Recently in Houston, I attended a Society of Petroleum Engineers Gulf Coast Section Westside Study Group luncheon. The speaker, Dan Pratt, discussed the importance of consistently sized perforations for unconventional reservoirs. Pratt is the vice president of engineering and technology for Owen Oil Tools, a division of Core Lab, and has been developing oil field explosives for almost 40 years. Through the years, he has come to specialize in developing oil field perforators and shaped charges. In fact, Pratt holds numerous U.S. patents relating to designs for shaped charges, charge liners and materials used in propellant stimulation. In my opinion, he may have one of the most interesting jobs in the oil field. Until hearing this presentation, I always had thought in terms of “perf it, pump it and produce it.” As it turns out, the perf portion of this process is slightly more important than I originally assumed.

At its core, the purpose of perforating always has been to create effective communication between the wellbore and formation. According to Pratt, until recently, any change in charge design revolved around increasing the depth of penetration into the reservoir or enlarging the hole size. However, as horizontal unconventional wells have become the norm for many operations, it has become necessary to develop new, enhanced perforating systems that are geared at hole size uniformity.

According to Pratt, an operator generally communicates the desired hole size to the service provider. Typically, perf sizes are selected to complement the fracturing treatment design and optimize pumping effectiveness. A good service company should have no problem creating the average desired hole size and meeting the operator’s design requirements on the surface. However, a closer look at the data around each specific perf often reveals a relatively large deviation between the actual maximum and minimum hole size in a particular orientation. Pratt warns that this inconsistency can increase perf friction and tortuosity while reducing cluster efficiency in multi-stage wells.

There are two components to perforating, Pratt explains. The first component creates a specifically-sized hole in the tubular and cement sheath surrounding the well. The second component creates hole length or a “perforating tunnel” into the formation. When designing a treatment, operators or engineers must consider hole size, information they can get from a variety of sources. The American Petroleum Institute conducts testing in actual well tubulars and has recommended practices for designing these treatments. Quality control testing and simulations are also available for consideration during design.

According to Pratt, the standard API hole size for 4.5-inch casing is 0.39 inches, but when he showed testing data, the hole size varied greatly. The actual sizes among four perforations he cited were 0.37, 0.39, 0.31 and 0.26 inches. While hardly uncommon, Pratt says this hole size variability can impact overall frac effectiveness and well performance.

Pratt went on to compare various treatments to show how the selection of quality treatments can improve the standard deviation among perforations. His first example showed actual data using the conventional low-cost charge. The difference from minimum to maximum was 0.25 of an inch or a standard deviation of 28.5 percent. The slightly costlier treatment design proved a little better with a difference from minimum to maximum of 0.14 inches or 15.9 percent standard deviation. Finally, a perforator specifically designed to create consistently-sized holes yielded a range of 0.03 inches between minimum and maximum, or a 3.2 percent standard deviation.

According to Pratt, the most commonly phased perf gun in today’s completions offers 60 degree phasing and the clearance between the gun’s outside diameter and the casing’s inside diameter varies according to gun position. In a horizontal well, the gun will be on the bottom of the wellbore, making the shots at 6 o’clock closer than those at 12 o’clock. Using conventional charges can reduce the perf hole size in the wellbore’s 12 o’clock portion and ultimately diminish the frac’s effectiveness in these perfs.

Like most techniques used to optimize treatments and well performance, getting it right takes a little more work and maybe some more upfront cost, however the increased success over time and among wells speaks for itself. As you design your next treatment or work with your service company, take a closer look at hole size among perforations and see if perf optimization makes sense for your operation.

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