Screens and Inflow Control Devices

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Schlumberger takes an engineering-driven, total-system approach to sand control completions that features the tools, fluid chemistries, technologies, software, services, and people needed to extend the life of a completion and to optimize production.

Modeling
We use proprietary modeling tools to understand a reservoir’s tendency to produce sand and the sand’s effects on the completion, including gas/water breakthrough, performance of screens and inflow control devices (ICDs), and cumulative production over a well’s life. Sand Advisor* screen and gravel-pack planning software for screen and gravel selection in openhole applications analyzes formation particle-size distribution and aids in gravel and screen sizing and selection. ICD Advisor* inflow control device planning software, a Petrel* E&P software platform plug-in, calculates critical drawdown pressure to help ensure optimal recovery.

Screen Selection
Screen selection involves a multidisciplinary, integrated approach that combines reservoir engineering, completion design, wellbore preparation, and filtercake removal. Our Sand Advisor software, based on an extensive database of actual particle-size distribution and laboratory results of sand retention tests, aids in gravel and screen sizing and selection. We use this information to optimize screen architecture so that your wells produce economically and at optimal rates.

Manufacturing
We use proprietary manufacturing techniques, precision engineering, and custom-built manufacturing machinery designed, built, and
maintained in-house to produce the most robust line of fit-for-purpose screens in the industry. Highly trained and experienced materials engineers and manufacturing personnel work in strategically placed facilities around the world to meet your immediate needs.

**Quality Control and Assurance**

Schlumberger quality management systems ensure that the efficiency and quality of our facilities and equipment are continually monitored and improved and that the processes meet the highest quality standards. For example, one proprietary manufacturing process uses a unique quality control system that measures and controls the accuracy of each slot produced in a screen. That way, when the screen arrives on onsite, you can be sure it will perform—both when it goes into the hole and when the well is producing.

The ResGauge slot-opening measurement system is a photo metric quality control device for direct-wrapped sand screens and measures every slot opening on a screen joint.
Sand Screen Portfolio

**Direct Wire-Wrapped Screens**
LineSlot* premium direct-wire-wrapped screens are made with a wire jacket shrink-wrapped directly to the basepipe. Screen components are welded to each other, but there is no welding between the screen and the basepipe, enabling the screen and basepipe to act as a single unit and ensuring that the tension, compression, and torque ratings of the screen are nearly the same as those of the basepipe. Basepipe perforations are designed to optimize flow while retaining strength.

**Premium Sintered Mesh Screens**
MeshSlot* premium sintered mesh screens have a single layer or multiple layers of woven wire mesh, sometimes sintered, forming a resilient filter and providing weld integrity and mechanical stability. Mesh screens maintain their strength during installation without altering the filter pore openings. With a unique construction, drainage layers, and an optimized number of basepipe perforations, these screens evenly distribute flow across the full area of mesh and reduce the risk of plugging at the screen face.

**Wire-Wrapped Screens**
WeldSlot* slip-on wire-wrapped screens are made of a wire-wrapped outer jacket manufactured separately from the basepipe. The jacket is fitted over the perforated basepipe and welded to the pipe at each end to provide structural support for high mechanical loads. These screens provide more open flow area than slotted liners, increasing flow and productivity.

**Prepacked Screens**
WeldSlot PP* slip-on wire-wrapped prepacked screens provide a cost-effective sand control alternative with added erosion protection when conventional gravel packing is not feasible or economical. The screen is built with a layer of resin-coated, consolidated gravel placed around it, contained by a second screen or outer shroud.
Alternate Path Sand Screens
Screens with Alternate Path\(^\dagger\) shunt tubes and nozzles bypass bridges and fill in voids that can occur during gravel and frac packing.
- **AllPAC\(^\dagger\)** Alternate Path cased hole gravel-pack screen
- **AllFRAC\(^\dagger\)** Alternate Path cased hole frac-pack screen
- **OptiPac\(^*\)** Alternate Path openhole gravel-pack screen
- **UltiPac\(^\dagger\)** Alternate Path extended-reach gravel-pack screen

Specialty Screens
Schlumberger specialty screens address emerging unconventional sand control applications, where conventional gravel packs or screens or both are insufficient, such as heavy oil applications in thermal or nonthermal environments. These screens meet rigid quality control standards to ensure maximum screen strength, erosion resistance, and sand retention.
- **MeshRite\(^\text{TM}\)** stainless-steel wool screen
- **FacsRite\(^\text{TM}\)** premium mesh disc screen
- **IntelliPac\(^*\)** fiber-optic-compatible screen

Inflow Control Devices
Inflow and injection control devices (ICDs) balance flow rates across the completion for the entire length of the interval. They dramatically reduce the effect of water and gas breakthrough and optimize injection rates across the full wellbore face.
- **ResFlow\(^*\)** inflow control device
- **ResInject\(^*\)** injection control device
Complete your Completion

COLOSSUS
Liner hanger systems

QUANTUM
Gravel-pack packer

FORTRESS
Premium isolation valve

RapidX
TAML 5 high-strength, sealing multilateral junction

ResPack
Swellable bonded-to-pipe packer

ResFlow
Inflow control device
A sand control solution needs to do more than control sand; it needs to be an integral part of the completion design from the outset and take into account the customer’s goals, constraints, and plan for the life of the well. Schlumberger Sand Management Services is supported by a rich history of technical domain expertise that informs every decision made and helps ensure the chosen solution is a success.
Case Studies

Deep water and shallow reservoir require innovative completion approach
An operator planned to produce undeveloped deepwater oil reserves near an existing deepwater platform offshore Indonesia. The deepwater environment (3,000 ft) and shallow reservoir depth of approximately 3,000 ft TVD below mudline required a wellbore trajectory with kickoff points very near the mudline. This environment was especially tough because of highly variable permeabilities and low pore pressures along the lateral.

Combined technologies meet requirements of ERD well
After considering various completion approaches, the Schlumberger team, in collaboration with the operator, settled on a strategy that included ICDs, swellable packers, stand-alone screens, and formation isolation valves. The final design had to accommodate the ERD wellbores and address the permeability and pressure conditions, fines and plugging potential, and possible screen damage from erosion and hot-spotting.

Screen filter minimizes plugging and optimizes gravel pack geometry
Stand-alone Endure* premium sintered mesh screens were selected as the optimal filter medium to minimize plugging. These screens are among the strongest premium mesh screens available with a small outer diameter. Inner and outer drainage layers help ensure uniform flow over the surface area of the filter medium and enable operators to optimize the completion geometry.

ICDs promote balanced inflow and protect screens
Geomodeling had shown significant permeability variations along the lateral, indicating that segregation of the segments was required. ResFlow ICDs were used to promote uniform distribution of inflow and heel-to-toe production, prevent fines transport...
Swellable packers compartmentalize variable flow regions along lateral

Openhole oil-swellable packers were spaced at every screen length to provide compartments of approximately 38 ft, depending on the permeability variations along the lateral. The packer’s elastomer swelled on contact with the oil and sealed the annulus around the screen, with differential sealing pressures from 1,000 to 1,600 psi, much higher than the 400 psi that was considered the minimal acceptable sealing pressure.

MFIV valve isolates upper and lower completions and prevents fluid loss

The MFIV* mechanically controlled isolation valve was run below the production packer and above the screens to allow the completion to be isolated while a tieback liner and the upper completion were installed. This isolation prevented completion fluid loss into the open hole and later, reduced fluid loss to the formation.

ERD completion succeeds where other completion types did not

Despite the inherent complexities, the ERD well produced at or above expectations with minimal solids production. Moreover, because of the extensive preparation and collaboration of the multidisciplined, cross-functional teams, the well came in ahead of schedule, under budget, and without incident.
**Introduction of ResFlow ICDs Transitions Wells from 100% Water Production to 70% Oil Production**

**Operator seeks better method of sand control**
A major operator offshore Nigeria planned to complete 16 openhole wells in an unconsolidated low-pressure sandstone formation. The formation contained compartmentalized heavy and viscous oil with variable fluid contact. Extended-reach wells were being used to access and drain the reserves. Lateral variations in permeability tended to create unbalanced inflow along the lateral, resulting in premature breakthrough of unwanted fluids. The operator needed to eliminate the problems that had interfered with production in wells completed in a previous drilling campaign in the same field. Those wells had used only stand-alone wire-wrapped sand screens, which had been unable to regulate flow, resulting in total water production.

**ResFlow ICDs succeeded where stand-alone screens could not**
To mitigate these problems, the operator chose the ResFlow ICD. ICDs are self-regulating nozzles that help balance flow across the reservoir. The nozzle configuration, including size and quantity, is designed prejob and can be adjusted at the rig site before a completion is run.

**ICDs regulated flow and prevented wells from watering out**
The initial well was completed with 93 ICDs distributed evenly along the horizontal section. When the well began producing, production logging test results showed that inflow was distributed uniformly from heel to toe, a length of almost 4,000 feet [1,219 m], and water breakthrough was greatly reduced compared with wells from the previous campaign.
This meant that the ICDs were performing as designed—improving sweep along the lateral, deferring the onset of water and gas breakthrough, and preventing the well from watering out at any single point. The oil was able to flow freely over the entire length of the lateral. As a result of this success, the operator elected to install ResFlow ICDs in the remaining 15 wells.

A production logging test conducted on the well with stand-alone screen showed water breakthrough near the toe. The oil and water flowed uniformly across the lateral until within 1,000 feet of the heel. There, the water cut increased dramatically, causing the well to prematurely water out.

A production logging test of the ICD well showed that water and gas breakthrough were clearly being managed. Oil flowed freely over the entire length of the horizontal section, almost 4,000 feet [1,219 m].
Innovative Completion Design and Job Execution Result in 100% Gravel Pack in 136° Fishhook Well

**Fishhook trajectory poses specific challenges for sand control completion**

An operator was developing a field along the coastline offshore southeast Asia. Targeting this marginal oil required drilling into multiple hydrocarbon prospects with stacked shale and water zones. Drilling the wells from offshore was deemed uneconomical. Accessing the oil from land wells that tied into existing onshore infrastructure would be more efficient and allow immediate production.

The company planned an openhole “fishhook” well with an upward trajectory of up to 136°. The openhole interval was to be more than 700 meters long and have six zones. Gravel packing had to be accomplished at the steep angle without exceeding the fracture pressure. The upward trajectory would make it difficult to keep the proppant from sliding and bridging in the wellbore, which would prevent a full annular pack.

**Innovative gravel-pack design minimizes friction pressure, ensures full gravel pack**

To mitigate the bridging and promote heel-toe packing, Schlumberger recommended an innovative gravel-packing system that would minimize friction pressure during the operation and help ensure a full annular gravel pack in the challenging environment.

A screen completion string, designed to accommodate six zones, included five oil-swellable packers to isolate the zones in the openhole interval. A sixth oil-swellable packer was placed inside the casing above the top of the screen to provide a bottom for the pack and to encourage heel-toe packing from inside the casing shoe. These fast-acting swellable packers were soaked in a diesel oil that allowed the elastomer to swell against the openhole rock before the zones were gravel packed, isolating the zones and preventing the pack from sliding downhill during gravel packing.
Pressure-activated diverter valves incorporated into the internal service string were evenly spaced along the openhole section to minimize the circulating pressure exerted on the formation during the packing operation. These valves short-circuited the washpipe at various locations, shortening the length of the washpipe through which the returning gravel-pack carrier fluid returned.

The system included the OptiPac screen, which has shunt tubes to prevent bridging. The shunts diverted slurry accumulations into the zones between the packers until the annulus was fully packed. Transport and packing tubes delivered slurry to the area between the screens and the wellbore. This design reduced slurry dehydration inside the shunts, eliminating the risk of bridging into the tubes and extending the potential length of the gravel-pack interval.

The Hornet* skid-mounted gravel-pack blender was used to optimize delivery. The ClearPAC* polymer-free gravel-pack fluid was chosen as the optimum gravel carrier fluid because of its capabilities to reduce friction and suspend the gravel at low shear rates. The viscoelastic gel also helped control leakoff through the nozzles of the packing tubes.

The antiswab washdown service tool stabilized the hydrostatic pressure in the open hole, eliminating the swabbing effects of hardware movement and ensuring filtercake integrity before gravel placement. After the excess gravel was screened out and reversed, the service tool allowed spotting of filtercake removal treatments, eliminating a dedicated cleanup run.

**Completion design and job execution ensure 100% gravel pack**

The combination of technologies resulted in a 100% gravel pack below the fracture pressure of the well. Accessing the well from an onshore location enabled the operator to reduce the costs and risks related to offshore operations. As a result of this success, 10 additional fishhook wells, both injectors and producers, were completed along the shore. This new completion design provides an alternative method for gravel packing fishhook wells with narrow frac/pore-pressure windows and to develop hydrocarbon prospects in shallow waters from onshore drilling locations.
Running washpipe is impractical in extended-reach, highly deviated wells
An operator needed to drill several wells in an oil field offshore Norway. This field is characterized by variations in permeability, with several shale zones interbedded between formation sand.

The operator planned to drill a long, horizontal well with a measured depth of 14,682 ft [4,475 m] and a total vertical depth of 6,476 ft [1,974 m]. The well would have a 90° deviation and an openhole span of 4,921 ft [1,500 m]. Because of the field’s geology, wells in this field had previously been completed with stand-alone screens and ResFlow ICDs that use nozzles to regulate flow along the length of the reservoir. These ICDs are typically run with washpipe (the inner string) to permit washdown operations while the screens are being run inhole. Washpipe also permits the placement of filtercake breaker along the entire openhole section after the screen reaches TD.

However, washpipe rental and rig time to run it in and pull it out increase costs, and the process complicates logistics and creates safety risks. Moreover, in wells as long as the one planned, the heavy washpipe tests the tensile limits of the service tool and makes it difficult to run the screens to TD.

New ResFlow CV ICD assembly eliminates need for washpipe
To reduce the costs and risks, Schlumberger recommended the use of the new ResFlow CV* check-valve ICD, which incorporates a check valve and does not require washpipe. The check valve assembly includes a ceramic nozzle, a ceramic or aluminum ball, and an aluminum plate. It replaces the standard ResFlow ICD nozzle assembly in the ICD housing. Standard ICD nozzles can be easily swapped out in the field with the check valves before the ICDs are run.

When this ICD is run inhole, the pressure of
the fluid being pumped down the completion string causes the ball to seal the check valve assembly. Fluid is thus prevented from leaking into the annulus through the nozzle and must travel the length of the completion string to the toe before returning up the annulus.

The ball and plate are removed from the wellbore with a standard fluid displacement process such as a filtercake breaker system. At that point, the ResFlow CV ICD works like the standard ResFlow ICD nozzle, helping balance inflow across the completion.

**Operator trims 24 hours and saves USD 800,000**

The well was successfully completed with zero NPT related to Schlumberger services or products. Because of the lighter weight of the assembly string, the completion was run without difficulty to TD. Eliminating the washpipe rental expenses and rig- and service-related costs saved the operator 24 hours and approximately USD 800,000.

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*During washdown*

*When fluid is being pumped downhole, fluid pressure causes the ball to seal the ResFlow CV ICD assembly, preventing fluid loss through the nozzle. This check valve function is eliminated before production starts.*

*During production*

*When the ball is removed, the hydrocarbons can flow from outside the annulus through the screen filter into the ICD housing and then into the basepipe through the nozzle.*
Schlumberger screens and ICDs are specially designed to provide the optimal interface between the reservoir and the wellbore.