

# Mercury in crude oil and natural gas

A concern for the oil and gas industry



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# Outline

- Introduction
- Technical challenges
- Product quality
- Health Safety and Environment
- Hg speciation
- Final remarks

# Introduction – This is Statoil

- A major oil producer: one million barrels per day
- World's third largest crude oil seller
- Markets two-thirds of all Norwegian gas to European customers
- Largest retailer of oil products in Scandinavia

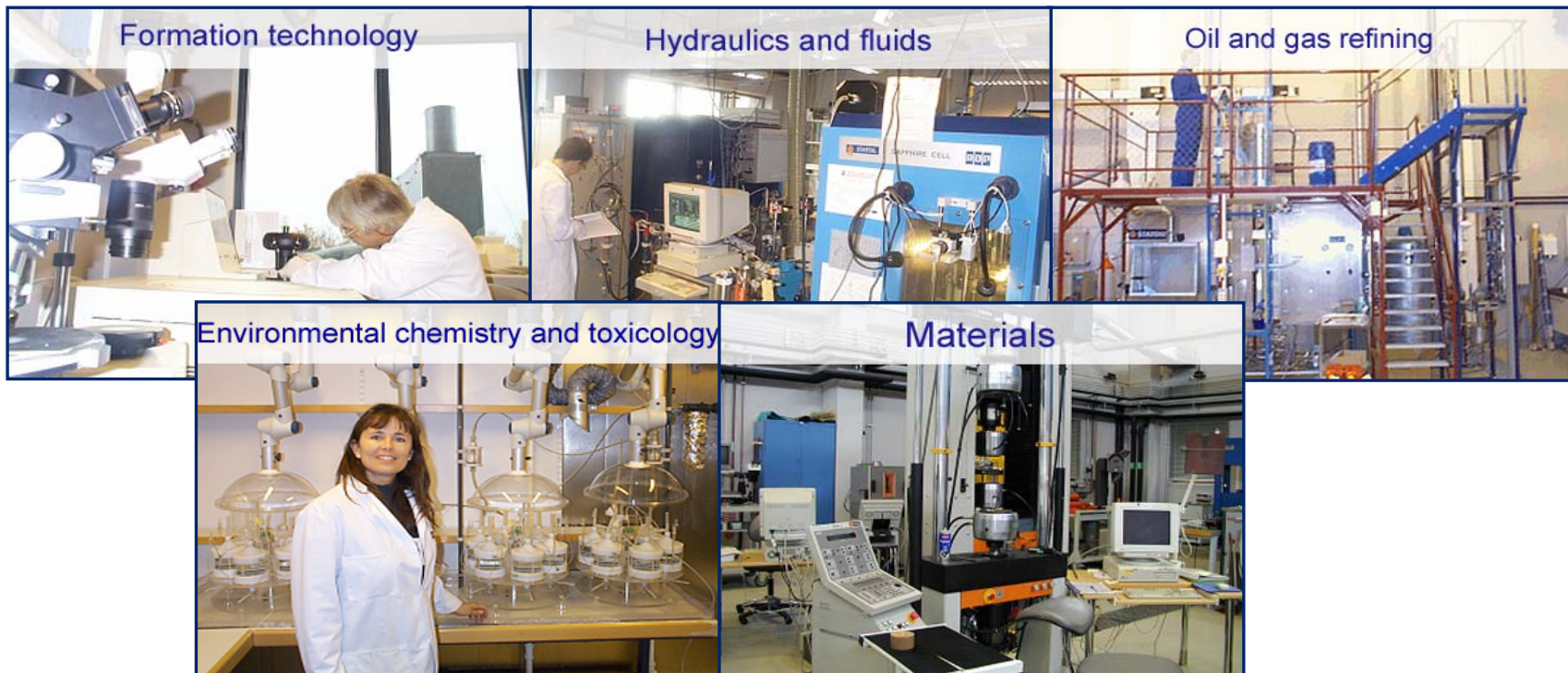


# Statoil Research & Technology (R&T)

## EXPERIMENTAL LABORATORY

### General facilities:

- 6 500 square metres of laboratory space
- a hall, including a transverse crane, dry dock and pool
- mechanical and electro- workshops



# Introduction - Mercury worldwide

- Found in almost all oil and gas reservoirs
- Highest concentrations normally found from reservoirs in South America and East Asia
- European/African/North American gas sources also contain mercury
- Lower concentrations from the Norwegian Continental Shelf

Location	Concentration ( $\mu\text{g}/\text{Nm}^3$ )
Groningen wellhead	180
Groningen to pipeline	12
Groningen at delivery	1-4
North Germany wellhead	15 - 450
South Germany wellhead	<0.1 - 0.3
South America	69 - 119
Sumatra, Indonesia	200 - 300
Far East	3 - 20
Far East	58 - 193
Far East	0.02 - 0.16
Algeria, wellhead	50 - 80
Algeria, to pipeline	0.1 - 89
Algeria Skikda plant inlet	0.001 - 0.65
Africa	0.3 - 130
Middle East	1 - 9
Eastern U.S. pipeline	0.019 - 0.44
Midwest U.S. pipeline	0.001 - 0.1
North America	0.005 - 0.04
SW Wyoming, U.S. plant inlet	8 - 24
Venezuela, plant inlet	0.6 - 1.3
Duval, Zapata counties, Texas, U.S.	466 - 579
Indonesia, plant inlet	250 - 300
North America, pipeline	<0.02 - <0.2
Hugotron field, U.S. (Amoco)	1 - 9
Amoco Painter NRU/NCL Plant entrance	2.65
Amoco Olyress Plant	45

Ref. Crippen, K., Chao, S.  
 "Mercury in natural gas and current measurement technology"  
 Gas quality and energy measurement symposium, Orlando, 1997

# Introduction – The source of Hg

- Origin - HgS (cinnabar) in reservoir.
- $\text{Hg}^0(\text{g})$  is the major Hg containing compound at reservoir conditions
- Major mercury compounds
  - $\text{Hg}^0(\text{g})$  and  $\text{HgS}(\text{s})$ .
- $\text{HgS}(\text{g})$  and  $\text{Hg}_2(\text{g}) \rightarrow$  negligible.
- Organic mercury components occur in insignificant concentrations/partial pressures



# Technical challenges

- Corrosion/embrittlement
  - Caused by elemental mercury
  - Mechanisms
    - Amalgamation
    - Amalgam corrosion
    - Liquid Metal Embrittlement, LME
    - Galvanic corrosion
- Precipitation (HgS)
  - Fouling
  - Plugging of compact equipment

# Product quality

- Mercury Removal
- LNG and pipeline gas transport
  - “No” mercury
  - 10 ng/Sm<sup>3</sup> THg
- Petrochemical industry
  - 5 ppbw THg
- Hg-species.
  - No specification

Parameter	Unit	Min	Max	Recommended implementation date
WI	kWh/m <sup>3</sup>	[13.60]	15.81	1/10/2010
d	m <sup>3</sup> /m <sup>3</sup>	0.555	0.700	1/10/2010
Total S	mg/m <sup>3</sup>	-	30	1/10/2006
H <sub>2</sub> S + COS (as S)	mg/m <sup>3</sup>	-	5	1/10/2006
RSH (as S)	mg/m <sup>3</sup>	-	6	1/10/2006
O <sub>2</sub>	mol %	-	[0.01]*	1/10/2010
CO <sub>2</sub>	mol %	-	2.5	1/10/2006
H <sub>2</sub> O DP	°C at 70 bar (a)	-	- 8	See note **
HC DP	°C at 1- 70 bar (a)	-	- 2	1/10/2006

\* EASEE gas have organised an oxygen measurement survey, which by end of 2005 will examine the maximum feasible limit equal to or at an alternative specified value below 0.01 mol%.

\*\*At certain cross border points, less stringent values are used than defined in this CBP. For these cross border points, these values can be maintained and the relevant producers, shippers and transporters should examine together how the CBP value can be met in the long run. At all other cross border points, this value can be adopted by 1<sup>st</sup> October 2006.

Gas Quality Harmonisation – Common Business Practice (EASEE-gas)



# HSE

- Normal operation
  - Produced water
  - Flue gas from gas turbines
- Modification and maintenance
  - Opening and entering equipment
  - Hot work
- Hg species
  - Norway, TWA :
    - 0.05mg/m<sup>3</sup> for inorganic and elemental mercury
    - 0.01mg/m<sup>3</sup> (note on allergy and skin absorption) for alkyl mercury.

# Hg Speciation

- Hg species have different properties wrt
  - Corrosion
  - Toxicity
- Experimental data is scarce → large uncertainty
- Thermodynamic modelling tools indicate negligible concentrations of organic species
  - need for validation

# Final remarks

- Mercury is a challenge with regard to:
  - Corrosion/fouling of piping and equipment
  - Product quality specifications
  - HSE aspects
- Monitoring of mercury level is important due to
  - System integrity
  - Gas specifications
  - Surrounding environment
  - Work environment

Thank you for your attention