Proactive Perforation Strategy in Monobore Gas Wells in Gulf of Thailand (GOT)

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Innovation Feature

A proactive perforating strategy is one where most of the sands in a gas well are perforated and commingled. Prior to 2006, this strategy was the standard in Chevron GOT assets. Starting in 2006, teams opted for a bottoms-up strategy; groups of sands are perforated, depleted and occasionally plugged before the next sand group is produced. That led to a decline in the percentage of initial perforation (ITTP) reserves, shown in Figure 1.

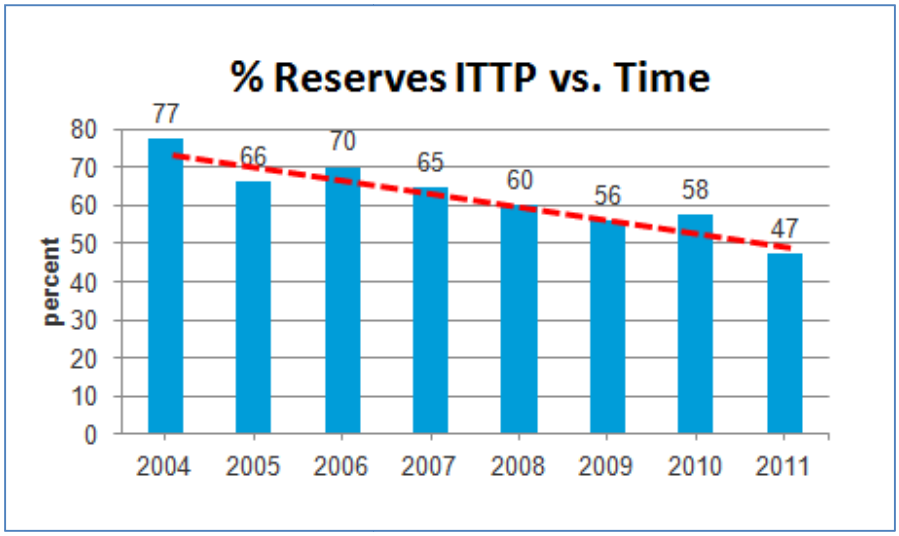


Figure 1 Percentage of perforated reserves during initial perforation campaign had decreased over time

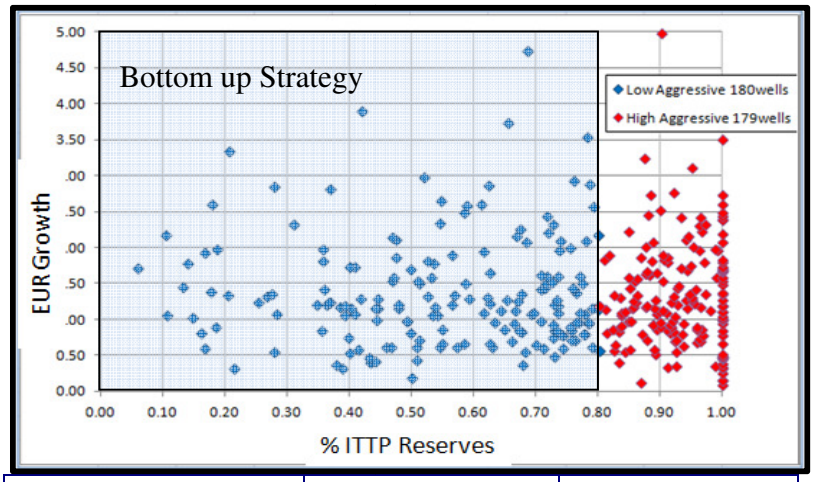
Recent studies have shown that the bottoms-up strategy has not increased recovery compared to the proactive strategy. In addition, perforating more sands increases well deliverability and improves well lifting capability which can lead to higher recovery in cases. It reduces well intervention work reducing costs and risk of fishing. The objective is to perforate all sands that are low to medium risk of excessive water production. With minimal water production, these sands can be effectively depleted.

Therefore, Chevron Thailand has published standards, adopted a gas well perforation target and started a training program. An Initial Completion Standard Operating Procedure which details high risk sands has been published. The target is 75% of all reserve should be perforated on a project and a portfolio basis. An analysis of all of our producing sands encountered demonstrates that 75% are low to medium risk of excessive water production. In December 2012, a class on the "Dynamics of Commingled Production" was introduced to increase the understanding of commingled well behavior.

Thailand E&P Industry Impact and Values

For typical Chevron wells in the Gulf of Thailand (GOT), there are several pay sands encountered in 4000 to 8000 vertical feet interval. The pay sands are composed of a series of heterogeneous stacked fluvial point bar sands that have limited areal extent and average 40 acre drainage areas. After combining more recent work with past studies, there are over 10 years of studies. The proactive perforation strategy was found appropriate for GOT environment; in order to achieve desired gas rate and sustained well deliverability.

As mentioned earlier, the proactive perforation does not deteriorate asset value, caused by reserves reduction, as demonstrated in Figure 2. Figure 2 is a plot of Estimated Ultimate Recovery (EUR) growth versus percentage of initial perforated reserves. Where EUR growth is determined by most recent performance based EUR/initial volumetric EUR. It is observed that both strategies yield similar variation of results, the average EUR growth difference is insignificant.



	Bottom Up Strategy	Proactive Strategy
Average EUR growth	**1.32**	**1.34**

Figure 2 Comparison between Bottom Up and Proactive Perforation Strategies on well EUR growth

There are two principles make a proactive completion strategy successful; understanding the dynamics of commingled production and the ability to identify sands that pose a risk in a commingled wellbore. With a depletion drive, all sands will contribute relative to their initial in place volume. The timing of this is a function of their deliverability. Early well life cross flow where gas from one zone cross flows to another is not detrimental. The gas will be recovered later in well life. Increasing the number of sands flowing increases a well's lifting capabilities and better draw down on all sands.

The biggest risk in commingled production is excessive water production, which lead to high terminal rate or prematurely flow seized. After reviewing over 500 production logging surveys, high risk for water production sands were clearly defined. These are sands that are typically the

shallowest sands having porosities greater than 25% and gas water contact (GWC) sands. This risk is mitigated by high water risk sands perforation deferral.

So far, the impacts of the proactive perforation have been noticed in several Lookback (post job evaluations) sessions, starting from platforms to field-wide level, as shown in Figures 3.

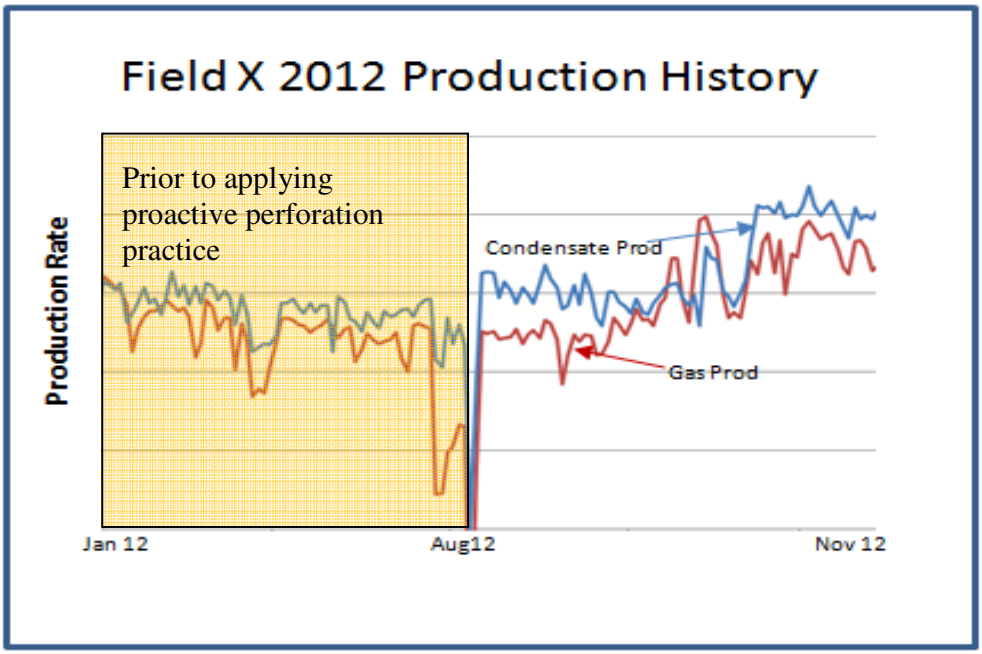


Figure 3 Impact of proactive perforation on Field X gas and condensate production

Field X, one of Chevron Thailand fields, had gas deliverability gap during early 2012 period, Chevron had encountered some short fall. After applying proactive perforation on some platform campaigns started in August, gas and condensate production ramped up and plateau nicely.

Why this practice should win the 2012 Thailand E&P award

Chevron Thailand supplies 1.8 BCF of gas to the kingdom of Thailand, or more than one third of the country's gas demand. The practice has impact on completion and production strategy throughout Chevron GOT assets, more than 3,000 active wells. This proactive commingled production yields higher and longer production plateau to fulfill gas market demand without interruption from unnecessary well intervention and without detrimental impact to resource recovery. It is win-win situation for both kingdom and Chevron.

For the kingdom of Thailand, consistent gas deliverability makes it easier to allocate production for each operator. This also leads to less consumption of more expensive alternative fuels, such as heating oil, LNG, and more expensive gas from neighboring country.

For Chevron, consistent deliverability means minimizing short fall penalties and better reputation as a prime GOT operator. The practice impacts several internal planning processes; more reliable production forecast, more stable drilling and completion units scheduling.

Conclusions

What we have learned

1. Commingling all gas sands that have low to medium risk of excessive water production has no negative effects on long term recovery.
2. Production logging data has defined sands that have a high risk of excessive water production. Deferring these sands to later.
3. Selective perforation on zero risk sands initially (Bottom Up strategy) created long backlog of well intervention and led to short in field gas deliverability.

Good practices

1. Proactive commingle production yields higher and longer production plateau to fulfill gas market demand with less well intervention
2. Having a functional organization (RM group) to review practices, establish standards and ensure effective use of those standards to drive consistency in asset teams is critical to success.
3. Published a standard that incorporates the combined learning's of more than 10 years of work on commingled well behavior
4. Developed a training program so this understanding of commingled well behavior is shared.

Upcoming challenges

1. Changing organizational practices takes an effort on many fronts: providing guidelines, training, setting targets and getting management support.
2. Application of this practice on future undiscovered resources; required annual lookback to fine tune the practice