Jason: Hello. I’m Jason your host for Halliburton’s RedTech™ podcasts, part of the technology learning series featured on www-dot-halliburton-dot-com-slash-redtech. This series of podcasts has been designed to highlight particularly significant products that Halliburton has recently brought to market. These technologies represent innovations that deliver reliability by simplifying complex completions, optimizing hydrocarbon recovery or economically optimizing production.

Jason: Joining us today is Dan, Halliburton’s global product champion for the StimWatch® Stimulation Monitoring Service. Hi, Dan!

Dan: Hi, Jason.
Jason: Dan, what challenges do operators face when stimulating wells?

Dan: Geological data interpretation can provide knowledge of natural fractures and injection profile predictions. And, fluid placement simulators are available. But, the fact of the matter is that real-time identification of the placement of stimulation treatments is a blind process. So, we haven’t known where the treatment actually went and in what volumes … until now!

Jason: Until now?

Dan: Well, Halliburton has a solution called the StimWatch service. It monitors what is actually happening downhole with fluids during a multi zone stimulation treatment. This service provides operators a real-time understanding of fluid placement for fracturing, acidizing and conformance treatments — identification of where and how much fluid is placed — and in turn, lets the operator make rapid changes to the job if necessary. This information enables real-time decisions to help optimize the treatment.
Jason: Then, StimWatch service is a lot like sending a “delivery receipt” e-mail that allows you to know when the recipient opens it; with StimWatch, you know when a zone has received the intended treatment.

Dan: Well, let’s carry that a little further, if you had no indication that the email had been received and opened, you would adjust how you would communicate with that person.

Jason: Yes, you’d probably pick up the phone and call them.

Dan: In that same way, if StimWatch service indicates a zone is not receiving a treatment, diverters can be used or other adjustments made – while the treatment is in progress – to make sure the message, or in this case, the treatment, gets through to the intended zone.
Jason: Now, even though fluid placement is critical to the success of any stimulation treatment – information such as this has not been previously available during the treatment.

Dan: That’s right. Unknown and unpredictable events can and do happen downhole that can significantly impact the results of the treatment. Because of that, successful stimulation treatments require information about a variety of conditions. These include location of natural fractures, the injection profile – you know, where the fluid is going and how much is going there – and the effectiveness of the diversion process, just to name a few.

Jason: So, the injection profile is fluid volume and placement and a diverter helps control where the stimulation fluid is going?

Dan: Right, and there are some conventional ways to monitor these conditions, but they provide limited information. For example, geological data interpretation provides the zonal volume. And, fluid-placement simulators provide a theoretical prediction of the injection profile. But, with Halliburton’s StimWatch monitoring service the treatment is being tracked – in real time – as it progresses downhole. This allows us to adjust the sequence of job stages, stage volume and diversion strategies to optimize the treatment.
**Jason:** So how does StimWatch enable this real-time “message received” process?

**Dan:** The service uses a fiber optic Distributed Temperature Sensing – or DTS – system with a fiber optic cable deployed in the well. We measure the change in wellbore temperatures caused by the cooling effects of pumping stimulation fluids. So, we process this temperature information in real time to provide the operator with both qualitative and quantitative indications of fluid distribution across the pay zones.

**Jason:** The fiber optic DTS system, is it permanently deployed?

**Dan:** It can be run in either a permanent or retrievable configuration in both vertical and horizontal wells. And, in a permanent installation, the cable assembly can be strapped to the completion casing or production tubing.
**Jason:** So, with the DTS, you track temperatures and that temperature data indicates the velocity and depth of the fluid.

**Dan:** Yes, this data is recorded in our InSite® Service for Stimulation software. Advanced software visualization allows us to make quick qualitative analysis of the temperature data as we continue to pump the treatment. For example, if we look at the zoomed in section of the temperature data across the perforations, we see a slope change in the temperature profiles signifies a change in fluid velocity. This is attributed to a loss of fluid into the formation at this depth. From here it is easy to identify a fluid entry point which is taking a majority of the treatment. This information is dynamic and changes throughout the job.

**Jason:** The fundamental benefit, then, is how the StimWatch service informs operators so that they can make better decisions based on better—and immediate—information.

**Dan:** That’s right. Although there are many more benefits. For instance, treatment time is minimized because we don’t have to mechanically isolate large pay intervals, we optimize pump time and fluid usage because we know how much of the target intervals have been treated. Operators can justify field decisions because we now have the information to make informed, real-time decisions.
**Jason:** Dan, earlier you mentioned that fluid-placement simulators provide a theoretical prediction of the injection profile.

**Dan:** And here’s an example. The visualization on the left represents what we would hope to achieve during a stimulation treatment. This chart is the results of our pre-job modeling using our fluid placement simulator. The expectation is that the fluids are evenly propagating into the formation. The various colors are the predictive model of the sequential stages of the treatment.

**Jason:** It looks perfectly symmetrical.

**Dan:** Right, this is what we would hope to achieve. Now, look at the chart on the right generated during a job. We can see that certain areas of the formation are not accepting the treatment while other areas are taking the treatment just as we expected. Those zones of color that remain closer to the center tells us that the fluid is not going into the formation. So, based on this information, we could apply diverters to change the injection profile. This type of visualization is available in real-time as the treatment is pumped so we can watch the penetration of fluid into the formation.

**Jason:** Wow, This is really valuable information to have!
Jason: During your pre-job planning don’t you model a variety of scenarios?
Dan: Absolutely. That’s an essential element of the work we do up front, and is a standard part of our pre-job modeling efforts. In the treatment we just looked at, we designed a treatment for what turned out to be the more difficult zones. So, we were ready to go with the diversion strategy that was developed before the job ran.
Jason: Contingency models help you determine and be prepared with the most effective diverters in certain situations so you can successfully change an injection profile?
Dan: Yes, and there are three different ways to accomplish this. A diversion strategy can use chemicals, foam or gel slugs; there are mechanical diverters such as balls or bridge plugs; or, in some instances just by simply changing the pump rates you can change where and how much fluid is being taken in by the target zone.
Jason: Dan, you also mentioned that with StimWatch service you can optimize fluid usage. Can you provide more details?

Dan: Sure, this is the point in time where StimWatch indicates that the treatment has achieved the desired results. No more guess work about when enough is enough. In fact, our customers get really excited about how we enable them to visualize the skin reduction. Looking at the calculated skin value in green in this chart we see a steady reduction in skin as the treatment progresses. But, once it levels out, we are finished. We can now stop treating the well since the return we are getting for pumping more acid with respect to skin reduction is minimal.

Jason: Skin reduction?

Dan: Let me explain skin this way: The process of drilling and completing the well means that the formation is being affected. Skin is the term we use to describe how close or far away the formation is to being in the natural state before all this development activity. A positive skin factor indicates the formation has been damaged and a negative skin number indicates the formation has been stimulated. So, it is important to reduce the skin number. A zero or negative skin factor is the goal. And, as we see here, when the skin number stops changing, it’s time to stop the treatment.

Jason: The goal with that treatment then is regaining or improving the state of the natural formation after the treatment. Zero or negative skin.
Jason: I understand that StimWatch Service was used with multi-zone fracturing treatments for the first time ever, right?

Dan: Yes, just this past summer. By using thermal tracers we were able to observe proppant pumping and placement. Historically we monitor pump rates and surface pressures which are indications that a fracturing treatment is proceeding, but the only thing we really know with these conventional methods is that fluid is exiting the wellbore through the perforations somewhere. A thermal velocity model allows us to track the thermal tracers and provide a quantitative estimate of fluid placement. As seen in this visual, we can analyze temperature anomalies collected during the treatment and as with other treatments, we know how much fluid – and in this case proppant – is going into the fracture.

Jason: Is the thermal tracer indicated by the spikes seen in between the two sets of perforations?

Dan: Right. Based on the quantitative analysis of the thermal tracers during this job, StimWatch analysis indicated that a majority of fluid was going into the upper interval so the treatment was modified while in progress to optimize placement in all the zones.

Jason: Operators simply haven’t been able to get accurate information like this in real time in the past – and certainly not for frac treatments.
**StimWatch® Stimulation Monitoring Service**

**Application**
- Multi-stage stimulations
- Large pay intervals
- Acidizing
- Fracturing
- Conformance Placement
- Scale Inhibitor

*Jason:* What projects can the StimWatch service benefit most?
*Dan:* Treatments involving vertical and horizontal multi-pay or large pay interval stimulation treatments. This information is very valuable for reservoir and field evaluation. Integration of this data with Halliburton’s ExactFrac® microseismic service will allow an operator to get a near field and far field look at how fracturing treatments are being applied downhole. It’s a cost-effective technology that helps operators significantly and reliably improve their stimulation treatments and truly increase their reserves that were previously un-recoverable.
Jason: Dan, do you have any field examples?
Dan: Sure. Here’s one from an Operator in California that planned a stimulation treatment for a well perforated in multiple sand and shale horizons. On this chart you can see two parallel lines. This is the hot baseline and cool treatment temperature gradients and they remained parallel through to 5400 feet.
Jason: And, that would be an indication that the treatment is being distributed throughout the wellbore.
Dan: However, as you can see the treatment temperature rises at the bottom of the wellbore and remains hot, the treatment did not penetrate the lowermost set of perforations. That told us that the initial diversion strategy wasn’t working. Because of this, we made adjustments and the second diversion was successful.
Production Profile Quantification

**Benefits**
- Verifies zonal production
- Provides return-on-investment information
- Indicates stimulation candidates
- Indicates post-stimulation production increase

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**Jason:** Now, what other applications are there related to the monitoring of wellbore temperatures?

**Dan:** Another great application is flow profiling. This chart shows how we can take the temperature profile and provide production information across the perforations. Over on the left, the black lines circled are the production from each zone and as you would expect, the magnitude of production is represented by the length of the line.

**Jason:** Is the production profile made post treatment?

**Dan:** Yes, to provide asset managers and production managers with information about the return on their investment. With StimWatch service, they not only know how much fluid they placed in each zone, but also the production from each zone treated. For re-stimulated wells this information can be obtained and compared pre- and post-job as well.
Dan: This technology is so advanced that it was one of four Halliburton solutions to receive Hart’s meritorious engineering achievement awards for 2006. And, we’ve delivered a number of industry papers on the topic, several of which are posted on the RedTech site.

Jason: Our time is about up, Dan. Can you give us a quick summary of StimWatch Service?

Dan: The bottom line is this: Real-time and actionable data to help operators reliably improve their stimulation treatments and increase their recoverable reserves from a well and field level. As a workflow of the Digital Asset, this service integrates distributed temperature sensing with Halliburton’s stimulation treatment services. The result is better quality treatments and optimized fluid usage because we have real knowledge about the treatment performance.
Jason: Thank you, Dan. And, to our listeners, thank you for joining us today. For additional learning materials, please visit our RedTech Learning Series at www.halliburton.com/redtech. We will continue to add podcasts and papers to the RedTech Learning Series site.