

# E&P

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A Hart Energy Publication

April 2008

## SUBSEA OPERATIONS

### Subsea Systems

*Technology firsts boost production*

### Offshore Logistics

*Challenges drive innovation*

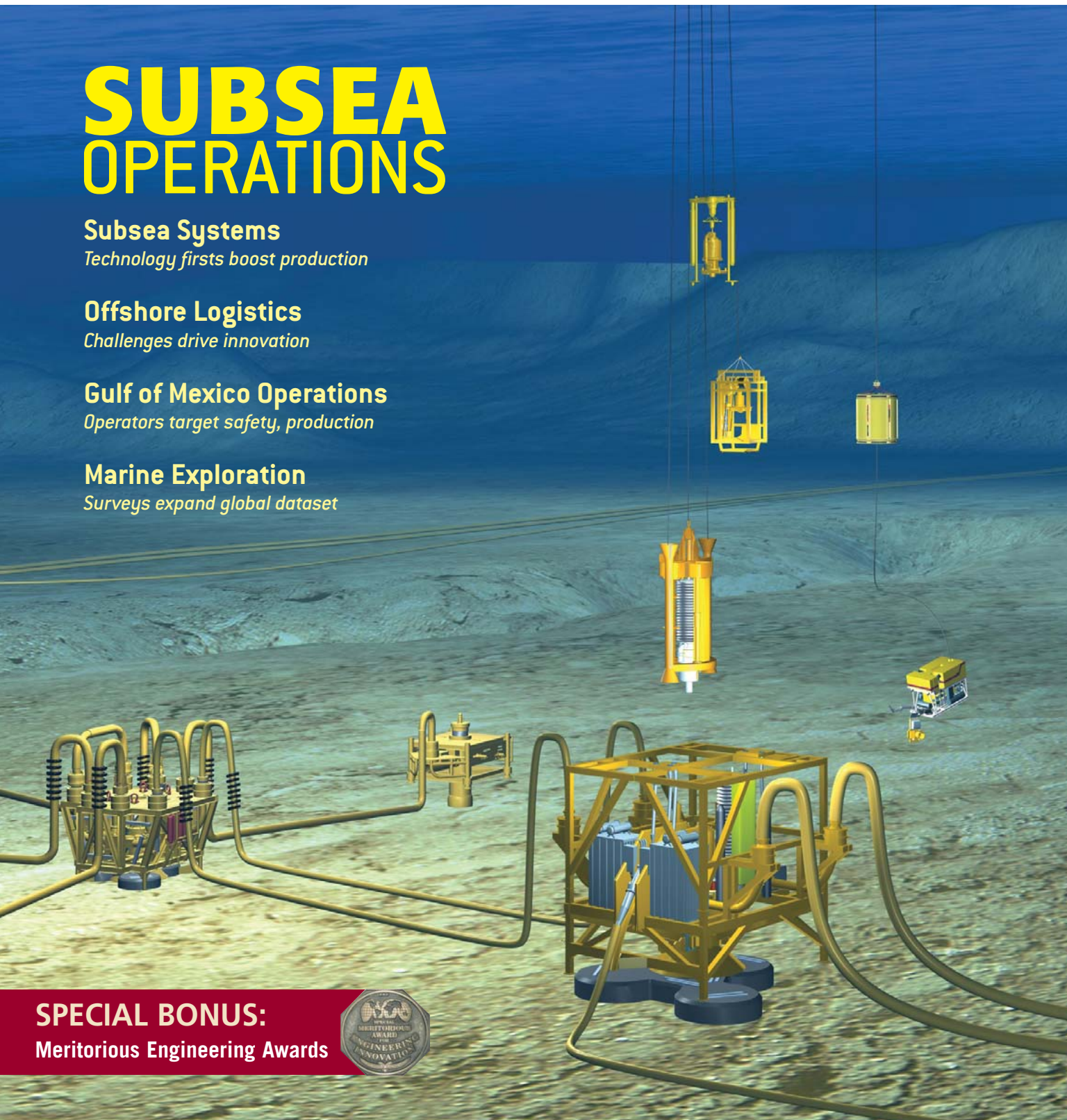
### Gulf of Mexico Operations

*Operators target safety, production*

### Marine Exploration

*Surveys expand global dataset*

**SPECIAL BONUS:**  
Meritorious Engineering Awards





**REMEDICATION  
FUTUR**

**WINNER  
SCHLUMBERGER**

## FUTUR overcomes the weak link

Many wells leak liquid or gaseous hydrocarbons or have sustained casing pressure (SCP). Managing leakage has been an enduring challenge, and related regulations are expected to become increasingly stringent over the coming years. Improving slurry designs and optimizing fluid placement help to prevent leaks, but once cement has set, it is vulnerable to hydrocarbon migration in the event of sheath damage.

Schlumberger has developed an isolation solution based on a responsive cement blend with intrinsic self-healing properties. FUTUR active-set cement technology is automatically activated upon contact with hydrocarbons, improving long-term zonal isolation and protecting against hydrocarbon leaks and SCP at the wellhead. Pumped and placed as part of any primary cementing operation, FUTUR creates a cement sheath that provides an additional level of protection above the reservoir, reacting whenever the cement sheath is damaged during the long-term productive life of the well.

If the integrity of the cement sheath is compromised, hydrocarbons flowing through either a crack or microannulus activate the FUTUR active set-cement system, which seals the pathways within hours. Once the flow paths are healed, the well's hydraulic integrity is fully restored. This self-healing response is repeatable if annular integrity is compro-

mised later in the life of the well.

In providing an extra level of insurance, FUTUR active set-cement technology incorporates safety factors into the well cementing design to enhance well integrity and zonal isolation during completion, production, future remedial work and after abandonment.

This active-set cement technology does not preclude good cementing practices but enhances the chance of success where the perceived long-term risk of SCP or hydrocarbon leakage is anticipated. The concept focuses on the long-term durability of the cement sheath in oil and gas wells and cement sheath repair without the need for well intervention.

Extensive laboratory and field tests indicate that FUTUR active-set cement systems outperform conventional cements in preventing hydrocarbon migration and the potential for SCP. FUTUR active-set cement technology has been used in production wells to address SCP, surface casing vent flows and gas migration issues that conventional systems could not adequately mitigate.

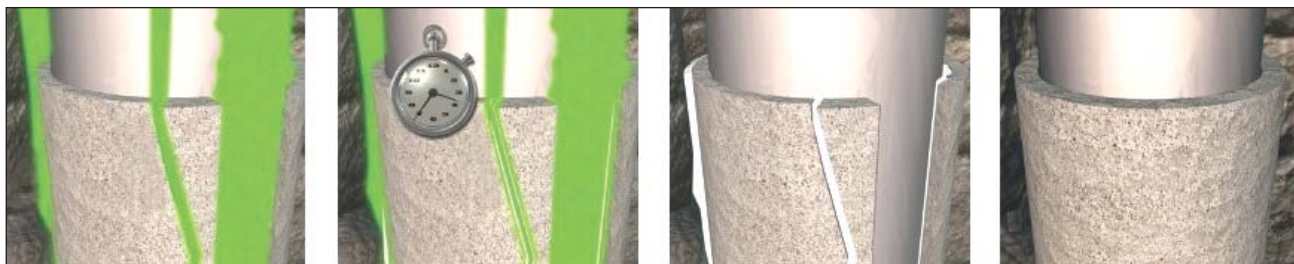
In one instance, this system closed a microannulus of 100 microns between the casing and cement in a flow loop test in less than six hours. The repaired matrix was able to prevent oil flow at a differential pressure of 5.3 MPa/m (233 psi/ft). In another test to determine the effectiveness of FUTUR cement systems

in gaseous hydrocarbons, gas flow across a sample at 21 MPa (3,000 psi) was reduced from 425 mL/min to 0.52 mL/min in less than one hour. This trend was not observed with a control sample of conventional cement. Tests conducted on cured samples after immersion in oil for one year indicated no deterioration of the integrity of the matrix or significant change in mechanical properties. Further tests performed on samples cured and immersed in water for more than one year continued to demonstrate self-healing properties when once again exposed to hydrocarbon.

In Italy, the technology was used to enhance zonal isolation in underground gas storage wells where well integrity is a major challenge.

An integrated solution applied in early 2007 included operations to improve stand-off, enhance mud removal and slurry placement along with the addition of gas migration control additives to prevent gas channeling. Engineers designed a slurry incorporating active set cement technology to mitigate gas leakage.

Well logging data indicated there was optimal cement bonding to casing and to formation, ensuring hydraulic isolation across permeable zones and making the well safe for gas injection and production. Validation of the technology will be reinforced over the longer term with injection/production cycling.



*If the integrity of the cement sheath is compromised, hydrocarbons flowing through either a crack or microannulus activate the FUTUR active set-cement system, which seals the pathways within hours. Hydrocarbon flow (shown in green) activates FUTUR active-set cement, sealing the leak path and re-establishing well integrity. (Photo courtesy of Schlumberger)*