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Latch Type Surface Casing Mandrel

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Abstract

The Latch Type SCM provides a novel method for installing the casing head onto surface casing with the following benefits: 1) Increased operational efficiency – time to install casing head is greatly reduced, 2) Improved safety – personnel are not performing any assembly in the cellar, and 3) Improved quality – eliminates the need for welding and casing head outlets can be fully assembled and tested prior to installation.

Introduction

Slip-On Weld (SOW) has served as the industry standard for attaching a casing head to surface casing. The installation method for SOW generates several challenges. The method involves cutting and beveling the surface casing after cementing to the correct height in the cellar, landing the casing head and then welding it to the surface casing. Casing heads go through strict quality control measures defined by API 6A to ensure material properties. SOW involves welding in less than desirable conditions leading to quality control issues including: 1) fluid must be bailed from the surface casing as the fluid acts as a heat sink leading to rapid cooling of the weld and, 2) pre/post weld heating is cumbersome in regions (i.e. Powder River Basin or Bakken) that experience extreme cold temperatures. Operators in cold weather regions have experienced weld failures due to pre/post weld heating issues. Operators working in more remote areas also must contend with long drives and extended call-out times for welders.

Alternatives to SOW have been developed to eliminate the need for welding and associated challenges. Alternatives such as slip-lock or utilizing a pre-welded pup joint in the bottom of the casing head have been used for many years. All involve the Field Service Technician (FST) performing work in the cellar to make-up the casing head to surface casing. The FST must also attach wing valves/flanges to the casing head side outlet*s*. This process, performed in the cellar, takes up to 3 hours in a dangerous environment.

To alleviate the issues associated with SOW alternatives, Downing developed a Latch-type Surface Casing Mandrel (SCM) System that eliminates welding, unnecessary work in the cellar and decreases overall installation time.

Installation Procedure

The installation of the surface casing mandrel wellhead system requires a landing ring, sized for the conductor pipe, to be tack welded on the conductor. A short pup joint of casing is bucked into the surface casing mandrel itself. A running tool is bucked onto a landing joint on top of the mandrel neck. The mandrel is landed out through the rotary table and rests on the landing ring; see Figure 1. Cement is then pumped through the landing joint. Once cementing operations are completed, the running tool is removed. The latch ring is installed onto the mandrel neck and the wellhead lowered on. The weight of the casing head is sufficient to collapse the latch ring. Once the casing head is at the proper position, the latch ring snaps into the receiving groove inside the head; see Figure 2. Seals are then tested through the test port in the side of the wellhead. Once a positive test is recorded, normal BOP installation procedures can be implemented.

Figure 1: Surface Casing Mandrel on Landing Ring

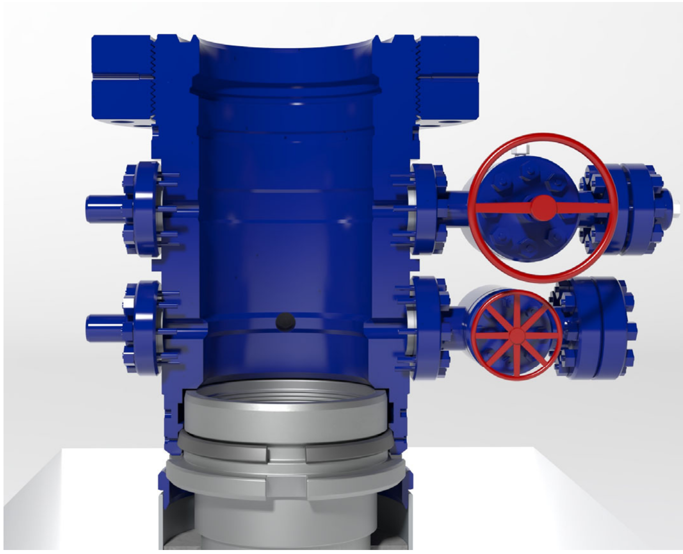

Figure 2: Casing Head Installed on Surface Casing Mandrel

Comparison of Installation Methods

Three primary methods for attaching a wellhead to surface casing were compared: Slip-on weld (SOW), Rotary Table (RT), and the Surface Casing Mandrel (SCM).

The Slip-on weld (SOW) is the traditional method of attaching a wellhead and involves having a welder on site in addition to the wellhead field service technician. After surface casing has been installed in the wellbore and cemented in place, the welder makes a cut using a torch and then grinds a bevel into the casing. The wellhead and baseplate assembly are then lowered over the stickup of casing. The wellhead housing is pre-heated to between 250- and 400-degrees F in preparation for the weld. A full weld around the circumference of the body is completed and then a post-weld heat treatment, 900- to 1000-degress F for 1 hour, is performed by the welder. The head is cooled below 200 degrees. The weld is pressure tested to 80% of the casing collapse pressure or working pressure of the head, whichever is less.

The Rotary Table (RT) installation method utilizes a "pup" joint. The "pup" joint is a short, 5-6 ft joint of casing pre-welded into the bottom preparation of the casing head in a shop setting following the same general steps as described in the slip-on weld procedure above. Plugs are installed in the wellhead outlets as no outlet valves are installed at this point. A casing head running tool is threaded on or flange connected to the top of the casing head with a running joint of casing threaded into the top. The baseplate is added to the bottom of the casing head and held with set screws. This joint of casing is generally equal to the KB height of the rig plus 5 feet. The casing head is raised to the rotary table and the top of the running tool is made up to the top drive. The 5 ft pup joint previously welded into the bottom of the casing head is bucked onto the final joint of surface casing and then lowered through the opening in the rotary table until the baseplate rests on the conductor pipe. The cementing process is started, typically lasting up to 4 hours. Plugs are removed, and wing valves are added to the casing head. The casing head running tool is removed and the threaded API flange installed. The BOP stack assembly is then re-installed. This process takes up to 3 hours and involves the most time the wellhead technician is in the cellar of the three methods.

A summary of the critical path time required for each installation method is in Table 1.

Table 1: Average Installation Time Breakdown

Method: Slip-On Weld (SOW)	
Steps:	**Time (hr):**
Cement casing	5
Prep-casing	0.5
slip wellhead over casing	0.5
pre-heat wellhead	1
full weld	0.75
post weld heat treat	1
Cooling time	0.5
Test	0.25
Total Time:	**9.5**
Method: Rotary Table	
Steps:	**Time (hr):**
Wellhead brought to rig floor and prepped	0.5
wellhead and baseplate landed onto conductor	0.5
Cement casing	5
Prep wellhead for drilling ops	1.5
Total Time:	**7.5**
Method: Surface Casing Mandrel	
Steps:	**Time (hr):**
Conductor landing ring installed (offline)	0
Surface casing mandrel landed	0.25
Running tool removed	0.25
Cement casing (offline)	0
Total Time:	**0.5**

Design and Validation

Designing a Latch system that is flexible enough to be energized by simply setting down the casing and stout enough to handle the pressure end load created a significant engineering challenge. In general, the flexibility of the latch ring and its load bearing capacity are inversely related, requiring an iterative approach to get the right design combination.

The growing supply chain disruptions occurring since 2020 complicated the design challenges further as a separate wellhead housing was required to fit the mandrel preparation in. To meet customer project lead-times as well as be economic, the Latch-type SCM system had to fit within available forging envelopes.

The design process started by defining the material and size envelope based on available forgings. A concept of the system was then roughly sized through hand calculations. The latch ring was analyzed utilizing finite element analysis to verify the latch ring could be energized by the weight of the casing head without yielding. An energizing force higher than the weight of the casing head would prevent installation of the wellhead. Conversely, yielding of the latch ring would prevent full engagement in the casing heads groove. A solution was achieved through multiple iterations.

After analyzing the active latch mechanism, the rated load of the system was determined by performing a plastic collapse and ratcheting FEA analysis per API 6X. Several iterations of latch ring were analyzed to ensure that both the energizing weight and rated load requirements were satisfied.

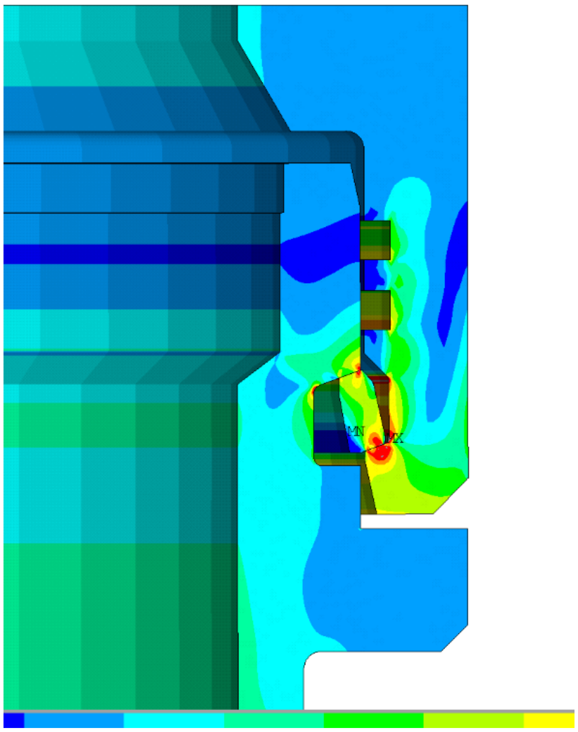

Figure 3: FEA of 13-5/8 Surface Casing Mandrel

The Latch-type Surface Casing Mandrel was validated per API 6A, Appendix F. The 13-5/8” Surface Casing Mandrel System is rated for a working pressure of 5,000 psi which correlates to a pressure end load of 1,007,824 lbf. The 11” Surface Casing Mandrel is rated for a working pressure of 10,000 psi which correlates to a pressure end load of 950,332 lbf. A “dummy” surface casing mandrel was manufactured and then bolted to Downing’s hydraulic load test cell. The casing head was then latched onto the surface casing mandrel. The equivalent pressure end load acting on the latch ring was applied by the hydraulic load cell for three cycles. After testing, the components were dimensional inspected to verify no deformation occurred that could affect the form, fit, or function.

Figure 4: 13-5/8 SCM System being assembled for validation.

Figure 5: Validation testing of 11" Surface Casing Mandrel

SCM Benefits

The surface casing mandrel provides reduced installation time onsite and is much safer as the wellhead technician spends far less time in the cellar. This method saved up to 3 hours of rig time as well as technician hazardous exposure.

When used in an off-line cementing application, the surface casing mandrel enables the surface casing string to be installed and the rig moved off to the next well. Cement can be pumped through the mandrel via a short pup joint in the top of the running tool or directly through the casing head itself. This method of cementing saves up to 5 hours of rig time.

Field Deployment and Case Study

Since the launch of the system, 87 surface casing mandrels have been deployed. Of these, seventy-eight SCM installations were used in the case study. Figure 6 shows the breakdown between critical path time and FST exposure time in the cellar.

Three operators in 3 different basins were used for the case history.

Operator 1: Permian Central Basin.
System Features: Surface casing mandrel with offline cementing. Operator reported 4-5 hours saved versus SOW.
Problem Solved: time savings through greater efficiency.

Operator 2: Powder River Basin.
System Features: Surface casing mandrel installation versus slip on weld.
Problem Solved: Cold weather welding issues eliminated.

Operator 3: Granite Wash (Texas Panhandle).
System Features: Surface casing mandrel with offline cementing.
Problem Solved: reduced service cost. Due to the distances to well sites, the surface casing mandrel has eliminated the requirement for the extended drive times for a welder.

Operator 1 (Permian) saved approximately 168 hours of rig time compared to the slip-on weld. In addition, utilizing batch drilling and offline cementing of surface casing, an additional 4 hours per well were saved compared to cementing with the primary drilling rig for additional 192 hours of rig time. This resulted in 360 hours saved over 48 wells. Offline Cementing (OLC) is not possible with SOW installation method and more time consuming with RT installation.

Operator 2 (Powder River Basin) saved 30 hours of rig time utilizing the surface casing mandrel in 20 wells vs the slip-on well method. The operator was primarily concerned with the difficulty of achieving a satisfactory weld on of the casing head. The surface casing mandrel eliminated this concern and the potential NPT. This operator has experienced several weld failures prior to switching the SCM system. Each weld failure resulted in roughly 18 hours of downtime. There have been zero installation issues with SCM system.

Operator 3 (Granite Wash) saved 35 hours of rig time over 10 wells. In addition to the rig time savings, the operator saved $3000 per well in service call out mileage and time.

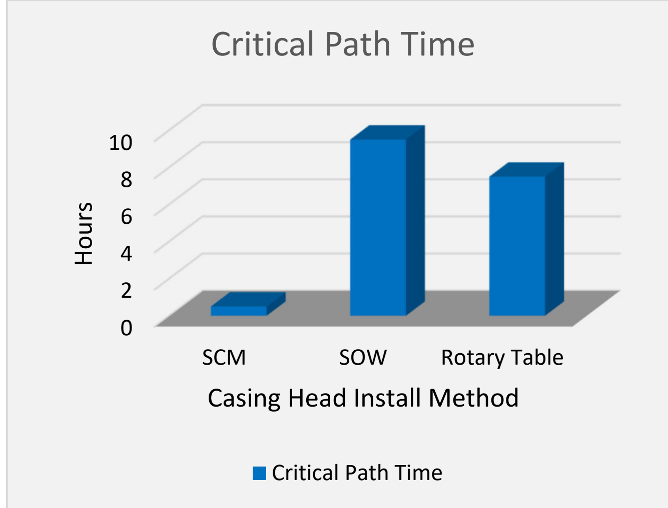

Figure 6: Casing Head Critical Path Time Comparison

Conclusions

Drawing from the operational history of the surface casing mandrel, the following benefits have been achieved. Significant time savings were achieved versus existing methods attaching wellhead to surface casing. In addition, the surface casing mandrel offers an alternate method of attaching wellhead to surface casing that addresses cold weather reliability issues with the SOW. And finally, the system provides the safest method of installing a casing head compared to current methods due to a significant reduction in time spent in the cellar.

Acknowledgments

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Nomenclature

SOW = *Slip-on Weld*
RT = *Rotary Table (used to denote process of landing casing head through rotary table.)*
KB = *Kelly Block*
FST = *Field Service Technician*
SCM = *Surface Casing Mandrel*
OLC = *Offline Cementing*

References

1. API Specification 6A, Specification for Wellhead and Tree Equipment, Twenty-First Edition, November 2018.
2. API Standard 6X, Design Calculations for Pressure-Containing Equipment, Second Edition, February 2019.