Produced water management under the Norwegian “Zero harmful discharge regime”

– Benefits with the risk based approach

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Background and Objective

• Zero harmful discharge initiative started late 1990’s
• Significant improvement in oil-in-water (oiw) performance for produced water (PW)
• Last years - a slight increase in oiw
• Regulator considers stricter oiw limit
• Industry recommend to continue the risk based approach (OSPAR/BAT)
Approach and Data

• Clarify:
  • Any common challenges/issues?
  • Difference in performance between solutions?
  • Costs and benefits of stricter regulations?

• Data:
  • OiW performance per month and year (2009-2014)
  • All relevant fields on Norwegian Continental Shelf (41)
  • Interviews for experience data
  • Cost data for 14 fields (CAPEX, OPEX)
Results: Performance

- Fields with primary solution re-injection vs. PW treatment
Results: Performance per main treatment solution

- One treatment solution performing better than others?
Results: Variation/stability in short and long term

- Monthly variation
- Year to year variation
Results: What influences performance?

- Oil density and surfactant properties
- Particles
- Oil droplet size
- Water quality
- Surfactant chemicals such as corrosion inhibitors and MEG/methanol
- Weather conditions
- Varying water flow
- Frequency and time of maintenance
- Adding flocculants
- Optimization of the operations, including online monitoring
- Dynamic changes in pressure (slugging)
- Change to low pressure production

- Instability in process at start-up of new wells or existing wells after shut-down
- Effects from well operations
- Tie-back of well stream from external fields with different fluid characteristics, temperature, chemicals, etc.
- Separation is particularly challenging at critical water-cut.
- For injection solutions, injection wells need maintenance which can give significant downtime.
- Several fields with injection are facing challenges with combined seawater and PW injection.
Results: Costs

- Cost correlation with volume processed and/or performance achieved?
Results: Effect of a new solution

- Performance before and after implementation of new PW solution
Results: Impacts (environmental risk potential contribution (EIF))

- Dispersed oil contribution to EIF

![Pie chart showing the contributions of different substances to EIF]

- Dispersed oil: 10%
- BTEX: 11%
- Phenol C6-8: 7%
- Phenol C5: 5%
- Phenol C4: 2%
- Phenol C0-C3: 5%
- 5 rings PAH: 13%
- 4 rings PAH: 17%
- 2-3 ring PAH: 16%
- Napthalene: 13%
- 4 rings PAH: 2%
- 5 rings PAH: 3%
- Dem 7 KII: 85%

![Pie chart showing the contributions of different substances to EIF]

- Dispersed oil: 1%
Discussion / Summary

• No single solution is globally better than another
• Significant field specific differences, variations and challenges
• No correlation between cost and performance
• A stricter fixed limit may cause excessive costs, have limited benefits and even challenge field developments for marginal developments
• The best environmental result is achieved through field/installation specific assessments – in a life time perspective – i.e. BAT assessment (Risk Based Approach)
• Focus on the most important issues – reduced downtime of PWRI and continue phase out of harmful chemicals.
• Current focus “Whole Effluent Toxicity Testing”
Based on:
- DNV GL report 2015-4277 to Norwegian Oil&Gas
- SPE 179326 (2016)

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