address: (1) oxygen pitting and general corrosion in the HRSGs, steam-turbine LP blades, and condenser hotwell; (2) startup- time improvement by achieving steam purity more quickly; (3) cycle chemistry improvement.

Solution

These problems were addressed over a few years using a multi-pronged approach that followed these three basic principles as described in “Cycle Chemistry Guidelines for Shutdown, Layup and Startup of Combined Cycle Units with Heat Recovery Steam Generators,” published by EPRI in 2006:

1. Maintain the same electrochemistry of HRSG water during operation and during wet layups.

2. Keep air away from water and/ or avoid water stagnation during wet layups.

3. Protect equipment (the steam turbine, for example) from moisture ingress during dry layups.

The solutions that satisfied these principles included the design and installation of equipment, optimization of chemistry, modification of operating procedures, and development of layup guidelines. Equipment installed included a (1) recirculation system (RS) for each HRSG's pressure section, (2) nitrogen generator (NG, Fig 25), (3) dehumidification system (DHS, Fig 26), and (4) gas-transfer membrane skid (GTMS, Fig 27).

The RS system allows water to be pumped from the economizer section to the evaporator section of each pressure system and includes a baffle bypass in each drum to ensure flow through the evaporator tubes (Principle 2, above).

The NG, which replaced the pressurized cylinders and paid for itself in less than a year, supplies 99.9% pure nitrogen at its design flow rate. Nitrogen is used to cap the HRSGs while pressure decays between runs (wet layup), and it is used to purge and blanket the HRSGs when they are drained for extended layups (Principles 2 and 3). The GTMS removes DO and CO2 from makeup water, where DO is decreased from 8 ppm to less than 5 ppb (Principle 2).

The DHS is used to circulate warm, dry air through the LP section of the steam turbine to the condenser hotwell for shutdowns longer than three days (Principle 3). The DHS maintains a relative humidity inside the turbine/hotwell of less than 15%. This reduces the chances for hotwell corrosion and turbine-blade pitting, which can lead to SCC and CF. During operation, the feedwater chemistry is AVT(O) where only ammonia is added to maintain a pH of 10. Going into wet layups, this chemistry is maintained and absolutely no reducing agent is added (Principle 1).

It was SOP to break vacuum for an overnight shutdown; however, this was changed to maintain condenser vacuum overnight to improve startup time and chemistry (Principle 2). Finally, a decision tree based on shutdown duration was developed to help guide plant operators choose between system layup options.

Results

1. No oxygen pitting was identified during the most recent HRSG inspection last spring and a salmoncolored protective oxide characteristic of oxidizing treatments was prevalent. Inspections in years prior to the upgrades indicated a good deal of oxygen pitting and general corrosion (Figs 28-31).

2. The improvements have led to a startup time savings of about 60 minutes from wet layup. The ability to be able to safely keep the HRSGs in a wet layup—instead of dry—for long periods (months), because of the NG, GTMS, and RS, saves six to eight hours from dispatch to full load. Depending on natural-gas prices, this reduces the startup cost by up to $45,000.

PROTON

THE LEADER IN **ON SITE** GAS GENERATION.

Salt Valley Generating Station

175-MW, gas-fired, 3 x 1 combined cycle located in Lincoln, Neb

Plant manager: Brad Hans

Key project participants: Vern Cochran, Maintenance Manager

Jim Dutton, Operations Manager

Dan Dixon, Project Engineer

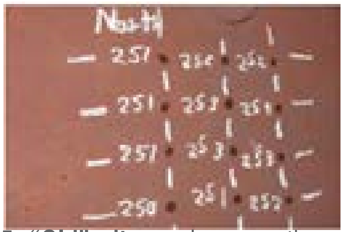
Tom Davlin, Manager of Projects Engineering

1. Nitrogen generator skid saves cost of rented,vendor-supplied compressed N_2 bottles

2. Desiccant wheel dehumidifier prevents pitting of LP steamturbine blades which could lead to CF or SCC

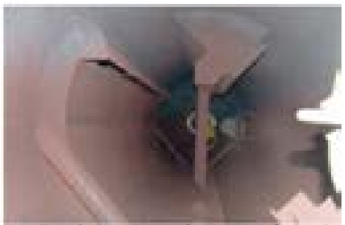
3. Gas-transfer membrane skid deoxygenates makeup water before it enters the steam cycle

4. Oxygen pitting in HP steam drum found during inspection in 2005



5. "Old" pits, no longer active, have been repassivated

6. LP baffle reveals protective oxide coating and no signs of FAC or oxygen pitting



7. Preferred salmon-colored protective oxidecoating also is evident in HP drum