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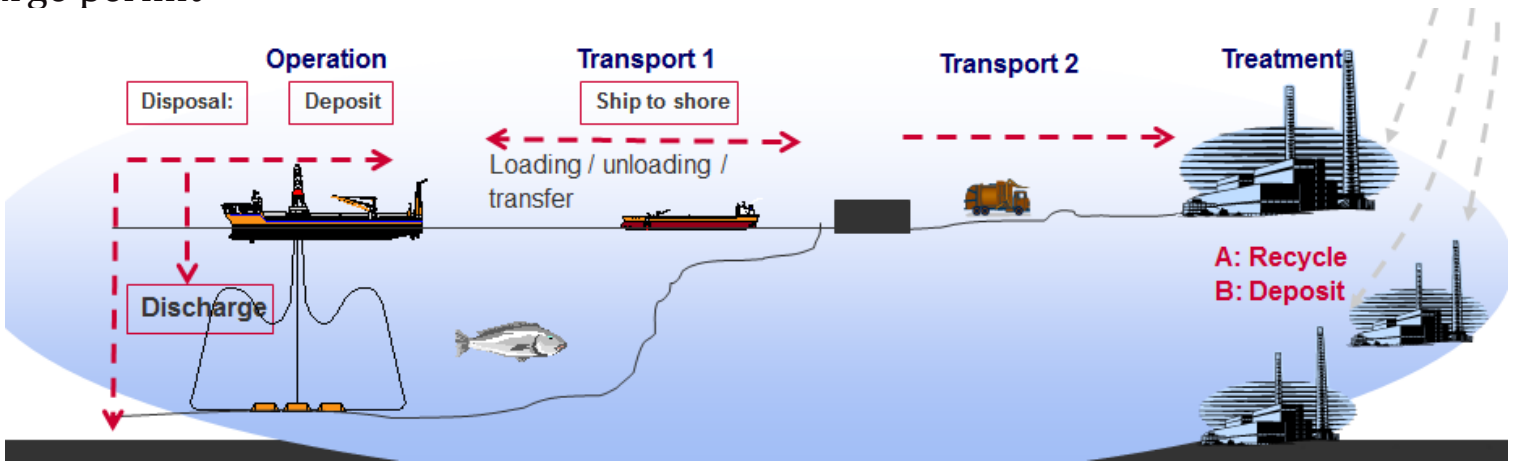
P&A and the environment

The whole P&A picture

Environmental risk assessment and handling of old drilling fluids from P&A-operations…. as governed by the discharge permit



- The closer to the source the P&A fluids are handled the less;
- chemicals you use
- the less waste you generate
- the less energy you consume
- More and more cleaning technologies are available offshore, no longer only available onshore
- Different exposure scenario and requirements offshore vs. onshore

- > Hence, we need to take the whole value chain into consideration……

Chemical composition

- The drilling fluids composition reflects functional requirements, hence you can't drop certain types of chemicals

- There has been some, but few, evolvement of the chemicals used within some of the functional groups of chemicals in the drilling fluid :
    - e.g. base fluid of oil based mud

- The inherit environmental risk of the chemicals used in the mud has changed little over time, however the problem today is chemicals (of water-based) classified as red and black and not allowed discharged due to:
    - First and foremost a lack of documentation and eco-test results of the chemicals in the old drilling fluids circulated out of the well
    - In some minority of cases the old drilling fluid is Performatrol (microplastic) or contain other problematic polymers

    ➢ Different fields – Different history– Different cases

Water-based drilling fluid

Function	Chemical	HOCNF
Basefluid	Water	Green
Viscosifier	Polymer (xanthan gum)	Green
pH reg.	Soda Ash	Green
Filter loss reg.	Polymer (starch)	Green
Shale stab.	KCl salt	Green
Shale stab.	glycol	Yellow
Weight material	Barite	Green
LCM	Graphite /CaCO3	Green

Oil-based drilling fluid

Function	Chemical	HOCNF
Basefluid	Mineral / parafin oil	Yellow
Viscosifier	Organoclay	Yellow/Red
Fluid-stab.	Emulsifier	Yellow
Filter-loss reg.	Organophilic matr./ Polymer-bas.	Yellow/Red
Emulsion stab.	Lime	Green
Emulsified water solutn	CaCl2 brine	Green
Weight material	Barite	Green
LCM	Graphite/ CaCO3	Green

Chemical classification

When chemicals of the old drilling fluid don't have a valid HOCNF available in NEMS , the chemicals are classified as follow:

1. The chemical is classified correctly using the OSPAR 2015 standard
2. Technical documentation and SDS is also used to estimate the OSPAR environmental class
3. Drilling fluid contractor's senior personnel are contacted for assistance in estimating the OSPAR environmental class
4. CAS number or chemical description of comparable chemical products are used as sources of chemical information of the products
5. The water content of the product is estimated to decrease the uncertainty in chemical environmental classification
6. Every chemical is classified environmentally black until documentation proves otherwise

Controlled discharge after setting P&A plug

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Ekofisk: Excess cmt and cmt interface routed to sea after setting cross sectional P&A plug

- Background:
  - In our drilling programs we typically set required cmt x 3 (or more). We avoid returns to the degree possible by hiding interface mix behind pipe
  - COP use the P/W/C technique for P&A
  - We have maximized cmt volume (100 bbl) which gives us required cmt x 2,85 and we have optimized parameters for cmt displacement.
  - Optimized parameters + maximized volume + optimized slurry = maximized QUALITY
  - The maximized QUALITY has a side effect: 65 bbl cmt returns + interphase

- Result:
  - Have selected to maximize quality
  - Have selected to controlled discharge excess cmt and cmt/mud interface

Routing to sea as a controlled event in a emergency situation

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Heidrun, 2011: The first discharge of old drilling fluid to sea due to toxic H_2S gas values above threshold values in AML

- Background:
  - The plan was to send the old drilling fluid onshore as waste as it contained chemicals classified environmentally as red and black
  - When the old drilling fluid contained H_2S values above threshold values in AML, the fluid was routed to sea as an emergency preparedness in order to protect personnel

  Then…
  - Later, whenever the risk of having to discharge old drilling fluids due to the presence of toxic gas was identified, the discharge was applied for prior to each single P&A operation as a precaution
  - Heidrun received restrictions: No discharge of red and black chemicals was permitted in the period of 15th March – 1st July due to fish larvae present in the area

- Result:
  - By implementing new and improved operational routines the need for discharging red and black chemicals to the sea was eliminated

Re-use and discharge of old drilling fluids

Troll: Old drilling fluids, re-use of slots and drilling of horizontal, multi-lateral wells (side steps)

- Background:
  - 2011: Large volumes of old drilling fluids circulated out from the wells during P&A-operations were frequently sent ashore as they contained chemicals environmentally classified as red chemicals and the permit did not allow discharge of these volumes to sea.
  - Simultaneously, large volumes of killing fluids/new chemicals were bought in and used in the P&A operations

- Result:
  - Applied and got discharge permit to re-use old drilling fluids and slop as kill fluids to the P&A-operations on Troll and to discharge until 80 kg chemicals environmentally classified as red chemicals annually
  - 2015: The re-use of old drilling fluids and slop as kill fluids have reduced the use of new chemicals and the amount of waste generated with approx. 600 ton, while reducing the need for transporting waste onshore by 1200 tons.

«From cradle to grave»

How changed conditions influence the design of fluids and the management throughout the field's life span

Planning of a well and a field

- Location
  - > Formation; requirements to and selection of drilling fluids
  - > Choice of development solution; possibility of (cleaning), re-use, discharge, storage, injection and transport
  - > Biology; vulnerable resources present?

Drilling and field development

- Extended lifespan? Different reservoir or depleted reservoir?
  - > Changes in reservoir and formation parameters
  - > Changed requirements to and selection of drilling fluids
  - > Changed possibility of (cleaning), re-use, discharge, storage, injection and transport

Estimated P&A- Norwegian Continental Shelf: 2019 – 2025
October 2018

Company	Estimated number of P&A 2019 → 2025	Estimated number of Slot Recovery 2019 → 2025	Estimated number of Sub Sea P&A 2019 → 2025	Contact person
AkerBP	14	30	2 subsea P&A	Egil Thorstensen
ConocoPhillips	+/- 50	+/-20		Ann Elin Mikalsen
Eni Norge	2	0	2 subsea P&A	Jan Terje Svendsen
Equinor	173	70/year		Steinar Strøm
Neptune Energy	0	1		Mehryar Nasseri
Faroe Petroleum	3-5	0	subsea P&A	Dan Sturdee
Lundin Norway	4	2	4 subsea P&A	Jakob Mo
Norske Shell	9	1	subsea P&A, LWI	Kjetil Skjeldestad
Repsol Norge	35	1		Øystein Østerhus
Total Norge	1-2	0	Subsea P&A	Johan Kverneland
Spirit Energy	0	0-1		Atle Knudsen
Wintershall	+/-6	+/-20		Mark van Aerssen
Point Resources	0	11	Subsea P&A	Sigve Krohn Næsheim

Key technical challenges:
Subsea P&A, Platform P&A, Dual casing strings across P&A zone, Slot recovery, Rigless P&A, Verification of cement / formation outside casing, Removal of tubing / casing, Challenge to set 50m plugs, Tubing access/collapse, verification methods, corroded tubulars, cross-department. Through tubing PWC, Logging through two strings, Deformed casing/tubing

Technical needs:
Dual string cross sectional plugging, Cutting/milling in large casing, Pull tubing, Logging challenges, PWC, Reliable and efficient barrier verification methods, Dual casing bond logging, Alternative plugging solutions, Rigless P&A