Screens and Inflow Control Technology

Why Halliburton Screens?


Whatever your challenge, Halliburton experts stand ready with solutions using the most effective, reliable, value-added sand control screens and inflow control technology in the business—with unequalled customer collaboration every step of the way. Today’s sand control needs are far reaching and diverse. Every reservoir has a unique set of attributes and problems that demand a customized sand control solution to maximize productivity and the life of the well. Halliburton prides itself on the ability to solve these problems and provide a reliable solution for any scenario. Halliburton is committed to setting the standards for well screen and inflow control technology design and manufacturing.

Manufacturing and Technology Centers

Carrollton Technology Center
The experience and knowledge of our people, coupled with a commitment to technological innovation, allows Halliburton to deliver technically superior, value-added products and services to our customers. The Carrollton Technology Center in Carrollton, Texas houses state-of-the-art testing and design facilities. This center has developed a steady stream of innovative oil industry products receiving numerous engineering innovation awards. The engineering test facilities provide engineering analysis and support, high-temperature/high-pressure testing, and tool prequalification to API and ISO requirements. The facility also features two working test wells with rig accessories which allow Halliburton to simulate actual well environments before running new tools in a customer’s well.

Singapore Technology and Manufacturing Center
To mirror the state-of-the-art testing and design facilities in the eastern hemisphere, Halliburton opened the Completion Technology and Manufacturing Center in Singapore. This facility includes an administration building, technology workshops, high-pressure/high-temperature testing capabilities, deep well simulators, and an 8,750-ft (2667-m) test well with a horizontal section and rig, enabling system integration testing products and services in simulated well conditions.

Lafayette Manufacturing Center
Located in Lafayette, Louisiana, the 200,000 ft² (18 581 m²) Lafayette Manufacturing Center includes 173,000 ft² (16 072 m²) of manufacturing shop floor space and onsite technology capacity. In addition to the manufacturing shop floor built for long parts, the facility includes a metallurgical lab capable of performing physical property tests on incoming raw materials and sample rubber. This state-of-the-art plant features an efficient shop-floor layout, new machines, and streamlined processes, allowing for maximum productivity. The facility’s cutting-edge technology and equipment for screen production includes hydraulic stress-relief racks and machines that help improve the screen jacket assembly process.

Malaysia Manufacturing and Technology Center
The Malaysia Manufacturing and Technology Center manufactures an extensive range of products, including swell and screens technology. The more than 300,000 ft² (27 871 m²) facility includes a manufacturing plant, a bulk plant, and an administration building. This site also offers technology capabilities, including high-pressure and physical property tests on location. Halliburton’s Malaysia Manufacturing and Technology Center plays a key role in meeting the growing needs of customers in the Eastern Hemisphere and globally.

Malaysia Manufacturing and Technology Center
Mesh Screens

PetroGuard® Mesh DS Screen

For sand control applications where a more efficient filtration media is required, the PetroGuard® Mesh DS (Dual Shroud) screen provides effective solids filtration in a shrouded, non-bonded mesh screen.

Woven mesh often provides better performance than a wire-wrapped screen in unconsolidated formations. This is especially true when it comes to filtering a high percentage of fines and in formations with more poorly sorted sands. The unique construction of the PetroGuard Mesh DS screen optimizes inflow area and filtration efficiency to provide superior sand control completion performance.

The screen consists of a perforated basepipe and a non-bonded mesh filter cartridge. The perforated outer shroud protects the mesh filter during deployment, while the dimples in the shroud lend stability to the mesh and ensure the filter layer remains overlapped, maintaining sand control integrity and reducing potential failure due to erosion.

The PetroGuard Mesh DS screen can be used as a standalone system or in conjunction with gravel or frac pack applications, providing a reliable barrier against production of formation sands. When used in conjunction with other technologies, such as EquiFlow® inflow control technology and zonal isolation tools, the PetroGuard Mesh DS screen is the heart of a total sand control solution.

Features
- Multiple filter cloth options (square, plain dutch, reverse dutch twill, etc.)
- Dimpled inner and outer shroud
- Crimped end rings
- Multiple drainage layer designs

Benefits
- Optimizes inflow performance, mesh layer support, and inflow efficiency
- Eliminates crossflow of solids at end of filter cartridge and provides superior cartridge attachment
- Compatible with inflow control devices, sliding sleeves, and provides control-line/fiber-optic deployment
- Improved flow efficiency into basepipe
## PetroGuard® Mesh DS Screen

<table>
<thead>
<tr>
<th>Basepipe OD</th>
<th>Basepipe Holes per ft</th>
<th>Basepipe Hole Size</th>
<th>Open Area of Basepipe Holes</th>
<th>Filter Jacket</th>
<th>Screen Radial Open Area**</th>
</tr>
</thead>
<tbody>
<tr>
<td>in.</td>
<td>mm</td>
<td>qty</td>
<td>in.²/ft cm²/m</td>
<td>in. mm</td>
<td>lb/ft kg/m</td>
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*Jackets are offered in 5, 10, 16, and 20-ft lengths.
**Based upon shroud/drainage layer not including filter mesh. For mesh screen data, contact your local Halliburton representative.
PetroGuard® Advanced Mesh Screen

PetroGuard® Advanced Mesh Screen brings superior filtration technology to the upstream oil and gas industry. Its multi-layered construction is designed to provide the highest solids retention and plugging resistance possible.

Conceived for fines-prone heavy oil reservoirs, development testing confirmed this breakthrough in oilfield filtration technology is ideal for a wide range of sand control applications. In fact, the more poorly sorted the sand, the better the relative performance of the PetroGuard advanced mesh screen when compared with wire-wrap and metal mesh screen products.

The PetroGuard advanced mesh screen is formed from a series of surface filter layers. This means precise pore size control and no tortuous flow paths, making it possible to backflush to clean the screen.

Features
- Custom designed for each project
- Multiple graduated filtration layers
- No tortuous flow path
- Precise pore size control

Benefits
- Optimized filtration for each field
- Higher solids retention
- Improved plugging resistance
- Improved inflow efficiency and backflushing capability
- Reduced need for pumped sand control solution

This technology allows the use of bare screen sand control techniques in completions where typically a pumped sand control solution was required due to poor grain size uniformity. Using graduated filtration layers, the PetroGuard advanced mesh screen filters progressively smaller particles from the production stream as flow moves toward the basepipe, allowing the valuable final filtration layer to be challenged by fewer solid particles.

Each screen is designed specifically for a project’s unique sand sample. The result is a custom-designed sand screen—a significant improvement over traditional screen sizing methods.
# PetroGuard® Advanced Mesh Screen

<table>
<thead>
<tr>
<th>Basepipe OD</th>
<th>Basepipe Holes per ft</th>
<th>Basepipe Hole Size</th>
<th>Open Area of Basepipe Holes</th>
<th>Filter Jacket</th>
<th>Screen Radial Open Area**</th>
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<td>Maximum Assembly OD</td>
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<td>qty in.</td>
<td>mm</td>
<td>in.²/ft</td>
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<td>9.53</td>
<td>16.6</td>
</tr>
</tbody>
</table>

*Jackets are offered in lengths of 54 in., 102 in., 150 in., and 198 in.

**Based upon shroud not including filter mesh. For mesh screen data, contact your local Halliburton representative.
**PoroMax® Screen**

Combining the global sand control experience of Halliburton with the recognized filtration technology of Purolator Facet, Inc., the PoroMax® screen is a premium shrouded, diffusion-bonded laminate screen product engineered for optimum inflow area. Diffusion bonding not only provides precise pore size control in all load conditions but also provides superior solids filtration and toughness. This makes the PoroMax screen suitable for installations with an extended reach and/or long open hole and for installation through a casing window (such as for multilateral completions) with or without centralization. With improved dirt-holding capacity and pressure drop performance due to its optimized inflow design, PoroMax screens are also suitable for high-flow applications.

*PoroMax is a registered trademark of Purolator Facet, Inc.*
## PoroMax® Screen

<table>
<thead>
<tr>
<th>Basepipe OD</th>
<th>Basepipe Holes per ft</th>
<th>Basepipe Hole Size</th>
<th>Open Area of Basepipe Holes</th>
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<tr>
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<td>4.6</td>
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<td>66</td>
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<td>3/8</td>
<td>9.53</td>
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</tr>
<tr>
<td>4.0</td>
<td>101.60</td>
<td>90</td>
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<td>9.53</td>
<td>9.9</td>
</tr>
<tr>
<td>4.5</td>
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<td>3/8</td>
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<td>127.00</td>
<td>114</td>
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</table>

*Jackets are offered in 55.5-in. to 222-in. lengths.

**Based upon shroud not including filter mesh. For mesh screen data, contact your local Halliburton representative.
Wire-Wrap Screens

Direct-Wrap Screens
Direct-wrap screens, often referred to as wrap-on-pipe, are wire-wrap-type screens featuring a filtration layer made up of shaped wires wrapped over and welded to support or rib wires. The resulting filter uses an interference fit created by wrapping directly onto the basepipe, enhanced by cooling and shrinking of the wire after welding, to create a remarkably strong attachment.

PetroGuard® Wrap Screen
Bringing together the latest machine technology and an optimized wire design results in a screen product with best-in-class performance—the PetroGuard® Wrap Screen. Its wrap-on-pipe design features wire wrapped directly onto the basepipe. Longitudinal ribs support the wrap wire and function as a drainage layer, ensuring an open flow path to the basepipe perforations. Wire is tightly wrapped around the basepipe with additional strength achieved when the wire is welded to the ribs and the cooling process shrinks the wire around the pipe. Basepipe perforations are designed to optimize flow while retaining strength.

Keystone-shaped wire helps reduce the risk of screen plugging associated with particles becoming lodged between wires, providing self-cleaning action and a great reduction in flow friction. The resulting screen provides a robust solids filter for use in both cased and openhole environments.

The PetroGuard wrap screen can be used as a standalone system or in conjunction with gravel or frac pack applications, providing a reliable barrier against production of formation sands. When used in conjunction with other technologies, such as EquiFlow® inflow control technology and zonal isolation tools, the PetroGuard Wrap screen forms part of a total sand control solution.

Features
- Available in basepipe sizes ranging from 2 7/8 to 7 in.
- Monitored wire wrapping process
- Optical slot verification
- Wrap wire welded to ribs at every contact point

Benefits
- Consistent gauge for reliable sand control
- Increased strength allows “working” of completion in the hole
### PetroGuard® Wrap Screen

<table>
<thead>
<tr>
<th>Basepipe OD</th>
<th>Basepipe Holes per ft</th>
<th>Basepipe Hole Size</th>
<th>Open Area of Basepipe Holes</th>
<th>Number of Ribs</th>
<th>Filter Jacket</th>
<th>Screen Radial Open Area**</th>
</tr>
</thead>
<tbody>
<tr>
<td>in.</td>
<td>mm</td>
<td>qty.</td>
<td>in.</td>
<td>mm</td>
<td>in.²/ft</td>
<td>cm²/m</td>
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<tr>
<td>2.38</td>
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<td>N/A</td>
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</table>

*Jackets are offered in lengths up to 432 in.

**Based upon 12 gauge screen
PetroGuard® Wrap Screen Gauge Measurement

The PetroGuard® Wrap screen gauge measurement uses state-of-the-art equipment designed to measure a full length of screen on every joint of screen produced. All slots on at least one plane between two ribs are measured to ensure screen gauge is within specified tolerances. The optical measuring system has been calibrated with National Institute of Standards and Technology (NIST) traceable standards and is accurate to 2.5 \( \mu \)m. The camera and manufacturing processes have been optimized to produce highly accurate, repeatable gauging results to 5 \( \mu \)m. All gauge data is traceable to each serialized screen joint and is summarized in a custom formatted output file for quick reference.

Halliburton Wire-Wrap Screen Wire Profiles

![Wire-Wrap Screen Wire Profiles](image-url)
Slip-On Screens

The wire-wrap filter component of slip-on wire wrap screens is fabricated in a separate step before being slipped over the basepipe and attached. This construction style allows low cost and flexibility in manufacturing schedules and locations, while still allowing high gauge accuracy and reliability. The Halliburton All-Weld screen uses this same construction style and has been a high-quality screen product manufactured continuously for more than 40 years. Halliburton prepacked screens also use this construction for one or more of the wire-wrap filter components.

All-Weld (Slip-On) Wire-Wrap Screens

The Halliburton All-Weld wire-wrap screen is field proven with years of reliable oilfield service. The keystone-shaped wire decreases screen plugging associated with particulates lodging between wires. The wire wrap is manufactured separately from the basepipe, and the wire wrapped jacket is then placed over the perforated basepipe and welded to the basepipe at either end.

All-Weld Wire-Wrap Screen

<table>
<thead>
<tr>
<th>Basepipe OD</th>
<th>Basepipe Holes per ft</th>
<th>Basepipe Hole Size</th>
<th>Open Area of Basepipe Holes</th>
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</tr>
</thead>
<tbody>
<tr>
<td>in.</td>
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<td>qty in. mm</td>
<td>in.²/ft cm²/m</td>
<td>qty in. mm</td>
<td>lb/ft kg/m</td>
<td>in.²/ft cm²/m</td>
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</tr>
</tbody>
</table>

*Jackets are offered in lengths up to 228 in.
**Based upon 12 gauge screen
Inflow Control Technology

EquiFlow® inflow control technology has been designed to improve completion efficiency and longevity by balancing inflow throughout the length of a horizontal completion. Differences in influx from the reservoir can result in premature water/gas breakthrough, leaving valuable reserves in the ground. Typical applications include wells experiencing “heel-toe effects,” breakthrough of water/gas, permeability differences, and water challenges in high viscosity reservoirs. By using EquiFlow inflow control technology, the reservoir inflow from low productivity zones is, in effect, stimulated to increase completion efficiency.

The Halliburton EquiFlow product family increases completion efficiency and well longevity as well as ultimate recovery from the well by delaying breakthrough of unwanted fluid.

The EquiFlow family consists of two main products—passive and autonomous inflow control devices.

EquiFlow® Inflow Control Device

Standard passive inflow control devices (ICD) are chokes installed in the completion string which create a pressure drop along the interval length. Differences in influx from the reservoir can result in premature water/gas breakthrough, leaving valuable reserves in the ground. EquiFlow® inflow control devices are designed to improve completion performance and efficiency by balancing inflow throughout the length of a completion. The desired placement locations of ICDs are typically determined in the project design phase.

The EquiFlow ICD consists of an annular chamber on a standard oilfield tubular. If a screen is required, the reservoir fluid is produced from the formation, through the sand screen, and into the flow chamber. The flow continues through a set of chokes, which create the pressure drop, and then into the pipe through a set of ports. The number of chokes and their ID are configured to deliver the pressure drop needed for optimum completion efficiency based on wellbore modeling.

Slotted/Pre-Drilled Liner Standalone Screen
Uneven production – early water/gas breakthrough likely, oil production declined

Passive EquiFlow® Inflow Control Device
Balanced influx – delayed water/gas breakthrough, oil production limited

EquiFlow® Autonomous Inflow Control Device
Balanced influx – breakthrough delayed and restricted, oil production stimulated
**EquiFlow Adjustable Inflow Control Devices**

Today’s reservoir challenges call for optimum completion solutions, and because no two reservoirs are alike, having multiple options can be of significant benefit. EquiFlow Adjustable ICDs can be reconfigured, if required, after the equipment has left the manufacturing facility. For applications where design flexibility is needed, this adjustable ICD allows the operator to change settings closer to the time of installation.

The EquiFlow Adjustable ICD helps improve logistics and reduce delivery time because it can be stocked knowing the wide range of configurations will meet most well requirements. This allows for determination of the final ICD profile later in the project, such as when the operator receives updated well data from measurement and logging operations. With this reconfiguration capability, backup devices can be used in other applications or projects.

The EquiFlow Adjustable ICD features external access to the chokes. The flow profile is changed by closing or opening a pre-determined set of chokes. This operation is carried out at the surface and can be completed before shipment to the rig or on location.

**Features**
- Externally adjustable
- No elastomers, all welded construction
- No orientation required
- Built as part of the completion string
- Simple construction
- Robust design
- No moving parts
- Can be used for both producers and injectors

**Benefits**
- Allows for last-minute changes to the configuration
- No potential leak paths
- Minimizes plugging risk
- Can decide on final flow profile configuration later in the project
- Can be re-configured to fit other applications or projects

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**EquiFlow® Adjustable Inflow Control Devices**

<table>
<thead>
<tr>
<th>Basepipe OD</th>
<th>EquiFlow Inflow Control Device OD</th>
<th>PetroGuard® Wrap Screen OD</th>
<th>PetroGuard® Mesh DS Screen OD</th>
<th>Inflow Control Device Length</th>
<th>Standard Metallurgy</th>
<th>Standard Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>in.</td>
<td>in.</td>
<td>in.</td>
<td>in.</td>
<td>in.</td>
<td>Material</td>
<td>°F</td>
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<tr>
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<td>325</td>
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<td>7.825</td>
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<td>325</td>
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</table>
Horizontal wellbores are often favored by operators for exploiting narrow, oil-bearing formations to maximize contact with the payzone. However, when production causes unwanted water/gas to migrate to the wellbore or uneven production distribution results due to pressure drop in the tubing, operators turn to the Halliburton EquiFlow® autonomous inflow control device (AICD). The EquiFlow AICD will not only delay breakthrough of unwanted fluids but also upon breakthrough, restricts zones with high water and gas flow.

The EquiFlow AICD uses innovative dynamic fluid technology to differentiate between fluids flowing through the device to maximize oil production. The EquiFlow AICD works like a passive ICD during oil production, balancing inflow, yet restricts the production of water and gas at breakthrough to minimize water and gas cuts dramatically. It uses no moving parts, does not require downhole orientation, and uses the dynamic properties of the fluid to direct flow. This technology employs an engineered system of flow paths and channels to control fluid flow.

Oil, which has high viscosity, has a short, direct path through the EquiFlow AICD which results in a low pressure differential and high total flow rate. Water and gas, which have a low viscosity, spin at a high velocity, wasting energy which results in a high pressure differential and low total flow rate. Viscosity is the primary property to distinguish fluids, although density and rate can also have an impact. EquiFlow AICDs work as a system in a well, first delaying water/gas breakthrough, and when a breakthrough does occur, the local EquiFlow AICD creates a greater restriction allowing other zones to continue high oil production, maximizing recovery and value for an operator.

<table>
<thead>
<tr>
<th>Description</th>
<th>Oil Range</th>
<th>Fluid Restriction</th>
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<tbody>
<tr>
<td>Range 1</td>
<td>0.6-1.5cP</td>
<td>Gas only</td>
</tr>
<tr>
<td>Range 2</td>
<td>1.5-10cP</td>
<td>Gas and Water*</td>
</tr>
<tr>
<td>Range 3</td>
<td>3-200cP</td>
<td>Gas and Water</td>
</tr>
<tr>
<td>Range 4</td>
<td>150+cP</td>
<td>Gas and Water</td>
</tr>
</tbody>
</table>

*Water restriction for temperatures at or above 150°F (65°C).

**Features**
- Operates autonomously
- Contains no moving parts, electronics, or connections to the surface
- Requires no intervention
- Requires no downhole orientation
- Will cease flow restriction if unwanted fluid recedes
- Designs available to produce oil and restrict either water or gas
- Uses innovative dynamic fluid technology to direct flow
- Functions as a standard ICD prior to water/gas breakthrough
- Each device functions independently for precise response to the reservoir

**Benefits**
- Maximizes ultimate recovery
- Increases reliability through design simplicity
- Minimizes undesired fluid production, helping reduce associated cost and risk
- Delays onset of unwanted water/gas production
Application and Installation

Both the standard EquiFlow® inflow control device (ICD) and EquiFlow® autonomous inflow control device (AICD) are installed as part of the completion string and require proper configuration for optimal functionality. This requires close collaboration between Halliburton and the operator to determine the well parameters affecting the completion. Once these criteria are known, Halliburton uses a combination of near-wellbore and full field reservoir simulations to arrive at the most effective completion arrangement. This determines the ideal number of compartments to be created, number of devices per compartment, and the proper pressure.

Note: The performance curves shown are for a three-insert range 3A EquiFlow® autonomous inflow control device. For flow performance specific to your application, contact your local Halliburton Screens representative.
Simulation Software for EquiFlow® ICD Completions

Simulation and modeling is critical to design optimized completions, which leads to greater value delivered by the well, using EquiFlow® inflow control devices (ICD) for injection and/or production. Halliburton has a unique software suite including NETool™ nodal analysis software and QuikLook® service to quantify the benefits and allow near-wellbore and long-term (transient) analysis of an EquiFlow completion.

NETool™ Simulation Software
NETool software is a steady-state, network-based simulator for quick calculation of multiphase fluid flow through a well completion and near-wellbore region. The software allows the user to study how production is affected by changes in well placement, length, and equipment selection.

EquiFlow ICD completions can be set up in NETool software to simulate designs varying inflow parameters such as water cut, permeability, skin models, etc. Using NETool software, numerous scenarios can be run quickly in order to compare results and optimize the completion.

QuikLook® Simulation Software
The QuikLook reservoir simulation tool studies the long-term effects (transient analysis) of an EquiFlow ICD completion on the reservoir. QuikLook simulation software is exceptionally versatile and easy to run with powerful visualization and output report capabilities. Data can be imported from other simulators if needed. It is also possible to switch between sanding prediction and geomechanical models. Designed with the practicing engineer in mind, QuikLook software combines the power of numerical reservoir simulators with a simpler user interface capable of processing a 1,000,000 grid model. Its reservoir fluid management tool has a superior graphic interface to enter complex well data, check data consistency, produce supplemental plots, display interactive graphics, launch and monitor simulation runs, and analyze results.

Time = 200 Days

QuikLook® Simulator
Screen Shot
**Collaborative Philosophy**

To maximize the benefits of an EquiFlow® inflow control device (ICD) completion, Halliburton works closely with clients to model completion and reservoir performance. This collaborative relationship allows both parties to agree on the expected results as well as build a basis for continuous improvement for future completions in the field.

**Workflow Overview**

Certain well and reservoir parameters must be known to begin the modeling process. The accuracy of the results depends greatly on the accuracy of the input data used by the software. Once input data is gathered, Halliburton Reservoir Engineers will use NETool™ software to model the completion and near-wellbore for up to three basic scenarios in most cases.

- **Barefoot completion** – Standard completion run in the field and used as a baseline against which all optimized completion scenarios are evaluated.
- **Base case EquiFlow ICD completion** – Run with an optimized EquiFlow ICD design in conjunction with compartmentalization of the pay interval using one or more zonal isolation devices.
- **Optimized EquiFlow ICD completion** – Model adjusted typically by increasing the number of compartments in the completion and employing EquiFlow ICDs with varying pressure drops.

The resulting outputs of these three scenarios clearly illustrate the benefits of leveling the production performance throughout the interval and are frequently considered sufficient evidence to move the project forward; however, more detailed reservoir response information is available.

Using a proprietary link between the NETool application and the QuikLook® reservoir simulator can quantify the benefits associated with each successive completion scenario. The result is a clear understanding of wellbore performance over time with regard to cumulative oil production increase, the amount of time unwanted water/gas production should be delayed, and the resulting cumulative reduction in unwanted water/gas production.
Zonal Isolation

Inflow control device (ICD) completions are most effective when compartments are created in the completion. There are two primary means of creating compartments in openhole inflow control completions: ZoneGuard® mechanical packers and Swellpacker® isolation systems.

**ZoneGuard® Hydraulic-Set Mechanical Packer**

The ZoneGuard packer family provides zonal isolation options for a wide range of openhole wellbore conditions. Applications include, but are not limited to, formation control, selective stimulation, and fracturing applications.

When an immediate seal is required, ZoneGuard packers include a hydraulic-set capability and a multi-durometer element package to deliver unsurpassed sealing performance.

**ZoneGuard HE Packer**

The ZoneGuard HE packer is designed for situations where a high-expansion sealing element is required and large variations in hole gauge diameter are anticipated. The packer can be used for zonal isolation in formation control, selective stimulation, and fracturing applications.

The ZoneGuard HE packer is run as part of the completion string and can be set hydraulically with plug set below or with an isolation straddle tool when plugging is not possible. The packer contains a hydrostatic assist feature, which helps maintain positive pressure on the packer at all times.

**Applications**

- Openhole applications (horizontal or vertical)
- Water shutoff
- Gas shutoff
- Stimulation
- Production testing
- Isolation
- Selective production
- Stage cementing
Features
- Small running OD
- Large element expansion capabilities
- Multi-piece/multi-durometer element package
- Adjustable setting shear value
- Internal locking system
- Long-term isolation reliability
- Hydraulically set plugged tubing and isolation straddle
- Hydrostatic assist allows positive pressure on element

Benefits
- Selective production management in horizontal wellbores
- Reliably control inflow or injection within selected sections of the wellbore
- Wide range of openhole isolation capabilities with one packer design

### ZoneGuard® HE Packer

<table>
<thead>
<tr>
<th>Maximum Metal OD</th>
<th>Minimum ID</th>
<th>Minimum Bore Hole</th>
<th>Maximum Bore Hole</th>
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<td>in.</td>
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<td>3.49</td>
<td>6 1/8</td>
<td>8 1/4</td>
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<td>8.000</td>
<td>4.88</td>
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<td>11 1/2</td>
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</table>
ZoneGuard® SR Packer

The ZoneGuard® SR (Short Radius) packer is designed for situations where tight radius well conditions are anticipated. The design features an anti-preset feature to help protect against premature setting of the packer during running operations. The packer can be used for zonal isolation in formation control, selective stimulation, and fracturing applications.

The ZoneGuard SR packer is run as an integral part of the production casing or casing string. The packer is set with hydraulic pressure either by setting a plug beneath the tool, or when plugging the completion string is not possible, by running an isolation straddle tool across the packer.

Applications
- Horizontal or vertical completions
- Openhole isolation
- Stimulation
- Stage cementing
- Water shutoff
- Gas shutoff
- Production testing
- Selective production

Features
- Long-term isolation reliability
- Small running OD
- Compact length for short radius well conditions
- Anti-preset feature
- Multi-piece/multi-durometer element package
- Adjustable setting shear value
- Internal locking system
- Multiple hydraulic setting methods

Benefits
- Ideally suited for short radius and higher differentials
- Enables selective production management in horizontal wellbores
- Reliably control inflow or injection within selected sections of the wellbore
## ZoneGuard® SR Packer

<table>
<thead>
<tr>
<th>Tool Connection</th>
<th>Maximum Metal OD</th>
<th>Minimum ID</th>
<th>Minimum Bore Hole</th>
<th>Maximum Bore Hole</th>
<th>Length</th>
<th>Temperature Rating</th>
<th>Pressure Rating</th>
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<td>in.</td>
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<td>in.</td>
<td>in.</td>
<td>in.</td>
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<td>3.850</td>
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<td>70.48</td>
<td>325</td>
<td>up to 10,000</td>
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<tr>
<td>4 1/2 13.5 lb API-LC</td>
<td>5.65</td>
<td>3.850</td>
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<td>6 1/4</td>
<td>60.01</td>
<td>325</td>
<td>up to 10,000</td>
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<tr>
<td>4 1/2 13.5 lb API-BC</td>
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<td>3.850</td>
<td>5 7/8</td>
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<td>4.670</td>
<td>7 1/2</td>
<td>7 7/8</td>
<td>80.24</td>
<td>325</td>
<td>up to 10,000</td>
</tr>
<tr>
<td>5 1/2 23.0 lb API-BC</td>
<td>7.25</td>
<td>4.670</td>
<td>7 1/2</td>
<td>7 7/8</td>
<td>80.24</td>
<td>325</td>
<td>up to 10,000</td>
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<td>5 1/2 Blank</td>
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<td>up to 10,000</td>
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<td>8 3/4</td>
<td>80.36</td>
<td>325</td>
<td>up to 10,000</td>
</tr>
</tbody>
</table>
Swellpacker® Isolation System

The Swellpacker® isolation system is based on the swelling properties of rubber in hydrocarbons or water, or both. The rubber swells up to 200% of its original volume, sealing the annulus around the pipe to achieve effective zonal isolation. Once deployed, the rubber retains its flexibility, allowing the Swellpacker isolation system to adapt to shifts in the formation over time, retaining the integrity of the seal. Its self-healing properties make this a truly innovative technology for all zonal isolation applications. It is a bonded-to-pipe product that can be delivered with any element length depending on the basepipe. Since the rubber is bonded to the basepipe, it is extremely robust and can hold significant differential pressures.

The Swellpacker system can be used in cased or openhole environments. In some openhole applications, operators may be able to avoid cementing and perforating altogether, reducing the expense associated with these operations. By reducing well construction costs, saving rig time, and isolating producing zones, the system helps enable previously unachievable levels of oilfield performance.

Swelling Delay Systems

To ensure the oil or water contained within well fluid does not affect the packer while it is run into the hole, Halliburton has engineered several systems that can delay the swelling process. These systems enable control of the elastomer swelling process so the setting time can be tailored according to customer needs, mitigating the risk of premature setting while optimizing the operating envelope. Swelling delay systems include polymers with built-in slower swelling properties and a variety of applied diffusion barriers. Customizing a design with either of these options, or using in combination, allows for creation of a well-specific engineered product.

End Ring Design

End rings assist in increasing the differential pressure capability and guide the packer when run into the hole. Depending on the application and metallurgy requirements, the design can be anchored using set screws, a crimping process, or welding.

The Halliburton K2 end ring protects the rubber element while running in hole and further eliminates element extrusion once the packer is set. One of the benefits of this unique end ring is the ability to shorten tool length, while maintaining differential pressure. It also increases absolute differential pressure performance of the tools with testing performed to 15,000 psi across the packer.
**Swellpacker® Cable System**

The Swellpacker® system can be delivered with a unique cable feed-through option that enables passage of single or multiple control lines and flatpacks for downhole monitoring, chemical injection, and SmartWell® completions without cutting the cables or lines. This removes the requirement for cable splices, control-line cuts, and cable stripping, greatly reducing the risk of failure. It provides an annular seal in cased and open hole, and a seal around the control lines or flatpacks capable of holding differential pressure. Installation of the cables through the Swellpacker system is performed on the rig floor at the time of running the completion and requires no extra rig time.

**Applications**
- Open and cased hole isolations
- Stimulation placement
- Open and cased hole straddles
- SmartWell completion systems
- Monitoring and chemical injection
- Water control
- Multilaterals
- Standalone screen sand control
- Compartmentalization for screen/ICD completions
- Gravel pack isolation
- Well construction

**Features**
- Manufactured on any oilfield tubular
- Suitable for cased and open holes
- Robust construction
- No moving parts
- Spliceless cable feed-through option
- Self-healing, interventionless technology
- Can be run in most all fluid environments
- Multiple polymers available to provide oil swelling, water swelling, and hybrid swelling solutions
- Engineered swelling delay system

**Benefits**
- No specialist operator required for installation
- Casing integrity is maintained
- Perfect seal for irregular borehole geometry
- Alternative solution to cementing and perforating in certain applications
- Complements cement to resolve well integrity issues
- Helps reduce operational risk
- Isolates producing zones more effectively
- Helps reduce well costs and rig time
- Cable feature increases system reliability by eliminating cable splicing and enables openhole SmartWell completions
**Swellpacker® Slip-On Isolation System**

The Swellpacker® slip-on isolation system is another option for effective zonal isolation. This unique slip-on packer retains a full length internal seal against the pipe. Once deployed, the rubber retains its flexibility, allowing the Swellpacker system to adapt to formation shifts over time to maintain seal integrity. Its self-healing properties make it a truly innovative technology for all zonal isolation applications.

The Swellpacker slip-on isolation system does not require basepipe to be supplied up front in the manufacturing process and is installed at the service location or rig site by sliding over the pin end of the casing or tubing joint. This allows storing and stocking of the tools, simplifying logistics, and reducing cost significantly.

The system can be used in cased or openhole environments. In some openhole applications, operators may be able to avoid cementing and perforating altogether, reducing the expense associated with these operations.

**Applications**

Swellpacker slip-on isolation systems can be key components in gravel packs for isolation and standalone screen completions to reduce fines migration. In reservoirs prone to sand production, the slip-on tool helps enable increased productivity and reduced well construction costs since it can be installed without specialized operating personnel. In completions using inflow control devices, slip-on tools are used to create shorter compartments for improved reservoir management.

One of the main applications for slip-on systems is with hydraulic stimulation operations. Halliburton horizontal completions provide operators with new options for completing horizontal multizone wellbores and enable highly accurate fracture placement with little to no intervention. The service allows operators to selectively access, isolate, and stimulate multiple payzones in a single wellbore with the option to close off one or more zones at a future date. This makes multizone stimulation possible in a shorter time interval, leading to reduced overall well completion costs.

**Features**

- Suitable for cased and open holes
- Install on any non-upset basepipe
- Robust construction
- No moving parts
- Self-healing, interventionless technology
- Can be run in most all fluid environments
- Multiple polymers available to provide oil swelling, water swelling, and hybrid swelling solutions
- Engineered swelling delay system

**Benefits**

- No specialist operator required for installation
- Casing integrity is maintained
- Simplified logistics
- Permits last minute adjustments to placement
- Perfect seal for irregular borehole geometry
- Protect sand screens from plugging
- Alternative solution to cementing and perforating
- Helps reduce operational risk
- Isolates producing zones more effectively
- Helps reduce well costs and rig time
Specialty Screens

Compliant Screens

PetroGuard® Swell Screen

The PetroGuard® Swell screen provides an alternative to traditional expandable sand control techniques. The design combines Halliburton Swell Technology with bonded mesh filtration media to provide a self-expanding screen which delivers the benefits associated with traditional expandable solutions but with greatly reduced risk.

The system uses basepipe coated with swellable elastomer. Low-profile screen louvers are bonded to the elastomer and feed production into common manifolds via telescoping inflow tubes. The manifolds also act as centralizers to protect the screen when running in hole.

As the elastomer swells, the screens are deployed to the formation face to provide a robust screen solution delivering borehole support without any reduction in the mechanical strength of the completion.

Features

- Combines proven swellable properties with mesh screen
- Available with all basepipe metallurgies and threads
- Polymers available to provide oil and water swelling
- Installed like conventional screens
- Easily adapted for zonal isolation between screen joints

Benefits

- No expansion risk
- Places positive stress on the formation to reduce formation damage
- No metallurgy or thread limitations
- No compromise on collapse or thread rating
- No specialized installation/expansion equipment
- Reduced rig time

<table>
<thead>
<tr>
<th>PetroGuard® Swell Screen</th>
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</thead>
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<table>
<thead>
<tr>
<th>Basepipe OD</th>
<th>Screen OD (Pre-Swell)</th>
<th>Centralizer OD</th>
<th>Screen OD (Post-Swell)</th>
<th>Louver Flow Area (Total Cross Section)</th>
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<td>in.</td>
<td>mm</td>
<td>in.²</td>
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<td>mm</td>
<td></td>
<td>mm</td>
<td></td>
<td>mm²</td>
</tr>
<tr>
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<td>88.9</td>
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</table>
Alternate Path Screens

PetroGuard® Shunt System

The PetroGuard® Shunt system for sand screens is an improved version of field-proven equipment. It provides an alternate flow path for gravel pack slurry distribution to help ensure a complete gravel (or man-made proppant) pack along the producing interval. The following can be achieved using the PetroGuard Shunt system:

- Resisting fluid leak-off to the reservoir while packing the interval
- Bypassing collapsed hole conditions
- Reducing erosion to the borehole wall/filter cake while pumping

Designed primarily for gravel packing in horizontal wells, the PetroGuard Shunt system is a 2 × 2 design featuring two larger transport tubes and two smaller packing tubes mounted to standard Halliburton PetroGuard or PoroMax® sand screens in an eccentric design. An oriented thread is used to align the eccentric design between joints of sand screen, and a special openhole centralizer is integral to the shunt system. The design allows a pressure rating of 5,000 psi (3,750 psi working) for internal pressure in the shunt tubes.

The round jumper tube system allows for quick, easy assembly and reliable sealing. There are no set screws or other components that require the use of small hand tools on the rig floor while running the system into the well. The shroud covering the connection between joints is an integral component of the design with no bulky clamshell hinges or pins to be assembled at each joint connection. A sturdy, custom-designed centralizer covers and anchors the connection shroud in the run-in-hole position. Operational testing indicates this connection design may be assembled in 60% of the time necessary for assembling competing designs.

Extensive computer flow modeling was used to design for reduced friction in flow transitions at tube connections, providing improved erosion resistance and lower pressure loss. The improved hydraulic connections between transport tubes and packing tubes enable gravel packing at the highest possible rates.

Separate from the sand screen ratings, the PetroGuard Shunt system components are tested to torque, tension, and compression capabilities. The tested and rated values for the torque, tension, and compression of the 5.5-in. basepipe system are 5,000 ft-lb, 60,000 lbf, and 60,000 lbf respectively. All values match or exceed common industry specifications. In addition, the system was tested for dogleg tolerance by running the equivalent of 2,000 ft (61 m) through a 15°/100-ft radius dogleg of varying orientation with no damage to the system.

Variations of the standard 2 × 2 configuration are possible for small wellbore sizes or other geometry constraints.
CAPS™ Concentric Annular Pack Screen Service

Halliburton’s CAPS™ concentric annular pack screen service coupled with advanced pumping and fluids technology helps ensure successful sand control completions in unconsolidated sands to achieve optimum well productivity and longevity.

Applications
- In FracPac™ system applications with:
  - Formations with varying permeability
  - Formations with distinct layer separations
  - Deviated wellbores through zone of interest
  - Zones separated by un-perforated casing
  - Requirement for enhanced FracPac system placement reliability
  - Need for complete annular pack
  - Immediate or future recovery of FracPac system bottomhole assembly
- In horizontal gravel pack applications with:
  - Potential for annular blockage
  - Changing hole diameters
  - Hole stability issues
  - Potential for screen damage while running in hole

Features
With CAPS service, a perforated shroud surrounds the screen and provides multiple flow paths. The concentric shroud with an engineered hole pattern increases the likelihood of placing a uniform frac pack treatment of complex intervals and complete gravel packing by allowing annular bridges to be bypassed. In addition, the shroud protects the screen, which can be of any type (mesh or direct wrap) while running into the well and resists future subsidence damage.

CAPS Service Adds Value
- Improves frac pack and annular gravel packing reliability of long or complex intervals
- Provides more uniform frac pack treatment of multiple sand layers
- Enhances alpha-beta packing for horizontal gravel packs
- Enables bypassing of annular bridges, unstable hole sections, or washouts

CAPS™ System Provides Flexibility for Well Conditions
- Fluid losses in excess of 50% can be tolerated without detrimental effects on pack efficiency
- Added strength protects the screen from subsidence damage
- Can pack past annular blockages
- Enhances the proven alpha-beta wave packing method
- Improved frac pack placement
- Time-saving makeup
- Smooth outer profile facilitates retrieval for workovers
- Economical
- Larger screen size in open hole than similar systems
- Lower friction pressure/higher rate capability
- Treatment simulators assist in design

With a conventional gravel pack, premature bridging causes incomplete packing.

CAPS™ service allows bypassing of bridges.

CAPS™ system enhances annular packing to form a complete pack.
Multizone Screens

PetroGuard® Modular Screen

Modular screens have an annular flow path outside the basepipe which is used to collect flow while gravel or frac packing around the screen or while producing the well and direct it to controlled entry points in the basepipe. This design enables shutoff of flow through some screen sections while others in the same well are open to flow, leaving the bore of all the screens open for service tools to pass through.

Flow from a modular screen enters the basepipe through one or more circulation/production sleeves connected to the modular screen joints. The number of these devices used is determined by the expected flow rates, and usually is less than the number of screens deployed. During packing, only a single sleeve at the bottom of the screen assembly is left open for circulating flow, eliminating the need for washpipe.

Modular screens are used with the ESTMZ™ enhanced single-trip multizone system to shut off some screens while others are being packed to eliminate the need for washpipe and enable screen isolation after packing is finished and the well is being completed.

With PetroGuard* direct-wrap technology, Halliburton has created a screen with an annular flow path under the screen filtration component, yet separate from the flow path inside the basepipe, using only a single pipe. Compared to alternative constructions using multiple pipes for creating a controllable annular flow path, the PetroGuard Modular screen is much more efficient in use of available space, enabling a larger ID or smaller OD.

The annular flow path is created by unique and larger screen rib wires between the non-perforated basepipe and screen filter media (wire-wrap or mesh). With this design, the annular flow path is connected between joints as needed through a communication sleeve installed over the connection after makeup.

This screen can be configured as a PetroGuard Wrap Modular screen or PetroGuard Mesh DS Modular screen.

Dual Basepipe Modular Screen

This screen provides an annular flow path much like a fixed absolute isolation system (AIS) when combined with mid-joint production and frac circulation sleeves. The modular screen is connected as a complete unit across each zone. Annular communication between joints is accomplished with the use of a bulkhead fitting on the inner basepipe. A single sleeve at the bottom of the screen is opened to allow flow, eliminating the need for washpipe seals and enabling the treatment of various zone lengths in the same wellbore.
Accessories

EquiFlow® Sliding Side-Door® Inflow Control Device

The EquiFlow® Sliding Side-Door® inflow control device (ICD) with PetroGuard® sand screen combines ICD technology with mechanical sliding sleeve functionality. The ICD balances the influx of fluids, and the SSD allows for selective shutoff of sections in the production interval. The combination provides a simple and robust system for controlling and isolating flow while ensuring reliable sand control.

Sliding Side-Door sleeves are a robust and reliable method of isolating the tubing ID from the reservoir for a variety of reasons including fluid loss control, activation of hydraulically set downhole tools, zonal stimulation and production, and ICD shutoff for ultimate production control.

Inflow control devices have proven to be valuable assets in balancing the influx profile in long horizontal wells. Whether it be eliminating the heel-toe effect or mitigating high permeability variances from zone to zone, the ICD is a cost effective solution that reaps large rewards in total oil recovery over the life of the well.

The EquiFlow ICD provides the ability to balance the inflow from high productivity zones with that from low productivity zones. This increases overall productivity and ultimate recovery, delaying unwanted water or gas production.

The adjustability of the EquiFlow ICD allows the operator to change pressure drop settings on the fly with ease and reduces stocking costs and logistics as a single EquiFlow Sliding Side-Door ICD can cover a wide range of production scenarios.

Combining the ICD with a sliding sleeve allows selective intervention with a mechanical shifting tool to shut off and re-open ICDs along the length of the producing interval.

System modularity allows for adding, changing, and removing all aspects of the tool from the Sliding Side-Door sleeve function to the ICD capability to the type of sand screen required. The system as a whole can function with all three or just one of any of the components.

Features
- Sliding Side-Door ICD functionality
- ICD adjustability capability
- Standard Sliding Side-Door sleeve shifting profiles
- Variety of sand control screens available

Benefits
- Balanced production fluid influx
- Delay of water/gas breakthrough
- Fluid loss control
- Full shutoff of ICD
PetroGuard® Screen and EquiFlow® Inflow Control Device with Remote-Open Valve

A remotely opened valve is available for use with PetroGuard® screens and EquiFlow® inflow control devices (ICD) that holds internal pressure when closed but opens the screen to full production flow after sufficient internal pressure is applied and released. This enables pressuring devices during completion operations even when screens are run for sand control. Valves are sealed to internal pressure only, allowing the screens to fill with well fluid when run into the well. When the screens are pressured high enough internally, they seal to prevent tubing-to-annulus flow. After pressure is released, the valves are opened permanently.

Any model of the PetroGuard sand screen compatible with an EquiFlow ICD can be built with the remote-open feature. Compatible screens can be supplied with the remote-open feature even if no ICD is used.
PetroGuard® Line and Cable System

The PetroGuard® Line and Cable system (LCS) enables encapsulation and protection of any standard cable or control line used in downhole applications on any standard Halliburton screen. The highly robust system can withstand the anticipated tension, torque, and bending loads that may be encountered while running in hole. Thorough testing has indicated the PetroGuard LCS system has no detrimental effect on screen strength and in fact increases some screen ratings. The system was also tested in burst using standard ISO 17824 procedures exceeding the ISO-rated burst pressure. In crush testing, it protected a standard 11 mm encapsulated fiber optic cable with the cable showing no loss in signal strength despite the screen being crushed flat.

The PetroGuard LCS system is compatible with any standard fiber optic, control, or electric-line configuration. It is fabricated eccentrically on any standard Halliburton sand screen with timed threads aligning the channels between joints. A purpose-built cable protector is used at connections between screen joints.

<table>
<thead>
<tr>
<th>Basepiper OD</th>
<th>Screen OD (Concentric)</th>
<th>System OD (Eccentric)*</th>
<th>Cable Capacity**</th>
</tr>
</thead>
<tbody>
<tr>
<td>in.</td>
<td>mm</td>
<td>in.</td>
<td>mm</td>
</tr>
<tr>
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<tr>
<td>6 5/8</td>
<td>168.28</td>
<td>7.46</td>
<td>189.48</td>
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</tbody>
</table>

*Timed threads required
**Other configurations are available, contact your Halliburton representative.
Testing

Halliburton Sand Control Screens are rigorously tested to validate mechanical and hydraulic performance. Screens and inflow control technology products are subjected to the industry’s most demanding testing protocol. Halliburton continuously strives to ensure products have been thoroughly proven in all loading scenarios. Burst and collapse testing of the sand screens portfolio is conducted in accordance with ISO 17824 Downhole Equipment Standard for Sand Screens. Contact your local Halliburton representative for more information about particular product ratings.

Screen Tensile Test
This test simulates screens under large tensile loads while running in hole. Screen joint (wire-wrap, shrouded mesh, etc.) is put under tensile load. Load is applied through the basepipe to test the effects on the filter media.

Screen Torque Test
This test simulates screens under large torque loads during make and break as well as running in hole. Screen joint (wire-wrap, shrouded mesh, etc.) is put under torque load. Load is applied through the basepipe to test effects on filter media.

Screen Cement Tensile Test
Filter media (wire-wrap, shrouded mesh, etc.) is cemented inside a length of casings such that there is no cement bond on the basepipe. Cemented casing is fixed and torque is applied to the basepipe. This test simulates a screen stuck inside an undersized or collapsed bore hole. Load is applied to the filter media and welds, not through the basepipe as in a traditional torque test.

Screen Cement Torque Test
Filter media (wire-wrap, shrouded mesh, etc.) is cemented inside a length of casings such that there is no cement bond on the basepipe. Cemented casing is fixed and torque is applied to the basepipe. This test simulates a screen stuck inside an undersized or collapsed bore hole. Load is applied to the filter media and welds, not through the basepipe as in a traditional torque test.

Screen Bending Test
This test simulates running the screen joint through doglegs and multilateral tool windows. Screen joint is fixed at both extremes. Two hydraulic rams inside the fixed points deploy radial load to the basepipe, forcing the screen joint to bend upward. Effects on the filter media are recorded at various bend angles.

Screen Crush Test
Screen joint is placed on a solid bed. A 16 × 12-in. steel plate is forced into the filter media applying radial force. Screen joint is crushed until the basepipe deforms. Effects on filter media are recorded at various basepipe deformation levels. This test simulates effects of a collapsed formation on a screen joint.

Screen Burst Test
End caps are placed on screen joint and a pre-sized plugging pill is pumped into the basepipe ID. The plugging pill bridges off on the filter media ID, creating hydraulic burst load. This test simulates maximum burst load a screen joint can withstand without damaging the filter media.

Screen Collapse Test
End caps are placed on screen joint and the entire joint is placed in a pressure vessel. A pre-sized plugging pill is pumped into the pressure vessel. The plugging pill bridges off on filter media OD, creating hydraulic collapse load. This test simulates the maximum collapse load a screen joint can withstand without damaging the filter media.