

# Yellow antifoam for oil process

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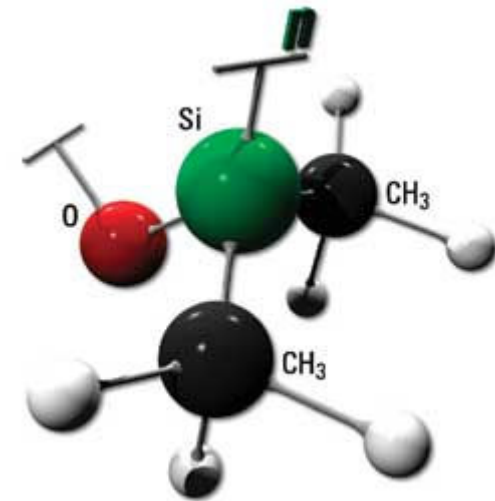


# Outline of presentation

- Introduction
- Foam stabilisation
- Defoaming
- Laboratory evaluations
- Field performance
- Conclusion
- Acknowledgement

# Introduction

- Since 2002 Statoil has challenged the chemical suppliers to replace silicone based antifoam products in the crude oil production;
  - Environmental classification
  - Silicone compounds pollute the catalysts in the refinery (Mongstad and Kalundborg)
- Work started with Statfjord C
  - Laboratory evaluation of new products
- Continued with Gullfaks and Heidrun
  - Laboratory and field testing
  - Implementation



# Introduction

Low toxicity

> 60%  
biodegradable

No negative effect  
on separation  
process

Non  
silicone

Cost efficient

Technical  
performance

Low solubility in  
the bulk phase  
and water

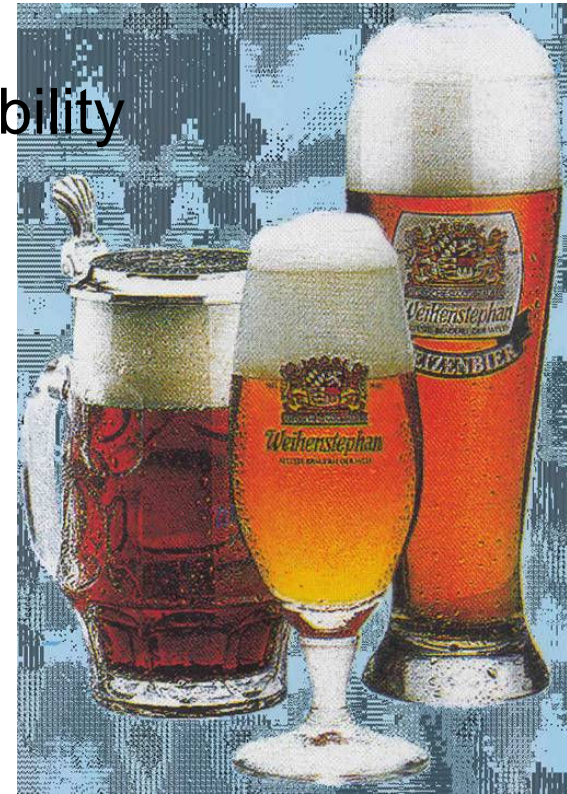
Not viscous at  
low  
temperature

Health  
category 3 or  
lower



# Foam stabilisation

- Foam is generally formed as a result of gas trying to break through the surface tension of a liquid
- Main factors to interfere with foam stability
  - Bulk viscosity
  - Surface rheology
  - Presence of surfactants



# Foam stabilisation

- Gibbs Elasticity

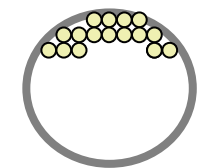
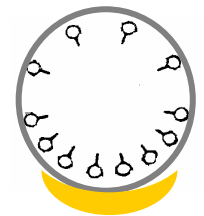
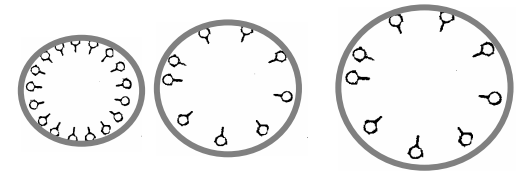
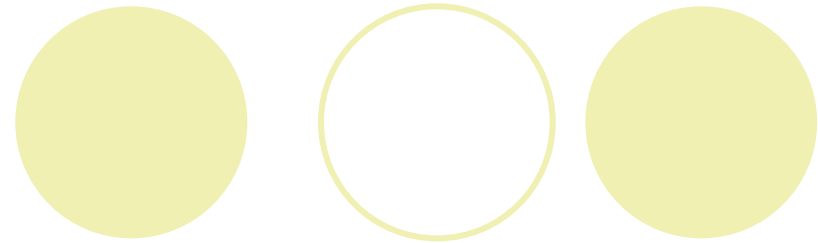
- Stretching cause depletion of surfactants and increased surface tension

- Marangoni Effect

- Draining of intra lamellar liquid interfere with concentration of surfactant along the bubble wall

- Foam viscosity

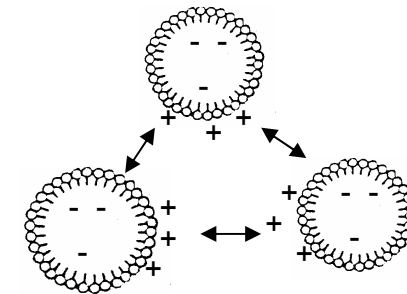
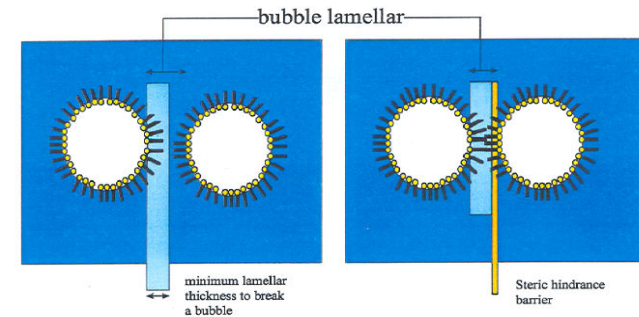
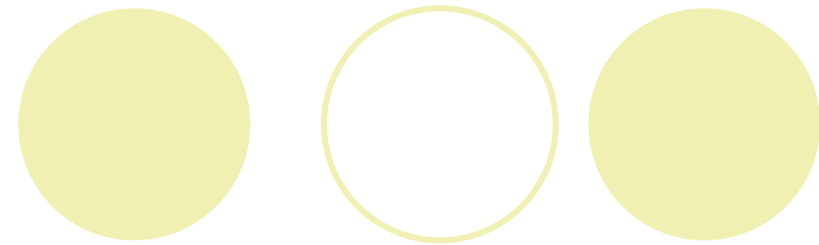
- Surfactants are packed tight to form crystalline layers and increase foam stability



# Foam stabilisation

- Steric Hindrance barrier
  - Long chain surfactants retard the thinning of the lamellar

- Electrostatic repulsion
  - Ionic surfactants adsorbed on the bubble give mutual charge repulsion



# Defoaming

A decorative graphic consisting of two rows of circles. The top row has two circles: a solid light green one on the left and an outlined light green one on the right. The bottom row has three circles: a solid light green one on the left, an outlined light green one in the middle, and a solid light green one on the right.

- The assumed mechanism of the new antifoam chemistries is that the molecule interferes with the surfactants that are stabilizing the bubble surface and this allow an increased liquid drainage to proceed until the bubble burst

# Laboratory evaluations

- alkyleneoxides  
e.g.:  $R-(CH_2-CH_2-O)_n-(CH_2-CH(CH_3)-O)_m-H$
- solvent systems (mineral oil, vegetable oil)
- fatty alcohols/glycols [R-CH<sub>2</sub>-OH]
- fatty acids [R-COOH]
- cationic molecules
- esters (e.g.: fatty alcohols, -acids)  
[R-C(O)O-CH<sub>2</sub>-R]
- amides [(RH)RHN(O)C-R]
- urea derivatives [RHNX-OCN-R-NCO-XNRH]



# Laboratory evaluations

- Field testing of new antifoam chemistries has been identified as high risk
- A joint project between Statoil and Clariant Oil Services started
- The two main objectives for this project were to;
  - Reduce risk/ uncertainty in future field trials by implementing a new method for antifoam evaluation
  - Include effects by shear force, water cut, field fluid compositions, pressure and temperature
  - Look at the option to improve existing gas sparging tube test for use as a screening method for use in laboratory both onshore and offshore

# Laboratory evaluations

- Thank you to Statoil Research at Rotvoll who allowed us to show this video



# Laboratory evaluations

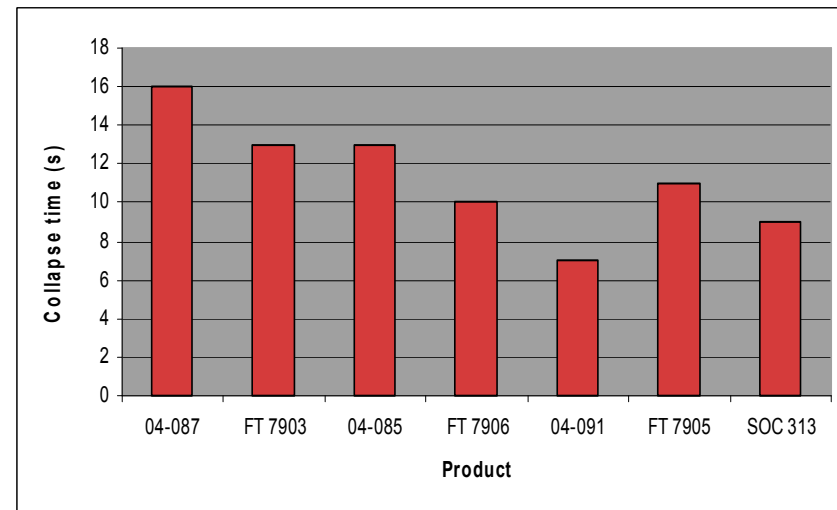
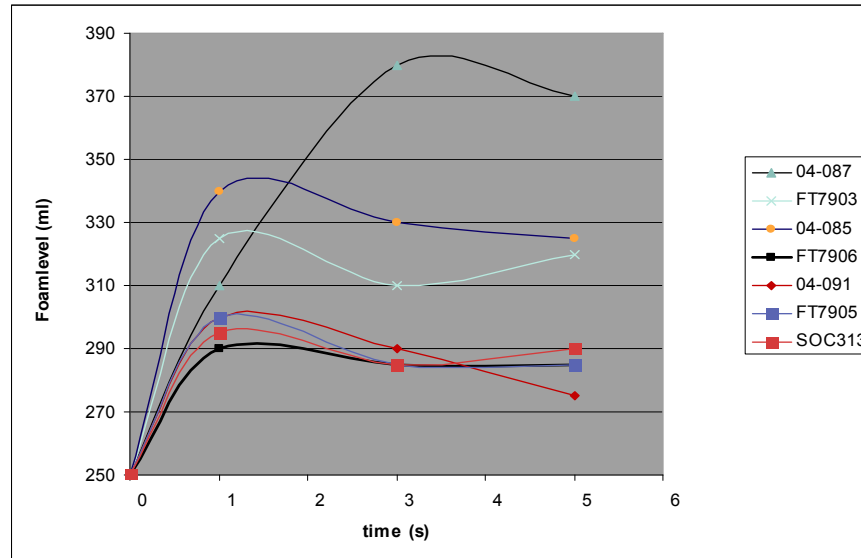
- This method will evaluate
  - foam tendency
  - foam stability
- Foam tendency is the foam volume generated at the actual gas flow rate over time
- Foam stability is determined from the foam collapse curve



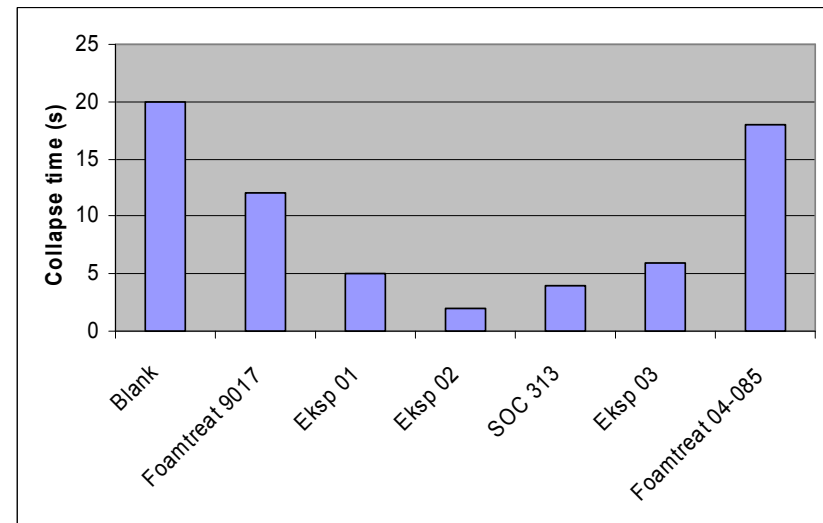
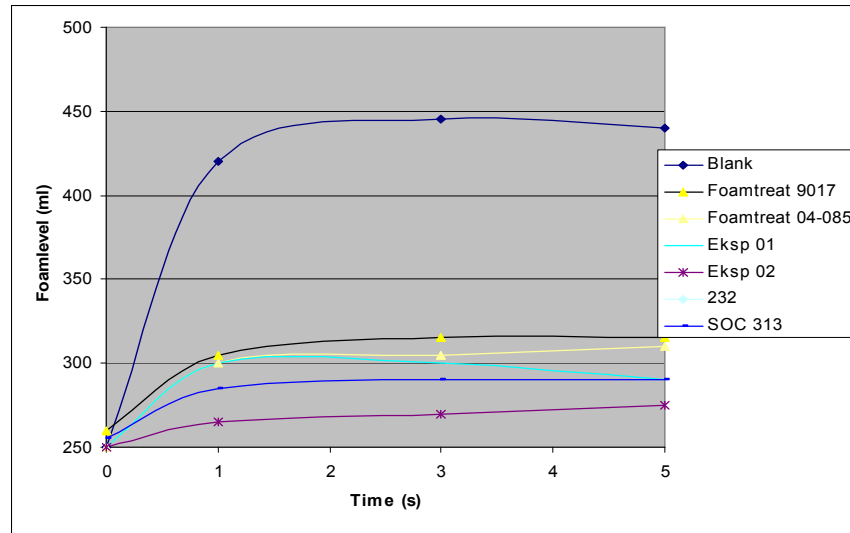
# Laboratory evaluations – Products

Product composition	Biodeg 28 d	Bioacc Log Pow	Toxicity				SFT Category	Health Risk
			Skeletonema 72t EC50 mg/l	Acartia Tonsa 48t LC50 mg/l	Fish 96t LC50 mg/kg	Sediment 10d LC50 mg/kg		
<b>Foamtreat 9017 (Foamtreat 05-160)</b>								
Fettyacidglycol	90,90 %	5,94	3198	> 2200	> 1000	4066		1
Glycol Ether	32,00 %	2,28	838	1234	548			Low
<b>Foamtreat 04-085</b>								
Alifatisk propylenglykol	91,00 %	2,72	1,3	5,2	24	350		2
Glycol Ether	32,00 %	2,28	838	1234	548			Insignificant
<b>SOC 313 Skumdemper</b>			2667	1329		617		
PDMS	0,00 %	< 1,5	180	> 2200	> 1000		8	2
Solvent	72,00 %	No peaks	192	439	> 3000	827		Insignificant
<b>Foamtreat 04-091</b>								
Alifatisk propylenglykol	91,00 %	2,72	1,3	5,2	24	350		2
Ester	97,00 %	2,2	17	5,7	9,2	430		Insignificant
Glycol Ether	32,00 %	2,28	838	1234	548			

# Laboratory evaluations - Gullfaks



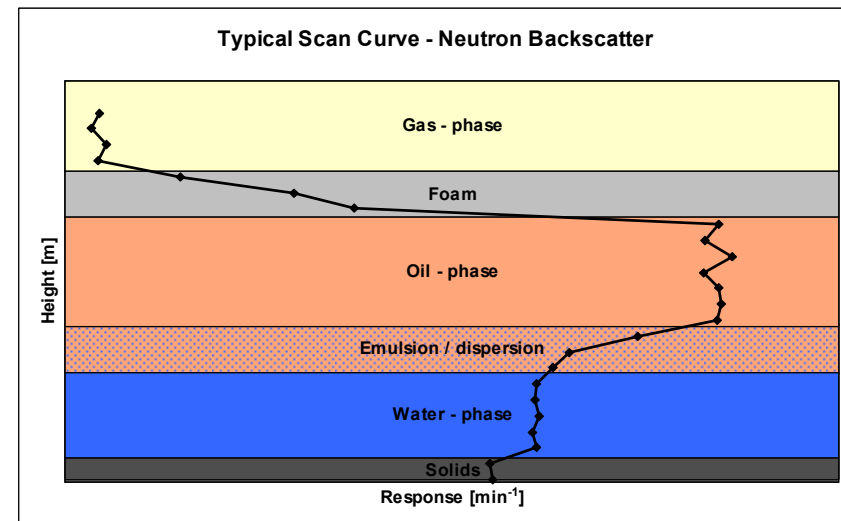
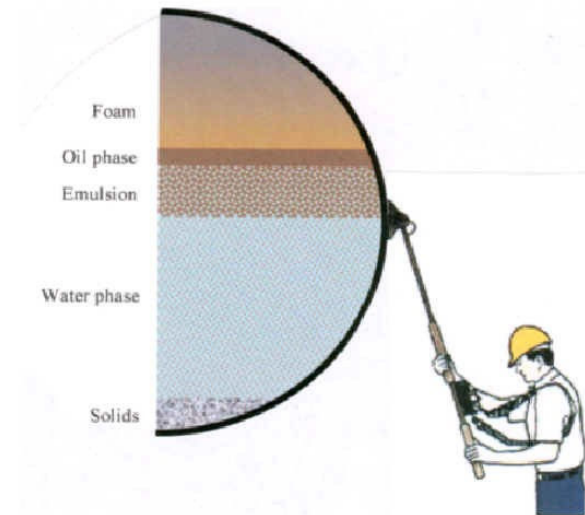
# Laboratory evaluations – Heidrun



# Field performance

## Testing of chemicals by Neutron Backscatter Technique

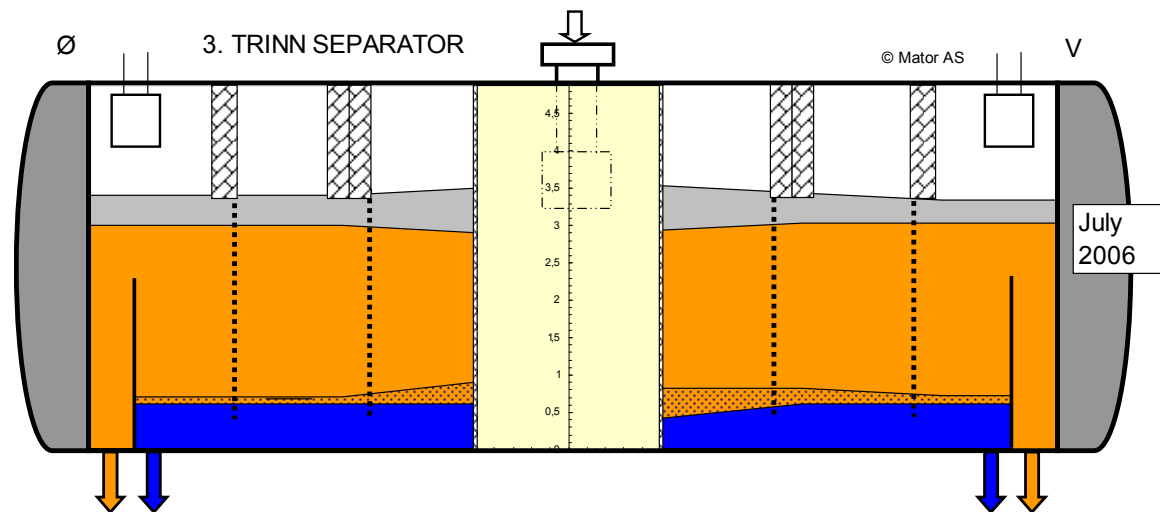
- The instrument consists of a radioactive neutron source, a detector and a data logger.
- Main principle:
  - Neutrons penetrate the separator wall, slows down in interactions with hydrogen atoms and reflects back.
  - The detector measures the reflected slow neutrons.
  - The logged signal is proportional to the hydrogen density inside the separator.
- Phase identification based on:
  - Gas – Low response
  - Oil – High response
  - Water – Medium response
  - Solids – Low response
- The results verify the propagation of each phase through the separator.



# Field performance

## Importance of knowing the baseline conditions

- Valuable knowledge of the process/separation system
  - Separation performance → gas/liquid & oil/water separation
  - Consistent online CCR level readings?
- Complete reference baseline before start-up of new chemicals
- Baseline example – Heidrun 3. stage separator
  - Foam height of approx. 30 cm at normal operational conditions



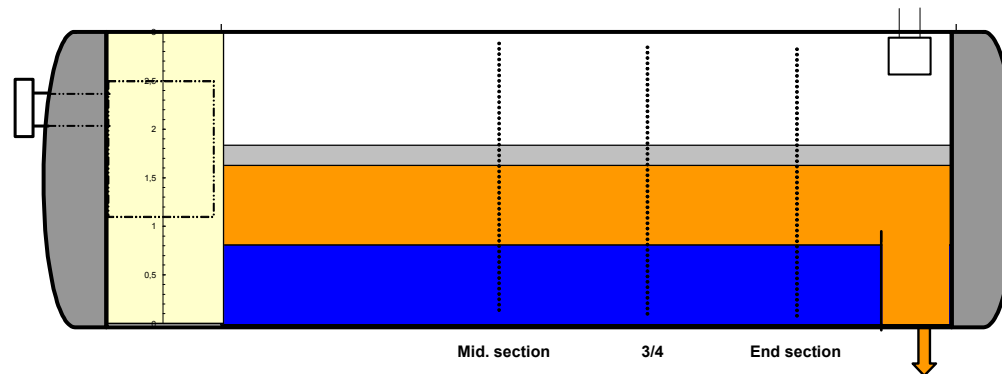
# Field performance Gullfaks C – October 2005

Based on laboratory testing, three products were tested on the 1st stage separator:

- Foamtreat 04-085
- Foamtreat 04-091
- Foamtreat 05-160

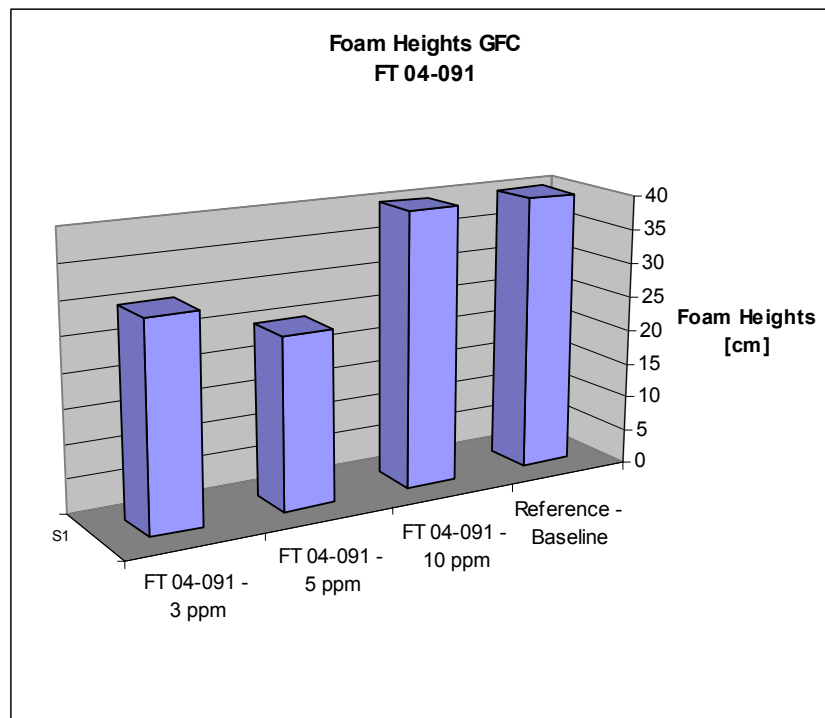
Each chemical was tested at three injection rates, i.e. 3 – 5 – 10 mg/l based on total liquid flow.

Mator AS, by using the neutron backscatter, monitored and reported foaming conditions at three positions along the separator:



# Field performance Gulfaks C – October 2005

## Chemical No. 1: Foamtreat 04-091

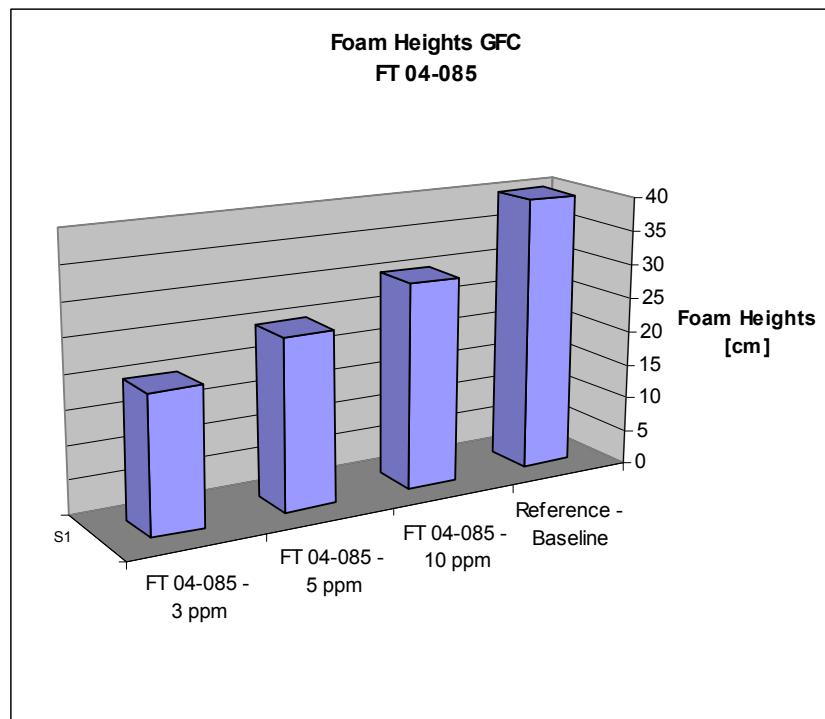


Chemical	OiW [mg/l]
SOC313 - 5ppm (baseline)	200
FT 04-091 - 10 ppm	250
FT 04-091 - 5 ppm	204
FT 04-091 - 3 ppm	231

Good performance as antifoam, and no negative observation on produced water quality compared to baseline data. Chemical recommended for long term field trial.

# Field performance Gullfaks C – October 2005

## Chemical No. 2: Foamtreat 04-085



Chemical	OiW [mg/l]
SOC313 - 5ppm (baseline)	200
FT 04-085 - 10 ppm	213
FT 04-085 - 5 ppm	148
FT 04-085 - 3 ppm	207

Medium/good performance as antifoam and slightly worse produced water quality compared to baseline data.

# Field performance Gullfaks C – October 2005

## Chemical No. 3: Foamtreat 05-160

Concentration	Foam height (cm) measured by Mator			Oil in Water
mg/l	Mid section	3/4	End section	mg/l
10				
5				
3	15	20	35	144

Medium/good performance as antifoam and improved water quality compared to baseline data.

Due to high viscosity it was not possible to test the chemical at higher injection rates. Composition was reformulated into a suitable solvent and given a new commercial name, Foamtreat 9017.

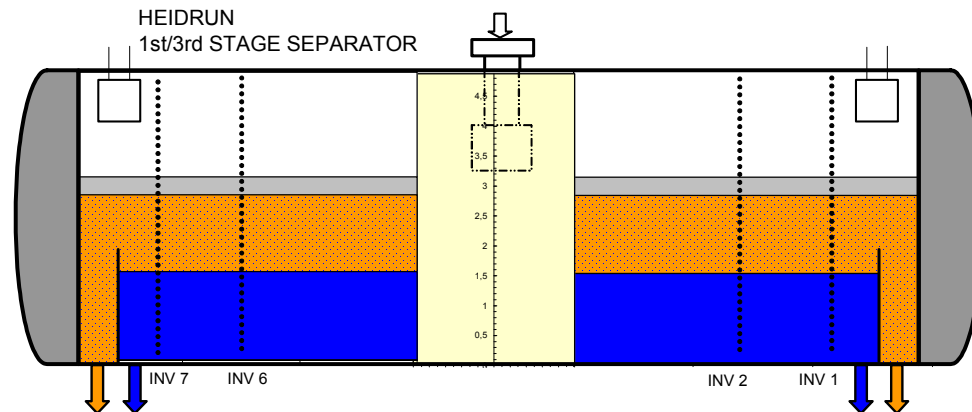
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A long term field trial of Foamtreat 9017 was started at Gullfaks C in December 2006. There has to date not been reported any production/process problems related to foam control after changing from the red product; SOC 313, to its yellow replacement; Foamtreat 9017.

# Field performance Heidrun – July/September 2006

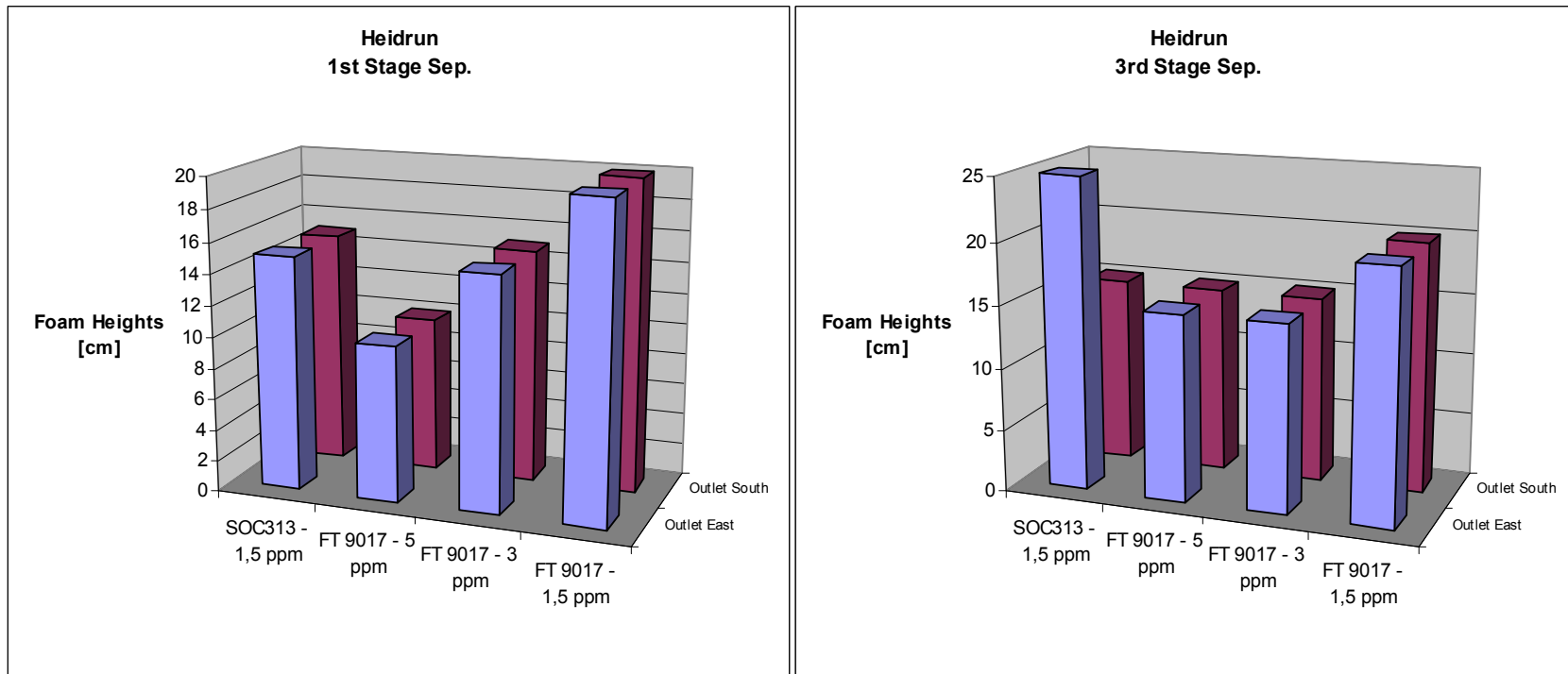
Foamtreat 9017 was tested at the Heidrun field during summer/autumn 2006. The product was tested on both the 1st and 3rd stage separator, at three injection rates, i.e. 3 – 5 – 10 mg/l based on total liquid flow.

Mator AS, by using the neutron backscatter, monitored and reported foaming conditions at four positions along the separators:



# Field performance Heidrun – july/september 2006

Foamtreat 9017 was tested at the Heidrun field during summer/autumn 2006. The product was tested on both the 1st and 3rd stage separator.



5 ppm injection of Foamtreat 9017 gave improved performance compared to the original product at 1,5 ppm. Chemical recommended for long term field trial

# Field performance Heidrun



A long term field trial of Foamtreat 9017 was started on Heidrun in December 2006.

Reported drifting level indicators on the 3rd stage separator.

Clariant Oil Services and Mator personnel reviewed injection on the Heidrun 3rd stage separator by accomplishing various tests.

- increasing injection rate to the 3rd stage separator
- using the same injection point as used during field testing in July and September 2006
- stopping the reject pump

Not able to achieve satisfactory level control in the 3rd stage separator due to heavy foam / gas-dispersion in the oil phase



# Conclusion

- Foamtreat 9017 successfully introduced to Gullfaks A
- Long term test with Foamtreat 9017 to be started at Gullfaks C
- Heidrun have returned to previous antifoam product until new internals have been installed in 3rd stage separator

# ACKNOWLEDGEMENT

## THANK YOU FOR YOUR ATTENTION

- The authors would like to thank Statoil and their partners in the Gullfaks and Heidrun licenses for permission to publish this paper
- Also we would like to thank the drifts organizations for their support during field trials and their patience with us

