DECLARATION

My name is William F. Diggons. I currently work for Qittitut Consulting where my job title is Managing Partner. I have worked at Qittitut Consulting since 2001 I am familiar with the preparation and publication of the article attached as Exhibit A.

Exhibit A is a true and correct copy of an article prepared by Qittitut Consulting. It is available on the Qittitut Consulting website at http://www.qittitut.com/qittitut-resources/technological-advancements/192-sleeves-vs-shots-the-debate-rages.

I declare under penalty of perjury that the foregoing is true and correct.

Date: April 4, 2017

Exhibit A

Qittitut Consulting

Openhole Multistage vs Plug-n-Perf Completions

Sleeves vs Shots—The Debate Rages

by Richard G. Ghiselin, P.E.

Sleeves vs Shots—The Debate Rages

Qittitut Consulting conducted extensive research on operator and service company preferences for using the two most popular methods for stimulating horizontal multistage completions. The results and the reasons for these preferences are a study in the economics of expediency versus the economics of a systematic approach.

Although each method has slight technical and procedural variations, the premise of the research was to examine completions categorized as openhole multistage (OHMS) versus those categorized as plug-and-perf (PNP). A broad spectrum of major and independent operators as well as stimulation service providers was polled during Q2 2011 (Table 1).

Table 1. Survey Respondent Demographics

Survey respondent type	Number of respondents
Equipment, service or supply company	2
Independent oil & gas company	47
Major oil & gas company	13
National oil & gas company	1
Other organizations or self-employed	4

Technique fundamentals

In the OHMS technique, the completion string is assembled with sliding sleeve ports and external isolation media in such a way that when the completion string is landed, the ports lie opposite the predetermined depths where formation stimulation will be initiated. The interzone isolation media—either external casing packers or swellable packers—are placed appropriately in competent strata with good borehole conditions. In the case of swellable packers, an appropriate time interval is allowed for the packers to set. This can take several hours or days and is accomplished before the frac crew is dispatched. Usually the completion rig is demobilized and moved off location during this interval.

After the frac crew arrives, the stimulation takes place as a continuous activity. The sliding sleeve ports are opened sequentially from toe to heel, and the treatment is pumped through the open port into the formation. Fracturing takes place in a typical fashion with the point of least resistance fractured first. If desired, diverters can be pumped to initiate additional fractures in order of next-to-least point of resistance until the entire stage treatment has been pumped.

At this point in the OHMS technique, the next subsequent port is opened while simultaneously closing off the zone just treated, and pumping continues on the second zone. The procedure is repeated until all zones have been treated. It is possible to skip a zone if its treatment is ill advised for any reason; it is not possible, however, to add a zone.

Pumping is only paused shortly between stages to allow time for sleeve shifting.

Recently, the OHMS technique has been used on cemented completions that use special acid-soluble cement. After the port sleeve is opened, acid is used to dissolve the cement opposite the open port, which provides access to the formation behind it so the treatment can be pumped. This modification eliminates the need for external zonal isolation devices and can constrain fracture initiation to the area where the cement sheath has been dissolved.

The OHMS technique has been applied in several plays, most frequently in unconventional horizontal well completions. The most attractive feature of the technique is its speed. Several stages can be stimulated in a single day. Initially, the technique was limited to about six stages, but technical improvements have raised that limit to more than 20 stages per well.

The PNP technique follows traditional completion procedures. A cemented liner can be set through the completion interval, or an uncemented liner can be used. Typically, a plug is attached to the bottom of a perforating gun and conveyed into the well. Any method (pump-down, tubing-conveyed perforating, wireline tractor-assisted conveyance or coiled tubing) can be used to position the plug/gun combination in the lateral. The plug is set at the appropriate depth below the toe zone, and the plug shears off. Then, the gun is pulled uphole and positioned precisely opposite the first zone to be stimulated. The gun is fired and pulled out of the hole. If desired, several intervals of the same stage can be shot using select-fire guns on the same trip. When the stage has been treated, the next gun/plug combination is deployed, and a composite frac plug is set to protect the zone. The process is repeated for the next stage. Although all stages are preplanned, the operator can change, delete or add a stage if observations indicate such a deviation from plan is advantageous.

Another type of PNP treatment involves ultra-high pressure abrasive jetting that is deployed on coiled tubing to perforate and treat individual intervals. Usually, a sand plug is set to protect previously treated intervals as the process is repeated for subsequent stages. The abrasive jet technique is used mostly on shallower wells, but it has the same flexibility as conventional PNP.

An earlier PNP technique that is rarely used now involves setting an uncemented liner in the lateral and treating the formation through perforations made at selected intervals. The theory behind this is that the formation will always fracture at its point of least resistance. Of course, this could be into an aquifer or an offset well. Most operators are no longer using this technique because of its unpredictability and the introduction of real-time microseismic fracture mapping.

Depending upon the number of stages to be treated, the PNP technique can take several days or more. The big advantage is that since each stage is treated individually, decisions can be made on the fly to change the location of the next stage, add or delete a stage, change the interval perforated, and so on—in other words, PNP affords complete flexibility. The PNP technique also favors the implementation of

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