Testing Oil Producers from Surface Measurements

The most common misconception that exists about the SPIDR® Well Testing System is that it is limited to only dry gas applications. In the past, Halliburton has done extensive work to broaden the range of wells that can be tested from the surface. Currently, in order for a well to be a valid candidate for surface testing, it must adhere to the following criteria:

1. Constant mass flow rate
2. Constant component flow rate
3. Effective fluid continuity from surface to bottomhole

These conditions mean that the well must flow above the critical unloading rate and cannot have a gas liquid interface in the wellbore inhibiting communication between the reservoir and the wellhead. Based on these requirements, the following subsets of wells are considered good candidates for surface testing:

1. Single Phase Wells
   a. Dry Gas Wells
   b. Gas-Condensate Wells that flow above the dew point
   c. Oil Wells that flow above the bubble point

2. Multiphase Gas Wells that flow above the critical rate to lift liquids
   a. The well is below the dew point while flowing
   b. The well continuously unloads all produced liquids (i.e. no slug flow)
   c. The well can shut in above or below the dew point

3. Some Multiphase Oil wells
   a. The well flows below the bubble point
   b. The well produces naturally
   c. The well exhibits a bubble-flow type flow pattern (SPE 77001)
   d. The well must shut in above the bubble point to test via build-up

This is a significant expansion of the range of wells that can be tested from the surface beyond dry gas. To illustrate this expansion, an example of an oil well successfully tested from the surface is presented. The well shown below produces at a rate of ~1,500 BBL/d with a GOR of ~1,000 SCF/BBL. The FTP’s for this well are below the bubble point for the produced fluid, but the SITP’s exceed the bubble point pressure. A quick check of the superficial phase velocities confirmed that the well was also in bubble flow when producing. This well satisfies the criteria for a multiphase oil well that can be tested from the surface.

A 72 hour build-up test was conducted on the well with both a SPIDR® gauge installed on the wellhead and a DHG on slickline. The goal of the test was two-fold: The operator wanted to evaluate Halliburton’s abilities to convert wells in this field as well as obtain an analysis for skin, permeability and P*. Once the test was completed, the SPIDR® data was transmitted to Halliburton and then converted to the DHG depth for a blind comparison with the data. Once the conversion was submitted to the operator, the DHG data was transmitted to Halliburton so that both data sets could be overlayed. Figure 1 below is a linear comparison of both data sets:
As can be seen above, there is a small difference in the flowing bottomhole pressures, and very good agreement between the shut-in pressures. Figures 2 and 3 below are semilog and derivative plots of the data which were used to obtain analyses of the two data sets:
These two plots show that, while there is a small difference in the early time data, for the most part the data sets virtually overlay one another. The early time difference is due to gauge placement; since the well is shut in at the surface, the SPIDR® gauge will see the shut-in response before the downhole gauge. The overall similarity of the curves should result in comparable results when analyzing for the well’s reservoir properties. Halliburton’s analysis of both data sets is presented in Table 1 below, confirming that the results are very close.

<table>
<thead>
<tr>
<th>Permeability (md)</th>
<th>SPIDR Conversion</th>
<th>DHG Data</th>
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</thead>
<tbody>
<tr>
<td>Skin</td>
<td>-4</td>
<td>-4</td>
</tr>
<tr>
<td>ΔP_{skin} (psi)</td>
<td>-1,280</td>
<td>-1,286</td>
</tr>
<tr>
<td>Flow Efficiency (%)</td>
<td>182</td>
<td>185</td>
</tr>
<tr>
<td>P* (psia)</td>
<td>9,230</td>
<td>9,235</td>
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**Table 1: Analysis Comparison**

At Halliburton, we believe the goal of surface testing should be to provide equivalent results to those obtained from running downhole gauges. Based on this successful test, the operator will have confidence going forward that they can use the SPIDR® well testing system as a no-risk, low-cost alternative for future well tests.

Please contact Halliburton to see if your wells are viable candidates for surface testing. Halliburton will work with you to help determine if your wells can be tested from the surface, and we are available to discuss any well test procedures or data to help answer any questions you may have. We are available anytime to help plan your upcoming tests or to look at any previous test data you may have to help determine a better path forward.

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