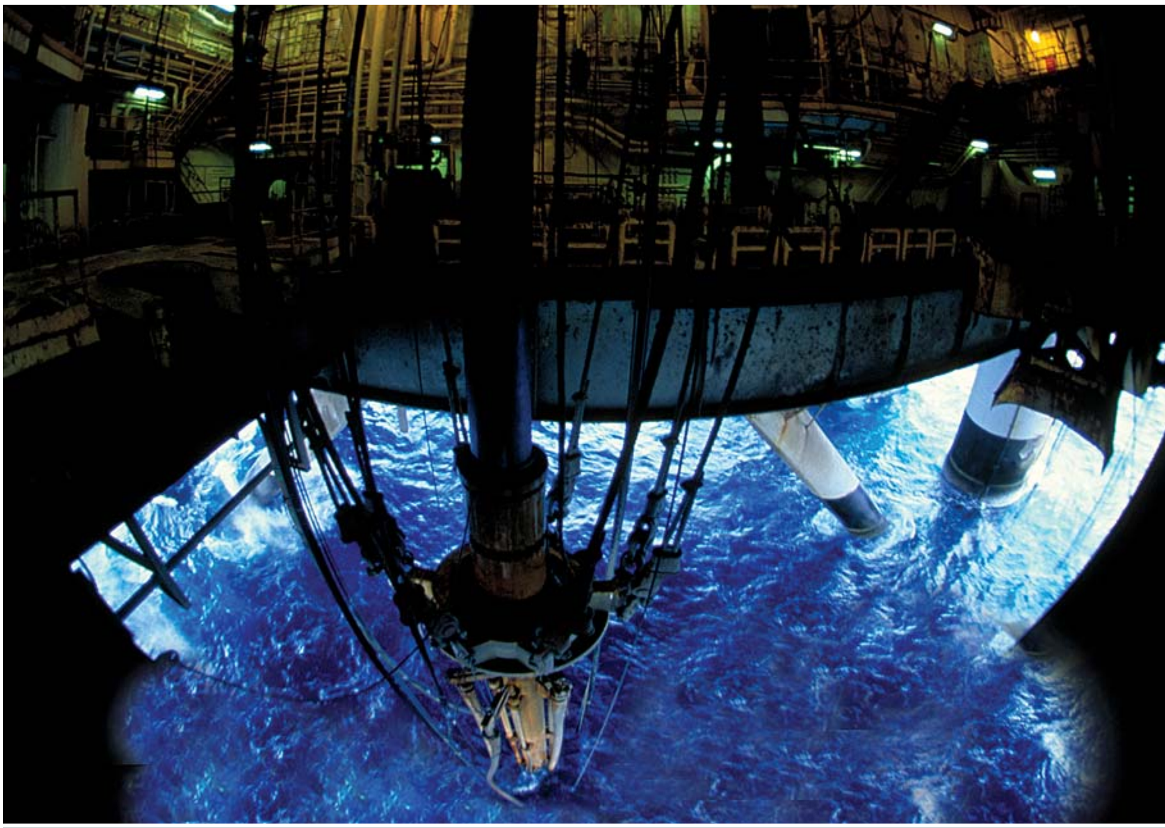
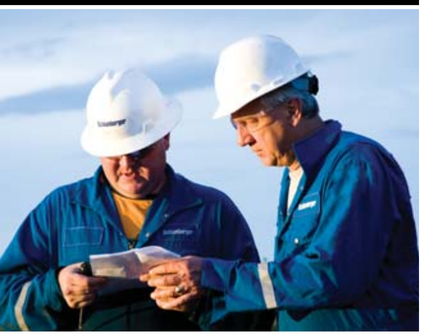
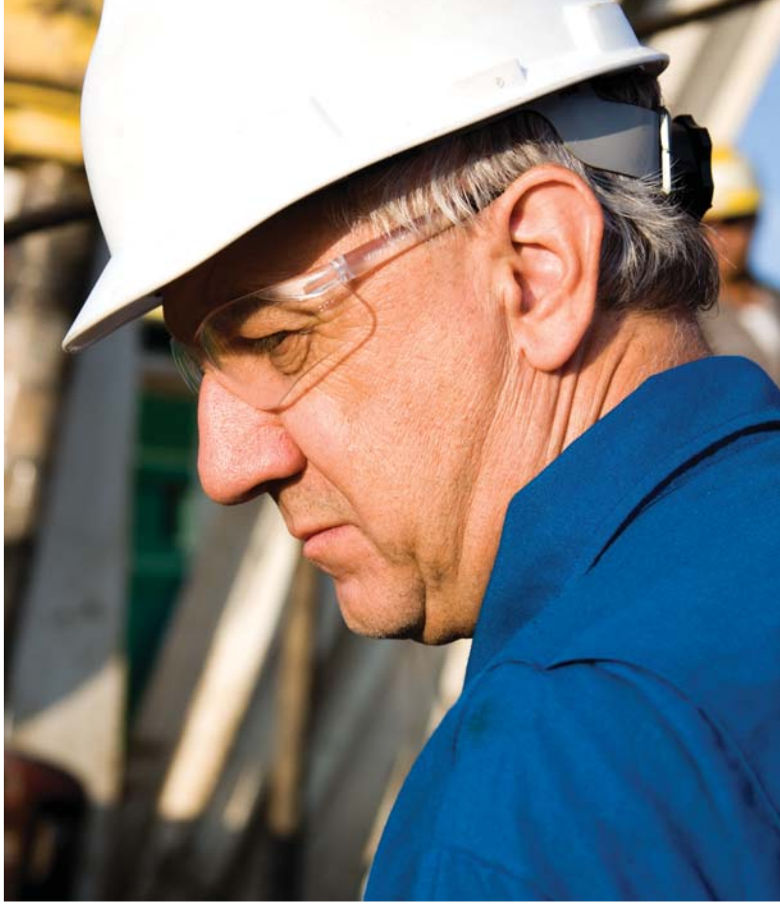
Schlumberger





Deepwater Cementing

A world of experience



Overcoming Deepwater Challenges Across the Globe

Because of the increasingly high global demand for hydrocarbons and the rapid decline of onshore and shallow water reserves, deep water is the current focus in the industry. Deepwater operations have large potential reserves and high production rates that require advanced technology.

Today, the latest generation of offshore deepwater rigs is designed to increase drilling efficiency and reduce operational time. Rig service costs can also be a major concern, especially to new operators in deepwater operations. Every minute is important, and reducing wait-on-cement (WOC) time is critical to keeping costs down.

Deep water is one of the most technically and logistically challenging environments for cementing operations because of the risks associated with the conductor and surface casing cementing. Understanding these technical challenges is key to designing cement slurries that can meet deepwater specifications and provide required zonal isolation.

TECHNICAL CHALLANGES

Low temperatures
Water depth has a direct effect on the temperature at the seabed (the deeper the water, the cooler the temperature). In the cold temperatures of the deepwater environment, cement takes longer to set and achieve the required compressive strength. Consequently, the WOC time is longer.

Low fracture gradient
Another challenge in deepwater operations is low fracture gradient. In many areas, deep water has unconsolidated formations below the seabed. To avoid the risk of inducing losses due to the narrow margin between the pore pressure and the fracture gradient, a low-density cement system is required to ensure cement coverage across the zones of interest.

Shallow flow hazards
The next biggest challenge is the high potential for shallow gas flow hazards and gas hydrates. Failure to control these problems can lead to serious consequences such as well control risks, excessive hole washouts, and destabilization of near-wellbore formations.

A WEALTH OF EXPERIENCE AND TECHNOLOGIES

With more than 25 years of experience in developing products and services especially for deepwater drilling, Schlumberger well services combines technology with expertise to help our customers improve efficiency and increase production.

DeepCRETE* cementing slurries and DeepCEM* cementing additives, which are used by many deepwater operators across the globe, offer rapid cement setting, control of potential gas flows, and long-term zonal isolation.

DeepCRETE deepwater cementing solution reduces WOC time. The cement system isolates a formation and develops compressive strength faster than conventional portland cement systems. When combined with Schlumberger gas migration technology, the DeepCRETE solution also controls shallow gas flow. Gas migration technology provides low fluid loss and low permeability when coupled with the particle size distribution technology of DeepCRETE cement, thereby inhibiting migration of fluids.

Cement slurries using DeepCEM additives exhibit the necessary slurry and set cement properties for deep water. Rheological properties are controlled, providing low viscosities and rapid gel strength development to control shallow flow even at the low temperatures encountered in deepwater environments. This allows early commencement of operations, reducing WOC time for costly deepwater rigs.

> "Despite 70% of the wells drilled having challenges with shallow water flow, all surface casings were successfully constructed using the DeepCRETE system."
>
> **Chris Flannery**
> **Deepwater Drilling Team Lead**
> **Murphy Oil Corporation**

CASE STUDIES

DeepCEM and DeepCRETE deepwater cementing solutions were used to mitigate the technical challenges associated with drilling in these offshore deepwater fields.

Malaysia

Murphy Oil Corporation

- Offshore Sabah Block K
  - Kakap, Jangas, Penaga, Rotan, Todak, Shrumbu, Senangin, and Rohu fields
  - 28 deepwater wells
  - Water depths between 2,625 ft [800 m] and 4,593 ft [1,400 m]
- Challenges
  - Weak, unconsolidated formations with a high pad-mud weight at 13 lbm/galUS [1,558 kg/m^3] because of well stability
  - Gas hydrates
  - Shallow water flow
  - Low temperature at seabed (41 degF [5 degC])
- Results
  - All wells cemented with no water flow
- Offshore Sabah Kikeh Development
  - 31 development wells, surface casing in batch sets consisting of 18 dry tree unit wells and 13 subsea completed wells
  - Field development using spar (its only use outside the Gulf of Mexico)
  - Water depths of approximately 4,429 ft [1,350 m]
- Challenges
  - Weak, unconsolidated formations with a high pad-mud weight at 13 lbm/galUS [1,558 kg/m^3] because of well stability
  - Shallow water flows in 70% of the wells
  - Consistency of the cement blend
  - Logistic management with more than 5,000 t of blend utilized in a period of 3 months
- Results
  - All wells cemented with no water flow
  - First phase batch wells completed 6 days ahead of planned schedule

Shell

- Offshore Sarawak field
  - 11 deepwater wells
  - Water depths between 3,280 ft [1,000 m] and 5,000 ft [1,524 m]
- Challenges
  - Gas hydrates
  - Shallow water flow
  - Low temperature at seabed (41 degF [5 degC])
- Results
  - All wells cemented with no water flow
  - Project completed on time and technical and financial objectives achieved

Indonesia

Chevron

- West Seno field
  - 27 deepwater wells
  - Water depths of approximately 3,510 ft [1,070 m]
- Challenges
  - Weak, unconsolidated shallow formations
  - Narrow margin between pore pressure and fracture gradient
  - Gas hydrates
  - Shallow water and gas flows
  - Low temperature at seabed (44.6 degF [7 degC])
- Results
  - Full returns to seabed, pumped total of 40,871 bbl of DeepCRETE cementing solution (11.2 lbm/galUS [1,342.05 kg/m^3]) to surface
  - 196 hours of operational time with 100% operational efficiency and no downtime throughout entire West Seno development campaign
  - Leakoff test (LOT) that exceeded client LOT objective
  - Logistic management with more than 235,788 ft^3 [6,677 m^3] of blended material
  - Technical, HSE, and financial objectives achieved

A World of **Experience in Deepwater Cementing**

ENI

- Bukat field (Tarakan basin)
  - 3 deepwater wells
  - Water depths between 2,638 ft [804 m] and 3,627 ft [1,106 m]
- Challenges
  - Weak, unconsolidated shallow formations
  - Low fracture gradient (0.58 psi/ft)
  - Gas hydrates
  - Shallow water and gas flows
  - Low temperature at seabed (42 degF [5.6 degC])
- Results
  - Full returns to seabed, pumped total of 2,225 bbl of DeepCRETE cementing solution (12 lbm/gal [1,437.9 kg/m^3]) to surface
  - Design execution with no lost time
  - LOT (11 lbm/gal [1,318.09 kg/m^3]) that exceeded LOT objective of 10.8 lbm/gal [1,294.12 kgm^3]
  - Rig time on WOC minimized, saving an average of 5 h rig time and USD 208,000 per job
  - Technical and financial objectives achieved

Pakistan

Shell

- Offshore block 2365-1
  - First deepwater exploration well Anne-AX
  - Water depth of approximately 4,290 ft [1,307 m]
- Challenges
  - Narrow margin between pore and fracture gradients
  - Weak, unconsolidated formation at the 17 1/2-in hole section
  - Low temperature at seabed (39 degF [4 degC])
  - Limited deck space at the Discovery 534 drillship
- Results
  - Full returns to seabed
  - Reduced WOC time for the 13 3/8-in casing
  - Drilled hard cement at the 13 3/8-in casing shoe
  - LOT achieved 10.9 lbm/galUS [1,306 kgm^3] equivalent mud weight, exceeding Shell's expectations

www.slb.com/deepcem

Schlumberger