OIL COUNTRY TUBULAR GOODS

Expandable technology gains ground as a planned-in option

From their beginnings as a last-resort solution for operators who would otherwise have to abandon a well, expandables are gradually gaining acceptance as a planned alternative to conventional tubing—more expensive, to be sure, but sometimes a better choice.

HENRY TERRELL, News Editor

Many different variations on expandable technology exist, but all work in a similar way. They depend on the ductile properties of the metal, which can be stretched within certain limits (up to about 20%) without unacceptable weakening. Expandable tubulars are run into an under-reamed hole and then permanently expanded using one of several methods. Generally, an expander of high-strength material is pulled upward by mechanical force or pushed downward by hydraulic force, increasing the inner and outer diameters of the tubulars (and, in the process, reducing the length). Some systems are expanded directly via inflatable packers.

Expandable tubing is used for casing repair in existing wells, to reconnect casing strings, to isolate old perforations in depleted or watered-out zones or to patch corroded or leaking casing. Its most important use is in drilling, allowing wider diameters in deep wells. Openhole systems are also used to isolate unstable zones on the way to a promising target, either as a substitute for cement or to support it. Some systems do not depend on the expanded tubular being tied back to the casing seat, but clad the casing to the formation instead.

The general trend in the industry is toward higher temperature capability and better metallurgies, stronger connections and increased reliability. This requires a better understanding of what is happening when tubulars are expanded in harsher downhole conditions, and methods are being developed to simulate such conditions in the lab. As costs and payoffs are weighed, expandables are finding greater acceptance, and an increasing number of wells have expandable technologies factored in from the outset.

Enventure

Last year, Enventure performed the first commercial installation of its 8-in. × 9%-in. MonoSET Openhole Clad system. The system expands proprietary solid steel tubulars using a shoeless hydro-mechanically operated expansion tool, Fig. 1. It isolates a problem formation in the well without anchoring back into the existing casing seat, and provides a standard 8½-in. pass-through below 9%-in. casing.

“Let’s actually cladding it into the open hole,” Enventure CEO David Crowley told World Oil. “If you can imagine a thief zone between 100 ft and 350 ft in length, we will put a liner across that. We will anchor it below and then expand it with our elastomers on the top joint and on the bottom joint. As we expand it, it seals against the formation above and below the loss zone. So it’s a cementless solution.”

Some older reservoirs in the Middle East have been produced for over four decades, leading to a large number of depleted zones that cause the operator to have to pump great quantities of lost-circulation material. The system was installed in the Middle East in two deviated wells to stabilize a shale section. Initially, the operator attempted to use cement-reinforced slotted expandables to isolate the section, but that solution proved unreliable. In one well, the 9%-in. casing was set at 1,279 ft and cemented in place back to surface. A 9½-in. bi-center bit and directional drilling assembly were then run, and the section was successfully drilled to 1,660 ft at 17° deviation. This was followed by an openhole caliper log run to confirm sufficient ID for the expandable installation.

The openhole clad system was run to depth and expanded using the mechanical expansion assembly. Once the 8½-in.
openhole section was drilled to 2,641 ft below the expanded cladding, a 7-in. liner was run back to the surface and cemented. This was followed by the drilling of a 6¾-in. open hole to 4,606 ft. The operator had been experiencing delays of up to seven days. By installing the openhole clad system, the operator saved four to five days.

Since introducing the technology, Enventure has been getting interest from operators in Europe and in the rest of the Middle East.

“We commercialized the technology in 2010 and have had two successful installations on it right now,” Crowley said. “I expect we’ll have between six and 12 installations in the next year. There are conditions that have to exist before this is a good solution. You need a very strong formation above and below the loss zone. We are proving up the technology on ‘low-consequence’ wells, where in case of failure there is less of a consequence to the client. That’s why we do beta testing on land, then head out into the offshore market where the savings could be more considerable.”

The company is in the pre-commercialized stage of developing further monobore technology—with an ultimate goal of being able to provide the same size hole from surface to total depth. In the nearer term, Enventure is testing metallurgy that allows a higher expansion ratio, which would be a significant development, particularly in the upper hole sections.

“The important thing is that the reliability rate for this technology is now up to 98%,” Crowley said. “Six years ago, one in five wells failed. Now it’s less than one in 25. We have over 1,210 installations. That alone is helping with acceptance of expandables in the field.”

READ WELL SERVICES

READ offers a line of solid expandable and wellbore isolation products designed to repair, connect or reconnect downhole oilfield tubular equipment. The connection principle is based on the elastic/plastic expansion of metals, a technology that won the UK’s Queen’s Award for Enterprise 2011 in the category of Innovation.

The HETS-EP external casing patch (HETS stands for Hydraulically Expandable Tubular System) provides a life-of-well gas-tight solution for reconnecting casing strings. Since commercialization, the system has been deployed and held on contingency for more than 50 wells in the UK, Norway, Denmark and the Netherlands. The connection is capable of withstanding bidirectional axial loads at well temperatures, while maintaining pressure integrity and full ID of the original casing. The HETS-EP overshot is run on casing and landed over the casing stub in the well. The casing is then hydraulically expanded into the overshot to form the connection. READ recently qualified a 7-in. version of the external casing patch, adding to its patches for use in 9½-in., 7¾-in., 13¾-in. and 14-in. casings. The company is currently developing versions for 4½-in. and 5½-in. casing.

The HETS-CP casing packer is an expandable annular metal packer that provides both a gas-tight seal for annular gas and an anchor capable of bearing high bidirectional axial loads induced by temperature variations. Suitable for both drilling with casing and conventional well construction, the HETS-CP has been used as a liner hanger packer on several wells where the liner might have been required to be rotated (drilled down) to reach TD. It is suitable as a contingency annular barrier, deployed as a mid-string packer and only expanded to make a seal if the cement job for the casing string is insufficient.

The HETS-ZIB zonal isolation barrier, a hydraulically expanded metal sleeve that provides an openhole annular barrier to flow, was deployed in two Norwegian fields during 2010, and operations are being prepared for a number of US fields this year. The ZIB may be used to support cementing operations to ensure that the cement stays in the correct place, as a contingency in case of a poor cement job, or as an alternative to cement and other open-hole packers when cement is not desired or possible, such as when running screens or in extended-reach wells. The barrier is available for 4½-in., 5-in., 5½-in., 6¼-in. and 7-in. liners and has been successfully tested to 10,000-psi frac pressure. A 15,000-psi model is in development.

The HETS-IP internal patch had its first field deployment in 2010. It is a hydraulically expandable sleeve that is carried into the well with the expansion tool and expanded in the well over problem zones, such as leaking tubing or liner, perforations that require sealing off or corroded or worn tubulars that require reinforcing. The patch enables tubular repairs and isolations through restrictions and previously patched sections. Additionally, the patch minimizes well restriction, reducing ID only by its own thickness. Available for 4½-in., 5½-in. and 7-in. tubulars, the system can be conveyed on drill pipe, coiled tubing or wireline. The product is currently under development for scaling up to suit 9⅝-in. and 10¾-in. casing.

TIW

Expandable technology from TIW continues to be centered on the X-Patch and X-Pak expandable hanger/packer systems, which provide metal-to-metal gas-tight seals at the liner top. Some 190 of the systems have been installed to date, deployed primarily in the US, Canada, South America and the North Sea, with systems being readied for projects in the Middle East in the third quarter of 2011. The company’s X-Pak expandable liner hanger system is available in sizes ranging from 3½-in. × 4½-in. through 18-in. × 22 in. The 7½-in. × 9¼-in. system has been the most commonly requested, accounting for 85% of the systems employed. Large-bore systems have been successfully run in liner sizes 9⅝ in. × 11¾ in., 11⅝ in. × 13½ in. and 13¾ in. × 16 in. The 18-in. × 22-in. system has completed testing and is available for deployment.

All of the X-Pak systems incorporate rotating capability for reaming and liner-drilling applications. They have been successful in drilling operations using 5½-in., 7½-in. and 11¾-in. liners. The system has been manufactured in multiple material grades including 13-chrome and high-nickel alloys. The company continues to provide extensive qualification testing of these systems and has completed ISO 14310 V0. Additional testing and qualification is ongoing on friction-reducing, anti-galling coatings to help reduce the setting forces required to expand the equipment and ultimately reduce surface pressure requirements. Post-expansion testing of the material is also a focus, examining material property changes during the expansion process.

TIW is currently in the design and testing phase of a second generation of setting tools and hanger systems to provide extreme torque capabilities for long, extended reach and large-bore systems, as well as high-temperature well conditions up to 650°F.
Although expandable tubulars have been increasing in reliability, costly failures still occur, most of them in the threaded connectors. Connections are machined to very precise standards, but when they are expanded, for practical purposes a new product is created, with different diameter, wall thickness, length, material properties and other parameters.

SALTEL INDUSTRIES

Restoring casing integrity means meeting the seemingly contradictory objectives of obtaining a high-pressure-resistant seal downhole without significantly reducing the casing diameter or restricting access to the wellbore below. A number of very different solutions have been used, including cement squeezes, injection of gels, straddle packers and various composite and steel patches, with varying levels of success. Saltel Industries has developed and deployed a new expandable technology for this type of remedial work.

The Saltel Expandable Steel Patch differs from other expandable technology primarily in the way the tool is set. A high-pressure inflatable packer is inserted into the steel patch, which is run into the hole via tubing and positioned adjacent to the old perforations. The packer is inflated by surface pressure to expand the top of the patch, anchoring it in position. The packer is then deflated and moved down 3 ft to just below the expanded section and inflated again to expand more of the patch, and the process is repeated as many times as needed until the entire patch is expanded, Fig. 2.

The patch will expand until it reaches the casing wall. It has an outer skin of hydrogenated nitrile, which has a machined sealing profile designed to maintain a seal with good burst and collapse pressure differentials. The patch is also made with a tapered entry cone at the top and bottom to allow other tools to pass through.

An expansion pressure of 4,000 psi is normally sufficient to expand a thin-walled steel patch, while pressures up to 8,000 psi may be required for thicker patches. The hydraulic unit should have a high pressure rating and the ability to pump at a low flowrate, along with a pressure-recording system. A downhole expansion tool is positioned between the inflatable packer and the tubing to manage downhole cycles and open the packer directly into the wellbore for rapid deflation. The expansion tool includes a mechanism to compensate for a differential pressure between the tubing and casing.

The system saw first field trials in 2009, and commercial operations began in 2010 in Canada, Europe and the Middle East. In an onshore well in Europe with 4½-in. casing, damage about 3 ft long was identified at 3,500-ft depth. Downhole temperature was 150°F. A 19-ft patch of stainless steel with a pre-expansion OD of 3.62 in. and 0.118-in. wall thickness was run. The patch was set with 6,000-psi pressure. Post-expansion ID was 3.71 in. After the patch was installed, the casing’s original internal differential pressure rating of 13,000 psi was restored.

A 7-in. casing in an oil well in the Middle East was producing excess water at 10,000 ft through a perforated interval 21 ft long. Downhole temperature was 212°F. A 5.6-in.-OD patch of 32.8-ft length was run and expanded using 4,630-psi pressure. The patch was expanded in 15 steps, after which a log confirmed that the patch had completely covered the perforated interval. Watercut was reduced from 61% to 22%.

The patch has been tested and shown to work well in tubing of regular or uneven diameters, and is also effective in corroded and washed-out conditions. Downhole temperature is currently limited to 250°F, but tests with different perfluoroelastomers promise the introduction in 2012 of patches rated to 610°F, which would allow use in steam-injection wells. Field tests are planned to shut off leaking ports in horizontal liners, and the company is also developing expandable pup joints able to seal ovalized or out-of-gauge boreholes.

WEATHERFORD

Although expandable tubulars have been increasing in reliability, costly failures
still occur. Almost all of these failures occur during the expansion, and the majority occur in the threaded connectors. Improving the reliability of connectors, therefore, is of prime interest to manufacturers and operators. To do that, the stresses that occur downhole must be understood. Unfortunately, expanded tubulars in wells are not generally retrievable to be studied directly.

Weatherford International is investigating the various loads that act on expandable tubulars downhole, at pressures and temperatures similar to those encountered in the well. Connectors are machined to very precise standards, but when they are expanded, for practical purposes, a new product is created. The new connectors have different diameters, wall thicknesses, lengths, material properties and other parameters.

One system for testing pipe is the so-called “parking-lot test,” in which a length of expandable pipe with connectors is tested while lying horizontally on the ground. An expansion cone is then forced through the pipe with hydraulic pressure, and the connectors are cut away to be studied. The problem with this approach is that it fails to mimic the loads placed on pipe in the field. The compressive and tensile forces above and below the cone have a significant effect on how connectors are changed by expansion.

Weatherford engineers designed an apparatus for expanding tubulars in simulated downhole conditions, Fig. 3. The Dynamic Load Expansion Bench (DLX) can simulate compression loads that occur above the expansion cone in a long string, as well as tension loads below the cone.

To perform a test, the expansion cone and swab cup are inserted into the test sample and an end cap is welded on. A tension cylinder rod is attached to the end cap, and the expansion cone assembly is connected to a workstring that passes through a fixed compression crosshead. The test apparatus puts the sample that is between the expansion cone and the compression crosshead into compression equal to the weight in air of the liner being simulated. Then the part of the sample between the cone and the end cap is put into tension to simulate the weight of the liner below the cone. Once the pre-loads are set, water pressure is added until the cone begins to move along the sample. The preset tension and compression loads are maintained until the cone has completed the sample expansion. When the liner is not stuck or constrained at both ends, referred to as “fixed-free” expansion, the pipe wall thickness and liner length will both decrease. When the liner is stuck or constrained at both ends, the expansion is referred to as “fixed-fixed.” In this case, the liner length doesn’t change, and the wall thickness decreases more than in the fixed-free condition. The expansion bench simulates both downhole conditions.

Tests showed that under different load conditions there are significant dimensional differences in both the connectors and the pipe after expansion, depending on whether the top, middle or bottom of the liner was being simulated. In some cases, expansion caused gaps to occur in the torque shoulders of previously tight connections. This was particularly pronounced in a top-of-string simulation. Engineers must account for these differences when planning to use expandable technology, especially in long vertical liners.