Cycle Chemistry

Experience of Anodamine in Plants with Air Cooled Condensers

ACCUG London, 23-25th of July 2024

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ANODAMINE

Facts about ACCs

1800s Groundwork for ACC by Carl von Linde and Willes Carrier

1800s Steam locomotives with ACC in arid regions

Post-WWII Growing need for efficient cooling – ACC improved

Mid-20th century Start use ACC in power plants in arid regions

Facts about ACCs

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Some words about cycle chemistry for PP with ACC

- No use of reducing agents or technologies which require low oxygen conditions
- High cycle pH AVT(O) required, or maybe OT chemistry?
- Huge ACC surface area leads to potential high oxide transport
- Ammoniumbicarbonate from seal water tank = primary contribution to high CACE
- Thoughts on mitigation of corrosion during operation ?
- Thoughts on proper preservation methods ?

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Things you want to achieve with chemistry

- Robust chemistry, dealing successfully with excursions, avoiding failures
- Low oxide transport
- Low deposit weight density on evaporator tubes, especially HP (avoiding UDC)
- Trustable on-line instrumentation
- Clean filters and working valves
- Good preservation

Some words about the Anodamine technology

- Non-amine based film forming technology
- Non toxic. EC50 >165.000mg/kg
- Added to the conventional chemistry
- Thermal stable >565C, no effect on CACE, compliant with steam purity requirements
- No effect on cycle pH, calculated pH as normal with SC
- Mitigation of (2 phase) FAC
- Preservation of both water and steam cycle

Some words about the different film forming technologies

- Amine based film forming technologies (Kurita, Chemtreat, Veolia, etc)
- Non-amine based film forming technologies (Nalco, Anodamine)
- Proprietary products as single substance or mixtures
- As “on-stop-shop-mixture” or added to conventional chemistry
- IAPWS recognized film forming amines: ODA, OLA, OLDA
- IAPWS TGD 8-16 for application of film forming substances

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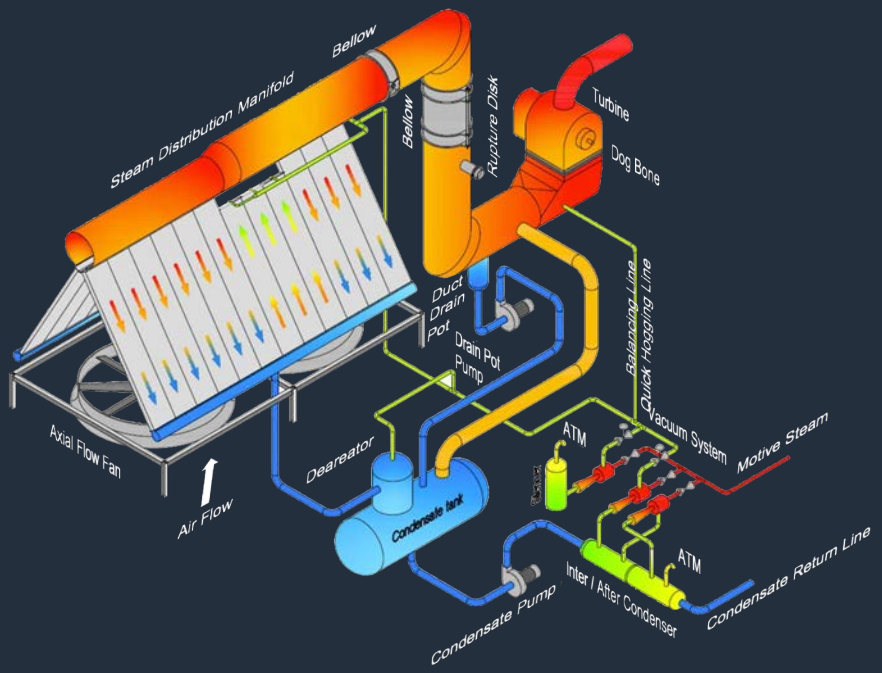
Some thoughts about the different film forming technologies

- Specific working mechanism ? (All surfaces? Metal only? Only water phase?)
- Degradation at temperature ? (How stable, which decomposition products?)
- Specific volatility of the film forming substance ? (Effective in which parts of the cycle?)
- Toxicity ? (handling, discharge, inspection? Check ECHA website)
- Effect on instrumentation ? (Deviation electrodes? Trustable reading?)
- Effects on IX, EDI, RO ? (Held back irreversibly? Clogging effect?)
- Compliant with international guidance for water and steam quality ?

Chemistry Challenges



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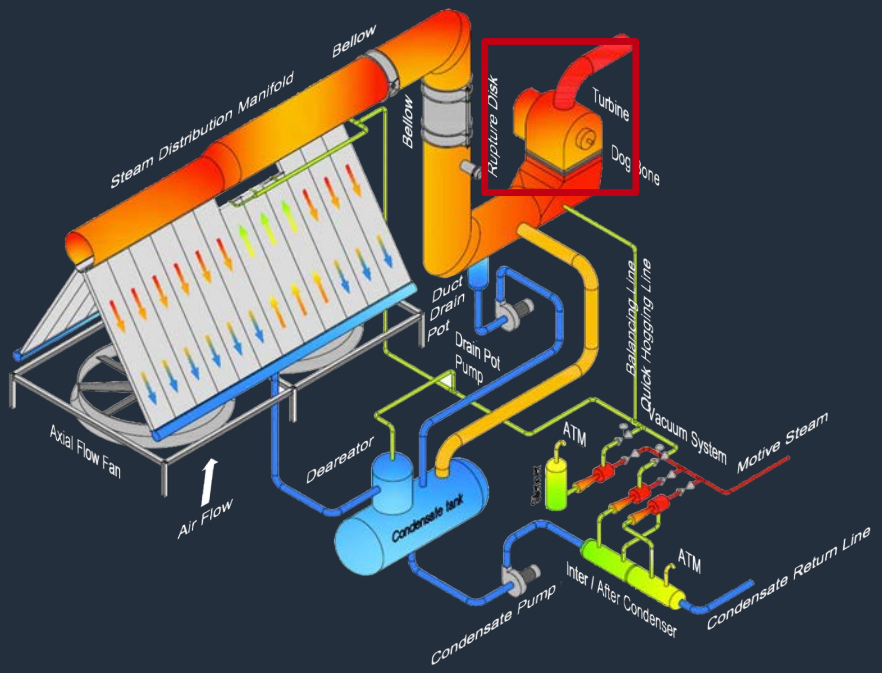
Chemistry Challenges



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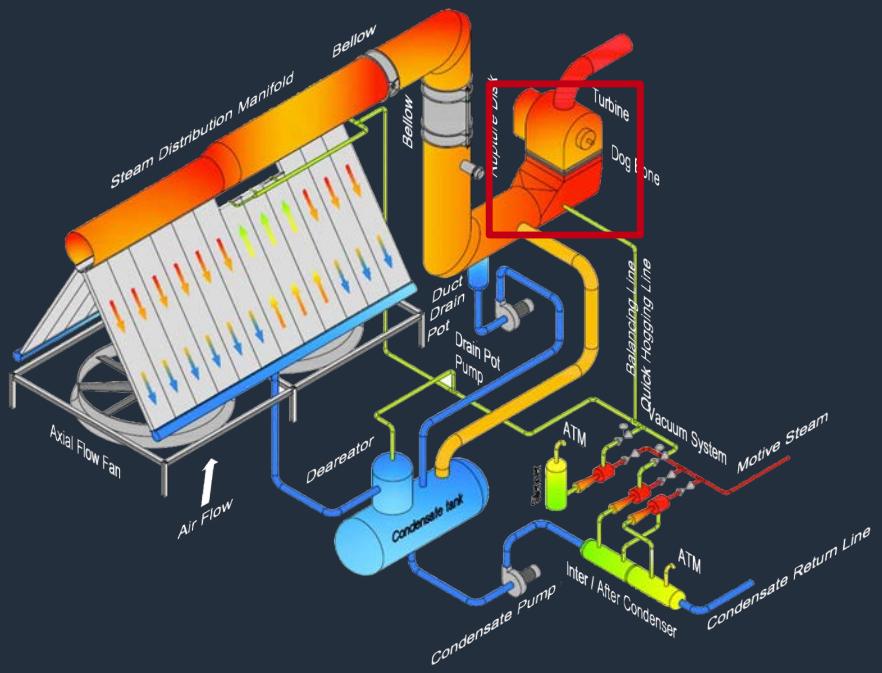
Solid Particle Corrosion (SPC)
Out-of-service corrosion pitting

Chemistry Challenges



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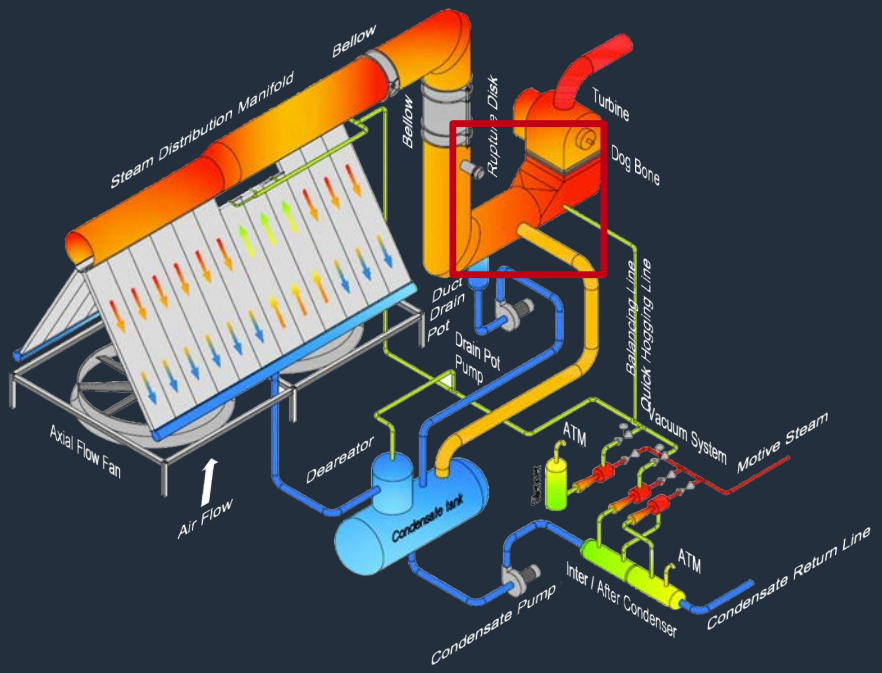
FAC ductwork LP turbine
Tiger striping

Chemistry Challenges



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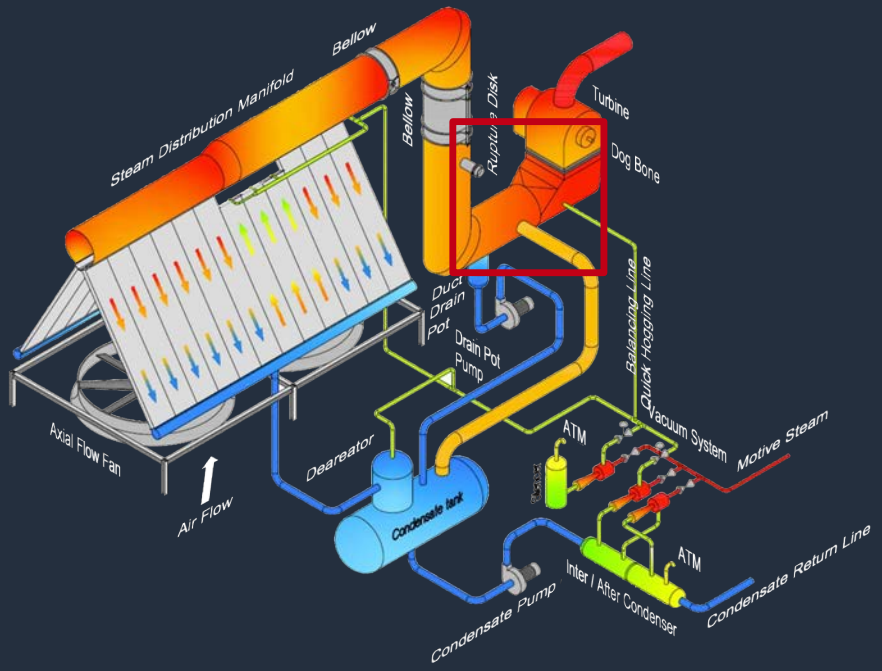
(2 phase) FAC
Out-of-service flash corrosion

Chemistry Challenges



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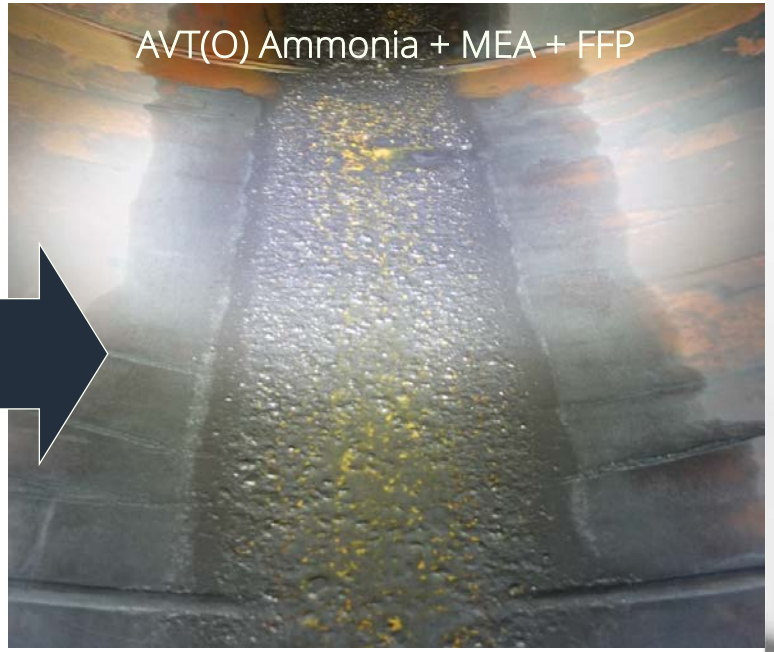
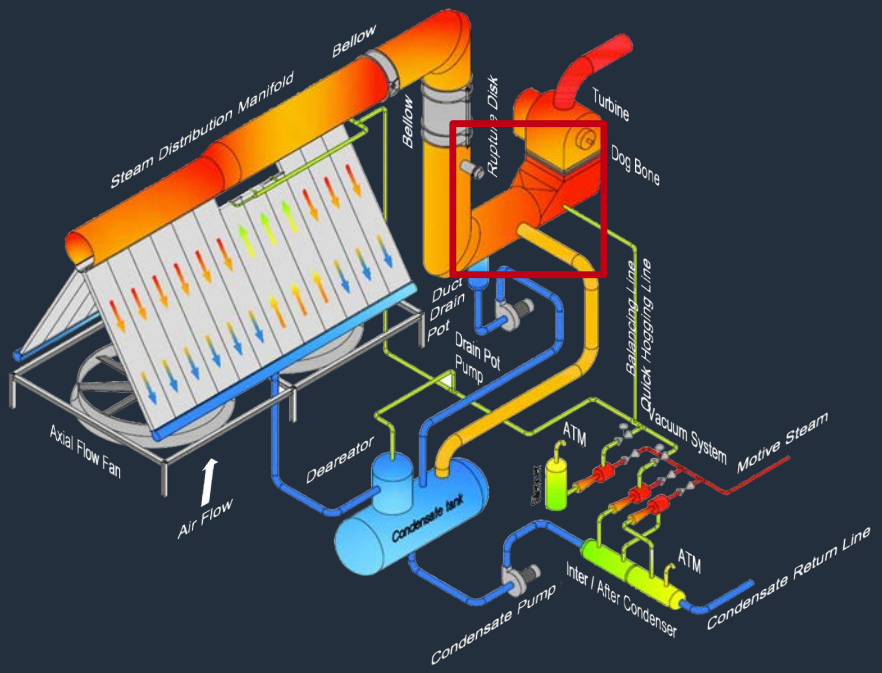


Oxide deposits

Chemistry Challenges



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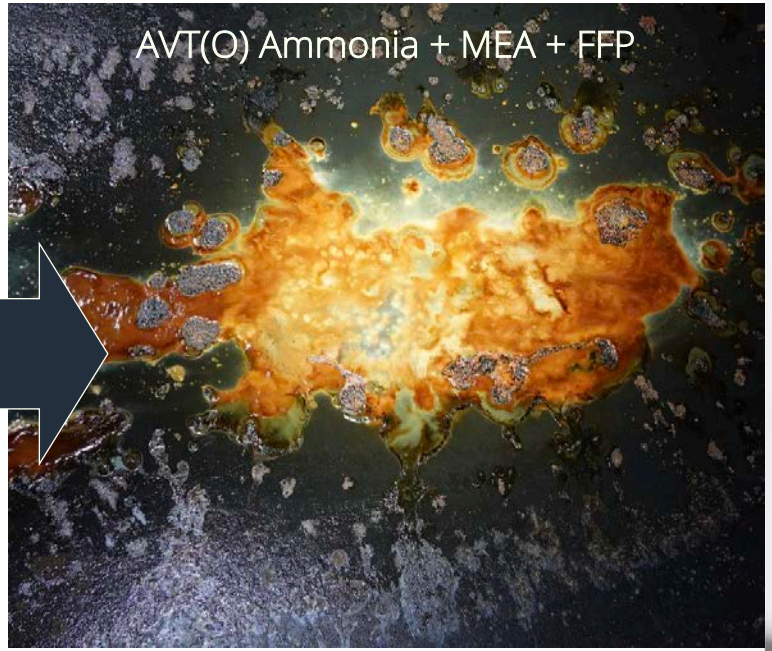
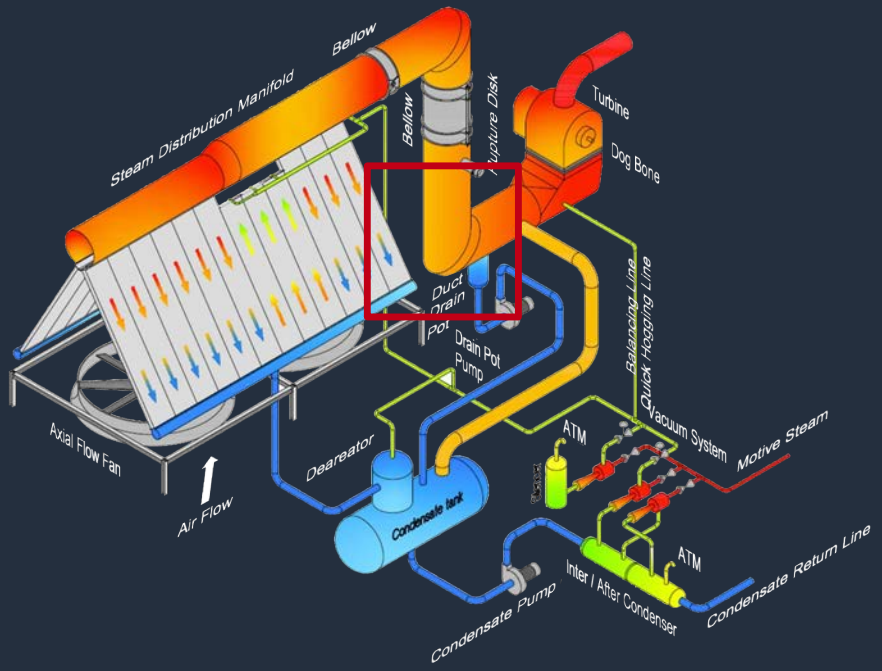


Gunk balls
Decomposition of organic products

Chemistry Challenges



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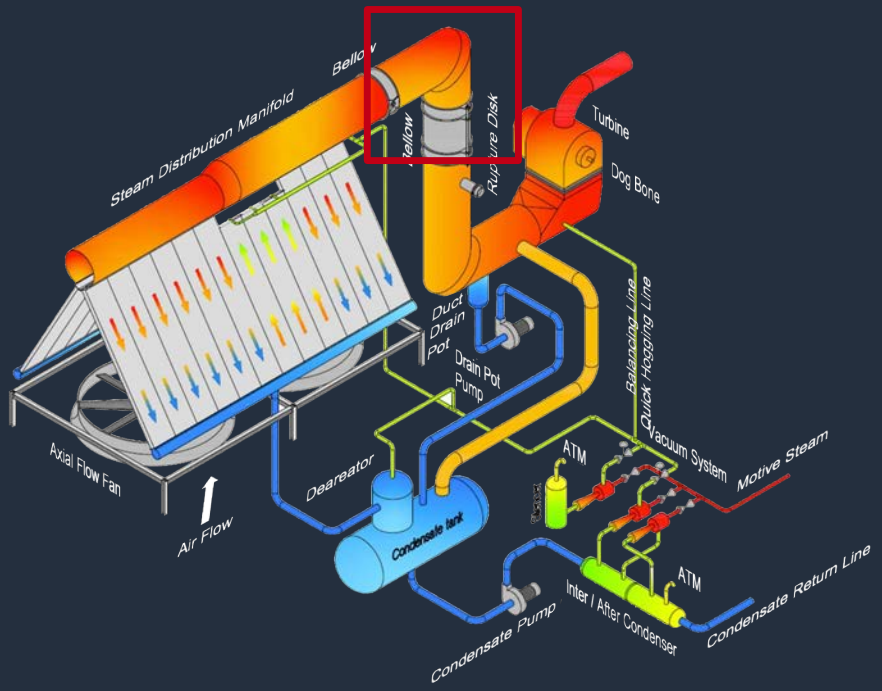

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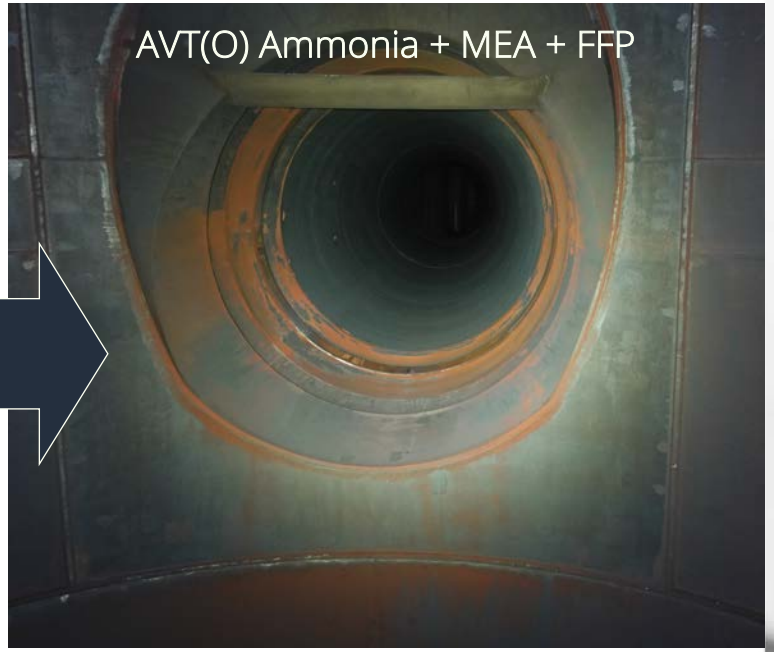
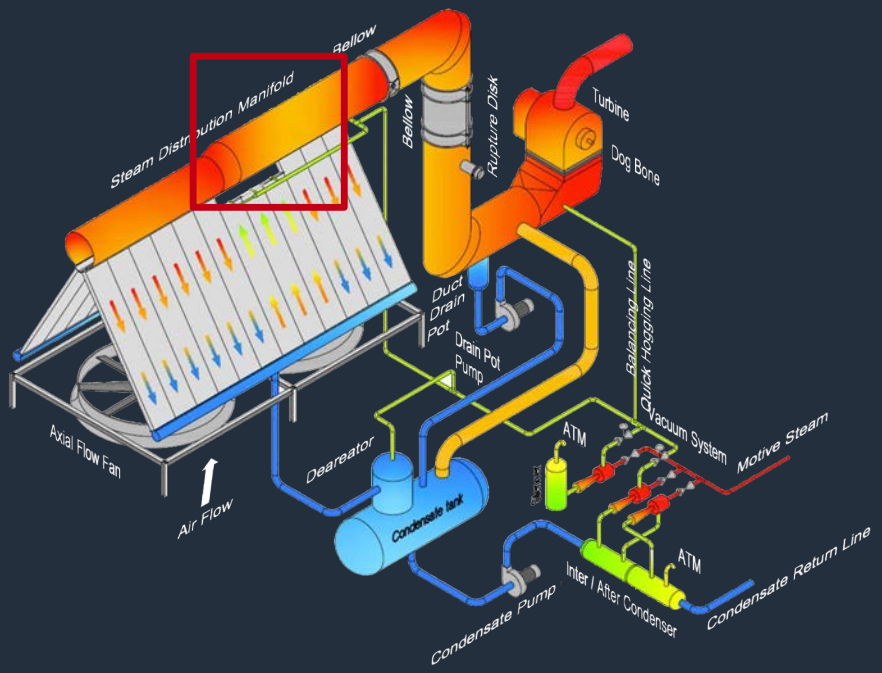


Insufficient passivation

Chemistry Challenges



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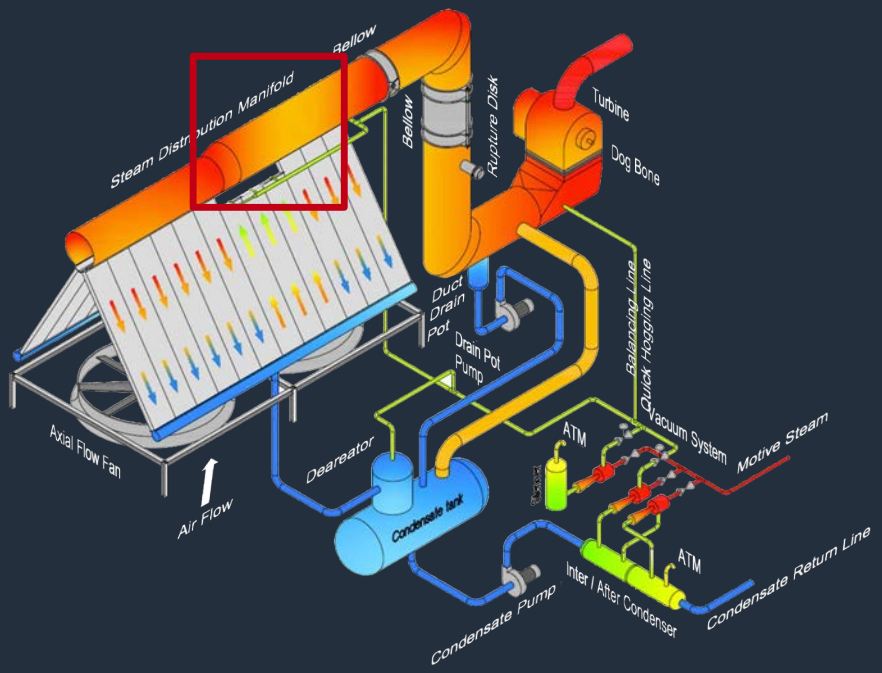

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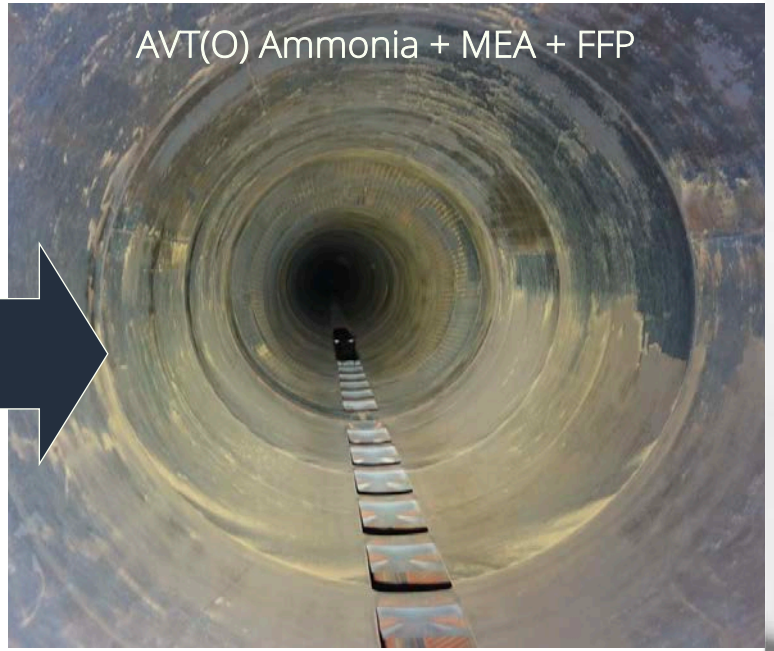

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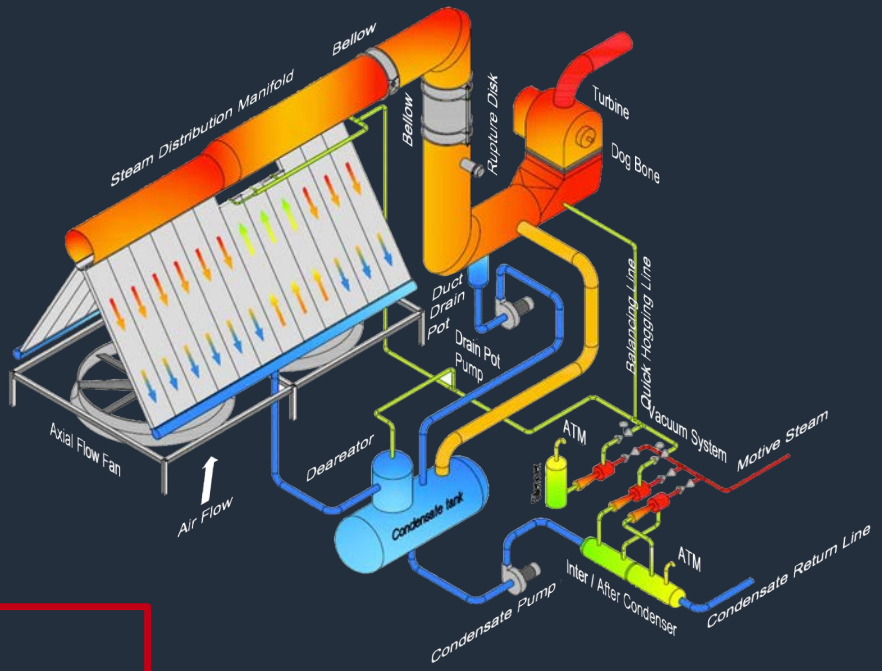

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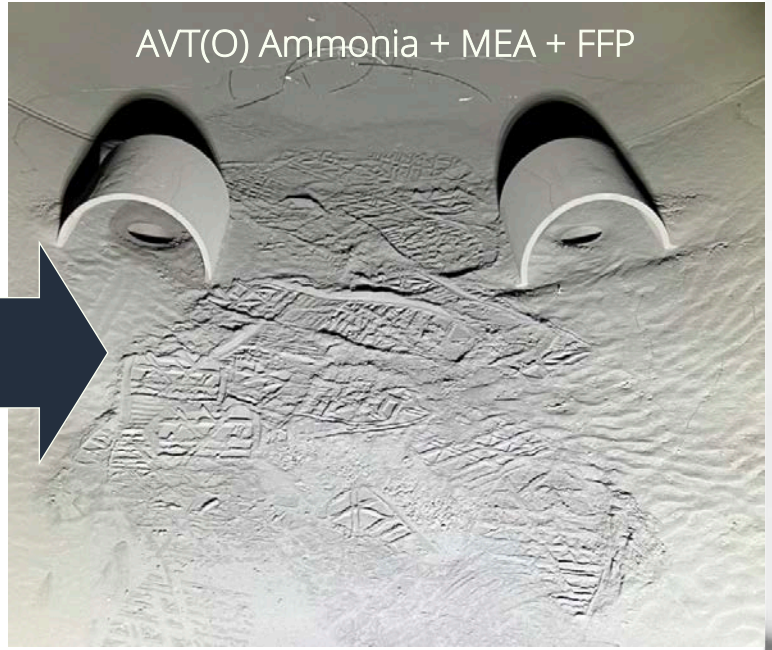
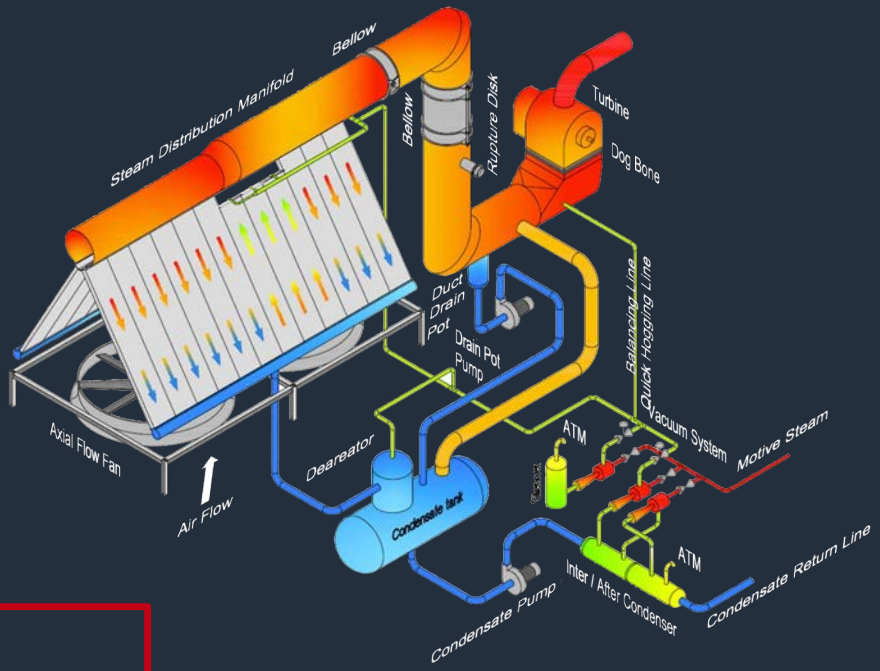


Other indications that something is wrong:
Oxide build up in HP drum (UDC risk)

Chemistry Challenges



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Other indications that something is wrong:
Vendor claims low oxide transport

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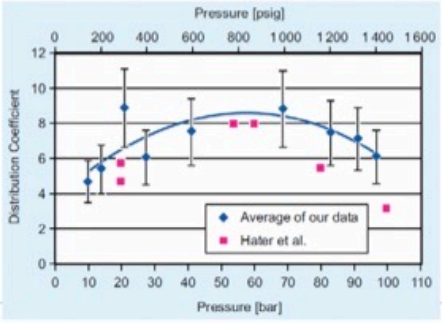
So why we see a lot of corrosion from the ST to the ACC ?

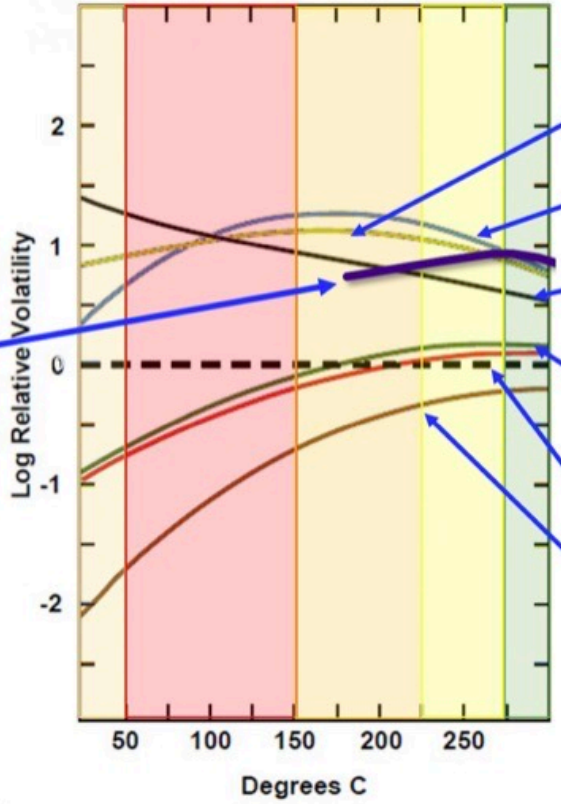
- Big 2 phase area with high voidage
- Volatile additive stays volatile and doesn't reach the metal surface
- Oxygen stays in the steam phase
- Organic breakdown products highly concentrate in the Phase Transition Zone (PTZ)
- Inorganic impurities highly concentrate in the PTZ

Neutralizing Amines – 3D's: Distribution – with OPDA Filming Amine Added

- Lower Volatility is Stronger affinity for Liquid Phase

OPDA
$C_{18}H_{36}$ –NH-$(CH_2)_3$ – NH_2





Abbrev.	Structure
DMA	H_3C–NH–CH_3
CHA	NH_2
NH3	NH_3
MOPA	H_3C–O–NH_2
Morph	HN, O
ETA	HO–NH_2

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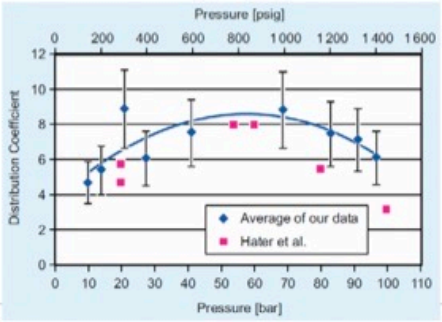

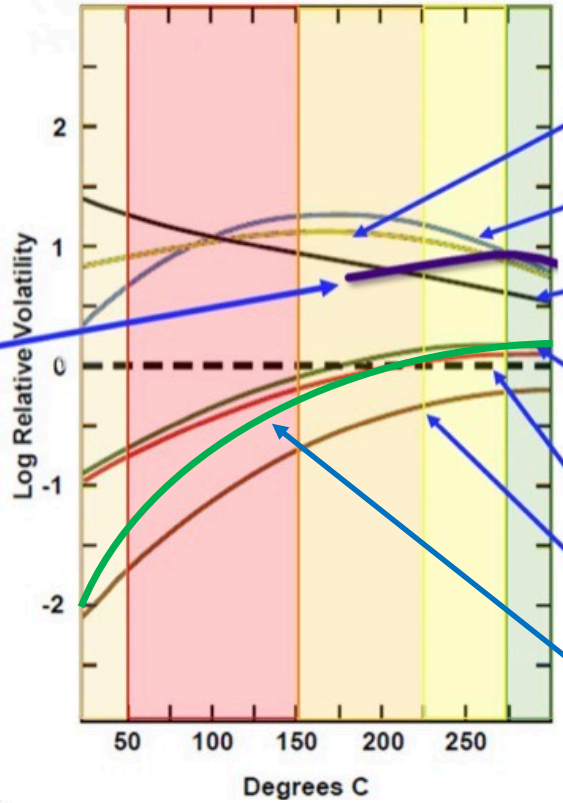

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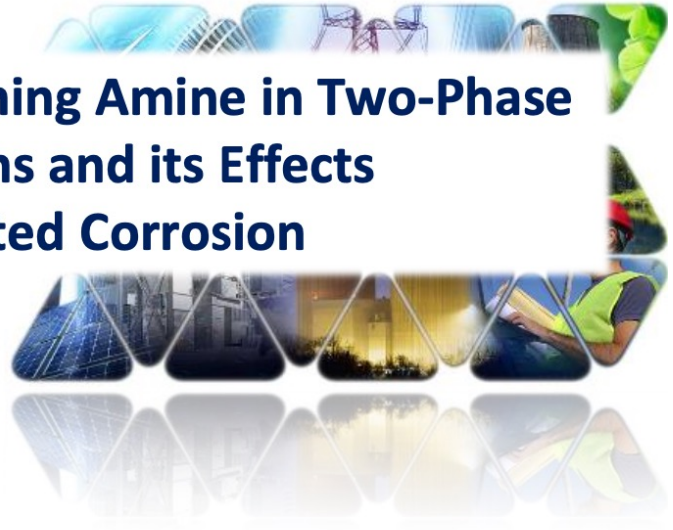
Anodamine HPFG

The Behaviour of a Film-Forming Amine in Two-Phase Steam-Water Systems and its Effects on Flow-Accelerated Corrosion



Derek Lister
Professor Emeritus, University of New Brunswick, Canada

12th International Conference on Cycle Chemistry in Fossil and Combined Cycle Plants
June 25 – June 29, 2018

Conclusions

Under two-phase conditions at 200°C and voidages of 60% to 97%...

- **The FFA product, Cetamine® V219, containing OLDA as an active film-forming component and CHA as an alkalizing component, showed no advantage over CHA alone in reducing FAC when added to the level of $pH_{25°C}$ 9.2.**
- **Both FFA and CHA partitioned mostly to the vapor-phase under these conditions.**
- **FFA could adsorb at 60% voidage, but it was not sufficient to protect the surface from FAC.**
- **No evidence of adsorbed FFA under higher voidage conditions.**
- **It is possible that the very high fluid velocities under two-phase conditions with voidages higher than 60% would not let the FFA deposit. As a result, no extra reduction in FAC over the effect of pH was observed.**

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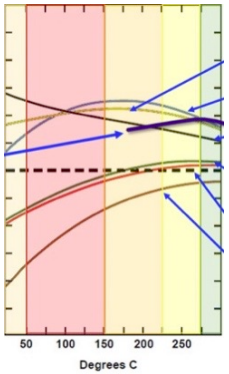

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Research was done with 2 ppm FFA residual
Operational FFA residual target is 0,2 ppm

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What about a film forming technology with low volatility?

AVT-O FFA Treatment

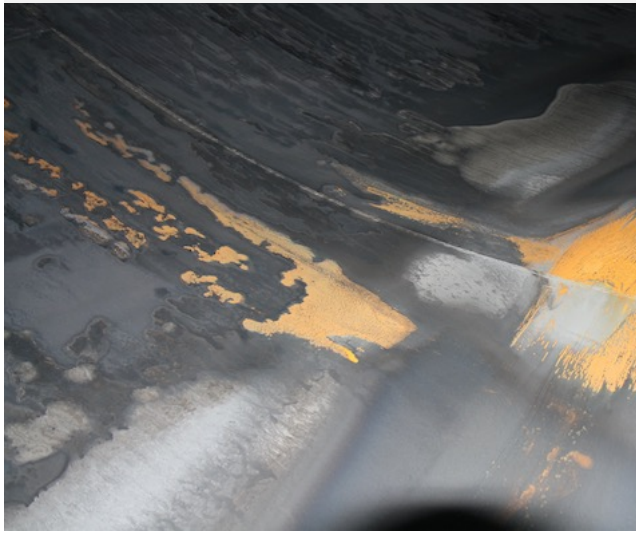
1-year AVT-O Anodamine

Turbine Exhaust Duct

H-Class CCGT+ACC in USA
160 bar, 565ºC
< 2020 AVT-O FFA
> 2020 AVT-O Anodamine

What about a film forming technology with low volatility?

AVT-O FFA Treatment



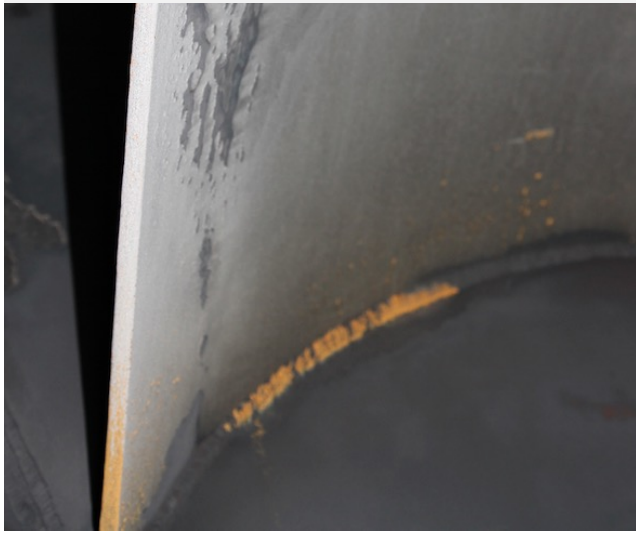
1-year AVT-O Anodamine

Turbine Exhaust Duct

F-Class CCGT+ACC in UK
130 bar, 560ºC
2017 AVT-O FFA Trial
2018 AVT-O Anodamine

What about a film forming technology with low volatility?

AVT-O FFA Treatment



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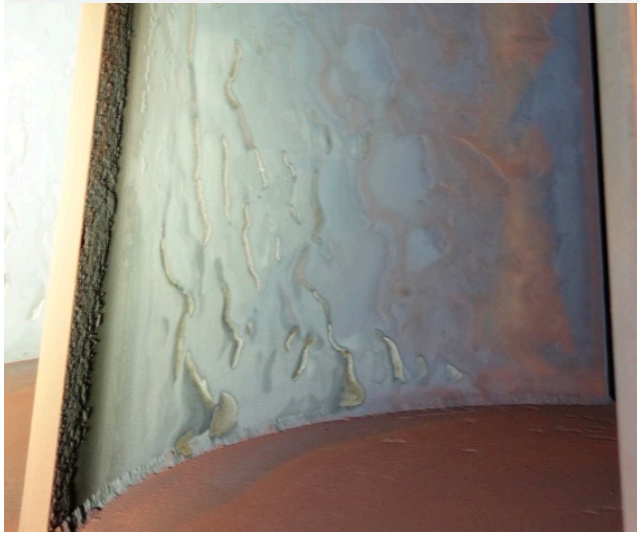

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What about a film forming technology with low volatility?

1-year AVT-O Anodamine

5-year AVT-O Anodamine

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What about a film forming technology with low volatility?

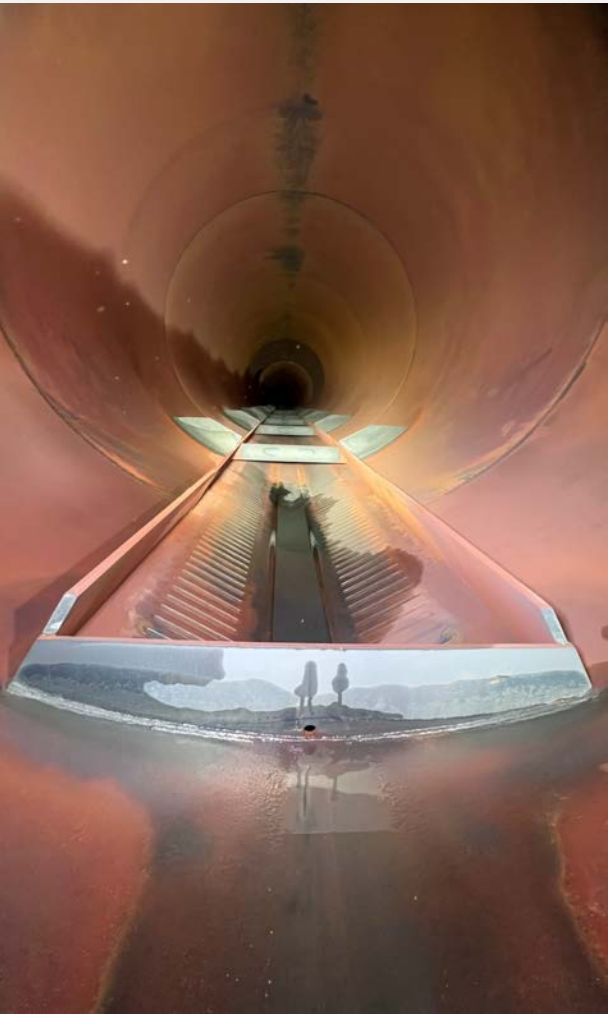
AVT-O low ORP NH3/MEA/FFP

2023 F-Class + ACC Italy

4-year AVT-O Anodamine

2023 F-Class + ACC Ireland

5-year with AVT-O Anodamine



Predominantly hematite based passive oxides
No flash rusting after 3 weeks.

Turbine Exhaust Duct

F-Class CCGT+ACC in UK
130 bar, 560ºC
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2018 AVT-O Anodamine

5-year with AVT-O Anodamine

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F-Class CCGT+ACC in UK
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Predominantly hematite based passive oxides in condenser channels

Turbine Exhaust Duct

F-Class CCGT+ACC in UK
130 bar, 560ºC
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2018 AVT-O Anodamine

5-year with AVT-O Anodamine

Here is standing water

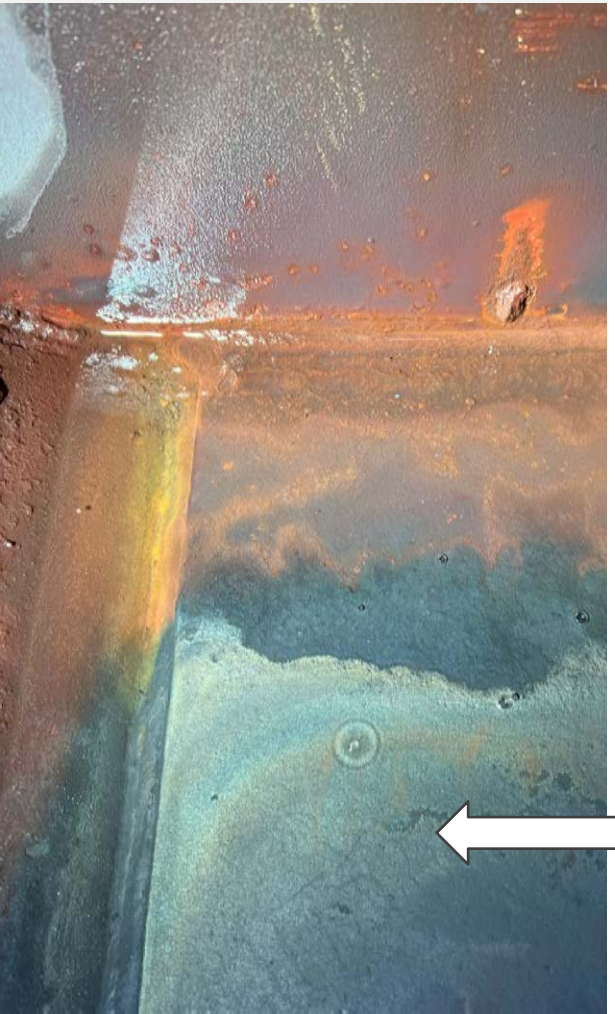
Even were is no protective oxide, metal surface is protected by Anodamine film forming technology.

No flash rust after 3 weeks exposure to atmospheric conditions.

Turbine Exhaust Duct

F-Class CCGT+ACC in UK
130 bar, 560ºC
2017 AVT-O FFA Trial
2018 AVT-O Anodamine

5-year with AVT-O Anodamine



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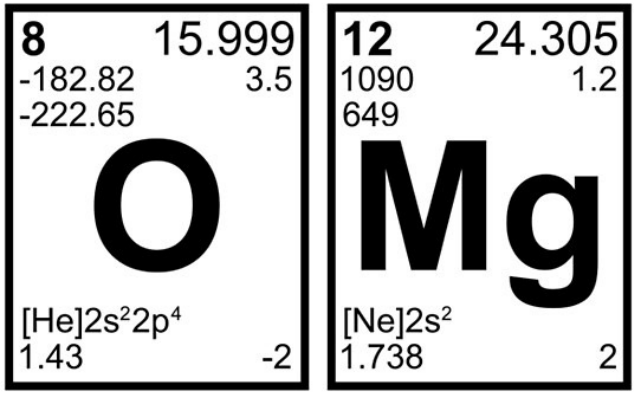

There’s a concept that actually works

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Thank you !!