
THE
GROWING
ROLE FOR
EXPANDABLES

Jerry Fritsch, Enventure, USA, discusses high performance solid expandables for HPHT and deepwater operations.

In the 15 years that solid expandable technology (SET) has been available, more than 1600 systems have been installed globally. This equates to enough solid expanded pipe to reach from earth to the International Space Station and beyond – over 260 miles (Figure 1). A growing portion of this pipe is designed for HPHT applications.

Over 14 000 ft of specialised SET pipe has been installed in high-pressure land, shelf and deepwater wellbores. Each application added significant value to the wellbore construction process by resolving unique problems, both in drilling and repairing the well. Bottomhole temperatures in these extremely deep wellbores can exceed the 400 ˚F (200 ˚C) rating of standard SET systems. To address these extremes, a 7 ⅝ in. high-temperature (HT) SET system has been developed that increases SET ratings by 50 ˚F (10 ˚C) to 450 ˚F (230 ˚C).

In the challenging operational and economic conditions presented by HPHT wellbore construction, the use of these HP and HT SET systems allow an operator to add additional casing strings that may be critical in reaching the planned depth with the optimal wellbore diameter.

High-performance solid expandables

The challenge: initial need for a high-performance solid expandable

The need for a high-performance expandable was initially recognised for a North Sea operator drilling HPHT wells in the Central Graben Area. The operation required an additional casing string to isolate high-pressured shales prior to drilling a lower pressure interval immediately below. The drilling was being executed from a wellhead platform that had been set some years earlier; therefore, adding an additional string to isolate the shales or changing the upper and/or intermediate casing strings were not options (Figure 2). In collaboration with the operator regarding the use of a solid expandable liner to cover the high-pressured shales, it was calculated that the pressure when drilling the lower pressure interval would create a collapse scenario with a negative differential of 2000 - 3000 psi on the expandable liner.[1] This differential could exceed the rating of a standard solid expandable liner. Thus, the need for a high-performance expandable liner was determined.

Development of a high performance solid expandable

Work began immediately to develop a 7 ⅝ in. SET system to provide at least a 50% increase in collapse rating. Development of the HP SET was completed in compliance with ISO9001 quality standards. Early testing verified that, in order to increase the collapse rating, an increase in wall thickness would be required. To attain the necessary collapse rating and retain optimal post-expanded diameter, a 0.500 in. wall thickness was selected. The thicker wall of the HP design (0.500 in. wall versus 0.375 in. for the standard system) slightly reduced the post-expanded inside diameter of the liner; however, it provided an acceptable diameter for drill-ahead diameter and running the next casing string.

The HP pipe was manufactured to proprietary product specifications using electric resistance welded (ERW) tubing produced by US Steel (formerly Lone Star Steel) and Nippon Steel. The manufacturing specifications met, and in certain instances exceeded, the requirements of API 5CT for L-80 casing. For example, SET casing has a tighter wall tolerance requirement of < 8% (versus API's 12.5% tolerance) and higher minimum-impact resistance values.

7 ⅝ in. HP SET specifications and first installation

The 7 ⅝ in. HP SET was shipped to location was run, cemented and expanded in a 17.5 ppg OBM environment to cover the known high-pressure shale section at a depth below 15 000 ft. This first 7 ⅝ in. HP SET system had a pre-expanded length of 1665 ft. After the liner was installed, the shoe was drilled out and mud weight reduced. These operations exerted more than 2000 psi collapse differential pressure across the post-expanded liner.[2] Drilling continued to the next casing point where the planned 6 ⅝ in. conventional casing was run and cemented. The wellbore was then successfully drilled to TD and completed with the planned tubular diameters (Figure 2).

Additional installations and sizes of high performance solid expandables

Since the installation of the first 7 ⅝ in. HP SET, additional applications were identified that required enhanced mechanical ratings. To support these special applications, both 11 ¾ in. and 8 ⅝ in. HP SET Systems have been developed and qualified (Table 1).

The 11 ¾ in. HP system was first installed in a deepwater Gulf of Mexico well. Subsequently, another system was run in a Caspian Sea well. The recently developed 8 ⅝ in. HP system was qualified for an operator with a specific challenge in the North Sea; the system has been a contingency on their last two wells, but it has not been run yet. To date, a total of 11 HP SET systems have been installed, five of which have been in deepwater Gulf of Mexico (Table 2).

Gulf of Mexico deepwater applications using high-performance expendables

Well repair installations

The first and second installations of HP SET in the Gulf of Mexico deepwater were used to repair the existing casing. The first liner was a 333 ft (pre-expanded) installation used to cover a section of 13 ⅜ in. base casing that experienced significant wall loss above a whipstock due to drill pipe rotation during sidetracking operations.[2] The wall loss was identified during a required regulatory casing calliper inspection log (Figure 3). After log evaluation, an 11 ¾ x 13 ⅜ in. HP SET was selected as the best option due to the liner's ability to restore both pressure and mechanical integrity to the wellbore with its 0.618 in. pre-expanded wall. Of utmost importance was the system's ability to provide the required post-expanded diameter to continue the wellbore construction with the planned casing programme. Following installation and successful pressure testing, the wellbore was approved by regulatory authorities to resume sidetracking operations. The well was successfully sidetracked, drilled to total depth and completed.

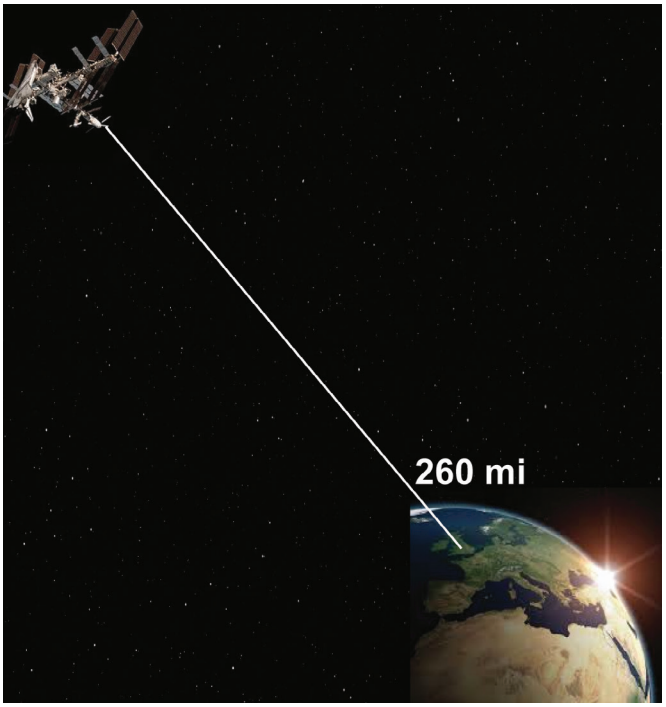

Figure 1. *Expanded pipe installations reach from Earth to beyond the International Space Station.*

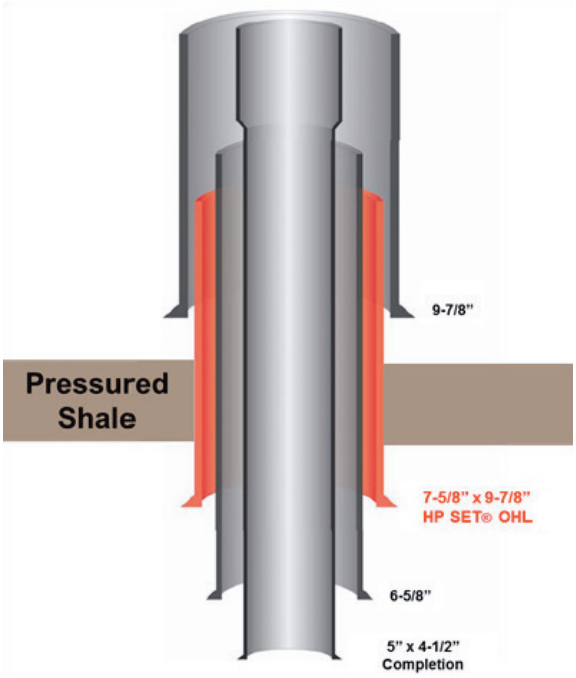

Figure 2. *Pressured shale requiring HP SET.*

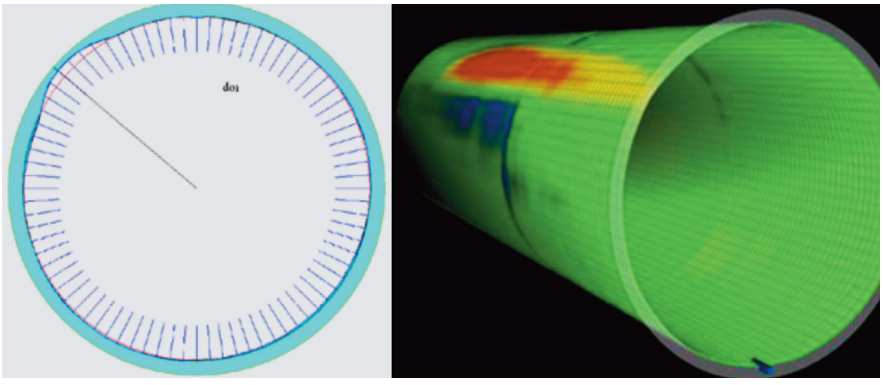

Figure 3. *Wall loss due to drill pipe rotation wear.*

The second Gulf of Mexico deepwater application used a 7 ⅝ x 9 ⅝ in. HP SET system to cover an unwanted set of perforations. The HP SET liner pre-expanded length was 46 ft. Following the installation and pressure test, the well completion was re-run and the well returned to production. Subsequent HP SET installations in the deepwater Gulf of Mexico have all been drilling liners utilising the 7 ⅝ in. system.

Drilling installations

After the first 7 ⅝ in. installation, additional HP SET systems that have been run outside the Gulf of Mexico deepwater, including one 11 ¾ in. and two 7 ⅝ in. HP SET systems (Caspian and Middle East shelf operations, respectively) and two 7 ⅝ in. HP SET systems run in the Western Hemisphere (an onshore sidetrack operation in Louisiana) and one additional Gulf of Mexico shelf installation.

The first Gulf of Mexico HP SET used in a drilling application was run in a subsalt exploration well. The objective of an exploratory wellbore is to reach planned depth with adequate diameter to properly evaluate the potential reservoir. As an exploratory wellbore progresses, there can be numerous anomalies involving pore pressures, fracture gradients and wellbore stability. In this wellbore, the operator experienced significant wellbore instability at the base of the salt. Due to insurmountable challenges, including loss of an entire BHA that required a sidetrack, the 9 ⅞ in. conventional casing was 3400 ft higher than originally planned (Figure 4).

The operator needed a solution that would preserve wellbore diameter and enable the planned depth to be reached. A 7 ⅝ in. x 9 ⅞ in. HP SET was ideal as it provided a post-expanded drift of 7.524 in. This diameter enabled the use of a rotary steerable assembly to drill an additional 5000 ft of directional hole below the HP SET liner, allowing the planned TD objective to be reached and evaluated. The liner had a pre-expanded length of 1936 ft and provided for a subsequent 7 in. liner option.

Two additional 7 ⅝ in. HP SET liners have been run as part of sidetracking operations in the deepwater Gulf of Mexico. A sidetracking operation has a fixed starting diameter and a required diameter at TD. This is an optimal application for SET liners as the expandable can provide a crucial additional casing string. Adding the HP SET greatly reduces the risk of not reaching TD due to changing and unknown pore pressures/fracture gradients.

In both installations, the HP liners exceeded the requirements of the wellbore conditions and enabled the sidetracked wellbore to reach the planned objective. The first liner was 2105 ft and the second 2566 ft in pre-expanded length.

HP value

The first Gulf of Mexico deepwater HP SET cased-hole liner effectively saved a wellbore that regulatory requirements had condemned due to base casing drill pipe wear. The SET liner restored integrity, leaving a post-expanded diameter enabling the well to be drilled to TD and completed with the originally designed casing size. This installation from a deepwater tension-leg platform (TLP) retained a production slot of immense value.

The first HP SET drilling liner run in Gulf of Mexico deepwater enabled the construction of an exploratory wellbore to TD despite having a critical 9 ⅞ in. casing string set 3400 ft higher than planned. The HP SET liner avoided a sidetrack and the risk of having to start the wellbore over. Loss of the deepwater wellbore at this point would have been a huge expense.

Both these wellbores were exploratory with a primary objective of reservoir evaluation upon reaching the targeted depth. However, the magnitude of the capital investment in Gulf of Mexico deepwater operations makes it an important secondary objective to be able to produce the well if there is a discovery. In one of these wells, a discovery was made and the well was completed and successfully put on production due to the optimal wellbore diameter provided by the HP SET liner.

The two most recent Gulf of Mexico deepwater HP SET installations were used in sidetracking operations. Both wells were sidetracked out of 9 ⅞ in. base casing; however, they were completed with 7 in. versus 5 in. conventional casing at TD due the application of HP SET. Given the difference

in the volume of hydrocarbons that can be produced through 7 in. versus 5 in. casing (a 100% increase in flow area), the value of the larger wellbore can potentially exceed hundreds of millions of dollars.

High-temperature solid expandables

As wells are drilled deeper, bottomhole temperatures are going to increase. Over the past 24 months, operators around the world have requested SET systems that can handle temperatures up to 450 ˚F (230 ˚C). To accommodate this requirement, a testing/qualification programme was commissioned to elevate the temperature rating of the 7 ⅝ in. SET system to 450 ˚F.

The 7 ⅝ in. SET system was selected as the first size to be qualified to 450 ˚F because most wellbores with a high bottomhole temperature are quite deep. The use of a SET system will likely occur after intermediate casing has been run and a smaller hole/casing size needed. However, larger SET system sizes can be qualified to high temperature as the need arises.

With the elevated temperature, all components of the SET system were evaluated for thermal degradation.

The 7 ⅝ in. SET system was successfully qualified to 450 ˚F operations. Additional high-temperature components, unique to this system, were added to inventory. This system is awaiting trial.

Conclusion

The development of HP SET with increased mechanical ratings and maximum temperatures extends expandable capabilities to address the growing extremes of HPHT wellbore construction.

Greater pressure ratings of HP SET enable the use of expandables in wellbores where pore pressure exceeds the mechanical rating of standard SET liners. The most common solution has been to move the solid expandable up or down one position in the casing design to alleviate the pressure issue.

However, some scenarios preclude that option, as in the example of the first HP SET where the wellhead platform was already in place. Another common scenario is when a well is being drilled and casing size change is no longer an option.

Three HP SET sizes (11 ¾ in., 8 ⅝ in., and 7 ⅝ in.) provide a range of options in dealing with unpredicted pore pressure changes.

HP SET liners have also demonstrated their value in remedial operations for restoring the pressure integrity of wellbores with severe casing wear, or to cover unwanted perforations to restore production.

For high-temperature applications, a 7 ⅝ in. SET is qualified and rated to 450 ˚F to address bottomhole extremes.

As wellbore construction continues to become more intricate, operators will continue to look for options to help them achieve their wellbore and economic objectives. Solid expandable systems have for the past 15 years greatly enabled their success. It is reasonable to expect that the ever-increasing demands on solid expandable tubulars as an enabling technology will propel its evolution and adaptation to further enhance HPHT wellbore construction.

References

1. Furniss, T. and Simpson, A., 'High-collapse Tubulars Address Common Problems Found in Extreme Conditions', Paper SPE presented at the Deep Offshore Technology Conference, Stavanger, Norway, (10 - 12 October, 2007).
2. MacEachren, 'Auger A-16 ST-02/3, The Deepest & Longest Sidetrack in the Gulf of Mexico', Paper SPE/AADE presented at the Deepwater Technical Symposium, New Orleans, Louisiana, (18 - 19 August 2010).

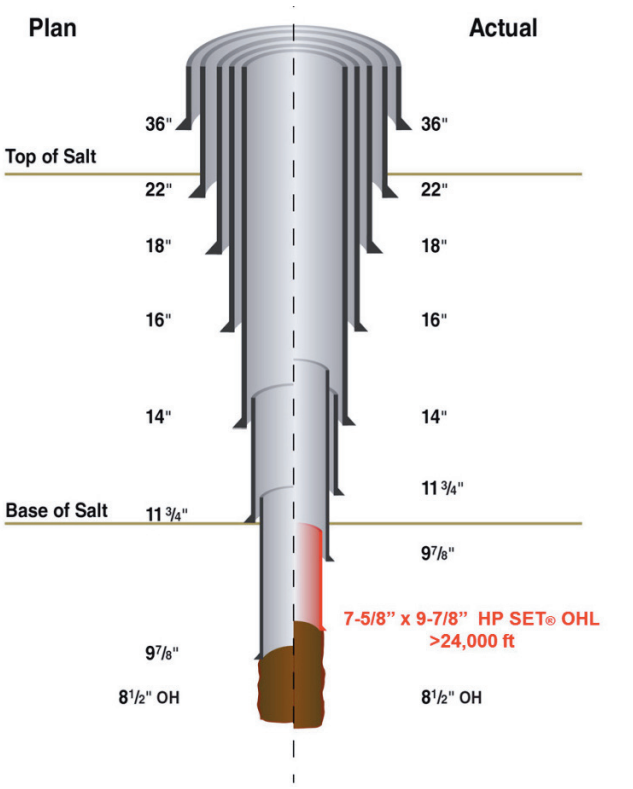

Figure 4. *First HP SET drilling liner in Gulf of Mexico deepwater well.*

Table 1. Standard versus high performance SET systems

SET liner sytem	Weight (lb/ft)	Wall (in.)	Internal yield (psi)	Collapse (psi)
7 ⅝ x 9 ⅝	29.7	0.375	6050	2660
7 ⅝ x 9 ⅝	39.0	0.500	8050	4690
8 ⅝ x 10 ¾	32.0	0.352	5100	1760
8 ⅝ x 10 ¾	44.0	0.500	7200	3830
11 ¾ x 13 ⅜	47.0	0.375	4370	1200
11 ¾ x 13 ⅜	74.6	0.618	7150	3780

Table 2. Global installations of HP SET

Job no.	HP SET Liner size	Location	Environment	System	Length (ft)	Depth (ft)	Mud weight (lb/gal)	Deviation (˚)
1	7 ⅝ x 9 ⅞	North Sea	Shelf	Drilling	1665	>15 000	17.5	90
2	11 ¾ x 13 ⅜	GoM	Deepwater	Repair	333	<10 000	14.2	0
3	7 ⅝ x 9 ⅝	Middle East	Shelf	Drilling	1788	>10 000	10.5	45
4	7 ⅝ x 9 ⅝	GoM	Deepwater	Repair	46	>15 000	13.1	20
5	11 ¾ x 13 ⅜	Caspian	Shelf	Drilling	1180	>10 000	16.1	35
6	7 ⅝ x 9 ⅞	GoM	Deepwater	Drilling	1936	>20 000	16.2	0
7	7 ⅝ x 9 ⅝	Middle East	Shelf	Drilling	505	>10 000	8.6	30
8	7 ⅝ x 9 ⅞	GoM	Shelf	Drilling	1100	>10 000	16.7	0
9	7 ⅝ x 9 ⅞	GoM	Deepwater	Drilling	2105	>10 000	11.3	53
10	7 ⅝ x 9 ⅝	USA	Land	Drilling	1124	>10 000	16.4	0
11	7 ⅝ x 9 ⅞	GoM	Deepwater	Drilling	2566	>10 000	12.1	66