# Toxicological Properties of Oil-Based Drilling Fluids

Elanor Ball

Health and Safety Executive

Bootle

# What are drilling fluids?

- Complex formulations that have specific properties for particular drilling applications.
- Drilling fluids need to carry out the following functions:
  - Support and lubricate the drill head and chain during drilling,
  - Remove cuttings from the drill head,
  - Support the borehole to prevent fracturing and,
  - Prevent exchange of fluids between the rock formation and borehole during drilling, and
- The composition is matched to the rock formations being drilled.
- Drilling fluids are therefore complex mixtures of variable composition.

# Issues for hazard assessment of complex mixtures

- Ideally hazard assessment will be informed by data addressing the hazardous properties of mixtures as they are encountered during use.
- The form in which a mixture is encountered will not necessarily be the same as the form of the bulk mixture.
  - Which fractions are workers exposed to?
  - What is the chemical composition of these fractions?
  - Depends on the process and its operating conditions.

# Which fractions are relevant?

- Need to consider:
  - Additive dusts
  - Vapours/mists
  - Aerosols
  - Splashes
- Vapours and aerosols are the most relevant fractions for setting airborne standards for oil-based drilling fluids.
- Unlikely to have health effects data for representative mixtures for these fractions so need to predict toxicological properties from components.

# Composition of a typical OBDF

| Component | Quantity | Mass (kg) | Volume (l) | % Mass | % Volume |
|---|---|---|---|---|---|
| Base fluid | 0.52 bbl | 63.64 | 83.31 | 30.37 | 52.40 |
| Viscosifier | 5 ppb | 2.26 | 1.40 | 1.08 | 0.88 |
| Emulsifier 1 | 0.8 gpb | 2.89 | 3.02 | 1.38 | 1.90 |
| Emulsifier 2 | 0.4 gpb | 1.49 | 1.51 | 0.71 | 0.95 |
| Lime | 5 ppb | 2.26 | 1.00 | 1.08 | 0.63 |
| Water | 0.3 ppb | 47.15 | 47.22 | 22.50 | 29.70 |
| $CaCl_2$ | 30.2 ppb | 13.70 | 3.35 | 6.54 | 2.11 |
| Barite | 167.9 ppb | 76.15 | 18.16 | 36.34 | 11.42 |

Source: HSE Offshore technology report – OTO 1999 089
http://www.hse.gov.uk/research/otohtm/1999/oto99089.htm

# Stability of composition in use

- The composition of the bulk fluid may change during use due to:
  - Particulate contamination from cuttings
  - Inward seepage of formation fluids and gases
  - Possible chemical reactions down hole
  - Adjustments to maintain technical performance
- HSL found little change in the relative proportion of hydrocarbons in 6 out of 8 fluids tested.
- One fluid had become contaminated with C5 to C8 paraffins,C6-C7 napthenes, benzene and toluene.
- One fluid had been mixed with a synthetic based fluid.
- The 'EPA 16 PAHs' were generally below the limits of detection as was N-nitrosodiethanolamine.

Simpson *et al*, 2002. Investigation of oil based drilling mud phase 1: Composition pre and post use. OMS/2002/11
http://www.hse.gov.uk/research/hsl_pdf/2007/hsl0710.pdf

# Vapour phase

- Expect hydrocarbons originating from the base oil to be major components.
- Expect solvents from additive formulations and any volatile/gaseous contaminants from the bore hole to be minor components.
- Volatility as well as concentration in the bulk drilling fluid will determine the concentration of a component in the vapour fraction.
- Key health concerns likely to be CNS depression and irritation but the data are inadequate to identify dose-response relationships.
- Limited data on longer-term effects.

# Aerosol phase

- The composition is expected to be similar to the bulk fluid.
- Main components expected to be base oil, aqueous brine and weighting agent.
- Minor components include:
  - Alkaline chemicals
  - Mineral particulates and organophillic clays (including crystalline silica as an impurty)
  - Emulsifier and surfactant formulations.
- No studies looking at the effects of inhaling drilling fluid formulations have been published.
- Difficult to make predictions given the large number of possible additives.

# Skin contact

- Anecdotal information and case reports have been published that identify drilling fluid as a cause of dermatitis.
- Patients affected include:
  - Deep sea diver
  - Roughnecks
  - Drillers
  - Laboratory supervisor
  - Mud engineer
  - Service engineer
- Agents responsible included:
  - Discarded drilling fluid on the sea bed
  - Base oil hydrocarbons
  - Polyamines used as emulsifiers

# What are the implications for setting exposure standards?

- Drilling fluids are complex mixtures of variable composition.
- Exposure standards must encompass all relevant fractions and all variations in composition.
- At present the data are insufficient to derive dose-response relationships for health effects of the vapour fraction and to relate these effects to markers of exposure.
- Longer term health effects are unclear.
- No scientific basis on which to set a health based limit.
- Exposure standards should therefore reflect levels that can be achieved using good practice.