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# Intelligent completions advances poised to catapult production technology forward

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Chief News Editor

**A** new generation of intelligent downhole technologies has long been heralded as the future of the upstream petroleum industry. A number of oil field service firms are developing such technologies, aimed at moving to the wellbore much of the work that is now done at the surface.

Schlumberger has disclosed the development of several new intelligent completions-related products that were developed in cooperation with operators. The firm has taken a systems integration-type approach that focuses on working with operators to develop customized solutions to problems specific to a given reservoir.

During the October opening of a new center at which Schlumberger will develop such custom solutions to reservoir performance problems, the firm described the progress of its intelligent completions development work. More than 500 representatives from operating companies turned out to hear about the new techniques, revealing the extent of industry interest in this early-stage technological revolution.

"On a par with 3D seismic and the advent of horizontal well technology, 'smart' completion technology and its cousins represent the next big breakthrough to increase well productivity and improve recovery," said Andrew Gould, executive vice-president of Schlumberger Oilfield Services. "...Advances in well completions—particularly 'smart' completions—provide the key to improving the short and long-term returns for our customers."

Now that 3D seismic and horizontal drilling have become commonplace, the industry's focus is shifting to the "plumbing" in the reservoir, says Gould, with multilateral drilling and completion technologies playing a key role. The ability to use multilateral technologies in any environment—including the deep water—provides "obvious improved economic return over individual wells..." he said.

Add to that capability the potential for "intelligent" systems that monitor and adjust to reservoir conditions to achieve an optimum completion, and the upstream sector is poised for a technological revolution that will take place in the wellbore itself.

## Smart wells

John Algeroy, business development manager for Schlumberger well process control, described three projects that focus on "intelligent completions" or "smart wells." Two of the projects have been implemented and are in service; the third has been proposed and is under evaluation by the operator.

The first such project was performed in Troll field in the Norwegian North Sea.

Troll is an enormous offshore gas field with a thin oil accumulation on the fringes of the gas reservoirs. In 1985, there were no plans to produce this oil, but the application of new technologies since then has resulted in a reserves estimate of more than 60 million bbl for Troll oil, says Algeroy. These technologies are geosteering, 3D seismic reservoir mapping, and horizontal drilling.

Surface-controlled, downhole, inflow-control valves were installed to help lift oil and water and further increase recovery when water influx warrants it.

"The Troll oil sand has an associated gas cap above it and a water aquifer below," said Algeroy. "Economic oil production from the subsea wells requires minimal gas production but can accommodate (some) water production."

To produce this 40-ft thick layer of oil, the operator opted to drill horizontal, extended-reach wellbores close to the aquifer and as far from the gas cap as possible, and to use intelligent gas lift (see figure, p. 34).

"To meet the need, we developed a hydraulically operated, surface-controlled inflow control valve, which provides variable injection-gas volumes on demand," said Algeroy. The gas will be produced from the gas zone into the tubing to help lift the oil, thus accelerating production. This means no gas compression equipment is required at the surface, which cuts costs significantly.

Five such installations have been completed; they are tested periodically to verify that the valves are functioning properly, said Algeroy. As many as 50 more installations are planned.

"It has been estimated that these completions will improve ultimate recovery by 5%," he said.

BP Amoco PLC chose a similar solution for Wytch Farm field in the UK.

The mature field is produced via extended-reach wells, drilled into an offshore reservoir from an onshore drill-site (OGJ, Jan. 19, 1998, p. 24). The wells are artificially lifted via the use of electric submersible pumps (ESPs).

"A way was needed to tap reserves from the eastern extremities of the reservoir to recover two pockets of oil bypassed when an older well had watered out," said Algeroy. BP Amoco chose to drill two new lateral bores from the existing well.

"This option required downhole flow-control capability in each new lateral," he said.

A valve allows or disallows flow between the well and the inside of the tubing string. The device also measures flow with a Venturi flow meter, raising the possibility of using downhole measurements to control flow, says Gould.

"To prolong the life of the new well in case of further water breakthrough, each new borehole was isolated from the other with flow-control devices installed to allow them to flow independently," Algeroy said. "Thus, when water breakthrough occurs in the lower lateral, the flow-control equipment shuts in production from this lateral. The flow-control equipment in the upper lateral is activated, allowing oil production to begin."

BP Amoco expects the application to result in incremental recovery at Wytch Farm of 1 million bbl.

A third potential application of this technology is in what Schlumberger calls the Khuff Autoinject Project at a Middle East offshore field.

"The operator is evaluating how best to maintain production of the depleting oil sand to ultimately increase recovery," said Algeroy. "The traditional approach would be to implement an extremely expensive repressuring project, which would require drilling additional wells and adding more offshore platform space to house gas cleaning, metering, and compression facilities.

"Fortunately," he added, "there is a large, high-pressure gas bed deeper in the field."

The operator is evaluating automatically reinjecting gas into the oil zone without bringing the gas to surface.

"Intelligent completion technology will produce and reinject the gas into

## North Sea (Troll field)

### Problem

Optimize oil recovery from a series of multiple-layered reservoirs containing an active water drive and a gas cap in a subsea development.

### Solution

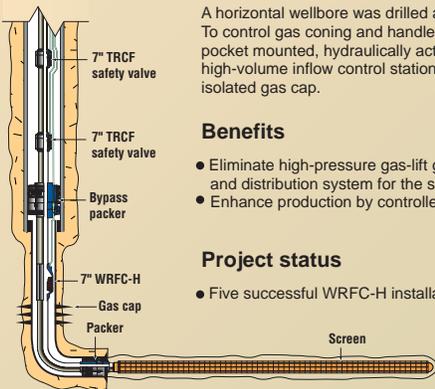
A horizontal wellbore was drilled adjacent to the water table. To control gas coning and handle increasing water cuts, a side pocket mounted, hydraulically actuated, surface-controlled, high-volume inflow control station was installed across the isolated gas cap.

### Benefits

- Eliminate high-pressure gas-lift gathering, compression, and distribution system for the subsea project.
- Enhance production by controlled injection of gas cap gas.

### Project status

- Five successful WRFC-H installations as of June 1999.



## UK (Wyth Farm field)

### Problem

Original extended-reach well watered out.

The original wellbore was drilled through a fault that carried premature water breakthrough. It was considered a possibility that new boreholes could also encounter a fault.

### Solution

Drill to tap additional reserves and increase oil production.

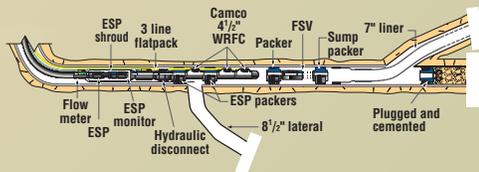
The new multilateral extended-reach well was completed with both wellbores isolated from each other within the production casing string. Flow-control stations were installed below an ESP to allow independent inflow control from both laterals.

### Benefits

- Early water shutoff.
- ESP pump alone retrievable for repair or replacement.
- Selective well test.

### Project status

- Well on production as of March 1999. Three WRFC-Hs installed and operating.



## Middle East (Khuff formation)

### Problem

Declining production from an offshore oil reservoir.

### Recommended solution

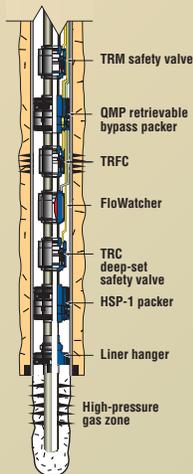
Gas injection into the depleting oil zone from a deeper, higher-pressure, sour gas reservoir within the same wellbore. Fluids are measured and controlled downhole in the common tubing string.

### Benefits

- Reduces number of wells.
- Eliminates high-pressure sour gas platform processing and compression facilities, enhancing platform safety.

### Project status

Under evaluation.



## West Africa

### Problem

Complete a subsea well with two oil zones, both requiring sand control, with simultaneous production through a single wellhead.

### Recommended solution

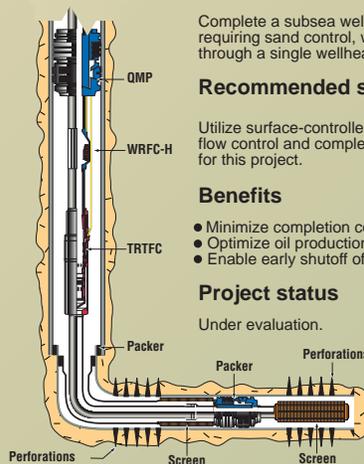
Utilize surface-controlled, hydraulically operated downhole flow control and completion equipment designed specifically for this project.

### Benefits

- Minimize completion costs.
- Optimize oil production.
- Enable early shutoff of unwanted gas or water production.

### Project status

Under evaluation.



Source: Schlumberger

OGJ

the oil reservoir downhole, reducing the number of wells by half and eliminating the additional surface facilities that the traditional approach would require," said Algeroy.

"We are already developing a second-generation device with integral gauging and flow-measurement capabilities," he added. This device will not

only save money but also increase safety, because the hot, high-pressure gas is not brought to the surface.

Could also expects further technological improvements to greatly enhance the capabilities of these intelligent techniques: "In the future, we expect to be able to offer separation of

water from oil downhole and then placement of the water in the aquifer below the oil. This requires another multilateral and more-intelligent valves downhole.

"This elegant solution is yet to be achieved, but it is not far off. The cost savings to the oil company will be huge."

## Related technologies

Other multilateral-related technologies that Schlumberger is introducing include two novel methods of providing integrity at the difficult Y-junctions in multilateral wells. One of these, called RapidSeal, is a multilateral completion and production system for a Technology Advancement for Multilaterals (TAML) Level 6 junction. (For an explanation of TAML classifications, see OGI, Jan. 18, 1999, p. 60.)

In this system, two 7-in. round casing legs are flattened slightly so that they fit into a 9 $\frac{1}{2}$ -in. casing, then heat-treated to maintain structural strength. Hydraulic pistons then re-expand the two inner casings to their original 7-in. diameter.

The RapidSeal junction was developed in conjunction with Agip SPA. It will be tested in the next few weeks and is scheduled to be installed in an onshore well in Italy next April.

The junction is made up to the bottom of the casing and run in the hole. The junction expansion tool is run on standard Schlumberger wireline and controlled from the surface. Once the expansion tool is installed into the junction, instrumentation embedded in it monitors the exact dimensions of the junction as it is opened.

After the junction is opened, the first lateral and the cement in it are drilled out, and the lateral to the reservoir is drilled and completed. After completing the first lateral liner, the second lat-

eral can be similarly drilled and completed.

The well can be produced with separate, independent tubing strings to the surface or with a single, comingled tubing string.

The next step, says Schlumberger, is to incorporate intelligent completions into the well to monitor and control each lateral. In this way, the operator could combine production from the two laterals while monitoring and controlling the contribution from each.

## Future

An important application of these new technologies will be in the deep water, once operators have gained confidence in them, says Gould. But first, they will be proven in onshore and shallow-water applications.

Most of these new technologies were developed one-on-one with the operator, tailored to fit the unique, complex requirements of an individual reservoir. In taking this customized, intelligent-well approach, Schlumberger combines its ability to manage the various hardware options with a thorough understanding of the reservoir through data.

With the opening of its Reservoir Completions Center in Rosharon, Tex., the service firm is increasing its focus on reservoir-driven, custom-solution services. The key to success via this method is early cooperation between

the operator and the service company, says Gould.

He is quick to point out that intelligent solutions are at a relatively early development stage. Well intervention from the surface, once a problem arises, is good, he says, but not good enough: "Ideally, we need to predict the undesirable flow (of water) and tune the completion to avoid it happening (altogether)...If you know how the (water) front is approaching and you have an intelligent completion, you can manipulate production downhole to ensure maximum sweep of the oil."

The new hardware being introduced by Schlumberger would allow this to be done today, says Gould. "The only problem is that we have no easy way to monitor a water front deep into the reservoir."

Schlumberger has such an instrument in the late stages of development, however.

In deep monitoring experiments, said Gould, "We have been able to follow the sweep of water being injected from the well. Its observed progress matches model predictions...."

"The dream of real-time reservoir management is therefore not far away," Gould concluded. "We have all the pieces and are right now assembling them. Downhole sensors will detect flow patterns in the reservoir, and immediate corrective action will be taken in the downhole completions to optimize the sweep of hydrocarbons." ■