



PEEK-BLEND ROD GUIDES EXTEND SERVICE LIFE IN HIGH-TEMPERATURE WELLS

Utilization of a proprietary polyether ether ketone (PEEK) blend allows rod guides to perform reliably in operating temperatures that can reach as high as 480°F

By Jeff Done and Darla Bugg

Going back to the early 1990s, oil-and-gas exploration companies were able to improve their operations by including in their downhole systems sucker-rod guides that were constructed of synthetic polyphthalamide, or PPA. PPA was effective in these applications because it has greater resistance than many plastics to a broad range of chemicals, along with high tensile strength and stiffness at high temperatures, better fatigue resistance, increased dimensional stability and high sensitivity to water absorption. That is why PPA became a preferred choice over metal and other plastics, especially in deeper wells that featured operating temperatures that could reach up to 300°F (149°C).

However, while PPA could perform reliably at higher temperatures – and is actually rated to 400°F (205°C) – it is not rated for continuous-service at that temperature.

This characteristic was discovered after PPA sucker-rod guides were tested using the Continuous Use Temperature (CUT) testing scale, which showed that the service life of continuous-use sucker-rod guides constructed of PPA would begin to be adversely affected in temperatures as low as 220°F (105°C).

The results of the tests indicated that various characteristics of the downhole production environment, such as bottom-hole temperature, chemicals used, side loads, duration of operation, water cut, viscosity of the fluid and well deviation, can reduce the CUT for PPA guides. Additionally, these well characteristics in combination with the varying types and amounts of fines, solids and corrosive elements that are encountered in the production tubing will cause PPA guides to wear faster than in a well with lower temperatures.

In fact, the CUT tests revealed that PPA-based compounds can experience rapid degradation, with greater than 50% loss of strength, after only six weeks of continuous exposure to water at 250°F (121°C) and complete disintegration after one week of continuous exposure to water at 400°F. The combination of chemicals in an aqueous solution at elevated water temperatures causes oxidative degradation of the PPA guide's molecular structure.

Premature and excessive wearing of sucker-rod guides in high temperatures will pose serious problems in downhole recovery systems. Sucker-rod guide failure will lead to premature tubing wear. In extreme cases, sucker-rod guides can begin to disintegrate, which will allow small fragments of plastic to enter into the production fluids. When this occurs, the fragments can also enter the pump and plug flow lines, causing substantial operational issues. Both cases of fragment incorporation will result in elevated expenses and downtime caused by the need to repair or replace downhole equipment, which will also lead to deferred production rates.

A PEEK Into The Future

With the CUT tests indicating that PPA sucker-rod guides were not capable of performing as reliably as thought in applications with higher downhole temperatures, Norris began searching for a new solution. They were fortunate to find one in a colorless thermoplastic polymer known as polyether ether ketone, or PEEK.

PEEK, which was originally developed in the early 1980s, possesses excellent mechanical and chemical-resistance properties that are retained in high-temperature operating environments, up to 480°F (249°C). PEEK is also highly resistant to thermal degradation and attack by aqueous solutions, which are two of the notable shortcomings of PPA.

Knowing that PPA guides were beginning to fail prematurely in high-temperature wells, Norris, a product brand of Apergy Corporation, began a lengthy process to identify a better material that could be used in sucker-rod-guide construction.



Norris High Temperature 'NHT' Sidewinder Sucker Rod Guides are designed to meet demanding applications with a proven design and a proprietary PEEK material blend.

"The industry needed a sucker-rod guide constructed of a material that could not only handle higher operating temperatures, but also supply the long-life service that synthetic polyphthalamide sucker-rod guides had previously demonstrated," said Frosty Gray, Director of Sales and Operations for Norris. "Norris' goal was to develop a new extended-life sucker-rod guide that could perform at elevated temperatures."

After extensive research and nearly two years of field testing, the solution was found: a new type of mold-ed-plastic sucker-rod guide that would be built with a PEEK blend. The new PEEK-blend sucker-rod guide is an ideal replacement for PPA models in shale wells because of PEEK's aforementioned ability to retain its mechanical and chemical-resistance properties even at very high temperatures when compared with most other thermoplastics. Specifically, when blended with other plastics, PEEK can produce reliable performance in operating temperatures as high as 480°F. This performance capability fits perfectly into the sweet spot for sucker-rod guides that are used in continuous-duty operations in deep, high-temperature shale wells.

Addressing A Problem

Beginning in 2015, a petroleum and natural gas exploration and production company that is a major operator in U.S. shale plays, experienced a series of sucker-rod string failures at its wellpads in the Eagle

Ford (TX) shale field. In just the third quarter of 2015 alone, this end user reported that 11 strings failed with a Mean Time Between Failure (MTBF) of 461 days, which is a low rate of reliability.

All of the failed strings were equipped with PPA sucker-rod guides. Bottom-hole temperatures in the wells ranged from 270°F to 295°F (132°C to 146°C). The failures occurred at depths of 6,950 feet to 10,756 feet. Levels of hydrogen sulfide (H₂S) ranged from 5 to 2,000 parts per million (ppm). The maximum side load in the failure section was 270 pounds per rod. After examination, the sucker-rod guide failures were attributed to the exposure of the PPA guides to an aqueous solution at elevated bottom-hole temperatures.

Based on its discovery that PEEK-blend guides could be a reliable solution to the failures of the PPA guides, Norris offered its PEEK-blend NHT Series Sucker-Rod Guides to this end user for testing. In creating the PEEK-blend guides, Norris incorporated manufacturing process improvements such as next-generation injection-molding machines that feature chilled molds and raw material dryers. These process improvements, as well as tighter quality controls, allow for the reliable production of guides that feature a homogenous microstructure, which improves their tensile strength and heat-resistant capabilities.

Specific features and benefits of the Norris PEEK-blend NHT sucker-rod guides include:

- Reduced tubing wear vs. other high-temperature plastics with wear characteristics similar to base PPA material
- A 400°F (205°C) continuous-service rating
- A 480°F (249°C) maximum service rating
- Superior chemical resistance in corrosive environments
- Reduced porosity vs. conventional rod-guide plastics
- Proven Sidewinder design (higher erodible wear volume with minimal fluid turbulence)
- Injection molded for maximum adhesion to rod body
- Separate hoppers for increased melt temperature, resulting in zero fluid contamination

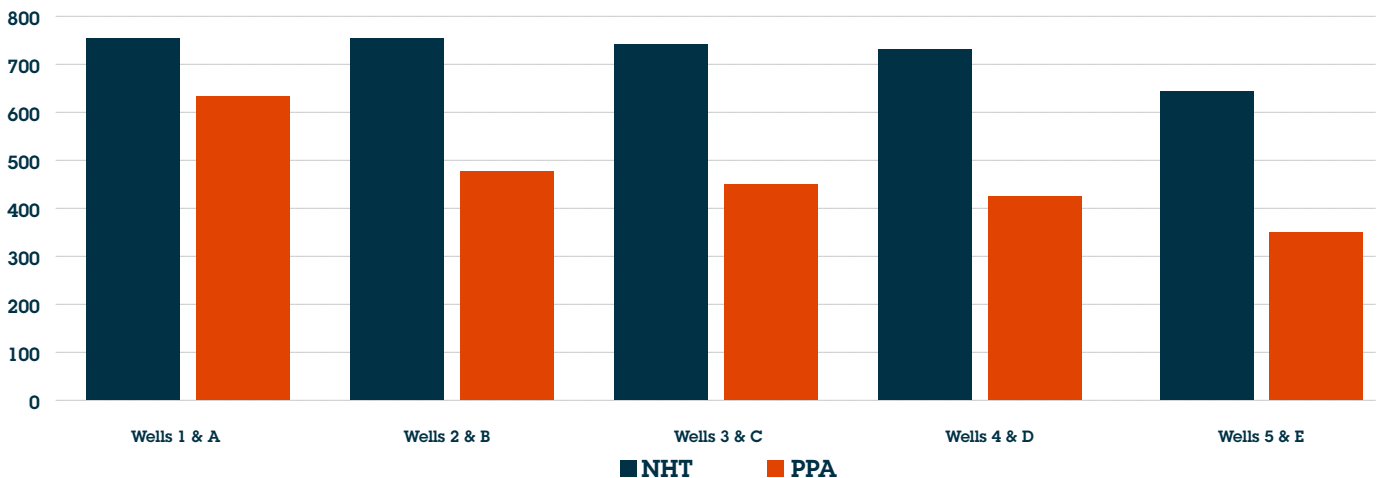
The Results S(PEEK) For Themselves

This end user installed Norris PEEK-blend NHT guides in 17 test wells. Six wells had alternating guides: one rod with PPA guide material then one rod with PEEK-blend NHT guide material. The other 11 wells were all outfitted with NHT guides from a depth of approximately 7,000 feet down to the pump.

Simply put, the results have been spectacular. In the wells that were outfitted with PEEK-blend Norris

NHT Outperforms PPA in High-Temp Wells

Run Time in Days



guides. nearly all premature sucker-rod guide failures in high-temperature environments were eliminated. No rod strings have required replacement since initial installation – and they have been running for more than 750 days, which is already a 50% increase in run time over the PPA guides that were failing prematurely.

In summary, the user had three goals in replacing the PPA sucker-rod guides with Norris' NHT models: first, outperform the PPA guide in high-temperature environments; second, double the MTBF when compared to the PPA guides; and third, perform as well in a high-temperature application as a PPA guide performs in a low-temperature well. The first two goals have been met, while the third is in the process of being achieved. These results illustrate unequivocally that Norris NHT sucker-rod guides can outperform and outlast PPA models in high-temperature applications.

Similar regional results have been experienced elsewhere that PEEK-blend NHT guides have been installed:

- Another South Texas operator had wells with operating conditions of 300°F (149°C), 20 ppm H₂S, with 150-lb. to 275-lb. predicted side load. After the rod string was pulled at 238 days for pump repair, the string was run in with NHT sucker-rod guides. The result: the NHT guides outperformed reaction-set polymers, PPS, PPS-X – all previously tested conventional organic polymers – and thermoplastic resins in terms of material loss and chemical permeability.
- Another of this operator's wells, with conditions of 300°F, 140-lb. to 200-lb. predicted side load and 50 ppm H₂S, experienced severe pump tagging and fluid pounding. At 261 days, the rod string parted. Norris NHT guides installed and outperformed reaction-set polymers, PPS, PPS-X, and thermoplastic resins in terms of material loss and chemical permeation.

These results show that an investment in Norris sucker-rod guides will produce a substantial return for well operators by extending sucker-rod service life and preventing premature tubing wear caused by guide failure. For example, in a typical Eagle Ford or Bakken



Guide OD measurement taken after operating 238 days resulting in a 10.53 to 13.53% guide wear.

shale well, remediation costs that include pulling the tubing string can exceed \$100,000. And this does not include the value of lost production. Eliminating these remediation costs and keeping the well producing more than offsets the small additional cost required to purchase premium Norris PEEK-blend rod guides.

Conclusion

While some operators prefer to run PEEK-blend guides from top to bottom, costs can be minimized by using PPA guides to the high-temperature zone and then PEEK-blend guides from there. Either way, operators can eliminate costly well-intervention, and keep the well online and producing.

In the end, selecting a field-proven sucker-rod guide for high-temperature applications will reduce rod-pumping expenses. In terms of ROI, there are few better places in artificial-lift operations to invest money than in Norris NHT Series Sucker-Rod Guides.

About the Authors

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