Comparison of Wet vs Solid Amine

Advantages and Disadvantages, along with Gas Detection for Risk Mitigation

ANALOX

Your Challenge, **Our Passion**

Nathan Stevenson

- BEng (Hons), IEG MIET - Electronics & Computer Engineering - Edinburgh Napier University (2013)
- Nathan joined Analox in 2014, progressing from Systems Engineer to System Architect in eight years.
- Leading the Systems team, he spearheaded major defense projects, including Analox's largest-ever contract.
- Recognized with Incorporated Engineer Status in 2022, Nathan's excellence earned him a nomination for IET's Engineer of the Year in 2023.

Who we are

- **30 years experience** in diving and submarine air monitoring
- **Bespoke design solutions** to meet submarine architecture & operational requirements
- **Cradle to grave** product design and support
- **Compliant with UK Export** and **US ITAR** controls
- **Expertise in hyperbaric sensors**
- **Through life support** & training
- **Sensing capabilities** including toxic, flammable and inert gases
- **Proven Operational Business Management** aligned to SC21

BAE SYSTEMS

Ministry of Defence

MARINE NATIONALE

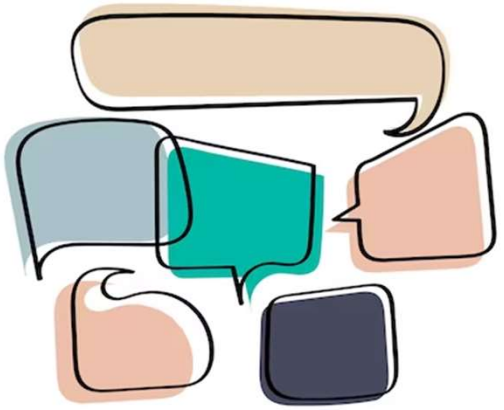
NATO OTAN

SAAB

MARINHA DO BRASIL

Themes

- Overview of the technologies
- Proposal for measuring MEA leaks on wet amine systems

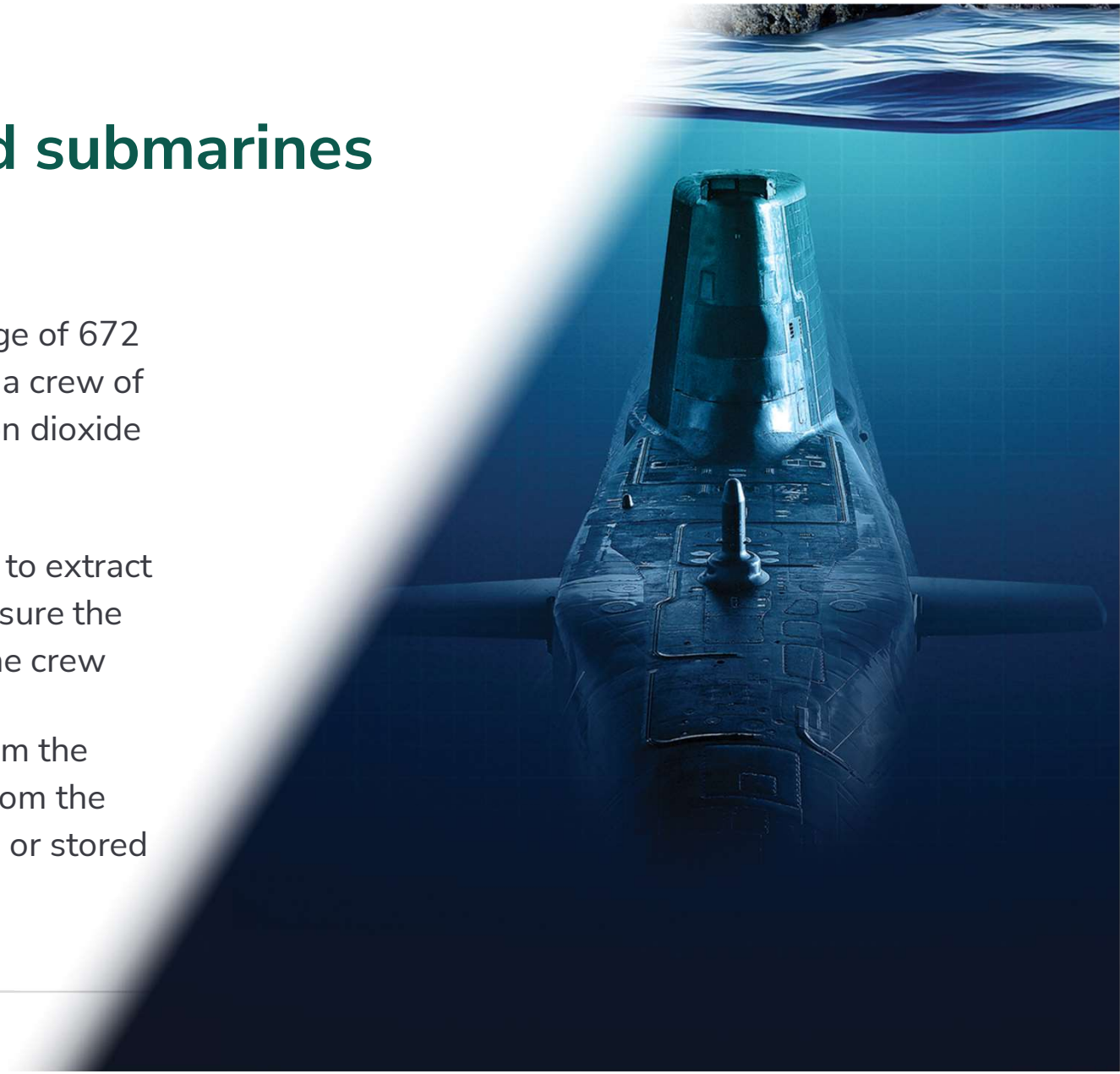


Use of amine on board submarines

A single crew member produces an average of 672 litres of carbon dioxide per day, assuming a crew of 100 people leads to 67,200 litres of carbon dioxide per day.

Amine is used on board many submarines to extract carbon dioxide from the atmosphere to ensure the submarine atmosphere remains safe for the crew

The amine captures the carbon dioxide from the atmosphere which can then be released from the amine via heat and then further processed or stored



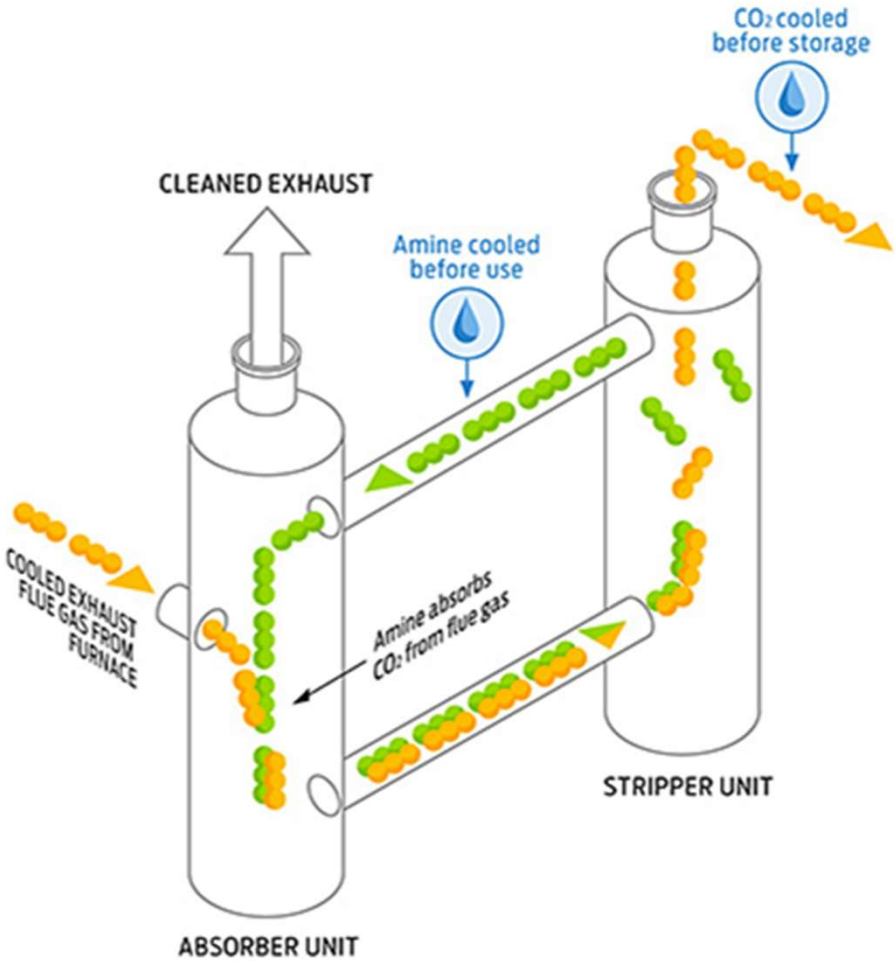
Wet Amine

Technology Overview

Air from the submarine is exposed to a wet amine spray which captures the CO2 from the air creating an amine/CO2 solution

The amine/CO2 solution is then heated releasing the captured CO2

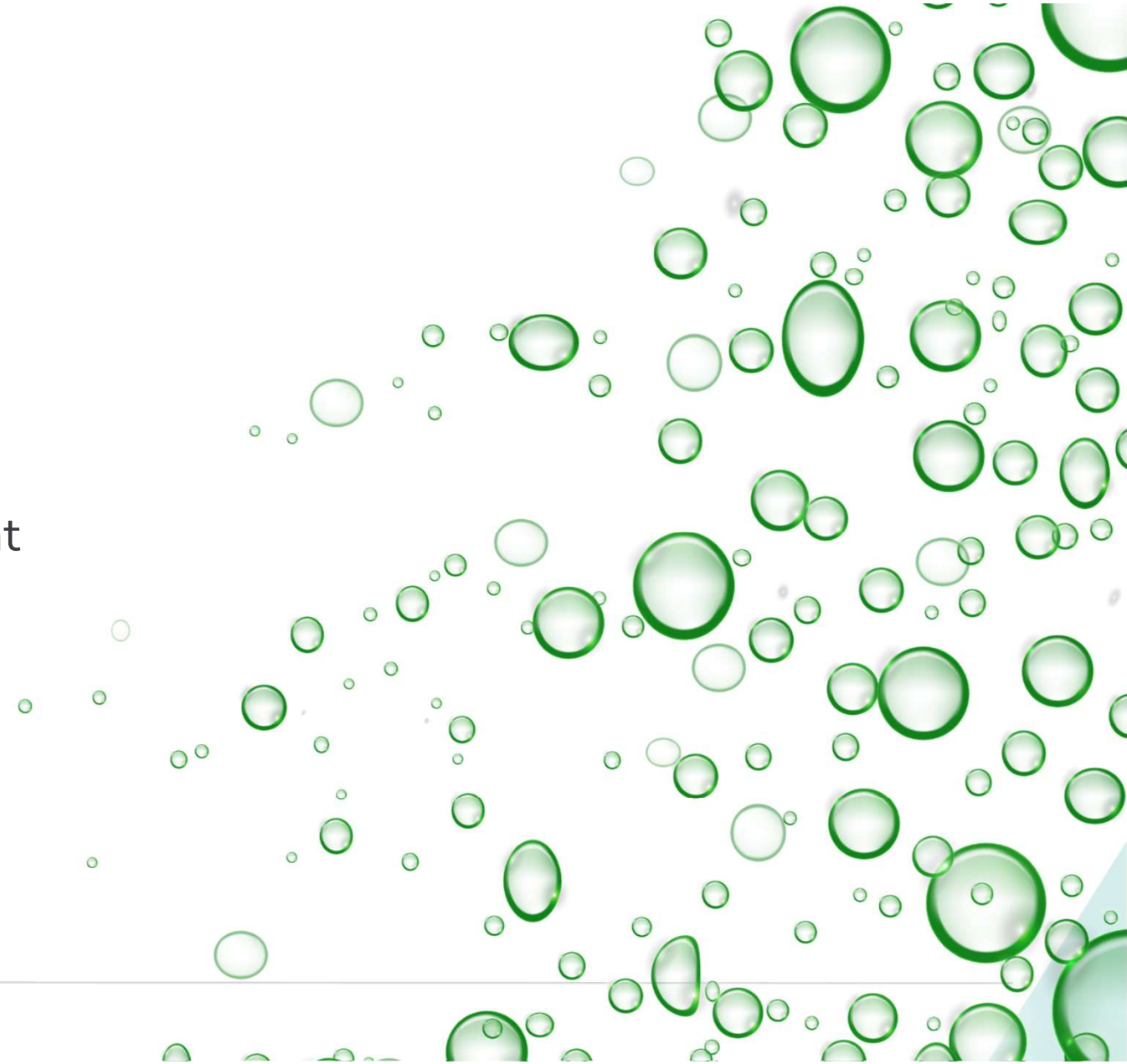
The heated amine can then be cooled and reused in the capture process



Wet Amine

Advantages

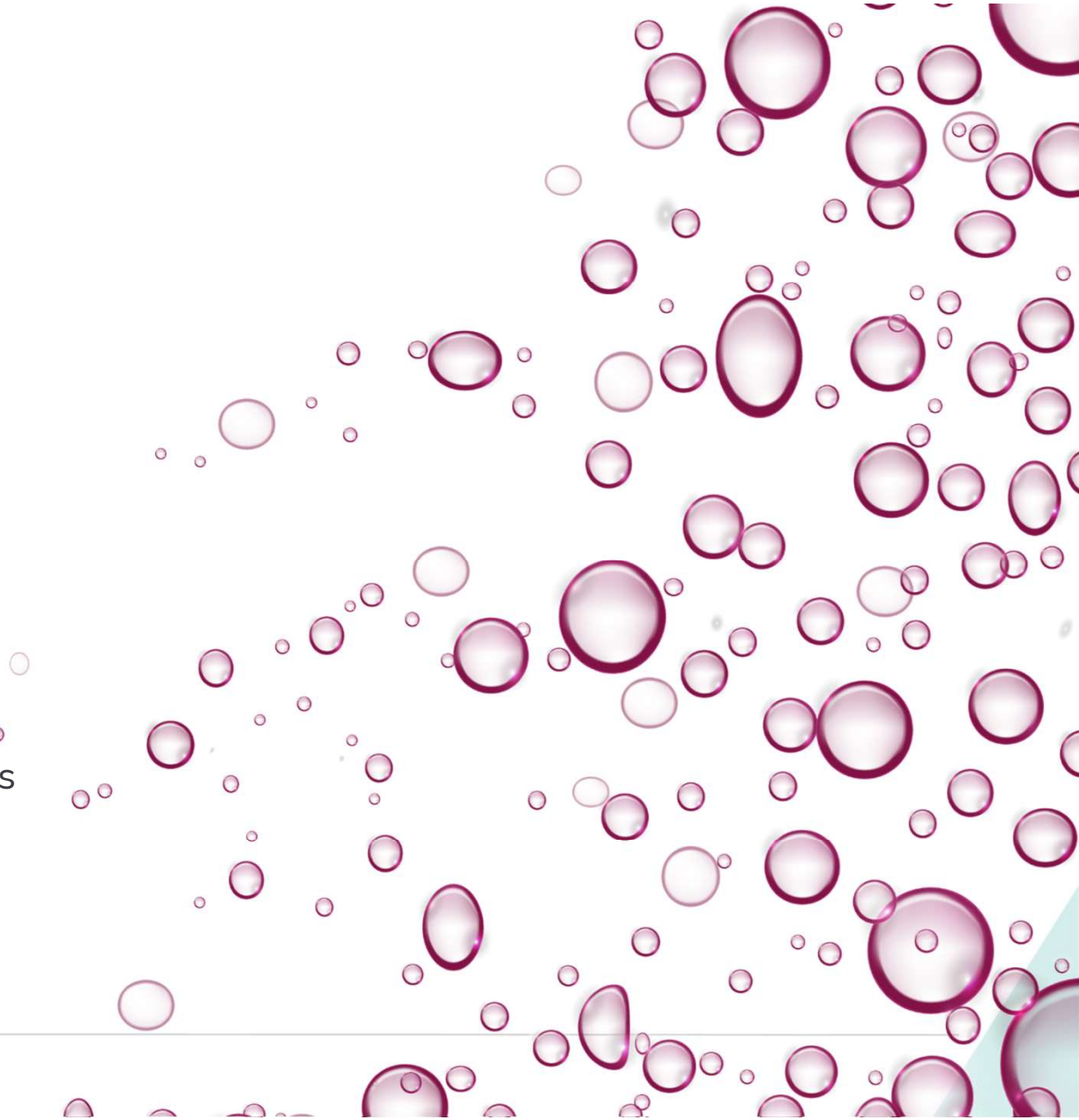
- Proven in use on-board submarines
- Space efficient
- Relatively energy efficient
- Continuous process



Wet Amine

Disadvantages

- Amine must be maintained in good condition otherwise it needs to be replaced.
- This requires frequent titration of the amine to ensure it remains balanced.
- It’s easy to “burn” the amine by over exposure to the heating elements
- Amine aerosol can be released to the submarine atmosphere, if the aerosol is not controlled properly.



Solid Amine

Technology Overview

- Amine is suspended in a honeycomb material which atmosphere is passed through allowing CO2 to be captured
- Once saturated steam is used to release the CO2 from the material
- Material is then dried out and cooled allowing CO2 to be captured again.
- 3 Bed system on rotation - Absorb/Release/Regeneration

Solid Amine

Advantages

Amine release to atmosphere is much easier to control due to no aerosol being created.

Amine does not need maintaining during use

Amine beds are replaced at the end of patrol

No liquid amine to be disturbed during maneuvers

Solid Amine

Disadvantage

- The process is not as efficient compared to wet amine
  - A larger volume of space is required to scrub the same amount of carbon dioxide
  - A large amount of steam is required to release the carbon dioxide
  - A larger power supply is required

Hazards of Amine

In normal use amines are an irritant at low levels causing issues to skin, eyes and mucous membranes

On board a submarine the high temperature burners will break down the amine in the atmosphere in to NO2 and NO which causes further health hazards such as coughing and or shortness of breath

As we better understand the hazards the occupational exposure limits for Nox are being decreased on a regular basis.

Measurement of Amine on board

Challenges

Due to the low vapour pressure and high boiling point MEA will be a liquid on board the submarine and will stick to cold surfaces.

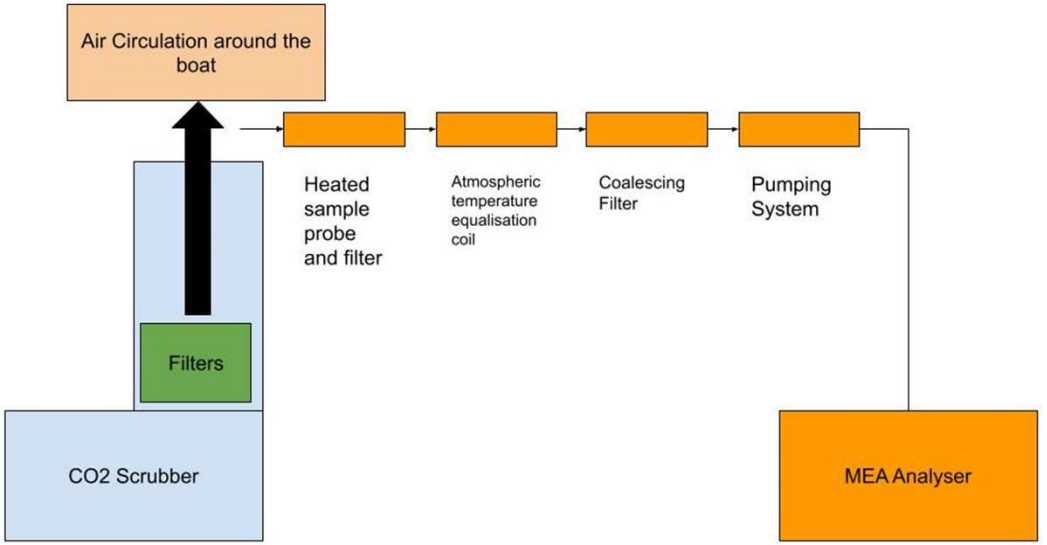
- Even large spillages of MEA will only be detectable as a gas in single digit PPM levels
- Gas analysers are only capable of measuring MEA as a gas not a liquid
- On wet amine scrubbers is believed that a mixture of liquid (aerosol) and vapour MEA is released into the submarine ventilation system
- If liquid amine gets in to the the gas measuring equipment it will coat the optics in liquid amine reducing performance and damaging the equipment

Properties	
Chemical formula	C_2H_7NO
Molar mass	61.084 g·mol^{-1}
Appearance	Viscous colourless liquid
Odor	Unpleasant ammonia-like odour
Density	1.0117 g/cm^3
Melting Point	10.3 °C (50.5 °F; 283.4 K)
Boiling point	170 °C (338 °F; 443 K)
Solubility in water	Miscible
Vapor pressure	64 Pa (20 °C)
Acidity (pK_a)	9.50
Refractive index (n_D)	1.4539 (20 °C)

Measurement of Amine on board

Alternative approach

- Heat the sample beyond the boiling point of MEA (170 Degrees Celsius)
- Once the MEA is in the gas phase, the temperature can then be reduced provided it does fall below the dew point of the MEA
- It can then be filtered for particulates and liquid phase water (if any) removed in a water trap
    - In normal operation, it is not expected that there will be any liquid phase water, the water trap is to prevent damage to the analyser in the event of a high humidity event.



Measurement of Amine on board

Potential measurement technologies

Analox has identified two potential measurement technologies

- **FTIR** - Currently used in Analox's Atmosphere Analyser, the FTIR is capable of measuring MEA at PPM levels
- **NOX Detector** - By catalysing the MEA the NOX released can be measured and used to determine the level of amine

Summary

- Both approaches work with their own unique set of drawbacks
- Wet amine could potentially be made safer via continuous monitoring of the amine emission
    - This can also help inform crew of required maintenance procedures to ensure crew safety
- Analox can supply amine analysis systems for use on board submarines

Get in touch!


analoxgroup.com


info@analoxgroup.com


Analox Group


UK/Global: +44 (0)1642 711 400
US Office: (714) 891 4478
US Toll Free: (877) 723 3247