GE Power & Water
Water & Process Technologies

Steam System Corrosion Protection Designed for the Refining Industry

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A Collaborative effort of GE Refinery Process and Boiler Research and Engineering

A Low-Salt/Polyamine Boiler Treatment Technology

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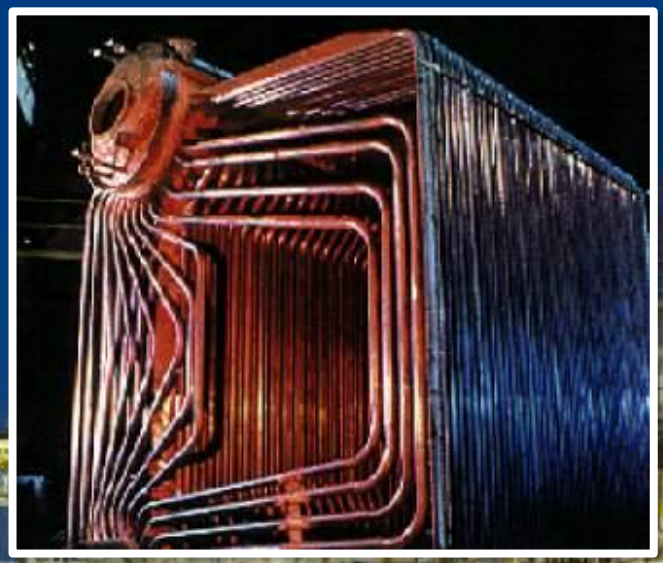
Low-Salt/Polyamine Condensate Treatment Technology

Integrated solution between refinery process and water treatment technology: Lower salting amine technology expanded to include steam condensate treatments



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Why Low-Salting Amines for steam treatment?

Condensate treatment tailored for the refining industry

- Developed utilizing state-of-the-art modeling capability developed at GE for both Water and Process operations
- **Low-Salt Neutralizing Amines** - utilizing amines that have less potential for forming corrosive amine chloride salts
- **Polyamine** - Effective protection of "difficult to treat" steam condensate – reboilers, high alkalinity make-up sources, users of flashed steam
- Equal or improved use-cost to the current boiler neutralizing amine products

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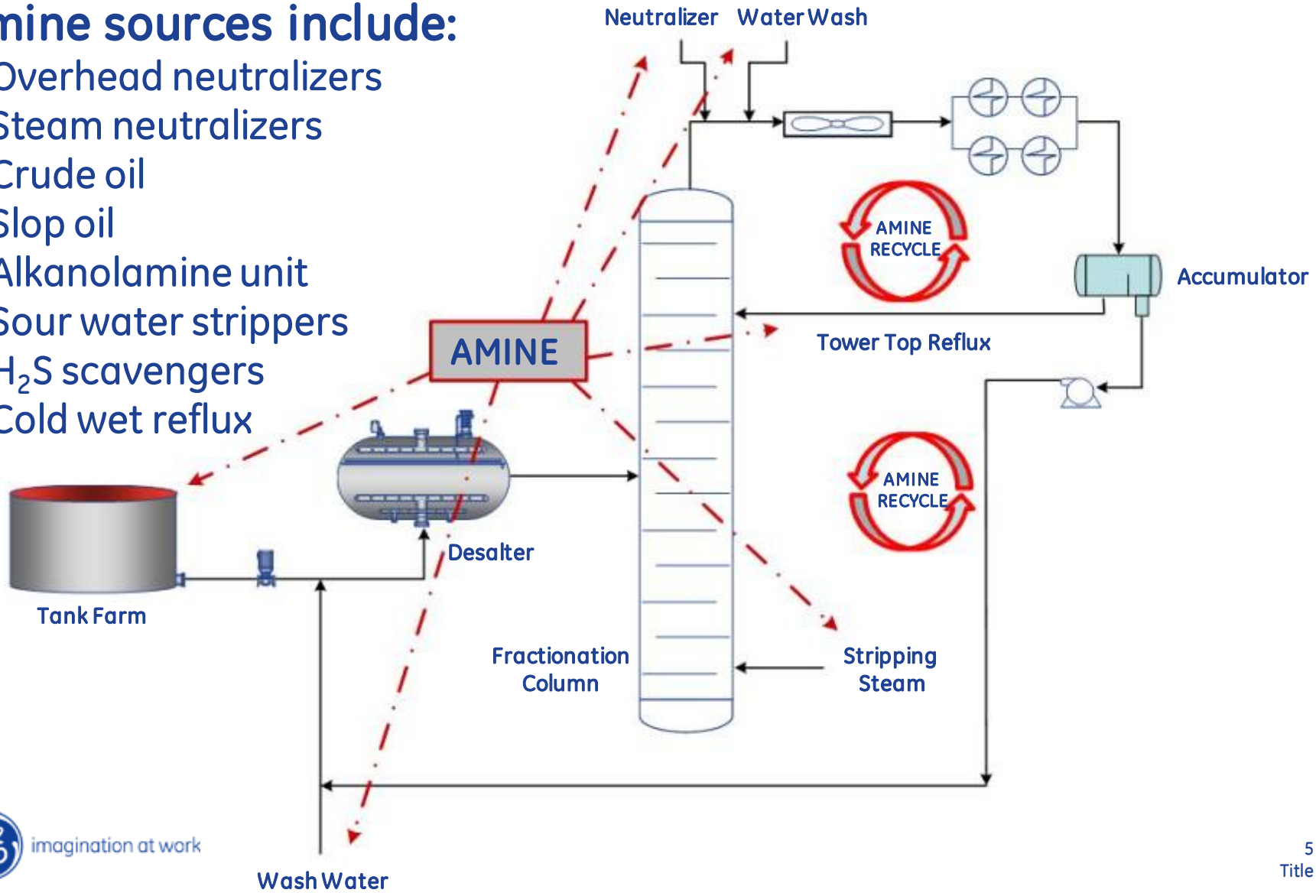
Amine sources and recycle loops

Amine sources include:

- Overhead neutralizers
- Steam neutralizers
- Crude oil
- Slop oil
- Alkanolamine unit
- Sour water strippers
- H_2S scavengers
- Cold wet reflux



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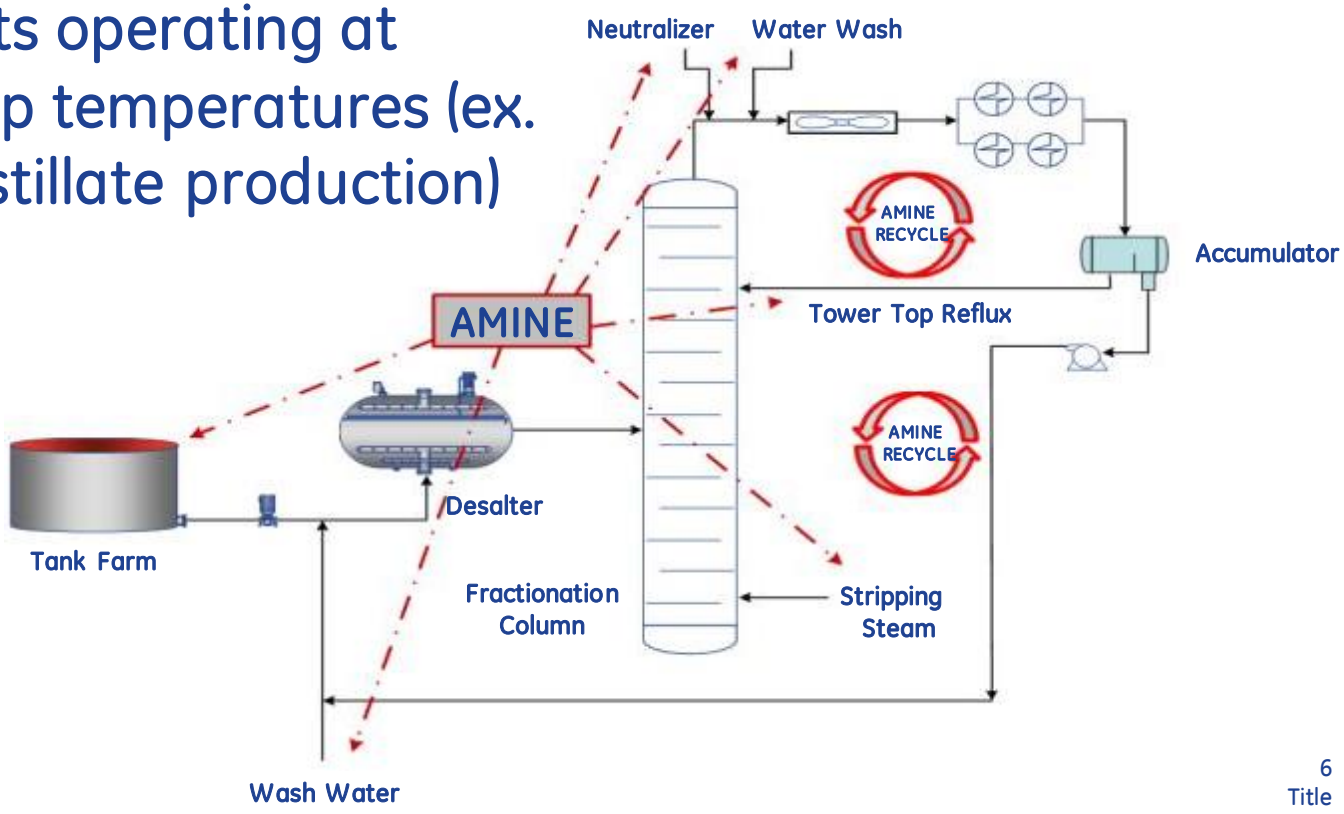
GE “Low Salt” for steam condensate

- Collaboration between Hydrocarbon Process and Water Technologies Research and Engineering Team
- Designed to reduce amine-chloride salt fouling and subsequent corrosion potential – especially in refinery distillation units operating at lower tower top temperatures (ex. maximizing distillate production)



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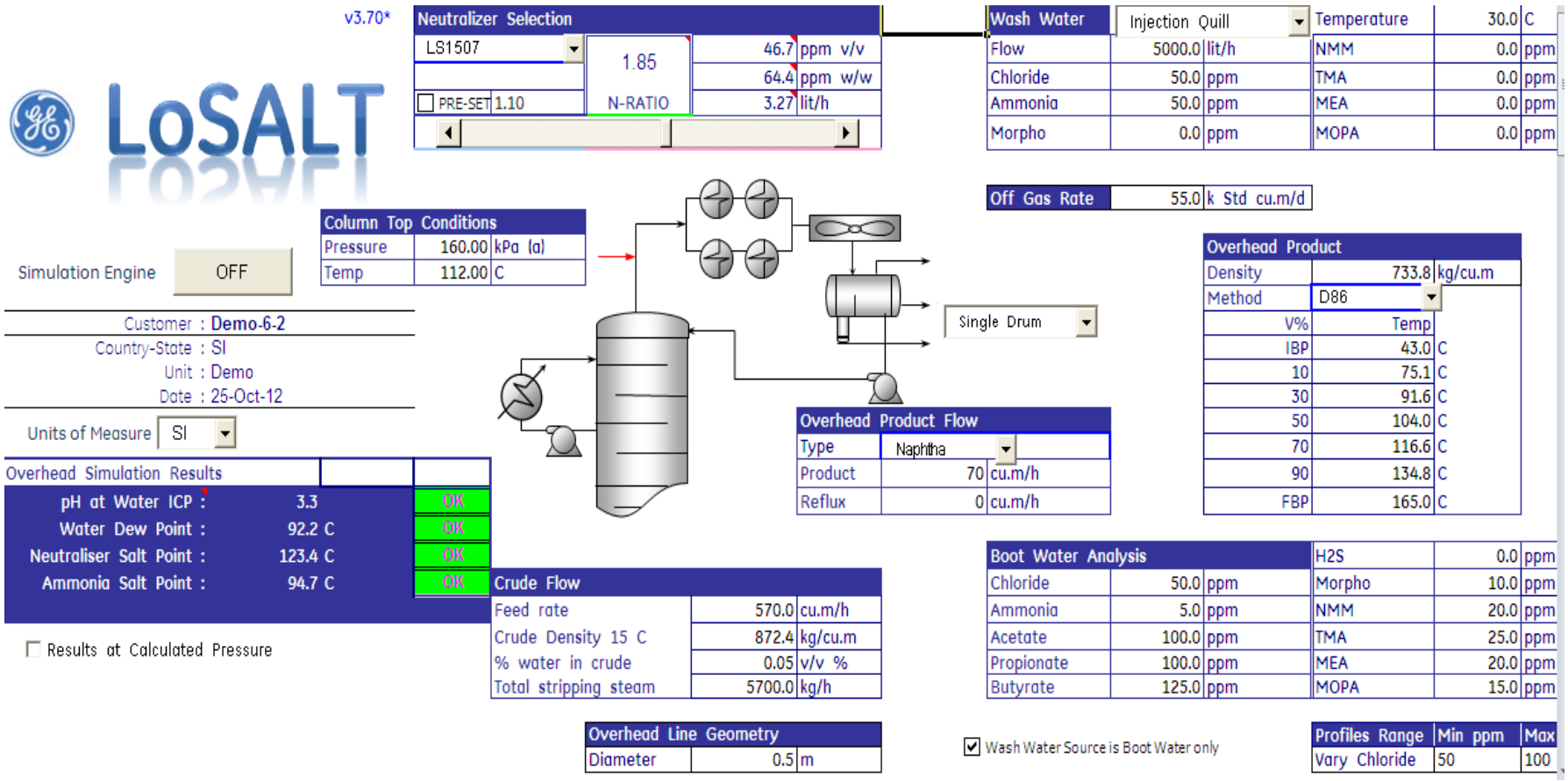
GE LoSalt™ modeling

Utilized for product design and the current operating impact of treatment chemistries



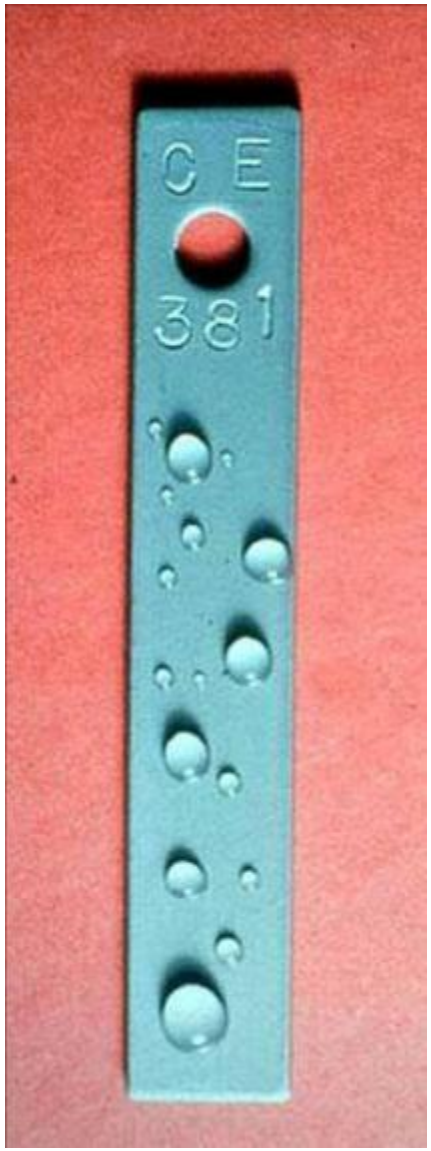
Low-Salt/Polyamine Condensate Treatment Technology

SALT POINT DATA OF AMINE BLENDS IN CRUDE UNIT OVERHEAD , Deg F			
Chloride	Steam Amine X	NA0660	Low-Salt/Polyamine
ppm	Pressure 8.7 psig		
10	227.8	212.1	184.2
20	243.9	224.1	197.6
40	260.7	236.7	211.5
70	274.8	247.1	223.2
100	284.1	254.0	230.9
130	291.1	259.1	236.7
160	296.8	263.2	241.4

GE Polyamine technology

Combining the strengths of neutralizing and state-of-the-art surface adsorption corrosion inhibition

- Four year research effort
- A unique, volatile surface adsorption inhibitor – the **Polyamine** - combined with … Low salting neutralizing amines designed specifically for refinery steam system protection



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GE Polyamine Technology

A novel approach to boiler system corrosion control

What is Polyamine technology?

- A unique, volatile corrosion inhibitor in combination with a high-performance neutralizing amine blend that provides protection against both carbonic acid and dissolved oxygen corrosion

How is it different from a traditional boiler treatment?

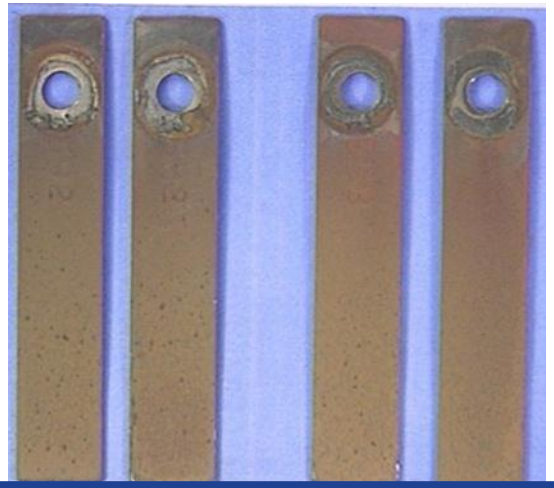
- In a system with an effective thermal deaerator, the Polyamine product provides oxygen corrosion protection in the BFW and condensate systems, by filming the metal surfaces. It may augment or replace the existing oxygen scavenger

Polyamine Corrosion Evaluation

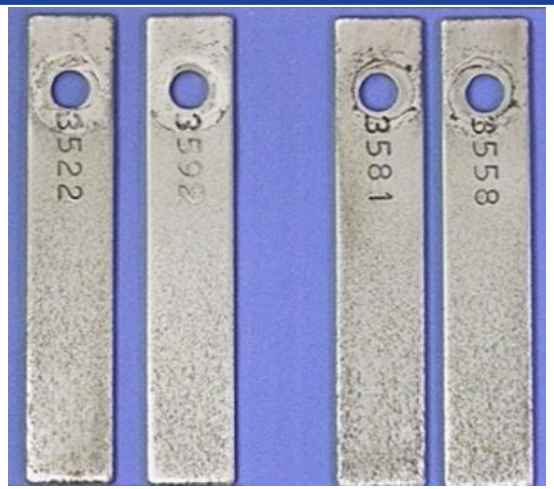
Under high corrosion stress → 100 ppb dissolved oxygen

- **Minimal pitting**
- **Minimal general corrosion**
- **Robust surface film**
- Water beads on low carbon steel test coupons exposed for seven days to 10 ppm of polyamine product, **100 ppb of dissolved O_2** and 110°C (230°F) in deionized water

Sulfite O_2 Scavenger

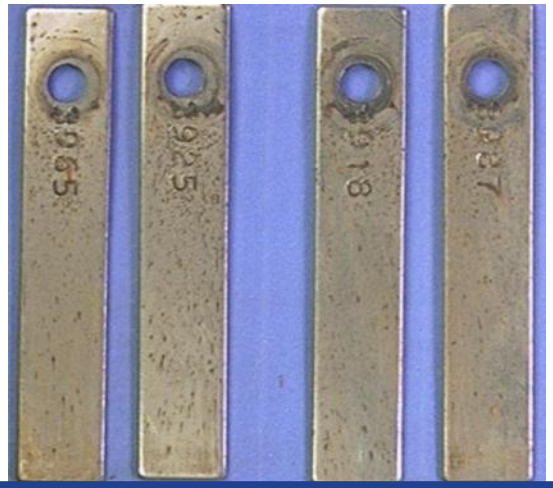


MPY 3.1

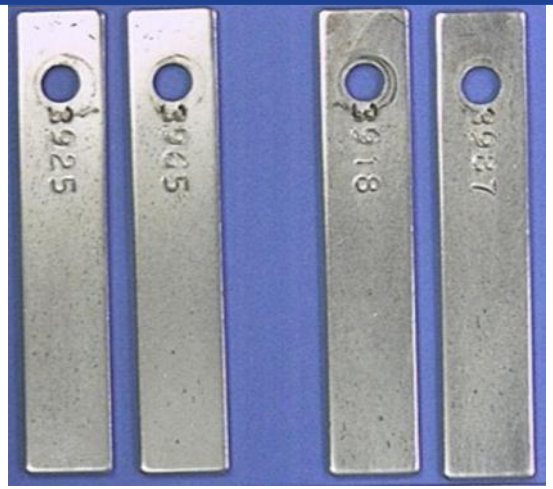


Coupons in same softened feedwater system

Polyamine



MPY 0.22, no pits



Both are averages of 3 tests
Each test run - 4 coupons for 14 days

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Key performance differences

Polyamine blends versus traditional amine treatments

Polyamine blends provide enhanced corrosion protection against:

- Dissolved oxygen corrosion and upsets, air in-leakage
- Erosion/flow assisted corrosion
- Downtime/storage corrosion
- Acidic corrosion - CO_2 , chloride/sulfate, organic acids

Polyamine program benefits

Why consider Polyamine technology?

Assurance and reliability

- **Dual corrosion protection mechanisms** of adsorption and neutralization reduces acidic/oxygen/FAC corrosion and iron transport
- **Off-line protection** - the Polyamine's effective distribution and tenacious adsorption to metal surfaces provides enhanced protection when the system is off-line

GE Low Salt/Polyamine "Steamate* LSA179x"

Steam System Modeling and Product Comparison

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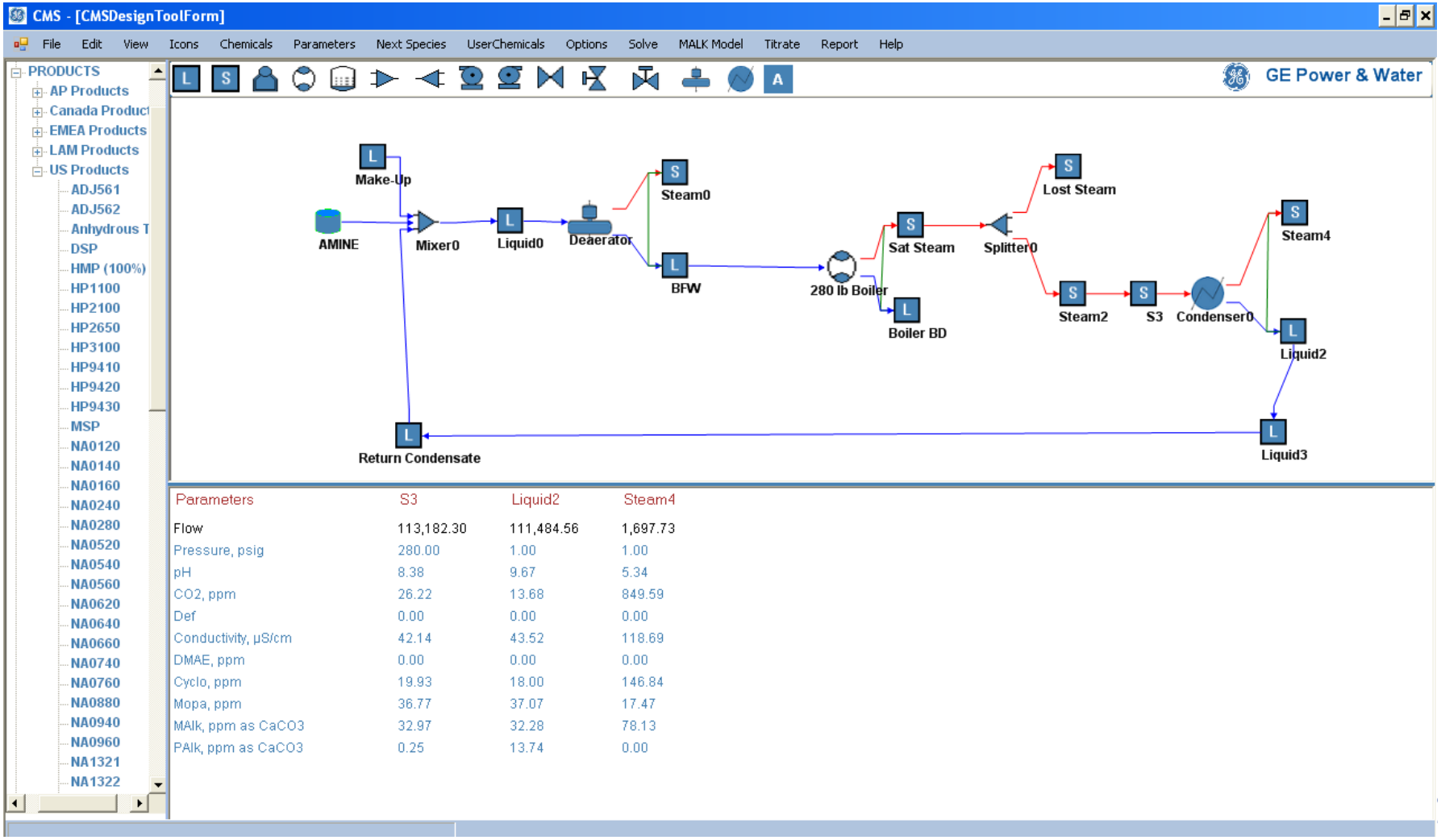
GE Steam System Computer Modeling

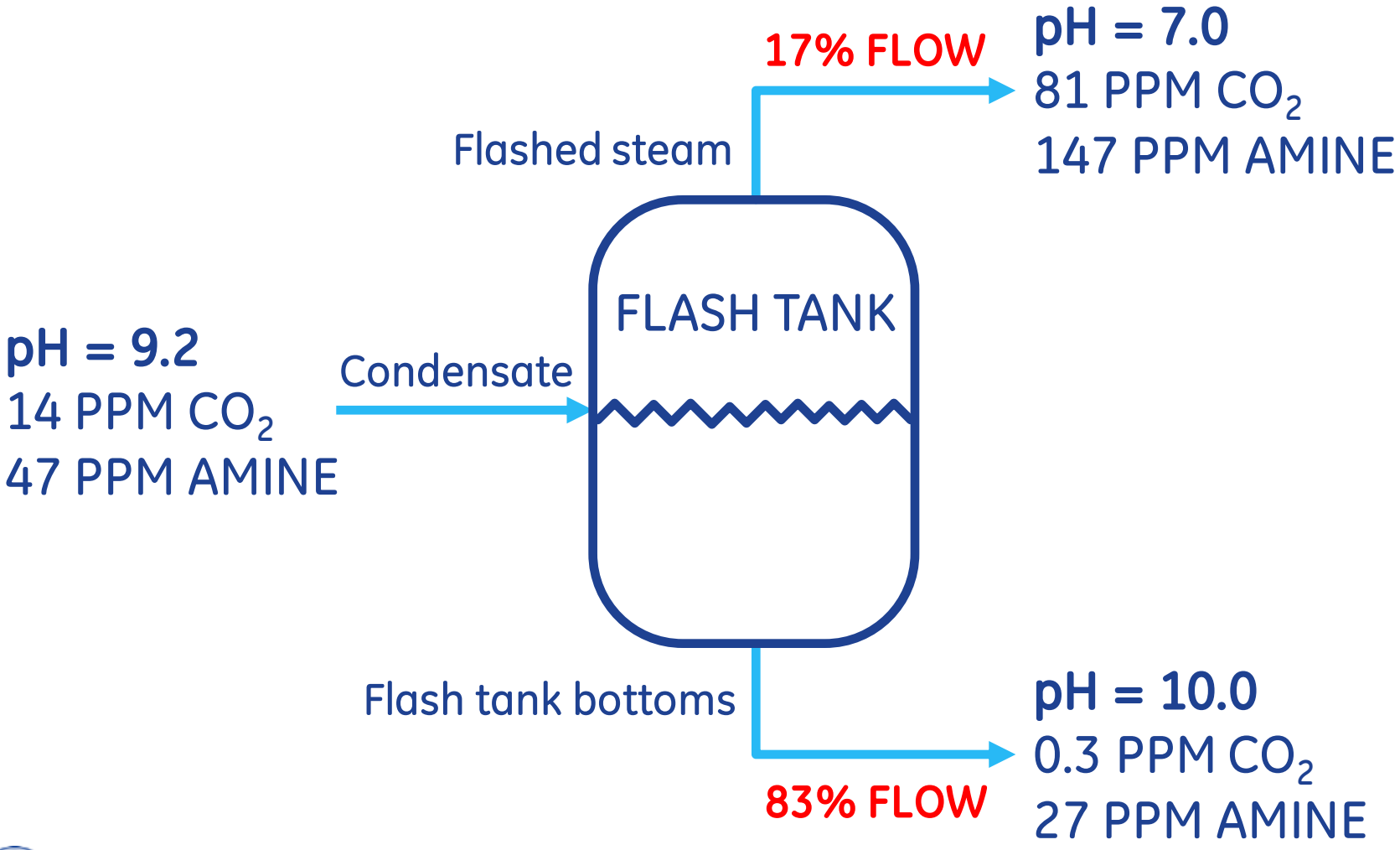
Optimizes product selection and cost optimization for complex steam systems



Parameters	S3	Liquid2	Steam4
Flow	113,182.30	111,484.56	1,697.73
Pressure, psig	280.00	1.00	1.00
pH	8.38	9.67	5.34
CO2, ppm	26.22	13.68	849.59
Def	0.00	0.00	0.00
Conductivity, µS/cm	42.14	43.52	118.69
DMAE, ppm	0.00	0.00	0.00
Cyclo, ppm	19.93	18.00	146.84
Mopa, ppm	36.77	37.07	17.47
MAlk, ppm as CaCO3	32.97	32.28	78.13
PAlk, ppm as CaCO3	0.25	13.74	0.00

GE Steam System Computer Modeling

Example: CO_2 and amine distribution in flash tank



GE “Polyamine”

New Technology in Condensate Treatment Chemistry

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Low Salt/Polyamine program goals

Qualification and evaluation

- Cost/performance evaluation – must provide superior feedwater/condensate protection at equal or lower cost – determined by GE steam system modeling and field analytical analysis
- Process units – must be superior in limiting amine chloride salt fouling potential – determined by GE LoSalt modeling and field analytical analysis

Low Salt/Polyamine opportunity

- Opportunity for boiler/steam system and refinery process reliability improvement
- Opportunity for treatment/chemical cost reduction
- Potential opportunity for refinery process operating flexibility/improved profit

Thank you for your time and partnership

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