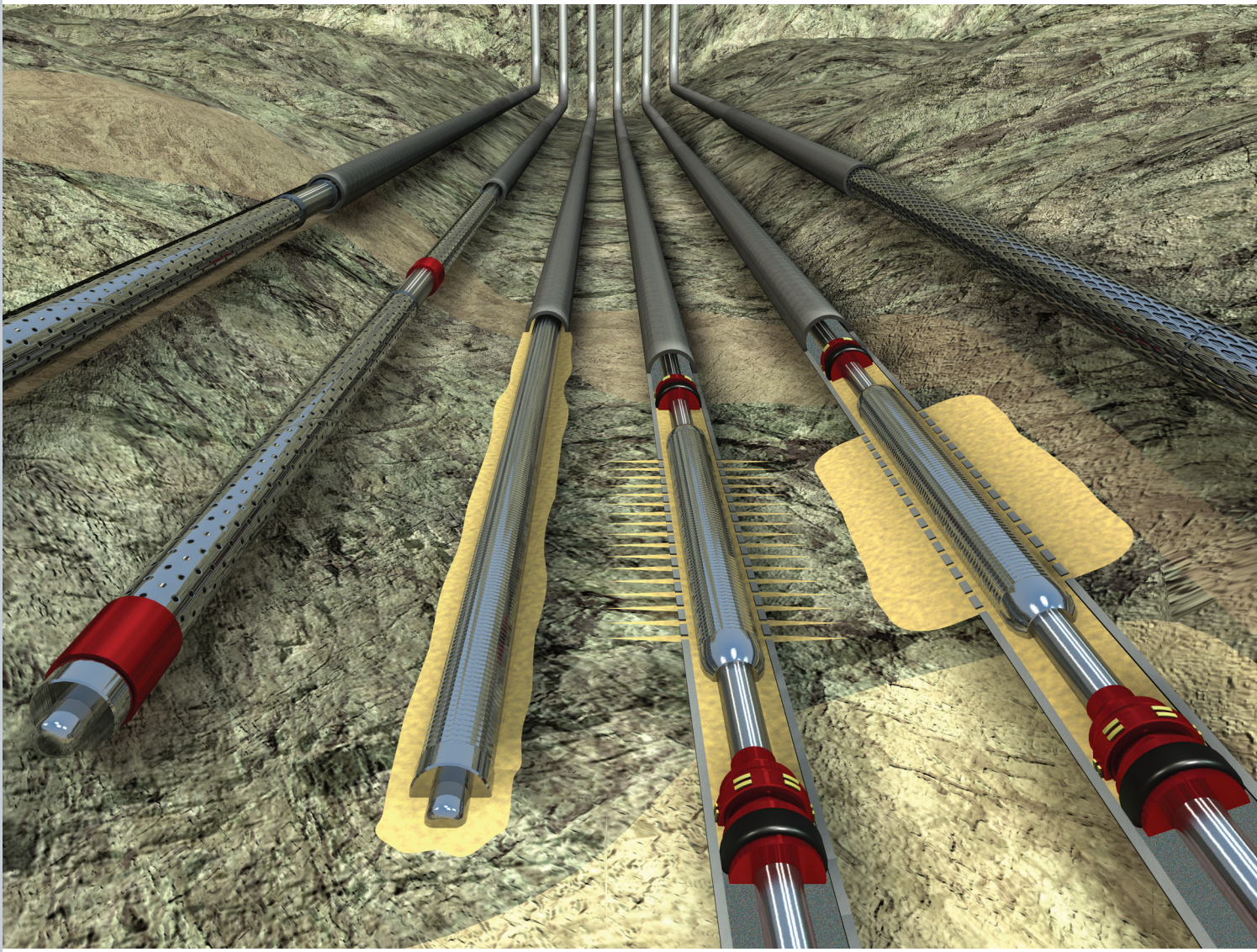
Weatherford®

Gravel Pack Systems



Drilling

Evaluation

Completion

Production

Intervention

Completions

Gravel Pack Systems
- Production Accessories
- Gravel Pack Service Tools
- Thru-Tubing Gravel Pack Systems
- Well Screens
- Ancillary Products

Solving your sand control challenges

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The Strength of Weatherford

We provide robust global resources.

Weatherford is one of the largest global providers of innovative mechanical solutions, technology and services for the drilling and production sectors of the oil and gas industry. Weatherford's existing infrastructure spans more than 100 countries, including 106 manufacturing locations, supporting more than 900 service bases and 16 state-of-the-art training facilities. Our certified manufacturing facilities are strategically located throughout the world. Since 2002, we have doubled our completions manufacturing capacity by adding new facilities, expanding existing ones, and investing significantly in the latest machining equipment.

We commit to technology development.

Weatherford is committed to the ongoing development of technology that helps clients maximize the value of their oil and gas assets. We are constantly and consistently developing new technologies for sand-control solutions through an extensive research and development investment. Client drivers will continue to power technological advancements that address sand-control challenges.

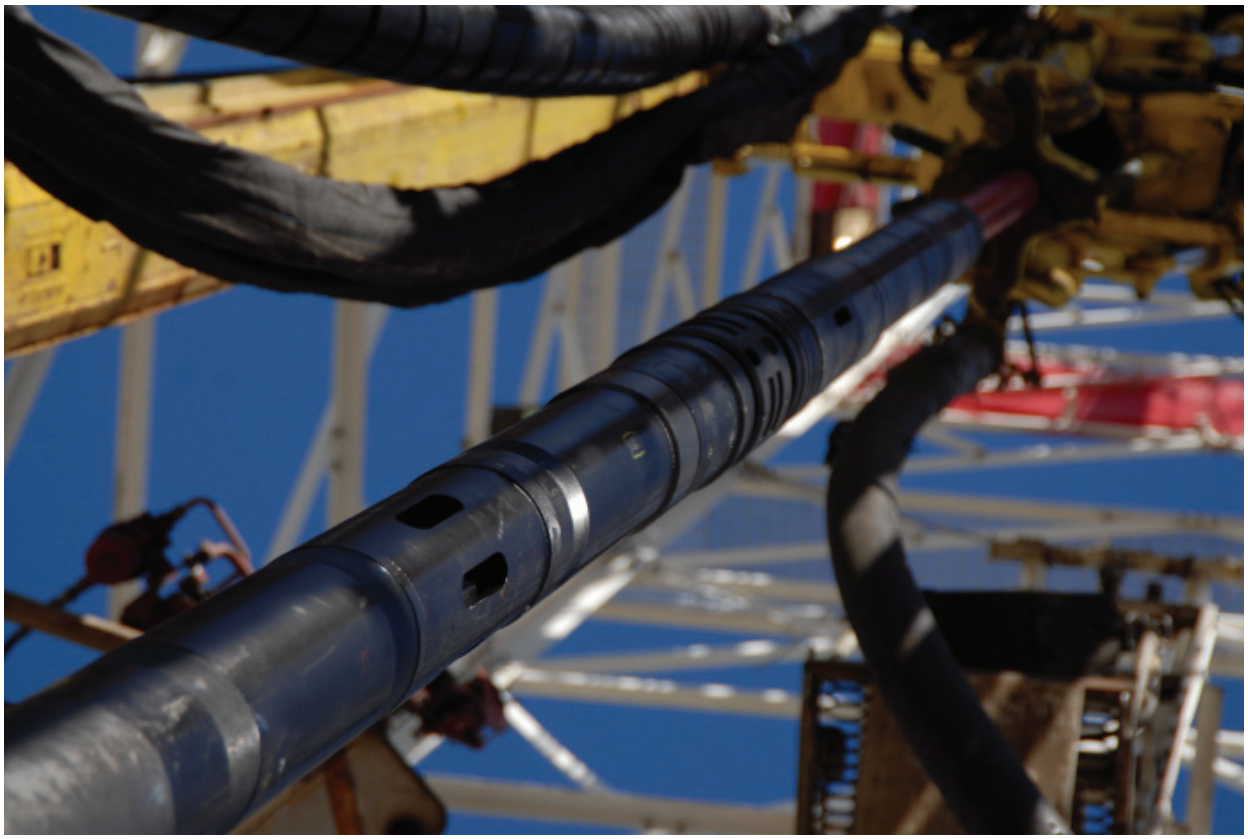
The Strength of Weatherford

We deliver superior quality control.

Weatherford's product engineering resources are based all around the world. We employ a range of engineers, designers and technical support staff whose breadth and depth of experience ensure our technologies meet the rigors of today's completion environments. Weatherford's manufacturing plants maintain the industry's highest quality, health, safety, security and environmental (QHSSE) standards. Our facilities have ISO- and API-certified quality management systems, as well as on-site QHSSE professionals, to help them achieve QHSSE objectives. Extensive training and competence assurance further assist efforts to produce high-quality completion products and to ensure the safety of personnel.

To support our equipment, we provide full service on-site.

Almost anywhere around the globe, you have access to the well-known Weatherford service. The service does not stop with the equipment. We offer 24/7, decentralized technical and engineering support for all our installations in all regions. Our global training program ensures local expertise whether the equipment is run in Singapore or the Gulf of Mexico. Local technical support personnel are rigorously trained before the release of new equipment. Our global training and competence standards ensure that we provide the same level of service quality in every location.



Manufacturing Infrastructure

Our sand-control products and services are offered worldwide.

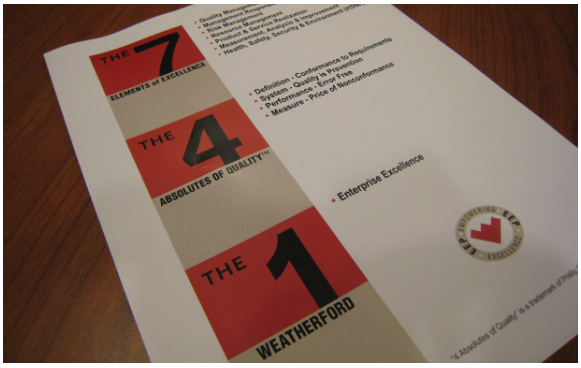
Weatherford manufactures and assembles a full line of sand-control systems and accessories at its facilities in the US, Brazil, Argentina, Vietnam, Cyprus and Singapore. Specific products include:

- Gravel-pack systems
- Conventional sand screens
- Expandable sand screen (ESS®)
- Openhole isolation packers
- Production packers
- Flow control systems
- Inflow control devices
- Downhole control valves
- Subsurface safety valves
- Intelligent wells
- Service tools

Our Enterprise Excellence Policy

Weatherford International Ltd. is committed to pursuing the highest standards of excellence in all our business processes. It is the policy of the company to:

- comply with all applicable laws and regulations of the areas within which we operate or exceed compliance with the laws and regulations where our stated expectations require;
- conduct all operations in a manner that promotes safe work practices and minimizes risk to our employees, our communities and the environment;
- implement the programs, training and internal controls necessary to achieve our goals.



Objective

Our objective is to achieve complete client satisfaction and to conform to mutually agreed requirements the first time, every time, while protecting the well-being of all personnel, assets and the environment.

This objective is achieved through a commitment to understanding and applying defined business processes, complying with established standards and implementing continual improvements. Rigorous attention will be given to achieving error-free processes, products and services and maintaining a safe environment.

Commitment

We empower each employee to take the appropriate action to ensure compliance with this policy and objective.

This policy and the associated objective and commitment statement describe the targets we have set for ourselves in achieving excellence. The principles described in this document define Weatherford's expectations that must be incorporated into the culture of the enterprise in order to achieve excellence.

Sand Production—Problems

Many of the world's oil and gas reserves are found in sandstone reservoirs. Extracting natural resources from these high-permeability, high-porosity formations is attractive to oil and gas operators. However, the downside to producing oil and gas from these highly transmissible reservoirs is that most of these formations produce sand at some point in the productive lifespan.

Two factors affecting whether a well produces sand are the restraining forces that hold the sandstone grains in place and the production stresses created by well fluids moving through the formation matrix.

Many highly unconsolidated formations produce sand during first production without any steps taken for active sand control. Competent formations produce sand later in the production cycle for various reasons, such as compaction effects from overburden stresses exceeding declining reservoir pressure, or water production effects on the naturally occurring cementation of sand grains. Regardless of intergranular restraining forces, particle movement does not occur without exposing the sand grains to fluid movement. Production rate, produced-fluids velocity, and produced-fluids viscosity affect the amount of frictional force placed on the sand grains. After the production-related stresses overcome the restraining forces of the formation matrix, solids are produced.

Produced sand particles are differentiated into two types, based on particle size: formation fines and load-bearing solids. Formations fines are particles that are less than 44 µm in diameter. The production of these small particles is generally not harmful to the formation and can be beneficial to well productivity by removing them from the pore spaces resulting in improved permeability. Moving larger load-bearing solids can damage the formation and the well equipment. Controlling load-bearing solids production stops the movement of these solids.

Producing formation sand with well fluids is detrimental to long-term well productivity, with rare exception. Managing excessive sand production for conventional wells is not economically feasible, but investing in an active sand-control program is better for operators.

Sand Production—Solutions

Numerous methods are available for controlling sand production. Because situations vary and numerous tradeoffs must be considered, there is no single preferred solution. The best method is determined by a careful analysis of the well in an effort to keep the well as productive as possible in the most economical manner.

Current sand-control methods are:

- Sand screens or slotted liners
- Expandable sand screens
- Cased-hole gravel packs
- Openhole gravel packs
- Frac packs
- Selective perforating
- Oriented perforating
- Chemical conglomeration
- Chemical consolidation
- Controlled production rates

All of these methods have both application advantages and disadvantages. Reservoir characteristics, production rates, production makeup, service infrastructure, and logistical issues are a few factors that influence the selection of a viable sand-control method.

To be considered successful, all sand-control completions should meet these objectives:

- Control the movement of load-bearing solids
- Create minimal negative impact to the well's productivity
- Remain effective for the well's productive lifespan

Weatherford combines a thorough understanding of reservoir characteristics and expertise in reservoir completion design to deliver solutions that control the inflow of hydrocarbons from the reservoir into the well and delivers sand-free production, optimizing long-term well performance and boosting recovery factors.

Weatherford integrates and applies reservoir data into the sand-control selection process. The correct sand-control method can mean the difference between maximizing productivity and losing the well. Weatherford's Sand Screen Selector incorporates previously collected data and reservoir sand properties such as particle size, particle size distribution and particle size uniformity into providing the right sand-control method for the well.

Solving Your Sand-Control Challenges

Weatherford offers a full line of reliable, cost-effective sand-control systems for open or cased holes and a full range of upper completion products.

- Gravel-pack systems
- Conventional sand screens
- ESS systems
- Openhole isolation packers
- Production packers
- Flow control systems
- Inflow control devices
- Downhole control valves
- Subsurface safety valves
- Intelligent wells
- Service tools

Combine experience with innovation

For 40 years, Weatherford has diligently expanded its portfolio to become what we are today – a premium completions provider and a high-value resource for maximizing your well-completion success. As the need for sand-control grows, Weatherford continues to provide cost-effective, quality solutions to prevent sand from restricting production or damaging wells.

Weatherford has a dedicated team of specialists in sand prediction, sand-control, reservoir engineering, production technology, petrophysics and petroleum engineering along with a world-class sand laboratory. We use this in-house expertise to identify, evaluate and rank completion designs, using an added-value-based perspective. This view may require the use of proprietary models and invokes a variety of analytical and numerical petroleum, geomechanical, reservoir and production engineering due-diligence studies, supported by laboratory testing.

In addition to experienced personnel, Weatherford is a leader in completion technologies such as *ESS* systems, conventional well screens, inflow control devices, production packers, and openhole isolation devices Weatherford provides a broad line of production-related tools used in sand-control completions, including packers, test casing and clean perforations, simple hookup nipple (HUN) gravel packs, standard cased-hole gravel pack and frac pack systems, and horizontal-well sand-control completion systems.

Solve your sand-control challenges.

Sand production occurs when production-related forces exceed the restraining forces of individual sand grains in formation stone, causing major problems with flow lines and surface production equipment and leading to costly repairs and lost production. To minimize sand production and maximize reservoir recovery, industry operators can employ a variety of methods for controlling sand production, including:

- Controlled production rates
- Chemical consolidation or conglomeration
- Cased-hole and openhole gravel packs
- Frac packs
- Stand alone sand screens
- *ESS* systems
- Thru-tubing gravel packs

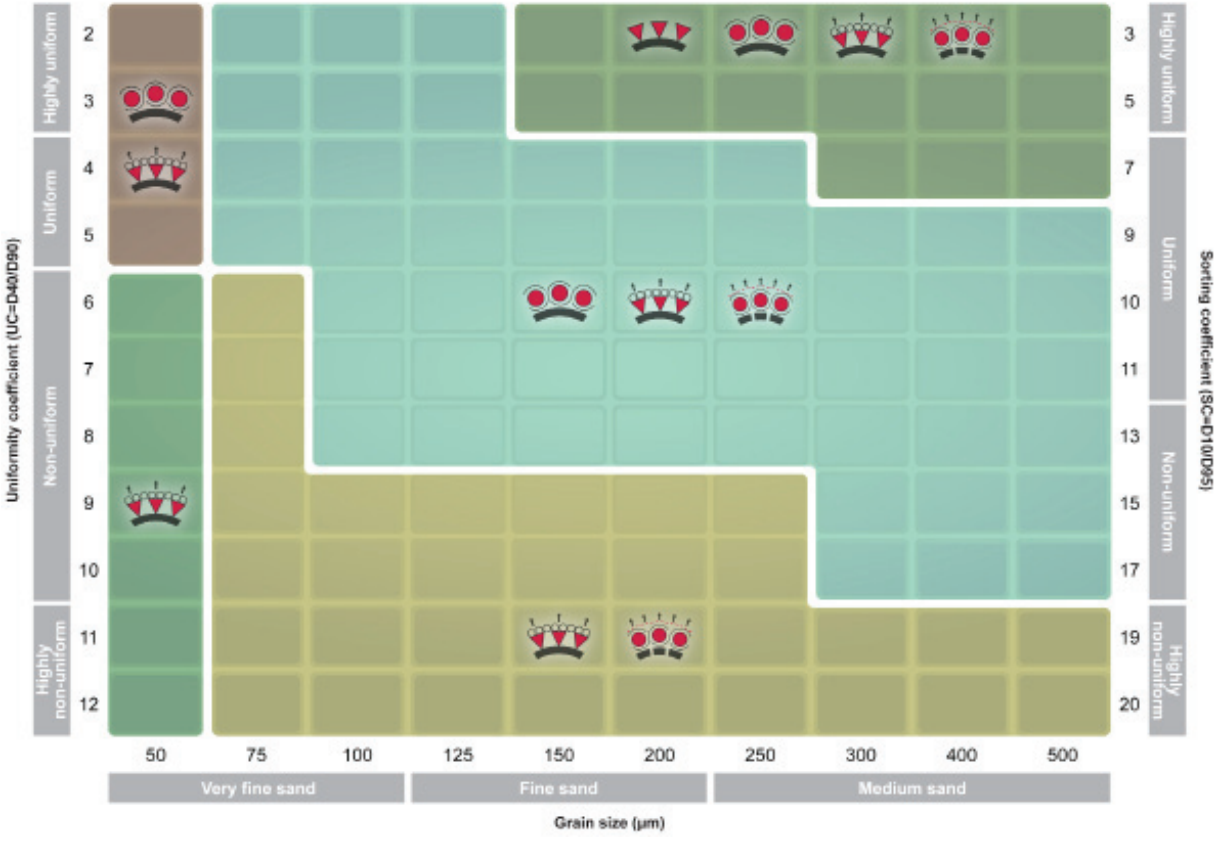
Solving Your Sand-Control Challenges

Choose the right sand-control method.

Most formations, at some point in their productive life, will produce sand. Highly unconsolidated formations may make sand with the onset of first production, while more competent formations may not make sand until later in their production history. There are numerous problems that can occur because of extended sand production, including:

- Reduced production
- Erosion of casing, tubing and surface equipment
- Loss of formation stone, making selective treatments difficult and contributing to formation subsidence and casing damage
- Production interruptions due to sanded-up flowlines and separators

Weatherford's Sand Screen Selector is a planning tool that guides you through the process of choosing the most effective sand control for the wellbore completion. Any sand-control completion design should be planned to control the movement of formation solids, create minimal negative impact to the well's productivity, and meet the well's long-term sand control needs. In addition, factors such as reservoir characteristics, production rates, production makeup, service infrastructure, and logistical issues need to be evaluated.



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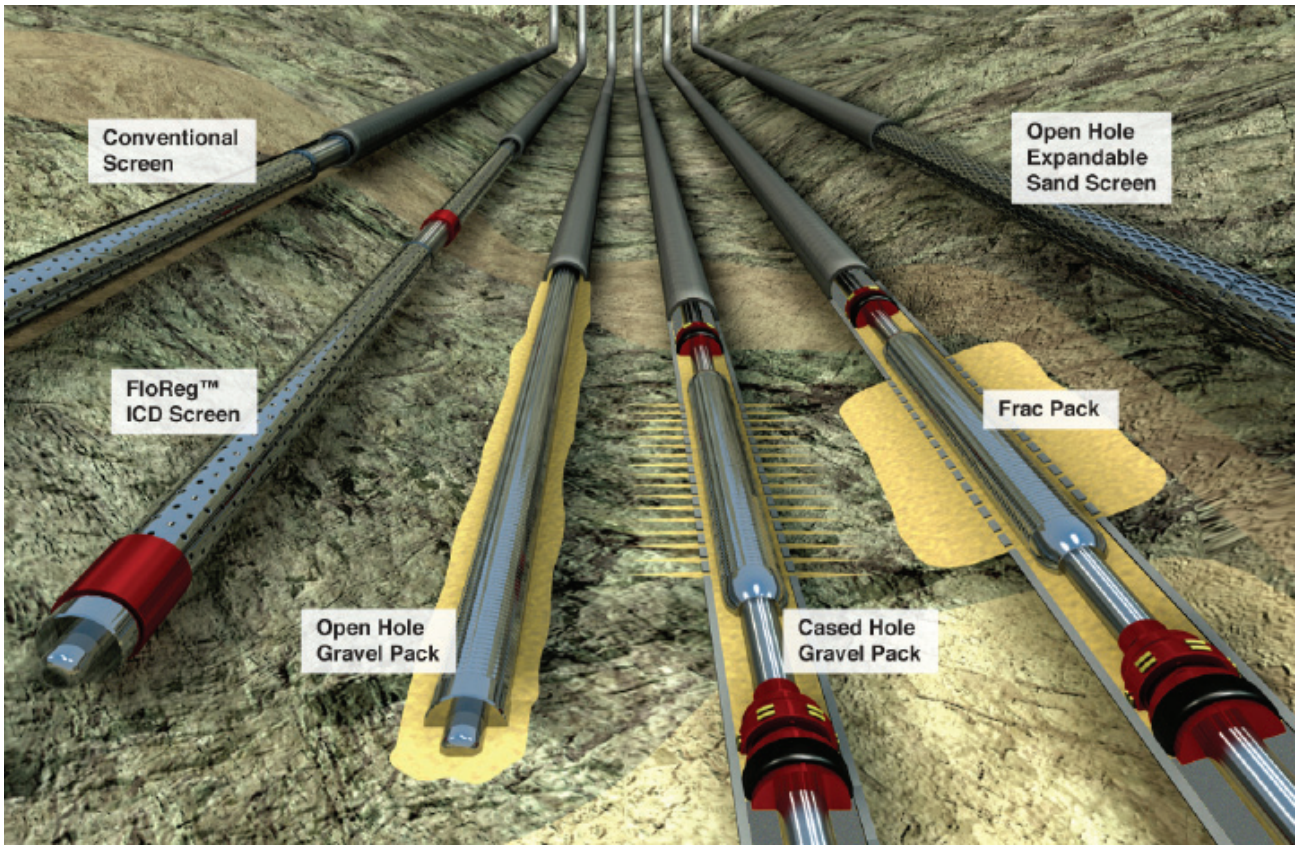
Sand-Control Completions Overview

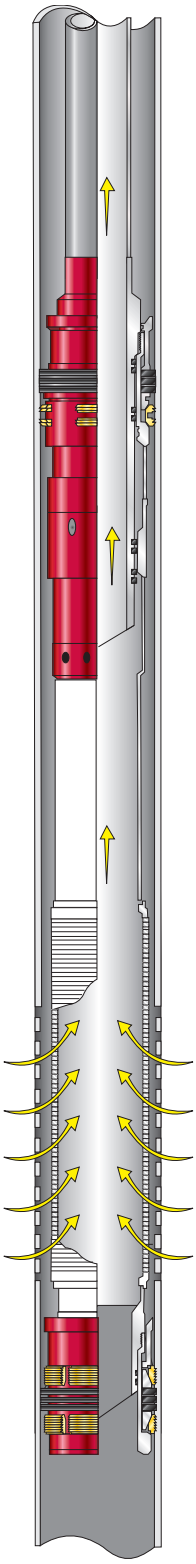
There are many different types and styles of sand-control completions, and the best method of controlling sand production depends on the operator's objectives, reservoir characteristics and production potential. Gravel packing, frac packing, and stand-alone screens are the more commonly practiced methods of sand control in cased-hole and openhole wells.



Gravel packing and frac packing are recognized as the most widely practiced and successful methods of sand control. These specialized completion methods require special completion and pumping equipment, but they are relatively inexpensive when the treatment cost extends over the expected life of the solution. In comparison, the negative effects of not addressing continued sand production far outweigh the treatment costs.

Stand alone sand screens are an effective sand-control treatment in wells with uniform sands and low fines production. Stand alone screens perform best when installed in an openhole well bore and spread out over a large area rather than having short, highly productive sections that create "hot spots" through the well screens. The *ESS* system is a very effective means of completing prolific oil and gas wells or water injectors with openhole wellbores.

Sand-Control Completions



Producing

Gravel-Pack Completion

Gravel packing creates a downhole sand retention mechanism to keep the formation grains undisturbed in their natural matrix. The operation requires installing a screen and packer into the wellbore across the producing interval using a work string and specialized tool system. Sand or gravel is pumped into the well to fill the annulus around the screen and voids in the formation. Implemented effectively, the formation interface with the wellbore will have continuous and compliant contact with a layer of properly matched, highly conductive, round gravel-pack sand or man-made proppant. The gravel pack sand or proppant supports perforation tunnels or the openhole, keeps formation grains in place, enables the passage of formation fines without plugging, and creates minimal pressure drop from the formation and into the production stream. Placing the sand into the well for gravel packing generally requires low-horsepower pumping units because treatments are normally performed at low rates and pressures.

Frac Pack completion

Frac packing is a hybrid process that stimulates a reservoir by hydraulically fracturing the formation and accomplishes an annular gravel pack in a single operation. Frac packs are typically performed in cased-hole wells. The packer and screens are deployed into the wellbore using a work string and a specialized tool system. The frac-pack slurry is pumped at high rates with pressures high enough to fracture the formation. As the slurry dehydrates at the fracture tip, the pressure increases, expanding the fracture width. Continued dehydration of the slurry packs the fracture with highly conductive proppant. The slurry remaining in the proppant screen annulus serves to pack the annular gap between the screen and casing. Frac packing requires different tools than gravel packing. The tools must withstand the erosive forces of the slurry delivered at high velocities with large volumes of proppant. Performing frac packs requires a substantial amount of specialized pumping equipment with high horsepower and bulk proppant handling capabilities.

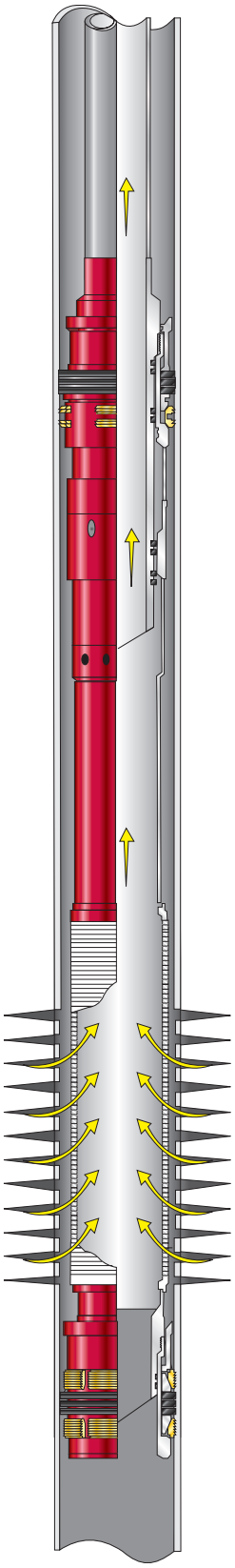
Sand-Control Completions

Cased-Hole Gravel-Pack Completion

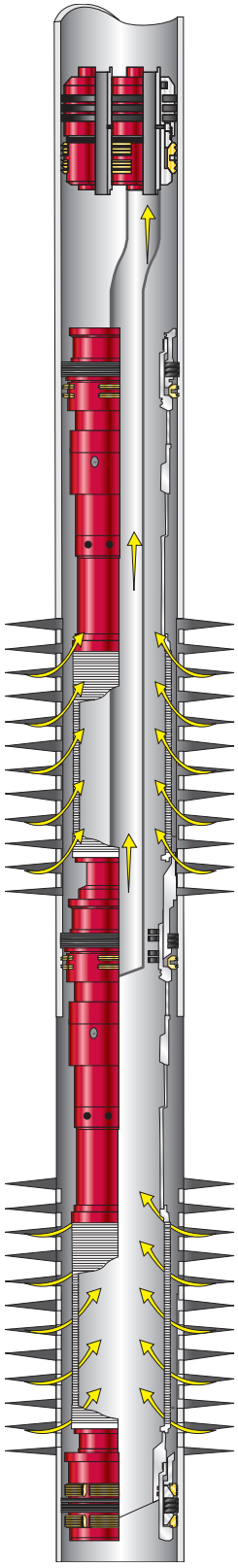
The cased-hole gravel pack (CHGP) completion using a retrievable sealbore packer is the most common method for active sand-control practiced throughout the oil and gas industry. A BlackCat™ GP or *BlackCat* WFX retrievable sealbore packer with a gravel pack extension, crossover tool, and screens are deployed into a cased well that has been perforated into the production zone. The screens use a snap-latch locator seal assembly installed on the bottom that seals into an UltraPak™ permanent sump packer. The snap-latch locator serves to provide a surface indication that the gravel pack assembly is properly located in the sump packer.

With the assembly in place, the upper packer is set, and the crossover tool is manipulated to its various positions to pump the gravel as well as any other treatements planned. The squeeze position is used to stimulate the formation or prepack the perforations. The circulating position is the standard crossover tool position that places gravel into the screen and casing annulus. Proper leakoff while circulating the gravel pack in place serves to fill the perforation tunnels. After placing the calculated amount of gravel pack sand in place and achieving a sandout, the crossover tool is raised to the reverse position and all excess slurry remaining in the work string is reverse-circulated to the surface for disposal. The crossover tool is removed, and the well is ready for the installation of the production tubing.

With the *BlackCat* retrievable sealbore packer remaining in the well as the production packer, the operator maintains the flexibility of inserting a production seal assembly into the packer, isolating the casing above the packer from well pressure and produced fluids or suspending the tubing above the packer, as in a well lifted by reciprocating rod lift or an electric submersible pump. Production tubing or artificial lift strings can be retrieved and rerun without disturbing the gravel pack setting.



Sand-Control Completions



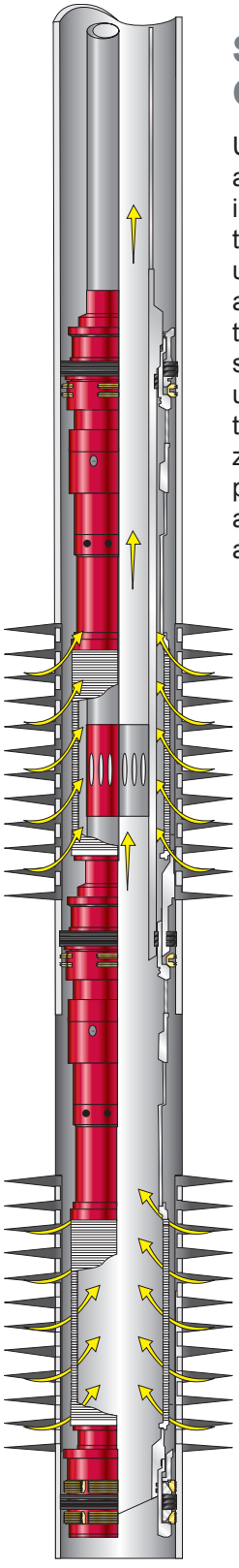
Cased-Hole Stacked Gravel-Pack Completion

Sealbore packer gravel-pack systems enables operators to easily and effectively complete multiple zones intersected in a wellbore with no extraordinary completion procedures. When zones are conveniently spaced, the gravel-pack packer for a lower zone can be used as the foundation or ‘sump packer’ for the next gravel pack higher in the well.

The lower zone is performed as a single gravel pack would be. The lowest zone is perforated at the start of operation. The lower-zone gravel-pack equipment is run into the well and installed with screens properly spaced across the perforations. If zone spacing permits, the gravel-pack packer is spaced out to just below the planned upper-perforated interval. If spacing of the zones is too distant, a separate isolation packer is set below the intended perforations. After the gravel pack is performed, a retrievable isolation plug is installed in the gravel pack or isolation packer to isolate the existing perforated zone from the next interval to be perforated. The plug serves to retain all perforation and formation debris in the casing where it can be easily cleaned out and circulated to surface. Once the wellbore is cleaned, the plug is retrieved, and the next gravel pack assembly is prepared for installation.

Upper gravel-pack assemblies are very similar to single-zone assemblies except that a polished-bore assembly is usually included below the screens that allows for the isolation of lower zones from pressures resulting from pumping into an upper zone. This same polished bore serves as the sealing area for the production string so that zones are isolated from each other during the production phase.

Sand-Control Completions



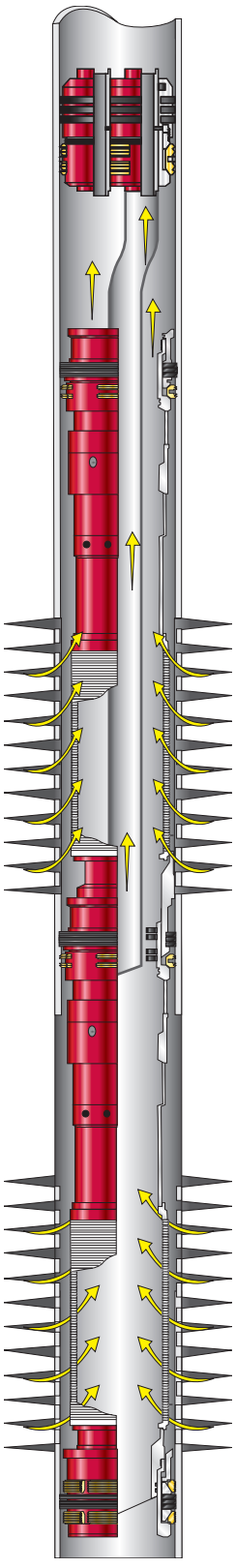
Single-String Selective CHGP Completion

Upon completion of the gravel packs, a single string of production tubing is installed into the well, including tubing that extends inside and through the upper gravel-pack assembly. A seal assembly is placed on the end of the tubing to isolate the lower zone and a second seal assembly is located in the upper gravel-pack packer to isolate the upper zone. Selective production, zone isolation, or comingled production from both zones is easily accomplished by using landing nipples and sliding sleeves.

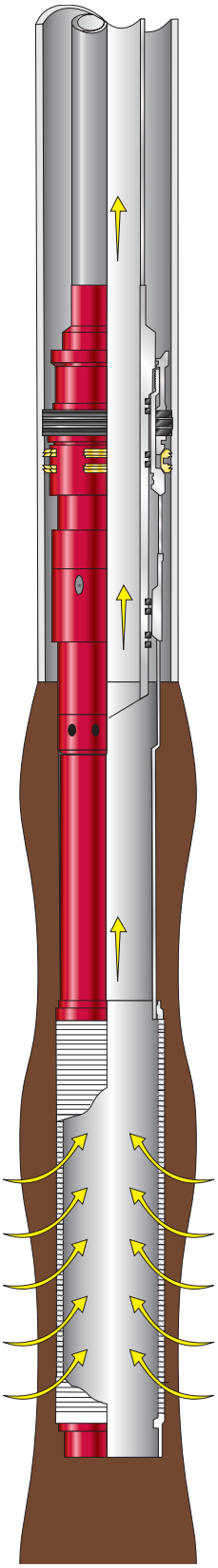
Dual-String CHGP Completion

There are many shallow heavy-oil reservoirs with low bottomhole temperatures that naturally keep the oil in a very viscous state. Without being heated, oil is virtually impossible to produce from the reservoirs as the oil is too thick to overcome the frictional forces of flowing through the reservoir pore spaces. Heat must be applied to these reservoirs in order to reduce the viscosity of the crude oil so that the oil will flow into the well bore where it can then be pumped to surface if reservoir pressures are not sufficient to produce the oil to surface. This heating is normally accomplished either through the injection of steam from surface into the formation or through fireflood by creating a combustion event downhole and feeding the fire with compressed air pumped from surface.

Regardless of the means of heating the reservoir, seals and elastomers normally used on production tools will not normally withstand the elevated temperatures of these techniques. In most applications, standard tools can be equipped with specialized seals to make them suitable for this service.



Sand-Control Completions



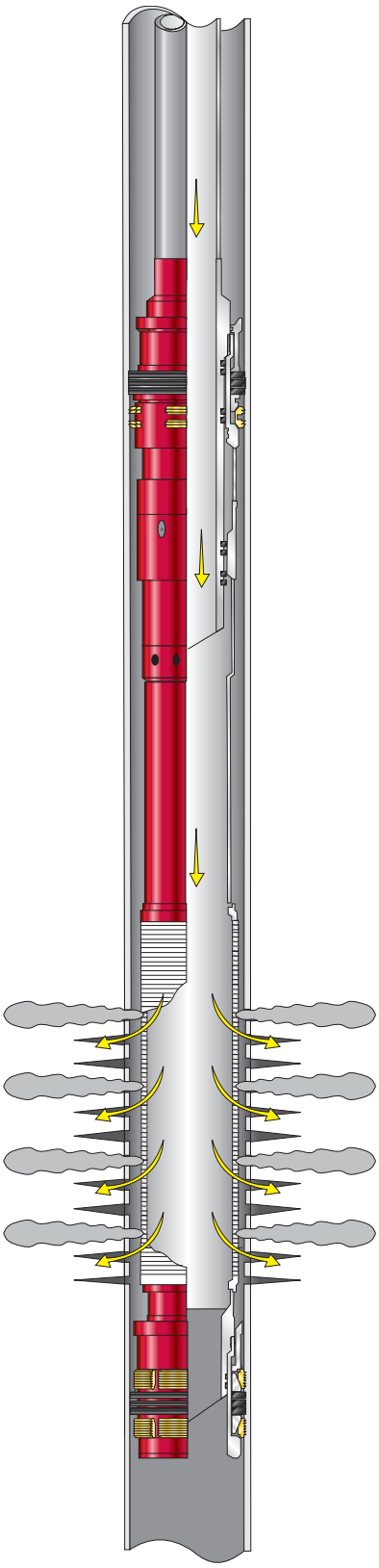
Vertical Openhole Gravel-Pack Completion

Openhole completions range from very simple operations to very complicated processes, depending on factors such as formation integrity, well deviation, openhole section length, sand quality, etc. By completing openhole, the perforation flow restriction present in cased-hole completions is eliminated along with the resulting pressure drop which is a definite benefit. Openhole completions offer a greater exposure to the reservoir than cased and perforated wells, resulting in lower matrix velocities and production-related stresses on the formation.

Thermal Gravel-Pack Completion

There are many shallow, heavy-oil reservoirs with low bottomhole temperatures that naturally keep the oil in a very viscous state. Without applying heat, the oil is too thick to overcome the frictional forces of flowing through the reservoir pore spaces and is virtually impossible to produce from the reservoirs. Heat must be applied to these reservoirs in order to reduce the viscosity of the crude oil so that the oil flows into the well bore and can then be pumped to surface. This heating is normally accomplished either through the injection of steam from surface into the formation, or through fireflood by creating a combustion event downhole and feeding the fire with compressed air pumped from surface.

Regardless of the heating type, the reservoir, seals, and elastomers used on production tools cannot normally withstand the elevated temperatures of these techniques. With most applications, standard tools can be equipped with specialized seals to make them suitable for this service.



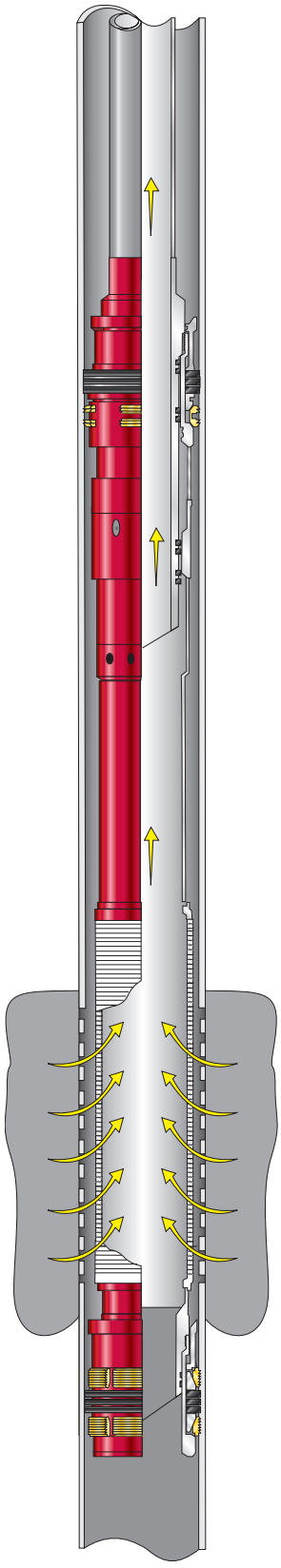
Sand-Control Completions

Cased-Hole Frac-Pack (CHFP) Completion

In the early 1990's, oil and gas operators were searching for a way to make low-permeability sandstone formations, or wells with drilling-related damage, more productive. Historically, hydraulically fracturing formations had been limited to carbonate reservoirs. Avoiding the fracture gradient in unconsolidated sandstone formations had always been the norm. The technique was eventually tried in 'soft rock' sandstones combining a hydraulic fracture treatment to stimulate the formation to improve its productivity with accomplishing an annular gravel pack to serve as sand control. Operators saw immediate success with increased productivity making previously uneconomical reservoirs now justifiable to exploit. The treatment proved so successful it is regularly employed in high-permeability formations, as well as for fines control and more uniform drainage of the reservoir.

Single CHFP completions are executed comparably to cased-hole gravel packs with downhole equipment similar in function and design, but specialized to withstand the extreme forces used in this type of treatment. Burst and collapse pressure ratings for frac-pack tools are typically higher than gravel-pack tools. This enables the tools to handle the pressure differential potentially realized at screenout. Fracturing treatments are pumped at very high rates with large volumes of proppant in order to support the resulting fracture width and stay conductive. Proppant pumped at these rates and volumes is very erosive and new tool designs and materials were necessary to address this issue.

Weatherford developed the WFX line of tools specifically for frac-pack applications.



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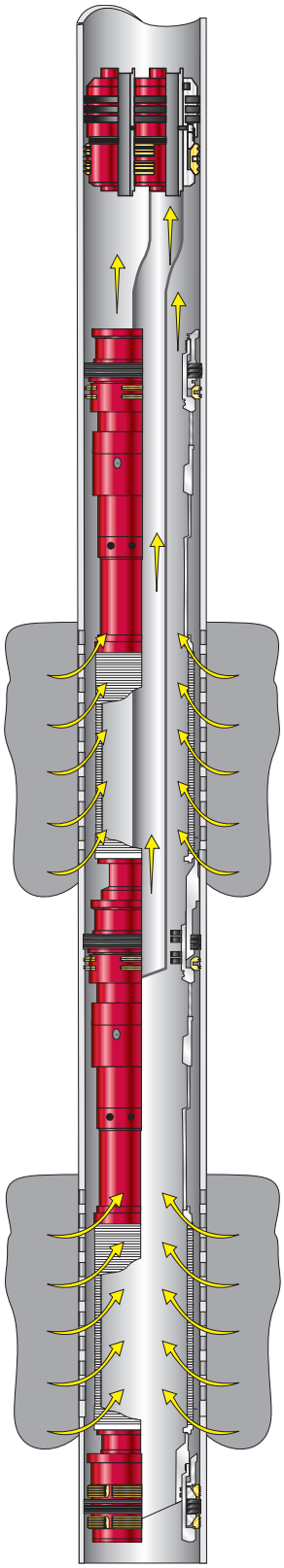


Cased-Hole Stacked Frac-Pack Completion

Similar to cased-hole stacked gravel-packed completions, equipment can be installed to perform multiple cased-hole frac packs, or the various zones can be gravel- or frac-packed, depending on the optimal treatment. In this case, confirmation is critical that the pressure rating of all equipment in contact with the perforations receiving the fracturing equipment can accommodate the maximum pressure exposed.

The procedure for installing multiple frac-pack completion-equipment settings into the wellbore is the same as for a single-zone completion, but repeated. Only the lowest zone is perforated at the start of operations. The lower-zone frac-pack equipment is run into the well and installed. If zone spacing permits, the frac-pack packer is spaced out to just below the perforated upper interval. If spacing of the zones is too distant, a separate isolation packer is set below the intended perforations. After the frac pack is performed, a retrievable isolation plug is installed in the frac-pack or isolation packer to isolate the existing perforated zone from the next interval to be perforated. The plug serves to retain all perforation and formation debris in the casing where it can be easily cleaned out and circulated to surface. Once the wellbore is cleaned, the plug is retrieved and the next frac-pack assembly is prepared for installation.

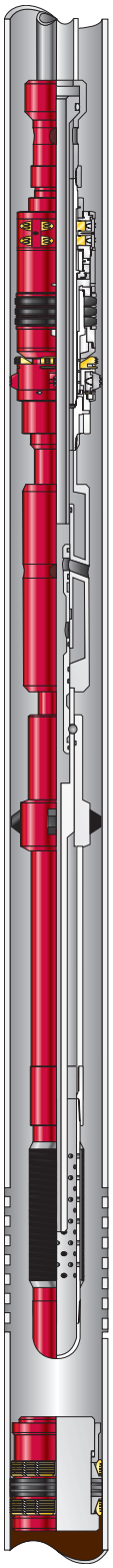
See the cased-hole stacked gravel-pack section for more details on type of installations.

Sand-Control Completions

Cased-Hole HUN Gravel-Pack Completion

Marginal wells sometimes need a more economical solution than conventional sealbore packer gravel pack equipment. The cased-hole HUN gravel-pack completion relies on a standard mechanical-service packer equipped with a modular gravel-pack kit to deploy the screens into a well and function as the gravel-pack packer and service tool. When on bottom, the service packer is set, the screens are released, and the gravel pack treatment is performed. After the gravel is successfully placed and all excess slurry is reverse-circulated to the surface, the service packer, the gravel pack kit, and washpipe are retrieved from the well.

The service assembly disconnects from the screen assembly at a HUN with a polished exterior surface that serves as the connection point when the completion string is run into the well. The completion string includes an overshot that connects to the HUN and a production packer suited to the operator needs and well conditions.



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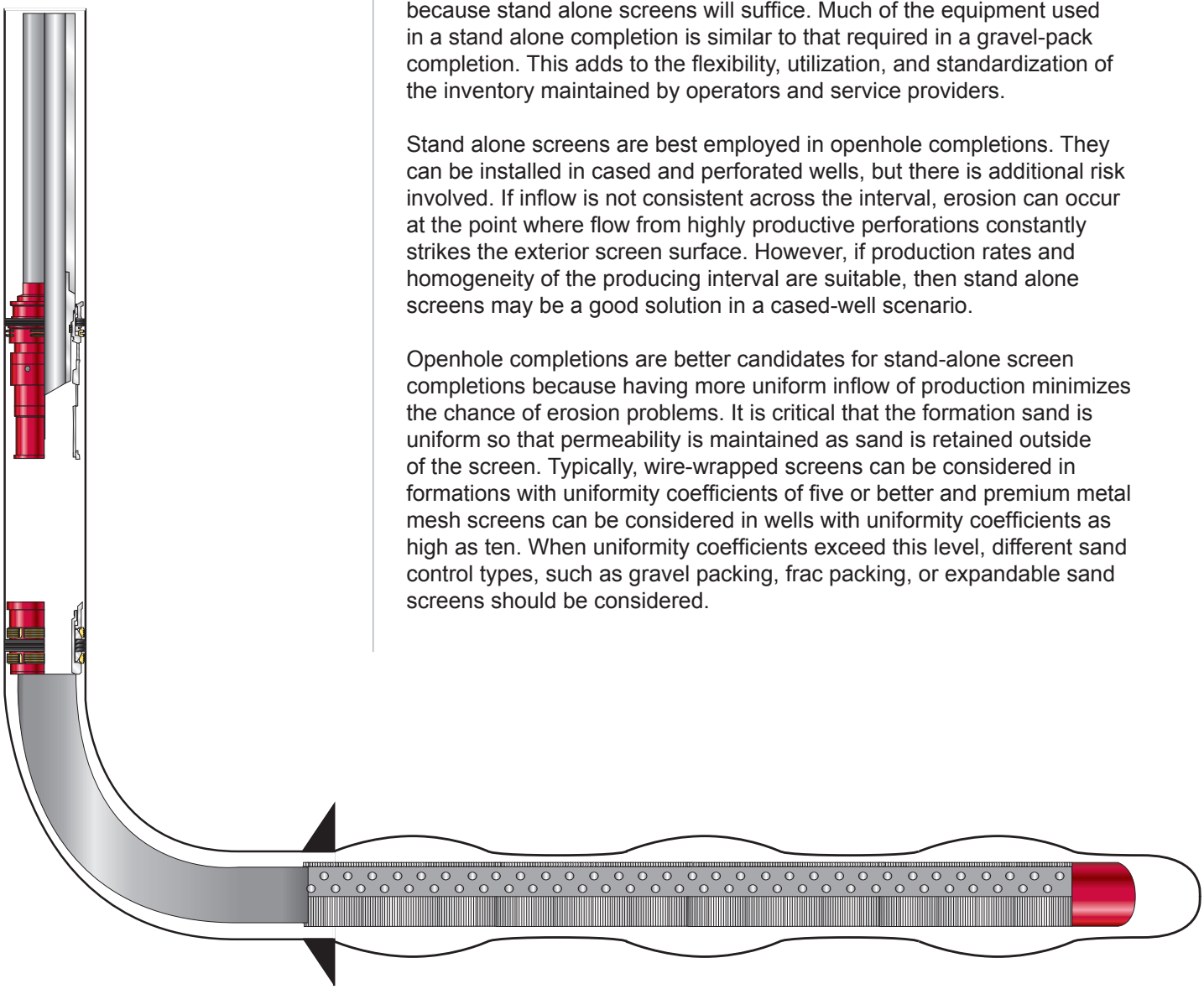


Standalone Screen Completions

Some reservoirs require sand control, but do not require a gravel-pack, because stand alone screens will suffice. Much of the equipment used in a stand alone completion is similar to that required in a gravel-pack completion. This adds to the flexibility, utilization, and standardization of the inventory maintained by operators and service providers.

Stand alone screens are best employed in openhole completions. They can be installed in cased and perforated wells, but there is additional risk involved. If inflow is not consistent across the interval, erosion can occur at the point where flow from highly productive perforations constantly strikes the exterior screen surface. However, if production rates and homogeneity of the producing interval are suitable, then stand alone screens may be a good solution in a cased-well scenario.

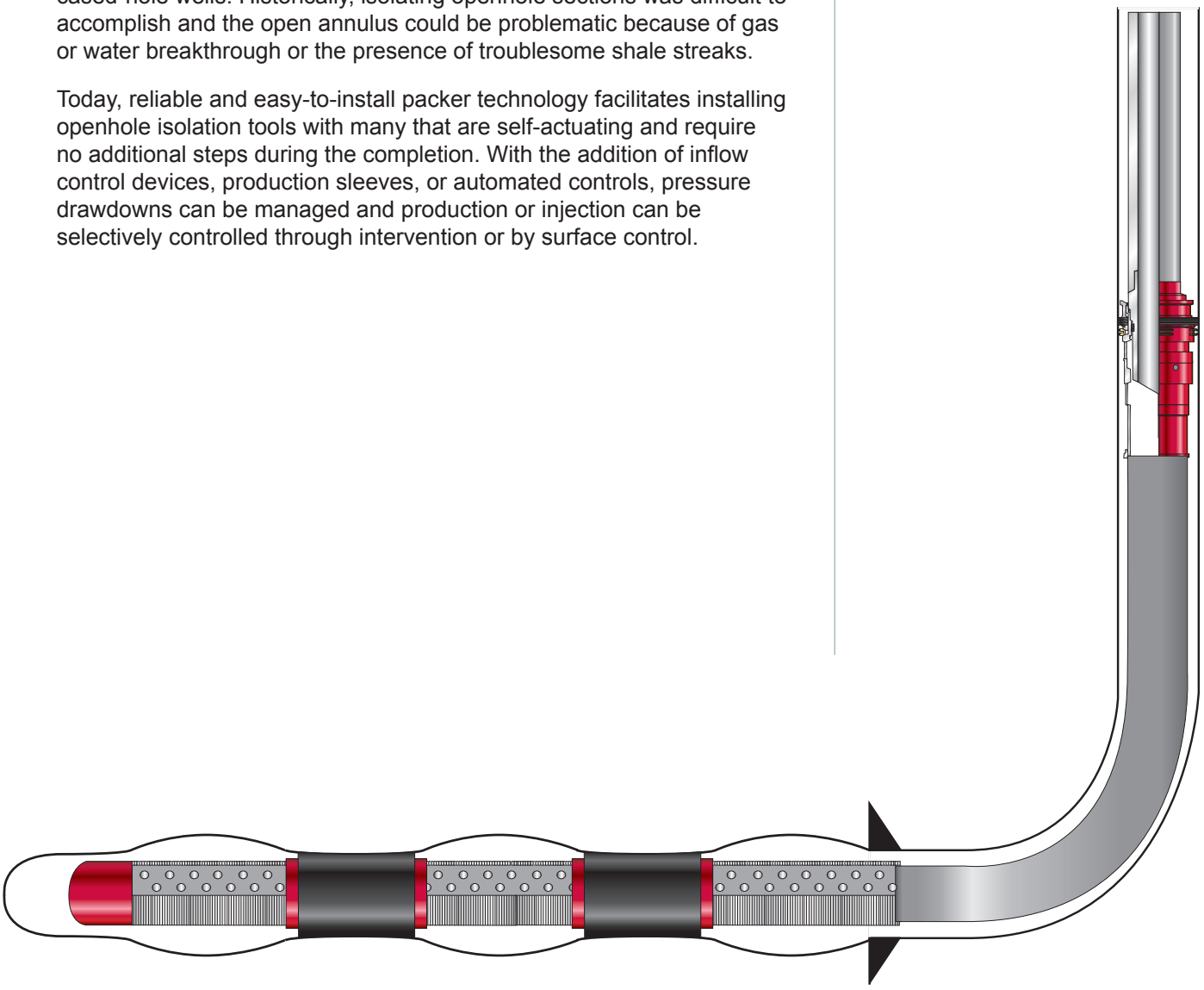
Openhole completions are better candidates for stand-alone screen completions because having more uniform inflow of production minimizes the chance of erosion problems. It is critical that the formation sand is uniform so that permeability is maintained as sand is retained outside of the screen. Typically, wire-wrapped screens can be considered in formations with uniformity coefficients of five or better and premium metal mesh screens can be considered in wells with uniformity coefficients as high as ten. When uniformity coefficients exceed this level, different sand control types, such as gravel packing, frac packing, or expandable sand screens should be considered.

Sand-Control Completions

Standalone Screen Completions with Isolation

With recent advancements in technology, it is easier to compartmentalize production or injection intervals in openhole and cased-hole wells. Historically, isolating openhole sections was difficult to accomplish and the open annulus could be problematic because of gas or water breakthrough or the presence of troublesome shale streaks.

Today, reliable and easy-to-install packer technology facilitates installing openhole isolation tools with many that are self-actuating and require no additional steps during the completion. With the addition of inflow control devices, production sleeves, or automated controls, pressure drawdowns can be managed and production or injection can be selectively controlled through intervention or by surface control.



Sand-Control Completions

ESS® System

Weatherford's proven *ESS* system has been changing the face of sand control for more than ten years.

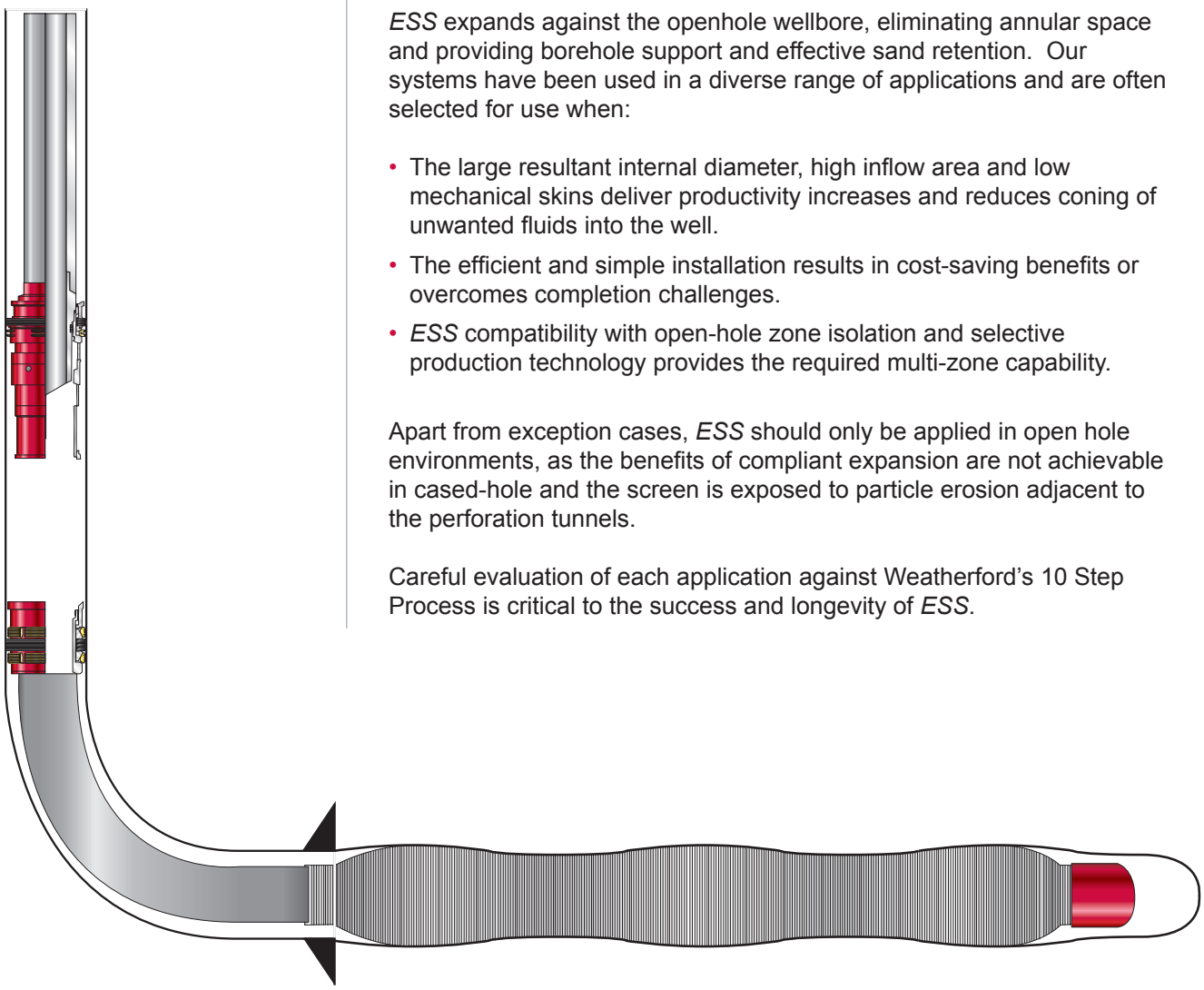
Expandable sand screens are not utilized in gravel-pack completions, but they are a technology that has been utilized in some wells with proper reservoir conditions.

ESS expands against the openhole wellbore, eliminating annular space and providing borehole support and effective sand retention. Our systems have been used in a diverse range of applications and are often selected for use when:

- The large resultant internal diameter, high inflow area and low mechanical skins deliver productivity increases and reduces coning of unwanted fluids into the well.
- The efficient and simple installation results in cost-saving benefits or overcomes completion challenges.
- *ESS* compatibility with open-hole zone isolation and selective production technology provides the required multi-zone capability.

Apart from exception cases, *ESS* should only be applied in open hole environments, as the benefits of compliant expansion are not achievable in cased-hole and the screen is exposed to particle erosion adjacent to the perforation tunnels.

Careful evaluation of each application against Weatherford's 10 Step Process is critical to the success and longevity of *ESS*.



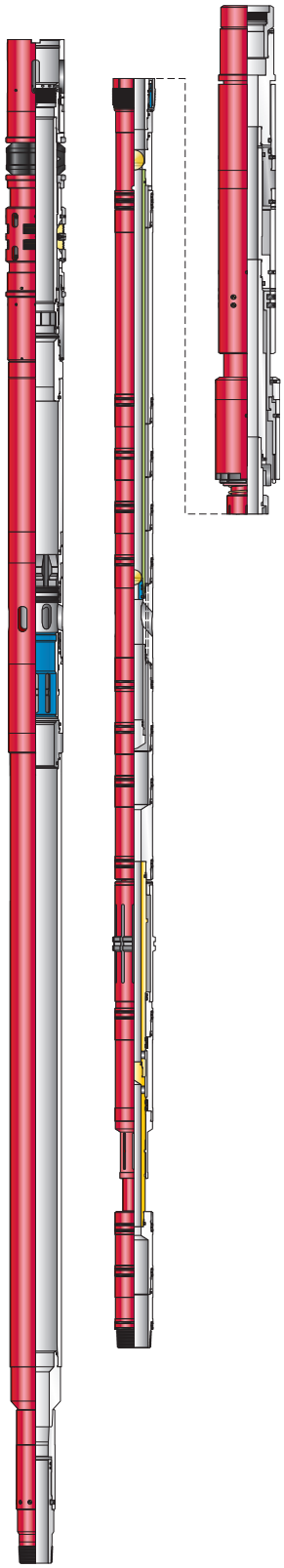
Gravel-Pack Systems

Weatherford is one of the largest completion-equipment companies in the world and provides quality products used in all types of oil and gas well completions. As the need for sand control grows, Weatherford continues to meet customers' needs with cost-effective, quality solutions that prevent sand from restricting production or damaging its customers' wells. Weatherford provides a very broad line of production-related tools that are used in sand-control completions, including service packers to test casing and clean perforations, simple HUN gravel-pack, standard cased-hole gravel pack systems, frac pack systems, and horizontal-well sand-control completion systems.

Weatherford is very active in the development of new and innovative sand-control solutions. Historically, Weatherford has participated in a very focused and limited aspect of this area, but market forces are encouraging the company to broaden its involvement. Because the industry views Weatherford as a new force in many different areas with innovative ideas and an attitude that is quick to respond to needs in the market, the expanded participation in the sand-control market is a benefit to oil and gas producers around the world. The company is a leader in completion technologies such as expandable sand screens, conventional well screens, inflow control, production packers, and openhole isolation devices. Being aware of the needs of our customers drives the continued development of solutions that meet the technological and commercial needs of operators by addressing the sand-control problems regardless of the nature of the reservoir and all associated economic drivers.

The systems outlined on the following pages highlight our more common gravel-pack systems that are designed to satisfy regular sand-control needs while meeting economic expectations.

Model WFX System—Frac Packing and Gravel Packing



Weatherford's WFX system is a designed-for-purpose system intended to handle the operational requirements and downhole stresses of frac packing oil and gas wells. It is versatile enough to be used on the most routine gravel-pack completions. Standard systems are rated to 10,000 psi (690 bar) at 300°F (150°C).

Major system components include:

Service Tool Assembly
- WFX setting tool
- WFX crossover tool

Gravel-Pack Assembly
- BlackCat™ WFX packer
- Model G2 sand-control extension
- Model SS shear subs
- Blank pipe
- Well screens—wire-wrapped, pre-pack, or metal mesh
- Snap-latch seal assembly
- UltraPak™ sump packer

The first well requirement is a quality sump packer that serves as the foundation for the total completion. Weatherford's *UltraPak* permanent sealbore packer is a proven and reliable packer that anchors in any yield casing. The packer can be set using electric line for accurate placement to ensure that perforating guns and the sand-control assembly are properly positioned while relying on pipe measurements. A repeatable snap-latch seal assembly installed on the bottom of the screens serves to give indication of the packer bore being unobstructed and the screens being on depth before setting the gravel-pack packer.

WFX system components are built with high-strength alloys that provide impressive tensile and torque ratings suitable for carrying long assemblies into tortuous and deviated wells. Torque capability through the setting tool and packer enable the operator to rotate the bottomhole assembly (BHA) to get past obstructions in the wellbore.

When the assembly is deployed to setting depth and the screens are properly positioned across the production or injection interval, the *BlackCat* WFX packer is set hydraulically by dropping a setting ball and applying pressure down the work string from surface. After the packer is set, the service tool is released from the packer, and the tool can be placed in various positions depending on the pumping operation and path of pumped fluids.

Model WFX System—Frac Packing and Gravel Packing

The WFX system uses an innovative circulating valve design that allows fixed-position gravel packing. The valve is located on the lower end of the crossover tool and resides in an environment that is free from well debris, gravel-pack proppant, and other solids that damage critical seals on the crossover tool or interfere with the operation. The system's fixed position capability permits both squeeze and circulating modes to be achieved with the crossover tool in the same position relative to the packer and with compressive force, that is "weight-down", securely fixing it in the intended position.

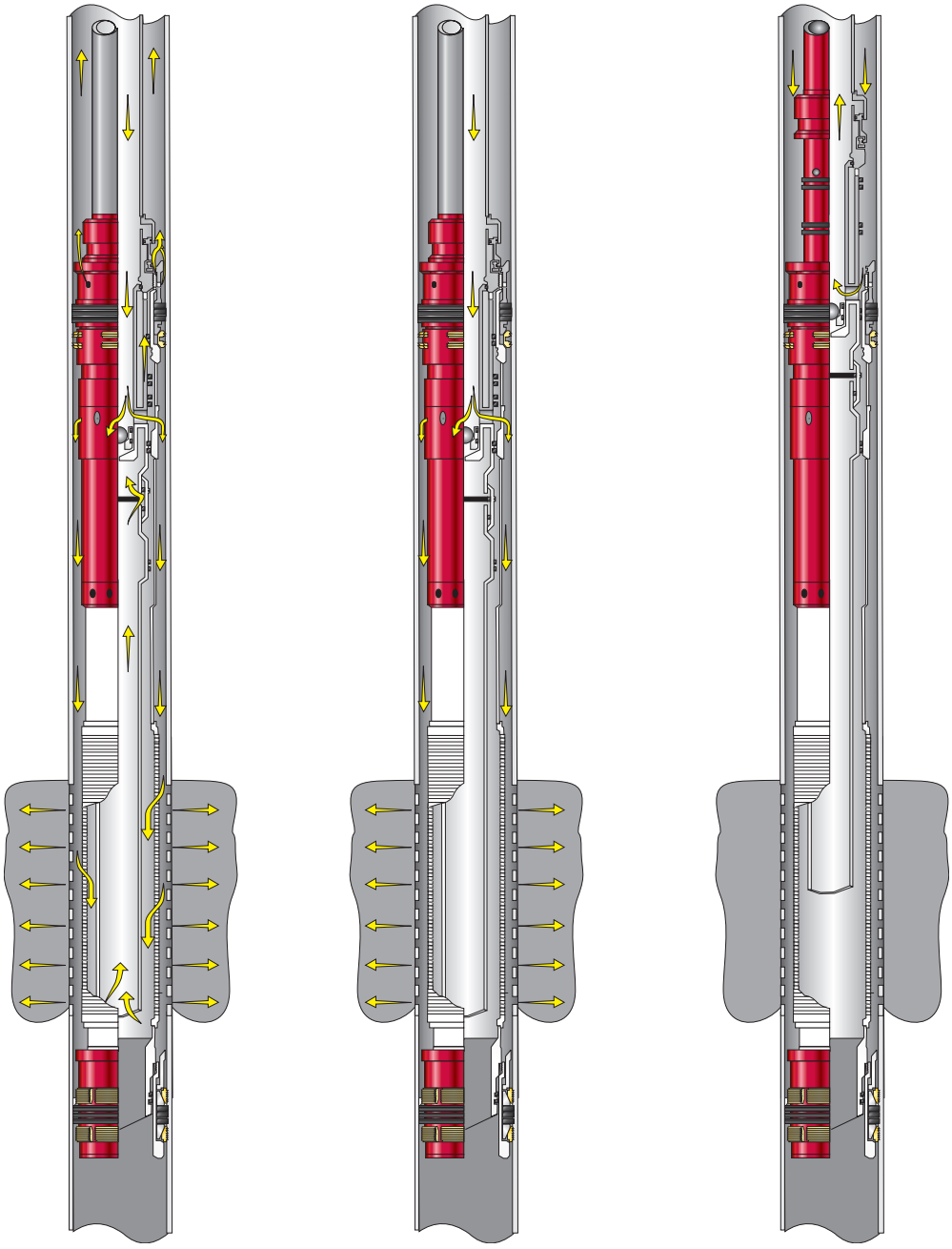
With conventional crossover tool designs, the upper seal on the crossover tool is placed in the packer bore to isolate the return path and place the tool in the squeeze mode. Pipe contraction or inadvertently raising the work string can reposition the tool to the circulating mode, possibly jeopardizing the success of the job. Using conventional tool designs and going to the circulating position requires moving the crossover tool up in the packer bore, disengaging the top seal, and leaving the work string and crossover tool in a 'neutral' position, which is very susceptible to any forces acting on the work string. Being able to leave the work string in compression during critical pumping phases in the squeeze or circulating modes increases the chances of unexpected occurrences that could lead to a failed job or nonproductive time.

The treatment is pumped with the crossover tool in the squeeze or circulating modes until achieving a tip screenout or sandout. Afterwards, the crossover tool is placed in the reverse position by raising the work string and crossover tool high enough to place the packing ports above the packer. Pressure is applied to the casing for reverse-circulating all sand slurry remaining in the work string to surface to be discarded.

After all excess slurry is removed from the well, the crossover tool can be placed back into the circulating position so that fluid can be pumped again to confirm a successful annular gravel pack, pulled from the packer to monitor the well, placed in the reverse position to change out well fluids, or pulled from the well. When the crossover tool is raised from the packer assembly, the shifting collet on the crossover tool automatically closes the closing sleeve below the BlackCat™ packer, isolating the ports through which the sand slurry was pumped. With the treatment complete and the well stable, the work string and crossover tool can be retrieved to surface and the production tubing installed into the well.

Model WFX System—Operational Sequence

The WFX system allows fixed-position gravel packing. A valve located at the lower end of the crossover tool enables or inhibits return flow up the washpipe. Changing the position of the crossover tool relative to the packer is not necessary to place the tool in the squeeze or circulating position. The system's fixed position capability permits both squeeze and circulating modes to be achieved and maintained with the crossover tool securely held in place with compressive force.



Squeezing | Circulating | Reversing out

Model 4P System—Gravel-Pack

Weatherford's Model 4P gravel-pack system is a basic system for cased-hole gravel-pack completions. This style of tool has been in operation for many years and is used around the world.

Major system components include:

Service Tool Assembly

- Hydraulic setting tool
- Model 4P crossover tool

Gravel-Pack Assembly

- BlackCat™ GP packer
- Model G1 sand control extension
- Model SS shear sub
- Blank pipe
- Well Screens—wire-wrapped, pre-pack, or metal mesh
- Snap latch seal assembly
- UltraPak™ sump packer

Components of the Model 4P system are built with standard steel alloys for pressure and rate service that handle most conventional and medium rate gravel-pack treatments. The various available sizes are generally rated to pressures of 6,000 psi (413 bar) and maximum gravel-packing rates of six to twelve barrels per minute (950 to 1900 lpm), depending on the crossover tool size. There are many placement methods for gravel-packing wells and each has its application. Conventional-rate gravel packing at two to four barrels per minute (320 to 640 lpm) has widespread application in wells around the world, because not every well can benefit from or justify high-rate, high-pressure treatments.

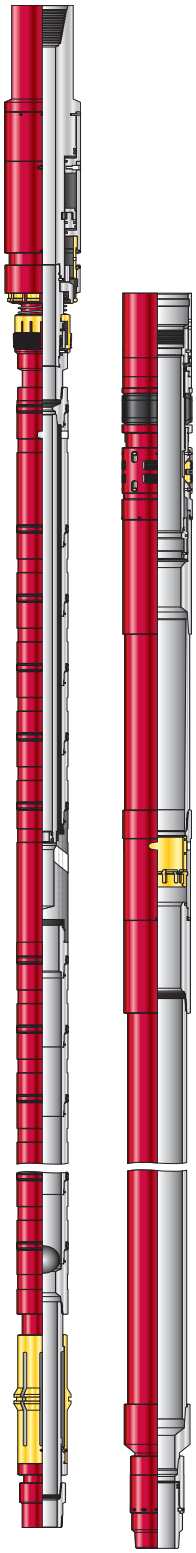
The first well requirement is a quality sump packer that serves as the foundation for the total completion. Weatherford's *UltraPak* permanent sealbore packer is a proven and reliable packer that anchors in any yield casing. The packer can be set using electric line for accurate placement to ensure that perforating guns and the sand-control assembly are properly positioned while relying on pipe measurements. A repeatable snap-latch seal assembly installed on the bottom of the screens serves to give indication of the packer bore being unobstructed and the screens being on-depth before setting the gravel-pack packer and sealing the end of the screens from the annular space being gravel-packed.

Once the assembly is deployed to setting depth and the screens are properly positioned across the production or injection interval, the *BlackCat* GP packer is set hydraulically by dropping a setting ball and applying pressure down the work string from surface. Once the packer is set, the service tool is released from the packer and the tool can be placed in various positions, depending on the pumping operation and path of pumped fluids.

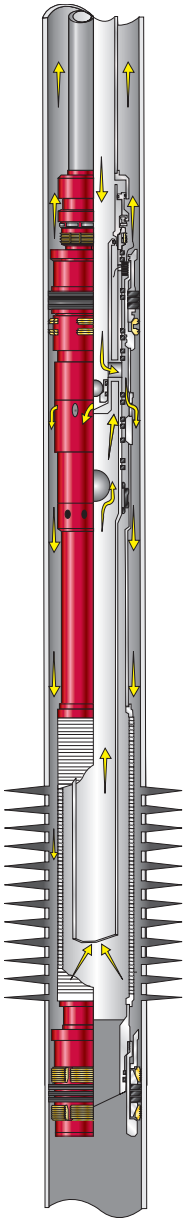
If the formation is to be stimulated prior to the gravel pack, the crossover tool is placed into the squeeze position so the acid is forced into perforations. This serves to open or breakdown the perforations, improving the leakoff into the formation and improving the chances of filling the perforation tunnels with clean, high-permeability gravel-pack sand. Typically, the gravel pack is pumped with the crossover tool in the circulating position. This position carries the sand slurry to the bottom of the sand screens. Fluid leakoff into the formation serves to carry sand into the perforation tunnels. After filling the annulus with sand that covers the well screens, a pressure increase is seen in the pump pressure. If sufficient sand is pumped to accomplish the gravel pack, the crossover tool is raised to the reverse position, placing the gravel-pack ports above the packer. Switching the lines at surface to pump down the casing allows reverse-circulation of all the sand slurry remaining in the work string to surface to be discarded.

After all excess slurry is removed from the well, the crossover tool can be placed back into the circulating position so that fluid can be pumped again to confirm a successful annular gravel pack, pulled from the packer to monitor the well, placed in the reverse position to change out well fluids, or pulled from the well. When the crossover tool is raised from the packer assembly, the shifting collet on the crossover tool automatically closes the closing sleeve below the *BlackCat* packer isolating the ports that the sand slurry was pumped through. With the treatment complete and the well stable, the work string and crossover tool can be retrieved to surface and the production tubing installed into the well.

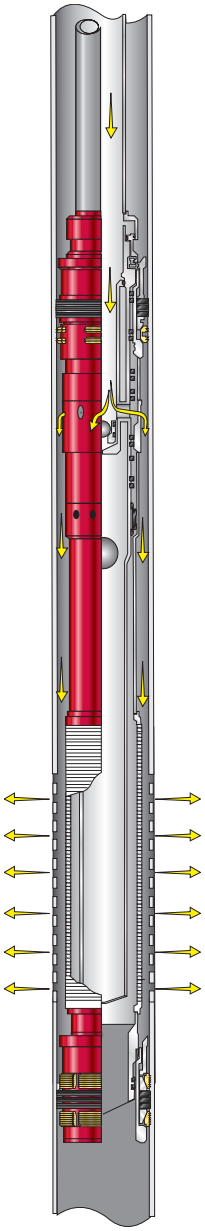
Model 4P—Operational Sequence



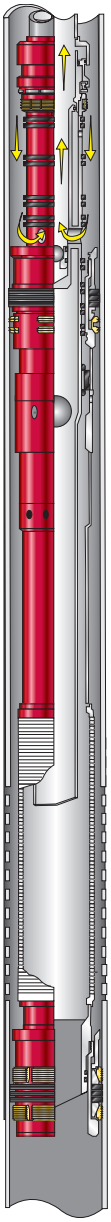
The Model 4P crossover tool is a conventional sand-control tool design. It is placed in the squeeze position by slacking off totally into the packer, the circulating position by raising the tool slightly relative to the packer, exposing the return ports to the upper annulus, and the reverse position by raising the tool until the gravel-pack ports are above the packer. This tool design is used in most markets around the world and is familiar to most tool operators, rig personnel, and customers.



Circulating



Squeezing



Reversing out

Model 4P Washdown System

Weatherford's Model 4P washdown gravel-pack system is a modification of the standard 4P system that permits circulating through a concentric passage in the crossover tool and down the washpipe inside the screen during the deployment process. This is accomplished by having a modified crossover port assembly in the crossover tool. This ported sub includes a movable piston, which, when run in the well, isolates the crossover ports and is open through its center. The piston includes a seat for the packer-setting ball and a flapper that serves as the low bottomhole-pressure check valve. When the setting ball is dropped and pressure is applied to set the packer, exceeding the setting pressure causes the piston to move down. This exposes the gravel-packing ports of the closing sleeve and causes the flapper to spring downward and functions as a check valve, enabling circulated fluid to return up the casing, but preventing fluid and pressure from the casing to transmit down the washpipe. The setting ball serves to plug the open bore of the crossover tool and divert pumped fluids through the crossover ports.

Major system components include:

Service Tool Assembly

- Hydraulic setting tool
- Model 4P washdown crossover tool

Gravel-Pack Assembly

- BlackCat™ GP packer
- Model G1 sand-control extension
- Model SS shear sub
- Blank pipe
- Well screens—wire-wrapped, pre-pack, or metal mesh
- Snap latch seal assembly
- UltraPak™ sump packer

All components and accessories are identical to those used with the standard 4P system.

The operating procedure for the Model 4P washdown crossover tool is the same as for the standard 4P crossover tool. The difference is that it is possible to circulate down the washpipe prior to setting the packer. This feature is necessary in wells where fluid is to be circulated from the bottom of the screens prior to performing the gravel pack. After the setting ball is dropped and the packer is set, the crossover tool functions as a standard crossover tool.

HUN System—Gravel-Pack

For a well with reserves that do not justify higher-end gravel-pack treatments, Weatherford's HUN system may be the right solution for the application. The HUN system uses common mechanical packers to deploy and perform the gravel pack. This service assembly is disconnected from the screen assembly prior to pumping the gravel-pack treatment. Once the gravel pack is complete, the packer and gravel-pack service assembly is retrieved from the well. A polished nipple is left in the well made up to the top of the blank pipe and serves as the connection point for the production tubing.

Major system components include:

Service Tool Assembly
- Model HD or PR3 mechanical packer
- HUN hydraulic release hookup nipple kit
  - Circulating
  - Squeeze

Gravel-Pack Assembly
- HUN hookup nipple
- Blank pipe
- Well screens—wire-wrapped, pre-pack, or metal mesh
- Bull plug

Production Assembly
- Production packer; e.g. ArrowSet 1X, Model PR3, Hydrow 1, etc.
- HUN overshot

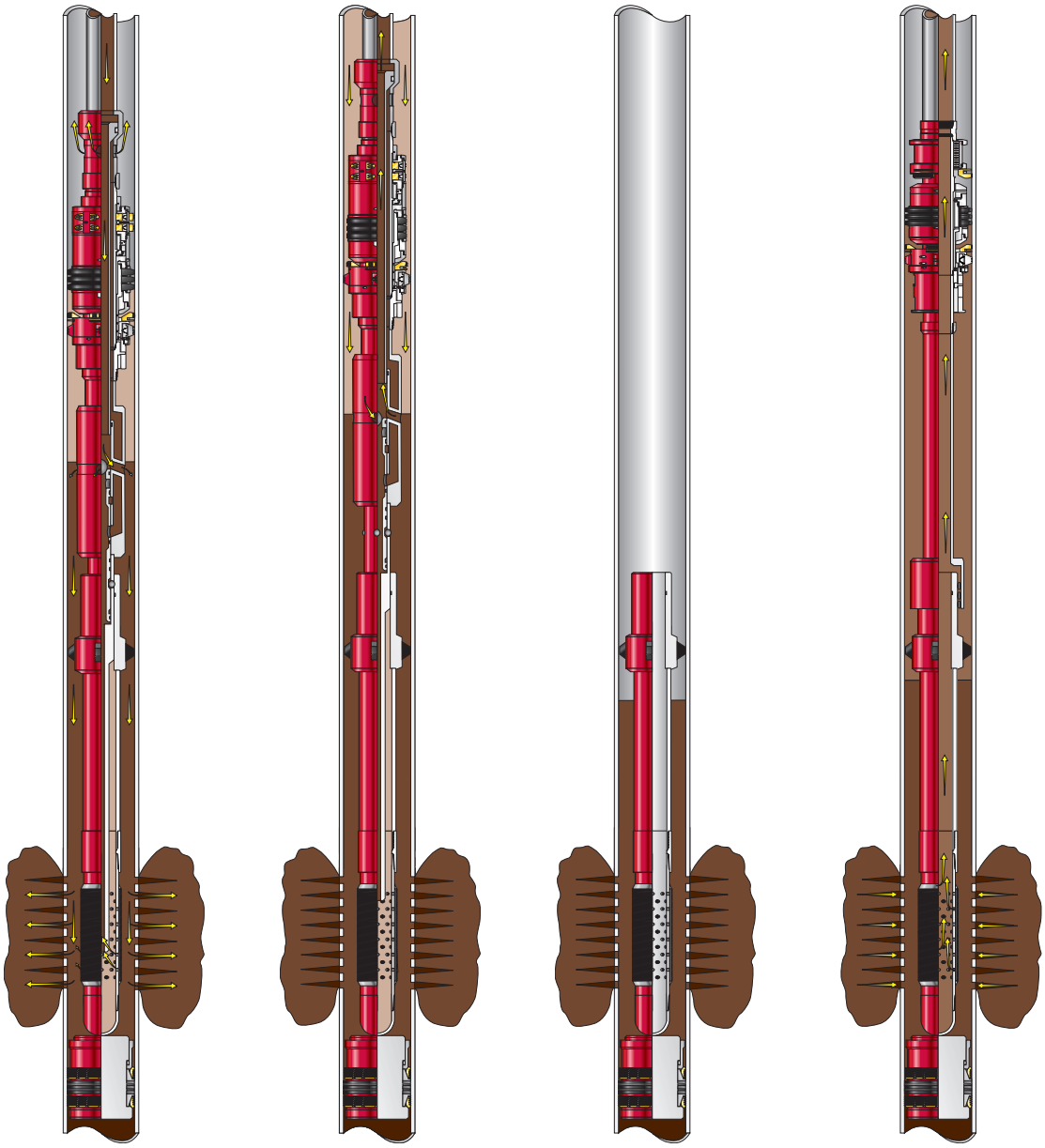
Unlike those systems utilizing a retrievable sealbore packer and crossover tool, HUN gravel-pack kits are either circulating style or squeeze style. The tools cannot be alternated between these fluid path modes. Generally, circulating a gravel pack in place is the preferred method and squeeze gravel packs are only chosen in specific situations, such as where the well has questionable casing integrity above the packer setting depth.

The well should be prepared by having a solid bottom, such as cement or a cast iron bridge plug in close proximity to the perforations. The well screens with a bull plug on the end, blank tubing, and the HUN gravel-pack kit assembled to a mechanical service packer, such as Weatherford's Model HD or Model PR3 packers, run into the well. The assembly is deployed to bottom. The assembly is raised enough to accommodate the setting stroke of the packer and to leave the bull plug just slightly off the bottom of the well. The packer is set by rotating to the right and slacking off enough weight to compress the packer elements. After pressure testing the packer to ensure an effective pressure seal with the casing, a ball is dropped down the work string, and pressure is applied to release the screens from the gravel-pack service-tool assembly. The weight of the screens causes them to fall until contacting the bottom of the well but the HUN at the top of the blank pipe remains in sealed contact with an expansion joint in the gravel-pack service-tool assembly.

The sand-control treatment can then be pumped. Once sandout is accomplished, the work string is raised to open the integral bypass of the service packer and fluid is pumped down the casing to reverse out the excess sand slurry remaining in the work string. The gravel-pack service tool assembly is pulled from the well, leaving the HUN extending from the top of the blank. The production tubing with an overshot for the HUN and a production packer can then be run into the well to prepare it for production.

HUN System—Operational Sequence

The HUN gravel-pack system is a service kit that is made up to a suitable mechanical packer and run into the well for the gravel-pack execution. After the gravel pack is performed, the service tools, including the packer, are pulled from the well. The screens are left in the well with a HUN facing up on top of the blank. The production tubing and packer are run into the well with an overshot on the bottom of the tubing that will engage the HUN and seal for flow-stream continuity.



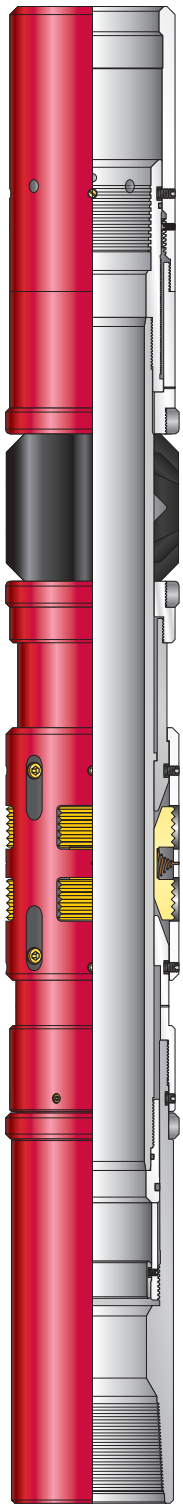
Set packer, drop ball And gravel-pack

Release packer, Reverse excess sand

Pull out of hole

Install production string

BlackCat™ GP Packer for the Model 4P Gravel-Pack System



Weatherford's *BlackCat* GP packer for the model 4P gravel-pack system provides reliable, high-pressure sand control for production, completion, and injection.

In a gravel-pack application, the packer is used with the gravel-pack hydraulic setting tool, Weatherford's model 4P crossover service tool, and model G1 gravel-pack extension. The packer can be run in a non-gravel-pack application, such as one with stand-alone sand screens, liners, or tubing-conveyed perforating (TCP) guns suspended beneath. The field-proven, reliable, ECNER® array packer element provides a superior seal that enables the packer to pack off easily and resist swabbing.

Components of the packer are rotationally locked. The field-proven packer cannot release with differential changes or tensile or compressive loading. Only a retrieving tool run on a work string removes the packer from the wellbore.

Applications

- Conventional and high-rate gravel packing
- Installation of stand-alone screens
- High-pressure production and injection
- Stimulation and fracture
- TCP completions

Features, Advantages and Benefits

- The slips are below the element to prevent the buildup of debris in and around them, reducing the times for circulation and total retrieval.
- The retrieval mechanism is protected from well debris and flow and must be actuated to release the packer, ensuring trouble-free retrieval on the first attempt.
- The components are rotationally locked to prevent them from spinning, which reduces milling time if the packer cannot be retrieved normally.

ECNER is a registered trademark of OEM Components, Inc.

BlackCat™ GP Packer for the Model 4P Gravel-Pack System

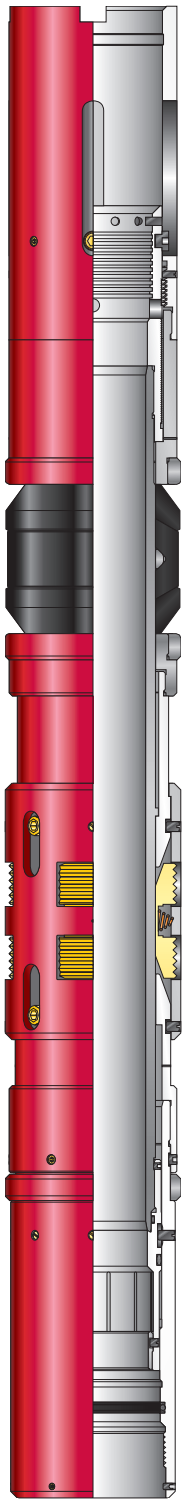
Specifications

Casing				Packer			
OD (in./*mm*)	Weight (lbm/ft, *kg/m*)	Minimum ID (in./*mm*)	Maximum ID (in./*mm*)	Maximum OD (in./*mm*)	Sealbore (in./*mm*)	Bottom Thread	Part Number
5-1/2 139.7	20.0 to 23.0 29.8 to 34.2	4.670 118.62	4.778 121.36	4.500 114.30	3.000 76.20	4-in. 8 SA[a] pin	1119607
	14.0 to 20.0 20.8 to 29.8	4.778 121.36	5.012 127.31	4.625 117.47			1119153
5-3/4 146.0	14.0 to 19.5 20.8 to 29.1	5.090 129.29	5.290 134.37	4.791 121.69			1124741
6 152.4	20.0 to 26.0 29.8 to 38.7	5.134 130.40	5.352 135.94	4.791 121.69			
6-5/8 168.3	20.0 to 28.0 29.8 to 41.7	5.791 147.09	6.049 153.64	5.540 140.72			1125798
7 177.8	29.0 to 35.0 43.2 to 52.1	6.004 152.50	6.184 157.07	5.813 147.65	4.000 101.60	5 1/2-in. LT&C[b]	905230
	23.0 to 32.0 34.2 to 47.6	6.094 154.79	6.366 161.70	5.938 150.82			905231
	20.0 to 26.0 29.8 to 38.6	6.276 159.41	6.456 163.98	6.026 153.06			1203228
7-5/8 193.7	29.7 to 39.0 44.2 to 58.0	6.625 168.28	6.875 174.62	6.438 163.52			905688
9-5/8 244.5	47.0 to 53.5 70.0 to 79.7	8.535 216.79	8.681 220.50	8.281 210.34	4.750 120.65	6 5/8-in. LT&C[b]	1337446
	36.0 to 43.5 53.7 to 64.8	8.755 222.38	8.921 226.59	8.539 216.89			TBD

[a]Stub Acme

[b]Long thread and coupling

WFX-Style BlackCat™ Packer



Weatherford's premium WFX-style *BlackCat* packer is an enhanced version of the reliable, field-proven *BlackCat* retrievable sealbore packer. The WFX-style *BlackCat* packer is specifically manufactured to meet the present and future demands of sand-control completion techniques. The packer can be used for production, injection, TCP, well testing, stand-alone screen deployment, gravel-packing, and frac-packing applications.

The WFX-style packer can be set by wireline or hydraulically. For optimal torque and weight-carrying capabilities, the packer should be set with Weatherford's WFX setting tool. A specialized profile on the packer's setting sleeve mates with a corresponding profile on the WFX setting tool, which allows for torque ratings through the assembly comparable to that of common tubing sizes. Setting on pipe enables the packer to be placed in highly deviated wells and helps to carry completion assemblies with high hang weights. Setting on wireline minimizes rig time and enables more accurate placement of the packer.

The WFX-style packer includes the patented ECNER® array packing element system, which provides a superior seal to allow the packer to pack-off easily and resist swab-off. These fully engineered packers have passed rigorous ISO 14310 test requirements. The packer can be retrieved with standard *BlackCat* retrieving tools, and shares common accessories with Weatherford's UltraPak™ permanent packer system.

Applications

- Frac packing
- Gravel packing
- Stand-alone screens
- Horizontal completions
- Liner deployments
- Production
- Injection
- Well testing
- TCP

ECNER is a registered trademark of OEM Components, Inc.

WFX-Style BlackCat™ Packer

Features, Advantages and Benefits

- The packer components are rotationally locked to the WFX setting tool to allow rotation into liner tops and past bridges in horizontal sections, thereby saving rig time.
- The retrievable seal bore packer can be removed without milling, which helps prevent damage to the wellbore and saves rig time.
- The packer's high-pressure rating improves reliability when it is exposed to pressure differentials, enabling deployment in high-pressure reservoirs.
- The high-tensile strength of the heavy-duty packer allows it to carry long lengths of production liner, isolation tubing, perforating guns, or sand-control screens, resulting in efficient and cost-effective completions.
- No rotation is required to run or retrieve the packer, which saves rig time and improves operational success.
- The ECNER array system reduces the swab-off effect and facilitates center packoff by enabling supporting force to be applied to the outer elements.
- The field-proven design, with the slips below the elements, prevents debris buildup in and around the retrieval mechanism, reducing circulation time while improving the success rate for retrieval operations.
- The packer can be set hydraulically or by wireline, which provides flexibility when deploying the packer.
- Compatibility with UltraPak™ permanent packer accessories reduces cost and inventory.

WFX-Style BlackCat™ Packer

Specifications

Casing				Packer		
OD (in./*mm*)	**Weight (lb/ft, *kg/m*)**	**Minimum ID (in./*mm*)**	**Maximum ID (in./*mm*)**	**Maximum OD (in./*mm*)**	**Seal Bore ID (in./*mm*)**	**Part Number**
5 *127.0*	18 *26.76*	4.276 *108.610*	4.276 *108.610*	3.969 *100.813*	2.688 *68.275*	882865
	13 to 15 *19.34 to 22.32*	4.408 *112.000*	4.494 *114.150*	4.250 *107.950*		882858
5-1/2 *139.7*	20 to 23 29.76 to 34.22	4.670 *118.618*	4.778 *121.361*	4.500 *114.300*		828238
	14 to 17 *20.83 to 25.29*	4.892 *124.257*	5.012 *127.305*	*4.642* *118.000*		826457
7 *177.8*	29 to 35 *43.15 to 52.07*	6.004 *152.502*	6.184 *157.074*	5.813 *147.650*	*4.000* *101.600*	1113437
	23 to 32 *34.22 to 47.61*	6.094 *154.788*	6.366 *161.696*	5.938 *150.825*		1113425
7-5/8 *193.7*	33.7 to 39 *50.14 to 58.03*	6.625 *168.275*	6.765 *171.831*	6.438 *163.525*		916858
	24 to 29.7 *35.71 to 44.19*	6.875 *174.625*	7.025 *178.435*	*6.688* *169.875*		916856
9-5/8 *244.5*	43.5 to 47 *64.73 to 69.93*	8.681 *220.497*	8.755 *222.377*	TBD	6.000 *152.400*	TBD
	47 to 53.5 *69.93 to 79.60*	8.755 *222.377*	8.535 *216.789*	8.319 *211.303*		1191001
10-3/4 *273.0*	79.2 to 85.3 *117.83 to 126.92*	9.282 *235.762*	9.156 *232.562*	8.875 *225.425*		1376691

Bottom Subs

Packer Size (in./*mm*)	**Packer Bore (in./*mm*)**	**Connects to:**		
		Model G2 Extension	**Seal Bore Extension**	**Blank***
5 *127.0*	2.688 *68.3*	890782	890841	890748
5-1/2 *139.7*		885999	886013	908064
7 *177.8*	4.000 *101.6*	1139356	1139357	902828
7-5/8 *193.7*		956368	956763	889874
9-5/8 *244.5*	6.000 *152.4*	1217391	1246697	1246259
10-3/4 *273.0*		TBD	TBD	TBD

* Additional bottom subs set up to various tubing and casing threads

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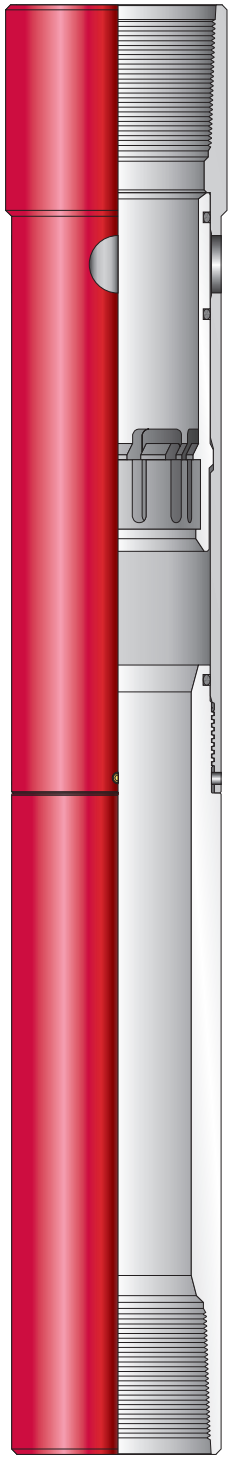
Model G1 Gravel-Pack Closing Sleeve



Weatherford's Model G1 gravel-pack closing sleeve provides the control path to the annulus for sand-slurry flow in gravel-pack completions. After the slurry is placed, the sleeve closes and provides reliable, long-term isolation of the inside of the well screens from the slurry. The sleeve is used with Weatherford's BlackCat™ GP retrievable sealbore packer and Model 4P crossover tool.

Casing extensions are installed above and below the sleeve housing to accommodate the crossover tool during deployment. A shifting tool installed as part of the crossover tool opens and closes the sleeve. The sleeve is usually deployed in the *open* position, enabling the work string to fill with fluid as the gravel-pack assembly is deployed in the well.

After the assembly is on-depth and the packer is set, the sand slurry is pumped and exits the sleeve, entering the annulus around the screen. A sealbore below the sleeve enables the crossover tool to seal below the ports, isolating the slurry flow path.

After the job, the sleeve is shut as the crossover and shifting tools are withdrawn. The annulus above the screen is isolated from the flow stream, preventing inadvertent sand flow through the gravel-pack ports. The closed, sealed ports also effectively enable the installation of zonal isolation devices in the blank and screen setting. The collet design enables the sleeve to be repeatedly opened and closed.

Applications

- Gravel packing
- Fluid change in openhole completions

Features, Advantages and Benefits

- The rugged construction of the sleeve enables it to be opened and closed multiple times and still maintain the sealing integrity.
- The large flow area for the sand slurry reduces the risk of erosion, contributing to a better gravel pack.

Model G1 Gravel-Pack Closing Sleeve

Specifications

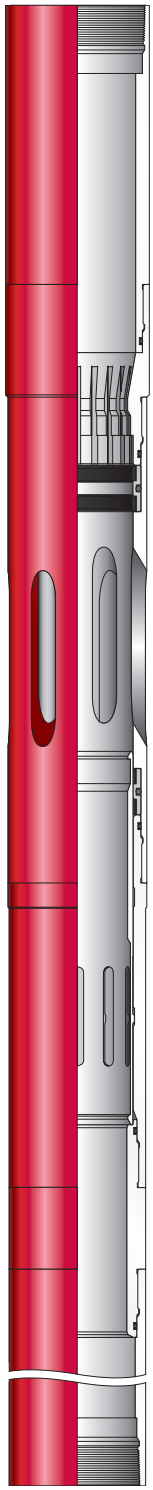
Sealbore size (in./*mm*)	3.00 *76.2*	4.00 *101.6*	4.75 *120.7*
Maximum OD (in./*mm*)	4.53 *115.1*	5.82 *147.8*	7.40 *188.0*
Minimum ID (in./*mm*)	3.00 *76.2*	4.00 *101.6*	4.75 *120.7*
Top thread box connection	4-in. 8 SA[1]	5 1/2-in. LTC[2]	6 5/8-in. STC[3]
Bottom thread box connection	4-in. NU[4] 8rd	5-in. LTC	6 5/8-in. STC
Flow port area (in.^{2}/*cm*^{2})	10.125 *65.322*	7.069 *45.606*	
Part numbers			
Closing sleeve	783723	173441	752957
Standard upper extension	Included	785887	1322683
Standard lower extension	806142	795091	1322675

[1]Stub Acme
[2]Long thread and coupling
[3]Short thread and coupling
[4]Nonupset
Note: Extensions to complete the assembly must be ordered separately

Options

- The sleeve is available in standard and premium metallurgy.
- Though the sleeve has standard oilfield connections, the casing extensions can be modified to meet rig requirements.

Model G2 Frac-Pack Extension



Weatherford's Model G2 frac-pack extension is a closing-sleeve extension that opens and closes repeatedly with the insertion and withdrawal of the WFX crossover tool. This heavy-duty, ported extension is specifically designed for sand control in rigorous high-rate, high-pressure, gravel-packing applications, such as frac packing. The ported housing of the G2 extension is designed for maximum flow rate with minimal erosion to the extension components and the well casing. Multiple flow ports are engineered to dissipate and distribute flow to minimize unwanted turbulence.

After sand-control treatment, the G2 extension is closed to isolate the gravel-pack ports and prevent the flow of sand up the annulus and into the gravel-pack assembly. The G2 extension also allows for the effective installation of fluid-loss control or zonal isolation before the well is brought on production. The Model G2 extension uses extremely durable, bonded elastomeric seals with redundant sealing mechanisms to ensure seal integrity, even after extensive sand concentrations have flowed at high rates through the assembly. The metal components are built with high-strength steels to enable the assembly to withstand the powerful collapse forces regularly experienced in high-rate, high-pressure treatments.

Applications

- Frac packing
- Gravel packing

Features, Advantages and Benefits

- Large flow areas lessen the velocity and turbulence of sand slurries, thereby mitigating erosion-related damage to completion equipment and the well casing.
- Exit ports are phased by 60° to divide the slurry into multiple streams when exiting the work string, which dissipates slurry energy and minimizes unwanted turbulence.
- Minimal flow restriction around the tool exterior allows the slurry to flow freely, thereby reducing backpressure.
- Durable, bonded elastomeric seals help ensure the pressure integrity of the closing sleeve.
- High-strength, high-torque assembly threads allow the tool to carry heavy BHAs, allowing for more efficient and cost-effective completions of longer intervals. The threads also allow rotation, when necessary, to bring the BHA on depth.

Model G2 Frac-Pack Extension

- High-yield strength metals improve reliability when the G2 extension is exposed to pressure differentials, enabling deployment in high-pressure reservoirs. High-pressure differentials also occur in low- and medium-pressure reservoirs, as sand-control treatments can advance an average reservoir into a high-pressure state in an instant.

Specifications

Standard Low Alloy Steel Assemblies

ID (in./*mm*)	OD (in./*mm*)	Length (in./*mm*)	Top Thread	Bottom Thread	Part Number
2.688 *68.28*	3.97 *100.84*	159 *4,039*	3.500 – 8 SA[1] box	3.500 – 8 SA box	879019
4.000 *101.60*	5.81 *147.57*	182 *4,623*	5.375 – 8 SA box	4.938 – 8 SA box	914688
6.000 *152.40*	8.01 *203.45*	189 *4,801*	7.313 – 8 SA box	7.188 – 8 SA box	1215521

Standard Lower Adapters to Screen

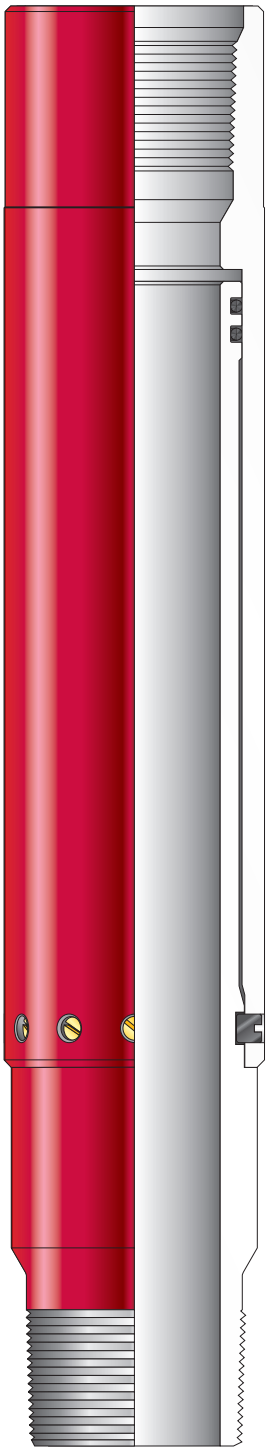
2.688 Model G2 Closing Sleeve				
Top Thread	3.500 – 8 SA pin	3.500 – 8 SA pin	3.500 – 8 SA pin	3.500 – 8 SA pin
Bottom Thread	2-3/8 EU[2] 8RD pin	2-3/8 NU[3] 10RD pin	2-7/8 EU 8RD pin	2-7/8 NU 8RD pin
Part number	1142275	1142273	1142263	1142258

4.000 Model G2 Closing Sleeve				
Top Thread	5.375 – 8 SA pin	5.375 – 8 SA pin	5.375 – 8 SA pin	5.375 – 8 SA pin
Bottom Thread	3-1/2 EU 8RD pin	3-1/2 NU 10RD pin	4.000 NU 8RD pin	4-1/2 LTC[4] pin
Part number	1142380	1142406	1142424	1142444

6.000 Model G2 Closing Sleeve		
Top Thread	7.188 – 8 SA pin	
Bottom Thread	5.00 LTC pin	5-1/2 LTC pin
Part number	1217633	1217623

[1]Stub Acme
[2]External upset
[3]Nonupset
[4]Long thread and coupling

Model SS Gravel-Pack Shear Sub



Weatherford's Model SS gravel-pack shear sub is a shear joint designed for installation below the BlackCat™ gravel-pack assembly and above the well screens. The shear sub provides a predetermined shear value that enables easy retrieval of the packer, while leaving the screen in place. The shear value of the sub is readily verifiable and adjustable in the field.

During workover operations, having a shear sub in place eliminates the need to run electric line for cutting blank pipe below the packer. The Model SS shear sub is designed and constructed so that torque is transmitted through the BHA, enabling rotation of the screens during deployment.

In fishing operations, when the Model SS shear sub is parted, the OD of the portion remaining in the well is of similar diameter with the thread OD of the original pipe string, ensuring the remaining sub does not impede fishing attempts or running a washpipe over the screen setting.

Applications

- Gravel-pack completions
- Stand-alone-screen installations
- Workover and fishing operations

Features, Advantages and Benefits

- The adjustable shear rating of the Model SS shear sub permits the operator to choose a shear value that matches the well conditions or rig capabilities, reducing the need for expensive fishing tools or more powerful rigs.
- The shear sub is designed and constructed to transmit torque through the BHA, enabling rotation of the screens during deployment. This feature decreases the difficulty of getting over liner tops or stinging into sump packers.
- A properly selected Model SS shear sub facilitates the fishing of the screen assembly, as overshots and washpipe will pass over the bottom sub. The use of this sub can minimize rig time and fishing costs.

Model SS Gravel-Pack Shear Sub

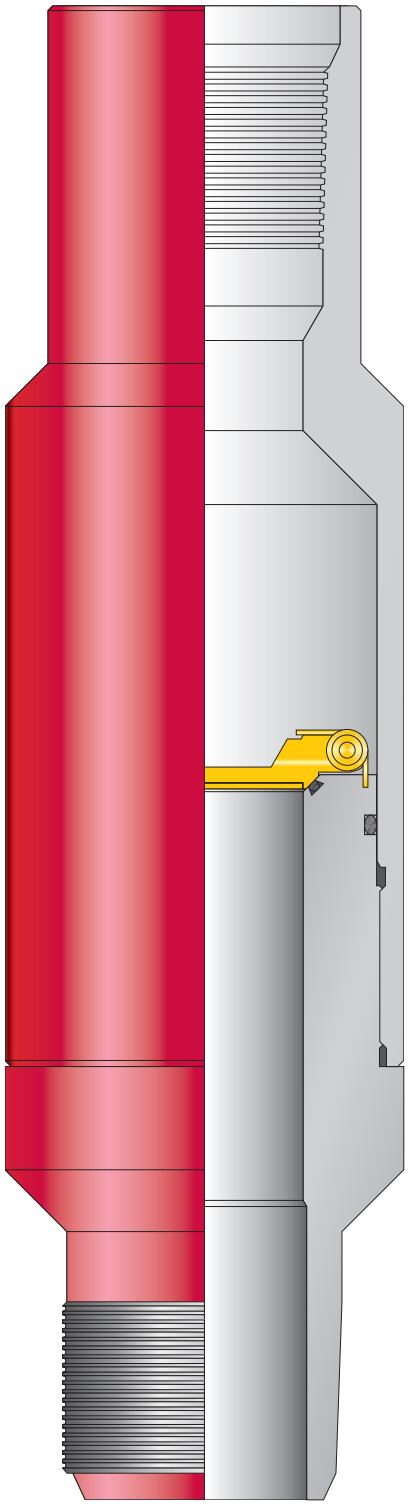
- The Model SS gravel-pack shear sub is available in both short- and long-stroke versions. In some operational environments, the likelihood of shearing the device during treatments increases. Having a longer sealing stroke provides more assurance of keeping seals in contact in the event of prematurely shearing the sub, preventing pumping sand inside the screen or having an unwanted flow path.

Specifications

Size	Thread B×P	Maximum OD (in./*mm*)	Fishing OD (in./*mm*)	Minimum ID (in./*mm*)	Maximum Shear Value (lb/*kg*)	Model SS4 4-in. Stroke	Model SS12 12-in. Stroke
2-3/8	EU[1] 8RD	3.10 *78.74*	2.89 *73.40*	1.98 *50.29*	43,500 *19,731*	918220	918243
	NU[2] 10RD					918251	918246
2-7/8	EU 8RD	3.71 *94.23*	3.55 *90.17*	2.43 *61.72*	43,500 *19,731*	1125211	1125682
	NU 10RD					1125446	1126786
3-1/2	EU 8RD	4.55 *115.57*	4.30 *109.22*	2.98 *75.69*	63,600 *28,848*	1125135	1127046
	NU 10RD					1126839	1127048
4	NU 8rd	4.80 *121.92*	4.80 *121.92*	3.46 *87.88*	63,600 *28,848*	1151965	1151986
4-1/2	LTC[3]	5.46 *138.68*	5.05 *128.27*	3.91 *99.31*	63,600 *28,848*	1152219	1152208
5	LTC	5.88 *149.35*	5.55 *140.97*	4.26 *108.20*	63,600 *28,848*	1312307	1291447
5-1/2	LTC	6.05 *153.67*	6.05 *153.67*	4.67 *118.62*	63,600 *28,848*	1312324	1321716

[1]External upset
[2]Nonupset
[3]Long thread and coupling

Model FLF Fluid-Loss Flapper Valve



Weatherford's model FLF fluid-loss flapper valve is a robust device that can help operators stem the undesired loss of well-completion fluid into a formation, after a production or gravel-pack packer is installed in the well. Perforated or openhole wells often experience severe fluid loss resulting from hydrostatic overbalance and good permeability. Fluid loss can occur as a result of different completion-related events, including perforating, removal, loss of filter cake or fluid-loss material, acidizing, gravel packing, or frac packing. Having a fluid-loss valve in the completion assembly can eliminate the need to spot fluid-loss pills, which can result in damage to the formation or additional intervention to remove.

The model FLF valve is a simple-to-operate valve that enables the completion process to continue without addressing fluid loss or the resulting well-control issues that could arise from the loss of hydrostatic pressure. The valve uses a spring-loaded, beryllium copper flapper, which is normally held open by a washpipe or a stinger made up to the packer setting tool. After the packer is set and the setting tool is withdrawn, the flapper closes. Hydrostatic overbalance keeps the flapper closed. If an underbalance is created above the flapper, it opens and the well can flow.

The flapper is normally removed at the end of the completion process by mechanically breaking it. This removal can be completed with the production seal assembly, slickline, or coiled tubing. The flapper fragments are then allowed to fall out of the way to the bottom of the well. The beryllium copper flapper is designed to break into small pieces, allowing the pieces to fall to the bottom of the well. It is not recommended to break this flapper with pressure.

Applications

- Gravel-pack and frac-pack completions
- Stand-alone screen completions

Features, Advantages and Benefits

- The FLF flapper valve is made in common screen and blank sizes and threads.
- If the BHA encounters obstructions, the valve's simple and torsionally locked design enables rotation of the assembly, which could eliminate the need to pull out of the well.
- The flapper valve prevents fluid loss into weak formations, saving rig time spent addressing fluid loss.

Model FLF Fluid-Loss Flapper Valve

- Use of the FLF flapper valve can prevent the spotting of fluid-loss pills, which could result in reduced productivity from the well.
- Removal methods of the valve are basic and inexpensive.

Specifications

Size (in./*mm*)	OD (in./*mm*)	ID (in./*mm*)	Material Yield (psi/*MPa*)	Housing Pressure Rating (psi/*MPa*)	Flapper Pressure Rating (psi/*MPa*)	Part Number
2-3/8 *60.33*	3.90 *99.06*	1.93 *49.02*	80,000 *550*	10,000 *68.95*	2,500 *17.24*	1135348
4 *101.60*	5.56 *141.22*	3.21 *81.53*	110,000 *758*	10,000 *68.95*	2,500 *17.24*	1165965
4-1/2 *114.30*		3.24 *82.30*				1165966
5 *127.00*	7.91 *200.91*	4.27 *108.46*	110,000 *758*	10,000 *68.95*	1,500 *10.34*	1333794
5-1/2 *139.70*		4.50 *114.30*				1331413

Splined Thermal Expansion Joint

Weatherford's splined thermal expansion joint compensates for tubing movement resulting from temperature and pressure variations during production, shut-in, or stimulation in single-string completions. The spline enables the tubing to transmit torque throughout the stroke length of the joint. A premium seal system maintains the pressure seal.

Applications

- Single-string completions
- High-temperature steam injection
- Cyclic steam injection
- Geothermal production
- Deviated and horizontal wells

Features, Advantages and Benefits

- The joint can be pressure tested at the surface to ensure seal integrity.
- The joint design enables it to be stacked for additional stroke requirements, reducing inventory and saving rig time.
- The rugged construction provides high-tensile strength for maximum durability.
- The full-bore construction provides an unrestricted ID that enables the maximum flow rate.

Splined Thermal Expansion Joint

Specifications

Tubing Size[1] (in./*mm*)	Maximum OD (in./*mm*)	Minimum ID (in./*mm*)	Stroke[2] (ft/*m*)	Part
2-3/8 *60.325*	3.260 *82.804*	1.990 *50.546*	10 *3*	00734840
2-7/8 *73.025*	4.010 *101.854*	2.370 *60.198*		00735048

[1]EUE connections are standard. NU and premium connections are available.
[2]Alternate strokes are available on special order.

Options

- Premium seal stacks are available in materials compatible with fluid environments.
- Long-life seal systems are available.

OptiSlim™ Sliding Sleeve

Weatherford's *OptiSlim* sliding sleeve is a reduced-OD version of the OptiSleeve™ sliding sleeve. This tubing-mounted device is sized to fit inside sand screens to regulate flow from individual producing zones or to control communication between the tubing and the annulus. Operators can choose one of three different shifting profiles to allow the operation of multiple sleeves in the same well. The non-elastomeric seals of the *OptiSlim* sleeve are chemically inert for most hostile environments. Either special tubing-mounted shifting tools or standard wireline equipment can be used to open and close the *OptiSlim* sleeve.

Applications

- Displacing fluids in tubing and annulus
- Producing multiple zones through a single string inside sand screens
- Gas lifting
- Circulating inhibitors for corrosion control
- Preserving completion fluids in post-gravel-pack operations

Features, Advantages and Benefits

- High-pressure, chevron-type seal stack is chemically inert for use in most hostile environments, including exposure to oil-based mud and amine inhibitors. This feature virtually eliminates the risk of seals becoming brittle or bonding to metal parts, which can lead to equipment failure.
- Non-elastomeric seals also provide reliable sealing at temperatures up to 375°F (190°C) and 10,000 psi (68.9 MPa) and maintain the seal when cooled down from higher to lower wellbore temperatures.
- The ability to open and close individual sleeves provides control over communication between zones, allowing various sleeves to be run in tandem, enhancing isolation and production of multiple zones.
- Integrated flow-control nipple profile can be chosen to integrate the sleeve with the rest of the completion, improving operational efficiency.
- Flow-control devices, such as plugs and separation sleeves, can be installed in the nipple profile, saving the cost of additional nipples in the completion.
- Special tubing-mounted shifting tools or standard wireline equipment can be used to open or close the sleeve, providing operational flexibility and equipment cost savings.
- Tool can be shifted under moderate differential pressure, preserving flow integrity when operating with sand-control equipment installed.

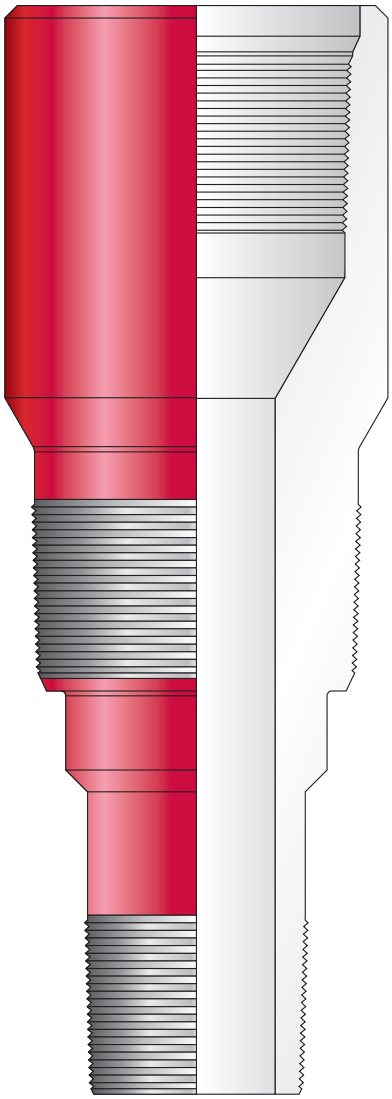
OptiSlim™ Sliding Sleeve

Specifications

Tubing Size (in.)	Seal Bore (in./*mm*)	Tool					
		OD (in./*mm*)	Maximum Pressure Rating (psi/*MPa*)	Maximum Temperature Rating (°F/°*C*)	Tensile Strength (lbf/*kN*)	Differential Operating Pressure (psi/*MPa*)	Seal Material
2-3/8	1.875 *47.62*	3.09 *78.49*	10,000 *68.95*	375 *190*	72,000 *320.27*	1,500 *10.34*	PEEK® PEEK HT™ Teflon®
2-7/8	2.188 *55.58*	3.20 *81.30*			136,000 *604.96*	2,000 *13.79*	
	2.312 *58.72*						
3-1/2	2.562 *65.07*	4.10 *104.10*			210,000 *796.23*	1,500 *10.34*	
	2.750 *69.85*						
	2.812 *71.42*						

PEEK, PEEK HT, and Teflon are registered trademarks of their respective owners.

Isolation-String Adapter



Weatherford's isolation-string adapter is used for permanent installation of a concentric inner string inside a larger outer string of tubing, such as a sliding-sleeve inner string inside a gravel-pack screen assembly. The isolation-string adapter is constructed of thick-wall tubular material to accommodate a wide range of threads and thus match well-specific tubing design requirements. Common thread choices for the inner connection of the three-way adapter are two-step, metal-to-metal, sealing threads such as Hydril CS®, Benoit™ BTS-8, or similar thread; but virtually any thread can be applied to the outer and inner connections.

In a gravel-pack or frac-pack application, use of the isolation-string adapter with a sliding-sleeve concentric inner string provides control over the flow of the formation. In this use, the sliding sleeve is usually open during the pumping phase to allow placement of gravel or frac fluids. After sandout is achieved, the formation is secured from fluid loss and unintentional flow by closing the sliding sleeve with a shifting tool located on the gravel-pack washpipe string. To start well production, the sliding sleeve is opened by slickline or coiled-tubing intervention after the production tubing has been installed.

The isolation-string adapter can also be used to isolate stand alone screen installations.

Applications

- Gravel-pack and frac-pack completions
- Stand alone screen installations

Isolation-String Adapter

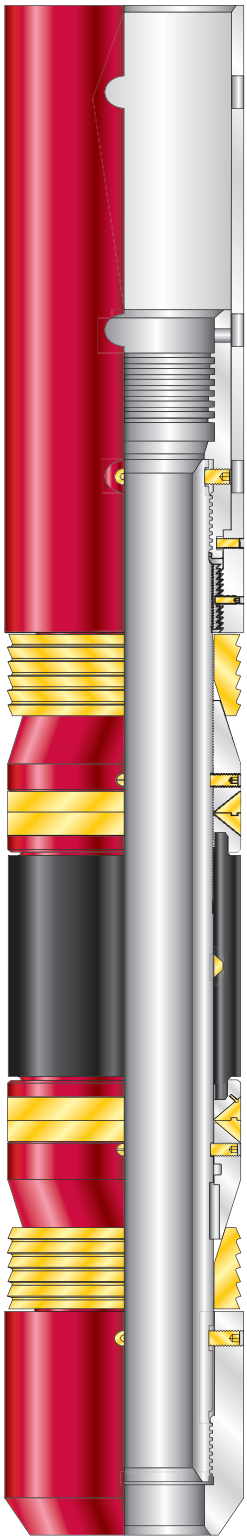
Specifications

Size (in.)	**4 × 2-3/8**	**4-1/2 × 2-7/8**	**5-1/2 × 3-1/2**
Maximum OD (in./*mm*)	4.800 *121.92*	5.050 *128.27*	6.110 *155.19*
Minimum ID (in./*mm*)	1.950 *49.53*	2.366 *60.10*	2.915 *74.04*
Maximum burst and collapse pressure	Equivalent to tubing size and material		
Maximum tensile load*	Equivalent to tubing size and material		

* Dependent on material yield and end-connection configuration

Outer Threads (Box × Pin)	**Inner Thread (Pin)**	**Maximum OD (in./*mm*)**	**Minimum ID (in./*mm*)**	**Part Number**
4 NU 8rd	2 3/8-in., 4.6-lb/ft BTS-8	4.80 *121.92*	1.95 *49.53*	1319449
4-1/2 LTC	2 7/8-in., 6.4-lb/ft BTS-8	5.05 *128.27*	2.37 *60.10*	1321802
5-1/2 LTC	3 1/2-in., 9.3-lb/ft BTS-8	6.11 *155.19*	2.91 *74.04*	1319440

UltraPak™ Permanent Seal-Bore Packer



Weatherford's *UltraPak* permanent seal-bore packer is designed for single- or multiple-zone completions in straight to highly deviated wellbores with high differential pressure. The robust, high-performance packer can be set on wireline or with a hydraulic setting tool.

The packer has passed rigorous ISO 14310 testing. Performance-rating envelopes developed for each size display combination loading from pressure and axial loads.

Applications

- High-pressure production or testing
- Fracture stimulations with anchored or floating tubing strings
- Lower-zone isolation, using the packer as a bridge plug
- Tubing removal without the need to unseat the packer

Features, Advantages and Benefits

- The packer is fully envelope-tested to ISO 14310 industry standards for improved safety and reliability.
- The packer has been tested in Q125 collapse-resistant casing to eliminate the need for carbide insert slips and reduce cost.
- The upper-scoop head design enables the easy stabbing of seals into the packer in deviated wellbores, simplifying installation and saving valuable rig time and costs.
- The packer is available with materials and elastomers for hostile environments, providing flexibility in wellbore applications.
- Ductile cast-iron full-strength, full-circle slips distribute the load evenly around the parent casing wall, maximizing the load rating and reliability.

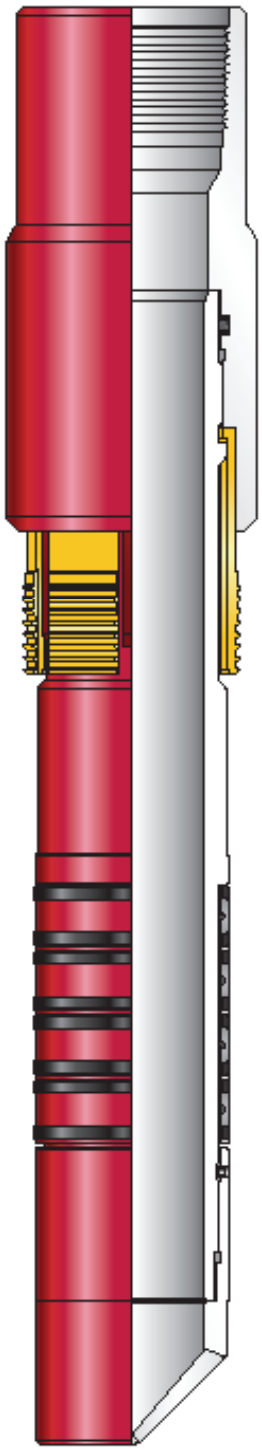
UltraPak™ Permanent Seal-Bore Packer

Specifications

Casing				Packer[1]			
OD (in./*mm*)	Weight (lbm/ft, *kg/m*)	Minimum ID (in./*mm*)	Maximum ID (in./*mm*)	Bore (in./*mm*)	Maximum OD (in./*mm*)	Basic Part	Elastomer
4-1/2 *114.3*	11.6 to 13.5 *17.3 to 20.1*	3.853 *97.87*	4.069 *103.35*	2.688 *68.28*	3.750 *95.25*	173369	NBR[2]
						747092	HNBR[3]
						742725	Aflas®
	15.1 to 16.6 *22.5 to 24.7*	3.669 *93.19*	3.904 *99.16*	2.390 *60.71*	3.574 *90.78*	166863	Nitrile
5-1/2 *139.7*	14.0 to 17.0 *20.8 to 25.3*	4.778 *121.36*	4.950 *125.73*	2.688 *68.28*	4.600 *116.84*	742814	Nitrile
				3.000 *76.20*		168508	NBR
						231098	Nitrile
						742805	Aflas
	17.0 to 23.0 *25.3 to 34.2*	4.670 *118.62*	4.892 *124.26*		4.435 *112.65*	167058	NBR
					4.440 *112.78*	166879	Nitrile
						896333	Aflas Kalrez® Teflon® Ryton®
7 *177.8*	23.0 to 32.0 *34.2 to 47.6*	5.900 *149.86*	6.466 *164.24*	3.250 *82.55*	5.875 *149.23*	168371	NBR
						747098	HNBR
						173510	Nitrile
						173309	Aflas
						747096	Aflas
				4.00 *101.60*	5.860 *148.84*	747100	Aflas
					5.875 *149.23*	718580	Nitrile
						762924	HNBR
						718580	Nitrile
	32.0 to 35.0 *47.6 to 52.1*	5.892 *149.66*	6.208 *157.68*		5.794 *147.17*	290138	HSN[4]
	35.0 to 38.0 *52.1 to 56.6*	5.801 *147.35*	6.123 *155.52*		5.710 *145.03*	742891	Aflas
						711054	HNBR
7-5/8 *193.7*	29.7 *44.2*	6.510 *165.35*	6.875 *174.63*	3.250 *82.55*	6.250 *158.75*	737016	NBR
	33.7 to 39.0 *50.2 to 58.0*		6.882 *174.80*			168563	NBR
				4.000 *101.60*	6.375 *161.93*	277814	WE-216
	29.7 *44.2*	6.781 *172.24*	6.987 *177.47*	3.250 *82.55*	6.250 *158.75*	737016	NBR
9-5/8 *244.5*	40.0 to 53.5 *59.5 to 79.6*	8.405 *213.49*	8.968 *227.79*	4.750 *120.65*	8.319 *211.30*	745634	Aflas
						173978	Nitrile
						743146	HNBR
	47.0 to 53.5 *69.9 to 79.6*	8.535 *216.79*	8.681 *220.50*	3.250 *82.55*	8.125 *206.38*	728071	NBR
				4.000 *101.60*		728191	NBR

[1]Has a wireline-guide bottom connection
[2]Nitrile butadiene rubber
[3]Hydrogenated nitrile butadiene rubber
[4]Highly saturated nitrile

GP Snap-Latch Seal Assembly



Weatherford's GP snap-latch seal assembly is installed below sand screens in gravel-pack completions for a positive surface indication that the screens are on-depth in the well.

The snap latch can be used in Weatherford's UltraPak™ or BlackCat™ packer. It engages the top sub of the sump packer or a lower gravel-pack packer, sealing in the packer's polished bore. Straight pickup of the pipe and snap-latch assembly provides an overpull indication on the weight indicator of the seal assembly being properly engaged in the packer. With 8,000 to 10,000 lbf (35.58 to 44.48 kN) of overpull, the collet collapses, releasing from the packer. This process can be repeated as many times as required.

Additional seal units and spacer tubes can be made up to the snap-latch seal assembly for use as a production seal assembly. The snap latch provides an indication of the assembly landing in a production packer.

The snap-latch seal assembly can also be used for verifying that TCP guns are on depth by installing the snap-latch assembly with all seals removed on the bottom of the guns. Stinging the snap latch into the sump packer, then raising the assembly to observe the overpull indicates the guns are on depth. The guns and snap-latch assembly are disengaged from the packer before firing to prevent damage. After the well has been perforated, the snap latch can be re-engaged into the packer to confirm that the packer bore is free of perforating debris.

Applications

- Gravel-pack installation
- TCP operations
- Production-packer installation

Features, Advantages and Benefits

- Straight pickup release eliminates the need to rotate, saving rig time and reducing the risk of torsionally damaging completion products.
- Visual confirmation of gravel-pack seals being engaged in the sump packer indicates a successful gravel pack, saving rig time and potential fishing costs.

GP Snap-Latch Seal Assembly

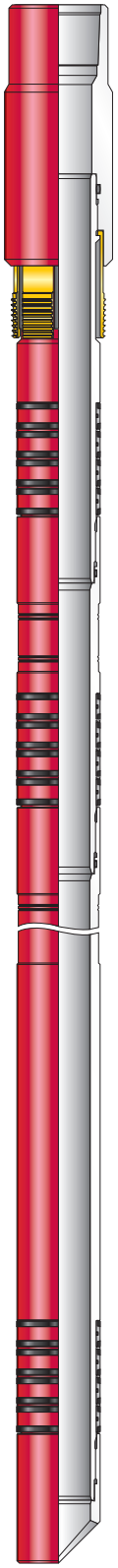
- Visual confirmation of positioning perforating guns on depth prevents perforating out of the zone and gauges expected production results.
- Visual confirmation of production-seal assemblies that are fully inserted into production packers saves rig time.

Specifications

Packer Bore (in./*mm*)	Maximum OD (in./*mm*)	Minimum ID (in./*mm*)	Top Thread (Box)	Part Number
2.688 *68.3*	3.38 *85.9*	1.93 *49.0*	2-3/8 EU[1] 8RD	1159364
3.000 *76.2*	3.77 *95.8*	2.35 *59.7*	2-7/8 EU 8RD	1160676
4.000 *101.6*	5.20 *132.1*	3.00 *76.2*	4 NU[2]	1178729
			4-1/2 LTC[3]	1178996
6.000 *152.4*	7.26 *184.4*	4.85 *123.2*	5 LTC	TBD
			5-1/2 LTC	1293804
	7.41 *188.2*		6-5/8 LTC	1297901

[1]External upset
[2]Nonupset
[3]Long thread and coupling

Polished-Bore Snap-Latch Anchor



Weatherford's polished-bore snap-latch anchor is used, along with standard WFX sand-control systems, in stacked sand-control completions.

The polished-bore snap-latch seals engage the seal bores of the BlackCat™ or UltraPak™ packer and the G2 extension and isolate the gravel-pack ports of the lower assembly. The anchor is installed on the lower end of the upper gravel-pack screen for an upper gravel pack or frac-pack. With a snap-out force of approximately 10,000 lb (44.5 kN), the snap latch confirms the setting of the upper gravel-pack assembly. This operation is repeatable to ensure that the gravel-pack assembly is correctly positioned and fully engaged in the lower packer. Once the proper depth is established, the upper packer can be set.

During treatment of the upper zone, the polished-bore snap-latch anchor can serve to isolate the lower zone from treatment pressures. For production, the polished-bore snap-latch anchor accepts seals on concentrically installed isolation strings, on selective isolation strings installed as part of the production tubing, or on the long string on a dual completion.

Standard seals for the polished-bore snap-latch anchor are highly durable HNBR bonded elastomer units. Alternative materials can be used to suit well conditions.

Applications

- Stacked gravel packs
- Stacked frac packs

Features, Advantages and Benefits

- Snap latch confirms screens are correctly positioned, simplifying gravel pack operations.
- Minimizes blank area above lower gravel pack packer.
- Spaced out for isolating gravel pack ports in lower gravel pack assemblies.

Polished-Bore Snap-Latch Anchor

Specifications

Mating Packer Sealbore ID (in./*mm*)	Top Thread (Box)	Minimum ID (in./*mm*)	Part Number
4.000 *101.60*	4-in. NU	3.000 *76.20*	912900
	4 1/2-in. LTC		913594
	4-in. NU	3.250 *82.55*	1287120
6.000 *152.40*	5 1/2-in. LTC	4.000 *101.60*	1290969
	6 5/8-in. LTC		1310734

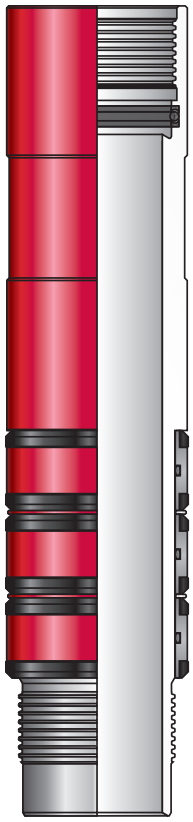
Seals, Locators and Muleshoes

Weatherford offers a wide selection of production-seal-unit accessories used in gravel-pack and frac-pack applications. For gravel-pack and frac-pack completions, standard seal assemblies consist of a shouldering type locator; a seal assembly spaced out to accommodate any expansion or contraction of the tubing and to isolate gravel-pack extension ports; and a muleshoe guide to aid entry into the packer or over liner tops.

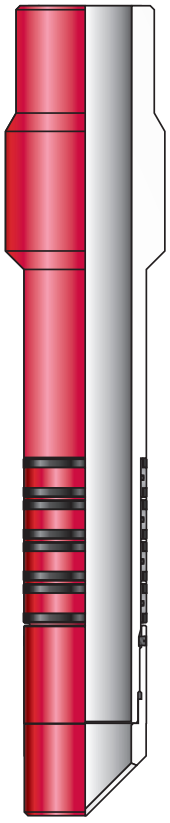
Indexing muleshoe guides are available for completions in which well deviation, upper completion equipment, control lines or umbilical lines render rotation of the tubing impractical.

Applications

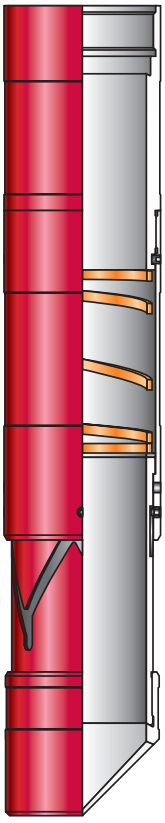
- Production seal assembly
- Test seals
- Well testing



Production seal assembly



Locator seal assembly



Indexing muleshoe

Seals, Locators and Muleshoes

Specifications

Locator Seal Assembly

Nominal Bore Size (in./*mm*)	Part Number	Top Thread[b]	Maximum OD (in./*mm*)	Minimum ID (in./*mm*)
2.688 *68.27*	166989	2-3/8 EU	3.41 *86.61*	1.93 *49.02*
3.000 *76.20*	166917	2-7/8 EU	3.78 *90.01*	2.35 *59.69*
4.000 *101.60*	173861	3-1/2 EU	5.20 *132.08*	2.99 *75.95*
4.750 *120.65*	166929	4-1/2 LTC	6.93 *176.02*	3.83 *97.28*

[a] All seals are standard bonded style.

[b] Different top threads are available on request.

Part Numbers

Nominal Bore Size (in./*mm*)	1-ft Seal Unit	2-ft Spacer	5-ft Spacer	Half Muleshoe	Indexing Muleshoe
2.688 *68.27*	167187	168737	168497	157301	1122374
3.000 *76.20*	168346	169043	168382	157322	1129332
4.000 *101.60*	173355	166987	166922	167353	1129050
4.75 *120.65*	731922	741244	741243	738360	1168771

New Vam is a registered trademark of Vallourec Mannesmann Oil & Gas France Corporation.

Hydraulic-Release HUN Circulating Gravel-Pack System

Weatherford's hydraulic-release HUN circulating gravel-pack system provides cost-effective and straightforward sand control in most oil and gas wells.

The HUN system uses Weatherford's robust, field-tested heavy-duty (HD) service packer, equipped with a gravel-pack kit, for the pumping phase of the sand-control operation. After the gravel pack is retrieved, the service packer and the gravel-pack kit are retrieved. The production tubing is then installed with a HUN overshot placed beneath one of Weatherford's production packers. The overshot establishes flow-stream integrity with the well screens, while the packer provides full-bore access through the tubing to the reservoir, isolating the upper casing annulus from well pressure and effluents.

Applications

The time-tested HUN system is best suited to relatively straight wells but can also be used in the following applications:

- Pre-gravel-pack reservoir stimulation
- Circulating slurry or water packs
- Cost-sensitive wells or developments
- Vertical and slightly deviated wells
- Flowing or artificial well lifts
- Production or injection wells

Features, Advantages and Benefits

- The system is simple to operate and rig friendly, lowering completion costs and saving time by eliminating the need for special equipment or complex downhole operations.
- The hydraulic release mechanism eliminates the need to rotate the work string to release the HUN and screen assembly, increasing the chance for successful deployment.
- The HUN circulating gravel-pack system is designed to allow circulation to the bottom of the screen with returns to the annulus, ensuring even sand placement for a higher-quality pack.
- Integral fluid and pressure bypass in the packers saves time by creating a circulating path without having to unset the packer.
- The HUN system lowers overall operator costs because the equipment can be redeployed in other wells.
- Available in virtually any casing size, the HUN circulating gravel-pack system is compatible with a wide range of Weatherford products

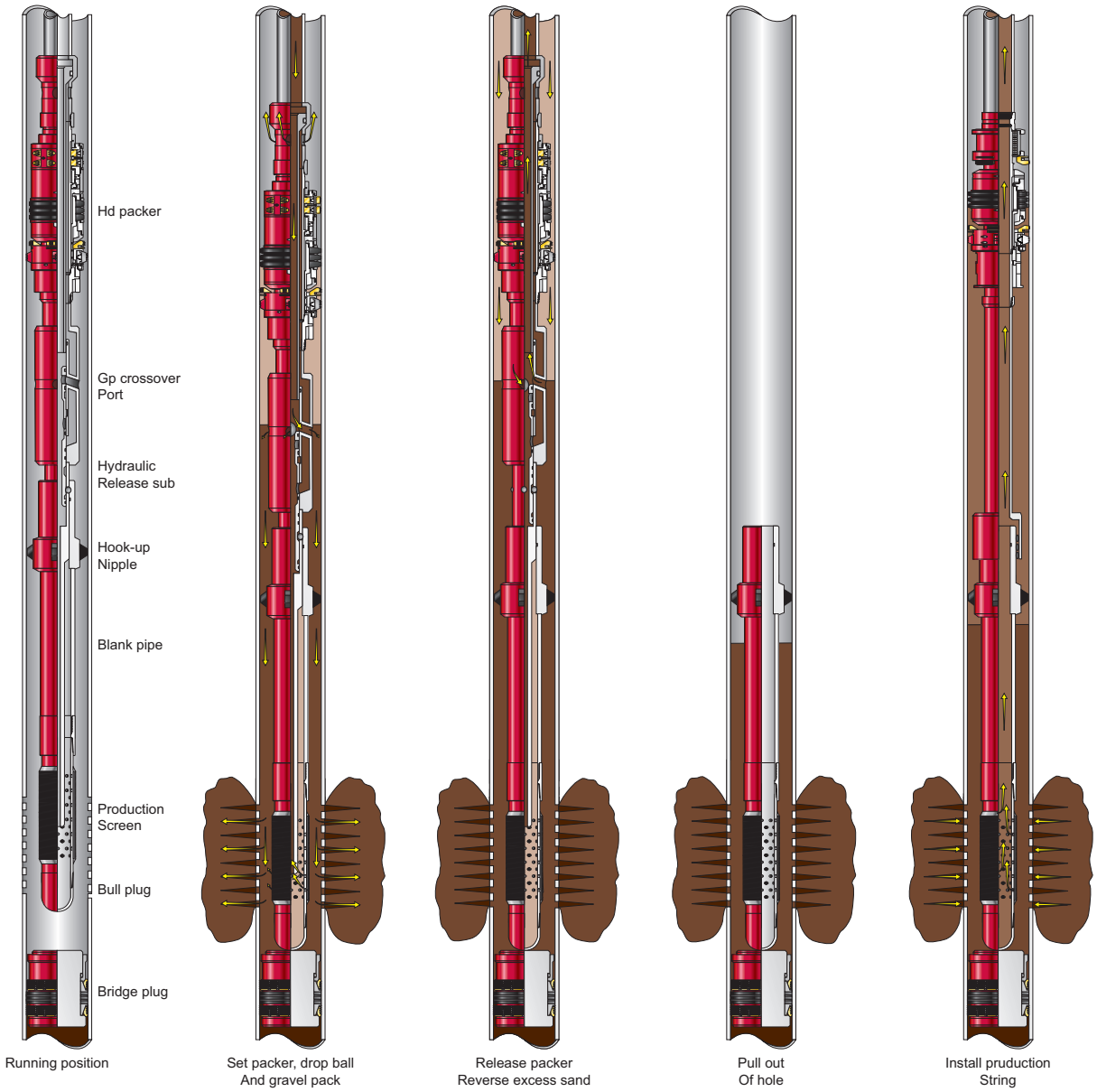
Hydraulic-Release HUN Circulating Gravel-Pack System

Specifications

Part Numbers

Threads	Circulating HUN Kit		Overshot*	Nipple*
	Part Number	Ball Check Sub		
2-3/8 EUE 8RD	763965	1295741	951224	951588
2-7/8 EUE 8RD	764940	1295796	951229	951594
3-1/2 EUE 8RD	764940	1295796	951234	951598

*Made of carbon steel (WS110)



HD Compression-Set Retrievable Service Packer

Weatherford's HD compression-set retrievable service packer isolates the annulus from the production conduit for general service. The packer can be run with a mechanically-set bridge plug to straddle intervals.

The internal bypass provides circulation around the packer and faster trips with less swabbing. Hydraulically-operated upper hold-down buttons anchor the packer against high differential pressure from below. Backup rings on all O-rings provide reliable sealing at high temperatures and pressures. An internal unloader enables circulation below the buttons, easing packer retrieval.

Applications

- General service
- Squeeze cementing
- Testing and treating
- Cased-hole production testing

Features, Advantages and Benefits

- The carbide slip and buttons improve durability and enable setting in high-grade casing.
- A one-quarter turn sets the packer, and a pickup unsets it, simplifying operation on the rig.
- The large-diameter hold-down buttons help protect against casing damage.
- The heavy-duty mandrel supports high hang-off weights, and its full bore enables the easy passage of wireline tools and maximum pump rates.

HD Compression-Set Retrievable Service Packer

Specifications

Casing				Packer			
OD (in./*mm*)	Weight (lb/ft, *kg/m*)	ID (in./*mm*)		Maximum OD (in./*mm*)	Minimum ID (in./*mm*)	Standard Thread Connection (in.)	Product
		Minimum	Maximum				
4 *101.6*	9.5 to 11.0 *14.1 to 16.4*	3.476 *88.29*	3.548 *90.12*	3.318 *84.28*	1.485 *37.72*	1.900 EU 10 RD	613-40-0C0
4-1/2 *114.3*	9.5 to 13.5 *14.1 to 20.1*	3.920 *99.57*	4.090 *103.89*	3.755 *95.38*	1.485 *37.72*	2-3/8 EU 8 RD	613-45-0C0
5 *127.0*	11.5 to 15.0 *17.1 to 22.3*	4.408 *111.96*	4.560 *115.82*	4.130 *104.90*	1.860 *47.24*	2-3/8 EU 8 RD	613-50-0C0
5-1/2 *139.7*	14.0 to 17.0 *20.8 to 25.3*	4.892 *124.26*	5.012 *101.90*	4.630 *117.60*	1.923 *48.84*	2-3/8 EU 8 RD	613-55-0C0
	20.0 to 23.0 *29.8 to 34.2*	4.670 *118.62*	4.778 *121.36*	4.505 *114.43*			613-57-0C0
6-5/8 *168.3*	28.0 to 35.0 *41.7 to 52.1*	5.595 *142.11*	5.791 *147.09*	5.380 *136.65*	2.485 *63.12*	2-7/8 EU 8 RD	613-67-0C0
7 *177.8*	17.0 to 26.0 *25.3 to 38.7*	6.276 *159.41*	6.538 *166.07*	6.125 *155.58*	2.485 *63.12*	2-7/8 EU 8 RD	613-72-0C0
	26.0 to 32.0 *38.7 to 47.6*	6.094 *154.79*	6.276 *159.41*	5.880 *149.35*			613-70-0C0
7-5/8 *193.7*	24.0 to 29.7 *35.7 to 44.2*	6.875 *174.63*	7.025 *178.44*	6.693 *170.00*	2.485 *63.12*	2-7/8 EU 8 RD	613-76-0C0
	33.7 to 39.0 *50.2 to 58.0*	6.625 *168.28*	6.765 *171.83*	6.458 *164.03*			613-75-0C0
9-5/8 *244.5*	43.5 to 53.5 *64.7 to 79.6*	8.535 *216.79*	8.755 *222.38*	8.255 *209.68*	3.985 *101.22*	4-1/2 EU 8 RD	613-95-0C0

Options

- The packer is available with a left-turn set, automatic release jay and other elastomers for hostile environments.

PR-3 Double-Grip Mechanical Production Packer

Weatherford's PR-3 double-grip mechanical production packer is a retrievable packer set by compression that isolates the annulus from the production conduit in most production, stimulation, and testing operations. The field-proven design includes rocker slips and a three-element packing system that helps to ensure correct setting and packoff. A hydraulic hold-down controls differential pressure from below.

Applications

- Injection
- Pumping
- Testing and production
- Zonal isolation

Features, Advantages and Benefits

- The packer parts are interchangeable with equipment from other manufacturers, reducing costs and inventory.
- The large bypass enables fluids to equalize quickly and reduces the swabbing effect during run-in and retrieval for faster running.
- The standard one-quarter right turn for packer setting provides simple operation on the rig.
- A differential lock helps to keep the bypass to the mandrel closed and locked during high-pressure operations to maintain integrity and prevent production loss and the need for a workover to pull out of the hole and redress the packer.
- The long-stroke mandrel simplifies fluid circulation without packer release.
- The packer automatically returns to the run-in position when moved up the hole to enable circulation through and around it.

PR-3 Double-Grip Mechanical Production Packer

Specifications

Casing				Packer		
OD (in./*mm*)	Weight (lb/ft, *kg/m*)	ID (in./*mm*)		Gauge Ring OD (in./*mm*)	Thread Connection (in.)	Product
		Minimum	Maximum			
4-1/2 *114.3*	9.5 to 13.5 *14.1 to 20.1*	3.920 *99.57*	4.090 *103.89*	3.771 *95.78*	2-3/8 EU[1] 8 RD[2]	43RD.1001
5 *127.0*	15.0 to 18.0 *22.3 to 26.8*	4.250 *107.95*	4.408 *111.96*	4.125 *104.78*	2-3/8 EU 8 RD	43RD.1003
	11.5 to 15.0 *17.1 to 22.3*	4.408 *111.96*	4.560 *115.82*	4.250 *107.95*		43RD.1005
5-1/2 *139.7*	20.0 to 23.0 *29.8 to 34.2*	4.670 *118.62*	4.778 *121.36*	4.500 *114.30*	2-3/8 EU 8 RD	45RD.1001
	15.5 to 20.0 *23.1 to 29.8*	4.778 *121.36*	4.950 *125.73*	4.641 *117.88*		45RD.1003
	13.0 to 15.5 *19.3 to 23.1*	4.950 *125.73*	5.044 *128.12*	4.781 *121.44*		45RD.1005
	20.0 to 23.0 *29.8 to 34.2*	4.670 *118.62*	4.778 121.36	4.500 *114.30*	2-7/8 EU 8 RD	45RDL.1003
	15.0 to 20.0 *22.3 to 29.8*	4.778 *121.36*	4.974 *126.34*	4.641 *117.88*		45RDL.1001
	13.0 to 15.5 *19.3 to 23.1*	4.950 *125.73*	5.044 *128.12*	4.781 *121.44*		45RDL.1002
5-3/4 *146.1*	22.5 *33.5*	4.950 *125.73*	5.190 *131.83*	4.781 *121.44*	2-3/8 EU 8 RD	45RD.1005
6 *152.4*	26.0 *38.7*	4.893 *124.28*	5.044 *128.12*	4.781 *121.44*	2-7/8 EU 8 RD	45RDL.1002
		4.950 *125.73*	5.190 *131.83*		2-3/8 EU 8 RD	45RD.1005
	20.0 to 23.0 *29.8 to 34.2*	5.240 *133.10*	5.352 *135.94*	5.062 *128.57*		60RD.1002
	15.0 to 18.0 *22.3 to 26.8*	5.424 *137.77*	5.524 *140.31*	5.156 *130.96*		60RD.1001
6-5/8 *168.3*	28.0 to 32.0 *41.7 to 47.6*	5.675 *144.15*	5.791 *147.09*	5.490 *139.45*	2-3/8 EU 8 RD	46RD.1002
	24.0 to 28.0 *35.7 to 41.7*	5.791 *147.09*	5.921 *150.39*			46RD.1001
	24.0 *35.7*	5.830 *148.08*	5.937 *150.80*	5.656 *143.66*	2-7/8 EU 8 RD	47RD.1001
	17.0 to 20.0 *25.3 to 29.8*	6.456 *163.98*	6.538 *166.07*	5.812 *147.62*		47RD.1002

[1]External upset
[2]Round

PR-3 Double-Grip Mechanical Production Packer

Specifications *(continued)*

Casing				Packer		
OD (in./*mm*)	Weight (lb/ft, *kg/m*)	ID (in./*mm*)		Gauge Ring OD (in./*mm*)	Thread Connection (in.)	Product
		Minimum	Maximum			
7 *177.8*	38.0 *56.6*	5.830 *148.08*	5.937 *150.80*	5.656 *143.66*	2-7/8 EU[1] 8 RD[2]	47RD.1001
	32.0 to 35.0 *47.6 to 52.1*	6.004 *152.50*	6.094 *154.79*	5.812 *147.62*		47RD.1002
	26.0 to 29.0 *38.7 to 43.2*	6.184 *157.07*	6.276 *159.41*	5.968 *151.59*		47RD.1003
					3-1/2 EU 8 RD	47RD.1013
	20.0 to 26.0 *29.8 to 38.7*	6.276 *159.41*	6.456 *163.98*	6.078 *154.38*	2-7/8 EU 8 RD	47RD.1004
	17.0 to 20.0 *25.3 to 29.8*	6.456 *163.98*	6.538 *166.07*	6.266 *159.16*		47RD.1005
7-5/8 *193.7*	33.7 to 39.0 *50.2 to 58.0*	6.625 *168.28*	6.765 *171.83*	6.453 *163.91*	2-7/8 EU 8 RD	47RD.1006
	24.0 to 29.7 *35.7 to 44.2*	6.875 *174.63*	7.025 *178.44*	6.672 *169.47*		47RD.1007
	20.0 to 24.0 *29.8 to 35.7*	7.025 *178.44*	7.125 *180.98*	6.812 *173.02*		47RD.1008
9-5/8 *244.5*	47.0 to 53.5 *69.9 to 79.6*	8.535 *216.79*	8.681 *220.50*	8.218 *208.74*	3-1/2 EU 8 RD	51RD.1002
	40.0 to 47.0 *59.5 to 69.9*	8.681 *220.50*	8.835 *224.41*	8.437 *214.30*		51RD.1004
	29.3 to 36.0 *43.6 to 53.6*	8.921 *226.59*	9.063 *230.20*	8.593 *218.26*		51RD.1006

[1]External upset
[2]Round

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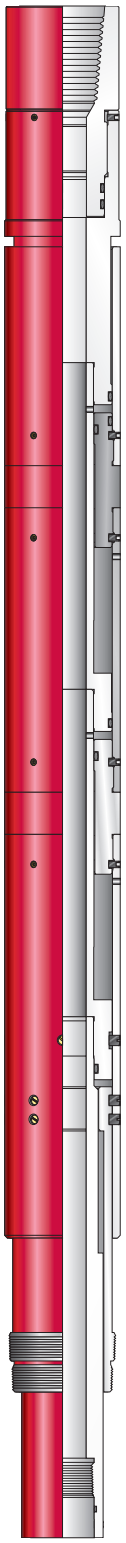
Model WFX Setting Tools



Weatherford's Model WFX setting tools are specifically designed for setting Weatherford's WFX-style BlackCat™ retrievable sealbore packers and for use with the WFX crossover tool. The heavy-duty WFX setting tool can be used as a component of the WFX sand-control system, in gravel-packing or frac-packing applications or deploying a stand-alone screen. These setting tools have sufficient tensile strength to carry assemblies with high hang weight. They are also capable of overcoming the drag routinely experienced in highly deviated and horizontal wells.

In addition to high-tensile strength, the WFX setting tools can transmit torque to specific versions of the *BlackCat* sealbore packer when the appropriate adapter kits are used. This characteristic enable rotating the packer and liner assembly, when necessary, to enter troublesome liner tops or to travel past bridges and obstructions in open hole sections.

The WFX setting tools have a large ID to allow high-rate pumping. They are rated for high-pressure service to accommodate the extreme pressures often encountered in high-rate treatments. These tools have a unique feature that is especially desirable when pumping. Once the packer is set, the setting piston is deactivated so that setting forces are not transmitted to the packer's setting sleeve during pumping operations.

Applications

- Frac packing
- Gravel packing
- Stand-alone screens
- Horizontal completions
- Liner deployments
- Production
- Injection
- Well testing
- TCP

Model WFX Setting Tools

Features, Advantages and Benefits

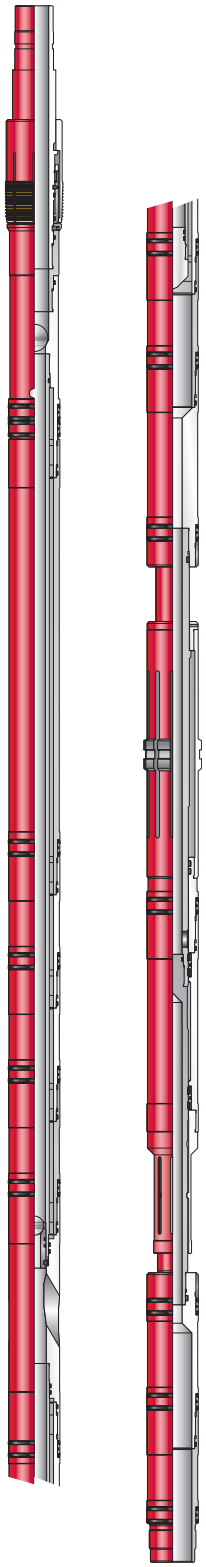
- High tensile strength enables the WFX tool to carry assemblies with high hang weight, enabling more efficient, single-trip completion of long intervals with a screen or liner.
- High torque strength enables the tool to transmit torque in the completion assembly without releasing from the packer. This feature allows rotation into liner tops and past bridges in horizontal sections, thereby saving rig time.
- Standard tubing or drillpipe connections on the top sub also match connections found on common work strings, saving time and money by matching the thread features to application requirements.
- Large ID reduces backpressure and friction during high-flow rate pumping operations, allowing optimal pumping rates to maximize zone potential.
- A 10,000-psi pressure rating ensures tool integrity, adds to system versatility, and allows for high-pressure stimulation techniques, resulting in increased well productivity.
- Use of multiple pistons lowers the required setting pressure, eliminating the need for specialized high-pressure pumps to set the packer, reducing operating costs.
- The setting tool is released primarily by annulus pressure for ease of operation while saving rig time.

Specifications

Size	Maximum OD (in./*mm*)	Minimum ID (in./*mm*)	Pistons	Total Piston Area (in.^{2}/*cm*^{2})	Pressure Rating (psi/*kPa*)	Part Number[1]
50	3.95 *100.33*	1.50 *38.10*	3	16.2 *104.52*	10,000 *68,948*	803066
70	5.50 *140.00*	2.26 *57.40*	2	33.48 *216.00*	10,000 *68,948*	877200
90	7.00 *177.80*	3.25 *82.55*	2	31.03 *200.19*	10,000 68,948	1175626

[1]Setting tools require that a top sub be ordered separately

Model WFX Crossover Tool



Weatherford's WFX crossover tool is a multi-position tool and the core component of the WFX sand-control system that includes the WFX setting tool, specific versions of the BlackCat™ retrievable sealbore packer, and the G2 gravel-pack extension. When used as part of the sand-control system, the cost-effective WFX crossover tool can effectively work with a variety of sand-control services, including conventional gravel packing, high-rate water packs, and frac-packing. The WFX crossover tool is designed to handle the extreme stresses of high-end sand-control treatments, and is resistant to the erosive nature of these treatments. This tool can also withstand the high-pressure differentials experienced during pumping and screenout.

The innovative design of the WFX crossover tool creates a compact and durable system that increases the chances of success without needless delays. The crossover tool remains in a weight-down or fixed position while in both the squeeze and circulation positions, unlike other multiple position tools. This feature is valuable when performing operations such as high-rate or high-volume pumping or when working from a floating vessel. The ability to maintain the tool's position with the work string in compression minimizes the chance of the crossover tool moving out of its intended position. This tool's ability to maintain its position is essential when thermal contraction of the work string or wave heave cause unintentional and undesirable work string movement.

Applications

- Conventional gravel packs
- High-rate water packs
- Frac packs
- Straight and deviated wells
- Fixed and floating rigs

Features, Advantages and Benefits

- High-yield-strength, low-alloy steel components increase the crossover tool's versatility for use in a wide variety of operational conditions.
- Large ID and flow area enables high pump rates with lower backpressure, minimizing fluid velocity, turbulence, erosion, and horsepower requirements.

Model WFX Crossover Tool

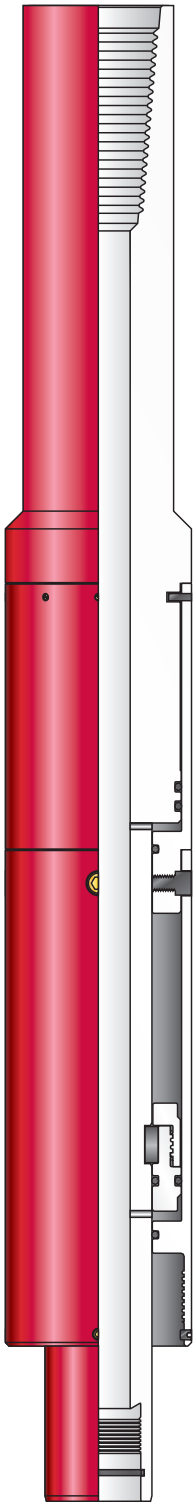
- Port geometry and orientation were developed using computational fluid dynamics (CFD) software. CFD's complex fluid-modeling capabilities enable the tool to minimize exposure to erosive slurry forces, resulting in less wear on the completion equipment and well casing.
- Innovative circulating valve allows a lower tool profile to minimize system costs.
- Maintained fixed position during treatment make location of circulating and squeeze positions easier, providing better results from stimulation and sand-control treatments.
- The tool maintains its position when the work string is in compression or weight-down mode, greatly reducing the chance of the tool coming out of its intended position when subjected to thermal contraction or wave heave. This feature helps to avoid problems during the pumping sequence and increases the effectiveness of the treatment.
- Large trash sump under the flow ports traps work-string debris, minimizing the chance of the ball seat remaining across the exit ports, while preventing damage to the crossover tool.
- A 10,000-psi pressure rating ensures tool integrity, adds to system versatility, and allows for high-pressure stimulation techniques, for increased well productivity.

Specifications

Packer Bore (in./*mm*)	Flow Tube ID (in./*mm*)	Pressure Rating (psi/*kPa*)	Part Number
2.688 *68.28*	1.24 *31.50*	10,000 *68,948*	825386
4.000 *101.60*	1.74 *44.20*	10,000 *68,948*	914704
6.000 *152.40*	2.875 *73.03*	10,000 *68,948*	1215786

Adapters to washpipe threads must be ordered separately

Dual-Piston Hydraulic Setting Tool



Weatherford's dual-piston hydraulic setting tool deploys the packer and screen assembly into the well in a single trip. The setting tool places the assembly across the perforated interval and sets and tests the packer without tripping in and out of the well, saving time and expense.

The dual-piston design reduces the required surface pressure to set the tool. Once the assembly is set, the well can be gravel-packed through the setting tool without concern for leakage or damage from erosion.

A crossover tool or a packer adapter kit is required for pressure actuation of this tool, which is designed and manufactured to work with common Weatherford gravel-pack accessories, including packer adapter kits and crossovers.

Applications

- Gravel-pack packers
- Production packers
- Isolation packers

Specifications

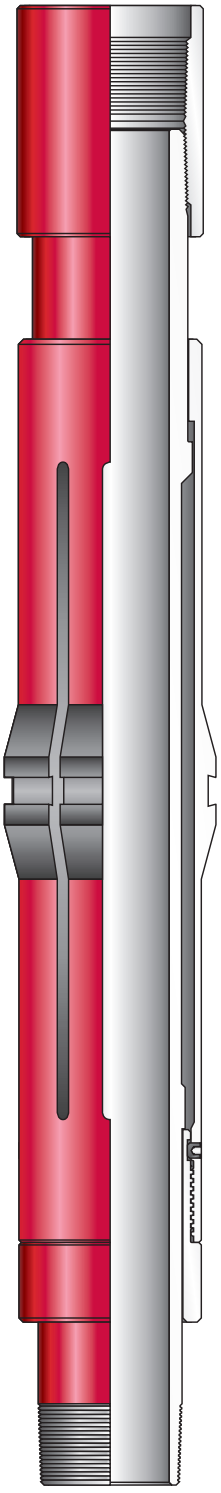
Setting Tool*	Piston Area (in.^{2}, *cm*^{2})	Packer Bore (in./*mm*)	Crossover Tool	Service Seal Unit
1120251	11.33 *73.10*	3.000 *76.20*	1120251	1224256
712224	25.40 *161.55*	4.000 *101.60*	785934	1332603
		4.750 *120.65*	1329912	NA
		4.750 × 6.000 *120.65 × 152.40*	1138282	NA

*Setting tools may require the use of an adapter kit and setting sleeve for use with various packers

Model 4P Shifting Tool

Weatherford's Model 4P shifting tool is designed to shift a Model G1 closing sleeve in gravel-pack completions. The 4P shifting tool is installed between a Model 4P crossover tool and a washpipe string.

The Model 4P shifting tool, deployed below the G1 closing sleeve during gravel-pack operations, travels upward, past the G1 closing sleeve, to automatically latch and shift the G1 closing sleeve into the closed position when the crossover-tool work string is raised. The shifting tool automatically releases from the G1 closing sleeve, allowing the crossover-tool work sting to be pulled from the well. Likewise, when the shifting-tool work string is moved downward through the G1 closing sleeve, it opens the sleeve and releases automatically so that the crossover tool can be properly positioned.



Applications

- Gravel packs
- Circulating sleeves

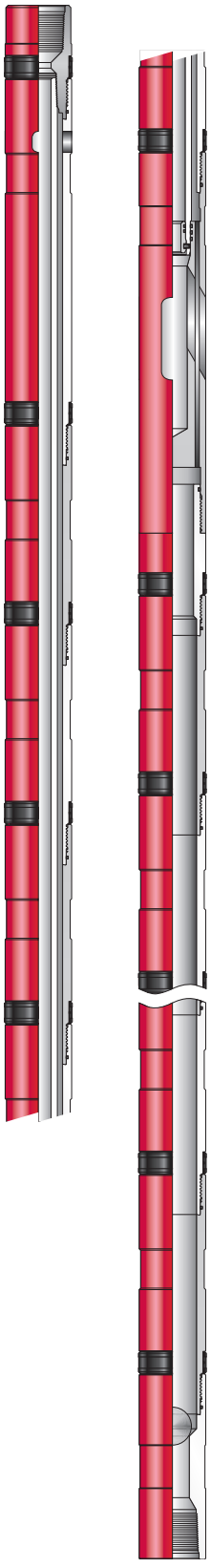
Features, Advantages and Benefits

- The large bore through the shifting tool facilitates circulation to the bottom of the screens.
- Opening and closing of the G1 closing sleeve is repeatable, without the need to trip out of the hole.

Specifications

Size (in./*mm*)	Part Number	Top thread	Bottom Thread
3.00 *76.20*	781657	1.66 EU 10RD box	1.66 EU 10RD pin
4.00 *101.60*	174295	2-7/8 EU 8RD box	2-7/8 EU 8RD pin
4.75 *120.65*	710810	3-1/2 EU 8RD box	3-1/2 NU 10RD pin

Model 4P Crossover Tool



Weatherford's Model 4P crossover tool is designed for reliable service and simplified wellsite procedures in executing conventional-rate gravel-pack completions. An assembly consisting of the BlackCat™ GP retrievable sealbore packer, the Model G1 closing sleeve, and this multiposition tool provides a robust, yet economical, completion system for wells in unconsolidated reservoirs that need gravel packs for prevention of unwanted production of formation sand.

The field-proven Model 4P crossover tool is constructed of high-quality low-alloy steel and uses durable bonded seals to maximize strength and ensure reliable and trouble-free operation. The ported sub is machine constructed to reduce the chance of erosion allowing communication between the flow path and return path, which could result in a failed job and potentially stuck tools and pipe.

Operation of the Model 4P tool system is simple, regardless of the type rig being used. The tool can be placed in the squeeze, circulating, or reverse positions with simple upward and downward movement of the work string. To place the tool in the squeeze position, simply slack weight off on the packer. The crossover ports align with the ports of the gravel-pack extension, and fluids can be pumped straight into the formation without transmission of fluid or pressure to the casing annulus above the packer. Raising the crossover tool exposes the return ports to the casing annulus; fluid pumped down the work string circulates in the annulus, around the screens, up the washpipe, and through the return bypass of the crossover tool, into the annulus above the packer.

To achieve the reverse position, raise the crossover tool further until its ports are above the *BlackCat* packer and the formation is isolated while reversing out or circulating above the packer.

Applications

- Single or multizone gravel packs
- Conventional gravel packs
- Squeeze or circulating gravel packs

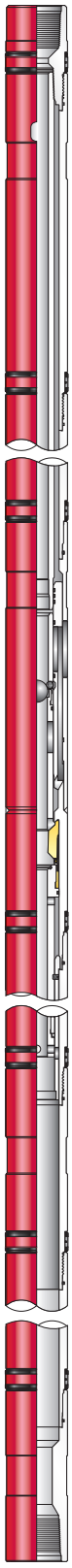
Model 4P Crossover Tool

Features, Advantages and Benefits

- Primary and secondary ball seats provide a packer setting contingency in the event low bottomhole pressure causes a premature shear of the primary seat, eliminating the need to pull an unset packer out of the well.
- Large flow ports minimize turbulence, reducing erosion and damage to the gravel-pack sand.
- Large return area reduces backpressure and fluid loss, improving the chances of a successful gravel pack.
- Machined crossover ported subs are more durable and erosion resistant than welded ported subs, reducing the potential for serious problems on the job.
- Durable, bonded seals are resistant to damage from sand, improving tool longevity.
- Reverse-out ball check isolates the formation from hydrostatic pressure and casing pressure while reversing, preventing fluid loss, which could be damaging to the formation or result in rig downtime.

Packer Bore Size (in./*mm*)	Part Number	Closing Sleeve Shifting Tool
3.000 *76.20*	1120252	781657
4.000 *101.60*	785934	174295
4.750 *120.65*	1329912	710810

Model 4P Washdown Crossover Tool



Weatherford's Model 4P washdown crossover tool enables circulation through the crossover tool and washpipe when a gravel-pack assembly is deployed into a well. Should bridges be encountered or should fluid require change-out before gravel-pack operations begin, this tool enables circulation to the bottom of the screen assembly. The flow path in the crossover tool changes to a conventional gravel-packing path when the packer setting ball is dropped and the packer is set.

Like Weatherford's standard Model 4P crossover tool, this washdown crossover is constructed of high-quality low-alloy steel and uses durable bonded seals to maximize strength and ensure reliable and trouble-free operation. An assembly consisting of the BlackCat™ GP retrievable sealbore packer, the Model G1 closing sleeve, and this multiposition tool provides a robust, yet economical, completion system for wells in unconsolidated reservoirs that need gravel packs for prevention of unwanted production of formation sand.

Operation of the Model 4P tool washdown system is simple and very similar to that of the standard Model 4P crossover tool. The tool can be placed in the *squeeze*, *circulating*, or *reverse* positions with simple upward and downward movement of the work string. To place the tool in the *squeeze* position, simply slack weight off on the packer. The crossover ports align with the ports of the gravel-pack extension, and fluids can be pumped straight into the formation without transmission of fluid or pressure to the casing annulus above the packer. Raising the crossover tool exposes the return ports to the casing annulus; fluid pumped down the work string circulates in the annulus, around the screens, up the washpipe, and through the return bypass of the crossover tool, into the annulus above the packer. To achieve the *reverse* position, raise the crossover tool further until its ports are above the *BlackCat* packer and the formation is isolated while reversing out or circulating above the packer.

Should the need arise to circulate while tripping into the well with the gravel-pack assembly, fluid pumped down the work string travels through a straight path through the crossover tool and down the washpipe to the end of the screen. When the packer setting ball is dropped and pressure is applied, a piston shifts downward, redirecting the fluid path through the ports of the crossover tool, and the return path for circulating fluid is established.

Model 4P Washdown Crossover Tool

Applications

- Single or multizone gravel packs
- Conventional gravel pack
- Squeeze or circulating gravel packs
- Openhole gravel packs
- Stand-alone-screen installations

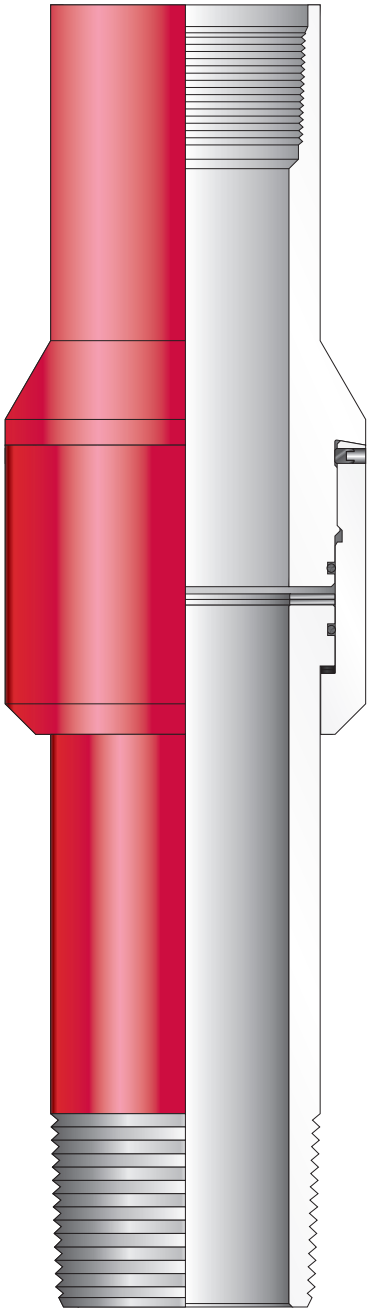
Features, Advantages and Benefits

- Washdown function enables circulation through the crossover tool and down the bottom of the screen assembly, washing through sand bridges or conditioning fluid in the openhole section before the packer is set.
- Primary and secondary ball seats provide a packer setting contingency in the event low bottomhole pressure causes a premature shear of the primary seat, eliminating the need to pull an unset packer out of the well.
- Large flow ports minimize turbulence, reducing erosion and damage to the gravel-pack sand.
- Large return area reduces backpressure and fluid loss, improving the chances of a successful gravel pack.
- Durable, bonded seals are resistant to damage from sand, improving tool longevity.
- Flapper-style reverse-out check valve isolates the formation from hydrostatic pressure and casing pressure while reversing, preventing fluid loss, which could be damaging to the formation or result in rig downtime.

Specifications

Packer Bore Size (in./*mm*)	Part Number	Closing Sleeve Shifting Tool
3.000 *76.20*	TBD	781657
4.000 *101.60*	819755	174295
4.750 *120.65*	1138284	710810

Swivel Sub Assembly



Weatherford's swivel sub assembly, an optional rental accessory for use with the WFX gravel-pack system, improves surface handling safety and reduces operational risk during run-in and retrieval of the gravel-pack work string. The swivel is intended for installation below a WFX service seal unit or a WFX crossover tool on the washpipe or concentric string inside long screen assemblies.

Running a tubing swivel inside long screen assemblies in wells that are highly deviated or even horizontal provides two operational advantages:

- Aids makeup of the packer assembly to the screens and washpipe inner string by allowing rotation of the swivel rather than rotation of the packer assembly suspended in the elevators.
- Reduces the amount of torque required to release from the packer by the secondary rotational release method.

Applications

- Horizontal-gravel-pack installation
- Stand-alone-screen installation
- Liner installation

Features, Advantages and Benefits

- The swivel sub assembly is robustly designed with torque-reducing bushings and tensile ratings compatible to the tubing size, improving the potential for successful retrieval in less than ideal conditions.
- The sealed, pressure-containing swivel sub assembly provides fluid circulation without loss to the bottom of the work string, enhancing flushing capabilities during run-in and thereby improving the potential for successfully reaching depth. This capability is particularly advantageous in highly deviated and horizontal wells.
- The sealed, pressure-containing swivel sub assembly ensures applied surface pressure to set a packer is not reduced, thus increasing the reliability for a fully set packer.
- The large, non-restrictive ID of the tubing swivel enables greater circulation rates with lower surface horsepower requirements.

Swivel Sub Assembly

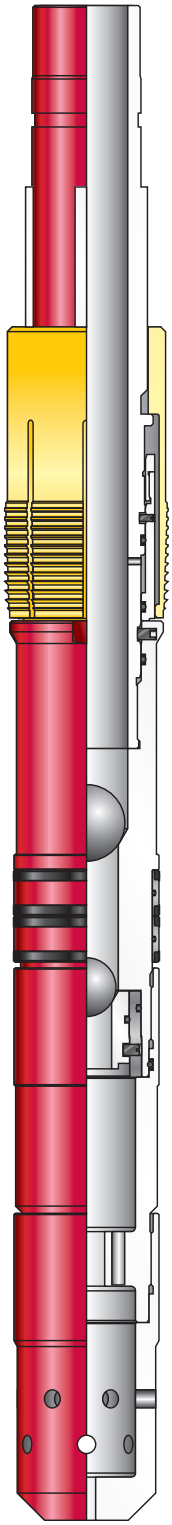
Specifications

Size (in.)	**2-7/8**	**4**
Maximum OD (in./*mm*)	3.950 *100.330*	5.910 *150.114*
Minimum ID (in./*mm*)	2.366 *60.096*	3.395 *86.233*
Overall length (in./*mm*)	20.800 *528.320*	21.300 *541.020*
Maximum burst and collapse pressure	Equivalent to tubing size and material	
Maximum tensile load*	Equivalent to tubing size and material	
Temperature range (°F/°*C*)	40° to 275° *4° to 135°*	
Standard metallic materials	Low alloy carbon steel	
Tubing thread connections	Hydril CS® standard; other threads as requested	

* Dependent on material yield and end-connection configuration

Packer Bore Size (in./*mm*)	**Maximum OD (in./*mm*)**	**Minimum ID (in./*mm*)**	**Thread B × P**	**Part Number**
4.000 *101.6*	3.95 *100.33*	2.36 *59.94*	2-7/8 Hydril CS	1169802
6.000 *152.4*	5.90 *149.86*	3.39 *86.11*	4 Hydril CS	1188649

WFX and GP Service Seal Unit



Weatherford's WFX and GP service seal unit is used with a hydraulic setting tool to set BlackCat™ retrievable sealbore packers in non-gravel-pack applications. In some sand-control completions, the *BlackCat* packer is used as a production, isolation, or stand-alone-screen deployment packer. In these applications, the WFX and GP service seal unit is used to set the *BlackCat* packer by dropping a ball from surface to plug the work string and allow application of surface pressure.

The WFX and GP service seal unit is equipped with a primary shearing ball seat to receive a setting ball. After the packer has been set, annulus pressure is applied to unsupport the snap latch, and straight pull releases the latch. The latch can also be released by rotating the work string eight to ten turns clockwise at the packer. If full pack-off is not achieved, a secondary, non-shearing ball seat within the service seal unit can be used to further set the packer. The secondary method may be necessary if low bottomhole pressure causes the primary seat to shear prematurely. If the secondary setting method is required, the secondary setting ball must be reverse-circulated to surface after setting and releasing from the packer to prevent pulling a wet string.

The standard seal unit features a perforated baffle plate and a perforated bull plug. The ported area through both the baffle plate and the bull plug offers generous drainage to minimize the potential for pulling the work string wet. Circulation through the work string is affected neither before nor after shearing the primary ball seat. The shearing ball seat is retained by the perforated baffle plate or perforated bull plug to prevent its loss in hole after it is sheared. If a liner is to be deployed with the packer, a concentric-string tube to provide circulation below the liner can be simply attached to the service seal unit by removing the bull plug and installing an adapter to the baffle plate.

Applications

- Production packers
- Isolation packers
- Stand-alone-screen installations

WFX and GP Service Seal Unit

Features, Advantages and Benefits

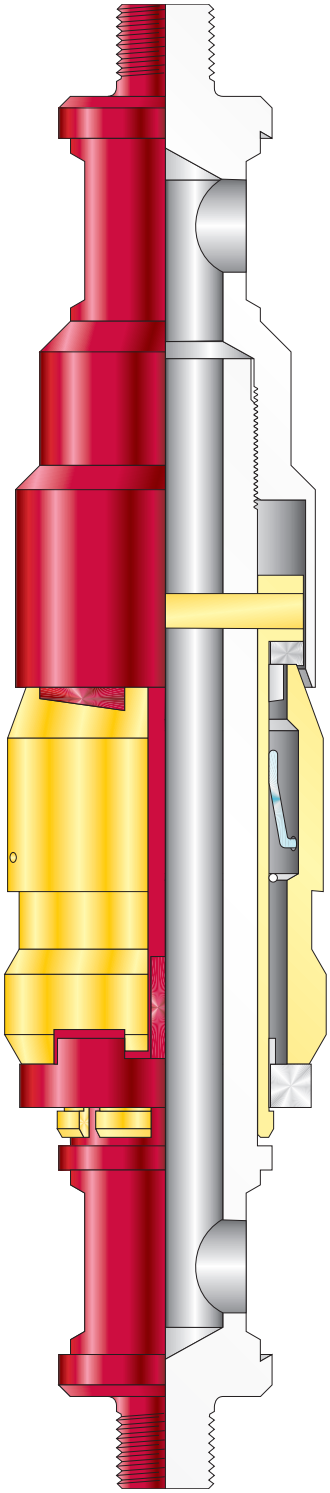
- A secondary ball seat helps avoid costly work-string trip operations.
- The ported baffle-plate and bull-plug arrangement allow the work string to fill during run-in, preventing premature packer setting. Similarly, the ported baffle plate and bull plug allow the work string to drain, preventing pulling wet strings.
- The seal service unit is reconfigured easily to accommodate a tubing adapter if a liner is installed on the bottom of the packer. The tubing adapter allows installation of a concentric string, providing circulation to the bottom of the liner and thereby facilitating liner run-in.

Specifications

Style	Size (in./*mm*)	Part Number	Setting Tool
WFX	2.688 *68.3*	1316185	803066
WFX	4.000 *101.6*	1170180	877200
WFX	6.000 *152.4*	1175745	1175626
GP	3.000 *76.2*	1224256	1120251
GP	4.000 *101.6*	1332603	712224

Note: Service seal unit may require an adapter kit.

Type B Shifting Tool



The Type B shifting tool is used to open or close all Weatherford and industry-standard sliding sleeves. Operation of the tool moves the inner sleeve to the open or closed position.

The shifting tool engages the profile in the upper or lower end of the inner sleeve to permit the sleeve to be shifted by jarring action. The tool is designed to release itself only after the sleeve reaches its fully open or closed position. A releasing profile on the key acts to compress the key spring and release the shifting tool.

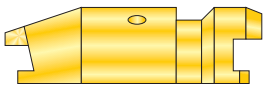
A shear pin is an added feature designed to release the tool in the event well conditions make it impossible to shift the sleeve.

Sets of nonreleasing keys are available for the WB shifting tool to permit shifting one among several circulating devices in one well bore. These keys do not have a releasing profile. The shifting tool pin must be sheared to release.

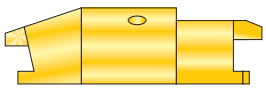
NOTE: The B shifting tool will not pass through position-1 S-type landing nipples.

When used to shift the Weatherford RIV Sliding Sleeve product, the B shifting tool uses the B-1, B-2*, B-3, and B-4 keys. These keys, designed by Weatherford, enable the shifting tool to run through a larger numbered sleeve, and shift the sleeve with a matching number or lower.

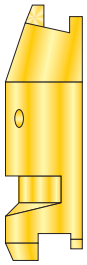
Key Guide



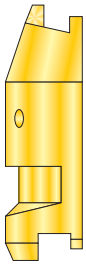
Self releasing



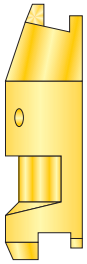
Non-releasing



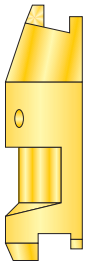
B-1



B-2*



B-3



B-4

*B-2 key is the industry standard.

Type B Shifting Tool

Specifications

Shifting Tool Size (in.)	Sleeve Polish Bore Size (in./*mm*)	Max Tool OD (keys retracted) (in./*mm*)	Max Tool OD (keys expanded) (in./*mm*)	Assembly Numbers			Connections	
				Self-Releasing	Nonreleasing	XL	Top (Pin)	Bottom (Pin)
1.500	1.500 *38.100*	1.455 *36.957*	1.638 *41.605*	S07.150.00	S07.150.01	N/A	15/16”-10 SR	15/16”-10 SR
1.625	1.625 *41.275*	1.590 *40.386*	TBA	S07.162.00	S07.162.01			
1.710	1.710 *43.434*			S07.171.00	S07.171.01	N/A	15/16”-10 SR	15/16”-10 SR
1.750	1.750 *44.450*		1.899 *48.235*	S07.175.00	S07.175.01	N/A	15/16”-10 SR	15/16”-10 SR
1.812	1.813 *46.050*	1.745 *44.323*	2.104 *53.442*	S07.181.00	S07.181.01	N/A	15/16”-10 SR	15/16”-10 SR
1.875	1.875 *47.625*		2.184 *55.474*	S07.187.00	S07.187.01	S07.187.02	15/16”-10 SR	15/16”-10 SR
2.125	2.125 *53.975*	1.965 *49.911*	2.473 *62.814*	S07.212.00	S07.212.01	S07.212.02	15/16”-10 SR	15/16”-10 SR
2.188	2.188 *55.575*	2.140 *54.356*	2.698 *68.529*	S07.231.00	S07.231.01	S07.231.02	15/16”-10 SR	15/16”-10 SR
2.313	2.313 *58.750*							
2.562	2.562 *65.075*	2.515 *63.881*	3.079 *78.207*	S07.256.00	S07.256.01	S07.256.02	15/16”-10 SR	15/16”-10 SR
2.750	2.750 *69.850*	2.725 *69.215*	3.141 *79.781*	S07.275.00	S07.275.01	S07.275.02	1-1/16”-10 SR	1-1/16”-10 SR
2.813	2.813 *71.450*		3.211 *81.559*					
3.313	3.313 *84.150*	3.245 *82.423*	3.749 *95.225*	S07.331.00	S07.331.01	N/A	1-1/16”-10 SR	1-1/16”-10 SR
3.562	3.562 *90.475*	TBA	TBA	S07.368.00	S07.368.01	N/A	1-1/16”-10 SR	1-1/16”-10 SR
3.688	3.688 *93.675*	3.655 *92.837*	4.270 *108.458*	S07.368.00	S07.368.01	S07.368.02	1-1/16”-10 SR	1-1/16”-10 SR
3.813	3.813 *96.850*	3.653 *92.786*	4.143 *105.232*	S07.381.00	S07.381.01	S07.381.02	1-1/16”-10 SR	1-1/16”-10 SR
4.313	4.313 *109.550*	TBA	5.017 *127.432*	S07.431.00	S07.431.01	N/A	1-1/16”-10 SR	1-1/16”-10 SR
4.562	4.562 *115.875*	4.520 *114.808*	5.222 *132.639*	S07.456.00	S07.456.01	N/A	1-1/16”-10 SR	1-1/16”-10 SR

Squeeze and Circulating Pack Operations

Running position

Weatherford offers systems for performing circulating or squeeze gravel packs in monobore applications using coiled tubing (CT).

The GP one-trip gravel-pack system uses a large-bore GP packer and a gravel-pack setting/crossover tool that enables packer setting and pressure testing to be performed in the same run. The GP packer is run with the required amount of blank pipe and gravel-pack screens below the packer. The GP packer is set hydraulically; increasing pressure actuates the opening of the gravel-pack ports below the GP packer. Injection into the perforations below the packer is established, and acid can be spotted, using the optional washpipe, or placed across the entire perforated interval. After the acid is allowed to soak, the annulus is closed, and the gravel-pack slurry is squeezed into the perforations, filling the perforation tunnels and the screen-casing annulus. The gravel is squeezed up to the calculated height in the blank pipe, and the screen-out valve in the crossover tool opens a port that diverts the flow from below the packer to the annulus above the packer. Opening the annulus allows excess gravel to be circulated out, if necessary; and pulling the crossover tool out of the packer mechanically and permanently closes the gravel-pack ports.

An option is available for defeating the screen-out valve, which allows the pack to be re-stressed before the crossover tool is picked up out of the packer bore. With this option, excess gravel is circulated after the crossover tool is picked up from the GP packer bore.

These systems are recommended for applications in which the packer system remains within the same basic ID in the production tubing or liner throughout the operation. GP packers are ISO 14310 V-3 certified.

Squeeze and Circulating Pack Operations

Packer set

Shear thrust sleeve

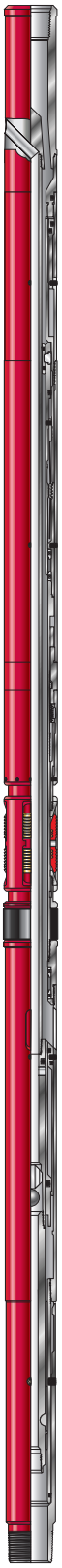
Circulation established and initiate gravel slurry

Screenout opens circulating ports and circulates out excess gravel

Crossover tool pulled

Production position

GP Gravel-Pack System



Weatherford's GP gravel-pack system is a patented one-trip coiled tubing (CT) circulating gravel-pack or squeeze-pack system.

Applications

- The GP gravel-pack system is designed to allow for one-trip circulating or squeeze CT gravel packing.

Features, Advantages and Benefits

- Gravel-pack setting tool incorporates a crossover function in the system, which enables setting, gravel packing, and retrieving the crossover tool in a single trip.
- Large bore provides enhanced flow area for increased sand-free production.
- CT or threaded-and-coupled tubing set provides multiple conveyance methods.
- Sealing integrity is tested before gravel-packing operations, minimizing misruns and saving time and cost.
- Multi-position, differentially activated crossover and squeeze tools facilitate conventional or reverse-circulation above the packer for pickling tubulars and/or spotting acid before gravel packing as well as reversing excess gravel when required.
- Release lock prevents partial set of slip mechanism after release, minimizing the need for fishing operations.

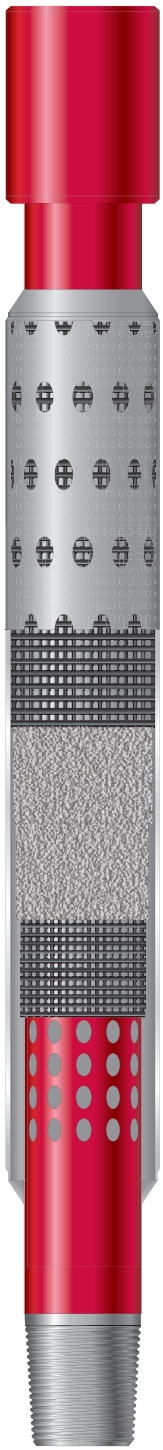
GP Gravel-Pack System

Specifications

Tubing Size (in.)	Tubing Weight (lb/ft) [ID Range] [in.]	Packer Size (in.)	Gauge Ring OD (in./*mm*)	Packing Element OD (in./*mm*)	Packer Body ID (in./*mm*)	Upper Seal Bore (in./*mm*)	Seal Anchor ID (in./*mm*)	Pressure Rating at 275°F/135°C (PSI/*kPa*)	Packer Release Force (lbf/*N*)	Standard Thread Connection
2-3/8	4.6 [1.930 to 2.046]	*180 x 106	1.800 *45.72*	1.770 *44.96*	1.063 *27.00*	1.330 *33.78*	0.875 *22.23*	5,000 *34,474*	3,700 *16,458*	1.315 NU 10RD
			1.865 *47.37*							
2-7/8	8.7 [2.173 to 2.332]	*211 x 106	2.110 *52.59*	2.080 *52.83*	1.063 *27.00*	1.330 *33.78*	0.875 *22.23*	5,000 *34,474*	3,700 *16,458*	1.660 NU 10RD
	7.9 [2.243 to 2.382]	*217 x 106	2.175 *55.25*							
	6.5 [2.373 to 2.494]	224 x 147	2.240 *56.90*	2.210 *56.13*	1.468 *37.29*	1.750 *44.45*	1.310 *33.27*			
		230 x 147	2.300 *58.42*							
3-1/2	12.95 [2.654 to 2.819]	255 x 147	2.550 *64.77*	2.520 *64.01*	1.468 *37.29*	1.750 *44.45*	1.310 *33.27*	5,000 *34,474*	3,700 *16,458*	1.900 NU 10RD
	9.3 to 10.2 [2.843 to 3.047]	274 x 181	2.740 *69.60*	2.705 *68.71*	*1.812* *46.03*	2.187 *55.55*	1.750 *44.45*	3,000 (*20,684*) above 5,000 (*34,474*) below		
4-1/2	10.5 to 15.1 [3.741 to 4.103]	367 x 238	3.670 *93.22*	3.630 *92.20*	2.375 *60.33*	2.875 *73.03*	2.250 *57.15*	3,000 (*20,684*) above 5,000 (*34,474*) below	5,000 *22,241*	2.875 NU 10RD
5-1/2	17.0 to 23.0 [4.574 to 4.892]	450 x 300	4.500 *114.30*	4.455 *113.16*	3.000 *76.20*	3.625 *92.08*	2.875 *73.03*	5,000 *34,474*	5,000 *22,241*	3.500 NU 10RD
	15.5 to 17.0 [4.815 to 5.031]	*459 x 300	4.590 *116.59*	4.540 *115.32*						

* Consult the applicable Weatherford global product line manager for availability of sizes noted.

Stratacoil TT™ Screen



Weatherford's Stratacoil thru-tubing screens are designed for optimal flow distribution. The porous metal fiber (PMF) media, which consists of metal fibers sintered between two layers of woven wire mesh, make these screens ideal for controlling non-uniform sands in horizontal and multilateral wells. The PMF media's engineered pore structure forms a specific range of pore sizes with an extremely high pore volume. Stratapac™ screens also provide superior damage tolerance. The strength and flexibility of the PMF media better resist the crushing forces of compacting reservoirs and provide longer-lasting, more reliable sand control.

Applications

- Coiled tubing gravel packs
- Repairing damaged gravel packed screens
- Marginal reservoirs requiring minimum investment
- Compacting reservoirs

Features, Advantages and Benefits

- Multi layered, variable pore-throat construction
- High pore volume for maximum flow capability
- Perforated core provides large base pipe ID for product OD – the best ID to ratio in thru-tubing screen offerings OD
- Inner and outer drainage layers provide even flow distribution to the media layers
- PMF independent multi-layer media can be customized to two, three or four layers to accommodate sand conditions; provides the ultimate in flow and sand retention capabilities; increases daily production rates by reducing drawdown; reduces friction loss in high-volume wells through high pore volume and prevents sand flow even after deformation
- Seam-welded PMF media design provides increased burst and collapse resistance, and the outer protective cover resists damage during installation through tight turns

Stratacoil TT™ Screen

Specifications

Screen Size (in./*mm*)	Perforated Core OD (in./*mm*)	Screen ID (in./*mm*)	Screen OD (in./*mm*)	Coupling OD (in./*mm*)	Product Weight (lb/ft, *kg/m*)	Tensile (lb)	Burst (PSI/*kPa*)	Collapse (PSI/*kPa*)	Minimum Size Tubing
1 *25.4*	1.315 *33.401*	0.950 *24.130*	1.640 *41.656*	1.660 *42.164*	2.65 *3.94*	9,380	1,360 *9,377*	1,800 *12,411*	2 3/8-in., 4.6 lb/ft, 1.995 ID
1-1/4 *31.8*	1.660 *42.164*	1.290 *32.766*	1.980 *50.292*	2.054 *52.172*	3.36 *5.00*	11,950	1,100 *7,584*	1,500 *10,342*	2 7/8-in., 6.4 lb/ft, 2.441 ID
1-1/2 *38.1*	1.900 *48.260*	1.500 *38.100*	2.190 *55.626*	2.200 *55.880*	3.84 *5.71*	13,604	990 *6,826*	1,200 *8,274*	2 7/8-in., 6.4 lb/ft, 2.441 ID
2-1/16 *52.4*	2.063 *52.400*	1.610 *40.894*	2.300 *58.420*	2.500 *63.500*	4.14 *6.16*	14,450	910 *6,274*	1,000 *6,895*	3 1/2-in., 10.2 lb/ft, 2.922 ID

Conventional Well Screens

Photometric inspection system measures wire, spacing the full length of each screen to meet client specifications.

Focused on Technology

Over the past several years, Weatherford has brought together a full-dimensional core well-screen offering that includes metal-mesh, wire-wrapped, and pre-pack conventional screens. In addition, our skilled engineers, technicians and subject matter experts bring a superb level of knowledge and experience and a drive to push the technology envelope. The result? A focused well-screen business prepared to serve clients as never before in the industry.

Production-Enabling Technologies that Convert Reserves into Revenues

Weatherford's ongoing technology focus continues to provide the right technologies for every application in the most cost-effective manner for our clients. Key criteria for technology development include products that drive down well costs, increase well productivity, maximize mature reservoirs and address the technical challenges of new fields.

Comprehensive Completion Products and Services

Weatherford's latest completion technologies range from our revolutionary, world-record-setting expandable technologies to continued expansion of our premium conventional screens line. We also continue to expand our product offerings with product-line extensions, such as packers for high-end, large-bore applications and proven liner systems for deepwater and extended-reach situations.

Conventional Well Screens

QHSSE and Weatherford Well Screens

Drilling technology has undergone many changes over the years. Operators drill ever deeper and into more difficult formations as the world demand for oil and gas increases. The technological expertise available for well completion has advanced dramatically in complexity and effectiveness. We know. Weatherford has been there since the beginning. We pioneered many of the advances in sand-control technology and currently hold some of the most important patents in the field.

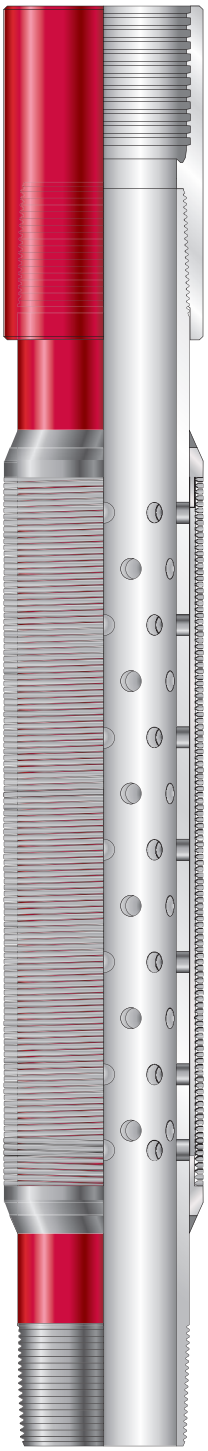
Onshore and offshore, in some of the deepest wells, under the most difficult downhole conditions, as well as in thousands of less dramatic oil, gas and water wells, Weatherford products have proved themselves again and again. We have always recognized that our well-screen technology represents the single most important factor affecting the efficiency of a producing well. Consequently, we operate the most complete well-screen manufacturing facilities in the industry.

To ensure the precision and quality of our products, we control every step of production.

Each order starts with custom materials to meet well-specific operating conditions. We draw, anneal and roll-form our own wedge-profile wire to exact dimensions. Screen-fabricating machines weld and assemble each screen, with careful quality checks at every stage.

These unmatched standards of excellence have fueled our growth in this critical industry. With complete operating plants in three locations and 900 service bases around the world, we can provide efficient service to your wells in any country or offshore location.

Super-Weld® Screen



Weatherford's *Super-Weld* screens have been the industry standard for pipe-based slip-on screens for more than 25 years. A wide variety of wire shapes, sizes, and metallurgies are available, including heavy-duty surface wire for increased erosion resistance. *Super-Weld* screens are available in multiple configurations and are engineered to meet client requirements.

These high-performance screens are effective in various applications, including the following:

- Gravel-pack completions with low pump rates and pressures
- Long-radius, open-hole stand-alone completions in well-sorted homogeneous reservoirs

Features, Advantages and Benefits

- Custom wire-to-axial-support-rod design provides exacting tolerances to achieve the ultimate performance in a pipe-based slip-on screen.
- Heat-resistant welding of surface wire to the support rods enhances strength and durability.
- Extra support ribs create a stronger and rounder screen jacket, which provides consistent slot control for better sand retention and mud flowback prevention.
- Specially designed end rings provide greater jacket-to-base-pipe strength.

Super-Weld® Screen

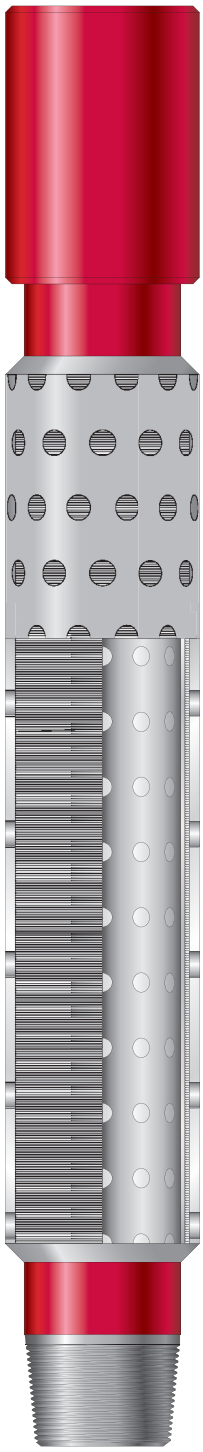
Specifications

All values are based on 316L screen jackets.

Base Pipe			End Ring		Screen					
Size (in.)	Weight (lb/ft, *kg/m*)	ID (in./*mm*)	Keystone OD (in./*mm*)	House OD (in./*mm*)	Keystone OD (in./*mm*)	House OD (in./*mm*)	Tensile Strength[1] (lb/*kg*)	Maximum Bend Angle[2] (°/100 ft)/(*°/30.5 m*)	Burst Resistance (PSI/*kPa*)	Collapse Resistance (PSI/*kPa*)
2-3/8	4.6 *6.854*	1.995 *50.67*	4.10 *104.14*	2.88 *73.15*	2.72 *69.09*	2.78 *70.61*	88,690 *40,229*	90	2,750 *18,961*	1,875 *12,928*
2-7/8	6.4 *9.536*	2.441 *62.00*	4.60 *116.84*	3.39 *86.11*	3.22 *81.79*	3.29 *83.57*	123,220 *55,892*	90	2,375 *16,375*	1,590 *10,963*
3-1/2	9.2 *13.708*	2.992 *76.00*	5.10 *129.54*	4.03 *102.36*	3.85 *97.79*	3.93 *99.82*	176,130 *79,891*	90	2,015 *13,893*	1,360 *9,377*
4	9.5 *14.155*	3.548 *90.12*	6.10 *154.94*	4.49 *114.05*	4.35 *110.49*	4.39 *111.51*	182,210 *82,649*	90	1,805 *12,445*	1,205 *8,308*
4-1/2	11.6 *17.284*	4.000 *101.60*	6.60 *167.64*	5.03 *127.76*	4.86 *123.44*	4.93 *125.22*	226,980 *102,956*	82	1,630 *11,238*	1,080 *7,446*
5	15.0 *22.350*	4.408 *111.96*	7.10 *180.34*	5.53 *140.46*	5.36 *136.14*	5.43 *137.92*	297,450 *134,921*	73	1,490 *10,273*	1,010 *6,964*
5-1/2	17.0 *25.330*	4.892 *124.26*	7.35 *186.69*	6.04 *153.42*	5.87 *149.10*	5.94 *150.88*	337,440 *153,060*	66	1,370 *9,446*	955 *6,584*
6-5/8	24.0 *35.760*	5.920 *150.37*	7.35 *186.69*	7.15 *181.61*	7.00 *177.80*	7.05 *179.07*	472,340 *214,250*	55	1,155 *7,963*	860 *5,929*

[1]Screen tensile strength is based on entire screen assembly.
[2]Maximum bend angle for screen may exceed allowable bend angle for some threads. See thread manufacturer's specifications.

Superflo™ Screen



Weatherford's *Superflo* screens live up to their name, with almost 80 percent more flow area than standard slip-on wire-wrap screens. The combination of this greater flow area with precise slot tolerances and reduced drawdown pressures can ultimately result in higher production rates.

Superflo screens offer advantages in many applications:

- They facilitate the design of optimal mud programs, effectively handling heavyweight muds (density exceeding 11.0 PPG) used in horizontal wells in high-pressure reservoirs.
- They are ideal for many open-hole applications, including multilaterals and sidetracks.
- They are effective for retention of moderately non-uniform fine sands in cased-hole or open-hole completions.

Features, Advantages and Benefits

- Consistent slot control enhances hydrocarbon flow while providing better sand retention and mud flowback prevention.
- Extra support ribs and heat-resistant welding create a stronger and rounder screen jacket for greater strength and consistent slot control.
- Protective cover and recessed fitting guard against damage while running into mulitilaterals and sidetracks.
- High-flow surface wire* and increased effective open area optimize hydrocarbon production; superior cleanability and the regained permeability help maintain higher production rates.

*Heavy-duty surface wire is available for enhanced erosion tolerance.

Superflo™ Screen

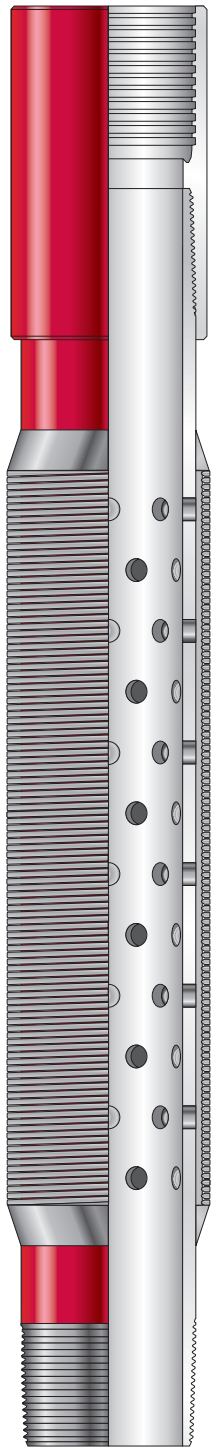
Specifications

All values are based on 316L screen jackets.

Base Pipe			Product	Screen					
Size (in.)	Weight (lb/ft, *kg/m*)	ID (in./*mm*)	OD (in./*mm*)	OD (in./*mm*)	Weight (lb/ft)	Tensile Strength[1] (lb/*kg*)	Maximum Bend Angle[2] (°/100 ft)/*(°/30.5 m)*	Burst Resistance (psi/*MPa*)	Collapse Resistance (psi/*MPa*)
2-3/8	4.6 *6.854*	1.995 *50.67*	2.90 *73.66*	2.77 *70.36*	7.0	88,690 *40,229*	90	3,025 *20.86*	2,150 *14.82*
2-7/8	6.4 *9.536*	2.441 *62.00*	3.40 *86.36*	3.27 *83.06*	9.0	123,220 *55,892*	90	2,615 *18.03*	1,820 *12.55*
3-1/2	9.2 *13.708*	2.992 *76.00*	4.03 *102.24*	3.90 *98.93*	12.5	176,130 *79,891*	90	2,220 *15,31*	1,530 *10.55*
4	9.5 *14.155*	3.548 *90.12*	4.53 *114.94*	4.40 *111.63*	13.3	182,210 *82,649*	90	1,985 *13.69*	1,365 *9.41*
4-1/2	11.6 *17.284*	4.000 *101.60*	5.03 *127.64*	4.90 *124.33*	15.0	226,980 *102,956*	82	1,795 *12.38*	1,225 *8.45*
5	15.0 *22.350*	4.408 *111.96*	5.53 *140.34*	5.40 *137.03*	19.5	297,450 *134,921*	73	1,640 *11.31*	1,110 *7.65*
5-1/2	17.0 *25.330*	4.892 *124.26*	6.03 *153.04*	5.90 *149.73*	22.0	337,440 *153,060*	66	1,505 *10.38*	1,020 *7.03*
6-5/8	24.0 *35.760*	5.920 *150.37*	7.15 *181.61*	7.02 *178.31*	30.0	472,340 *215,611*	55	1,270 *8.76*	860 *5.93*

[1]Screen tensile strength is based on entire screen assembly.
[2]Maximum bend angle for screen may exceed allowable bend angle for some threads. See thread manufacturer's specifications.

Dura-Grip® Screen



Weatherford's *Dura-Grip* screens are designed for optimal performance in cased-hole and openhole completions. Weatherford invented the shrink-fit process more than 25 years ago and has perfected this technology, which features heat-resistant welding of profile surface wire to a series of axial-support rods directly on the perforated base pipe. The result is a product of remarkable strength that delivers superior, longer-lasting sand control.

Applications

- Thermal/steam-injection wells
- Openhole stand-alone completions in well-sorted, homogeneous reservoirs
- Cased-hole and openhole, gravel-pack completions with moderate pump rates and pressures

Features, Advantages and Benefits

- The patented *Dura-Grip* manufacturing process shrink-fits the screen to the pipe to provide greatly improved tensile, torque, and collapse strength over conventional slip-on screens.
- High-precision slot tolerances and precision-formed, application-specific wire profiles provide optimal exclusion of formation materials while maximizing production of hydrocarbons.
  - Original keystone-shaped wire configuration for maximal nonclogging, self-cleaning, and free flow of materials.
  - House-shaped wire available for greater erosion resistance.
- *Dura-Grip* screens are easily retrievable, even in the most rigorous fishing operations.
- *Dura-Grip* screens are available in a wide selection of stainless steel and high-nickel alloys for optimal customization to the application.

Dura-Grip® Screen

Specifications

Base Pipe			End Ring	Screen					
Size (in.)	Weight (lb/ft, *kg/m*)	ID (in./*mm*)	OD (in./*mm*)	OD (in./*mm*)	Weight (lb/ft, *kg/m*)	Tensile Strength[1] (lbf/*kN*)	Maximum Bend Angle[2] (°/100 ft)	Burst Resistance (psi/*MPa*)	Collapse Resistance (psi/*MPa*)
2-3/8	4.6 *6.854*	2.00 *50.80*	2.78 *70.61*	2.65 *67.31*	7.3 *10.877*	88,690 *395*	120	3,500 *24.14*	4,200 *28.96*
2-7/8	6.4 *9.536*	2.44 *61.97*	3.28 *83.31*	3.15 *80.01*	9.1 *13.559*	123,220 *548*	105	3,200 *22.07*	4,200 *28.96*
3-1/2	9.2 *13.708*	2.99 *75.94*	3.90 *99.06*	3.77 *95.75*	11.9 *17.731*	176,130 *783*	86	3,000 *20.69*	4,200 *28.96*
4	9.5 *14.155*	3.55 *90.17*	*4.40* *111.76*	*4.27* *108.45*	12.2 *18.178*	182,210 *811*	75	2,750 *18.96*	4,000 *27.58*
4-1/2	11.6 *17.284*	4.00 *101.60*	4.90 *124.46*	4.77 *121.15*	14.3 *21.307*	226,980 *1,010*	67	2,500 *17.24*	3,800 *26.20*
5	15.0 *22.350*	4.41 *112.01*	5.40 *137.16*	5.27 *133.85*	17.7 *26.373*	297,450 *1,323*	60	2,250 *15.52*	3,700 *25.52*
5-1/2	17.0 *25.330*	4.89 *124.20*	5.90 *149.86*	5.77 *146.55*	19.7 *29.353*	337,440 *1,501*	54	2,000 *13.79*	3,600 *24.83*
6-5/8	24.0 *35.760*	*5.92* *150.36*	*7.03* *178.56*	*6.90* *175.26*	26.7 *39.783*	*472,340* *2,101*	45	*1,900* *13.10*	*3,450* *23.79*
7	26.0 *38.740*	*6.28* *159.51*	*7.40* *187.96*	*7.27* *184.65*	28.7 *42.763*	*513,340* *2,283*	43	*1,800* *12.41*	*3,300* *22.76*

[1]Screen tensile strength is based on entire screen assembly.

[2]Maximum bend angle for screen is based on L80 pipe.

Notes:

Maximum dogleg severity is 50% of bend angle.

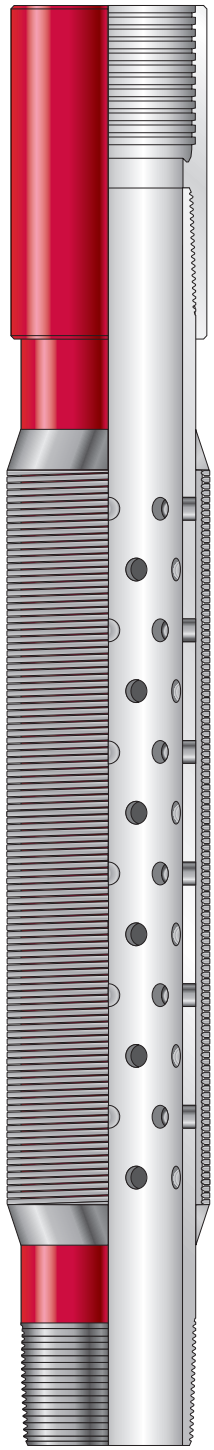
All values are based on 316L screen jackets.

Collapse and burst resistance are based on tests using ISO 17824 sand-screen test procedures.

All OD dimensions are maximum, based on nominal API pipe dimensions.

All values are nominal, except for the above noted OD dimensions.

Ultra-Grip™ Screen



Weatherford's *Ultra-Grip* screens are the most highly evolved wrapped-on-pipe screens, with lineage going back to Weatherford's invention of the shrink-fit manufacturing process more than 25 years ago. These screens provide excellent mechanical strength to perform in the most demanding openhole and cased-hole environments.

Applications

- Openhole and cased-hole completions with high-pump rates and pressures
- Openhole, stand-alone completions in well-sorted, homogeneous reservoirs
- Horizontal and extended-reach wells
- Thermal/steam-injection wells

Features, Advantages and Benefits

- Patented *Ultra-Grip* manufacturing process shrink-fits the screen to the pipe to provide greatly improved tensile, torque, and collapse strength over conventional slip-on screens.
- Profile surface wire is heat-resistant welded to a series of shaped support rods directly on the perforated base pipe.
- Heavy-duty surface wire provides greater erosion resistance, increased mechanical strength and longer life in the most demanding environments.
  - Original keystone-shaped wire configuration for maximal nonclogging, self-cleaning, and free flow of materials.
  - House-shaped wire for increased flow area and greater erosion resistance.
- Shaped rods and shaped wrap wire provide superior weld-to-weld strength.
- High-precision slot tolerances and precision-formed, application-specific wire profiles provide optimal exclusion of formation materials while maximizing production of hydrocarbons.
- *Ultra-Grip* screens are available in a wide selection of stainless steel and high-nickel alloys for optimum customization to the application.
- *Ultra-Grip* screens are easily retrievable, even in the most rigorous fishing operations.

Ultra-Grip™ Screen

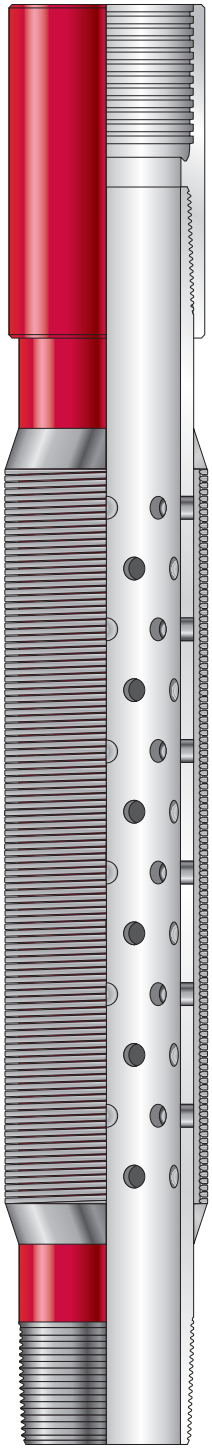
Specifications

Base Pipe			End Ring	Screen					
Size (in.)	**Weight (lb/ft, *kg/m*)**	**ID (in./*mm*)**	**OD (in./*mm*)**	**OD (in./*mm*)**	**Weight (lb/ft, *kg/m*)**	**Tensile Strength[1] (lbf/*kN*)**	**Maximum Bend Angle[2] (°/100 ft)**	**Burst Resistance (psi/*MPa*)**	**Collapse Resistance (psi/*MPa*)**
3-1/2	9.2 *13.708*	2.99 *76.07*	4.01 *101.85*	3.88 *98.55*	12.6 *18.774*	88,690 *395*	86	3,500 *24.14*	4,800 *33.10*
4	9.5 *14.155*	3.55 *90.17*	4.51 *114.55*	4.38 *111.25*	12.9 *19.221*	182,210 *811*	75	3,400 *23.45*	4,600 *31.72*
4-1/2	11.6 *17.284*	4.00 *101.60*	5.01 *127.25*	4.88 *123.95*	15.0 *22.350*	226,980 *1,010*	67	3,200 *22.07*	4,400 *30.34*
5	15.0 *22.350*	4.41 *111.96*	5.51 *139.95*	5.38 *136.65*	18.4 *27.416*	297,450 *1,323*	60	3,000 *20.69*	4,200 *28.96*
5-1/2	17.0 *25.330*	4.89 *124.26*	6.01 *152.65*	5.88 *149.35*	19.4 *28.906*	337,440 *1,501*	54	2,800 *19.31*	4,400 *27.59*
6-5/8	24.0 *35.760*	5.92 *150.37*	7.13 *181.10*	7.00 *177.80*	27.4 *40.826*	472,340 *2,101*	45	2,650 *18.27*	3,800 *26.21*
7	26.0 *38.740*	6.276 *159.41*	7.51 *190.75*	7.38 *187.45*	29.4 *43.806*	513,340 *2,283*	43	2,500 *17.27*	3,700 *25.52*

[1]Screen tensile strength is based on entire screen assembly.
[2]Maximum bend angle for screen is based on L80 pipe.

Notes:
Maximum dogleg severity is 50% of bend angle.
All values are based on 316L screen jackets.
Collapse and burst resistance are based on tests using ISO 17824 sand-screen test procedures.
All OD dimensions are maximum, based on nominal API pipe dimensions.
All values are nominal, except for the above noted OD dimensions.

Ultra-Grip™ HD Screen



Weatherford's *Ultra-Grip* screens feature both heavy-duty service wrap wire and axial-support rods. They are a more robust version of our wrapped-on-pipe *Ultra-Grip* screen. Weatherford invented the shrink-fit process more than 25 years ago and has perfected this technology, which features heat-resistant welding of profile surface wire to a series of axial-support rods directly on the perforated base pipe. The result is a product of remarkable strength that delivers superior, longer-lasting sand control. Weatherford's *Ultra-Grip* HD screens are designed for optimal performance in cased-hole and openhole applications.

Applications

- Thermal/steam-injection wells
- Stand-alone completions in well sorted homogeneous reservoirs
- Horizontal, multilateral, and extended-reach wells

Completions with high pump rates and pressures

Features, Advantages and Benefits

- The patented *Ultra-Grip* HD manufacturing process shrink-fits the screen to the pipe to provide greatly improved tensile, torque, and collapse strength over conventional slip-on screens.
- Heavy-duty surface wire provides greater erosion resistance, increased mechanical strength and longer life in the most demanding environments.
  - Original keystone-shape wire configuration for maximum nonclogging, self-cleaning, and free flow of materials
  - House-shape wire for greater erosion resistance
- *Ultra-Grip* HD screens are the most easily retrievable of all screen products, even in the most rigorous fishing operations.
- *Ultra-Grip* HD screens are available in a wide selection of stainless steel and high-nickel alloys for optimum customization to the application.

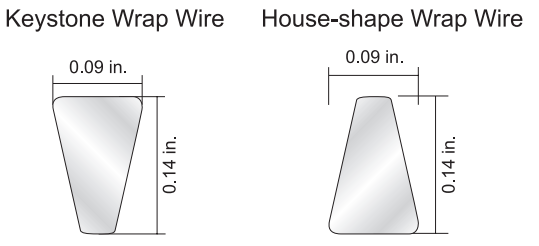
Ultra-Grip™ HD Screen

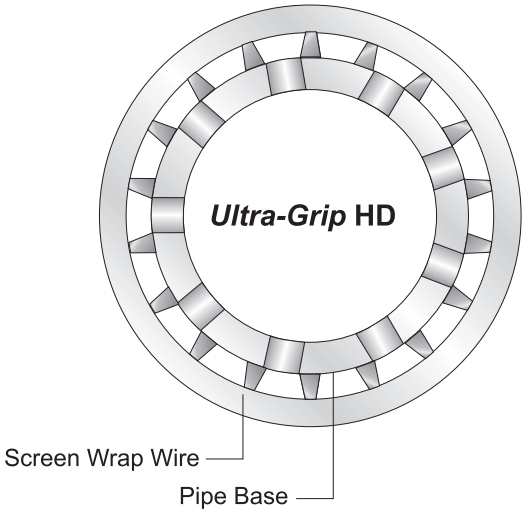
Specifications

Base Pipe			End Ring	Screen					
Size (in.)	**Weight (lb/ft, *kg/m*)**	**ID (in./*mm*)**	**OD (in./*mm*)**	**OD (in./*mm*)**	**Weight (lb/ft, *kg/m*)**	**Tensile Strength[1] (lbf/*kN*)**	**Maximum Bend Angle[2] (°/100 ft)**	**Burst Resistance (psi/*MPa*)**	**Collapse Resistance (psi/*MPa*)**
3-1/2	9.2 *13.708*	2.99 *75.94*	4.13 *104.90*	4.00 *101.60*	12.6 *18.774*	176,130 *783*	86	4,000 *27.59*	5,400 *37.42*
4	9.5 *14.155*	3.55 *90.17*	4.63 *117.60*	4.50 *114.30*	12.9 *19.221*	182,210 *811*	75	3,800 *26.21*	5,200 *35.86*
4-1/2	11.6 *17.284*	4.00 *101.60*	5.13 *130.30*	5.00 *127.00*	15.0 *22.350*	226,980 *1,010*	67	3,650 *25.17*	5,000 *34.48*
5	15.0 *22.350*	4.41 *112.01*	*5.63* *143.00*	*5.50* *139.70*	18.4 *27.416*	297,450 *1,323*	60	3,500 *24.14*	4,800 *33.10*
5-1/2	17.0 *25.330*	4.89 *124.20*	6.13 *155.70*	6.00 *152.40*	19.4 *28.906*	337,440 *1,501*	54	3,350 *23.10*	4,600 *31.72*
6-5/8	24.0 *35.760*	5.92 *150.37*	7.25 *184.15*	7.12 *180.84*	27.4 *40.826*	472,340 *2,101*	45	3,150 *21.72*	4,450 *30.69*
7	26.0 *38.740*	6.28 *159.51*	7.63 *193.80*	7.50 *190.50*	29.4 *43.806*	513,340 *2,283*	43	3,000 *20.69*	4,300 *29.65*

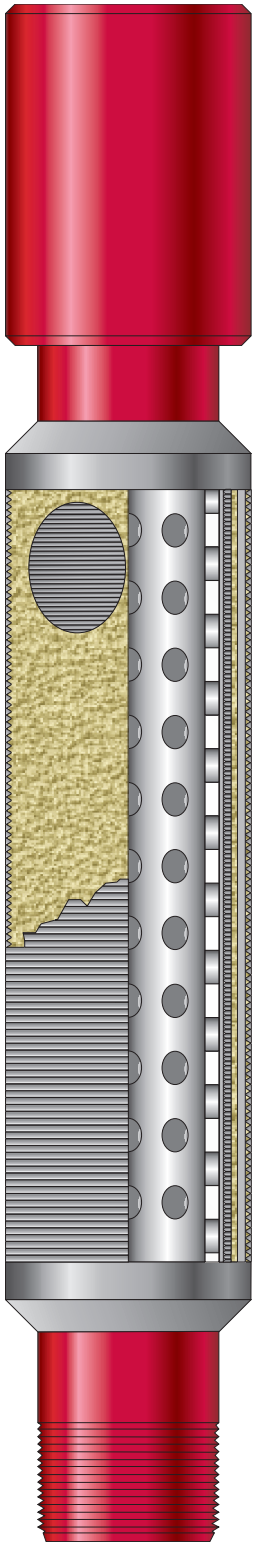
[1]Screen tensile strength is based on entire screen assembly.
[2]Maximum bend angle for screen is based on L80 pipe.

Notes:
Maximum dogleg severity is 50% of bend angle.
All values are based on 316L screen jackets.
Collapse and burst resistance are based on tests using ISO 17824 sand-screen test procedures.
All OD dimensions are maximum, based on nominal API pipe dimensions.
All values are nominal, except for the above noted OD dimensions.





Micro-Pak® Screen



Weatherford's *Micro-Pak* screens provide security against voids in gravel packs and aid the placement of gravel into the formation. *Micro-Pak* screens also increase erosion tolerance during the pumping process.

Construction consists of an inner Dura-Grip® screen with an outer screen jacket. The annular space between the screens is packed with the appropriate, specified media type and size. Weatherford's unique industrial vibration packing system ensures proper compactness. Weatherford's exclusive curing process provides a uniform cure cycle when resin-coated media are specified as the pack material.

Applications

- Horizontal completions
- Cased-hole frac-pack and high-rate water-pack completions
- Completions requiring a reduced-OD, pre-packed screen

Features, Advantages and Benefits

- Reduced OD maximizes base-pipe size.
- *Dura-Grip* inner screen adds strength and collapse resistance.

Options

- *Micro-Pak* screens can be manufactured with full screen wrap on Range III joints.
- *Micro-Pak* screens are available in various metallurgies.
- *Micro-Pak* screens are available in the appropriate size and type of pack media for the application.

Micro-Pak® Screen

Specifications

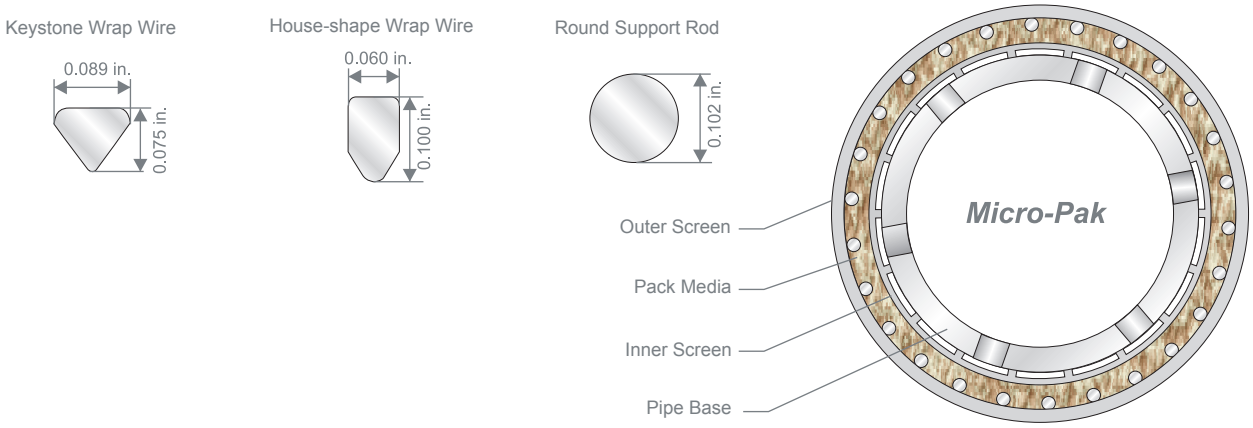
Base Pipe			End Ring		Screen						
Size (in.)	Weight (lb/ft, *kg/m*)	ID (in./*mm*)	Keystone OD (in./*mm*)	House OD (in./*mm*)	Keystone OD (in./*mm*)	House OD (in./*mm*)	Weight (lb/ft, *kg/m*)	Tensile Strength[c] (psi/*MPa*)	Maximum Bend Angle[d] (°/100 ft)	Burst Resistance (psi/*Mpa*)	Collapse Resistance (psi/*MPa*)
2-3/8	4.6 *6.854*	1.995 *50.673*	3.18 *80.78*	3.23 *82.04*	3.08 *78.23*	3.13 *79.50*	8.20 *12.218*	88,690 *611.49*	45°	5,720 *39.44*	8,830 *60.88*
2-7/8	6.4 *9.536*	2.441 *62.001*	3.68 *93.47*	3.73 *94.74*	3.58 *90.93*	3.63 *92.20*	10.60 *15.794*	123,220 *849.57*	45°	4,810 *33.16*	8,370 *57.71*
3-1/2	9.2 *13.708*	2.992 *75.997*	4.30 *109.22*	4.35 *110.49*	4.20 *106.68*	4.25 *107.95*	14.10 *21.009*	176,130 *1,214.37*	45°	4,610 *31.78*	7,890 *54.40*
4	9.5 *14.155*	3.548 *90.119*	4.80 *121.92*	4.85 *123.19*	4.70 *119.38*	4.75 *120.65*	15.00 *22.350*	182,210 *1,256.29*	45°	4,030 *27.785*	4,940 *34.06*
4-1/2	11.6 *17.284*	3.958 *100.533*	5.30 *134.62*	5.35 *135.89*	5.20 *132.08*	5.25 *133.35*	16.70 *24.883*	226,980 *1,564.97*	45°	3,900 *26.89*	4,760 *32.82*
5	15.0 *22.350*	4.408 *111.963*	5.80 *147.32*	5.85 *148.59*	5.70 *144.78*	5.75 *146.05*	21.70 *32.333*	297,450 *2,050.84*	45°	3,770 *25.99*	5,430 *37.44*
5-1/2	17.0 *25.330*	4.892 *124.257*	6.30 *160.02*	6.35 *161.29*	6.20 *157.48*	6.25 *158.75*	24.40 *36.356*	337,440 *2,326.57*	45°	3,250 *22.41*	4,710 *32.47*
6-5/8	24.0 *35.760*	5.920 *150.368*	7.43 *188.72*	7.48 *189.99*	7.33 *186.18*	7.38 *187.45*	32.70 *48.723*	472,340 *3,256.67*	45°	2,990 *20.61*	4,320 *29.78*

a All values are based on 316L screen jackets.

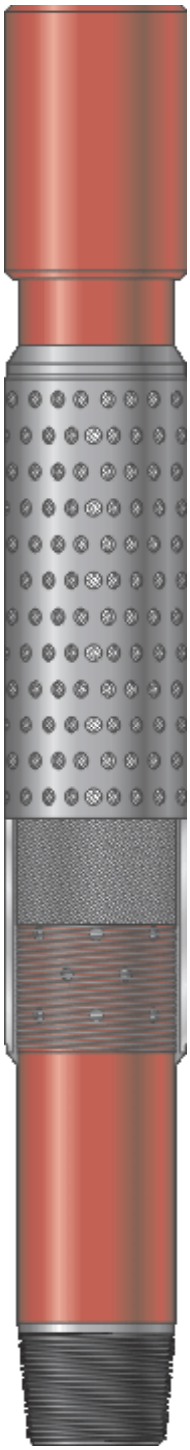
b Weatherford recommends the use of synthetic proppant to improve screen permeability.

c Screen tensile strength is based on entire screen assembly.

d Maximum bend angle for screen may exceed allowable bend angle for some threads. See thread manufacturer's specifications.



Maxflo® Screen



Weatherford's *Maxflo* screens are a metal-mesh screen product, designed for openhole completions. Soft sintering of the Dutch twill-woven wire mesh locks the wires together for a robust construction. The result is an array of fixed pore sizes that provide optimal strength and sand retention needed in oil and gas applications. A simple, strong, and efficient weld seam is used to form the woven media into tubes. *Maxflo* screens provide long-lasting and reliable sand control.

Applications

- Stand-alone solution for openhole completions
- Short-radius sidetrack and multilateral completions
- Moderate gravel-packed, cased-hole completions
- Gravel-packed, openhole completions.

Features, Advantages and Benefits

- Exclusive patented drainage support provides a greater flow area for hydrocarbons between the woven wire mesh and the perforated pipe, increasing production rates.
- Pressure buildup rates are minimized and provide improved erosion resistance of the metal media.
- Sintered mesh media provides an array of fixed pore sizes for strength and superior sand retention.
- The seam-welded, sintered, mesh-media design extends the life and reliability of the screen.
- The *Maxflo* screen can provide secondary sand control for difficult gravel-packed completions.
- The screen can be used with zonal isolation and/or inflow control devices (ICDs) and/or optimal flow rate and drawdown.

Maxflo® Screen

Specifications

Base Pipe			Screen					
Size (in.)	Weight (lb/ft, *kg/m*)	ID (in./*mm*)	Cover Maximum OD (in./*mm*)	Weight (lb/ft, *kg/m*)	Tensile Strength[1] (lbf/*kN*)	Maximum Bend Angle[2] (°/100 ft)	Burst Resistance (psi/*MPa*)	Collapse Resistance (psi/*MPa*)
2-3/8	4.6 *6.854*	2.00 *50.67*	*3.27* *83.06*	7.9 *11.771*	88,690 *395*	120	2,700 *18.62*	6,000 *41.38*
2-7/8	6.4 *9.536*	2.44 *62.00*	3.77 *95.76*	10.2 *15.198*	123,220 *548*	105	2,700 *18.62*	6,000 *41.38*
3-1/2	9.2 *13.708*	2.99 *76.00*	4.22 *107.19*	13.5 *20.115*	176,130 *783*	86	2,250 *15.52*	6,000 *41.38*
4	9.5 *14.155*	3.55 *90.12*	4.72 *119.89*	14.4 *21.456*	182,210 *811*	75	1,875 *12.93*	5,200 *35.86*
4-1/2	11.6 *17.284*	4.00 *101.60*	5.23 *132.84*	16.9 *25.181*	226,980 *1,010*	67	1,400 *9.65*	4,800 *33.10*
5	15.0 *22.350*	4.41 *111.96*	5.74 *145.80*	20.8 *30.992*	297,450 *1,323*	60	1,300 *8.96*	4,400 *30.34*
5-1/2	17.0 *25.330*	4.89 *124.26*	6.24 *158.50*	23.2 *34.568*	337,440 *1,501*	54	1,200 *8.27*	4,000 *27.59*
6-5/8	24.0 *35.760*	5.92 *150.37*	7.38 *187.45*	31.1 *46.339*	472,340 *2,101*	45	1,100 7.59	3,600 *24.83*

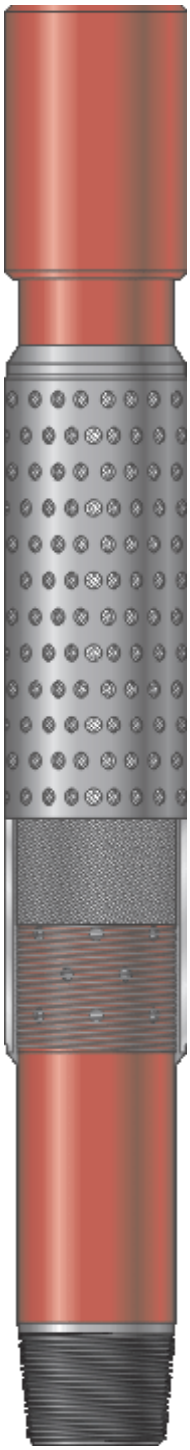
[1]Screen tensile strength is based on entire screen assembly.
[2]Maximum bend angle for screen is based on L80 pipe.

Notes:

Maximum dogleg severity is 50% of bend angle.
Collapse and burst values are based on tests using ISO 17824 sand-screen test procedure.
Pipe available in L80, P110, or CRA alloys in R1, R2, and R3 lengths.
Media available in 316L or Carpenter 20.
All OD dimensions are maximum, based on nominal API pipe dimensions with 175-micron weave.
All values are nominal, except for the above noted OD dimensions.

Performance Capabilities			
Media	Formation Sand Size	Cut Point	Air Permeability at 1-in. H_20
FSM	Fine	147	250
MSM	Medium	200	350
CSM	Coarse	310	800

Excelflo® Screen



Weatherford's *Excelflo* metal-mesh, sintered, laminate screens are designed for optimal flow distribution and maximal damage tolerance. These screens have the highest-rated burst and collapse resistance of any premium screens in the industry. *Excelflo* screens incorporate a strong, flexible, fusion-bonded media that can better resist the crushing forces of compacting reservoirs to provide longer-lasting, more reliable sand control. These screens can withstand highly aggressive, well-cleanup procedures.

Applications

- Stand-alone solution for cased-hole and openhole completions
- High-pressure wells
- Short-radius, sidetrack, and multilateral completions
- High-rate, gravel-pack, cased-hole and openhole completions
- High-pressure, compacting reservoirs
- Gravel-packed, openhole completions

Features, Advantages and Benefits

- Exclusive patented drainage-support teams with sintered laminate media increase potential production rates with a greater flow area for hydrocarbons between the sintered laminate and perforated pipe.
- The *Excelflo* screen reduces pressure buildup rates and increases erosion resistance and the life of sintered laminate media by up to 50%.
- The *Excelflo* screen offers a wide selection of media in fixed-pore sizes, ensuring optimal sand retention, thereby increasing daily production rates by reducing drawdown because of high-pore volume, which prevents sand flow even after deformation in compacting reservoirs.
- This screen provides sand control even after deformation in compacting reservoirs.
- Seam-welded, sintered, laminate media design provides optimal burst and collapse resistance. Outer protective cover/shroud resists damage during installation even through tight radius turns.
- The *Excelflo* screen can provide secondary sand control for difficult gravel-packed completions.
- This screen can be used with zonal isolation and/or inflow control devices (ICDs) for optimal flow rate and drawdown.

Excelflo® Screen

Specifications

Base Pipe			Screen					
Size (in.)	Weight (lb/ft, *kg/m*)	ID (in./*mm*)	Cover Maximum OD (in./*mm*)	Weight (lb/ft, *kg/m*)	Tensile Strength[1] (lbf/*kN*)	Maximum Bend Angle[2] (°/100 ft)	Burst Resistance (psi/*MPa*)	Collapse Resistance (psi/*MPa*)
2-3/8	4.6 *6.854*	2.00 *50.80*	3.08 *78.23*	7.9 *11.771*	88,690 *395*	120	3,250 *22.41*	9,225 *63.62*
2-7/8	6.4 *9.536*	2.44 *62.00*	3.57 *90.68*	10.2 *15.198*	123,220 *548*	105	2,500 *17.24*	8,100 *55.86*
3-1/2	9.2 *13.708*	2.99 *76.00*	4.11 *104.40*	13.5 *20.115*	176,130 *783*	86	2,250 *15.52*	7,050 *48.62*
4	9.5 *14.155*	*3.55* *90.12*	4.61 *117.09*	14.4 *21.456*	182,210 *811*	75	1,975 *13.62*	6,400 *44.14*
4-1/2	11.6 *17.284*	4.00 *101.60*	5.12 *130.05*	16.9 *25.181*	226,980 *1,010*	67	1,600 *11.03*	5,425 *37.41*
5	15.0 *22.350*	4.41 *111.96*	5.63 *143.00*	20.8 *30.992*	297,450 *1,323*	60	1,475 *10.17*	5,050 *34.83*
5-1/2	17.0 *25.330*	4.89 *124.26*	6.13 *155.70*	23.2 *34.568*	337,440 *1,501*	54	1,350 *9.31*	4,800 *33.10*
6-5/8	24.0 *35.760*	5.92 *150.37*	7.27 *184.66*	31.1 *46.339*	472,340 *2,101*	45	1,200 *8.27*	4,500 *31.03*

[1]Screen tensile strength is based on entire screen assembly.

[2]Angle for screen is based on L80 pipe manufacturer's specifications.

[2]Maximum bend

Notes:

Maximum dogleg severity is 50% of bend angle.

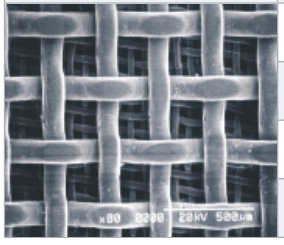
Collapse and burst values are based on tests using ISO 17824 sand-screen test procedure.

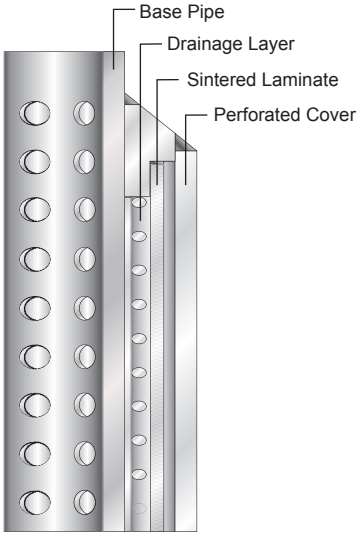
Pipe is available in L80, P110, or CRA alloys in R1, R2, and R3 lengths.

Media is available in 316L or Carpenter 20.

All OD dimensions are maximum, based on nominal API pipe dimensions with 175-micron weave.

All values are nominal, except for the above noted OD dimensions.

Performance Capabilities			
Media Structure	Nominal Pore Size (micron)	Cut Point	Air Permeability at 1-in. H_20
	75	85	375
	125	135	450
	175	189	650
	250	275	900



ISO-Flow Screen

Weatherford's ISO-Flow screen offers an innovative way of isolating perforations without any major changes in standard job procedures or the addition of rig time. The ISO-Flow screen is constructed using Weatherford's WXD sliding sleeve and nonperforated base pipe. The sliding sleeve and base pipe subassembly are placed inside a jacket of Super-Weld® screen to create the ISO-Flow screen, providing both effective sand control and selective production, injection, or isolation of the perforated interval.

For wells that are fluid sensitive or have extremely low bottomhole pressure, the ISO-Flow screen can prevent fluid loss after the gravel pack by closing the sleeve. After a circulating gravel pack is performed, the shifting tool installed on the washpipe closes the sleeve as the crossover tool is pulled from the well. During production operations, the WXD sleeve is opened or closed on slickline with a standard B-type shifting tool.

For wells with multiple zones, individual zones can be produced or shut-in as reservoir or market conditions warrant. In gravel packing, a long, horizontal well with water or gas cap drive, an ISO-Flow screen can be placed with isolation packers to control unwanted water cut or gas cut by closing the WXD sliding sleeve, removing the contribution from that interval.

The ISO-Flow screen is built to order with specified pipe grades, threads, and wire metallurgy.

Applications

- Squeeze-gravel packs
- Circulating gravel packs
- Fluid-loss control
- Selective production, injection, or isolation

Features, Advantages and Benefits

- Field-proven Super-Weld screen coupled with WXD sliding sleeve provides economical and effective zonal shutoff in gravel-packed wells, lowering maintenance costs.
- ISO-Flow screen can provide immediate zone isolation after gravel packs and stimulation treatments, enhancing well operation safety and preventing fluid loss or well flow.
- The capability to select production from gas and oil zones within a common well enables operators to change production profiles based on changing needs, contractual requirements, or peak season rates, providing operational flexibility.

ISO-Flow Screen

Specifications

Base Pipe			Screen			
Size (in.)	Weight (lb/ft, *kg/m*)	Base Pipe ID (in./*mm*)	Seal Bore ID - WXD (in./*mm*)	Screen Housing OD (in./*mm*)	End-Ring OD (in./*mm*)	Part Number
2-7/8	6.4 *9.536*	2.441 *62.0*	1.875 *47.6*	3.460 *87.9*	3.660 *93.0*	1392625
3-1/2	9.2 *13.708*	2.992 *76.0*	2.313 *58.7*	4.077 *103.6*	4.280 *108.7*	1392626
4-1/2	11.6 *17.284*	4.000 *101.6*	2.813 *71.4*	5.161 *131.1*	5.365 *136.3*	1392627

ISO-Flow NE Screen

Weatherford's ISO-Flow NE screen offers an innovative way of isolating perforations without any major changes in standard job procedures or the addition of rig time. The ISO-Flow NE screen is constructed using Weatherford's premium nonelastomeric OptiSleeve-D sliding sleeve and nonperforated base pipe. The sliding sleeve and base pipe subassembly are placed inside a jacket of Super-Weld® screen to create the ISO-Flow NE screen, providing both effective sand control and selective production, injection, or isolation of the perforated interval.

For wells that are fluid sensitive or have extremely low bottomhole pressure, the ISO-Flow NE screen can prevent fluid loss after the gravel pack by closing the sleeve. After a circulating gravel pack is performed, the shifting tool installed on the washpipe closes the sleeve as the crossover tool is pulled from the well. During production operations, the OptiSleeve-D sleeve is opened or closed on slickline with a standard B-type shifting tool.

For wells with multiple zones, individual zones can be produced or shut-in as reservoir or market conditions warrant. In gravel packing, a long, horizontal well with water or gas cap drive, an ISO-Flow NE screen can be placed with isolation packers to control unwanted water cut or gas cut by closing the OptiSleeve-D sliding sleeve, removing the contribution from that interval.

The ISO-Flow NE screen is built to order with specified pipe grades, threads, and wire metallurgy.

Applications

- Squeeze-gravel packs
- Circulating gravel packs
- Fluid-loss control
- Selective production, injection, or isolation
- Gas wells

Features, Advantages and Benefits

- Field-proven Super-Weld screen coupled with the premium nonelastomeric sealing OptiSleeve-D sliding sleeve provides effective zonal shutoff in gravel-packed wells, lowering maintenance and costs.
- ISO-Flow NE screen can provide immediate zone isolation after gravel packs and stimulation treatments, enhancing well operation safety and preventing the occurrence of fluid loss or well flow.

ISO-Flow NE Screen

- The capability to select production from gas and oil zones within a common well enables operators to change production profiles based on changing needs, contractual requirements, or peak season rates, providing operational flexibility.

Specifications

Base Pipe			Screen			
Size (in.)	**Weight (lb/ft, *kg/m*)**	**Base Pipe ID (in./*mm*)**	**Seal Bore ID OptiSleeve (in./*mm*)**	**Screen Housing OD (in./*mm*)**	**End-Ring OD (in./*mm*)**	**Part Number**
2-7/8	6.4 *9.536*	2.441 *62.0*	1.875 *47.6*	NA	NA	TBD
3-1/2	9.2 *13.708*	2.992 *76.0*	2.313 *58.7*	4.077 *103.6*	4.207 *106.9*	1392628
4-1/2	11.6 *17.284*	4.000 *101.6*	2.813 *71.4*	5.161 *131.1*	5.291 *134.4*	1392629

MultiPak Packer

Weatherford's MultiPak packer is an innovative product which provides mechanical isolation between perforation intervals in a single-stage, cased-hole, gravel-pack application. The MultiPak packer's compact length enables annular isolation of closely spaced perforation intervals. The MultiPak packer provides a simple solution to implement selective isolation between tightly spaced intervals.

With the Weatherford MultiPak packer, a single conventional gravel pack assembly is run with multiple intervals of production screen and MultiPak packers spaced out to accommodate each interval of interest. A standard Weatherford gravel pack system is used to deploy the assembly and pump the gravel pack through. The sand slurry is pumped into the screen–casing annulus in a conventional manner, but as it reaches the MultiPak packer, the slurry is routed through a baffle system to the annulus below the packer. As the lower screens are covered with the gravel pack sand, fluid returns through the lower screen will cease and be diverted to the upper screens. This change in flow path will isolate the lower zone as sand packs off around the upper screens and above the MultiPak packer. This leaves the annulus immediately below the MultiPak packer free of sand. The empty annular space enables an integral GENISIS® swell packer to expand unimpeded, sealing the screen-casing annulus from pressure and fluid flow. Elastomer swell time can be configured to meet customer requirements and downhole conditions.

When integrated with Weatherford's ISO-Flow screens, production intervals can be selectively produced or shut-in with slickline operations to open or close standard production sleeves. Oil and gas intervals can be selectively controlled for production changes to meet market conditions. Intervals that water-out can be shut in without affecting the performance of adjacent intervals. Low pressure oil zones can be naturally and selectively gas lifted from proximate gas zones.

Applications

- Multiple-interval, single-trip, cased-hole gravel packs
- Single-trip completion of long laminated intervals
- Selective production from multiple perforated intervals
- Selective isolation of multiple perforated intervals

MultiPak Packer

Features, Advantages and Benefits

- Multiple perforated intervals can be gravel packed and isolated in a single operation saving well completion time.
- The bonded swellable elastomer is activated through natural wellbore fluids, including water, oil, or a combination of both—enabling resealing capability for the life of the well.
- Compact packer length enables isolation of tightly spaced zones in stacked pack completions to prevent annular cross flow between different perforated intervals reducing the chance of reservoir damage or production inefficiency.
- MultiPak packers combined with ISO-Flow screen provide effective production isolation between multiple perforated intervals in a single operation improving life of well economics.

Specifications

Length (ft/*m*)		**5** ***1.5***	**10** ***3.0***	**15** ***4.6***	**20** ***6.1***
Maximum differential pressure (psi/*MPa*)		1,500 *10.34*	3,000 *20.68*	5,000 *34.47*	7,500 *51.71*
Maximum operating temperature (˚F/˚*C*)	Water Swellable	280° *138°*			
	Oil/Hybrid Swellable	300° *150°*			
Setting time		Customizable*			
Activation fluid		Aqueous, hydrocarbon, both			

* Fully customizable to client requirements

Casing				**Packer**				
OD (in./*mm*)	**Weight (lb/ft, *kg/m*)**	**Minimum ID (in./*mm*)**	**Maximum ID (in./*mm*)**	**Mandrel (in./*mm*)**	**Maximum OD* (in./*mm*)**	**Minimum ID (in./*mm*)**	**Length (ft/*m*)**	**Connection**
5-1/2 *139.7*	14.0 to 23.0 *20.9 to 34.3*	5.012 *127.7*	4.670 *118.6*	2-7/8 *73.03*	4.650 *118.1*	1.990 *50.5*	6.0 *1.8*	NUE 10Rd
7 *177.80*	23.0 to 32.0 *34.3 to 47.6*	6.366 *161.7*	6.094 *154.8*	3-1/2 *88.90*	5.980 *151.9*	2.440 *62.0*	6.0 *1.8*	NUE 10Rd

* Maximum OD is based on maximum steel component OD. Cup elements will be larger than packer OD.

GENISIS® Annulus Swellable Packer

Weatherford's *GENISIS* series of annulus swellable packers provide a one-trip, self-setting isolation system designed to activate and seal through the natural contact of in-situ wellbore fluids. Suitable for cased-hole and openhole well environments, *GENISIS* swellable packers are easily deployed by integrating them into tubing or casing strings or through conventional well-service operations such as coiled tubing and slickline. A wide range of configurations is available to suit specific size and well-performance requirements.

Applications

- Interzonal and point-anomaly (shale, fracture, water) isolation
- Isolation of fluid contacts
- Gas and water coning management
- Reservoir compartmentalization
- Cementing and perforating replacement
- Isolation in stimulation and/or frac jobs
- Straddle isolation systems
- Multilateral junction isolation
- Ensuring casing-shoe integrity, stopping sustained casing pressure

Features, Advantages and Benefits

- Absence of mechanical or moving parts allows for easy deployment, reducing well construction costs and required rig personnel.
- Conforming element enables isolation in irregular hole shapes and changing annular geometries.
- Bonded swellable elastomer element is activated through natural contact with wellbore fluids, increasing the OD and progressively sealing off the annulus enabling reseal capability for the life of the well.
- Solid-metal gauge ring functions as a radial standoff device that protects the swelling element during installation.

GENISIS® Annulus Swellable Packer

Specifications

Feet	5	10	15	20
Maximum Differential Pressure (psi/*MPa*)	1,500 *10.342*	3,000 *20.684*	5,000 *34.474*	7,500 *51.710*
Maximum Operating Temperature (˚F/˚*C*)	150° *300°*			
Swell Ratio	Up to 150%			
Setting Time	Customizable			
Activation Fluid	Aqueous, hydrocarbon, both			

Hole Size[1] (in./*mm*)	Mandrel (in./*mm*)	Standard Element OD (in./*mm*)
4-1/8 *104.78*	2-3/8 *60.33*	3-3/4 *95.25*
	2-7/8 *73.03*	
6 *152.40*	2-3/8 *60.33*	5-5/8 *142.88*
	2-7/8 *73.03*	
	3-1/2 *88.90*	
	4-1/2 *114.3*	
6-1/8 *155.58*	2-3/8 *60.33*	5-3/4 *146.05*
	2-7/8 *73.03*	
	3-1/2 *88.90*	
	4-1/2 *114.3*	
	5 *127.0*	
8-1/2 *215.90*	2-3/8 *60.33*	8 *203.20*
	2-7/8 *73.03*	
	3-1/2 *88.90*	
	4-1/2 *114.3*	
	5 *127.0*	
	5-1/2 *139.7*	8-1/4 *209.55*
	6-5/8 *168.3*	
	7 *177.8*	

[1]Additional sizes available upon request.

MORPHISIS® Annulus Swellable Packer

Weatherford's *MORPHISIS* series of annulus swellable packers is a fit-for-purpose modular tool kit that enables operators to install personalized swellable packer systems into their tubing or casing joints. Modular swellable elements are installed and sealed on standard API tubulars through a proprietary slide-on tool installation. The short, modular elements rotate and reciprocate freely on the basepipe tubular before setting, increasing the chance of successful deployment through tight doglegs or highly deviated well sections. When configured with Weatherford's Swell Cage® technology, modular swellable elements provide integral centralization functionality, maximizing deployment efficiency. The combination of Weatherford's advanced swelling elastomer technology and *MORPHISIS* modular system provides operators with ultimate control over their swellable packer design.

Applications

- Interzonal and point-anomoly (shale, fracture, or water) isolation
- Isolation of fluid contacts
- Gas and water coning management
- Reservoir compartmentalization
- Cementing and perforating placement
- Isolation in stimulation and/or frac jobs
- Straddle isolation systems
- Multilateral junction isolation
- Ensuring casing-shoe integrity and stopping sustained casing pressure

Features, Advantages and Benefits

- Fully customizable swellable isolation system enables fit-for-purpose design and operational flexibility.
- The modular system can be installed on the operator's basepipe as it is run in the hole to enable faster operations.
- Absence of mechanical or moving parts allows for easy deployment, reducing well construction costs and required rig personnel.
- Conforming element enables isolation in irregular hole shapes and changing annular geometries.
- Swellable elastomer element is activated through natural contact with wellbore fluids, increasing the OD and progressively sealing off the annulus enabling reseal capability for the life of the well.

MORPHISIS® Annulus Swellable Packer

- Integral centralization and rotation capabilities provide maximum efficiency.
- End-ring options are stop collars for low pressure environments, grub-screwed gauge rings are used for higher pressures, and robust torque-on gauge rings keep the unit properly placed.

Specifications

Basepipe size (in.)	2-3/8 to 20
Maximum differential pressure (psi/*kPa*)	250 to 6,000* *1,723 to 41,368*
Maximum operating temperature (˚F/˚*C*)	150 *300*
Swell ratio	Up to 150%
Setting time	Customizable
Activation fluid	Aqueous or hydrocarbon

*Depending on the number of *MORPHISIS* packers placed in series, standard rating is 500 psi per packer.

Hole Size* (in./*mm*)	Mandrel (in./*mm*)	Standard Element OD (in./*mm*)
4-1/8 *104.78*	2-3/8 *60.33*	3-3/4 *95.25*
	2-7/8 *73.03*	
6 *152.40*	2-3/8 *60.33*	5-5/8 *142.88*
	2-7/8 *73.03*	
	3-1/2 *88.90*	
	4-1/2 *114.3*	
6-1/8 *155.58*	2-3/8 *60.33*	5-3/4 *146.05*
	2-7/8 *73.03*	
	3-1/2 *88.90*	
	4-1/2 *114.3*	
	5 *127.0*	
8-1/2 *215.90*	2-3/8 *60.33*	8 *203.20*
	2-7/8 *73.03*	
	3-1/2 *88.90*	
	4-1/2 *114.3*	
	5 *127.0*	
	5-1/2 *139.7*	8-1/4 *209.55*
	6-5/8 *168.3*	
	7 *177.8*	

*Additional sizes are available upon request.

NEMISIS® Annulus Swellable Packer

Weatherford's *NEMISIS* series of ASP® annulus swellable packers (ASPs) include proprietary high-strength elastomers and extrusion-eliminating backup systems. The patented antiextrusion system is self-actuated by the swellable element and extends to the full swell range, producing elements that maintain high-differential-pressure operations in over-gauge hole sizes while also offering thermal stability in well applications that may experience downhole temperature changes.

Similar in form and function to Weatherford's GENISIS® series packers, *NEMISIS* ASPs have shorter, slimmer elements that aid deployment efficiency and minimize the risk of sticking while running through high-dogleg well intervals.

Applications

- Interzonal isolation
- Gas- and water-coning management
- Reservoir compartmentalization and wellbore segmentation
- Isolation of fluid contacts
- Straddle isolation systems (shales, fractures, water)
- Isolation control in stimulation and/or fracturing jobs
- Plugging and abandoning
- Isolation of build sections from horizontal pay zones
- Casing-shoe integrity/sustained-casing-pressure isolation
- Isolation at lateral junctions or milled windows

Features, Advantages and Benefits

- Shorter, slimmer design minimizes the potential for sticking while providing a higher pressure differential for enhanced operational efficiency.
- Pressure-sensitive, conforming element enables isolation in irregular hole shapes and changing annular geometries without damaging the reservoir.
- Bonded swellable elastomer element is activated through natural contact with wellbore fluids, increasing the OD and progressively sealing off the annulus and enabling reseal capability for the life of the well.
- Solid metal gauge ring functions as a radial standoff device that protects the swelling element during installation.

NEMISIS® Annulus Swellable Packer

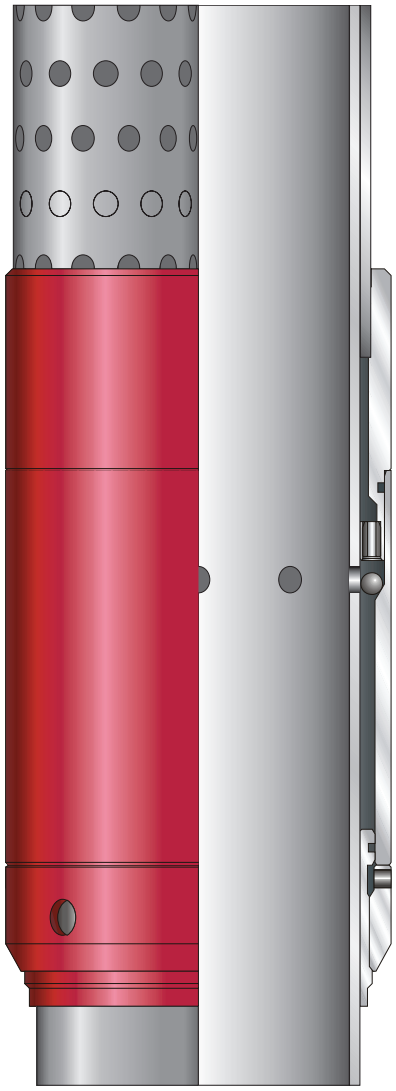
Specifications

Length (ft/*m*)	**5.0** ***1.5***	**7.5** ***2.3***	**10** ***3.0***
Maximum differential pressure (psi/*MPa*)	3,500 *24.131*	5,000 *34.474*	7,500 *51.710*
Maximum operating temperature (˚F/˚C)	300° *150°*		
Swell ratio	Customizable		
Setting time	Customizable		
Activation fluid	Aqueous, hydrocarbon, or both		

Hole Size* **(in./*mm*)**	**Mandrel (in./*mm*)**	**Standard Element OD (in./*mm*)**
4-3/4 *120.65*	2-7/8 *73.03*	4.400 *111.76*
	3-1/2 *88.90*	
6 *152.40*	3-1/2 *88.90*	5.650 *143.51*
	4-1/2 *114.30*	
6-1/8 *155.58*	3-1/2 *88.90*	5.750 *146.05*
	4-1/2 *114.30*	
	5 *127.00*	
8-1/2 *215.90*	4-1/2 *114.30*	8.150 *207.01*
	5 *127.00*	
	5-1/2 *139.70*	
	6-5/8 *168.30*	
	7 *177.80*	
12-1/4 *311.15*	9-5/8 *244.48*	11.900 *302.26*

*Additional sizes are available upon request.

FloReg™ Inflow Control Device



Weatherford's *FloReg* inflow control device (ICD) is designed to help evenly distribute inflow throughout a horizontal wellbore. This device reduces the tendency of early water or gas production, allowing the reservoir to drain more efficiently while maximizing production and recovery. The *FloReg* ICD allows for uniform production and flow contribution along a sand-face completion in horizontal wells. The system can be retrofitted with a range of Weatherford's screens.

The *FloReg* device enables predetermined setting of the desired pressure drop (heel-to-toe) along a screen section, using multiple open or closed flow ports to provide the required reservoir management. *FloReg* ICDs have proven the potential of extending well life by prolonging the plateau period, minimizing water and/or gas production, lessening annular flow, and increasing recovery.

Features, Advantages and Benefits

- Weatherford's well screens are assembled on non-perforated basepipe. The produced fluid flows between the screen jacket and basepipe and is routed to the multiple flow ports on the *FloReg* ICD. This arrangement allows the unique predetermined setup of flow contribution from each screen joint so that all screen joints contribute equally to control the production flow profile.
- Pressure drop in each flow port is viscosity independent, but density dependent, thus inhibiting water breakthrough.
- Since the *FloReg* device eliminates the need for control-line-operated interval control valves (ICVs) or instrumentation, it also eliminates the cost and risk associated with these more complex flow-control approaches for horizontal wells.
- Rigorous flow testing has confirmed the performance characteristics of the *FloReg* device. This testing allowed the development of empirical operating envelopes that aid modelling before completion operations.
- The number of open flow ports can be adjusted to the prescribed setting, based on the latest data. This procedure is conducted at surface, that is, prior to shipment or on location while the screens are still on the pipe rack, saving valuable rig time.
- Each *FloReg* device is standard (rather than machined) to suit a specific application. This flexibility can translate into significant cost savings since it reduces the need for multiple screens held in inventory or on location.
- *FloReg* flow ports are tungsten carbide, mitigating flow-induced erosion.

FloReg™ Inflow Control Device

Specifications

Size (in.)	2-3/8	2-7/8	3-1/2	4	4-1/2	5	5-1/2	6-5/8	7
Suitable screen selection	Metal-mesh and wire-wrap screens								
Overall tool length (in./*mm*)	10.4 *264.16*								
OD (in./*mm*)	3.32 *84.33*	3.90 *99.06*	4.44 *112.78*	5.00 *127.00*	5.44 *138.18*	6.00 *152.40*	6.50 *165.10*	7.69 *195.33*	8.12 *206.25*
Flow port quantity	5	10							
Flow port sizes (in./*mm*)	1/8 or 3/32 *3.175 or 2.381*								
Length of flow port (in./*mm*)	0.50 *12.70*								
Flow port material	Tungsten carbide								
Base material and stress intensity (ksi/*MPa*)	13Cr 110 *758*				or	L80 80 551			
Elastomer material*	FKM95								

*Alternative elastomer material is available

API Tubing Sizes and Capacities

API TUBING SIZES AND CAPACITIES							
OD (in/*mm*)	**Weight (lb/ft)**	**ID (in/*mm*)**	**Drift (in/*mm*)**	**Barrels per Lin. Ft**	**Lin. Ft per Barrel**	**Cubic Meters per Meter**	**Meter per Cubic Meters**
1.050 26,67	1.14/1.20	0.824 *20,93*	0.730 *18,54*	0.001	1516.11	0.000	2906.39
1.315 33,40	1.70/1.80	1.049 *26,64*	0.955 *24,26*	0.001	935.48	0.001	1793.32
1.660 42,16	2.30/2.40	1.380 *35,05*	1.286 *32,66*	0.002	540.54	0.001	1036.22
	2.33	1.380 *35,05*	1.286 *32,66*	0.002	540.54	0.001	1036.22
1.990 *50,55*	2.40	1.650 *41,91*		0.003	378.11	0.001	724.84
	2.75/2.90	1.610 *40,89*	1.516 *38,51*	0.003	397.13	0.001	761.30
2-1/16 *52,39*	3.25	1.751 *44,48*		0.003	335.75	0.002	643.63
2-3/8 *60,33*	4.00	2.041 *51,84*	1.947 *49,45*	0.004	247.11	0.002	473.72
	4.60/4.70	1.995 *50,67*	1.901 *48,29*	0.004	258.64	0.002	495.82
	5.80/5.95	1.867 *47,42*	1.773 *45,03*	0.003	295.32	0.002	566.13
2-7/8 *70,03*	6.40/6.50	2.441 *62,00*	2.347 *59,61*	0.006	172.76	0.003	331.19
	8.60/8.70	2.259 *57,38*	2.165 *54,99*	0.005	201.72	0.003	386.70
3-1/2 *88,90*	7.70	3.068 *77,93*	2.943 *74,75*	0.009	109.36	0.005	209.65
	9.20/9.30	2.992 *75,99*	2.867 *72,82*	0.009	114.99	0.005	220.44
	10.20	2.922 *74,22*	2.797 *71,04*	0.008	120.57	0.004	231.13
	12.70/12.95	2.750 *69,85*	2.625 *66,68*	0.007	136.12	0.004	260.94
4 *100,60*	9.50	3.548 *90,12*	3.423 *86,94*	0.012	81.77	0.006	156.76
	11.00	3.476 *90,12*	3.423 *86,94*	0.012	85.20	0.006	163.32
4-1/2 *114,30*	12.60/12.75	3.958 *100,53*	3.833 *97,36*	0.015	65.71	0.008	125.97

Casing Sizes and Capacities

CASING SIZES AND CAPACITIES							
OD (in/*mm*)	**Weight (lb/ft)**	**ID (in/*mm*)**	**Drift (in/*mm*)**	**Barrels per Lin. Ft**	**Lin. Ft per Barrel**	**Cubic Meters per Meter**	**Meter per Cubic Meters**
4-1/2 *114,3*	9.50	4.090 *103,90*	3.965 *100,7*	0.016	61.54	0.008	117.97
	10.50	4.052 *102,90*	3.927 *99,75*	0.016	62.70	0.008	120.19
	11.60	4.000 *101,60*	3.875 *98,43*	0.016	64.34	0.008	123.34
	12.60	3.958 *100,50*	3.833 *97,36*	0.015	65.71	0.008	125.97
	13.50	3.920 *99,57*	3.795 *96,39*	0.015	66.99	0.008	128.42
	15.10	3.826 *97,18*	3.701 *94,00*	0.014	70.32	0.007	134.81
	16.60	3.754 *95,35*	3.629 *92,17*	0.014	73.05	0.007	140.03
	17.70	3.740 *93,87*	3.571 *90,70*	0.014	73.59	0.007	141.08
	18.80	3.696 *93,88*	3.515 *89,28*	0.013	75.36	0.007	144.46
	21.60	3.640 *88,90*	3.375 *85,73*	0.013	77.69	0.007	148.94
	24.60	3.500 *85,85*	3.255 *82,68*	0.012	84.03	0.006	161.09
	26.50	3.380 *82,29*	3.115 *79,12*	0.011	90.11	0.006	172.73
5 *127,0*	11.50	4.560 *115,82*	4.435 *112,65*	0.020	49.51	0.011	94.90
	13.00	4.494 *114,14*	4.369 *110,97*	0.020	50.97	0.010	97.71
	15.00	4.408 *111,96*	4.283 *108,79*	0.019	52.98	0.010	101.56
	18.00	4.276 *108,61*	4.151 *105,44*	0.018	56.30	0.009	107.93
	20.30	4.184 *106,27*	4.059 *103,09*	0.017	58.80	0.009	112.73
	20.80	4.156 *105,56*	4.031 *102,39*	0.017	59.60	0.009	114.25
	23.20	4.044 *102,72*	3.919 *99,54*	0.016	62.95	0.008	120.67
	24.20	4.000 *101,60*	3.875 *98,43*	0.016	64.34	0.008	123.34

Casing Sizes and Capacities

CASING SIZES AND CAPACITIES							
OD (in/*mm*)	**Weight (lb/ft)**	**ID (in/*mm*)**	**Drift (in/*mm*)**	**Barrels per Lin. Ft**	**Lin. Ft per Barrel**	**Cubic Meters per Meter**	**Meter per Cubic Meters**
5-1/2 *139,7*	14.00	5.012 *127,30*	4.887 124,13	0.024	40.98	0.013	78.56
	15.50	4.950 *125,73*	4.825 122,56	0.024	42.01	0.012	80.54
	17.00	4.892 *124,26*	4.767 121,08	0.023	43.01	0.012	82.46
	20.00	4.778 *121,36*	4.653 118,19	0.022	45.09	0.012	86.44
	23.00	4.670 *118,62*	4.545 115,44	0.021	47.20	0.011	90.48
	26.00	4.548 *115,52*	4.423 112,34	0.020	49.77	0.010	95.40
	28.40	4.440 *112,78*	4.315 109,60	0.019	52.22	0.010	100.10
	32.30	4.276 *108,61*	4.151 105,44	0.018	56.30	0.009	107.93
	36.40	4.090 *103,89*	3.965 100,71	0.016	61.54	0.008	117.97
6 *152,4*	18.00	5.424 *137,77*	5.299 134,59	0.029	34.99	0.015	67.08
	20.00	5.352 *135,94*	5.227 132,80	0.028	35.94	0.015	68.89
	23.00	5.240 *133,09*	5.115 129,92	0.027	37.49	0.014	71.87
	26.00	5.132 *130,35*	5.007 127,18	0.026	39.09	0.013	74.93
6-5/8 *168,3*	20.00	6.049 *153,65*	5.924 150,47	0.036	28.13	0.019	53.93
	24.00	5.921 *150,39*	5.796 147,22	0.034	29.36	0.018	56.29
	28.00	5.791 *147,09*	5.666 143,92	0.033	30.70	0.017	58.84
	32.00	5.675 *144,15*	5.550 140,97	0.031	31.96	0.016	61.27
7 *177,8*	17.00	6.538 *166,07*	6.413 162,89	0.042	24.08	0.022	46.17
	20.00	6.456 *163,98*	6.331 160,81	0.040	24.70	0.021	47.35
	23.00	6.366 *161,69*	6.241 158,52	0.039	25.40	0.021	48.69

Casing Sizes and Capacities

CASING SIZES AND CAPACITIES							
OD (in/*mm*)	**Weight (lb/ft)**	**ID (in/*mm*)**	**Drift (in/*mm*)**	**Barrels per Lin. Ft**	**Lin. Ft per Barrel**	**Cubic Meters per Meter**	**Meter per Cubic Meters**
7 *177,8*	26.00	6.276 *159,41*	6.151 *156,26*	0.038	26.13	0.020	50.10
	29.00	6.184 *157,07*	6.059 *153,89*	0.037	26.92	0.019	51.60
	32.00	6.094 *154,79*	5.969 *151,61*	0.036	27.72	0.019	53.14
	35.00	6.004 *152,50*	5.879 *149,33*	0.035	28.56	0.018	54.74
	38.00	5.920 *150,37*	5.795 *147,19*	0.034	29.37	0.018	56.31
	41.00	5.820 *147,83*	5.695 *144,65*	0.033	30.39	0.017	58.26
	44.00	5.720 *145,29*	5.595 *142,11*	0.032	31.46	0.017	60.31
	49.50	5.540 *140,72*	5.415 *137,54*	0.030	33.54	0.016	64.30
7-5/8 *193,70*	24.00	7.025 *178,44*	6.900 *175,26*	0.048	20.86	0.025	39.99
	26.40	6.969 *177,01*	6.844 *173,84*	0.047	21.20	0.025	40.63
	29.70	6.875 *174,62*	6.750 *171,45*	0.046	21.78	0.024	41.75
	33.70	6.765 *171,83*	6.640 *168,66*	0.044	22.49	0.023	43.12
	39.00	6.625 *168,28*	6.500 *165,10*	0.043	23.45	0.022	44.96
	45.30	6.435 *163,45*	6.310 *160,27*	0.040	24.86	0.021	47.66
8-5/8 *219,10*	24.00	8.097 *205,56*	7.972 *202,49*	0.064	15.70	0.033	30.10
	28.00	8.017 *203,63*	7.892 *200,46*	0.062	16.02	0.033	30.70
	32.00	7.921 *201,19*	7.796 *198,02*	0.061	16.41	0.032	31.45
	36.00	7.825 *198,76*	7.700 *195,58*	0.059	16.81	0.031	32.23
	40.00	7.725 *196,22*	7.600 *193,04*	0.058	17.25	0.030	33.07
	44.00	7.625 *193,68*	7.500 *190,50*	0.056	17.71	0.029	33.94

Casing Sizes and Capacities

CASING SIZES AND CAPACITIES							
OD (in/*mm*)	**Weight (lb/ft)**	**ID (in/*mm*)**	**Drift (in/*mm*)**	**Barrels per Lin. Ft**	**Lin. Ft per Barrel**	**Cubic Meters per Meter**	**Meter per Cubic Meters**
8-5/8 *219,10*	49.00	7.511 *190,78*	7.386 *187,60*	0.055	18.25	0.029	34.98
	52.00	7.435 *188,85*	7.310 *185,67*	0.054	18.62	0.028	35.70
9-5/8 *244,50*	32.60	9.001 *228,63*	8.845 *224,66*	0.079	12.71	0.041	24.36
	36.00	8.921 *226,59*	8.765 *222,63*	0.077	12.93	0.040	24.80
	40.00	8.835 *224,40*	8.679 *220,45*	0.076	13.19	0.040	25.28
	43.50	8.755 *222,38*	8.599 *218,41*	0.074	13.43	0.039	25.75
	47.00	8.681 *220,49*	8.525 *216,54*	0.073	13.66	0.038	26.19
	53.50	8.535 *216,79*	8.379 *212,83*	0.071	14.13	0.037	27.09
	58.40	8.435 *214,25*	8.279 *210,29*	0.069	14.47	0.036	27.74
	61.10	8.375 *212,73*	8.219 *208,76*	0.068	14.68	0.036	28.13
	71.80	8.125 *206,38*	7.969 *202,41*	0.064	15.59	0.033	29.89
9-7/8 *250,83*	62.80	8.625 *219,08*	8.500 *215,90*	0.072	13.84	0.038	26.53
10-3/4 *273,10*	32.75	10.192 *258,88*	10.036 *254,91*	0.101	9.91	0.053	19.00
	40.50	10.050 *255,27*	9.894 *251,31*	0.098	10.19	0.051	19.54
	45.50	9.950 *252,73*	9.794 *248,77*	0.096	10.40	0.050	19.93
	51.00	9.850 *250,19*	9.694 *246,23*	0.094	10.61	0.049	20.34
	55.50	9.760 *247,90*	9.604 *243,94*	0.093	10.81	0.048	20.72
	60.70	9.660 *245,36*	9.504 *241,40*	0.091	11.03	0.047	21.15
	65.70	9.560 *242,82*	9.404 *238,86*	0.089	11.26	0.046	21.59
	71.10	9.450 *240,03*	9.29+48 *236,07*	0.087	11.53	0.045	22.10

Casing Sizes and Capacities

CASING SIZES AND CAPACITIES							
OD (in/*mm*)	**Weight (lb/ft)**	**ID (in/*mm*)**	**Drift (in/*mm*)**	**Barrels per Lin. Ft**	**Lin. Ft per Barrel**	**Cubic Meters per Meter**	**Meter per Cubic Meters**
10-3/4 *273,10*	76.00	9.350 *237,49*	9.194 *233,53*	0.085	11.78	0.044	22.57
	81.00	9.250 *234,95*	9.094 *230,99*	0.083	12.03	0.043	23.06
11-3/4 *298,50*	42.00	11.084 *281,53*	10.928 *277,57*	0.119	8.38	0.062	16.06
	47.00	11.000 *279,40*	10.844 *275,44*	0.118	8.51	0.061	16.31
	54.00	10.880 *276,35*	10.724 *272,39*	0.115	8.70	0.060	16.67
	60.00	10.722 *273,61*	10.616 *269,65*	0.112	8.95	0.058	17.17
	65.00	10.682 *271,32*	10.526 *267,36*	0.111	9.02	0.058	17.29
	71.00	10.586 *268,88*	10.430 *264,92*	0.109	9.19	0.057	17.61
13-3/8 *339,70*	48.00	12.715 *322,96*	12.559 *318,99*	0.157	6.37	0.082	12.21
	54.50	12.615 *320,42*	12.459 *316,46*	0.155	6.47	0.081	12.40
	61.00	12.515 *317,88*	12.359 *313,46*	0.152	6.57	0.079	12.60
	68.00	12.415 *315,34*	12.259 *311,38*	0.150	6.68	0.078	12.80
	72.00	12.347 *313,61*	12.191 *309,65*	0.148	6.75	0.077	12.94
	80.70	12.215 *310,25*	12.059 *306,28*	0.145	6.90	0.076	13.23
	85.00	12.159 *308,84*	12.003 *304,88*	0.144	6.96	0.075	13.35
	86.00	12.125 *307,98*	11.969 *304,01*	0.143	7.00	0.074	13.42
	92.00	12.031 *305,59*	11.875 *301,63*	0.141	7.11	0.073	13.63
	98.00	11.937 *303,19*	11.781 *299,24*	0.138	7.22	0.072	13.85
13-5/8 *346,08*	88.20	12.375 *314,33*	12.250 *311,15*	0.149	6.72	0.078	12.89

Casing Sizes and Capacities

CASING SIZES AND CAPACITIES							
OD (in/*mm*)	**Weight (lb/ft)**	**ID (in/*mm*)**	**Drift (in/*mm*)**	**Barrels per Lin. Ft**	**Lin. Ft per Barrel**	**Cubic Meters per Meter**	**Meter per Cubic Meters**
16 *406,40*	65.00	15.250 *292,74*	15.062 *382,57*	0.226	4.43	0.118	8.49
	75.00	15.124 *384,15*	14.936 *379,37*	0.222	4.50	0.116	8.63
	84.00	15.010 *381,25*	14.822 *376,48*	0.219	4.57	0.114	8.76
	109.00	14.688 *373,08*	14.500 *368,30*	0.210	4.77	0.109	9.15
18-5/8 *473,08*	87.50	17.755 *450,98*	17.567 *446,20*	0.306	3.27	0.160	6.26
20 *508,00*	94.00	19.124 *485,75*	18.936 *480,97*	0.355	2.81	0.185	5.40
	106.50	19.000 *482,60*	18.812 *477,82*	0.351	2.85	0.183	5.47
	133.00	18.730 *475,74*	18.542 *470,97*	0.341	2.93	0.178	5.63
	169.00	18.376 *466,75*	18.188 *461,98*	0.328	3.05	0.171	5.84

Drill-Pipe Sizes and Capacities

DRILL-PIPE SIZES AND CAPACITIES						
OD (in/*mm*)	**Weight (lb/ft)**	**ID (in/*mm*)**	**Barrels per Lin. Ft**	**Lin. Ft per Barrel**	**Cubic Meters per Meter**	**Meter per Cubic Meters**
2-3/8 *60,33*	4.80	2.000 *50,00*	0.004	257.35	0.002	493.34
	6.65	1.815 *46,10*	0.003	312.49	0.002	599.04
2-7/8 *73,03*	8.35	2.323 *59,00*	0.005	190.76	0.003	365.69
	10.40	2.151 *54,64*	0.004	222.49	0.002	426.51
3-1/2 *88,90*	11.20	2.900 *73,66*	0.008	122.40	0.004	234.65
	13.30	2.764 *70,21*	0.007	134.74	0.004	258.30
	15.50	2.602 *66,09*	0.007	152.04	0.003	291.47
4 *101,60*	14.00	3.340 *84,84*	0.011	92.28	0.006	176.89
	15.70	3.240 *82,30*	0.010	98.06	0.005	187.98
4-1/2 *114,30*	13.75	3.958 *100,53*	0.015	65.71	0.008	125.97
	16.60	3.826 *97,18*	0.014	70.32	0.007	134.81
	18.10	3.754 *95,35*	0.014	73.05	0.007	140.03
	20.00	3.640 *92,46*	0.013	77.69	0.007	148.94
5 *127,00*	16.25	4.408 *111,96*	0.019	52.98	0.010	101.56
	19.50	4.276 *108,61*	0.018	56.30	0.009	107.93
5-1/2 *139,70*	21.90	4.778 *121,36*	0.022	45.09	0.012	86.44
	24.70	4.670 *118,62*	0.021	47.20	0.011	90.48
6-5/8 *168,28*	22.20	6.065 *154,05*	0.036	27.98	0.019	53.65
	25.20	5.965 *151,51*	0.035	28.93	0.018	55.46
	31.90	5.761 *146,33*	0.032	31.02	0.017	59.46

Fluid Density, Pressure and Buoyancy Factor

Fluid Density, Pressure and Buoyancy Factor						
		Density		Fluid Head		
Degrees API	Specific Gravity	lb/gal (US)	kg/m^3	psi/ft	(kg/cm^2)/m	Buoyancy Factor
60	0.738	6.153	738.00	0.320	0.074	0.906
55	0.758	6.319	758.00	0.329	0.076	0.904
50	0.779	6.495	779.00	0.338	0.078	0.901
45	0.801	6.678	801.00	0.347	0.080	0.898
40	0.825	6.878	825.00	0.358	0.083	0.895
35	0.849	7.078	849.00	0.368	0.085	0.892
30	0.876	7.305	876.16	0.380	0.088	0.888
25	0.904	7.538	904.15	0.392	0.090	0.885
20	0.933	7.778	933.00	0.404	0.093	0.881
15	0.965	8.045	965.00	0.418	0.097	0.877
10	1.000	8.337	1000.00	0.434	0.100	0.873
	1.008	8.400	1007.56	0.437	0.101	0.872
	1.020	8.500	1019.55	0.442	0.102	0.870
	1.032	8.600	1031.55	0.447	0.103	0.869
	1.044	8.700	1043.54	0.452	0.104	0.867
	1.056	8.800	1055.54	0.458	0.106	0.866
	1.068	8.900	1067.53	0.463	0.107	0.864
	1.080	9.000	1079.53	0.468	0.108	0.863
	1.092	9.100	1091.52	0.473	0.109	0.861
	1.104	9.200	1103.51	0.478	0.110	0.860
	1.116	9.300	1115.51	0.484	0.112	0.858
	1.128	9.400	1127.50	0.489	0.113	0.856
	1.139	9.500	1139.50	0.494	0.114	0.855
	1.151	9.600	1151.49	0.499	0.115	0.853
	1.163	9.700	1163.49	0.504	0.116	0.852
	1.175	9.800	1175.48	0.510	0.118	0.850
	1.187	9.900	1187.48	0.515	0.119	0.849
	1.199	10.000	1199.47	0.520	0.120	0.847

Fluid Density, Pressure and Buoyancy Factor

Fluid Density, Pressure and Buoyancy Factor						
		Density		Fluid Head		
Degrees API	Specific Gravity	lb/gal (US)	kg/m³	psi/ft	(kg/cm²)/m	Buoyancy Factor
	1.211	10.100	1211.47	0.525	0.121	0.846
	1.223	10.200	1223.46	0.530	0.122	0.844
	1.235	10.300	1235.46	0.536	0.124	0.843
	1.247	10.400	1247.45	0.541	0.125	0.841
	1.259	10.500	1259.45	0.546	0.126	0.840
	1.271	10.600	1271.44	0.551	0.127	0.838
	1.283	10.700	1283.44	0.556	0.128	0.837
	1.295	10.800	1295.43	0.562	0.130	0.835
	1.307	10.900	1307.42	0.567	0.131	0.834
	1.319	11.000	1319.42	0.572	0.132	0.832
	1.331	11.100	1331.41	0.577	0.133	0.831
	1.343	11.200	1343.41	0.582	0.134	0.829
	1.355	11.300	1355.40	0.588	0.136	0.827
	1.367	11.400	1367.40	0.593	0.137	0.826
	1.379	11.500	1379.39	0.598	0.138	0.824
	1.391	11.600	1391.39	0.603	0.139	0.823
	1.403	11.700	1403.38	0.608	0.140	0.821
	1.415	11.800	1415.38	0.614	0.142	0.820
	1.427	11.900	1427.37	0.619	0.143	0.818
	1.439	12.000	1439.37	0.624	0.144	0.817
	1.451	12.100	1451.36	0.629	0.145	0.815
	1.463	12.200	1463.36	0.634	0.146	0.814
	1.475	12.300	1475.35	0.640	0.148	0.812
	1.487	12.400	1487.35	0.645	0.149	0.811
	1.499	12.500	1499.34	0.650	0.150	0.809
	1.511	12.600	1511.34	0.655	0.151	0.808
	1.523	12.700	1523.33	0.660	0.152	0.806
	1.535	12.800	1535.32	0.666	0.154	0.805

Fluid Density, Pressure and Buoyancy Factor

Fluid Density, Pressure and Buoyancy Factor						
		Density		Fluid Head		
Degrees API	Specific Gravity	lb/gal (US)	kg/m³	psi/ft	(kg/cm²)/m	Buoyancy Factor
	1.547	12.900	1547.32	0.671	0.155	0.803
	1.559	13.000	1559.31	0.676	0.156	0.802
	1.571	13.100	1571.31	0.681	0.157	0.800
	1.583	13.200	1583.30	0.686	0.158	0.798
	1.595	13.300	1595.30	0.692	0.160	0.797
	1.607	13.400	1607.29	0.697	0.161	0.795
	1.619	13.500	1619.29	0.702	0.162	0.794
	1.631	13.600	1631.28	0.707	0.163	0.792
	1.643	13.700	1643.28	0.712	0.164	0.791
	1.655	13.800	1655.27	0.718	0.166	0.789
	1.667	13.900	1667.27	0.723	0.167	0.788
	1.679	14.000	1679.26	0.728	0.168	0.786
	1.691	14.100	1691.26	0.733	0.169	0.785
	1.703	14.200	1703.25	0.738	0.170	0.783
	1.715	14.300	1715.25	0.744	0.172	0.782
	1.727	14.400	1727.24	0.749	0.173	0.780
	1.739	14.500	1739.23	0.754	0.174	0.779
	1.751	14.600	1751.23	0.759	0.175	0.777
	1.763	14.700	1763.22	0.764	0.176	0.776
	1.775	14.800	1775.22	0.770	0.178	0.774
	1.787	14.900	1787.21	0.775	0.179	0.773
	1.799	15.000	1799.21	0.780	0.180	0.771
	1.811	15.100	1811.20	0.785	0.181	0.769
	1.823	15.200	1823.20	0.790	0.182	0.768
	1.835	15.300	1835.19	0.796	0.184	0.766
	1.847	15.400	1847.19	0.801	0.185	0.765
	1.859	15.500	1859.18	0.806	0.186	0.763
	1.871	15.600	1871.18	0.811	0.187	0.762
	1.883	15.700	1883.17	0.816	0.188	0.760
	1.895	15.800	1895.17	0.822	0.190	0.759

Fluid Density, Pressure and Buoyancy Factor

Fluid Density, Pressure and Buoyancy Factor						
		Density		Fluid Head		
Degrees API	Specific Gravity	lb/gal (US)	kg/m^3	psi/ft	(kg/cm^2)/m	Buoyancy Factor
	1.907	15.900	1907.16	0.827	0.191	0.757
	1.919	16.000	1919.16	0.832	0.192	0.756
	1.931	16.100	1931.15	0.837	0.193	0.754
	1.943	16.200	1943.15	0.842	0.194	0.753
	1.955	16.300	1955.14	0.848	0.196	0.751
	1.967	16.400	1967.13	0.853	0.197	0.750
	1.979	16.500	1979.13	0.858	0.198	0.748
	1.991	16.600	1991.12	0.863	0.199	0.747
	2.003	16.700	2003.12	0.868	0.200	0.745
	2.02	16.80	2015.11	0.87	0.20	0.74
	2.027	16.900	2027.11	0.879	0.203	0.742
	2.039	17.000	2039.10	0.884	0.204	0.740
	2.051	17.100	2051.10	0.889	0.205	0.739
	2.063	17.200	2063.09	0.894	0.206	0.737
	2.075	17.300	2075.09	0.900	0.208	0.736
	2.087	17.400	2087.08	0.905	0.209	0.734
	2.099	17.500	2099.08	0.910	0.210	0.733
	2.111	17.600	2111.07	0.915	0.211	0.731
	2.123	17.700	2123.07	0.920	0.212	0.730
	2.135	17.800	2135.06	0.926	0.214	0.728
	2.147	17.900	2147.06	0.931	0.215	0.727
	2.159	18.000	2159.05	0.936	0.216	0.725
	2.171	18.100	2171.04	0.941	0.217	0.724
	2.183	18.200	2183.04	0.946	0.218	0.722
	2.195	18.300	2195.03	0.952	0.220	0.721
	2.207	18.400	2207.03	0.957	0.221	0.719
	2.219	18.500	2219.02	0.962	0.222	0.718
	2.231	18.600	2231.02	0.967	0.223	0.716
	2.243	18.700	2243.01	0.972	0.224	0.715
	2.255	18.800	2255.01	0.978	0.226	0.713

Fluid Density, Pressure and Buoyancy Factor

Fluid Density, Pressure and Buoyancy Factor						
		Density		Fluid Head		
Degrees API	Specific Gravity	lb/gal (US)	kg/m³	psi/ft	(kg/cm²)/m	Buoyancy Factor
	2.267	18.900	2267.00	0.983	0.227	0.711
	2.279	19.000	2279.00	0.988	0.228	0.710
	2.291	19.100	2290.99	0.993	0.229	0.708
	2.303	19.200	2302.99	0.998	0.230	0.707
	2.315	19.300	2314.98	1.004	0.231	0.705
	2.327	19.400	2326.98	1.009	0.233	0.704
	2.339	19.500	2338.97	1.014	0.234	0.702
	2.351	19.600	2350.97	1.019	0.235	0.701
	2.363	19.700	2362.96	1.024	0.236	0.699
	2.375	19.800	2374.96	1.030	0.237	0.698
	2.387	19.900	2386.95	1.035	0.239	0.696
	2.399	20.000	2398.94	1.040	0.240	0.695

Buoyancy Factor = (65.5- MW) / 65.5
Open Ended Pipe Weight (wet) = Pipe Weight (dry) x Buoyancy Factor
Density at 68° F (20 °C) : Water (8.34 ppg) - Steel (65.5 ppg)

Common Completion Brines

Common Completion Brines				
		Maximum Density		
Brine	Symbol	lb/gal (US)	Specific Gravity	(kg/m²)
Potassium Chloride	KCl	9.7	1.16	1160
Sodium Chloride	NaCl	10.0	1.20	1200
Calcium Chloride	$CaCl_2$	11.6	1.39	1390
Sodium Bromide	$NaBr_2$	12.7	1.52	1520
Calcium Bromide	$CaBr_2$	14.2	1.70	1700
Zinc Bromide	$ZnBr_2$	21.0	2.52	2520
Sodium Formate	$NaCHO_2$	12.2	1.46	1460
Potassium Formate	$KCHO_2$	13.1	1.57	1570
Cesium Formate	$CsCHO_2$	19.2	2.30	2300

Salt Dilution

Salt Dilution					
KCl - Potassium Chloride*			NH4Cl - Ammonium Chloride*		
% Soln	S.G.	Density (lb/gal) (US)	% Soln	S.G.	Density (lb/gal) (US)
0.0	1.000	8.34	0.0	1.000	8.34
1.0	1.005	8.37	1.0	1.001	8.35
2.0	1.011	8.43	2.0	1.004	8.38
4.0	1.024	8.53	4.0	1.011	8.43
6.0	1.037	8.64	6.0	1.017	8.48
8.0	1.050	8.75	8.0	1.023	8.53
10.0	1.063	8.86	10.0	1.029	8.58
12.0	1.077	8.97	12.0	1.034	8.63
14.0	1.091	9.09	14.0	1.040	8.67
16.0	1.104	9.20	16.0	1.046	8.72
18.0	1.119	9.32	18.0	1.051	8.77
20.0	1.133	9.44	20.0	1.057	8.81
22.0	1.147	9.56	22.0	1.062	8.86
24.0	1.162	9.69	24.0	1.067	8.90

* As mixed in a fresh water base

Hydrochloric Acid Solution

Hydrochloric Acid Solution			
		Density	Hydrostatic Gradient
HCl - %	Specific Gravity	lb/gal (US)	psi/ft
1	1.005	8.369	0.435
2	1.010	8.41	0.437
3	1.015	8.452	0.440
4	1.020	8.493	0.442
5	1.025	8.535	0.444
6	1.030	8.576	0.446
7	1.035	8.618	0.448
8	1.040	8.659	0.450
9	1.045	8.701	0.453
10	1.050	8.743	0.455
11	1.055	8.785	0.457
12	1.060	8.827	0.459
13	1.065	8.868	0.461
14	1.070	8.91	0.463
15	1.075	8.952	0.466
16	1.080	8.994	0.468
17	1.085	9.036	0.470
18	1.090	9.078	0.472
19	1.095	9.12	0.474
20	1.100	9.162	0.476
21	1.105	9.204	0.479
22	1.110	9.246	0.481
23	1.115	9.288	0.483
24	1.120	9.33	0.485
25	1.125	9.372	0.487
26	1.130	9.414	0.490
27	1.135	9.456	0.492
28	1.140	9.498	0.494
29	1.145	9.54	0.496
30	1.150	9.582	0.498
31	1.155	9.624	0.500
32	1.160	9.666	0.503
33	1.165	9.708	0.505
34	1.171	9.75	0.507
35	1.176	9.792	0.509
36	1.181	9.835	0.511

Summary of API RP 58

Summary of API RP 58						
Recommended Practices for Testing Sand Used in Gravel packing Operations						
Sand Size - US Mesh	**8/16**	**12/20**	**16/30**	**20/40**	**30/50**	**40/60**
Nest of U.S.A. Sieves Recommended for Testing	6	8	12	16	20	30
	8	12	16	20	30	40
	10	14	18	25	35	45
	12	16	20	30	40	50
	14	18	25	35	45	60
	16	20	30	40	50	70
	Pan	Pan	Pan	Pan	Pan	Pan

Property	Specification
Sieving	Minimum 96% should pass the coarse designated sieve. Not over 1/10% should be larger than the largest sieve size. Not over 2% should be smaller than the smallest sieve size.
Sphericity*	.6 or greater
Roundness*	.6 or greater
Acid Solubility**	1% or less
Turbidity	250 Formazin Turbidity Units (FTU) or less

Crush Resistance	**8/16**	**12/20**	**16/30**	**20/40**	**30/50**	**40/60**
Stress on Sand	2000 psi					
Maximum Fines by Weight	8%	4%	2%			

* Spericity and Roundness estimated as per Krumbein and Sloss chart

** Solubility in a 12% hydrochloric - 3% hydrofluoric (by weight) acid solution

Common Gravel-Pack Sand Sizes and Permeabilities

Common Gravel-Pack Sand Sizes and Permeabilities					
Gravel Size	Gravel Grain Size Range		Median Grain Diameter - D50		Approximate Permeability Resieved Gravel
U.S. Mesh	Inches	*mm*	Inches	*mm*	Darcies
8/12	.0937 - .0661	*2.38 - 1.68*	0.080	*2.029*	1965
12/20	.0661 - .0331	*1.68 - .841*	0.050	*1.260*	520
16/30	.0469 - .0280	*1.19 - .711*	0.037	*0.951*	400
20/40	.0331 - .0165	*.841 - .419*	0.025	*0.630*	135
30/50	.0232 - .0117	*.711 - .297*	0.017	*0.443*	100
40/60	.0165 - .0098	*.419 - .249*	0.013	*0.334*	60
50/70	.0117 - .0083	*.297 - .211*	0.010	*0.254*	30

Gravel-Pack Sand Sizing

Gravel-Pack Sand Sizing						
Gravel	Inches			Millimeters		
	GP Sand D50	Formation d50		GP Sand D50	Formation d50	
		From	To		From	To
U.S. Mesh		(D50/6)	(D50/5)		(D50/6)	(D50/5)
8/12	0.080	0.013	0.016	2.029	0.338	0.406
12/20	0.050	0.008	0.010	1.260	0.210	0.252
16/30	0.037	0.006	0.007	0.951	0.159	0.190
20/40	0.025	0.004	0.005	0.630	0.105	0.126
30/50	0.017	0.003	0.003	0.443	0.074	0.089
40/60	0.013	0.002	0.003	0.334	0.056	0.067
50/70	0.010	0.002	0.002	0.254	0.042	0.051

Industry standard gravel sizing methodology - Saucier's Rule

Frac Pack Ceramic Proppant Sizing						
Proppant	Inches			Millimeters		
	Proppant D50	Formation d50		GP Sand D50	Formation d50	
		From	To		From	To
U.S. Mesh		(D50/10)	(D50/8)		(D50/10)	(D50/8)
16/30	0.035	0.004	0.004	0.890	0.089	0.111
20/40	0.025	0.002	0.003	0.630	0.063	0.079
30/60	0.017	0.002	0.002	0.419	0.042	0.052
40/70	0.012	0.001	0.002	0.315	0.031	0.039

Based on tendency is to size frac pack proppant larger than Saucier' Rule

Sand and Proppant Density

Sand and Proppant Density			
Type	Name	Specific Gravity	BulkDensity (lb/ft³)
Sand	50/70 Gravel	2.65	100
Sand	40/60 Gravel	2.65	100
Sand	20/40 Gravel	2.65	100
Sand	16/30 Gravel	2.65	100
Sand	12/20 Gravel	2.65	100
Sand	10/20 Gravel	2.65	100
Sand	10/16 Gravel	2.65	100
Sand	8/12 Gravel	2.65	100
Sand	40/70 Jordan-Unimin	2.65	100
Sand	20/40 Jordan-Unimin	2.65	100
Sand	16/30 Jordan-Unimin	2.65	100
Sand	12/20 Jordan-Unimin	2.65	100
Sand	20/40 Brady	2.65	100
Sand	16/30 Brady	2.65	99.47
Sand	12/20 Brady	2.65	99.68
Sand	10/20 Brady	2.65	99.68
Sand	8/16 Brady	2.65	98.38
Sand	40/70 Badger	2.65	98
Sand	20/40 Badger	2.65	100
Sand	16/30 Badger	2.65	100
Sand	12/20 Badger	2.65	100
Ceramic	20/40 CarboLite®	2.71	102
Ceramic	16/20 CarboLite®	2.71	102
Ceramic	12/18 CarboLite®	2.71	100
Ceramic	8/12 CarboLite®	2.71	99

Sand and Proppant Density			
Type	Name	Specific Gravity	BulkDensity (lb/ft³)
Ceramic	30/50 Econoprop®	2.70	97
Ceramic	20/40 Econoprop®	2.72	96
Ceramic	20/40 CarboProp®	3.27	124
Ceramic	16/30 CarboProp®	3.27	123
Ceramic	12/20 CarboProp®	3.27	112
Ceramic	6/10 CarboProp®	3.27	112
Ceramic	30/60 Carbo-HSP2000	3.61	131
Ceramic	20/40 Carbo HSP®2000	3.56	125
Ceramic	18/30 Carbo HSP®2000	3.56	125
Ceramic	16/30 Carbo HSP®2000	3.56	130
Ceramic	16/20 Carbo HSP®2000	3.56	130
Ceramic	12/18 Carbo-HSP®2000	3.56	130
Ceramic	30/50 Sintered Bauxite	3.49	125
Ceramic	20/40 Sintered Bauxite	3.49	125
Ceramic	16/30 Sintered Bauxite	3.49	125
Ceramic	30/50 Sinterball	3.62	133
Ceramic	20/40 Sinterball	3.64	134
Ceramic	16/30 Sinterball	3.63	133
Ceramic	16/20 Sinterball	3.60	133
Ceramic	14/20 Sinterball	3.60	133
Ceramic	20/40 Interprop®	3.15	113
Ceramic	16/30 Interprop®	3.15	113
Ceramic	16/20 Carboprop	3.27	117
Ceramic	12/18 Carboprop	3.27	117
Ceramic	8/14 Carboprop	3.27	117

Slurry Density

Slurry Density Table for 20/40 Sand with a SG of 2.65 and Specific Volume of 0.0456						
PPA	**Water**	**7% KCl**	**9ppg Brine**	**10ppg Brine**	**11ppg Brine**	**12ppg Brine**
0	8.34	8.70	9.00	10.00	11.00	12.00
0.5	8.64	8.99	9.29	10.27	11.24	12.22
1	8.93	9.28	9.56	10.52	11.48	12.43
1.5	9.21	9.55	9.83	10.76	11.70	12.64
2	9.48	9.81	10.08	11.00	11.91	12.83
3	9.98	10.29	10.56	11.44	12.32	13.19
4	10.44	10.74	10.99	11.84	12.69	13.53
5	10.86	11.16	11.40	12.21	13.03	13.84
6	11.26	11.54	11.78	12.56	13.35	14.13
7	11.63	11.90	12.13	12.89	13.64	14.40
8	11.97	12.24	12.46	13.19	13.92	14.65
9	12.29	12.55	12.76	13.47	14.18	14.89
10	12.60	12.84	13.05	13.74	14.42	15.11
12	13.15	13.38	13.57	14.22	14.87	15.51
14	13.64	13.85	14.04	14.65	15.26	15.87
16	14.07	14.28	14.45	15.03	15.61	16.19

Formula: Ds = (Dcb + PPA) / ((.0456 * PPA) + 1

Where: Ds = Density of slurry
Dcb = Density of completion brine
PPA = pounds proppant added

Table for 20/40 Sand

Fill up Table for 20/40 Sand with a SG of 2.65 and Specific Volume of 0.0456		
PPA (lb/gal)	**Fill Up (%)**	**Sand in Slurry (lb/bbl)**
0	0.00	0.00
0.5	3.66	20.53
1	7.15	40.17
1.5	10.50	58.97
2	13.71	76.98
3	19.74	110.84
4	25.30	142.09
5	30.45	171.02
6	35.23	197.87
7	39.68	222.87
8	43.84	246.20
9	47.72	268.02
10	51.36	288.48
12	58.00	325.77
14	63.90	358.91
16	69.18	388.56

Screen Gauge or Pore Sizing for Gravel Packs

Screen Gauge or Pore Sizing for Gravel Packs									
Gravel Size	**Gravel Grain Size Range**		**Approximate Pore Size**		**70% Minimum Mesh**		**Recommended Gauge/Pore Size**		
U.S. Mesh	**Inches**	***mm***	**Inches**	***mm***	**Inches**	***mm***	**Wire Wrapped Screen Gauge**	**Exelflo Pore Size**	**Maxflo Pore Size**
8/12	.0937 - .0661	*2.38 - 1.68*	0.012	*0.315*	0.046	*1.176*	50	250	CSM
12/20	.0661 - .0331	*1.68 - .841*	0.007	*0.178*	0.023	*0.589*	20	250	CSM
16/30	.0469 - .0232	*1.19 - .595*	0.006	*0.140*	0.016	*0.417*	15	250	CSM
20/40	.0331 - .0165	*.841 - .400*	0.004	*0.099*	0.012	*0.280*	12	175, 250	CSM
30/50	.0232 - .0117	*.595 - .297*	0.003	*0.079*	0.008	*0.082*	8	125	FSM
40/60	.0165 - .0098	*.400 - .250*	0.002	*0.053*	0.007	*0.175*	6	125	FSM
50/70	.0117 - .0083	*.297 - .210*	0.002	*0.038*	0.006	*0.147*	5	75	NA

Please consult with Weatherford Sand Control personnel for sizing screen for stand-alone applications

Screen Base Pipe and Washpipe Ratios

Screen Base Pipe and Washpipe Ratios									
Screen					Flush Joint Washpipe OD		Screen ID to Washpipe OD		
Base Pipe OD		Wt.	Base Pipe ID				Ratio	Radial Clearance	
Inches	mm	ppf	Inches	*mm*	Inches	*mm*		Inches	*mm*
2 3/8	60.3	4.6	1.995	*50.6*	1.660	*42.2*	0.832	0.168	*4.200*
2 7/8	73.0	6.4	2.441	*62.0*	1.900	*48.3*	0.778	0.271	*6.850*
3 1/2	88.9	9.2	2.992	*76.0*	2.375	*60.3*	0.794	0.309	*7.850*
4	101.6	11.0	3.476	*88.3*	2.375	*60.3*	0.683	0.551	*14.000*
4 1/2	114.3	13.5	3.920	*99.6*	2.875	*73.0*	0.733	0.523	*13.300*
5	127.0	18.0	4.276	*108.6*	3.500	*88.9*	0.819	0.388	*9.850*
5 1/2	139.7	20.0	4.778	*121.4*	3.500	*88.9*	0.733	0.639	*16.250*

Industry recommendations are to use a washpipe with an OD equal to 70-80% of the base pipe ID.

Standard Sieve Conversions

Standard Sieve Conversions			
U.S. mesh	Inches	Microns	Millimeters
3	0.265	6730	6.730
4	0.187	4760	4.760
5	0.157	4000	4.000
6	0.132	3360	3.360
7	0.111	2830	2.830
8	0.094	2380	2.380
10	0.079	2000	2.000
12	0.066	1680	1.680
14	0.056	1410	1.410
16	0.047	1190	1.190
18	0.039	1000	1.000
20	0.033	841	0.841
25	0.028	707	0.707
30	0.023	595	0.595
35	0.020	500	0.500
40	0.017	400	0.400
45	0.014	354	0.354
50	0.012	297	0.297
60	0.010	250	0.250
70	0.008	210	0.210
80	0.007	177	0.177
100	0.006	149	0.149
120	0.005	125	0.125
140	0.004	105	0.105
170	0.004	88	0.088
200	0.003	74	0.074
230	0.002	63	0.063
270	0.002	53	0.053
325	0.002	44	0.044
400	0.002	37	0.037

Notes

Notes

Solving Your Sand Control Challenges

Turn to Weatherford for the optimal balance between sand-control investment and return. Contact your authorized Weatherford representative, or visit **weatherford.com/sandcontrol**

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