Produced Water Measurement Challenges

Dr Ming Yang

TÜV SÜD National Engineering Laboratory

Content

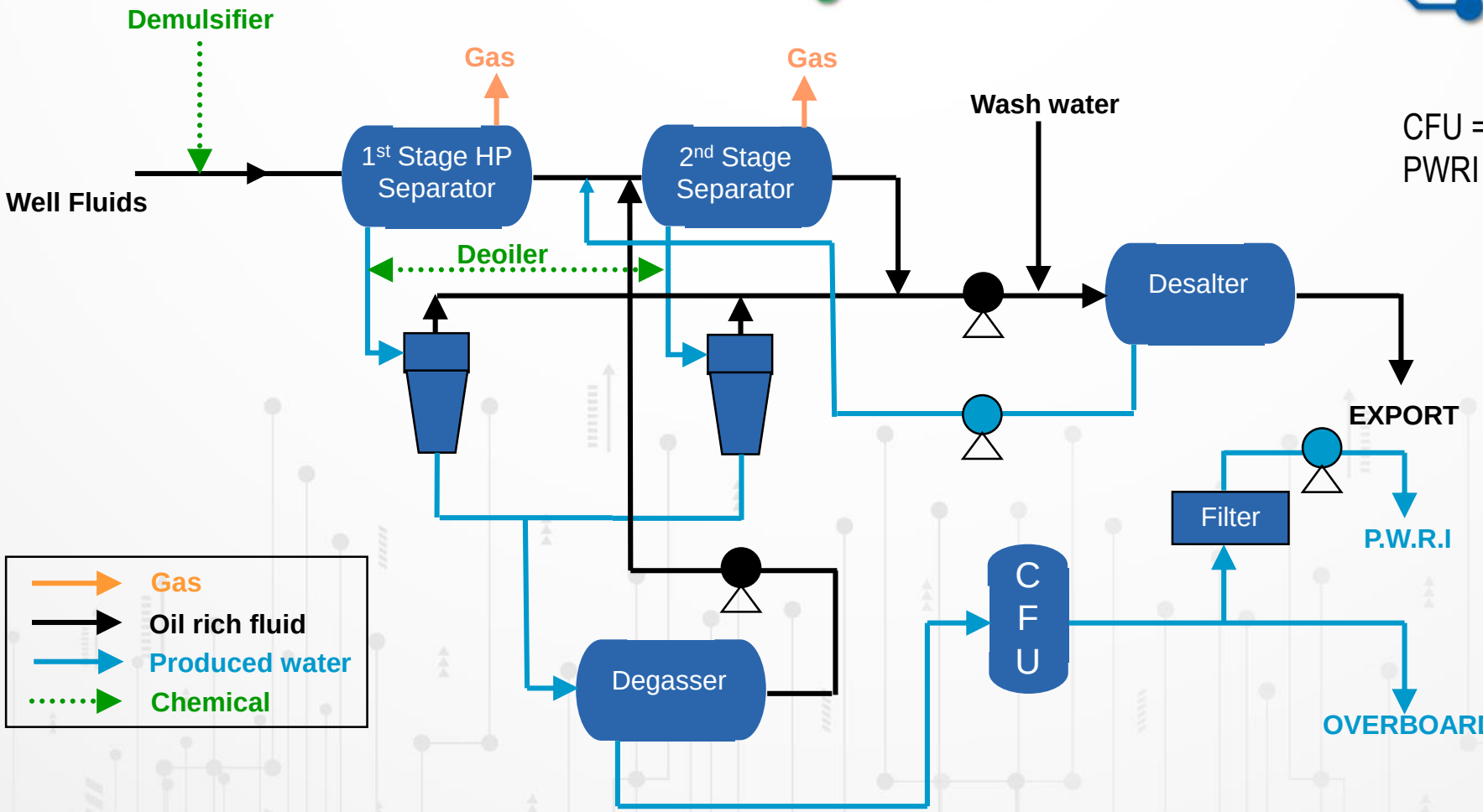
- What Is Produced Water?
- What is Produced Water Measurement and Why is it Important?
- Oil-in-Water (OiW): Definition, Measurement Methods, Issues and Challenges
- NEL's Key Projects on the Subject
- Summary

What Is Produced Water?

Is a **WASTE** stream / a **BY-PRODUCT** in oil and gas production. May include:

Formation Water	Saline formation brines in the reservoir
Condensation Water	Water vapour condensing during production
Returned injection water	Water injected to boost the reservoir pressure
Water used for de-salting	Washing the crude with clean water and removing

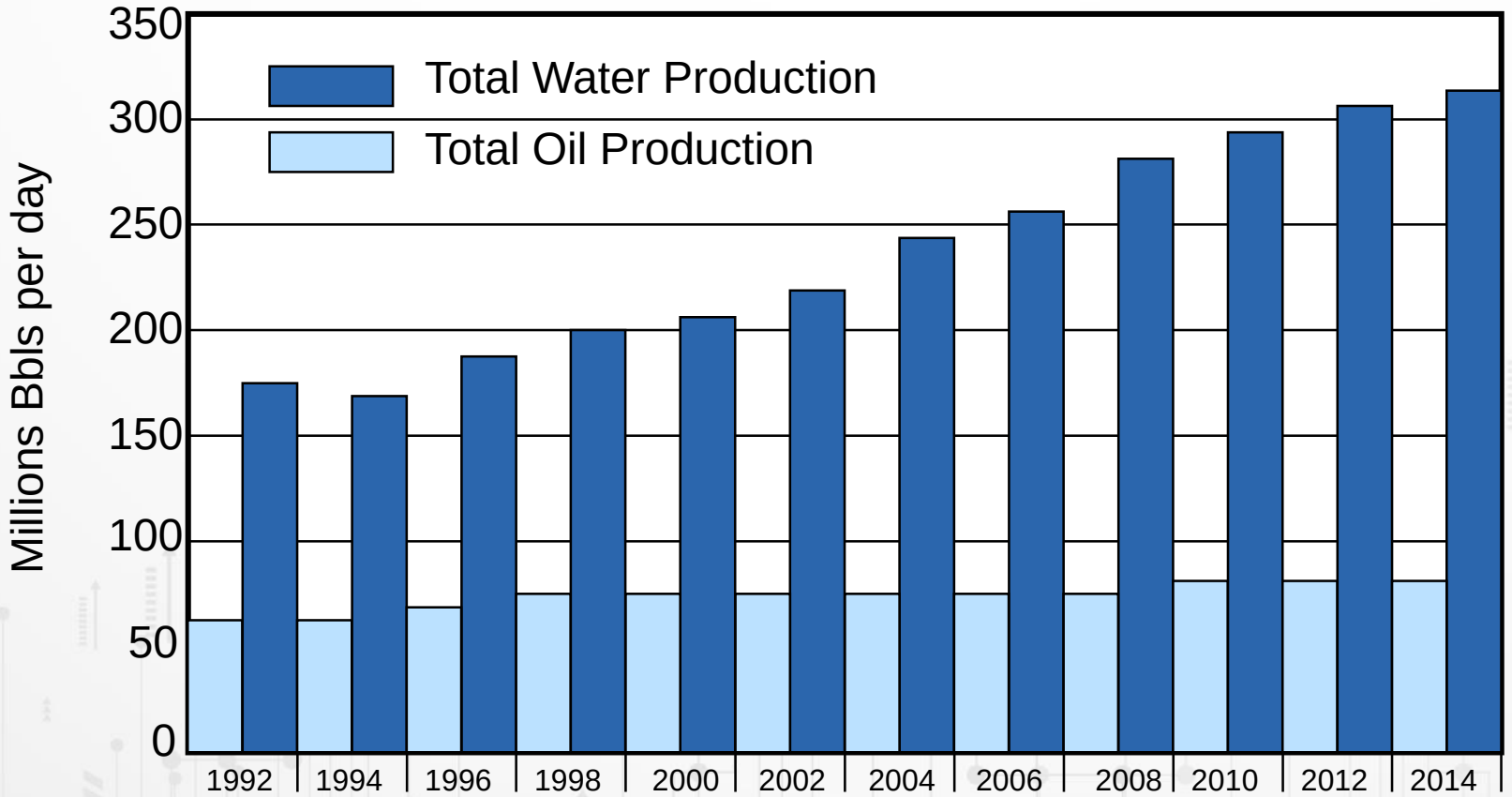
What Is Produced Water? – Typical Process Train



CFU = Compact Flotation Unit
PWRI = Produced Water Re-Injection

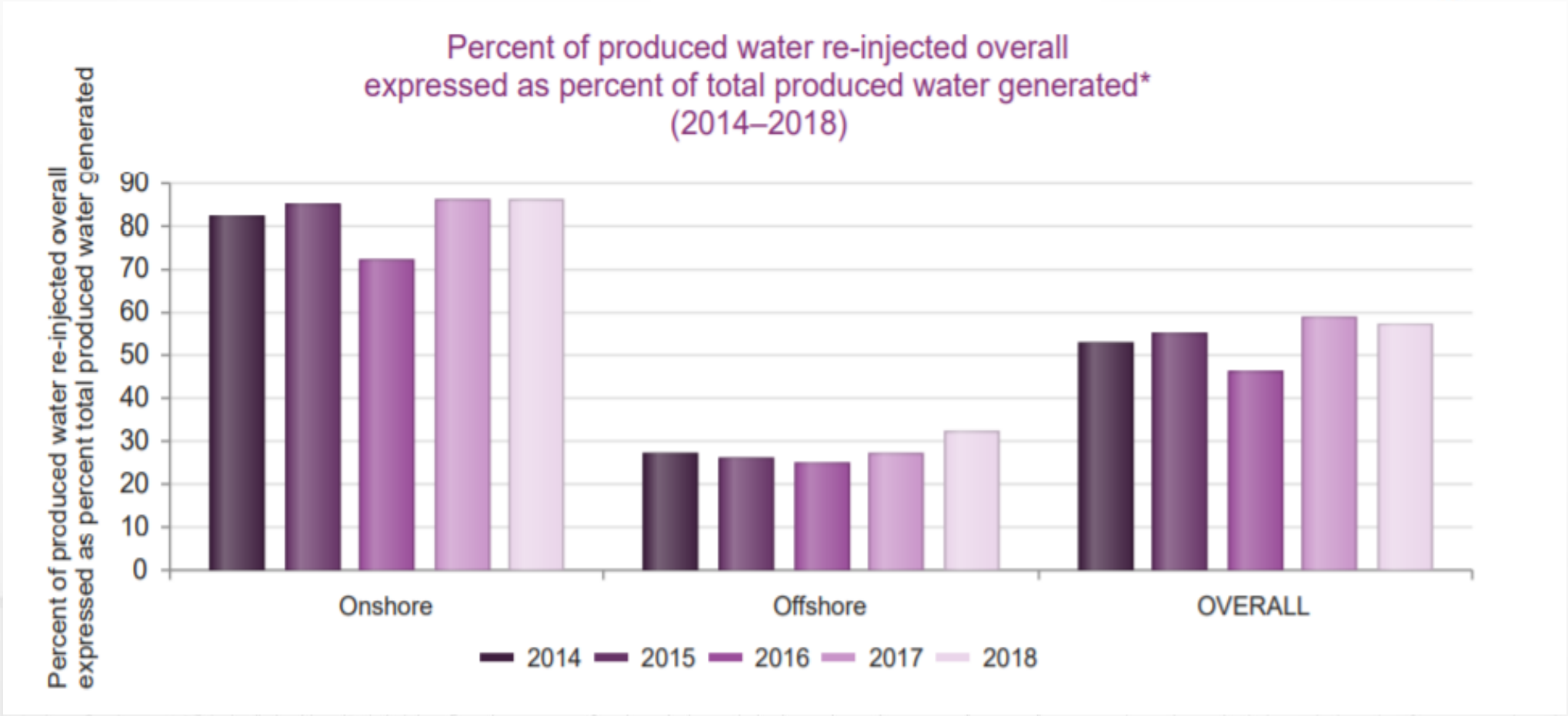
What Is Produced Water? – Amount Produced

For every 1 barrel of oil, roughly 4/5 barrels of produced water!



Source: S. Robertson & L. Jahsen, NEL 4th Produced Water Workshop

What Is Produced Water? - % Re-Injected



Source: IOGP (International Association of Oil & Gas Producers) Report 2018e (Sept. 2020)

What is Produced Water Measurement and Why is it Important?

What?

- OiW concentration
- Volume
- Solid-in-water (concentration and size)

Why?

- Legal (OiW, volume) – in the UK
  - Monthly avg: < 30 mg/L
  - Individual sample OiW max.: 100 mg/L
  - 12 hrs max. OiW discharge: < 1 tonne
  - Volume uncertainty: +/- 10%
- Operational (OiW, solids, volume)
  - Process optimisation
  - Water quality affects injectivity

Oil-in-Water (OiW) Definition - General

- **Definition of OiW – General**

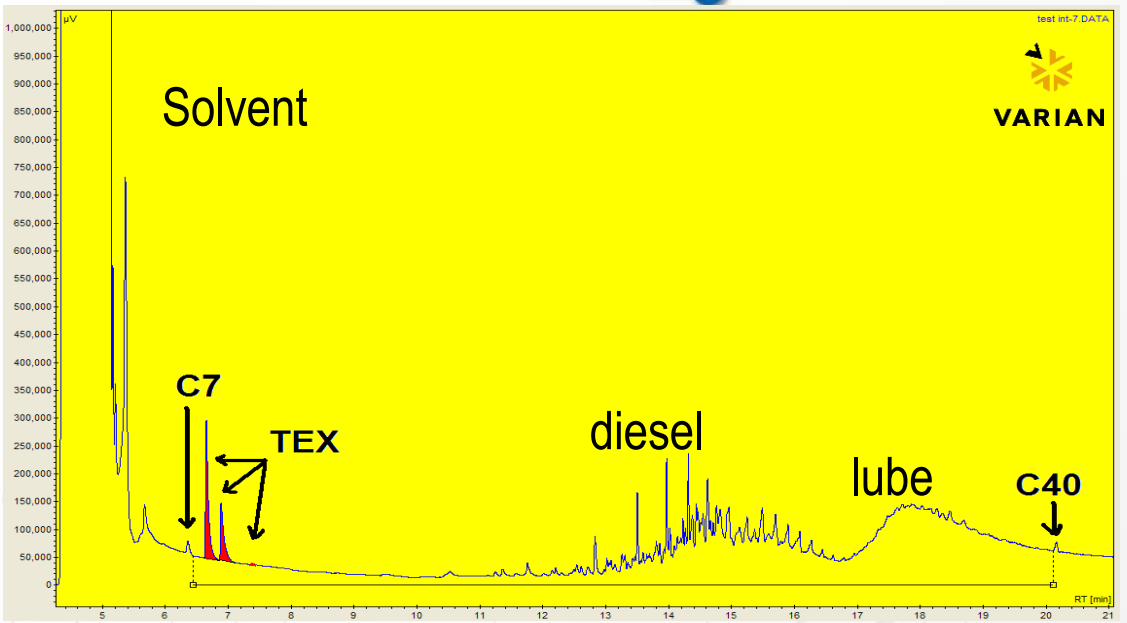
  - **Dissolved** – oil in the dissolved form in produced water. Hydrocarbons (HCs) may include BETX, NPDs and PAHs. Non-HCs may include organic acids and phenols.

  - **Dispersed** – oil in the form of small droplets, say in the range from submicron to hundreds of microns. Majority HCs, but also organic acids and phenols.

  - **Free oil**- floating on the surface of water or in the forms of large droplets that will settle quickly

OiW Definition – Legal OSPAR / North Sea

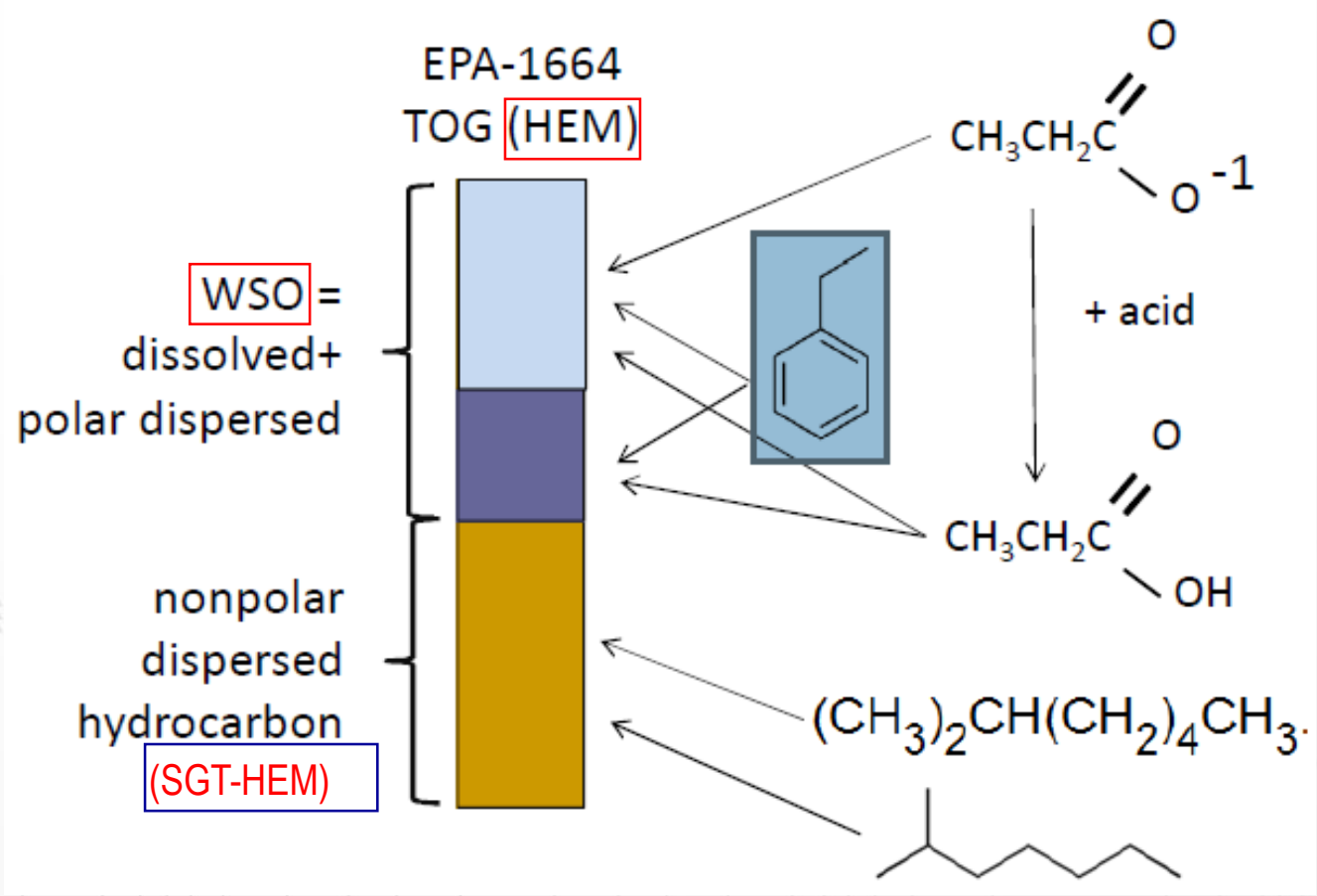
- **Definition of OiW – Legal – OSPAR / North Sea**
  - ‘Dispersed oil’ means the **hydrocarbons** as determined according to the OSPAR GC-FID reference method (**OSPAR Agreement 2005-15**)
  - *“The sum of the concentrations of compounds extractable with n-pentane, not adsorbed on Florisil and which may be chromatographed with retention times between those of n-heptane (C_7H_{16}) and n-tetracontane ($C_{40}H_{82}$) excluding the concentrations of the aromatic hydrocarbons toluene, ethyl benzene and the three isomers of xylene (TEX).”*



Oil in produced water will essentially be the hydrocarbons with carbon number between C7-C40 excluding the TEX. Acids, phenols and hydrocarbons with carbon number above C40 and below C7 will not be included.

OiW Definition – Legal USA

- **Definition of OiW – Legal – USA**
  - **Oil and Grease or n-Hexane Extraction Materials:** as determined by the **EPA** (Environmental Protection Agency) **Method 1664**.



Source: John Walsh, SPE Webinar, presentation, 2015

OiW Measurement Methods

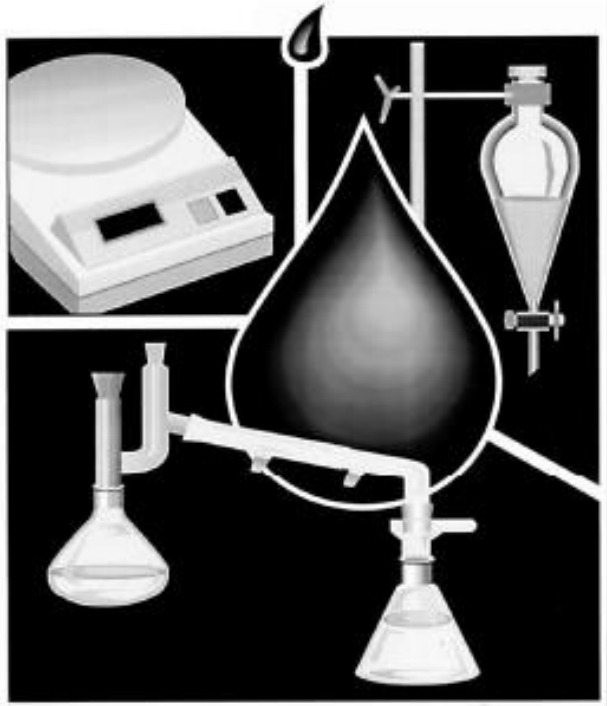
- **Reference Methods**
  - Infrared (IR)
  - GC-FID
  - Gravimetric

  ✓ Defining what OiW is
  ✓ Compliance monitoring
  ✓ But they can be complex, expensive, time consuming…

- **Field Measurement Methods**
  - Bench top
  - Online

  ✓ Avoid the use of certain solvents
  ✓ Quick results
  ✓ Simpler method for routine analyses
  ✓ Concern of costs (capital, running …)

Very important point: OiW is a method-defined parameter!



OiW Measurement Issues & Challenges

- Uncertainties associated with OiW sampling and measurements

- Use of online OiW analysers for PW management
  - For discharge reporting (manned, unmanned and subsea)
  - For operations (manned, unmanned and subsea)

OiW Measurement Issues & Challenges

- Uncertainties associated with OiW sampling and measurement
  - ➢ A subject not very well understood and documented
  - ➢ Yet, it can impact on
    - Regulatory compliance monitoring
    - Performance testing and assessment of online OiW monitors / analysers
    - Developing an acceptance of non-reference method for reporting purposes

Example Uncertainty of OiPW

15 ± 7.3 mg/L (95% confidence)

Ref. Method	Principle	Precision Information	s_r(%) or s_R(%) (at 15 mg/L)
ASTM D 7066-04	S-316 extraction & IR	Overall standard deviation of 47.1 %, 49.9 %, 66.3 %, 50.3 %, 37.2 % and 24.7 % were found for mean values respectively at 30.5 mg/L, 21.2 mg/L, 6.6 mg/L., 6.4 mg/L, 429.9 mg/L, 551.2 mg/L	s_R > 47 %
SM 5520 B	Gravimetric	Standard deviation of the percent recovery (s_r) for oil and grease	s_r = 10 %
EPA 1664	Gravimetric	Standard deviation of the percent recovery (s_r) for HEM	s_r = 11 %
IP 426/98 (Energy Institute)	Tetrachloroethylene and IR using Florisil	Repeatability = 1 mg/kg over 0.5 mg/kg to 5 mg/kg range Repeatability = 0.2127 (x+5) mg/kg where x is the mean of the oiw concentration over 5 mg/kg – 150 mg/kg range	s_r = 10.1 %
ASTM D 7575-10	Membrane recoverable and IR	Overall standard deviation of 16.8 %, 19.6 %, 11.6 %, 10.5 %, 10.2 % and 10.2 % were found for mean values respectively at 13.6 mg/L, 12.4 mg/L, 68.7 mg/L, 62.8 mg/L, 107.1 mg/L, 95.3 mg/L	s_R ≈ 16.8 %

OiW Measurement Issues & Challenges

Benefits of Using Online Analysers

Operational

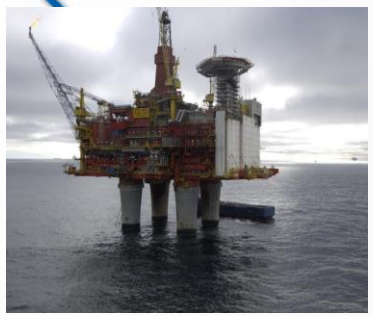
- Providing continuous OiW concentration information
- Detecting process upsets quickly
- Reducing the number of samples for lab analyses

HSE

- Potentially reducing the usage of solvents associated with lab OiW analysis methods
- Likely to provide more accurate oil to sea discharge figures

Online OiW analysers for Reporting

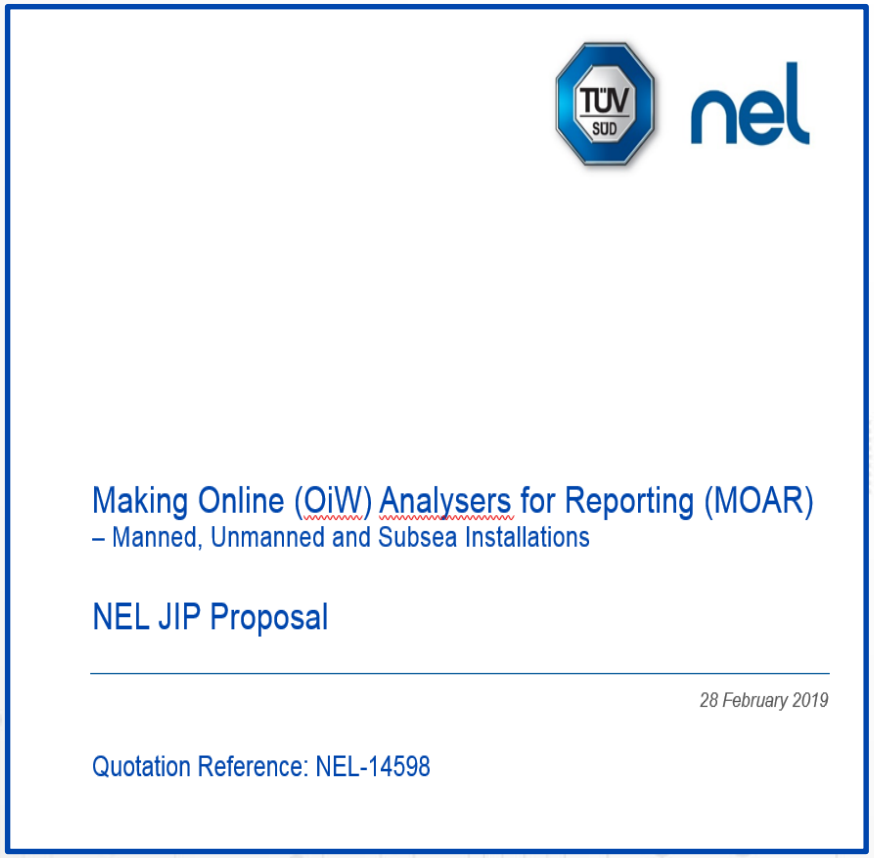
- **Equinor:** Statfjord B – from 2017



- **Aker BP:** Alvheim – from 2015

- **Lundin – Norway:** Edvard Grieg – from 2019

OiW Measurement Issues & Challenges



Scope of Work

- To provide a status report
- To understand uncertainties
- To refine acceptance / validation criteria
- To develop regulatory requirements for subsea discharges
- To develop guidance for unmanned / subsea applications
- To propose changes to improve existing guidance

NEL's Key Projects on the Subject

- "**OIW Analysis Method (OIWAM) JIP**" (2005): supported by 8 operators and 2 government bodies; resulted the development of UK and OSPAR guidance on oil in produced water sampling and measurement.
- "**Produced Water Volume Determination** JIP" (2007), supported by 5 operators and 1 government body, resulted in guidance developed for sponsors on how to best quantify produced water volume.
- "**Collaborative study to determine method performance data for OSPAR GC-FID method**" (2010), a JIP supported by 10 organisations across Europe.
- **3 JIPs** on the subject of developing a subsea water quality measurement device (2009 to 2017)
- "**Making Online (OiW) Analysers for Report (MOAR)** – Manned, Unmanned and Subsea Installations" (2020), supported by 6 operators and 1 government body. Proposed recommendations made to update existing OSPAR, BEIS, Norsk Olje&Gass guidances

Summary

- Produced water is an inevitable by-product / waste stream of oil and gas production
- It is commonly treated and then either discharged or re-injected or re-used
- Measurement is important both for operations and compliance monitoring
- OiW is one of most important parameters in produced water measurement
- OiW is a method-defined parameter. Legal definitions can be quite different!
- Measurement methods include: reference & non reference
- Key OiW measurement issues and challenges include:
  - Uncertainty
  - The use of online analysers for reporting
- NEL has been assisting operators, regulators and other stakeholders in addressing these issues, and will continue to do so through research, commercial projects and JIPs

New JIP idea being developed:

Maintenance Free Online Continuous Oil-in-Water (OiW) Analysers – Development and Field Trial

NORTH SEA FLOW MEASUREMENT WORKSHOP

measuring for the energy transition

National Engineering Laboratory

Contact Us

Dr Ming Yang

TÜV SÜD National Engineering Laboratory

East Kilbride

Glasgow G75 0QF

Scotland

Website: www.tuvsud.com/uk

Email: Ming.Yang@tuvsud.com

Tel: +44 (0) 7717277879