# EXPANDABLE STEEL TECHNOLOGY: THE GROUNDBREAKING SOLUTION FOR DOWNHOLE ISOLATION

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Traditionally, there are 3 technologies available for permanent packers used in completions: Inflatables, Hydro-Mechanical, and Swellables. Using Expandable Steel as the reinforcement of a sealing system is an innovation bringing game changing features unseen before. A long history of completion repair and seal off led and allowed Saltel Industries to develop isolation systems to develop unique ways to create isolation systems with expanded metals.
The Saltel Expandable Steel Annular Zonal Isolation Packer (SES Packer) is designed in a unique way. It is slid onto the casing, before both extremities are positioned and fixed on this casing by welding or crimping. Once at depth, high pressure inside the casing (or a straddle tool) is transmitted inside the packer through an expansion port. This triggers the plastic expansion of the expandable steel, which will mold to the inside of the borehole, sealing-off the annulus for the life of the well. This simple philosophy enables Saltel Industries to provide sturdy, reliable and cost effective annular isolation packers for a variety of applications.

Its simple design increases the reliability and the success ratio of operations, as well as its cost efficiency. With no moving part, and reduced length and Outside Diameter (OD), it is sturdy to reach Total Depth (TD) safely. The packer molds to the formation or casing, even in oval or out-of-gauge boreholes. By controlling very accurately the expansion of the metal sleeve, the operation allows to predict the stresses that will be applied to the formation. The packer seals even with severe temperature variations, for the life of the well.
The sealing profile and pressure compensation systems are tailored to fit the application needs. The innovation brings:

- An increased reliability and lifespan to ECP (External Casing Packers) used in cement stage operations, with a gas tight efficiency and a 10,000 psi internal pressure rating to sustain frac pressures.
- A 10 to 15k differential rating even with temperature drops with the FracPacker used in Open-hole completions (with ball-drop sleeves of CTAS)
- A slim profile for existing well isolation to mitigate the ID loss for Refrac or Remedial application with the Slimline Packer
- A preserved Well Integrity after the setting of the Well-Integrity Annular Zonal Isolation (WI-AZIP)

This paper will describe in details, the advantages of Expandable Steel technology applied in annular Packers for various applications. The paper will go through the necessary qualification process used for demanding environments, and describe case studies that contributed to field prove the technology.

## 1. WORKING PRINCIPLES

The Saltel Expandable Steel packer can be considered as a “solid metal structure” inflatable packer. The SES packers and inflatables are both using hydraulic internal pressure to inflate to set.

In the case of an inflatable packer, the material is made of a deformable elastomer (rubber) matrix composite material. The rubber itself is not able to sustain a lot of pressure, and indeed needs to be reinforced. Just like car tires use many steel cords to hold the internal air pressure. Inflatable packers have an orientation of the reinforcement that allows its deformation. They can be steel cords or slates. Inflatables also have a sliding end, allowing the shortening of the packer during its setting. This is why inflatable packers have one of the best expansion ratios (Max setting ID / running OD) of the available technologies.
Those packers can be used in cased-hole or open-hole. Utilized as a permanent solution, or on the contrary, as a temporary system. During testing operations, the element is indeed deflated by releasing the pressure inside it, and removed.

This is the major difference with the SES Packer. Indeed, the material of the Expandable Steel packer is made of a solid pipe covered with an elastomer layer. When pressure is applied inside the casing and transmitted

inside the packer through an expansion port, the steel starts expanding “elastically” (meaning a release of the pressure at this time would allow it to bounce back to its original diameter), then “plastically” (the steel is permanently deformed).
When increasing the pressure, the packer reaches the ID of the borehole where it is set, and seals the annulus. During this phase, the elastomer layer on the outside of the expandable steel sleeve is compressed and creates the sealing.
When bleeding off the pressure inside the casing, the spring back effect of the steel reduces slightly the OD of the packer. The sealing layer then relaxes, but it is still compressed even with no pressure inside the casing, guaranteeing the sealing.

Specialized Running Equipment

There is no setting tool required to set the SES packers. Pressure alone pumped in the casing string is sufficient to expand after RIH. The drop of a ball of a valve on a toe collar is necessary.
If used between sand-screens, a special tool run on coil tubing isolates the expansion port to increase pressure locally at the level of the packer.

Necessary rig Equipment

The SES packers being composed of steel, the expansion pressure required to set them is relatively high. Depending on the packer configuration and diameter, the downhole setting pressure lies between 2,000 psi and 6,500psi. Therefore, there are a few things that require verification:
Pressure rating of the casing string: the setting pressure needs to be below 80% of its burst rating of the pipe and the connections.
Pressure rating of the toe port or DV tool, needing to be pinned up at a higher pressure than the packer activation pressure
Pressure pumping power available at the time to set the packers. The ECP range has been specially developed to decrease the setting pressure, as only the rig pump is usually available during drilling and cementing operations.

## 2. TECHNICAL DIFFERENTIATION

This section compares the SES technology to the technologies already available and presents the useful features for the particular applications they are dedicated to.

### 2.1 Stage cementing

The stage cementing isolation packer market is mostly using inflatable systems. They are interesting due to 2 reasons:

- High expansion ratio: they can adapt to irregular and large boreholes, useful in the open-hole.
- Low expansion pressure: they need to be the first element to be activated.

Inflatable systems have limitations that are inconvenient and cannot be improved because inherent to their concept.
During Run In Hole (RIH): the sliding end allowing their expansion may not allow the rotation or reciprocation of the casing string to reach TD. Indeed, the inflation of such packers requires having a sliding end cap that translates over a polished surface, while keeping a good seal. To prevent the premature setting of the packer during the RIH, shear pins lock this cap in place. This restricts the compression and torque that can be applied to the casing string.
In the SES ECP, there is no moving part. Both extremities of the packer are fixed onto the casing which is the mechanical structure of the packer. There is therefore no weakness added to the casing string due to the packer. Moreover, the expandable steel element is rather short in length, and can go through severe doglegs without having the risk of becoming stuck or damaging the sealing profile. SES packer seals, made of high performance HNBR rubber and CNC machined, are protected during the RIH by the end caps.
Pressure rating: The differential pressure rating is achieved when a closing valve shuts down the communication between the inside of the casing and the inside of the packer. This valve traps pressure inside the packer, allowing the hold of the differential pressure. It is composed of moving parts with tight tolerances and short adjustments that can lead to failure.
The elastomer matrix composite material of the inflatable packer does not allow very high internal pressure ratings. The elastomer has the tendency to extrude through the reinforcements with high pressures, especially at high temperature, when it is softer.

To overcome those issues, the SES ECP, made of expandable steel does not rely on a valve to sustain pressure in the annulus. The casing internal pressure is transmitted in an expanded solid metal pressure vessel, which has ability to sustain high internal pressures. As soon as the sealing profile on the outside of the expandable sleeve is compressed against the borehole, the seal is created. When higher differential pressures are required, a thicker sleeve is recommended. This however leads to an increase of the necessary pumping power necessary to expand the steel during the setting. It is therefore recommended to check on the rating of the casing string and the pumping pressure at surface before choosing this solution. If used in conjunction with a stage tool (DV), it is important to pin the valve up so that it opens at a higher pressure than the activation pressure of the ECP.

In operations very demanding on the DP rating, a valve can be added, under specific conditions.

For inflatable packers, there is also a rather short life span during which the seal is effective. With temperature and time, elastomers age, and performance is altered. The SES ECP is using long lasting materials that will not be significantly damaged with time. The SES packer acts as an efficient annular secondary barrier along with the cement.

For the SES ECP, the materials used are chosen to resist the environment fluids, and also the galvanic corrosion that occurs when 2 different alloys are assembled together. The SES ECPs assemblies are welded onto a 10' pup-joint consisting of L-80 grade pipe. When downhole fluids are extremely corrosive, with high content of H2S, CO2 and / or HCl, the casing used must be of a higher grade. In such cases, Saltel Industries can propose the SES AZIP alternative (Annular Zonal Isolation Packer) that uses a crimping operation for the assembly to the casing, to get rid of the difficult process of welding highly alloyed steel. It allows using any casing metallurgy and weight as a base pipe.

### 2.2 Open-hole multistage

The use of packers to create mechanical isolation downhole to frac through sliding sleeves has been done for years in the Open-Hole Multi-Stage (OHMS) wells. It uses two rather different packer technologies to create annular isolation in uncemented casings. Depending mostly on the formation consolidation, operators are using either hydro-mechanical or swellable packers.

With tight rock, mechanical packers are commonly used. The seal created by the compression of an elastomer packing sealing the inside of the borehole.
There are some advantages using this technology, but also limitations. With a rather solid and cylindrical hole, the seal is usually good. Their short length goes through severe doglegs, and their activation is a matter of minutes. However, to obtain a good seal, the packer does not tolerate irregular borehole geometries, and does not cope with localized washouts. The moving parts of the mechanism leads to a system which can be comparatively large for the running OD, and can cause limitations to rotate or reciprocate. There is a lot of stress applied to the formation right after the setting of those packers. This has been proven to often create fracture initiation in front of the sealing element, causing poor stage isolation and unwanted fracture placement.

When the formation is not as consolidated, the borehole is not as regular, and the swellable packers are usually preferred. They are using a thick layer of non-reinforced rubber that will swell by absorbing the surrounding down-hole fluids. They have the ability to take the shape of the borehole, and benefit from an extremely simple design, that can keep the mechanical failure rate to a minimum. However, this technology is weak for many other reasons. First, the seal is not efficient. During the setting, the rubber is unable to create a solid seal as it does not energize significantly the formation: it creates a pressure drop through it but do not plug the annulus. The packer therefore relies on the length of the elastomer to provide a sufficient restriction. This length can be problematic for the RIH, as the sealing profile can be damaged in the curve, especially in severe doglegs. They do not centralize during the setting, and require centralizers that create a drag during RIH. Also, the time they take to set depends on the surrounding fluids and temperature. This can lead to premature setting, or on the contrary, to packers not fully isolating the annulus before the frac treatment.

The SES FracPacker combined the advantages of the swellable and the mechanical technologies, and eliminates their limitations.

As the mechanical structure of the packer is the same as the rest of the casing string, the make-up of the connections of the packer is just like assembling any other piece of pipe. They are provided on a 10ft pup to have a long pipe length on both sides of the sealing element for tong placement on the rig floor.

During the RIH, no significant weakness is brought by the packers, and the casing string can be rotated and reciprocated at will. The sealing profile is protected by the fixed end caps. The packers are relatively short (around 2.5ft) to pass through severe doglegs. The outside diameter is comparatively low, with a running OD of 5.5" for 4.5" completions. They do not require any centralization as the packers are using the setting pressure to centralize. The drag is therefore limited compared to other technologies.

During the setting, the SES packers are using a rather high internal pressure in the casing to expand. This avoids any premature setting from occurring. They are self-adapting to the borehole, even if highly ovalized (~20%) or out of gauge. As an example, the FracPacker used in 6"1/8 holes still guarantees the same differential pressure rating in front of washout up to 6"3/4 in diameter.
With years of experience of running expandable steel patches in many different conditions, Saltel Industries is capable of predicting the pressure at which the packer will reach the inside diameter of the open-hole, and at which pressure the packers will be successfully set.
The stress applied to the formation is very limited. The pressure transmitted to the formation is the one necessary to compress the seals, which is no more than a few hundred psi. As this sealing layer is 2-3ft, there is extremely limited stress concentration, as the stress is evenly spread on a large surface area avoiding any stress concentration. The setting operation requires less than 30 minutes and does not require field personnel.

During the stimulation, the SES FracPacker creates no internal restriction, therefore potential pressure drop. To ensure a sold seal, it uses the pressure from the treatment to hold the seal. Above the ball activating the sliding sleeve, or above the BHA in a Coil Tubing Activated Sleeve (CTAS), the stimulation pressure inside the casing is transmitted inside the expandable steel through the expansion port: the more pressure is used, the more the packer pressurizes the formation and therefore seals. Though, under the ball (or the CTAS tools), there is no pressure in the casing that can be transferred inside the packer close to the toe. The patented dual sleeve system of the FracPacker transfers the pressure from the annulus interval inside the packer. During the packer setting, two layers of expandable steel were expanded. The outside layer of steel has many compensation ports facing the interval side. Those ports allow pressure to be equalized inside the packer close to the toe during the stimulation. The inside layer will collapse during this phase, letting the pressure inside the packer, and blocking the expansion port.

A temperature drop can be expected while using a high flow rate of cold water through a well. As the energy of the stimulation is used to hold the seal, temperature variations do not affect the seal.
The anchoring of the packer to the formation is also important during the stimulation.

Finally, the unique characteristics of the SES FracPackers are allowing a long term seal. This is a supplementary benefit when many operators today are looking at the possibility to stimulate wells by using re-frac technologies that are being tested for a few years.

This is why the FracPacker proposes the highest pressure rating, the strongest structure and the best adaptiveness to downhole conditions. Their unique performance can help to develop the OHMS technique in areas where traditional isolation packers are failing. Also, because their design is simple, the SES FracPackers are cost-efficient and allow safer operations.

### 2.3 Slim-hole recompletion

There are several reasons to use tubing to recomplete a well. The most obvious is to take care of corrosion issues that lead to many casing leaks that prevent the use from a short casing patch. There is also an increasing interest in re-stimulation techniques for EOR in frac wells. The new tubing can be used from heel to toe, or on a significant length of the well.

The isolation system described here, the SES Slimline Packer, proposes an interesting alternative to existing technologies like solid expandable technology, slim-hole recompletions using hydro-mechanical packers and cemented liners.

Compared to expandable liners, The SES Slimline packer enables a safe operation, from the RIH to the setting, at a competitive price.
Both ends of the expandable steel sleeve are fixed on the base pipe. The packer has no moving parts, which makes it, along with its short length (2.5ft.), very safe to RIH. To get the best compression ratio possible, the tubing string uses semi-premium couplings that provide a competitive performance/price ratio compared to API

or Premium connections. DWC/C from VAM® or equivalent has a lower OD than the packers, and has a much better compression performance than flush connections used in expandable or cemented liners.
On the operational side, all the SES Slimline packers are set simultaneously, allowing a very rapid setting (less than 30 minutes when pumping is initiated). This leads to significant cost savings for the operation.
The expandable steel sleeve is hydraulically expanded with pressure transmitted from the casing by an expansion port like explained before. This expandable membrane of the packer molds the wellbore ID enabling a good seal even in corroded or ovalized casings, which expandable liners can have difficulties with, as only expanding concentrically. Also, in old wells, the remaining casing wall might be very thin. The SES Slimline packer equipped completion has the ability to control the pressure applied to the old casing to create a seal between zones.
This is why with SES Slimline packers, operational risks are very low, for a fraction of the costs of expandable liners.

Compared to recompletion systems using hydro-mechanical packers (also called scab liner or straddle packer) the SES Slimline packers provide mechanical isolation with a limited ID loss. They have a very slim profile, as they are set around tubing chosen to fit nicely inside the original casing, with a clearance for the RIH kept to a minimum.
Assembled onto the new pipe used for the recompletion, the SES Slimline packer has a slick ID that mitigates friction during the re-frac operations, and enables the use or larger diameter tools compared to hydro-mechanical packers. Its profile, trimmed down to be the slimmest possible, allows a small RIH OD (4.66") for 5.5" (#17).
To obtain such large ID, cemented liners are the only alternative. However, this technique are difficult for the RIH, because of the short clearance, the low compression rating of flush connections and the need to use centralizers to obtain a concentric cement barrier. Also, the cement leads to near wellbore damage that will require the re-establishment of formation communication after the recompletion.

The Slim-Line packer reduces the ID to a minimum and is available in 4" liners for 5.5" casing sizes. It is 10k psi rated, and qualified to ISO 14310 V3. A lighter tubing weight can also be proposed for lower re-frac pressures, with a better ID. Other sizes are soon available, using 3.5" liners 4.5" in wells, and 4.5" liners in light 5.5" wells.
The SES packers design simplicity ensures its reliability. Is also helps to keep pricing to a minimum, and provide a lower cost than traditional isolation techniques, with a much better performance.

## 3. QUALIFICATION PROCESS

The SES packers were thoroughly tested to be proven to adapt to harsh conditions in the oilfield. Saltel Industries owns and operate state of the art testing apparatus, able to apply high stress to packers being tested. The test jigs can apply:
20,000psi pressure, internally and in the annulus
500°F of temperature, with the ability to operate rapid changes
500 metric tons of axial load

The packers are tested to conditions never seen before to prove its behavior.
For the FracPacker, a sudden temperature drop is expected to occur during the stimulation treatment. The sealing of the packer is therefore tested at high temperature, then, back to ambient temperature before going back up again to max temperature. It is a testing cycle very unique, and that proves that the FracPackers are sealing even with temperature cycles that usually shrinks the elastomer seals of competitive technologies.
The packer anchoring inside the borehole is tested by applying an axial load to the packer while it is set inside casing. This conservative approach tests the anchoring force created by the packer with or without pressure inside it.
Finally, pressures are applied internally and externally on the packers, to stimulate all the conditions that can take place downhole.
The performance envelop can be shared when available to measure the performance of the packer under all those parameters.

## 4. CASE HISTORIES: EXAMPLES OF RECENT APPLICATIONS

After years of various casing patch operations, and years of development on the SES packer, the field trial period of the technology began in 2015. Here lies below some of the field trials that confirmed the superior performance of the isolation elements made of steel that were measured during the qualification process.

## 2.1 Case history No.1: SES FracPackers 4.5" (10k Dynamic Seals)

*Area:*
Alberta, Canada

*Well Type and Conditions:*
Gas producer, horizontal well with open-hole multi-stage completion (ball-drop sleeves)
4 ½ in 13.5 lb. /ft. P110 (special drift with ID=3.92in / 99.6mm)
Drilling rig to RIH the packers
Frac fleet to expand the packers

Only 5 FracPackers were run at the toe of a completion also equipped with 15 packers from another vendor, hydraulically set mechanical packers. The idea for the Operator testing SES packers for the first time was to limit the risk: stimulation and production from the heel part of the well is still possible in the unlikely event of a failure from the expandable steels packers at the toe.

*Packer configuration*
The packers were fitted with dynamic seals on both extremities of the bonded elastomer layer.
Every packer is delivered set on a 12' pup joint.
The connections are LTC, pin and box.

*Setting*
The up and down side of the packers is clearly indicated on the product
Setting fluid: brine

*Setting specifications*
Borehole ID = 6.125in / 125.6mm
Stage spacing 330' / 100m
Measured depth between 12,675ft (3850m) and 13,800ft (4200m)

*Frac data*
1. Volume: 2855bbl ; Avg. pressure: 6,815psi ; Max pressure: 7,395psi;
2. Volume: 2409bbl ; Avg. pressure: 6,670psi; Max pressure: 7,395psi;
3. Volume: 2271bbl ; Avg. pressure: 6,380psi; Max pressure: 7,395psi;
4. Volume: 2107bbl ; Avg. pressure: 6,380psi; Max pressure: 6,815psi;
5. Volume: 2289bbl ; Avg. pressure: 5,945psi; Max pressure: 7,395psi;

*Trial data*
The efficiency of the isolation system was monitored with two methods.
A classic approach to check the pressures and rates of each frac treatment in the intervals isolated by the SES FracPackers has shown a solid annular isolation.
Also, micro-seismic studies on the well was carried out to see if a more effective isolation was producing more seismic events than the conventional isolation packers. Though official results have not been released yet, the Operator representative acknowledged that the fracturing signature was better with the SES FracPacker than with conventional packers (hydro-mechanical packers).

Following this success, the Operator decided to install SES FracPackers on all the stages on the completion of a well in the same area. 36 packers were run at the end of 2015.

## 2.2 Case history No.2: 7 in SES ECP

*Area*
Queensland, Australia

*Well type and conditions: Vertical well, Coal Seam Gas producer*
Set on 7" 23lb/ft. L80 casing (ID 6.366in / 161.7mm)
Set inside a 9"5/8 36lb/ft. casing (8.961in / 226.6mm)
Setting depth at 1070' (326m)

*Running Assembly, Setting*
Packer is delivered set on a 10' pup joint.

The connections are BTC, pin and box.

*Setting specifications and Results*
Cased hole of 8.961" ID
Setting fluid: drilling mud
Setting pressure 2,200 psi (152bar)

Packer correctly set as cement circulated to surface.
The operator found the SES ECP inflation "simplistic and used friendly for field operators, without the necessary inflation and bleed-off procedures of a conventional inflatable ECP".

### 2.3 Case history No.3: 7 in SES ECP

*Area*
Queensland, Australia

*Well type and conditions: Vertical well, Coal Seam Gas producer*
Set on 7" 23lb/ft. L80 casing (ID 6.366in / 161.7mm)
Set inside 8.75" open-hole (222.2mm)
Setting depth at 1070' (326m)

*Running Assembly, Setting*
Packer is delivered set on a 10' pup joint.
The connections are BTC, pin and box.

The Operator had a lot of trouble to run the casing through under gauge hole. Casing was rotated and reciprocated while pumping, but the string did not reach TD. When the casing was pulled back, the SES ECP showed absolutely no sign of deformation, and was run again. It has been successfully set during the second run after a successful RIH.

*Setting specifications and Results*
Setting fluid: drilling mud
Setting pressure 2,150 psi (148bar)

Packer correctly set as cement was able to be circulated to the surface.

## 5. CONCLUSION AND POTENTIAL FUTURE DEVELOPMENTS

The tremendous experience of Saltel Industries in the Expandable Steel field empowered them to develop a high performance yet simple line of packers with unique advantages. With pressure ratings guaranteed up to 15,000psi, temperature ratings up to 320°F, self-adaptation and centralization in the borehole and durability, the SES packers are a game changer.

Reaching the end of their development, the range of annular packers is already wide, with sizes from 2-7/8" to 9-5/8". They are now being tested successfully in the field. They are available to resolve technical challenges, and also to bring a cost-effective alternative to solutions currently available in horizontal and vertical wells, open or cased hole environments, onshore or offshore.

The unique performance of the SES packers is enabling the use of packers in conditions that were not possible before. The current developments are focusing on offshore applications, where additional features are added to the previously listed advantages.
The Well Integrity AZIP (WI-AZIP) restores the casing integrity once installed. This is particularly useful in out of production zones closely overseen by the regulator.
The E-WI-AZIP provides sensors in the annulus isolated by the packer. They are transmitting pressure and temperature readings from the B annulus, from one or the other side of the packer. The data transfer is wireless, and the data can be retrieved along the life of the well thanks to a wireline tool, even through tubing.

There are of course, many other possible developments, as well as standard product adaptations to particular well conditions. The responsive R&D team, the integrated processes and the flexible organization of Saltel Industries

allows rapid and efficient solutions delivery, to various fields and environments. With a special attention to detail, performance and quality, Saltel Industries is dedicated to customer satisfaction.

## 6. TABLE AND FIGURES

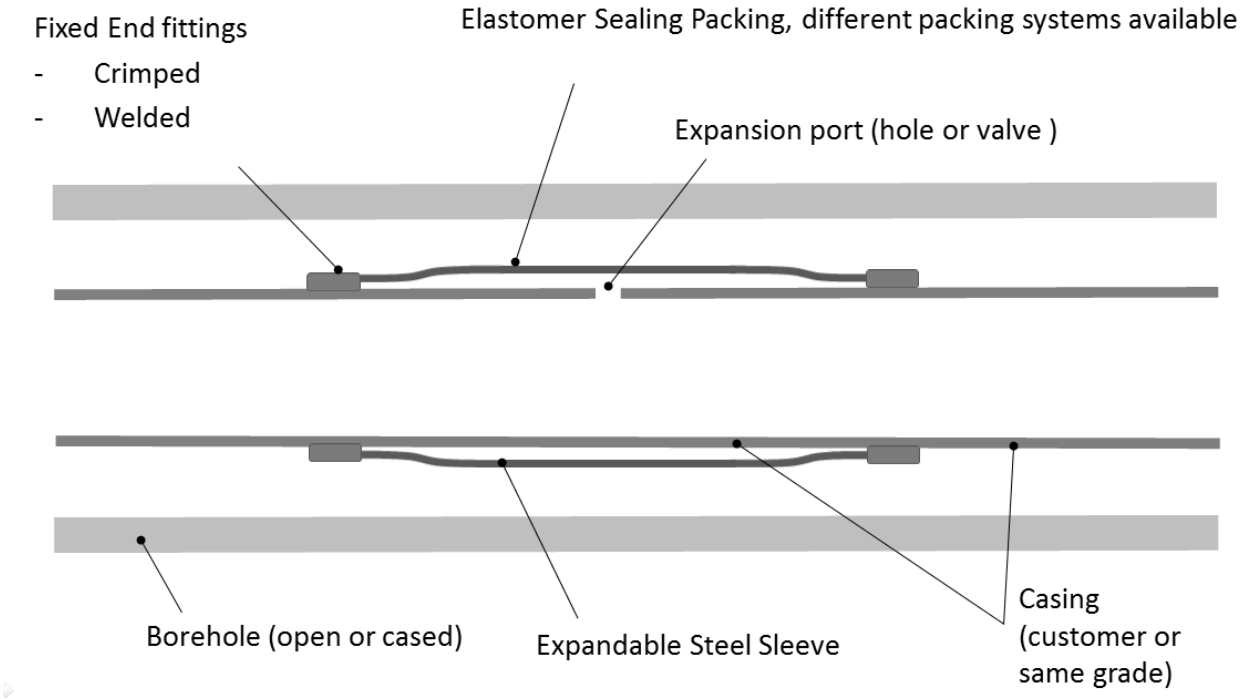


**Figure 1, SES ECP principle**

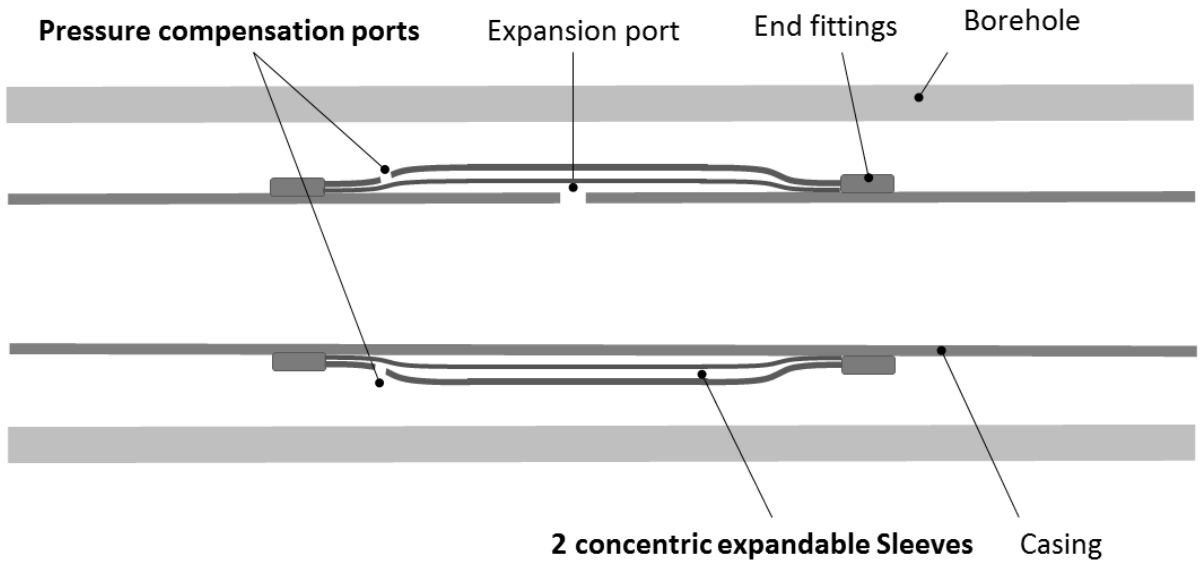

**Figure 2, SES FracPacker principle**

| SES FracPacker 10k<br>Double sleeve design | Refrac 4.5 in. Completions |
|---|---|
| Base pipe | 4.5 in 13.5 lb/ft P110 |
| Tool ID (No restriction) | 3.875 in. |
| RIH External OD | 5.5 in. |
| Nominal borehole diameter to set in | 6.125 in. |
| Maximum borehole diameter to set in | 6.6 in. |
| Ovalized borehole | OK |
| Overall length of the packer (a) | 3.3 ft |
| Sealing contact length (b) | 1.40 ft |
| Pup Joint length | 10 ft |
| Threaded connection* | BTC or LTC |
| Max. service temperature | 250°F (320°F) |
| DLS (Dogleg Severity) | 15 deg/100 ft. |
| Minimum pressure to initiate packer expansion | 2,000 psi |
| Expansion pressure to reach casing ID** | 4,500 – 5,800 psi |
| Expansion pressure to compress the Elastomer sealing cover** | 5,500 - 6,800 psi |
| Internal pressure rating (set in casing) | 10,000 psi |
| Differential annular pressure rating across the packer | 10,000 psi |
| Annulus to casing ID differential without pressure compensation* | 700 psi |

**Figure 3, SES FracPacker performance**

| SES Slimline Packer | Refrac 4.5 in. Completions | | Refrac 5.5 in. 17 lb/ft Completions | Refrac 5.5 in. 20 lb/ft Completions |
|---|---|---|---|---|
| | **3.5 in.** | | 4.5 in. | 4 in. |
| Base pipe | 3.3 in 12.7 lb/ft L80 | | 4.3 in.15.1 lb/ft L80 | 4 in.9.5 lb/ft or 4in 13.2 lb/ft |
| Tool ID (No restriction) | 2.750 in. | | 3.826 in. | 9.5lb/ft = 3.548 in. 13.3 lb/ft = 3.340 in. |
| RIH External OD | 3.65 in. | | 4.65 in. | 4.52 in. |
| Casing to be set in | 4.5 in 11.6 lb/ft | 4.5 in. 13.5 lb/ft | 5.5 in. 17 lb/ft | 5.5in. 20lb/ft |
| ID of Casing to be set in | 4.00 in. | ID 3.92in. | 4.89 in. | 4.78 in. |
| RIH Clearance with casing ID | 0.35 in. | 0.27 in. | 0.24 in. | 0.26 in. |
| Overall length of the packer (a) | 1.95 ft | | 2.50 ft | 2.50 ft |
| Sealing contact length (b) | 1.40 ft | | 1.80 ft | 1.80 ft |
| Pup Joint length | 10 ft | | 10 ft | 10 ft |
| Threaded connection* | DWC/C® (or equivalent) | | DWC/C® (or equivalent) | DWC/C® (or equivalent) |
| Max. service temperature | 250°F | | 250 °F | 250 °F |
| DLS (Dogleg Severity) | 15 deg/100 ft. | | 15 deg/100 ft. | 15 deg/100 ft. |
| Minimum pressure to initiate packer expansion | 2,000 psi | | 1,500 psi | 1,500 psi |
| Expansion pressure to reach casing ID** | 3,500 - 4,000 psi | | 2,700 - 3,200 psi | 2,700 - 3,200 psi |
| Expansion pressure to compress the Elastomer sealing cover** | 4,500 - 5,000 psi | | 3,700 - 4,200 psi | 3,700 - 4,200 psi |
| Internal pressure rating (set in casing) | 10,000 psi | | 10,000 psi | 9.5lb/ft = 6,500 psi. / 13.3 lb/ft = 10,000 psi |
| Differential annular pressure rating across the packer | 10,000 psi | | 10,000 psi | 9.5lb/ft = 6,500 psi. / 13.3 lb/ft = 10,000 psi |
| Annulus to casing ID differential without pressure compensation* | 950 psi | | 700 psi | 700 psi |