MINIMIZE RISK AND INCREASE RELIABILITY OF BALANCED CEMENT PLUGS WITH TAILPIPE DISCONNECT TOOL

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ABSTRACT

The development of horizontal drilling combined with hydraulic fracturing operations has enabled operators to develop unconventional plays previously considered uneconomical. As operators move toward drilling of more complex sections in these plays, proper placement of a competent cement plug on the first attempt becomes increasingly challenging. The use of a bottomhole kickoff assembly (BHKA) helps minimize risk and increase reliability for all balanced cement plug operations—plugback, kickoff, and/or abandonment. This tool disconnects from the sacrificial tailpipe run at the end of the workstring, eliminating the need to pull the workstring through the cement plug.

An operator in the Delaware Basin planned to drill vertical pilot holes in two wells to evaluate potential target zones. The operator sought to plugback the pilot holes and kickoff to drill the horizontal section into the target zone. This paper describes the use of the BHKA disconnect tool to set 1,200-ft plugbacks in these wells.

INTRODUCTION

The Permian Basin of West Texas and southeastern New Mexico is one of the most prolific oil and gas areas in the world, having produced 30 billion bbl of oil and 75 trillion ft^3 of natural gas in almost 100 years (Clemente 2017). Technology breakthroughs in horizontal drilling and hydraulic fracturing have allowed operators to produce from pay zones previously considered uneconomical. As drilling techniques advance and wellbores become more complex, placing a successful kickoff plug on the first attempt becomes more challenging. A failed kickoff plug results in increased drilling time and costs. Figure 1 shows the cumulative drilling rig nonproductive time (NPT) incurred as cement plug failures increased (Heathman and Carpenter 1994).

Setting cement plugs downhole can present several challenges and risks. Wellbore conditions, such as washouts, rat hole length, mud characteristics, bottomhole temperatures, deviation, dog-leg severity, pore pressures, and weak zones, affect the outcome of plug cementing operations. The most common cement plug placement technique is the balance plug method. To set a balanced plug, the workstring is run at the required plug base depth, and the designed volume of cement slurry is pumped through the workstring until the level of cement outside is equal to that on the inside of the workstring. A spacer is pumped ahead and behind the cement slurry to achieve equal heights in the annulus and inside the workstring, thus resulting in a balanced system (Figure 2). The workstring is then pulled, leaving the balanced cement plug in place. This is the most important part of the plug setting operation because removal of the steel volume occupied by the workstring often results in contamination of the cement slurry, resulting in plug failure. Inadequate cement setting time or contamination of the cement slurry with wellbore fluids could result in the workstring becoming stuck, leading to costly remedial operations and/or well abandonment in worst-case scenarios. The most common causes of cement plug failures are slurry contamination during or after placement, plug slippage after placement, and insufficient wait-on-cement time before resuming drilling operations.

To minimize the risk of plug failure, it is strongly recommended that drilling engineers and operators adhere to a simple outline of best practices that were developed over time (Al-Yami et al. 2008; Araiza et al. 2007;

Calvert et al. 1995). Although not all methods need to be used during all plugging operations, following the best practices will help increase the likelihood of success. Particular attention should be focused on the cement volume to ensure there is sufficient excess to account for washouts as well as contamination. The rate at which the rig pulls the workstring through the plug is crucial to its integrity, and if pulled too quickly, can strip the plug. Advanced cementing analytical software developed during the last two decades can simulate cement plug placement. Such software allows for user input and simulation of well configuration, tubulars, caliper logs, formation pore pressures and fracture gradients, loss circulation volume compensation, rheological fluid hierarchy, friction pressures, workstring movement and centralization, dynamic temperature effects, and optimal wait-on-cement time. Additionally, three-dimensional (3D) modeling of fluid interfaces and contamination as well as workstring pullout calculations can be conducted. The enhanced plug calculation method calculates the volumes necessary to balance the fluids when a tapered string has pulled out to the top of the plug, allowing the cement to "U-tube" into place, thus helping prevent the workstring pulling wet on the rig floor. Additional recommendations include the following:

- Determining appropriate plug length
- Rotating workstring while pumping cement and displacement
- Determining the optimum spacer volume and system
- Achieving proper hole conditioning to remove and displace mud
- Using a stinger to minimize stripping
- Using diverter tools to redirect flow
- Circulating the workstring clean well above the top of the cement plug
- Determining appropriate wait-on-cement time
- Ensuring a firm base on which to spot the cement plug, such as a viscous reactive pill or a mechanical base
- Using mechanical aids, such as the BHKA disconnect tool

The BHKA disconnect tool helps eliminate many of the risks associated with downhole cement plugs placement.

BHKA TAILPIPE DISCONNECT TOOL

The primary purpose of the BHKA disconnect tool is to achieve a competent cement plug on the first attempt. This tool greatly reduces the risks associated with setting a balanced cement plug by eliminating the need to pull the workstring through the cement plug, therefore reducing contamination and the likelihood of the workstring becoming stuck. This is accomplished by the combination of the tool's release mechanism and the use of sacrificial tailpipe, which can be drillable or nondrillable, depending on the type of cement plug and application. Local regulations might also require the use of drillable tailpipe. The sacrificial tailpipe length should be the length of the cement plug plus a safety factor.

The BHKA disconnect tool assembly and sacrificial tailpipe are connected to the workstring using a reusable workstring adapter (Figure 3). This assembly is run at the depth of the planned top of cement (TOC) to minimize contamination and swabbing when the workstring is pulled out of the hole. The cement slurry is pumped down the workstring and through the BHKA disconnect tool into the sacrificial tailpipe and out into the wellbore using the balanced plug method (Figure 6). A wiper dart (Figure 4) is dropped into the workstring to displace the cement slurry to the BHKA disconnect tool. The wiper dart latches into the BHKA disconnect tool sliding sleeve, sealing the workstring and allowing pressure to be increased. The sliding sleeve is held inside a collet retainer mechanism by shear pins calibrated to shear at 2,500 ±500 psi. Once the workstring pressure reaches this value and the pins are sheared, the sliding sleeve shifts downward, allowing the collets to fold inwardly, releasing the BHKA disconnect tool assembly and the sacrificial tailpipe. The workstring is pulled out of the hole and the cement plug is left undisturbed downhole to set and build compressive strength. Figure 5 shows the BHKA disconnect tool assembly.

The BHKA disconnect tool adds a level of flexibility for cement plug designs. By eliminating the need to pull the workstring through the cement plug, aggressive thixotropic cement slurries can be pumped for rapid gel strength development without risking the workstring becoming stuck. This is crucial for lost circulation applications and where potential high-fluid-flow conditions exist. Likewise, lower concentrations of cement retarders could be used, leading to faster compressive strength development and less wait-on-cement time.

Several optional features are available to supplement the BHKA disconnect tool. A diverter sub can be run at the end of the sacrificial tailpipe to provide optimum flow for wellbore cleanout and cementing operations. Furthermore, a tailpipe inflatable packer is available to support the cement plug and provide additional stability. This is particularly useful in lost circulation conditions and above weak zones.

PERMIAN BASIN BHKA TAILPIPE DISCONNECT TOOL: CASE STUDY

An operator in the Delaware Basin of West Texas planned to drill its first wells in a new area. The operator planned to drill pilot holes to obtain valuable geological data and evaluate potential target zones by means of openhole log analysis. After setting a 9 5/8-in. intermediate casing at 10,130 ft true vertical depth (TVD), the operator proceeded to drill an 8 1/2-in. pilot hole to 11,300 ft TVD into the Wolfcamp formation. To reduce rig time while waiting on multiple cement plugback operations, the operator decided to use the BHKA disconnect tool to plugback the entire openhole interval in a single operation. A caliper log showed a near-gauge wellbore with only minor washouts below the intermediate casing shoe. Approximately 1,200 ft of 2 7/8-in. fiberglass tubing was run into the hole as sacrificial tailpipe connected to the BHKA disconnect tool assembly and approximately 10,100 ft of 4 1/2-in. drillpipe. After conditioning the wellbore, cementing operations began by pumping 20 bbl of 13.5-lbm/gal rheologically enhanced spacer (Table 1) designed to displace the 11.8-lbm/gal water-based mud, followed by 93 bbl of 17.5-lbm/gal plug cement (Table 2, Figures 8 and 9). The BHKA disconnect tool wiper dart was dropped into the drillpipe and displaced with 7 bbl of rheologically enhanced spacer and 171 bbl of mud to achieve a balanced system. After the wiper dart landed on the BHKA disconnect assembly, the drillpipe was pressured up to 2,514 psi to engage the tailpipe release mechanism. Figure 7 shows a summary of the cementing operation. Subsequently, the drillpipe was pulled out of the hole. After wait-on-cement time, the drillpipe and curve bottomhole assembly was run into the hole, and hard cement was tagged at the intermediate casing shoe with no indications of contamination. The operator proceeded to drill the curve into the 21,300 ft measured depth (MD) lateral section. A similar operation was repeated on a second well, located 31 miles away, with the same results.

CONCLUSION

Using the recommended cementing practices discussed in this paper, along with the BHKA disconnect tool, operators can greatly increase the reliability of setting downhole cement plugs. Recurring cement plug failure results in increased NPT and drilling costs. Since 1999, the BHKA disconnect tool has been used globally to place hundreds of cement plugs successfully on the first attempt (Rogers et al. 2016; Rogers and Poole 2012; Rogers et al. 2009; Rogers et al. 2006), thus validating it as a dependable plug setting aid.

As operators push the limit on wellbore complexity and horizontal drilling, a tailored plug cementing process, along with the BHKA disconnect tool, becomes a reliable method to place downhole cement plugs on the first attempt, minimizing risks and increasing reliability of cementing and drilling operations.

REFERENCES

Al-Yami, A. S., Nasr-El-Din, H. A., Jennings, S. S., and Al-Humaidi, A. S. 2008. New Cement Systems Developed for Sidetrack Drilling. Presented at the SPE Indian Oil and Gas Technical Conference and Exhibition, Mumbai, India, 4-6 March. SPE-113092-MS. https://doi.org/10.2118/113092-MS.

Araiza, G. G., Rogers, H. E., Peña, L., and Montoya, S. 2007. Successful Placement Technique of Openhole Plugs In Adverse Conditions. Presented at the Asia Pacific Oil and Gas Conference and Exhibition, Jakarta, Indonesia, 30 October-1 November. SPE-109649-MS. https://doi.org/10.2118/109649-MS.

Calvert, D. G., Heathman, J. F., and Griffith, J. E. 1995. Plug Cementing: Horizontal to Vertical Conditions. Presented at the SPE Annual Technical Conference and Exhibition, Dallas, Texas, USA, 22-25 October. SPE-30514-MS. https://doi.org/10.2118/30514-MS.

Clemente, J. 2017. Texas' Permian Basin: An Oil And Natural Gas Production Machine. *Forbes*, 12 February 2017, https://www.forbes.com/sites/judeclemente/2017/02/12/texas-permian-basin-an-oil-and-natural-gas-production-machine/#221504123150 (accessed 23 January 2018).

Heathman, J. and Carpenter, R. 1994. Quality Management Alliance Eliminates Plug Failures. Presented at the SPE Annual Technical Conference and Exhibition, New Orleans, Louisiana, USA, 25-28 September. SPE-28321-MS. https://doi.org/10.2118/28321-MS.

Nelson, E. B. and Guillot, D. 2006. *Well Cementing*, second edition. Sugar Land, Texas: Schlumberger.

Rogers, H. E. and Poole, D. A. 2012. Tailpipe Disconnects Ideal for Setting Cement Plugs in Complex Wellbores; Procedures and Case Histories Provided. Presented at the SPE Oil and Gas India Conference and Exhibition, Mumbai, India, 28-30 March. SPE-154632-MS. https://doi.org/10.2118/154632-MS.

Rogers, H., Stair, T., and Makowiecki, G. 2016. Plug Setting Aid Retooled for Improved Downhole Slurry Placement Provides Greater Versatility to the Operator When Planning and Executing Section or Hole Abandonments. Presented at the SPE Kingdom of Saudi Arabia Annual Technical Symposium and Exhibition, Dammam, Saudi Arabia 25-28 April. SPE-182735-MS. https://doi.org/10.2118/182735-MS.

Rogers, H. E., Thornton, P., Fairchild, M. A., and Austin, D. 2006. Drillable Tailpipe Disconnect: Used Successfully in More Than 120 Wells Worldwide. Presented at the SPE Annual Technical Conference and Exhibition, San Antonio, Texas, USA, 24-27 September. SPE-102534-MS. https://doi.org/10.2118/102534-MS.

Rogers, H. E., Winslow, D. W., and Boddy, P. A. 2009. Plug Setting Aid Retooled for Up-Hole Down-Dip Plug Back Application Enables Pin Point Slurry Placement in Complex Up-Dip Wellbore. Presented at the Middle East Drilling Technology Conference & Exhibition, Manama, Bahrain, 26-28 October. SPE-125446-MS. https://doi.org/10.2118/125446-MS.

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Table 1 – Case Study Rheologically Enhanced Spacer Design

Component	Concentration
Rheological enhancer	26.4 lbm/bbl
Barite	263.5 lbm/bbl
Citric acid	0.35 lbm/bbl
Defoamer	0.5 gal/bbl
Surfactant	4.0 lbm/bbl
Fresh water	32.1 gal/sk
Spacer density = 13.5 lbm/gal	

Table 2 – Case Study Cement Plug Design

Component	Concentration
Class H cement	94 lbm/sk
Potassium chloride	3.0% BWOW*
Dispersant	0.5% BWOC**
Lignin-based retarder	0.5% BWOC
Fresh water	3.53 gal/sk
Slurry density = 17.5 lbm/gal Slurry yield = 0.957 ft^3/sk	

*BWOW = by weight of water
**BWOC = by weight of cement

FIGURES

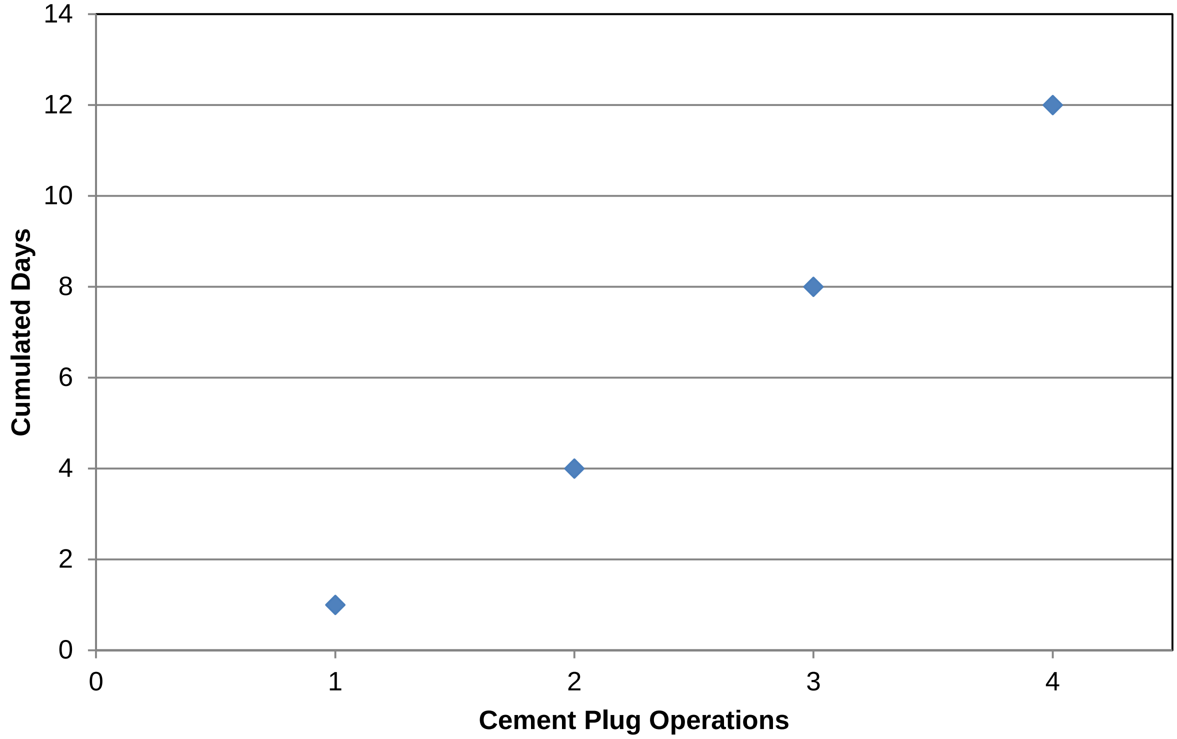


Figure 1 – Cumulative rig NPT vs. failed cement plugs (Heathman and Carpenter 1994).

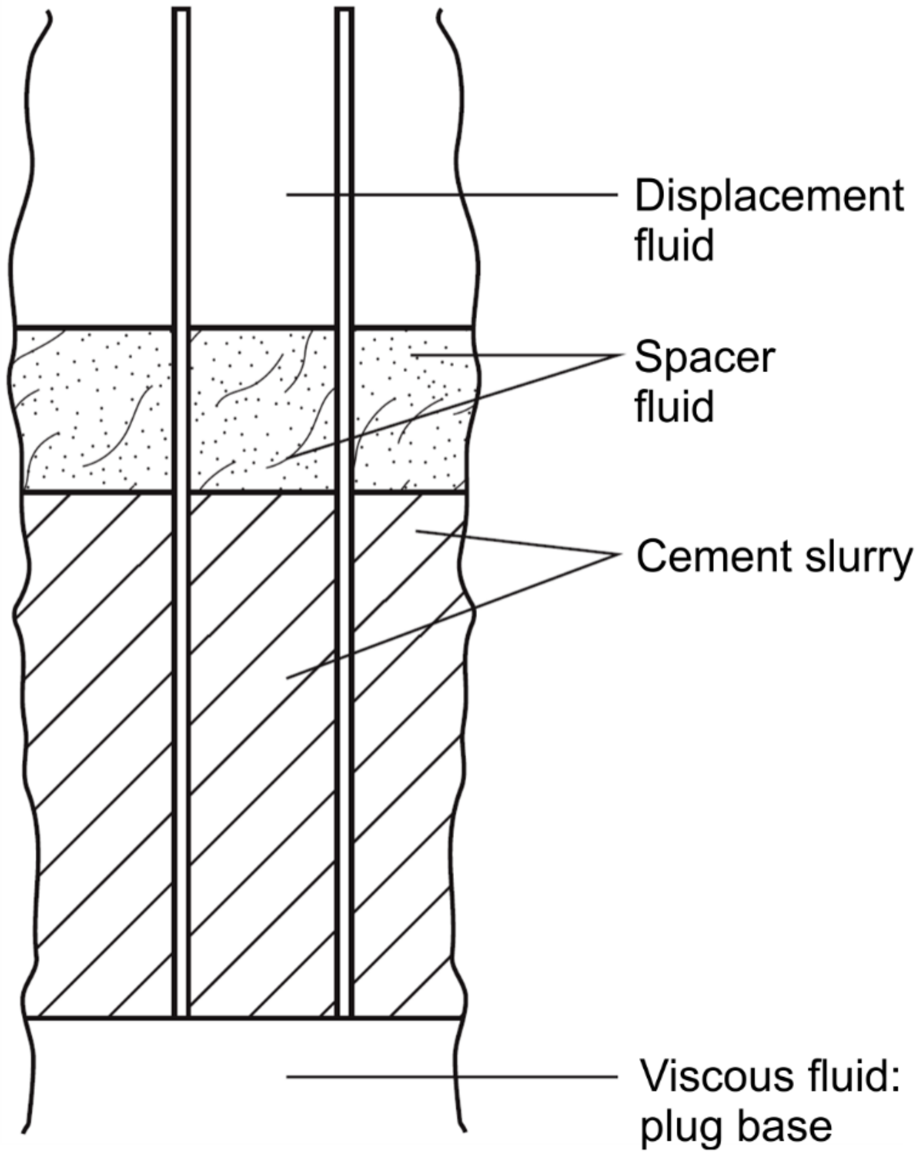


Figure 2 – Typical balanced cement plug operation (Nelson and Guillot 2006).

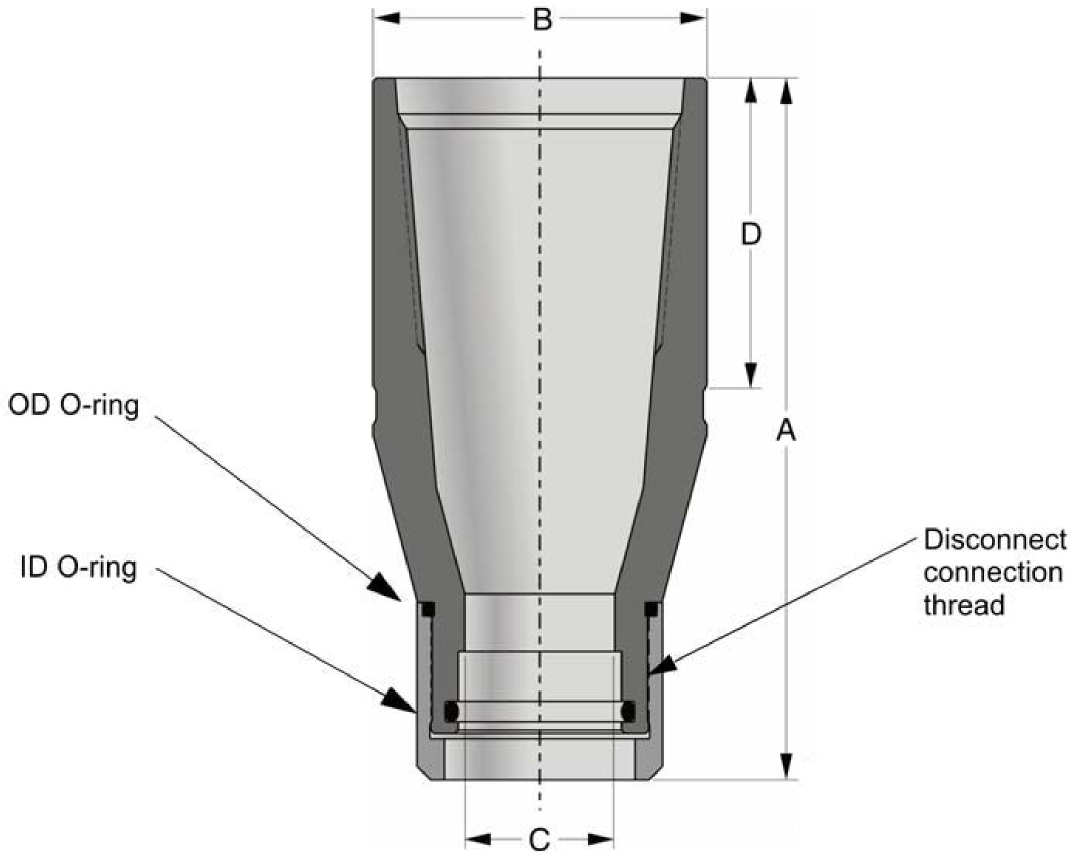


Figure 3 – Workstring adapter to connect to the BHKA disconnect tool assembly.

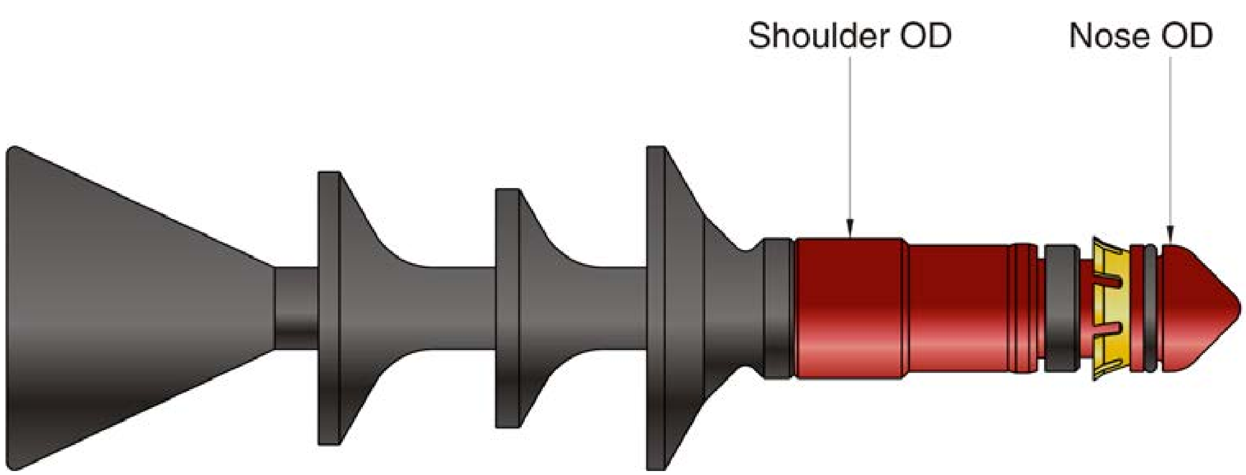


Figure 4 – The BHKA disconnect tool wiper dart is selected according to workstring size.

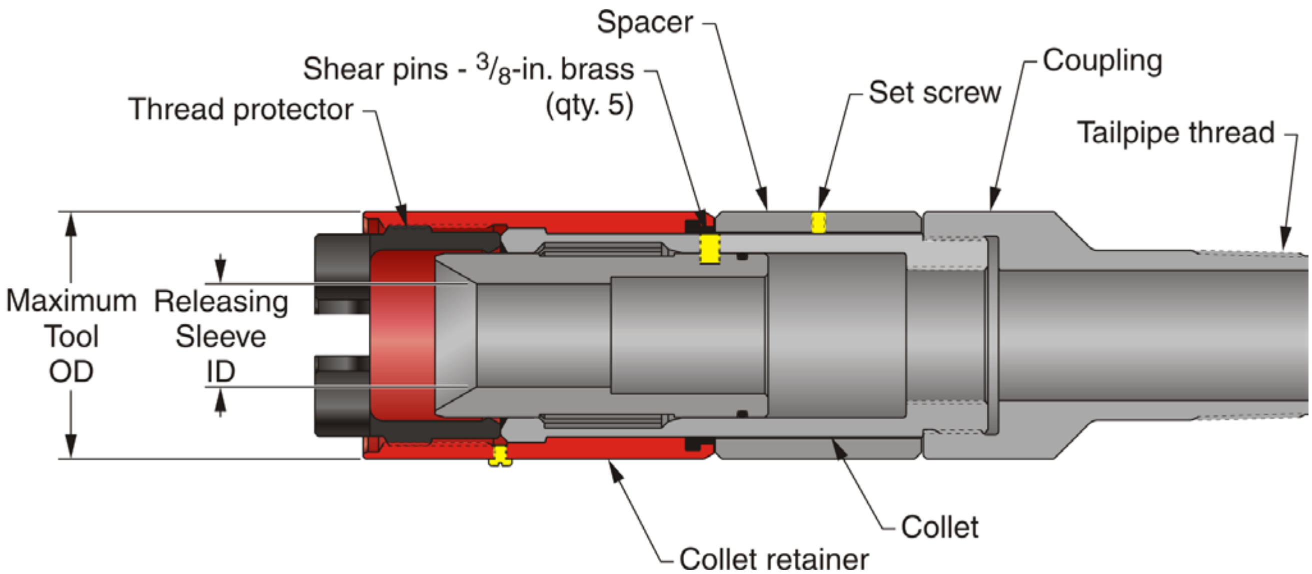


Figure 5 – BHKA disconnect tool assembly.

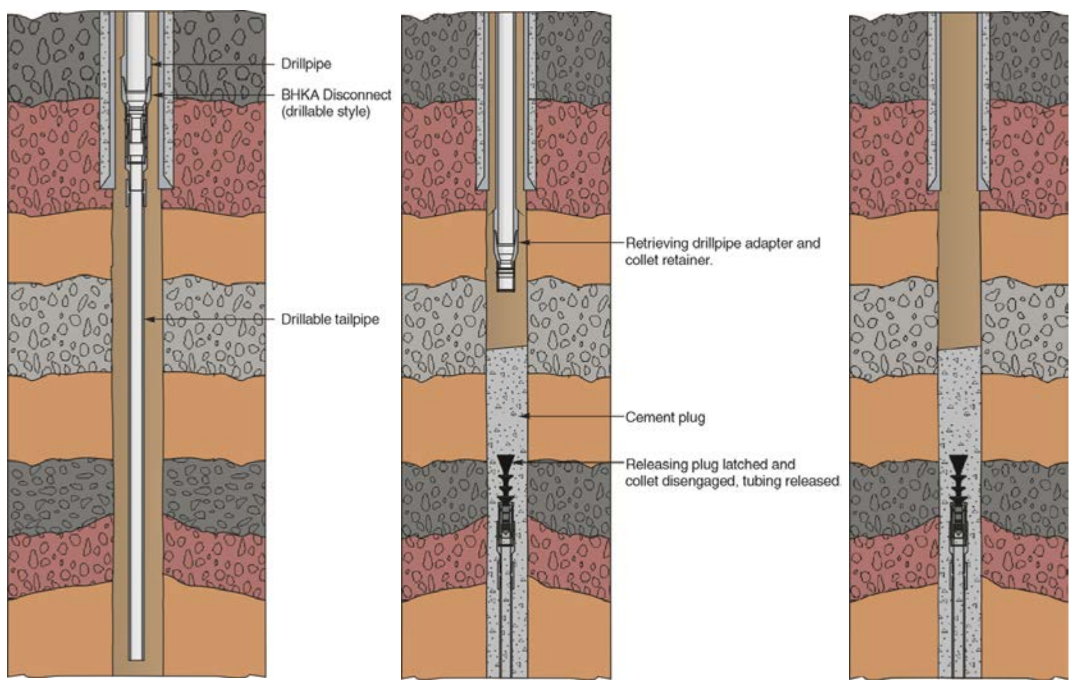
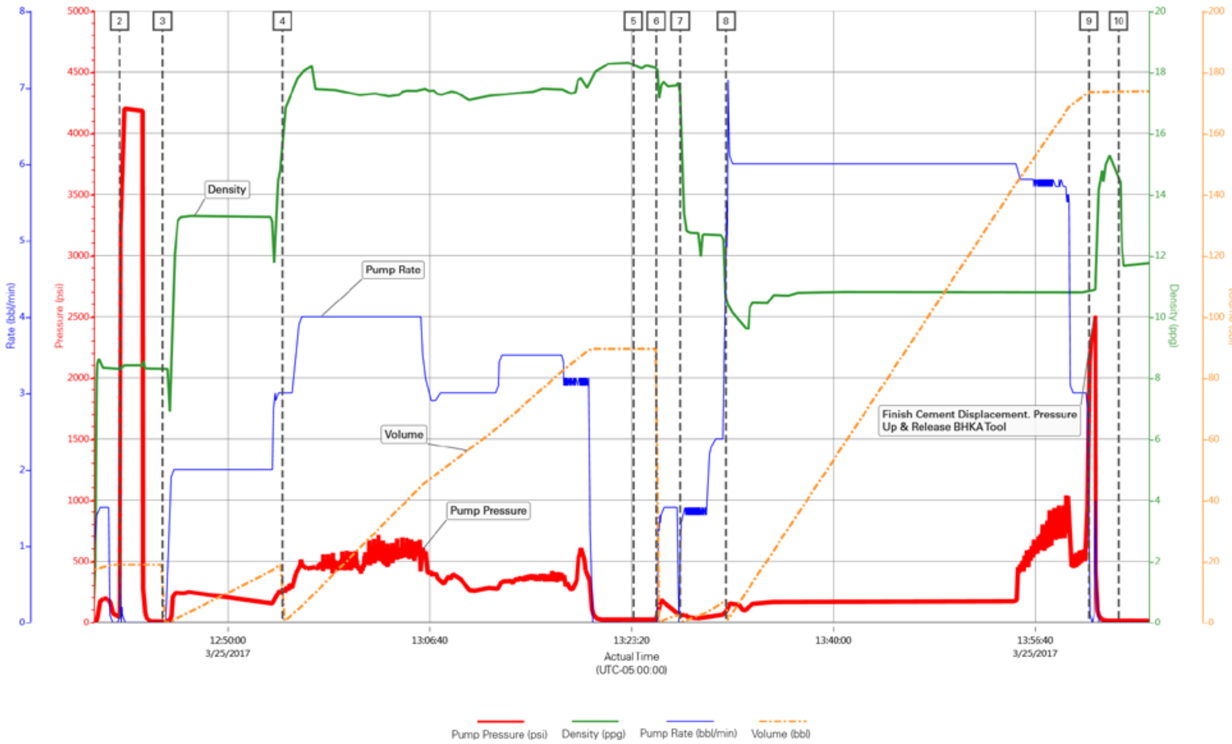


Figure 6 – Steps showing the use of a BHKA disconnect tool to set a balanced cement plug. (a) The BHKA tool and sacrificial tailpipe are run in the hole, with the BHKA placed near the TOC. (b) The cement slurry is pumped through the BHKA, into the sacrificial tailpipe, and out into the wellbore. A wiper dart separates the cement slurry and the displacement fluid. The workstring is released from the tailpipe after the wiper dart lands on the BHKA tool release sliding sleeve and pressure is increased to 2,500 ±500 psi. (c) The workstring is pulled out of the wellbore while the cement remains in place to set undisturbed.



Seq No.	Graph Label	Time	Seq No.	Graph Label	Time	Seq No.	Graph Label	Time
2	Test Lines	12:41:03	5	Drop Wiper Dart	13:23:29	8	Pump Displacement	13:31:09
3	Pump Spacer	12:44:36	6	Pump Cement Behind Dart	13:25:22	9	Pressure Up / Release BHKA Tool	14:01:06
4	Pump Cement	12:54:30	7	Pump Spacer	13:27:21	10	End Job	14:03:33

Figure 7 – BHKA disconnect tool case study real-time cementing operation.

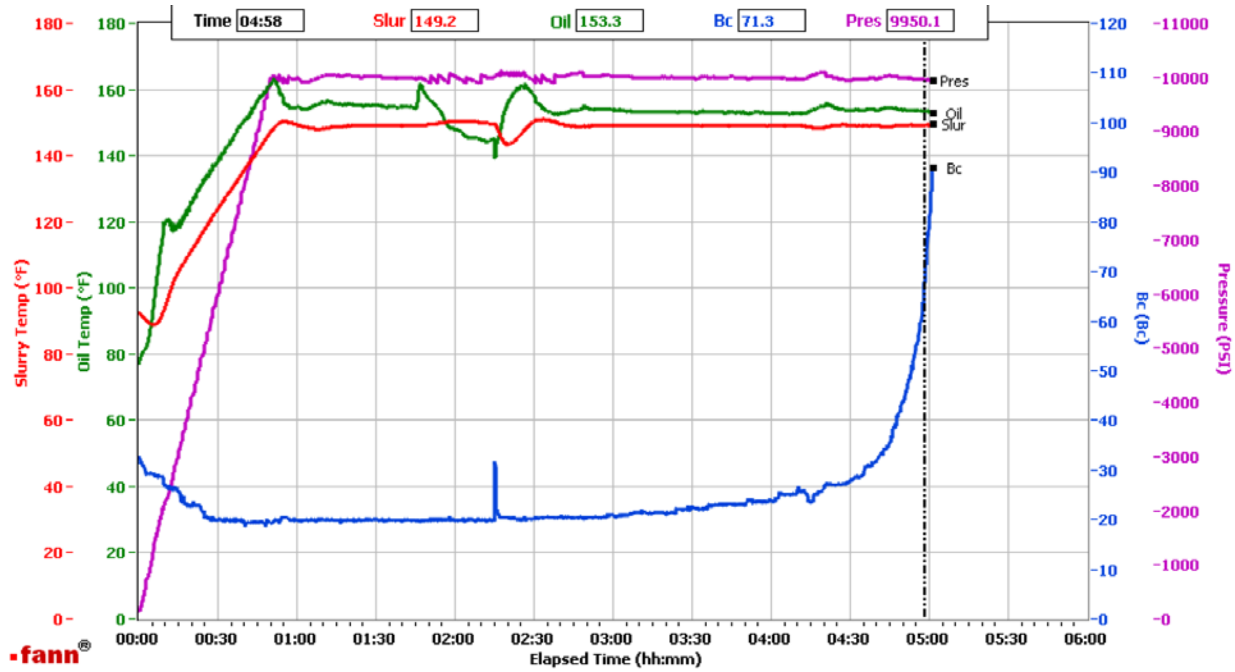


Figure 8 – Case study plug cement thickening time test graph.

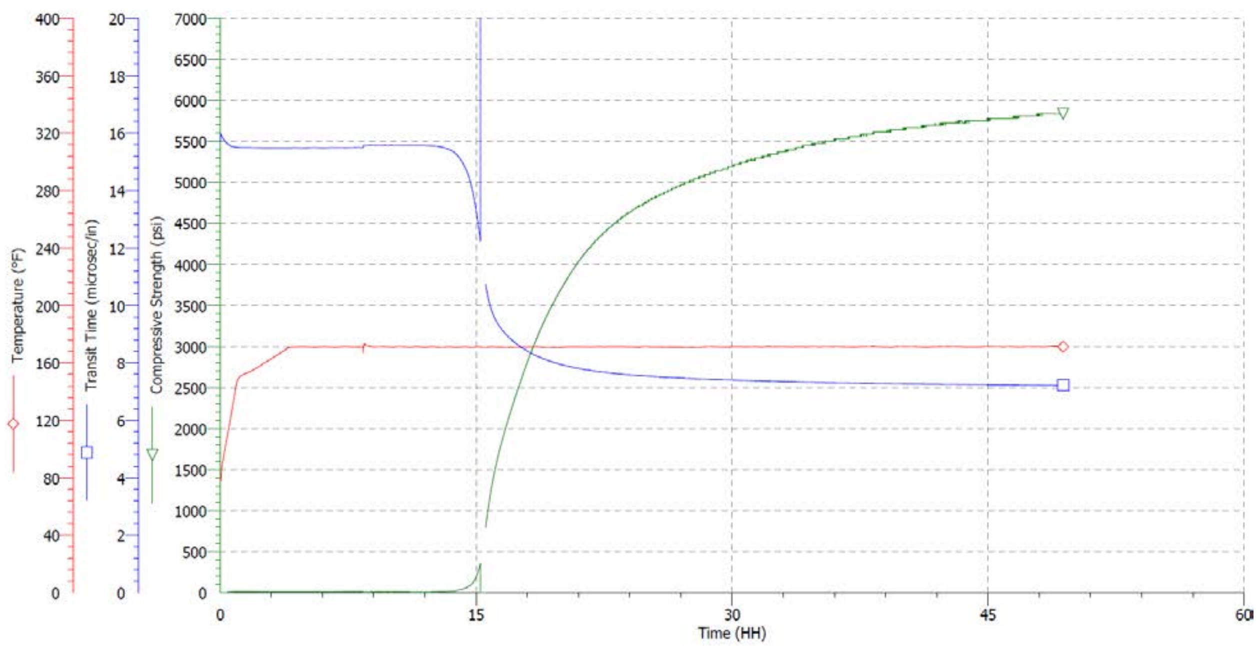


Figure 9 – Case study plug cement compressive strength development graph.