Renewable Integration and Sustainable Energy Initiative (RISE)

Coal Based Flexible Generation Pilot

- **Power Plant Flexible Generation – Cycle Chemistry**
- Date: Aug 24-25, 2018.
- Venue: Power Management Institute, NTPC, NOIDA, India
- Presenters: Nikhil Kumar, Intertek Engineering Consulting, USA

GREENING THE GRID (GTG) PROGRAM
A PARTNERSHIP BETWEEN USAID/INDIA AND GOVERNMENT OF INDIA

KEYS TO WORLD CLASS CHEMISTRY

EPRI's "world-class" cycle chemistry program:

- O&M of a "core" set of instrumentations, including appropriate control room alarms
- Training of operations staff in chemistry issues and problems, what to look out for and what to do if it happens
- Effective elimination of copper from the cycle, primarily through feedwater heater replacements
- Transition to a modern water treatment regime, either AVT or OT, and elimination of treatments which introduce corrosion products (phosphate and caustic based approaches)
- Installation and appropriate use of condensate polishers

PREVENTABLE CYCLE CHEMISTRY RELATED DAMAGE

- High level of corrosion products
  - Guidelines suggest level of corrosion products
  - Preferred treatment approach can change over the life of the unit
- HP evaporator deposition
  - Corrosion products deposit on heat transfer surfaces
  - Most plants will perform a deposit density analysis
- Chemical cleaning
  - Delaying chemical cleaning
  - Use of solvent, inhibitor, additives.
  - Verification that waterside deposits removal was successful
- Contaminant ingress
  - Unavoidable, but action is required by plant staff
- Drum carryover
  - Don't wait for deposition in the ST. Instead check carryover at more than one saturated steam off-takes
- Air in-leakage
  - O2 at the condensate pump discharge should be less than 10 ug/kg
  - In cycles with mixed metallurgy feedwater system increased air in-leakage in the presence of ammonia results in non-optimal protection of copper materials.
- Shutdown procedures, or lack of
  - Each time a unit shuts down without protection (nitrogen, dehumidified air, etc.) results in additional failure over time.
- Inadequate instrumentation
- Procedures

COPPER IN THE SYSTEM

The following steps to avoid copper corrosion are suggested:

- Monitor, optimize and continuously maintain the economizer inlet ORP (both on-line and during shutdowns/layups)
- Monitor copper concentrations during steady state operation and during startups (the steady load copper concentrations should be < 2ppb)
- During shutdowns/layups maintain the reducing agent/ORP and avoid adding air saturated makeup water to the cycle
- Replace copper components with copper free materials and chemically clean the system to remove all the deposited copper
- Reduce air in-leakage
- Add make-up water oxygen removal system (deaerators, filters)
- Establish and use nitrogen blanketing systems on the LP/HP heaters for intermediate term wet layups

CHEMISTRY BEST PRACTICE

Cycling conditions create opportunities for chemical pumps to be inadvertently turned on or left on. The EPRI Core Online Monitoring. EPRI recommends degassed cation conductivity on all its samples. If the unit breaks vacuum between cycles, the degassed cation conductivity at the condensate pump discharge would be helpful for removing the carbon dioxide interference which will be present in the hotwell during startup.

Cycling operation uses a great deal of demineralized water. Cleanup of condensate also facilitates reaching operating pressure without experiencing undue delays to control silica. If the equipment cannot consistently produce high purity water with a conductivity of < 0.1µS/cm and < 10 ppb silica, or if these parameters are not being continuously monitored, the condition of the boiler, and especially the turbine, could be at risk of damage. Data supplied by the plant shows that boiler startups are monitored by a lab technician regardless of the time when the unit is started, at least until the chemistry is within limits and the boiler is released for full-pressure operation. This is an excellent practice. It is hoped that it will be continued when the unit is cycling, at least on cold starts.

The site should develop written procedures to cover unit layup for units returned to service: 1) within 72 hours, 2) within seven days, and 3) for long-term storage.

TABLE OF CHEMISTRY LIMITS – TURBINES

Parameter	Unit	Normal / Target Values
Conductivity after cation exchange @ 25 °C	µS/cm	< 0.20
Sodium as Na	µg/kg	< 2
Silica as SiO_2	µg/kg	<10

Steam should not be sent to the turbine if the concentration of sodium exceeds 20 µg/kg. The immediate need at startup to ensure compliance with this limit requires a sodium monitor for steam.

Steam should not be sent to the turbine if the CACE exceeds 0.5 µS/cm. Allowance may be given to possible contributions from carbon dioxide.

In addition to developing a set of Action Levels, it is also necessary to define a set of cycle chemistry conditions under which a unit must be shut down because of severe contamination.

Na µg/kg	CACE * µS/cm	Restrictions
> 20	> 2	Do not pass steam to turbine
10 … 20	1 … 2	- Steam production < 40% nominal - Max 30 min per startup
n … 10	*n* … 1	Max 8 hours per startup

CYCLE CHEMISTRY GUIDELINES FOR OT

Locations / Parameters	Normal / Target Values	
	AVT (O)	OT
Condensate Pump Discharge (CPD)		
Conductivity after Cation Exchange, µS/cm	< 0.3	< 0.3
Dissolved Oxygen, µg/kg	< 10	< 10
Sodium, µg/kg	< 3	< 3
Condensate Polisher Outlet (CPO)		
Conductivity after Cation Exchange, µS/cm	< 0.2	< 0.15
Sodium, µg/kg	< 2	< 2
Economizer Inlet (EI)		
Conductivity, µS/cm	Consistent with pH	Consistent with pH
Conductivity after Cation Exchange, µS/cm	< 0.2	< 0.15
pH	9.2 - 9.8	8.6 - 9.8
Dissolved Oxygen, µg/kg	5 - 10	Per Recirculation Ratio
Boiler Drum / Blowdown (BD) / Downcomer (BDC) (preferred for OT)		
Conductivity, µS/cm	Consistent with pH	Consistent with pH
Conductivity after Cation Exchange, µS/cm	< 1.5	< 1.5
pH	9 - 9.6	8.5 – 9.5
Dissolved Oxygen (for OT), µg/kg	*not applicable*	< 10
Saturated Steam (SS)		
Conductivity after Cation Exchange, µS/cm	< 0.2	< 0.15
Sodium, µg/kg	< 2	< 2
Main Steam (MS) / Reheat Steam (RH)		
Conductivity after Cation Exchange, µS/cm	< 0.2	< 0.15
Sodium, µg/kg	< 2	< 2
Makeup (MU)		
Conductivity, µS/cm	< 0.1	< 0.1
Conductivity after Cation Exchange, µS/cm	< 0.1	< 0.1
SiO_2, µg/kg	< 10	< 10

THANK YOU

Thank you and your support staff for the hospitality and cooperation.

Thank you also for being patient, we do ask for a lot of data!