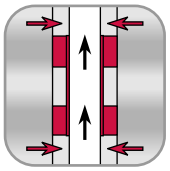
Expandable Completion Systems

Providing the organizational capabilities, well-screen technology understanding, system reliability and installation experience to effectively address your sand control challenges.

High Productivity



Effective Isolation

Weatherford®

Solving your sand control challenges.

Weatherford has been accelerating the implementation of all expandable technologies, related tools and accessories since the mid-1990s.

Weatherford International Ltd.

Weatherford International Ltd. (NYSE:WFT) is the fourth largest diversified upstream oilfield service company in the world, providing industry-leading technologies through a worldwide infrastructure of 18,000 employees in 108 countries. Weatherford's products and services span the drilling, completion, production and intervention cycles of oil and natural gas.

A key strategy for Weatherford is the development and deployment of production-enabling technologies that convert reserves to revenue. These technologies range from enabling ones, such as expandable systems, to upgrades of our classic product lines, such as tubular running services and cementation systems.

To learn more about Weatherford's full capabilities, visit **weatherford.com.**

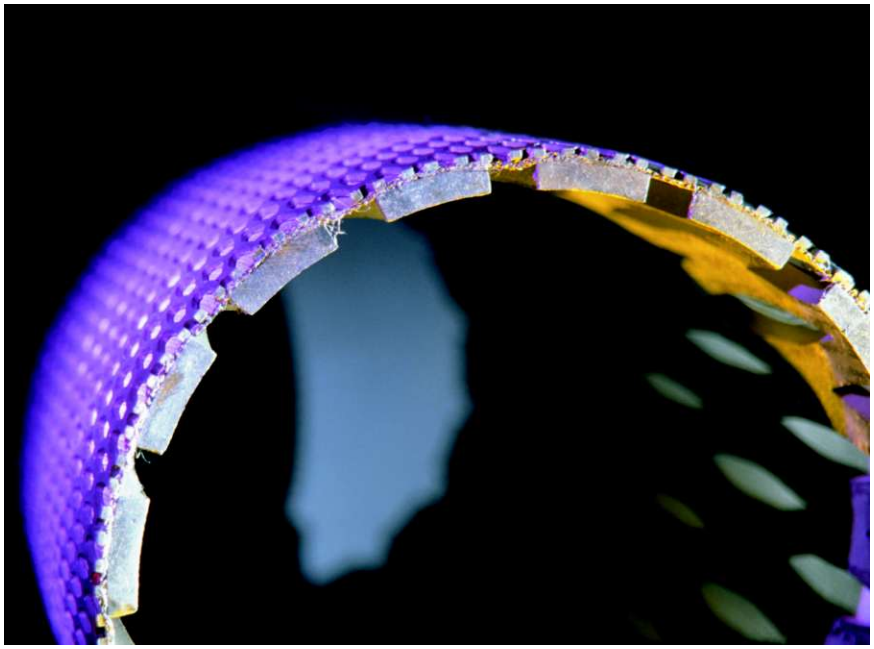
Weatherford: The Expandable Completion Experts™

Often Imitated, Never Duplicated

Today's expandable system providers are not all created equal. Why? Because while each provider offers systems that expand steel downhole, the similarities end there.

Weatherford has been a leader in expandable completion technologies since the mid 1990s. From the beginning we have focused on designing, developing, installing and continuously improving expandable technology that overcomes conventional completion design limitations. Along the way we've created a unique and far-reaching knowledge, engineering, manufacturing and distribution infrastructure that cannot be duplicated by any other expandable completion provider.

In short, we now have the organizational capabilities, well-screen technology understanding, system reliability and installation experience to effectively address your sand-control challenges.



The simple and reliable ESS® sand control technique was the stepping stone for Weatherford's expandable completion system offering.

The result is a modular expandable completion system that can be designed to address your specific well challenges, ultimately helping you maximize reservoir productivity and reserves recovery while minimizing risk and cost. It is an expandable completion system you can't get from any other company but Weatherford, The Expandable Completion Experts™. Our pioneering expandable technologies include:

Expandable Sand Screens (ESS®)

Weatherford's proven *ESS* system has been changing the face of sand control for more than five years, improving well productivity and significantly reducing costs compared to a gravel pack. Our system has been especially successful in long, single-zone reservoir sections. The *ESS* section is expanded compliantly against the wellbore, eliminating the annular space and providing borehole support and sand exclusion, thus removing the need to place gravel for filtration of formation sand. The system has been run in more than 500 installations around the world.

Expandable Solid Tubular Technology

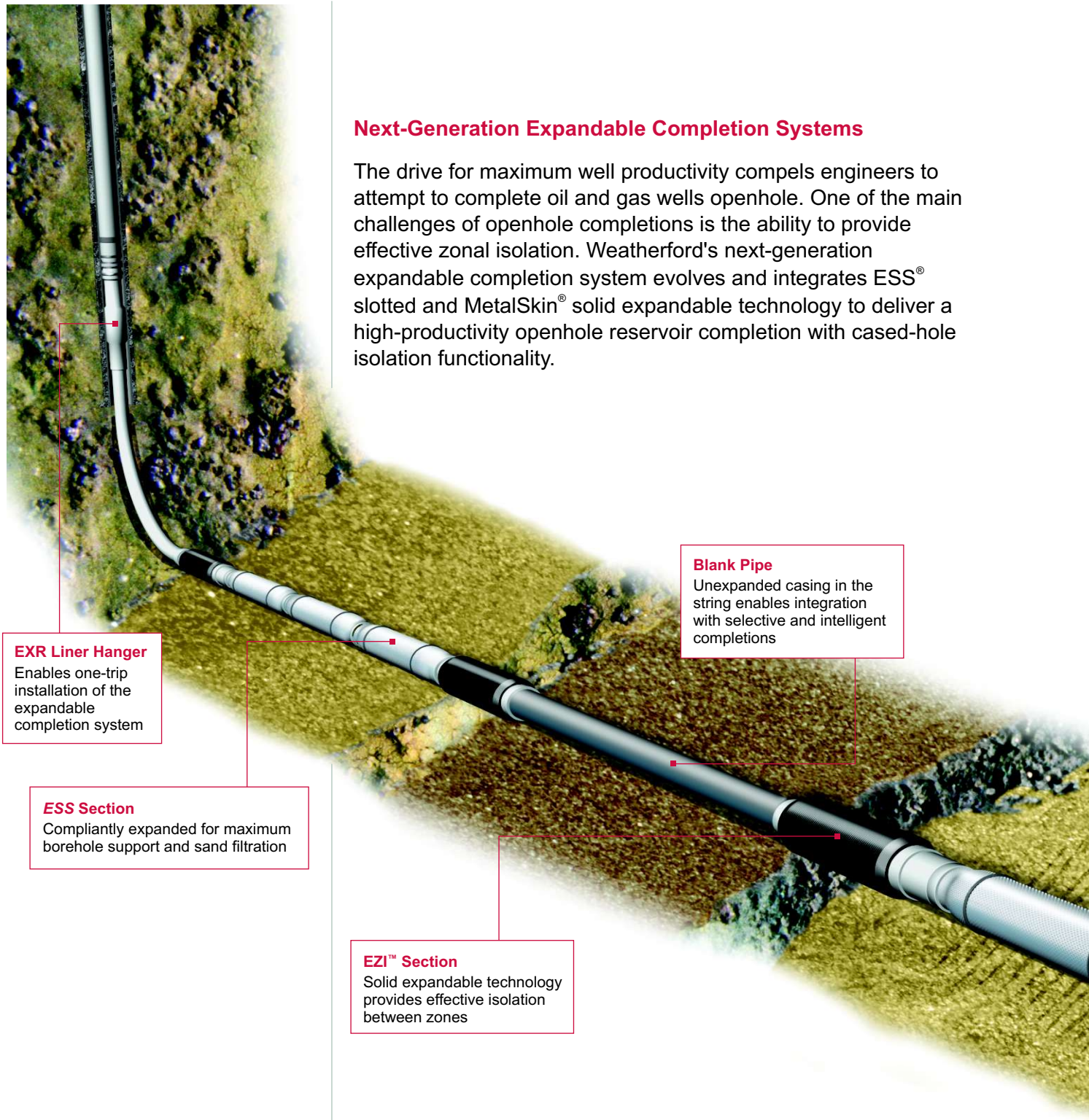
Weatherford pioneered the development of compliant rotary expansion of solid tubulars, facilitating the downhole expansion of solid pipes to contact casing wall or wellbore with zero annulus. The MetalSkin® family of products uses this proprietary technology to provide unique solutions for a number of applications from casing repair to isolation of troublesome formations during drilling. On securing a license from Shell in 2002, Weatherford gained access to fixed-cone solid expandable technology. Since then we have developed a range of products that are installed as intermediate drilling liners to help reduce the telescoping effect associated with conventional well construction.

Typically, well costs have been cut by 20 percent or more, and productivity increased by up to 70 percent with *ESS* systems.

Weatherford has developed a range of solid expandable technologies that reduce the costs typically associated with conventional well construction.

Next-Generation Expandable Completion Systems

The drive for maximum well productivity compels engineers to attempt to complete oil and gas wells openhole. One of the main challenges of openhole completions is the ability to provide effective zonal isolation. Weatherford's next-generation expandable completion system evolves and integrates ESS® slotted and MetalSkin® solid expandable technology to deliver a high-productivity openhole reservoir completion with cased-hole isolation functionality.



And there are other valuable benefits. By eliminating the need for cementing and perforating, our expandable completion system can reduce well construction costs; the efficiency of single-trip installation saves rig time; and the openhole completion increases oil and gas recovery and reduces formation damage.

The modular, single-trip expandable completion system can be designed for almost unlimited combinations of components that include the following:

- ESS® sections selectively expand to control the transfer of reservoir solids to the wellbore, maximize productivity, optimize reliability and increase operational efficiency.
- MetalSkin® expandable zonal isolation (EZI™) compliant-expanded solid tubulars provide positive zonal isolation while maximizing ID to provide better well access for future interventions.
- The slotted expandable completion liner (ECL™), expanded against the formation wall to eliminate the requirement for perforating, is applicable where downhole sand control is not required.

Sections of blank pipe also can remain unexpanded between the *ESS*, *EZI* and *ECL* components, providing conventional wellbore geometries for setting selective and intelligent completions and truly delivering unparalleled flexibility in completion design.

Primary Benefits of Expandable Completion Systems

- Openhole productivity with cased-hole functionality
- Unparalleled flexibility in completion design
- Natural extension of proven *ESS* technology

Our expandable-specific capabilities are supported by Weatherford's worldwide R&D network. The network includes two of the industry's largest R&D, testing and training facilities, located in Houston and Aberdeen.

Automated *ESS* Construction Process

Automated High-Pressure Water Jet Slotting

Organizational *Capabilities*

Unrivaled R&D, Engineering and Manufacturing Facilities

Petroline WellSystems Ltd. manufactured the first prototype ESS® system in 1997.

After aquiring Petroline in 1999, Weatherford made a significant investment in manufacturing and technical service support systems and infrastructure, all of which have helped accelerate the development of the technology.

Specialized Engineering Knowledge

Weatherford has assembled a highly talented team of completion specialists whose depth of expertise and breadth of disciplines range from mechanical, petroleum and reservoir engineering to highly specialized metallurgy and rock mechanics.

Custom-Build Manufacturing Facility

Weatherford manufactures the full spectrum of expandable products at our own purpose-built facility in Aberdeen, Scotland. Our advanced manufacturing methods and equipment include the world's only four-head laser cutting machine and the world's largest abrasive water-jet equipment. We also use custom-built, automated slotting, weave wrapping and welding machines to manufacture *ESS* systems to our exacting specifications.

Controlled Bench Testing of Expandables

Weatherford's unique expansion test and qualification rig has a complete data-acquisition suite and a power capability equal to that of a full-scale drilling rig. Data acquisition is networked to our design office to give dedicated design engineers immediate access to all test information.

We conduct tests to model actual pending installation operations for specific clients and then analyze the data to formalize design limits and develop best deployment practices. Weatherford also uses this physical testing to validate state-of-the-art, three-dimensional, nonlinear finite element analysis (FEA). FEA deepens our understanding of the plastic deformation process and is fundamental to the development of next-generation systems.

Expandable Technology *Understanding*

Better Candidate Selection Process, Knowledge of Successful Operating Envelopes

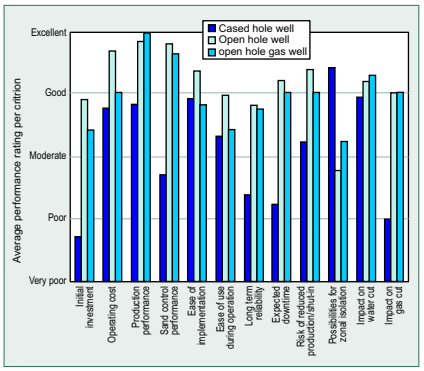
With more than 500 ESS® systems now installed in a variety of operating conditions in numerous locations worldwide, we've amassed a significant body of knowledge and gained an unparalleled understanding of how to apply the technology.

We also conducted a detailed study on more than 70 of our installations. This study has helped us further improve expandable candidate selection procedures, determine successful operating envelopes, and scope out the next generation of expandable completion systems, which are now available. Highlights of what we've learned:

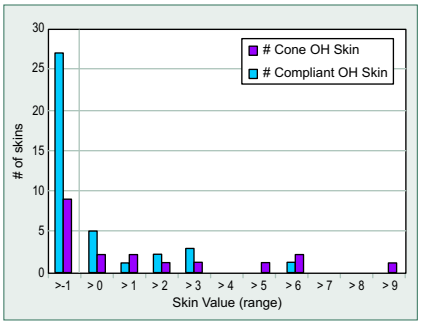
- **Expandable completion systems work best in openhole applications, where they have a track record for improving productivity and controlling sand production.** We compared the results of *ESS* systems in openhole versus cased-hole applications and found that the performance of this technology in both openhole oil and gas wells ranged from good to excellent in the areas of productivity, sand control and ease of implementation. In cased-hole applications, installed *ESS* systems ranked lower.

  These findings were not surprising. *ESS* technology was not originally designed for cased-hole applications; however, as a result of this knowledge, we significantly tightened our cased-hole *ESS* application guidelines and incorporated most of the current design features of *ESS* technology into the next-generation system.

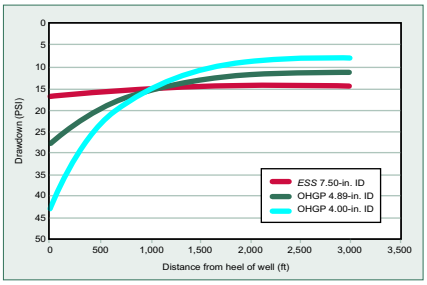
- **Compliant expansion and the large ID of the *ESS* system stabilize the borehole and significantly contribute to improved production performance.** Various third-party studies confirm that eliminating the annulus through compliant expansion improves sand control. Our own studies further proved this finding. We compared skin caused by wellbore damage in 70 wells where we've collected this type of data. The average skin for the compliantly expanded *ESS* system was 0.3, while systems expanded with by non-compliant methods exhibited an average skin of 2.3.



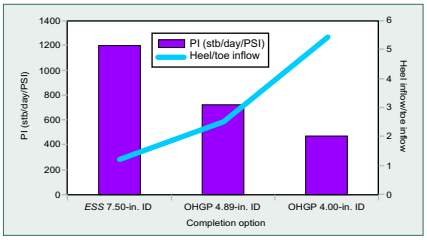
ESS Performance per Criteron per Well Type



Compliant Expansion and Increased Productivity



Large ID and optimal inflow: For wells flowing at the same rate, the drawdown profile for the *ESS* system is much flatter than those for the two horizontal openhole gravel pack options. The flatter drawdown profile gives the *ESS* system a much higher productivity index and a flatter inflow profile. The flatter inflow profile has the potential to slow the influx of water into the well and to improve the ultimate recovery of oil.



Lab Tests for Weave Filtration Media

Likewise, the large ID of the ESS® system has an intrinsically low friction-induced flowing pressure reduction. This advantage helps increase productivity, reduce water or gas coning and improve overall recovery in the reservoir. A smaller-ID completion, on the other hand, induces preferential inflow at the heel of the well, which causes water or gas to be drawn in at the heel, reducing oil flow and ultimately recovery.

- **Using the coarsest weave possible for a particular sand reduces the possibility of plugging by mud or the mud filter cake.** We've conducted lab tests measuring pressure and sand retention build-up on *ESS* weaves with various reservoir sands since the beginning of 2002. Results show a good correlation between the largest particles in a distribution and the retention performance of the weave.

  Consequently, part of our in-house specialists' filter media selection process includes evaluation of particle-size information, by sieving or laser diffraction, and sand retention, mud-flowback and full-scale screen testing before recommendation of an appropriate weave.

- **Metallurgy affects performance in terms of expansion, collapse and tensile bond.** We typically conduct an assessment of well corrosivity and provide specific material recommendations for all *ESS* applications. For production wells, we assess the fluid, temperature and pressure data to determine the partial pressures of acid gases and estimate the potential in situ pH of produced waters. We then assess the in situ pH, pH_2S and chloride content and temperature levels to evaluate the risk of localized corrosion or environmental cracking.

  As a result, we usually recommend an austenitic stainless steel, which offers high ductility, strain-hardening rate and fracture toughness for the base pipe and shroud sections. This specification is well suited to moderately corrosive CO_2-bearing reservoirs. For connectors, we use super duplex stainless steels, which have a minimum yield strength more than double that of the austenitic base pipe. Weatherford can upgrade these materials as needed for specific applications.

Documented *Reliability* with Well-Engineered Products

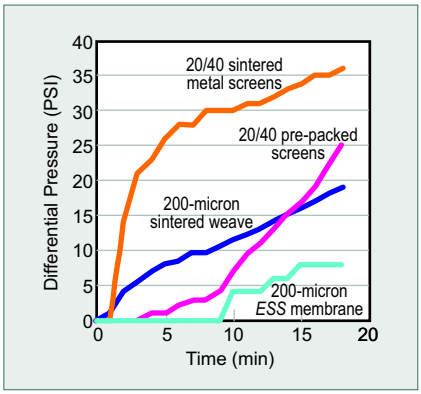
Compliant Expansion Design Is Key

The ESS® System

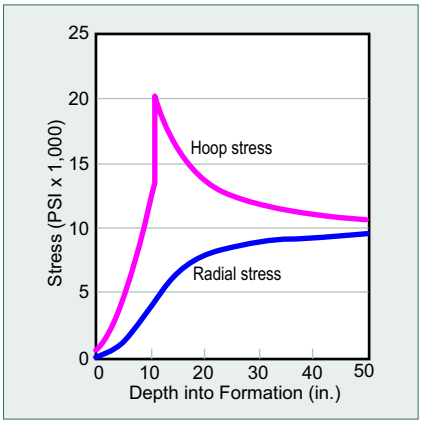
Designed for reliability, the *ESS* system is a combination of four overlapping rectangular sheets of Petroweave™ metal weave filters attached to a slotted expandable base pipe and encased within a protective metal shroud. This construction provides a mechanical, permeable sand filter that supports the original wellbore. Compliant expansion minimizes the annulus and reduces near-wellbore stress-induced damage, significantly reducing the likelihood of fines production and migration.

In addition, the unique wellbore-compliant design, combined with the in situ properties of the rocks that the *ESS* system supports, enables the *ESS* system to withstand large changes in formation stresses caused by drawdown and depletion.

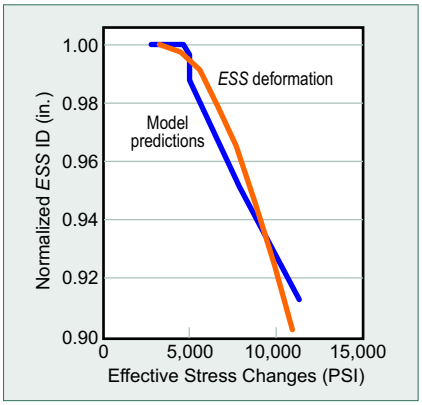
- ***Proven collapse resistance.*** An independent third-party joint industry project, started in 2001, studied the borehole stabilization effects of the *ESS* system in large-scale pressure vessel tests. The *ESS* system was expanded in situ either to be compliant or to leave an annulus of known dimensions. The tests were conducted in a variety of weak rock and unconsolidated sands to investigate the effects of an annulus, breakouts and the interface between weak and strong materials. Very large simulated-depletion and drawdown-induced stress changes (up to 10,000 PSI) were applied, with no loss of *ESS* system stability or sand retention integrity.
- ***Wellbore stability model.*** We've used the results of the tests to qualify an expandables wellbore stability model, with which we screen all applications for collapse. A limit of 20 percent reduction in ID in application screening ensures that the deformation of the *ESS* system never results in an operating ID less than the minimum ID of the completion or a loss of sand retention integration.



Sand Screen Blockage Comparison

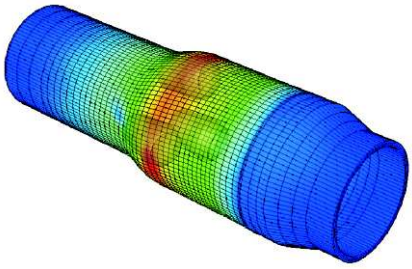


Stress Arch Development in the Formation



Experimental *ESS* Deformation and Model Predictions for Large Changes in Effective Stress

The ultimate goal of solid tubular technology is reduction of the telescopic nature of well design and construction.



Parametric finite element analysis models are calibrated with physical testing and are used to predict expansion parameters and steer next-generation designs.

Expandable Tubular Systems

Weatherford has acquired considerable experience in predicting the effects of expansion on tubular performance. Tubular expansion is a deformation process that naturally effects changes in material properties concurrent with changes in dimensions. As different materials respond differently to the introduction of plastic strain, the ability to use material data in conjunction with dimensional changes in various orientations has been key to developing predictive capabilities for such properties as tensile strength, toughness, and burst and collapse resistance. Such predictive capabilities enhance the reliability of new system designs and have been reinforced by extensive product testing.

Weatherford's MetalSkin® technology has been used extensively to address wellbore isolation challenges. Unique, proprietary compliant expansion technology enables a tubular-to-wellbore fit, eliminating annular flow and resisting differential pressures.

Proven Expandables Installation *Experience*

Installing More Expandables Each Year Than Any Other Company

Since its first commercial application of an ESS® system, in January 1999, Weatherford has broken a number of new expandable technology barriers and set several industry records. The following timeline captures the highlights.

1993: Shell and Petroline sign slotted research and development agreement.

1995: An installation in west Texas marks the first commercial application of slotted alternative borehole liner (ABL®) tubulars.

1999: Weatherford acquires Petroline and commercially launches the *ESS* system.

An installation in Nigeria marks the first horizontal *ESS* application.

2000: Weatherford begins developing solid expandables.

A record-setting *ABL* installation takes place in Oman.

2001: Weatherford's installation of an *ESS* system in the North Sea represents the longest *ESS* installation to date.

An *ESS* installation in Asia marks the first multizone application.

2002: Shell and Weatherford sign new global license agreement covering slotted and solid expandable technology.

In Asia, Weatherford deploys its solid expandable liner hanger system for the first time.

In California, Weatherford deploys its MetalSkin® cased-hole remediation system for the first time.

2003: A job in the Niger Delta marks the 225th *ESS* installation.

2004: More than 300 *ESS* systems have been installed around the world, including the Gulf of Mexico, South America, Asia, North Sea, Middle East, Azerbaijan, Africa and Australia.

2005: The world's first 7-in. expandable isolation system is successfully installed in a trial well in south Texas.

2007: More than 500 *ESS* systems installed around the world.

Weatherford has expanded more than 36 miles of its *ESS* product in locations around the world.

Solving your sand control challenges.

Weatherford®

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