Why Amine Systems Fail

Michael Sheilan, P.Eng.
Senior Staff Engineer
Amine Experts Inc.

GPAC

Webinar Part Two
Gas Processing Focus

amine eXperts

1

Happy New Year!

Welcome to the January 28, 2021 Webinar

Overview of Amine-Based Gas Sweetening
Part 2

Mike Sheilan, P.Eng

GPAC 2

2

Introduction

- GPAC is a non-profit organization formed to promote the interaction and exchange of ideas and technology to those involved in the hydrocarbon processing industry.
- GPAC has many exciting things planned for 2021 including 12 technical webinars
- GPAC has operated in Alberta since 1959 because of the support of our membership and generous sponsors. A big thank you to:

Gold Sponsors

Equinox Engineering Ltd
Gas Liquids Engineering
Rangeland Engineering
Spartan Controls

Silver Sponsors

Enerflex
Tundra Process Solutions Ltd.

GPAC

3

3

GPAC UPCOMING EVENTS

TECHNICAL WEBINARS

4 Part Hydrogen Series
$40 for Members $50 for Non-Members

PART 1: Hydrogen and the Net-Zero Emission Challenge
Presented By: Dr. David Layzell
February 11th | 11:30-12:30pm

PART 2: The Techno-Economics of Hydrogen as a Fuel
Presented By: Dr. David Layzell
February 19th | 11:30-12:30pm

PART 3: Building a Hydrogen Economy - The Greater Edmonton Region Hydrogen Node
Presented By: Dr. David Layzell
February 25th | 11:30-12:30pm

PART 4: Transportation and Storage Solutions of Hydrogen
Presented By: Brian Hall and Andy Jacobson
March 4th | 11:30-1:00pm

Follow us on LinkedIn to stay up to date with GPAC

SOCIAL EVENTS

Dates subject to change based on Federal and/or Provincial Health guidelines surrounding Covid-19

Clay Shooting
May 14

Stampede Lunch
July 12

Classic Golf Tournament
September 9

4

5

Mike Sheilan

- 40 years in the industry
- 19 years at Brenntag/Travis Chemicals
  - Technical Service Manager, Dow Chemical support in Canada
  - first supply company to provide engineering technical support to Canadian Oil & Gas Industry
- 21 years at Amine Experts Inc.
  - Senior Staff Engineer – troubleshooting, training, etc.
- Senior Advisor LRGCC at University of Oklahoma
- Published author and Conference Presenter
- Member GPAC, APEGA and NACE

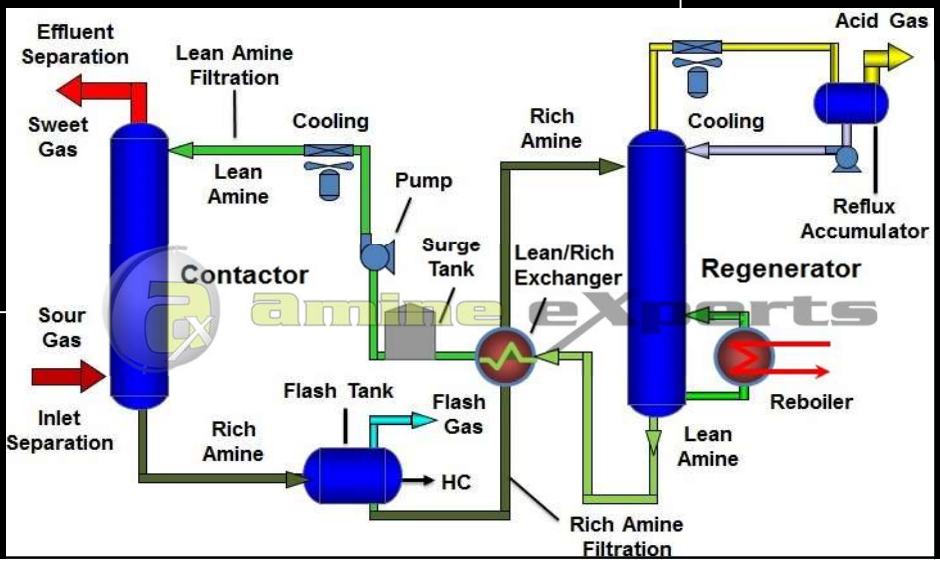
6

amine eXperts Sulphur eXperts dehydration eXperts

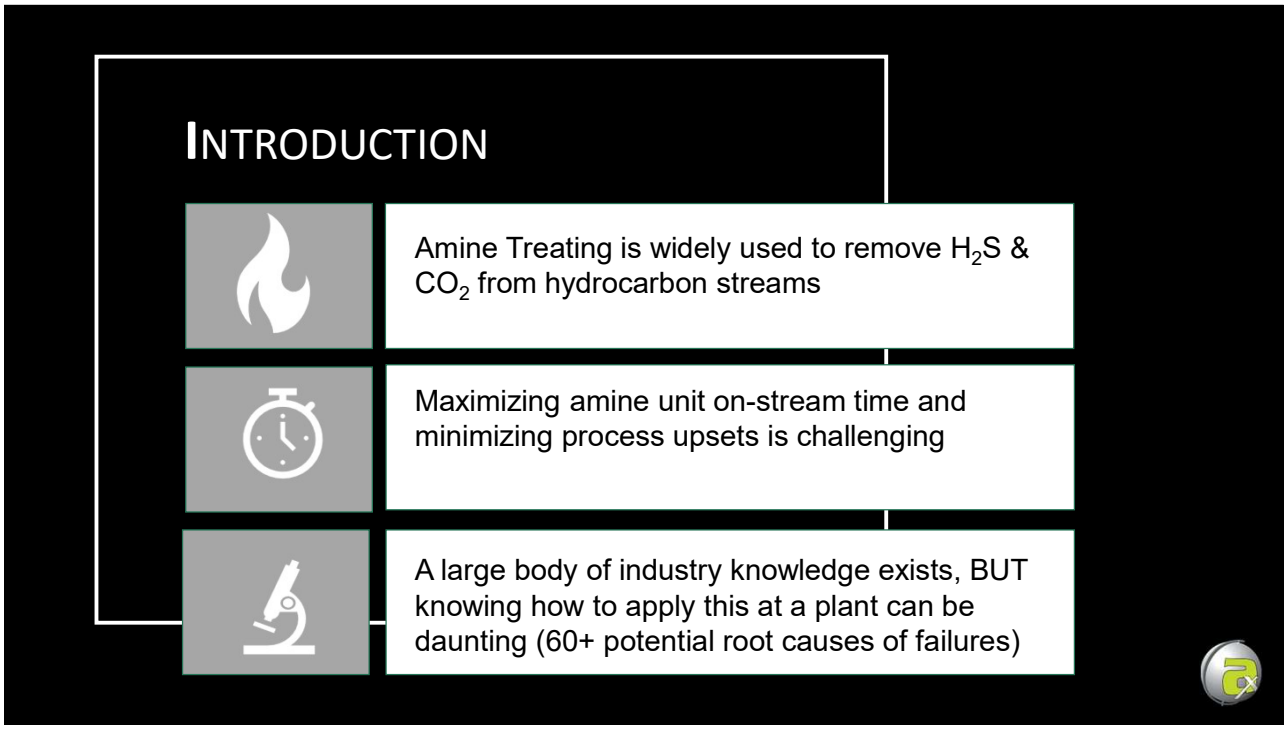
- Headquartered in Calgary, Alberta
- over 3000 projects in over 60 countries
  - 285 Amine and Sulphur projects in 2019
- senior staff has over 350 years combined experience
- employees have authored more than 70 papers
- provide technical support to every major oil and gas company in the world
- provide technical support to all major process licensors

7

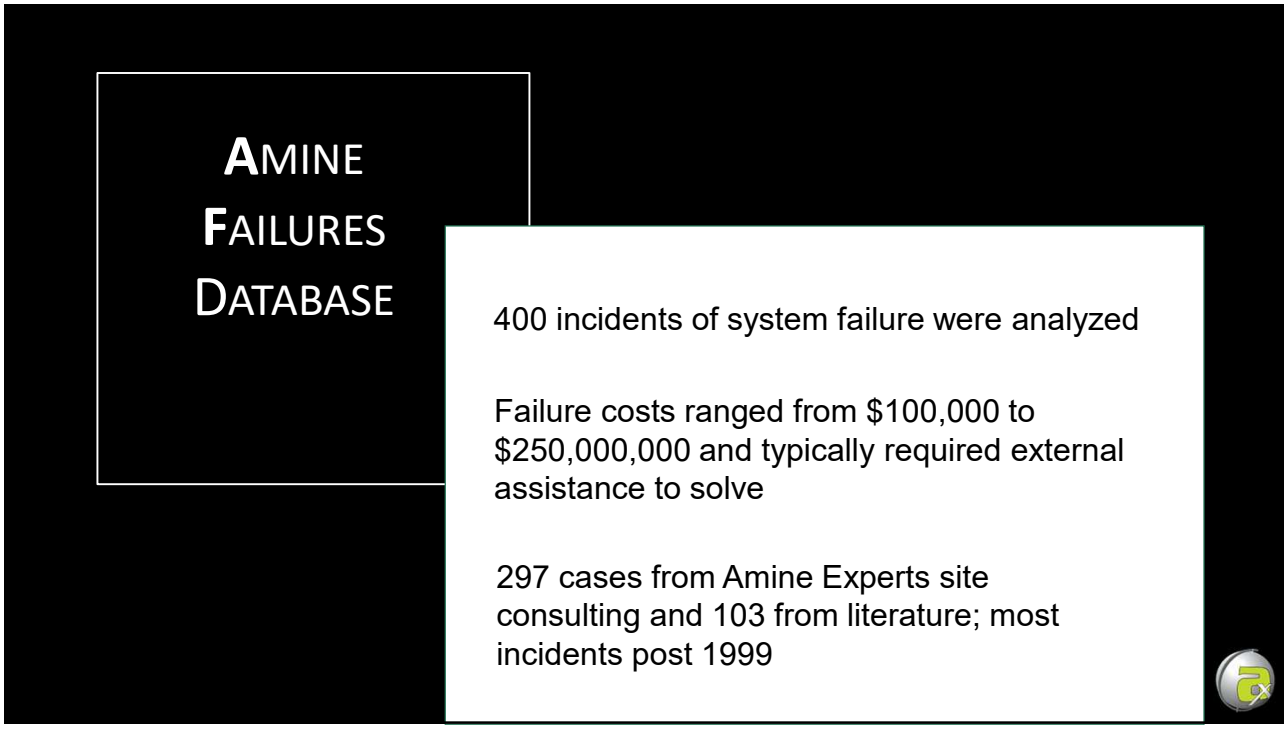
AMINE SYSTEM FLOWSHEET REVIEW



8


INTRODUCTION
Amine Treating is widely used to remove H_2S & CO_2 from hydrocarbon streams
Maximizing amine unit on-stream time and minimizing process upsets is challenging
A large body of industry knowledge exists, BUT knowing how to apply this at a plant can be daunting (60+ potential root causes of failures)

9

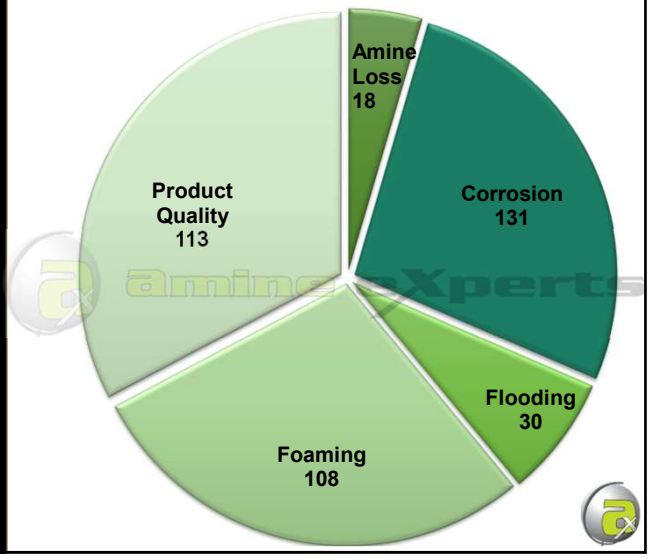

AMINE FAILURES DATABASE
400 incidents of system failure were analyzed
Failure costs ranged from $100,000 to $250,000,000 and typically required external assistance to solve
297 cases from Amine Experts site consulting and 103 from literature; most incidents post 1999

10

FAILURE TYPE

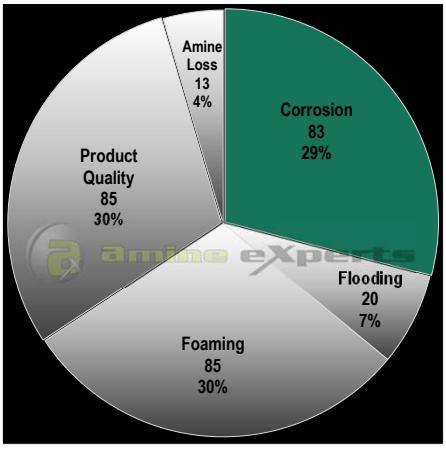
Corrosion, Foaming and Off-Specification Product are the biggest operational threats

"CO_2 – only" removal systems are more likely to experience corrosion

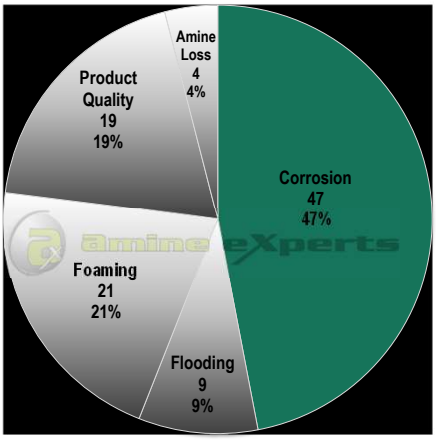


11

SWEET OR SOUR?



>1000ppmv H_2S in feed gas



<1000ppmv H_2S in feed gas

12

MEETING SPECIFICATION

CAN YOU AFFORD TO FLARE IF YOU ARE OFF-SPEC?

13

MEETING H_2S SPECIFICATION

4-16 PPMV

The three factors that most affect treated gas H_2S content:

- lean amine loading (the lower the better)
- lean amine temperature (the lower the better)
- adequate contact between the amine and gas (H_2S absorption is *gas-phase dependent*, and *equilibrium limited*

14

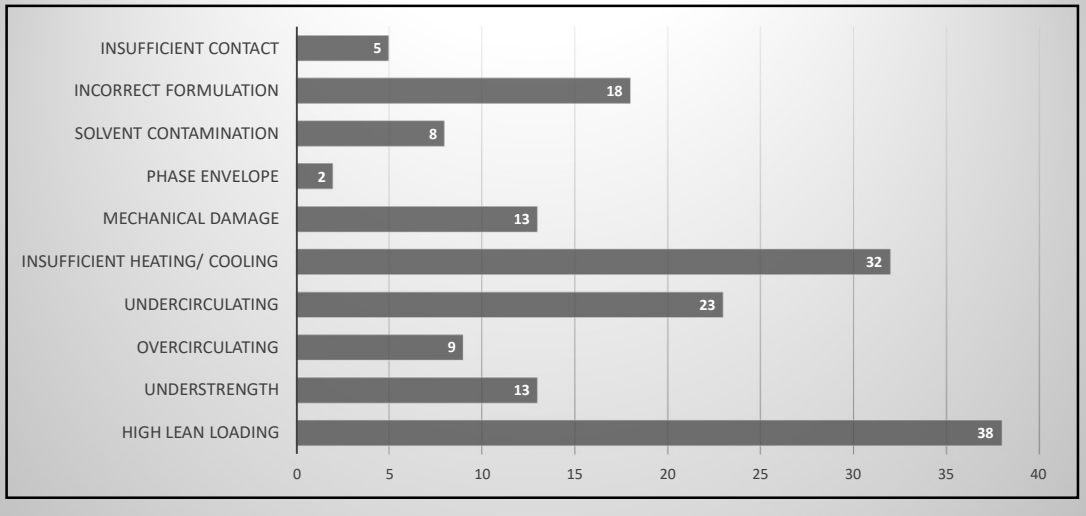
MEETING CO_2 SPECIFICATION

<2 MOL%
<50 PPM (LNG)

- Primary or secondary amines provide little selectivity (DIPA is an exception)
  - Expected outlet CO_2 will be in ppm range
- Tertiary and hindered amines allow for the ability to custom treat CO_2 content
  - CO_2 slip can result in increased sales gas
  - provides a better feed to the SRU
  - CO_2 absorption is *kinetically limited* and *liquid-phase dependent*

15

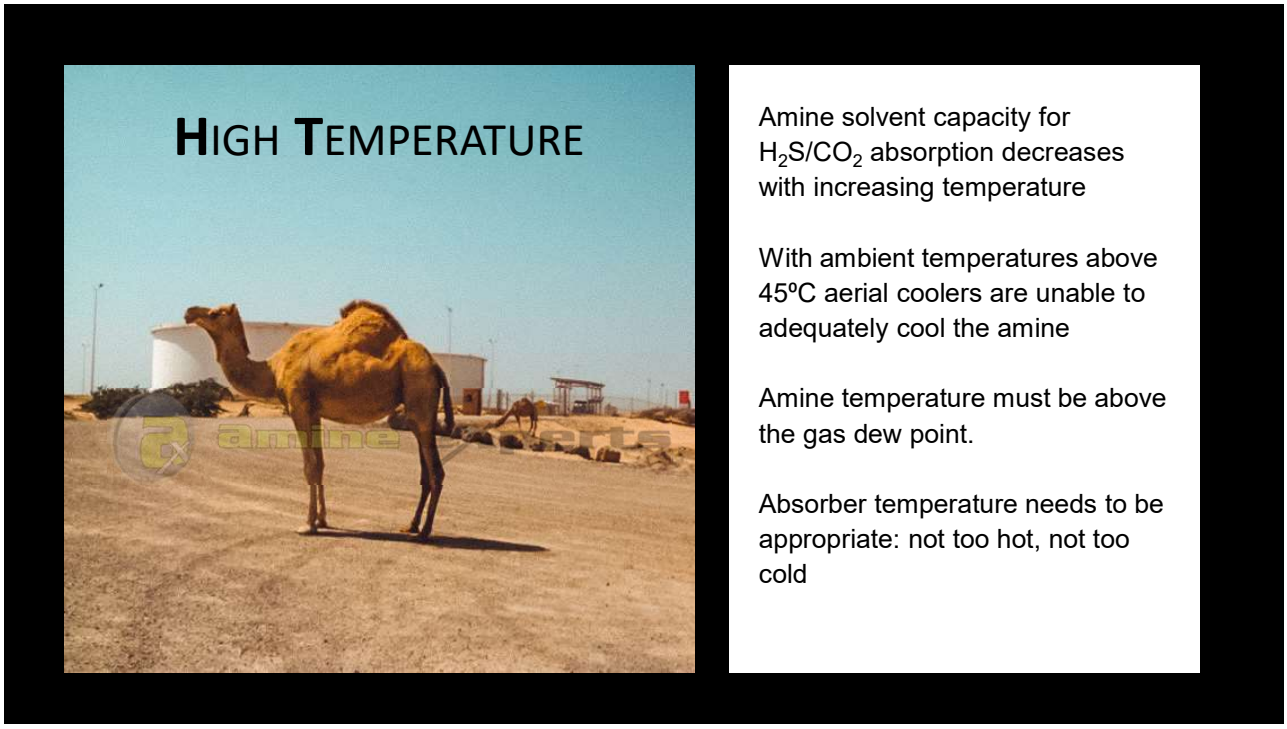
MEETING SPECIFICATION / PRODUCT QUALITY



16

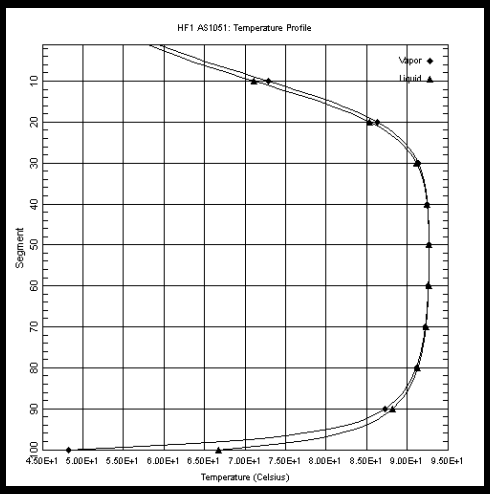

MECHANICAL DAMAGE

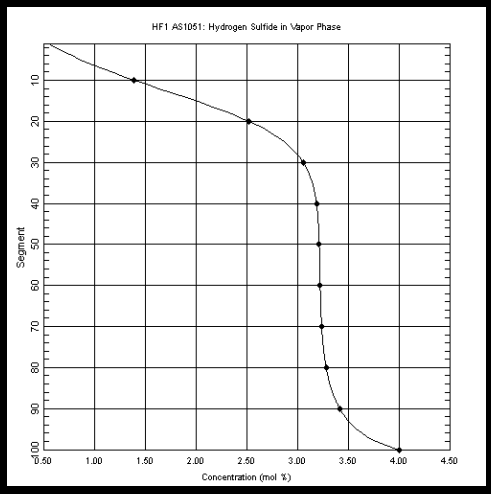
17


HIGH TEMPERATURE
Amine solvent capacity for H_2S/CO_2 absorption decreases with increasing temperature
With ambient temperatures above 45ºC aerial coolers are unable to adequately cool the amine
Amine temperature must be above the gas dew point.
Absorber temperature needs to be appropriate: not too hot, not too cold

18

Contactor Temperature vs H_2S Removal Efficiency

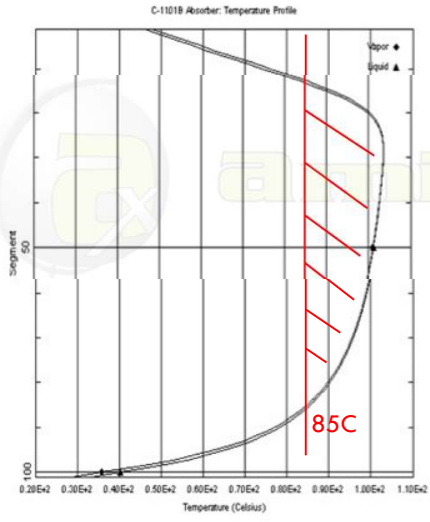


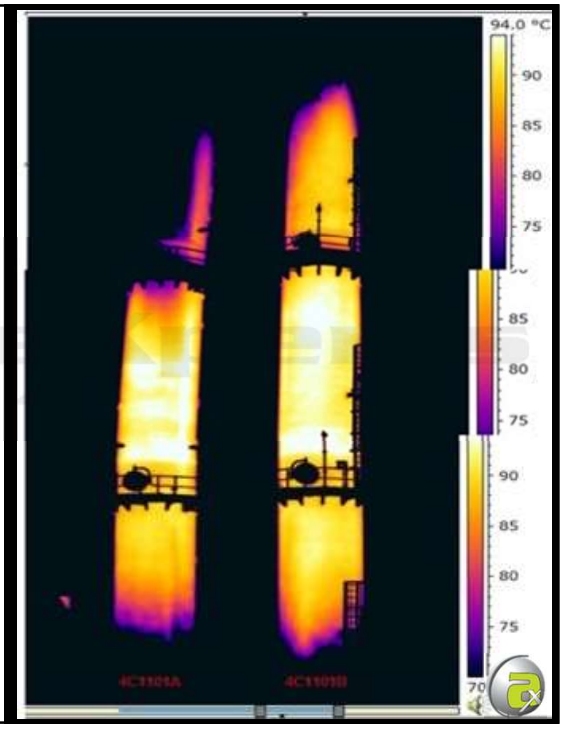


High temperatures….. **Poor H_2S removal**

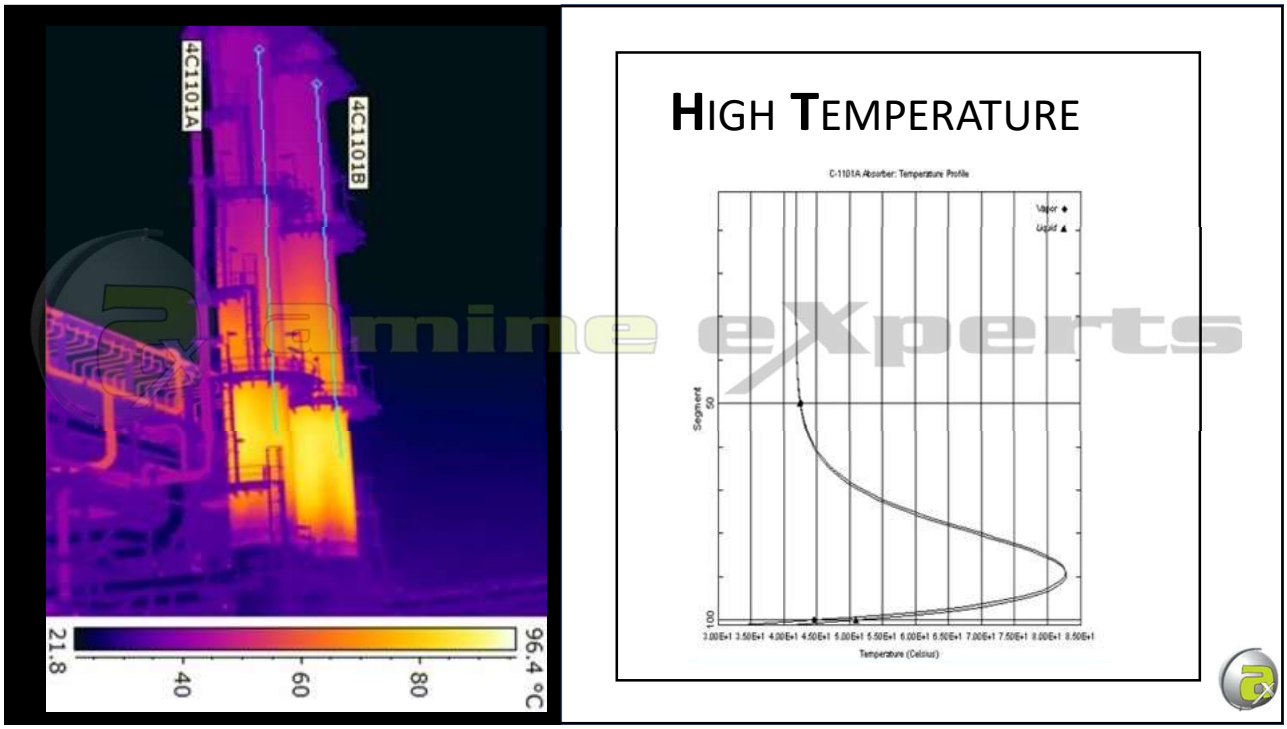
19

HIGH TEMPERATURE

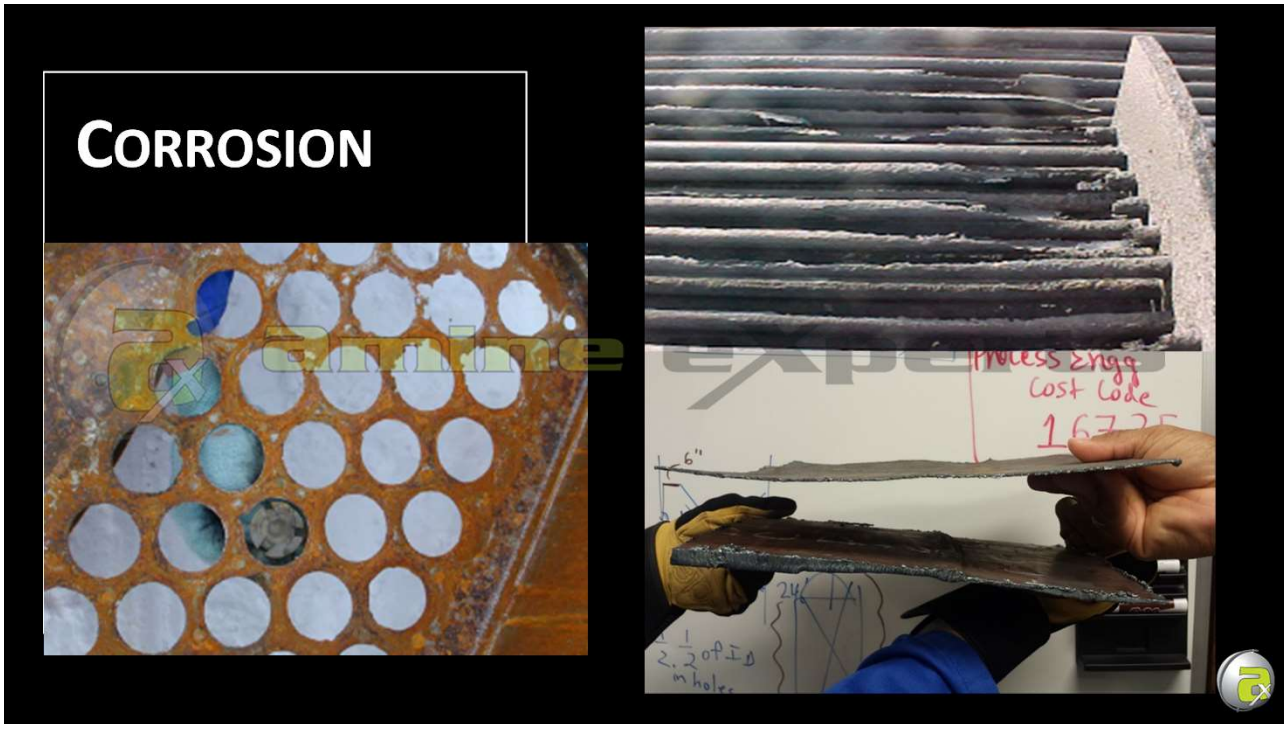




20

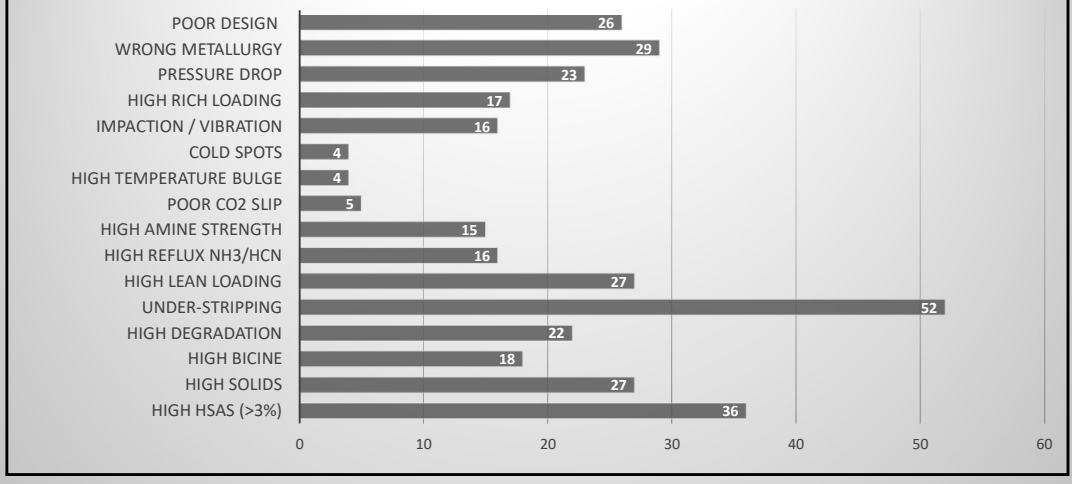

4C1101A
4C1101B
21.8
40
60
80
96.4 °C
HIGH TEMPERATURE
C-1101A Absorber: Temperature Profile
Vapor
Liquid
Segment
1
50
100
3.00E+1 3.50E+1 4.00E+1 4.50E+1 5.00E+1 5.50E+1 6.00E+1 6.50E+1 7.00E+1 7.50E+1 8.00E+1 8.50E+1
Temperature (Celsius)

21


CORROSION
Process Engg
Cost Code
6"

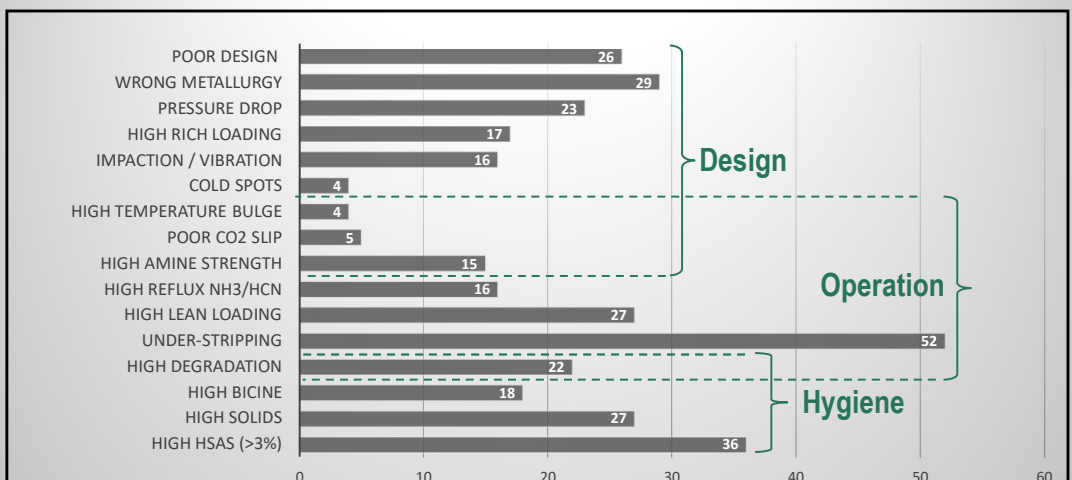
22

CORROSION ROOT CAUSES



23

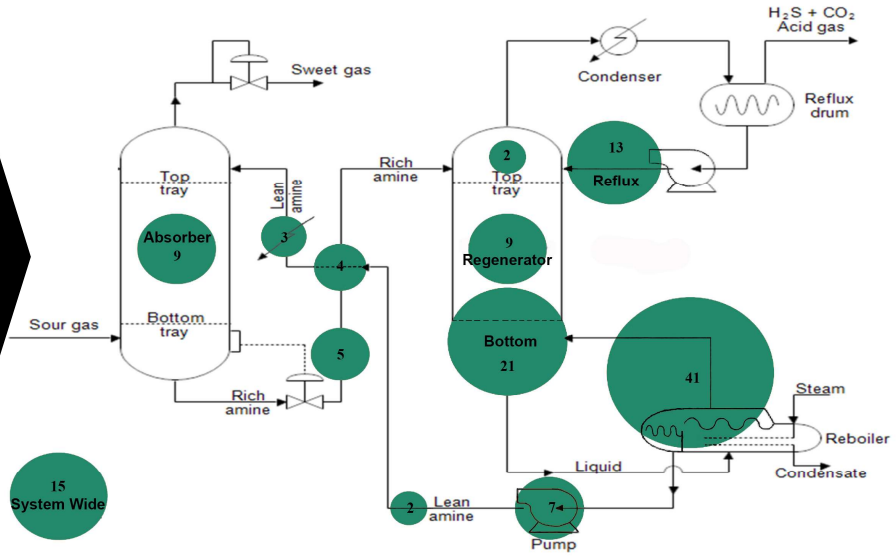
CORROSION ROOT CAUSES



24

CORROSION LOCATION

131 CASES



25

REBOILER & LOWER REGENERATOR CORROSION

Insufficient regeneration of the amine in the stripping column results in excessive H_2S and CO_2 in hot, wet stagnant reboiler

Poorly regenerated solutions are caused by:		
insufficient steam traffic up the column	cold rich amine feed	high column back-pressure

26

27

Amine Hygiene Guidelines

Heat Stable Amine Salts

- Corrosion typically occurs above 3 wt% HSAS
- Exception: In conjunction with other corrosive factors corrosion in the 1.5 to 3 wt% HSAS range has been observed on some MDEA plants

Degradation Products

- Corrosion typically occurs above 5 wt% of degradation products in the Amine Solution

Based on Database

28

LOADINGS & VELOCITIES

Carbon Steel

- Rich Amine Less than 0.40 → 0.55 mol/mol
- Lean Amine less than 0.1 m/m (MEA); <0.04 m/m (DEA); <0.01 m/m (MDEA)
- Velocity less than 3 m/s

Stainless Steel

- Rich Amine loading maximum undetermined.
- Velocity less than 6 m/s

Based on Industry Guidelines

29

POST WELD HEAT TREATMENT

Hydrogen diffusion into steel can induce cracking

Traditionally extremely prevalent in gas treating

Carbon steel in amine service MUST be heat treated

30

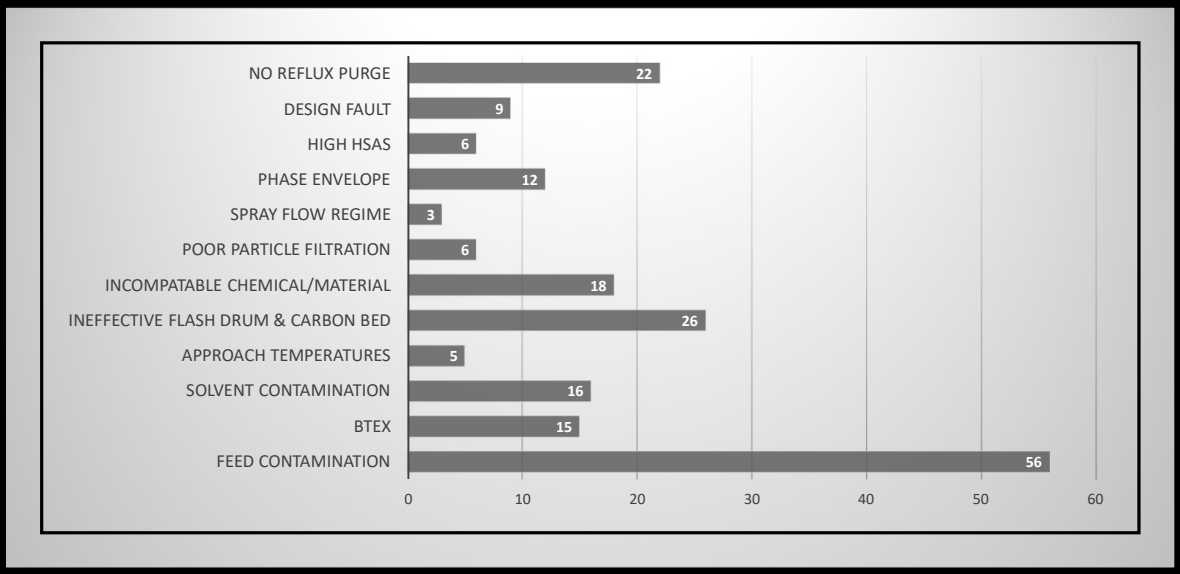
31

FOAMING

Water
Triethanolamine
Iso-butane
Propane
n-Butane
Stearic (organic) Acid
Laureth 23
Sodium Lauryl Sulphate
Fragrance
BHT

32

FOAMING: ROOT CAUSES



33

CONTAMINANTS IN GAS STREAMS

Liquids

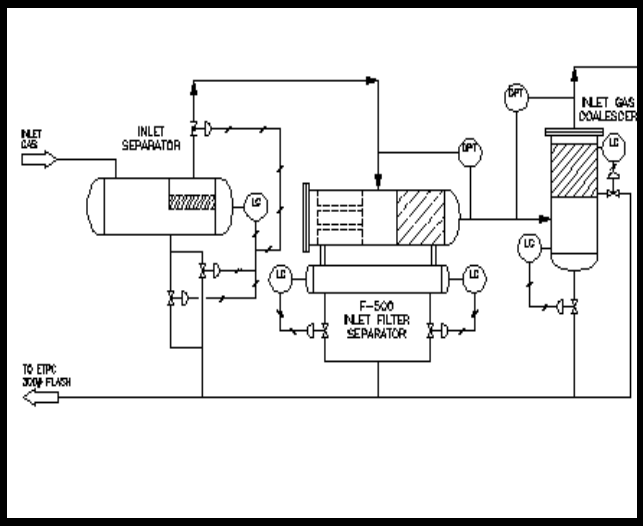
- Compressor lube oils
- Hydrocarbon condensates
- Organic acids
- Pipeline Chemicals
- Completion fluids
- Well brines

Solids

- Iron sulphides
- Iron oxides
- Corrosion products
- Scale
- Dirt (silica, etc.)
- Desiccant fines
- Catalyst fines

34

INLET SEPARATION



- Knock-Out Drum / 3-phase separator
- Coalescer
- Tie-Ins for:
  - Water Washes
  - Mechanical Filter

35

FOAMING PLANT

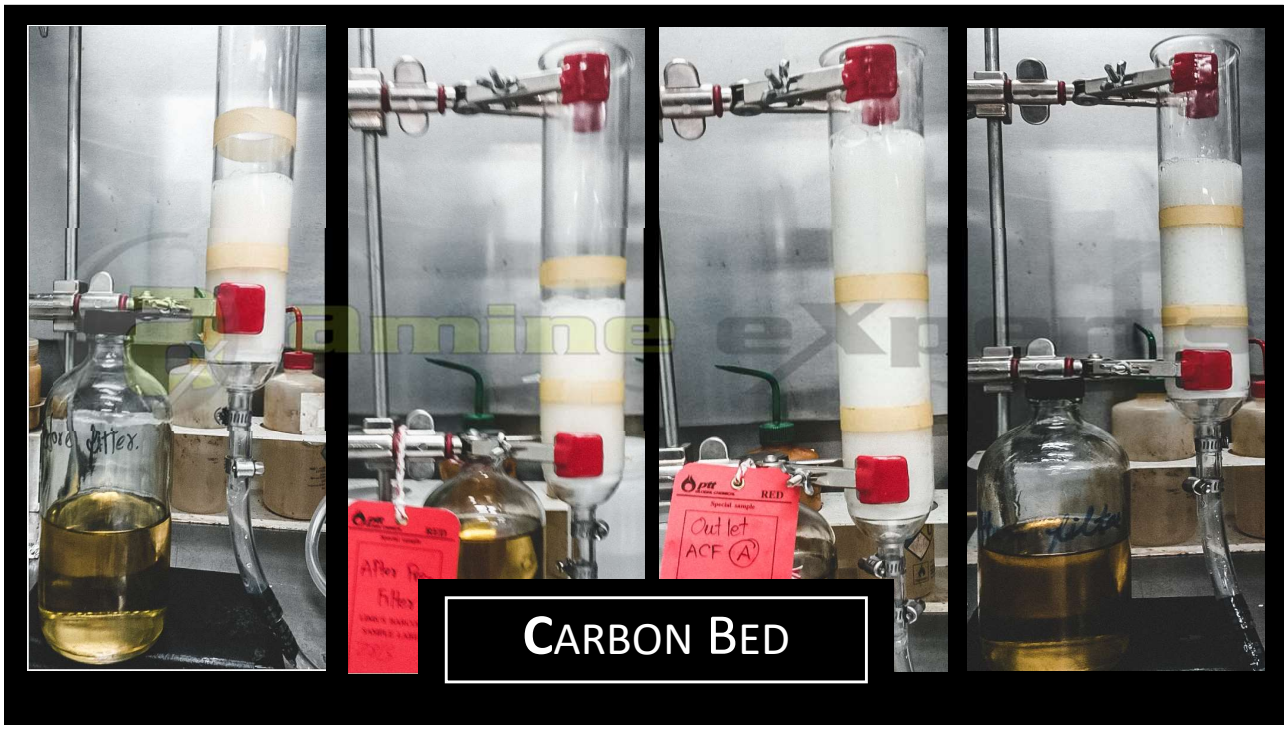
36

FILTRATION

37

MATERIAL INCOMPATIBILITY

38



39

REFLUX PURGE:

CONTAMINANTS CAN CONCENTRATE IN THE REFLUX LOOP

40

ANTI-FOAMING: PREVENTION OR CURE?

Anti-foam normally dramatically reduces the foaming in a system.

Continuous anti-foam dosing is generally not good practice and allows contaminants to accumulate to high levels.

Antifoams may degrade with time; antifoam injection equipment should be cleaned annually.

Anti-foams float on an aqueous surface; this means that they should not be diluted with water in an injection tote and should be injected close to the source of foaming as they do not disperse through the system

Overdosing of antifoam has been reported to result in incidents of foaming and fouling.

41

ANTI-FOAM:

SILICONE
POLYGLYCOLS
HIGH MW ALCOHOLS
HIGH MW POLYALKYLOXALATES

42

KEY FOCUS AREAS

1. LOW LEAN LOADINGS & TEMP
2. SEPARATION EQUIPMENT
3. DO NOT UNDER-STRIP THE AMINE
4. GOOD AMINE SYSTEM HYGIENE

FOCUS ON THESE AREAS WILL HALVE THE LIKELIHOOD OF A MAJOR SYSTEM FAILURE ON YOUR PLANT!

43

amine eXperts

Paper available: “Trends in Tragedy – An In-Depth Study of Amine System Failures”

E-mail: mike.sheilan@amineexperts.com

Sulphur Experts YouTube Channel

44