Extreme Limited Entry: A Well Design Application to Reduce Stage Count

6X: Modelling Extreme Limited Entry Completions to Reduce Stage Count

Extreme Limited Entry designed wells can improve the distribution of completion fluid and proppant across clusters. The combination of limiting the number of perforations per cluster and designing with step increases in slurry rate to maintain sufficient treatment pressure to overcome the perforation friction pressure drop enables treatment of all the clusters from the heel to the tow of a stage. This design in turn the allows the stage length to be increased while maintaining cluster efficiency.

How can you design an Extreme Limited Entry completion with 6X?

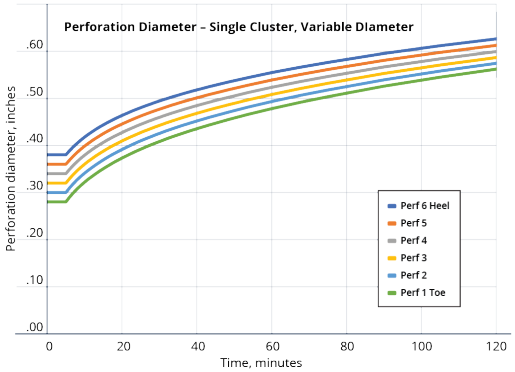
The 6X completion model incorporates the Bernoulli perforation flow model to describe the pressure drop across a perforation. Perforation erosion leads to an increase in perforation diameter during the pumping of the fluid and proppant. While erosion occurs at a slow rate, photography has shown that it can be significant. The simulator models erosion as a dynamic increase in perforation diameter and it is based on correlations from field and laboratory observations. The perforation diameter is time dependent; it is a function of proppant size and concentration in the completion fluid, fluid rate and an erosion rate. As the perforation diameter grows, the pressure drop across the perforation decreases resulting in the perforation taking a reduced fluid and proppant volume. Increasing the slurry rate while pumping maintains sufficient pressure in the wellbore above the perforation friction drop pressure enabling treatment all the way to the toe cluster, despite the perforation erosion.

Combine this with 6X's unique Implicit Stress Solution that models the stress change as the completion is pumped. The simulator models the cluster entry pressure, the fracture initiation pressure, the stress increase and the fracture growth at each cluster as the completion is pumped.

Once the pumping schedule is complete, a production forecast can be run. The stress decrease is modeled as the reservoir depletes and the fracture closes. The model may be calibrated to observed data. Perforation size and cluster spacing can be optimized, and in turn designed stage length increased.

6X Extreme Limited Entry Design Parameters:

- Design perforation size, select proppant and fluid
- Design cluster locations with limited entry perforations
- Optimize fluid pump schedule to ensure fracture entry pressure is attained for all clusters in the presence of erosion
- Assess dynamic stress changes for the life of wells
- Optimize cluster spacing, clusters per stage and design a well with reduced stage spacing



Assess and optimize your Extreme Limited Entry design to reduce stage spacing, improve well performance and maximize drainage.

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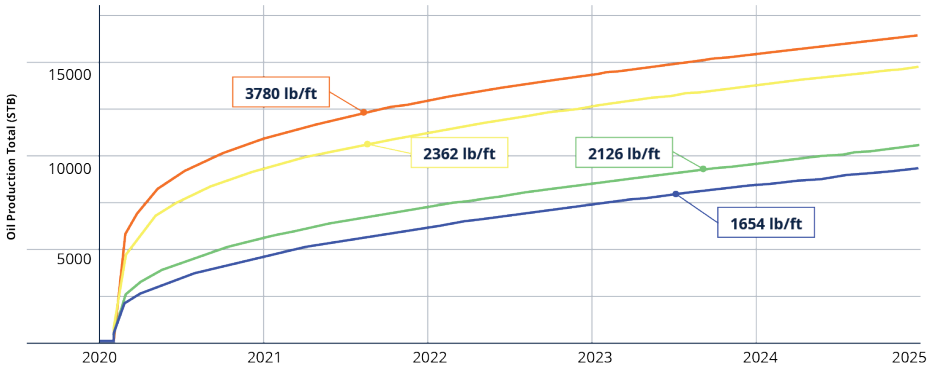
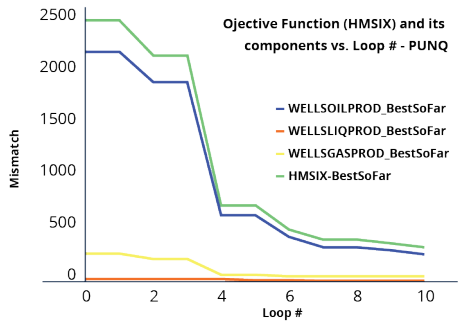
Multiple Realizations – Integral to Every Decision

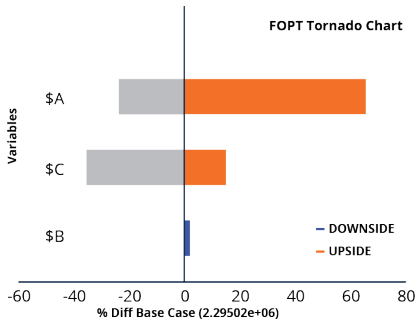
6X: Fully Integrated Multiple Realizations

Quantification of uncertainty can be difficult and time consuming. Subsurface uncertainty exists from intrinsic geological complexity. A desire to quantify development options drives the successful application of Multiple Realizations (MR); a pragmatic approach to optimize performance and maximize recovery from oil and gas reservoirs. It has successfully been applied from development appraisal stage projects to mature field projects and has increased project net present value.



Different proppant concentration injection sensitivities – run simultaneously on multiple cores from one dataset.





6X Multiple Realization workflows

6X provides integrated functionality to create automated workflows performing hundreds of runs to quantify uncertainty in the following:

- Geological and fluid parameter sensitivities
- Experimental Design uncertainty quantification
- Assisted History Matching (AHM)
- Well and completion development selection
- Well and reservoir depletion forecasting

Unconventional reservoirs: well design to optimizing recovery

Many decisions are required to optimize recovery and economics from an unconventional well program. How may stages, how many clusters per stage, how much fluid and proppant to pump; how to determine the optimal well spacing and how many wells are required to develop a multi-bench drill spacing unit (DSU). A 6X Multiple Realization modeling workflow generates a range of outcomes to understand the hydraulic fracture growth and depletion to optimize EUR against net present value for a DSU.

No hidden extras – a 6X license includes the MR module

The Multiple Realizations functionality exploits modern massively parallel architecture of 6X and runs on multi-CPU and multi-GPU systems. With the breakthrough and general availability of Cloud systems, clients can access 6X on Amazon AWS, Microsoft Azure and Google GCP.

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