Recently, I came across an article in the *Hydraulic Fracturing Journal* that highlighted why, in certain cases, a screen-out is not necessarily a bad thing. The article, by BP’s Prue Smith, explains that during conventional hydraulic fracturing operations, the term “screen-out” can carry a very negative connotation associated with additional cost, complexity and time. However, during “frac pack” operations, two screen-out events not only are planned for, but constitute integral parts of a successful outcome. A tip screen-out (TSO) is designed to increase the average fracture conductivity, and a wellbore screen-out during the packing phase of operations is designed to ensure the pack’s quality.

The frac pack technique is applied widely in high permeability reservoirs to eliminate sand production, penetrate past formation damage and maximize the well’s sand-free productivity. In a highly permeable well, the required fracture conductivity \((k_{fw})\) is the primary deciding factor in frac design and a shorter fracture with higher conductivity tends to be more desirable than the type of long frac that typically is designed for tighter reservoirs. In order to maximize fracture conductivity, a frac pack is designed to include a TSO. This phenomenon is observed on the Nolte-Smith plot through a slope of one (or greater). This event creates a wide propped fracture with a maximized fracture conductivity.

Toward the end of the pumping operation, a wellbore screen-out also is planned in order to efficiently pack the casing/screen annulus. The wellbore screen-out is observed when surface tubing pressure spikes as the annulus is packed. Both screen-out timings are planned during the frac pack design phase, although in execution one or both of the screen-outs may not occur because of treatment/formation variance. When this occurs, an operator will have appropriate contingency plans to adjust/influence behavior during the pumping operations (such as reducing pump rate, extending the proppant-laden fluid or reducing the cross-link). These adjustments can have unintended consequences, such as severely impacting fracture conductivity (and distribution) and thereby ultimately hurting the well’s production.

Frac packing became widely used in the industry thanks to production increases that resulted directly from a design that maximized fracture conductivity. Conductivity is the product of frac width and permeability \((k_{fw})\) and is the paramount variable in frac packing, as it allows packing a high concentration of proppant throughout the fracture and increases overall production. As opposed to traditional hard-rock fracturing in low-to-moderate permeability environments, which entails efforts to open very long fractures to create a long conductive highway, frac packing designs for short, wide fractures to achieve the paramount goal of conductivity.

Frac packing became very popular in the 1980s as completions in the deepwater Gulf of Mexico increased. The TSO method originally was performed in the North Sea, where it developed high conductivity fractures in a high permeability environment. During the treatment, the low concentration, proppant-laden slurry rapidly flows to the tip of the fracture and halts the fracture propagation, creating the TSO. Once the tip screens out, proppant concentration increases as pumping continues and the fracture balloons, increasing aperture, conductivity and net pressure. The TSO method helps create the ‘frac’ part of the frac pack.

After achieving TSO and shortly the end of pumping commences, a pack around the screen annulus is designed for at the wellbore. In order to create an annular pack, a wellbore screen-out is designed at the end of the job. The wellbore screen-out creates the ‘pack’ part of the frac pack, and is apparent as a surface tubing pressure spike. The frac pack method has proven itself through low skin values and production increases, and therefore has been adopted widely across the industry for all frac pack designs.

Smith’s article concludes that, as long as the pump rate exceeds the fluid loss rate, then the fracture should remain open and increase in width and conductivity. If rate reduction is chosen to try and induce TSO, then the pump rate must outpace fluid loss in order to prevent an unplanned wellbore screen-out. TSO possibly may be induced by extending the proppant-laden slurry. Circulating in the annular pack using a step-down schedule versus wellbore screen-out at maximum rate demonstrates very little difference in results. Maximum rate wellbore screen-out may compromise downhole equipment, and therefore it may be better to circulate in the annular pack.