

ResFlow ICDs in Horizontal Openhole Wells Optimize Production in Thin Oil-Rim Reservoir

Case study: Use of inflow control devices offshore East Malaysia reduces water cut and eliminates sand production

Challenge

Develop small oil rim in multiple unconsolidated sand layers, balance inflow along horizontal well section, and contain early water and gas breakthrough and uneven depletion profile.

Solution

Install wire-wrapped screens with ResFlow* nozzle-type inflow control devices (ICDs) for optimum sweep.

Results

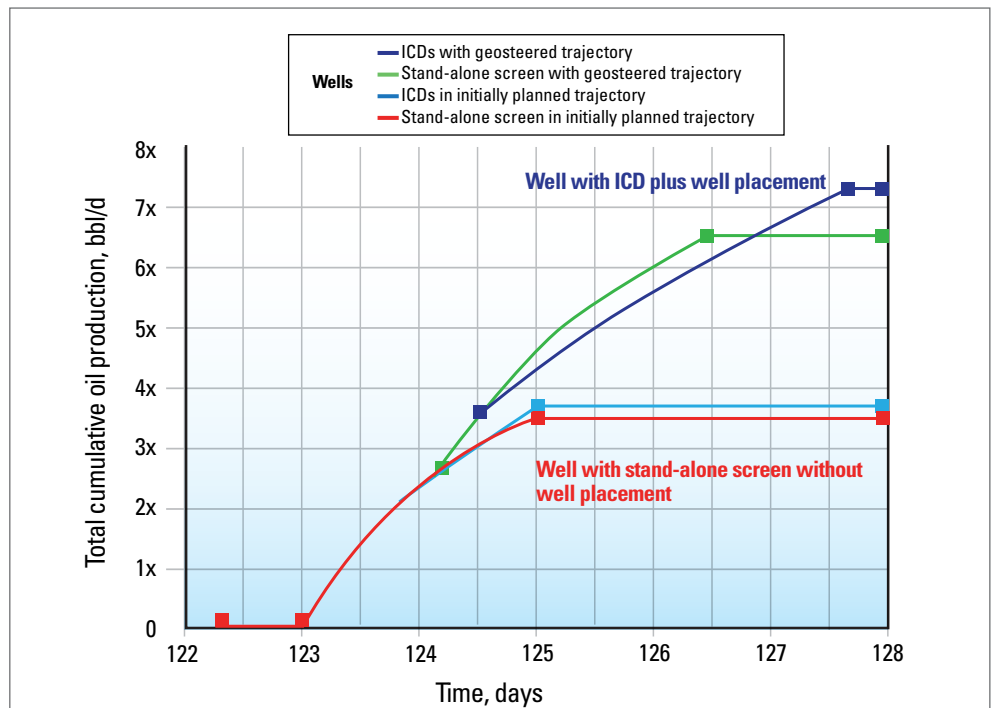
Balanced inflow, reduced and delayed water cut in the reservoir without sand production, and confirmed these results by comparing them with those of horizontal wells in the field completed with stand-alone screens and internal gravel packs.

ResFlow ICDs are part of the Transcend* family of openhole sand management services. Transcend services include screens and injection and inflow control devices, AquaPac* integrated water packing technologies, OptiPac* Alternate Path† gravel-pack systems, and IntelliPac* measurements in real time.

Thin oil-rim reservoir poses challenges

Horizontal wells generally produce more, and more efficiently, than do vertical wells because they have more contact with the reservoir. However, these wells are subject to early water and gas coning toward the heel because of the flow's frictional pressure drops along the horizontal section. Moreover, variations in permeability can result in unbalanced inflow along the horizontal section and accelerate early water and gas breakthrough and uneven inflow downhole. These conditions can limit sweep efficiency and reduce hydrocarbon recovery from horizontal wells, leaving bypassed oil.

An operator in the Baram field offshore east Malaysia planned to develop the thin oil-rim reservoir by controlling the inflow of two horizontal wells to maximize recovery and retard the usually fast-approaching water coning without producing sand. To understand the effect of the ICDs, the operator completed two other horizontal wells, one with a stand-alone wire-wrapped screen and the other with an internal gravel pack; these wells were drilled 4.92-ft [1.5-m] up dip in the same sand zone as the two wells with ICDs.



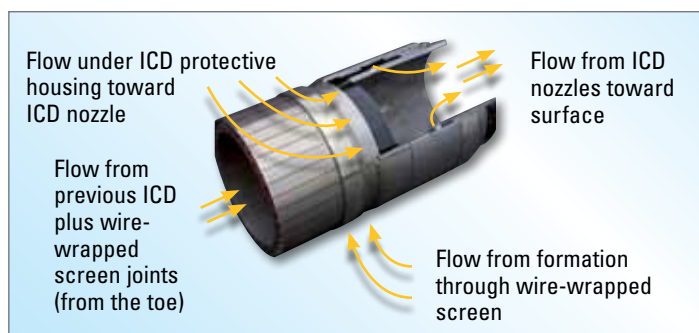
The ECLIPSE* reservoir simulation showed that total cumulative oil production over time for the completion with ResFlow ICDs (blue) was more than double what the initial non-ICD, nonmapped well (red) would have been.

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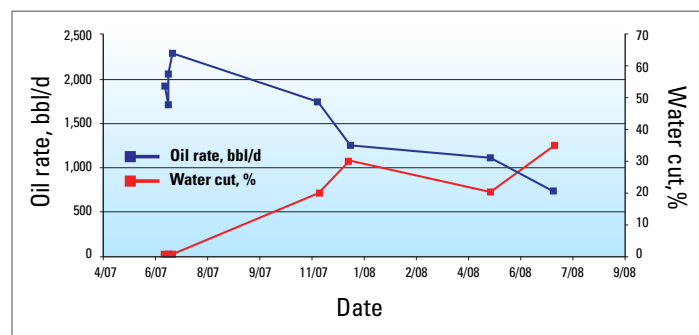
Balanced flow and effective draining

ResFlow ICDs are self-regulating choking devices that have two or more nozzles exposed to fluid inflow. They operate through nozzle restriction based on the Bernoulli pressure-drop effect. Because of the proven track record of the ResFlow nozzle-flow ICD, especially in the Middle East, the operator was aware of the advantages of the nozzle mechanism, which is less sensitive to downhole fluid viscosity changes.

The key advantage of using ResFlow ICDs was that they would balance the flow across the thin oil-rim layer for optimum sweep and effective draining without premature gassing out or watering out of the well. Two additional ICD features assured the operator that the proposed reservoir-centric approach would work: the capability to fine-tune nozzle configuration on the basis of the real-time LWD log from the PeriScope* bed boundary mapper and the ability to swap different nozzle sizes and numbers at the rig site before the completion was run in the hole.



The ResFlow ICD equalizes reservoir inflow along the entire length of the well.



Production profile from a well with ResFlow ICDs: The oil flow (blue) decreased in a typical pattern, whereas the water cut (red) remained at about 30% after the unavoidable water breakthrough.

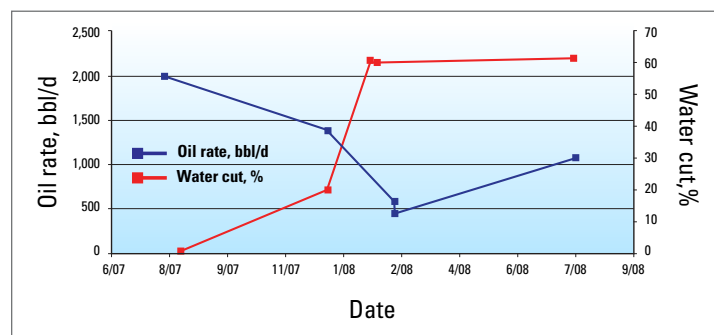
After the job, the results of the ECLIPSE reservoir simulation of the ICD wells, including data from the geosteered trajectory and final ICD configuration, were compared with the projected results of the initial, proposed trajectory of that well. The results showed that the ResFlow ICD well with the precise well placement had a total cumulative oil production that was double that of the initial well without ICDs or precise well placement.

Improved recovery, maximized production

Use of the field-adjustable nozzles for the two completions with ICDs, with precise well placement determined by the PeriScope* bed boundary mapper, enabled the operator to economically develop the small oil-rim layer of hydrocarbon remaining in this mature field and maximize production and the recoverable reserves.

When production started in July 2007, the ResFlow ICD well was producing 100% oil at 2,200 bbl/d. Field production results since then have clearly shown the benefits of installing the ICDs. Water cut has been maintained at about 30%, compared with the water cut of an adjacent well with stand-alone wire-wrapped screens. In that well, the production water cut rose aggressively to 60%, jeopardizing the natural lift in the well.

The sustained lower water-cut production confirmed the effectiveness of the Bernoulli principle on the nozzles' inflow: the higher the velocity of the high-mobile-phase water approaching the nozzles for inflow, the more backpressure was imposed by the nozzles to restrict water influx. As a result, the inflow of oil from low-productivity and low-permeability zones was eased in other sections of the horizontal sections to ensure that designed surface rates were achieved.



Production profile from the adjacent well with stand-alone wire-wrapped screens but no ResFlow ICDs: The oil flow (blue) decreased dramatically, and the water cut (red) was double that of the well with ICDs.

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