

ACC Chemistry Issues and Film Forming Products Trials



Four Identical H-Class 1x1 Combined Cycles Triple Pressure HRSGs Stand Alone LP Design ~2300 PSIG / 1050 F Main Steam Air Cooled Condenser

Plant 1 UNIT 10 AMMONIA ONLY Plant 1 UNIT 20 Anodamine TREATMENT Plant 2 UNIT 10 Filming Amine TREATMENT Plant 2 UNIT 20 Filming Amine TREATMENT





- Plugged Condensate Pump Strainers
- Plugged Feed Pump Strainers
- Bound up Main and Reheat Stop / Control Valves
- Plugged Main / Reheat Steam Strainers
- Plugged Impulse lines on Pressure Transmitters and Level Sensors
- Stuck Attemperation Block Valves
- Solid Particle Erosion
 - Severe service valves rebuilding 2x per year
 - BFP check valves seats damaged
 - Steam Turbine degradation
 - High Pressure Drains
 - $\circ \quad \text{Globe valves turning into toothpicks}$
 - Steam jets caused repeated ruptures of drain header
 - Recent collapse of drain header standpipe
- Over 2000 hours of lost availability in the first three years

Chemistry Evolution



Plant 1 Unit 10 2016 Commercial Operation 2017 Raised pH Set Points 2019 Filming Amine Trials 2019 Reverted to AVT(O) 2021 Started Anodamine Plant 1 Unit 20
2016 Commercial Operation
2017 Raised pH Set Points
2019 Anodamine Trials
2020 Trials to optimize Anodamine Dosage

Plant 2 Unit 10 2016 Commercial Operation 2018 Raised pH Set Points 2020 Filming Amine Trials 2020 Trials with Increased Filmer Dose 2021 Reverted to AVT(O) 2021 Started Anodamine Plant 2 Unit 20 2016 Commercial Operation 2018 Raised pH Set Points 2020 Filming AMine Trials 2021 Reverted to AVT(O) 2021 Started Anodamine

Typical Chemistry Today



Unit 10	Unit 20
10.7 pH	10.2 pH
9.6 pH	10.4 pH
10.0 pH	9.9 pH
10.5 pH	10.4 pH
1.1 µS	1.8 µS
1.0 µS	1.5 µS
2.2 µS	2.8 µS
1.9 µS	1.6 µS
1.9 µS	1.5 µS
1.5 µS	1.3 µS
1.6 µS	1.4 µS
1.5 µS	1.4 µS
28.2 µS	27.1 µS
	Unit 10 10.7 pH 9.6 pH 10.0 pH 10.5 pH 1.1 µS 1.0 µS 2.2 µS 1.9 µS 1.9 µS 1.5 µS 1.5 µS 28.2 µS



What's Driving Cation Conductivity?



Volatile contaminants including Ammonium Carbonate are cycled up in the vacuum pump seal water and returned with the overflow water back to the condensate!



FILMING AMINE / ANODAMINE TRIAL RESULTS

With inspection photos

Both Filming Amines and Anodamine showed Promising Results





- Overall 70%-90% Reduction in Corrosion Product Transport compared to AVT(O)
- FFA Achieved <5 ppb Fe in the condensate and <10 ppb Fe in the Drums "most of the time" using millipores
- Anodamine Achieved <1 ppb Fe in all samples most of the time using ferrozine digestion
- Reduction in the frequency of rebuilding severe service valves to annually
- Still finding buildup in major steam valves, but not clear if that's historical or new
- The OLDA products outperformed in reducing corrosion the LP and IP drums, but did little for the HP Drums, or ACC. Problems with condensate strainers plugging. Problems with gunk balls never resolved
- The Anodamine product outperformed in recovering from longer outages, and did not cause problems



- Filming Amines contain amines and may impact pH
- Filming Amines and their break-down products increase baseline cation conductivity and may reduce pH in some portions of the water/steam cycle.
- Filming Amines may cause trouble with online monitors.
- Filming Amine residual methods may not be accurate at the desired concentrations.
- Filming Amines are not water-soluble and depending on formulation may not be easy to handle or inject
- With Filming Amines there is risk associated with underfeed, including pitting, localized corrosion, and under-deposit corrosion.
- Filming Amine overfeed conditions promotes"gunk ball" formation and can cause operational problems

- The formulation we used did not impact bulk pH
- Baseline cation conductivity was so high that the impact of Filming Amines was not noticeable. We did not notice any low pH areas of the cycle
- Online pH instrumentation was not able to be maintained on units with Filming Amines.
- Residual levels were monitored. The data seemed noisy, but generally trended well
- The formulation we used was easy to handle and inject, and did not present solubility issues up to the point of injection
- No increase in localized corrosion was noted, even in areas that did not exhibit protection, when compared to the unit that was using Ammonia only
- "gunk balls" in the turbine exhaust duct on one unit using Filming Amines, but not the other units. These appeared at the end of a prolonged outage, in puddles of standing water, after freezing conditions. The gunk balls probably contributed to subsequent condensate pump strainer plugging.

Condensate Pump Strainer Fouling on Units with OLDA-based Filming Amine





- After the 2020 Fall outage, condensate pump strainers started plugging up approximately daily
- There is only 1 strainer per condensate pump, and both pumps are needed for full load
- Each unit would need to lower to half load for about an hour to clean the strainers.
- Switched all units to Anodamine on 3/1/2021
- Plugging stopped ~3 weeks after switching to Anodamine
- Overall, about 16,000 MWh were lost in this incident





Early Inspection Photos











LP Drum Comparison Photos AVT(O) vs Anodamine vs Filming Amine









Filming Amine

Anodamine

IP Drum Comparison Photos AVT(O) vs Anodamine vs Filming Amine





AVT(O)







Filming Amine

HP Drum Comparison Photos AVT(O) vs Anodamine vs Filming Amine





AVT(O)



Filming Amine



Anodamine

"Monkey Bars" Comparison Photos AVT(O) vs Anodamine vs Filming Amine







Filming Amine (2 Weeks after shutdown



Anodamine (2 Weeks After S₁₆hutdown)

Turning Vanes Comparison Photos AVT(O) vs Anodamine vs Filming Amine





AVT(O) 2 Days After Shutdown



Filming Amine 2 Weeks After Shutdown



Anodamine 2 Weeks After Shutdown

Bypass Diffuser Comparison Photos AVT(O) vs Anodamine vs Filming Amine



AVT(O) 2 Days after shutdown



COGEN

ENERGY

Filming Amine 2 weeks after shutdown



Anodamine 2 weeks after shutdown

Steam Turbine Exit Comparison Photos AVT(O) vs Anodamine vs Filming Amine





Anodamine







XRD detection limit is approximately 3 – 5% and limited to crystalline compounds. Non-crystalline compounds are not detectable with XRD

Note: XRD match for CaSO4 was a "best match". XRD also matched: para-substituted aromatic hydrocarbons, thiazolidine, sucrose, pentaerythritol, and benzyl alcohol



















ACC Upper Exhaust Duct: Before and After FFP





ACC First Cell: Before and After FFP







Some with very little damage

A few with no protection and some damage







Condensate Headers Borescope Before and After FFP





Turbine Exhaust Duct: Before and After FFP



Before





After



