ANODAMINE

Unrivaled performance. Not a slogan. A standard.

Programmatic Corrosion Mitigation in ACCs Using Anodamine

ACCUG Annual Meeting: 7/30/2024

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Installation Information

- Four Identical H-Class 1x1 CCGT
  - Two Sites
- Triple Pressure SALP HRSGs
- 2300 PSIG / 1050 F Main Steam
- Air Cooled Condenser
- 2016 Commercial Operation
- Baseload
- **Chemistry Evolution**
  - **2017-2018:** Raised pH set points
    - > 9.8 in FW
  - **2019:** OLDA vs. Anodamine side by side trial at plant 1
  - **2020:** OLDA filming amine trial

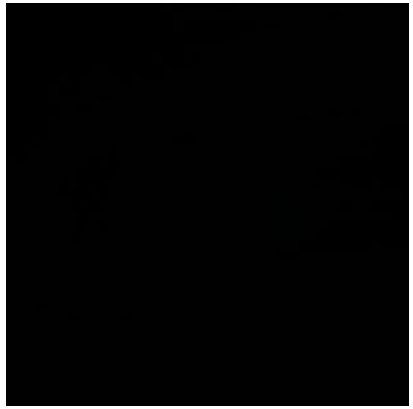
As of 2021 all units are running Anodamine AVT(O) with Ammonia

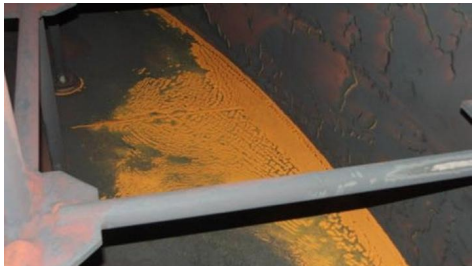
Severe ACC Corrosion

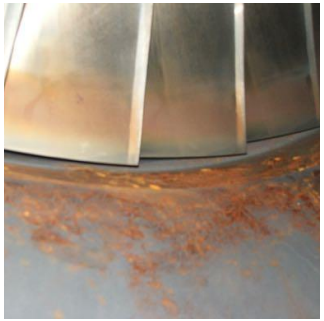
Chemistry was root cause of these issues

- Majority of ACC tube inlets were DHACI 3/4 and DHACI B/C in the lower ducts
- Plugged condensate, feed pump, and main/reheat strainers
  - Plant shutdown to clean out
- Bound up main and reheat control valves
- False trips due to plugged level sensors
- Stuck attemperation valves/no steam temp control
- Solid particle erosion
  - High pressure drains
    - Globe valves turning into toothpicks
    - Ruptures of drain header
    - Collapse of drain header standpipe
  - Service valves rebuilt 2x per year
  - Steam turbine degradations

Over 2000 hours of lost availability in the first 3 years of operation!







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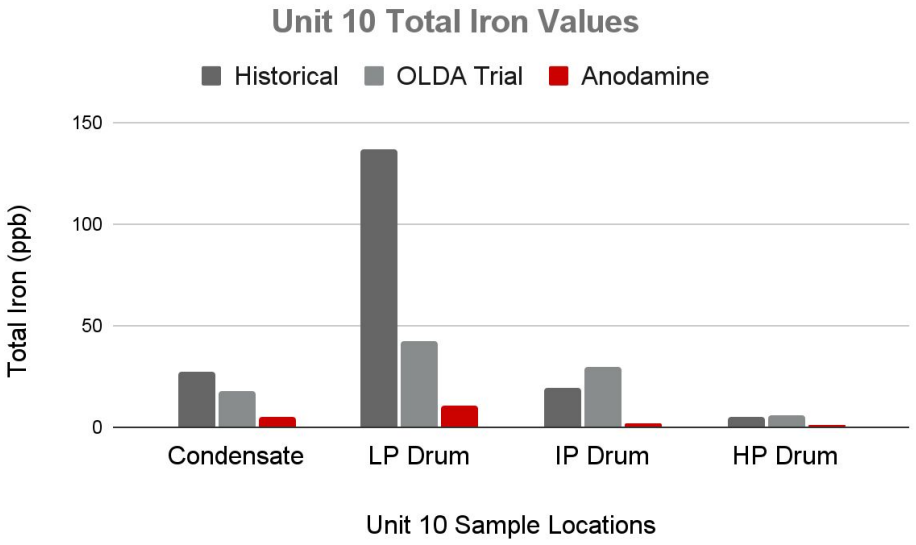
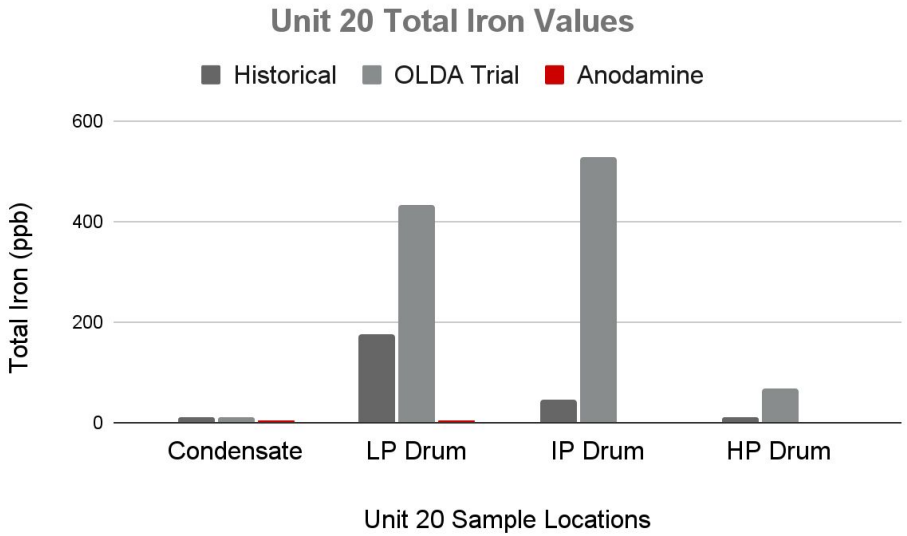
Trial Goal: Decrease iron corrosion transport

Trial Results - Unit 10 Total Iron



Unit 10 Total Iron Values (ppb)				% Decrease	
	Historical	OLDA Trial	Anodamine	Anodamine vs Historical	Anodamine vs OLDA
Condensate	27	18	5	*81%*	*72%*
LP Drum	**137**	42	11	*92%*	*74%*
IP Drum	19	30	2	*89%*	*93%*
HP Drum	5	6	1	*80%*	*83%*

Trial Results - Unit 20 Total Iron



Unit 20 Total Iron Values (ppb)				% Decrease	
	Historical	OLDA Trial	Anodamine	Anodamine vs Historical	Anodamine vs OLDA
Condensate	10	12	4	*60%*	*67%*
LP Drum	**175**	***434***	4	*98%*	*99%*
IP Drum	47	***527***	2	*96%*	*100%*
HP Drum	11	67	3	*73%*	*96%*

Millipore Sample - OLDA vs Anodamine Trial

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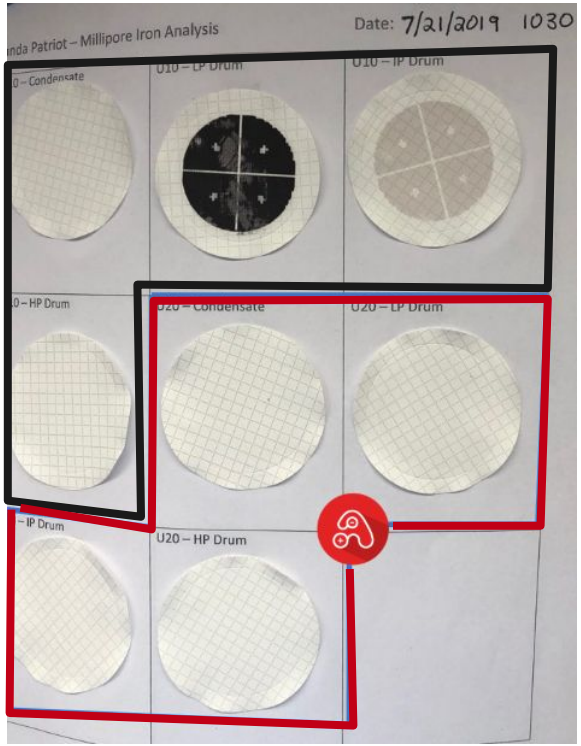
OLDA



Anodamine

Total Iron - Millipore

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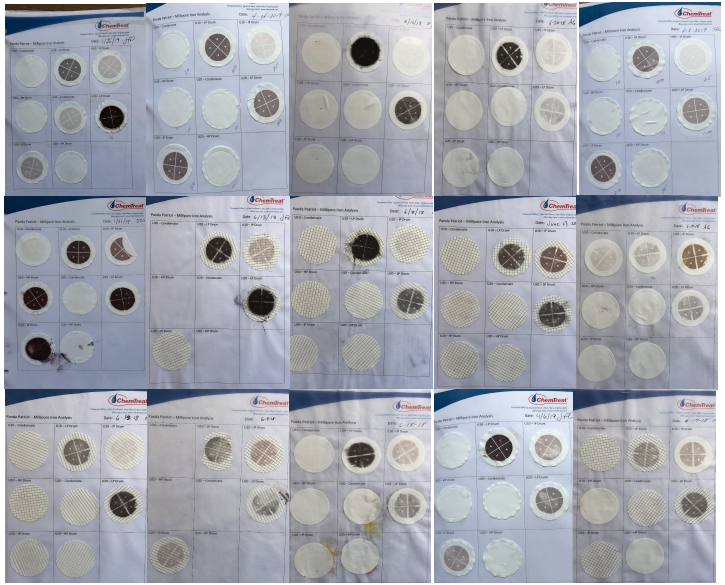
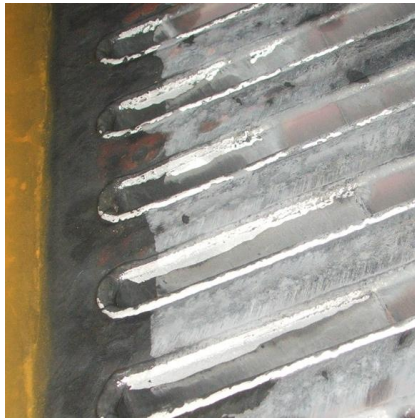
Before Anodamine



After Anodamine

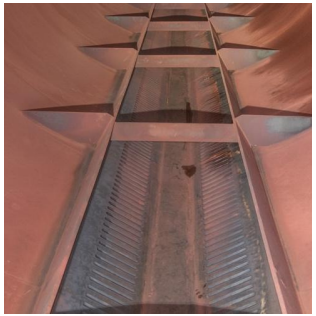
ACC:Before and After Anodamine

OLDA-type FFA



DHACI 4

AVT-O Anodamine



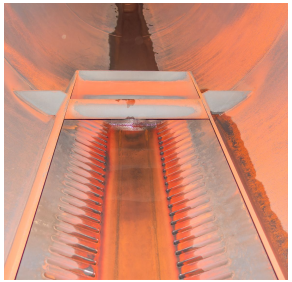
DHACI 1/2

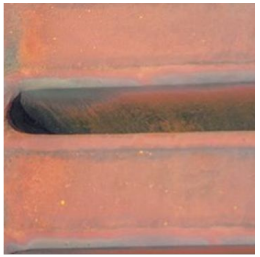
ACC:Before and After Anodamine

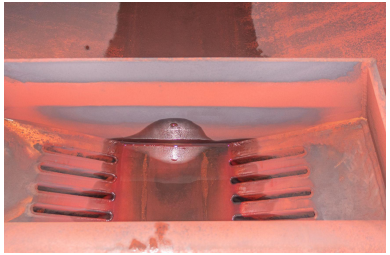
OLDA-type FFA

DHACI 4

AVT-O Anodamine







DHACI 1/2

Turbine Extraction Ducting

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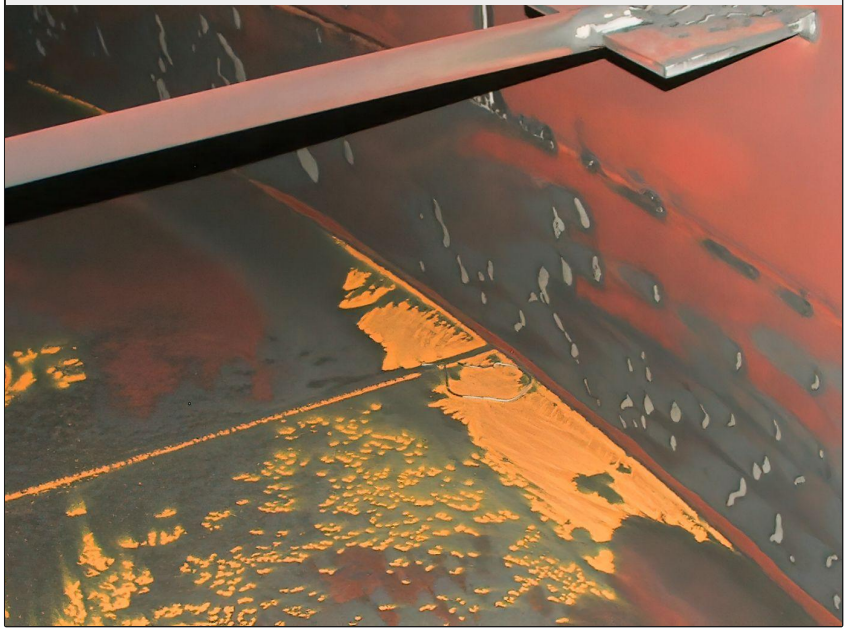
OLDA-type FFA



DHACI C

AVT-O Anodamine

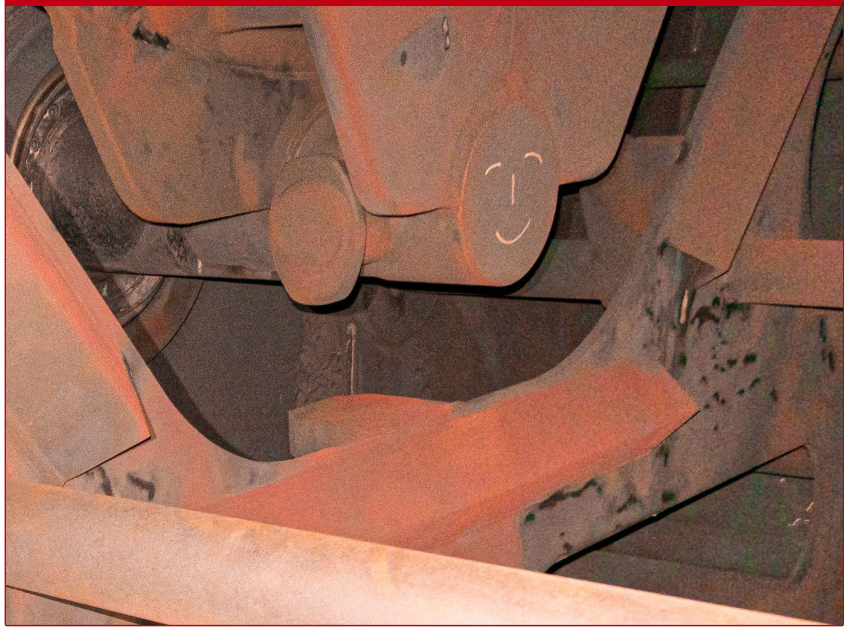
DHACI A/B

Turbine Extraction Duct

OLDA-type FFA

DHACI C

AVT-O Anodamine



DHACI A

Turbine Extraction Duct

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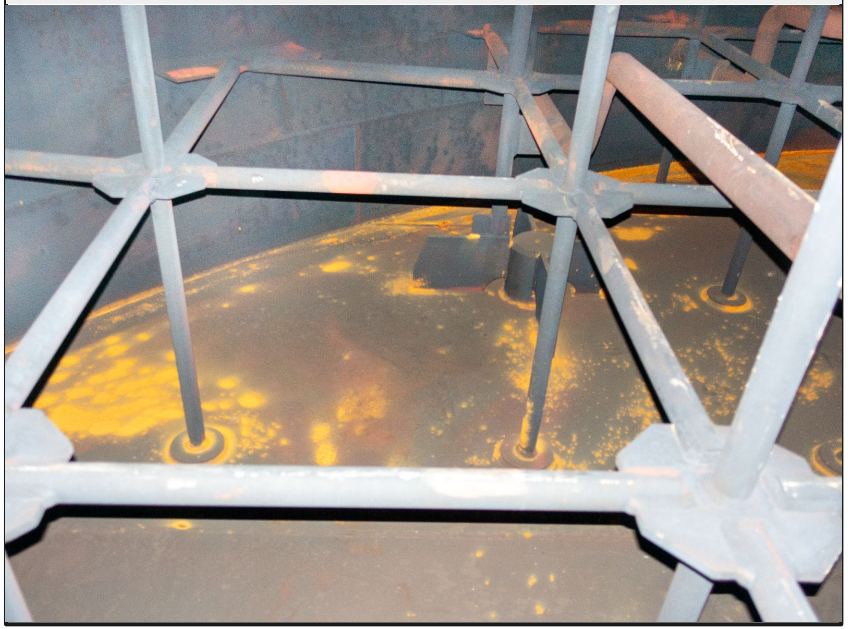
OLDA-type FFA



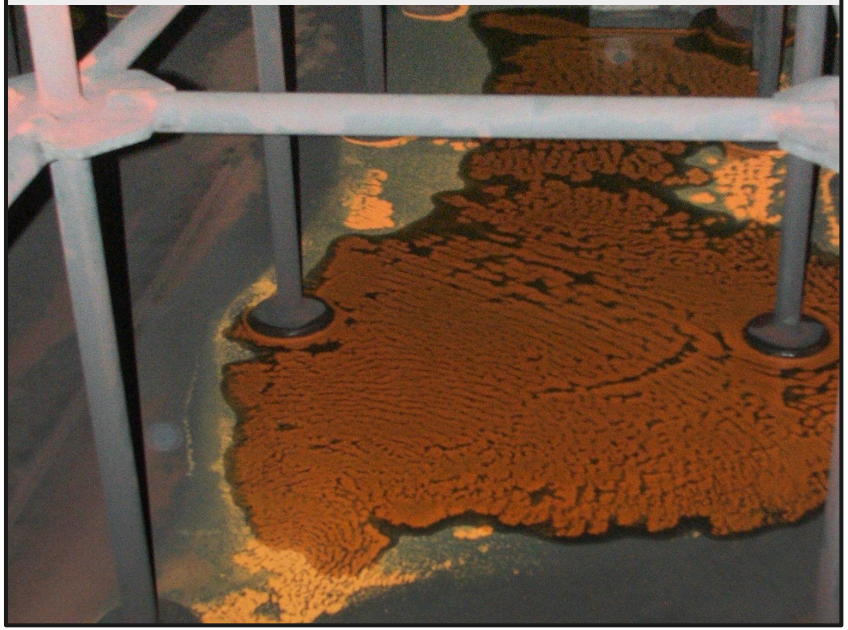
DHACI B

AVT-O Anodamine

DHACI A

Turbine Extraction Duct

OLDA-type FFA



DHACI C

AVT-O Anodamine

DHACI A

Turbine Extraction Duct

6 months after OLDA-type FFA

DHACI C

AVT-O Anodamine

DHACI A

LP Steam Turbine

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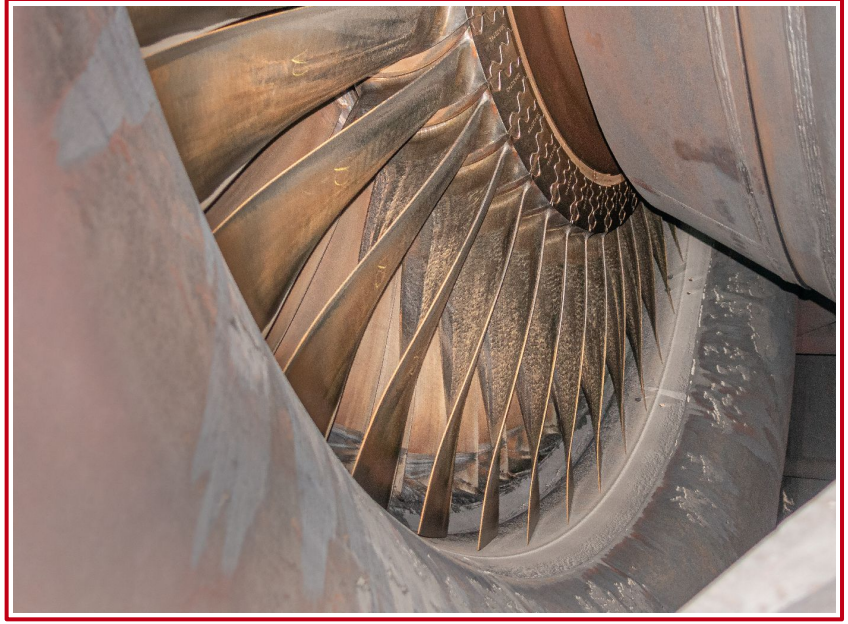
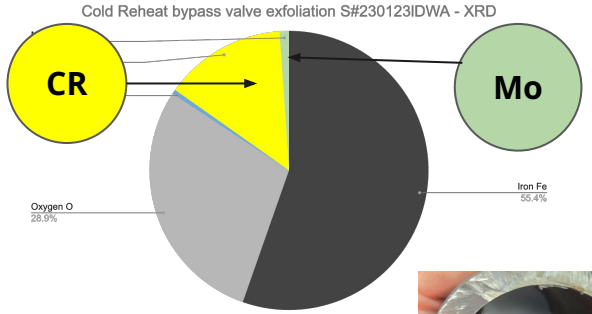
OLDA-type FFA

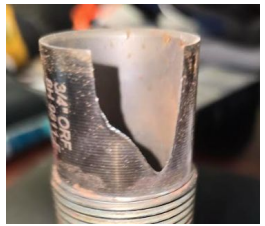
AVT-O Anodamine



SPE and Anodamine

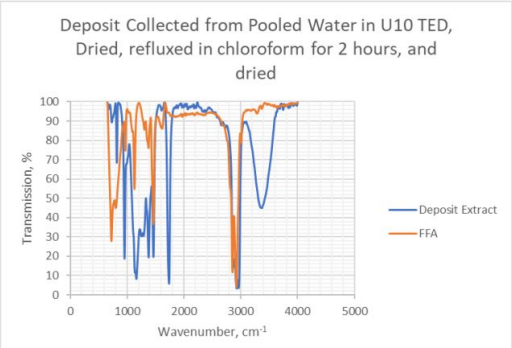
- Both stations (identical units) have a history of solid particle erosion (SPE) on HP steam turbine equipment, deterioration in turbine performance and deposit causing sticking valves with traditional AVT-O treatment . **Root cause was determined to be steam oxide growth and exfoliation**.
- OLDA treated units continued to have steam oxide growth and exfoliation issues
- **Since Anodamine treatment, exfoliation and related issues have disappeared**
- 1 unit had an Anodamine pump issue and did not dose for several months
    - Exfoliation caused a reheat bypass valve failure in 4/2023
    - Once Anodamine dosing was corrected there has not been any additional issues





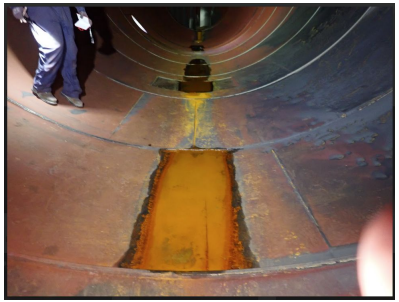
FFA Risks

- **Gunk balls/Slime Trail**
  - Found in the TED and **are still present today**
  - **Caused daily plant shutdowns due to clogging of condensate pump strainers**
    - **16,000 MWh were lost!**
- **Online sensors**
  - Online pH measurements
    - Doesn't match conductivity
  - Sodium analyzers



2020 Inspection - TED

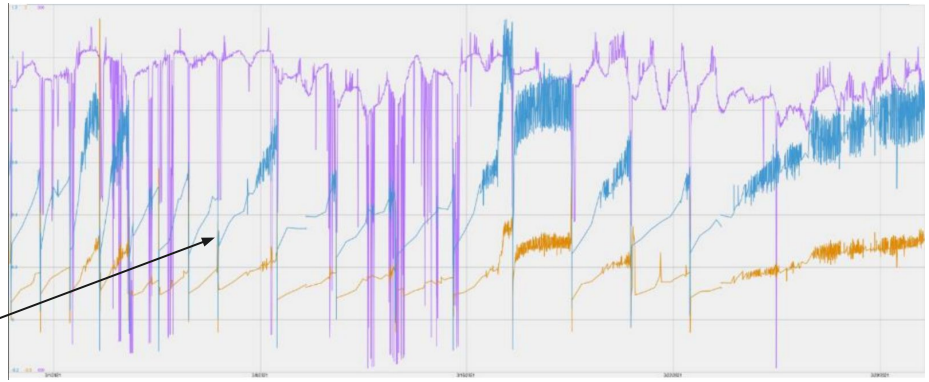
2025 Inspection - TED



16,000 MWh Lost Due to Fouled Strainers - OLDA

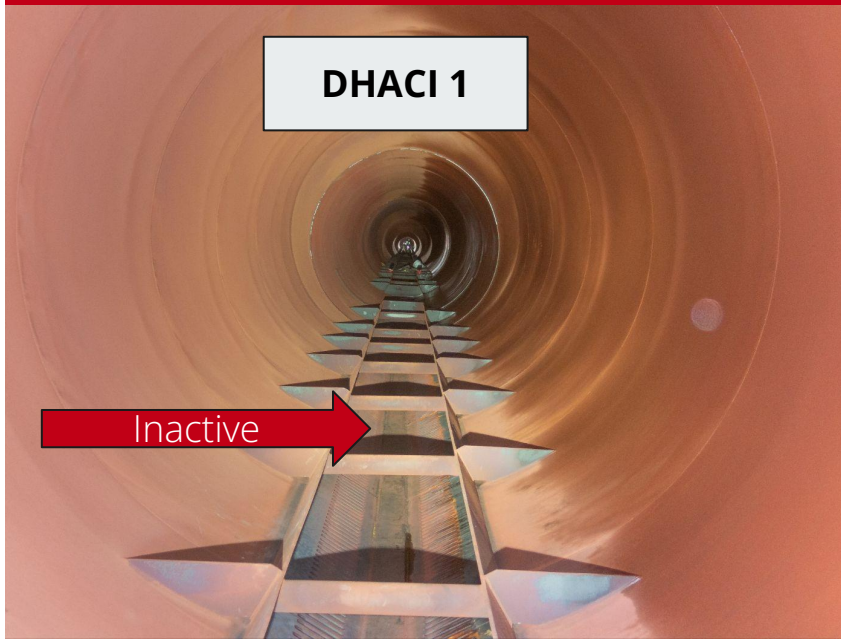
Condensate strainers were plugging up after gunk balls were noticed

- After fall 2020 outage condensate pump strainers were plugging daily
- Daily **50% load reductions**
- All units switched to Anodamine on March 2021
- Plugging stopped 3 weeks after switching to Anodamine

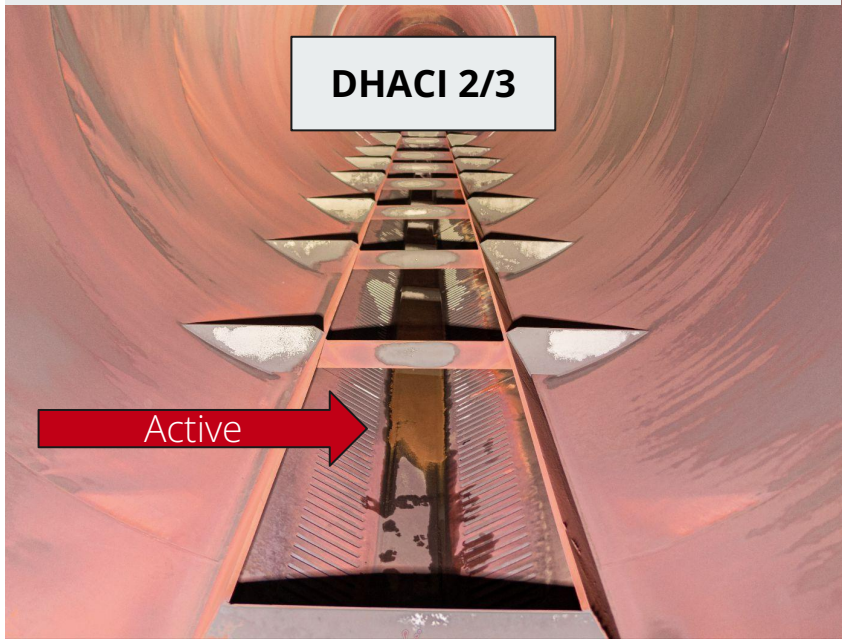


pH is Not Enough

2021 - 6-months on Anodamine treatment

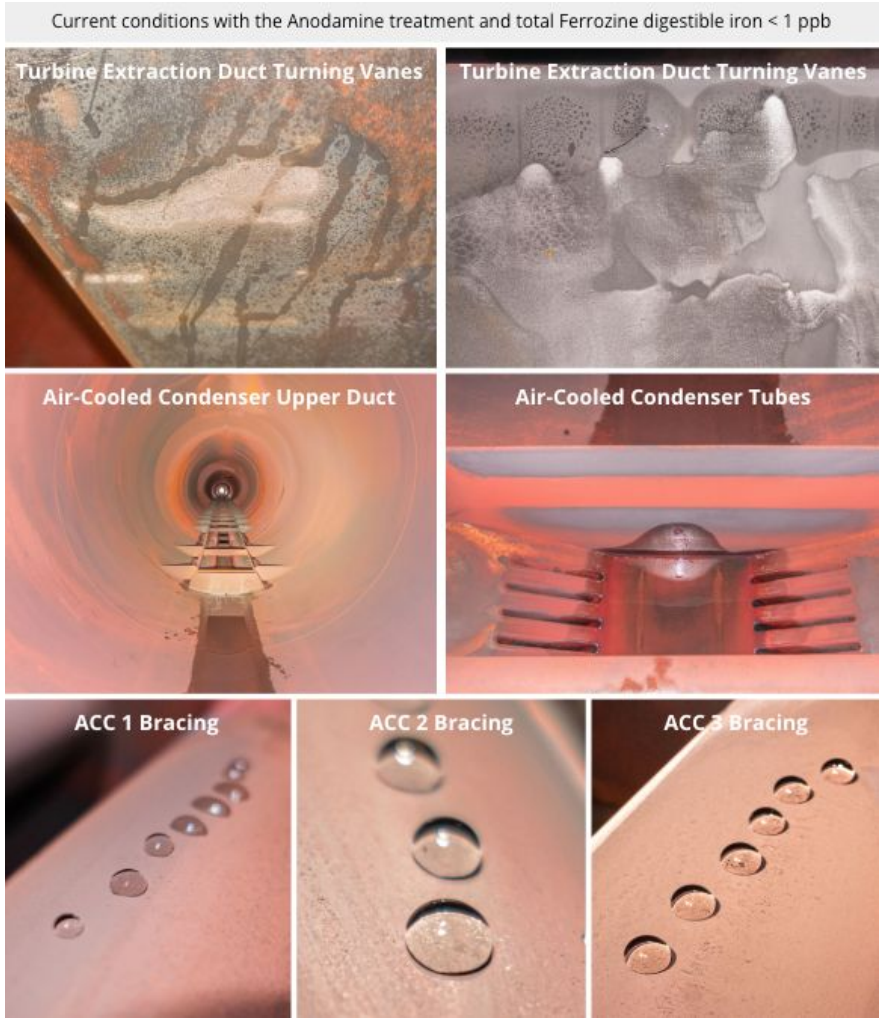


2023 - 6-months **NO** Anodamine Treatment



Anodamine Success

- Anodamine was able to reduce total iron by **~80%**
- Plant reliability at 100%
  - No shutdowns due to corrosion related issues or failures
- No negative side effects
  - Online instrumentation
  - No gunk balls
  - No increase is CC or DCACE
  - Non-toxic
- ACC tube inlets corrosion index **improved from a 4 to a 1-2**
- Lower ducts **improved from a B-C to an A**



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Questions