DFIT™ Testing: Downhole vs Surface Data

Halliburton has built its reputation as the best surface well testing company by providing a “blind” comparison to downhole gauge data on a pressure transient test to new customers or in new areas. This has allowed for two things, first for the customer to see that Halliburton’s technology works and is a viable substitute to running gauges downhole, and secondly to provide Halliburton with additional data with which to further improve our conversion models. Obviously those two work hand in hand to ultimately provide an ever better result for the customer, which is what our reputation is founded on. A significant percentage of our recent work have been DFIT™ testing services on very tight gas sands or shales. These tests involve pumping a relatively small volume (20-50 bbls) of fluid (typically 2% KCl or similar) into the formation over a period of 10-20 minutes creating a small fracture, and then shutting the well in and watching the pressure decline. Various properties such as fracture closure time and closure pressure, fluid efficiency, reservoir pressure, and permeability can be then be determined and used for later work. Because the fluid being injected is an incompressible fluid and is continuous from the perforations to the wellhead, surface testing is a perfect way to capture the data for these types of tests in a majority of wells. The conversion to downhole pressures is straight forward as the density of the fluid is well known. However there have been some concerns voiced over whether the results of an analysis on actual downhole gauge data would be the same as those from surface data. As we have done with our traditional PTA testing, we recently ran a test where a downhole gauge was also in the wellbore during the mini-frac while the SPIDR® gauge was on surface. The results of this comparison follow, and show that surface data provides the same results as downhole data.

Figure 1 and 2 are regression analyses on the surface and downhole data to determine closure pressure and time, net pressure, and fluid efficiency, and use the Nolte G function time. The downhole pressures in the surface data plot are computed based on the depth and fluid gravity input into the software, and the surface pressures in the downhole data are likewise computed. As can be seen, the results compare very well with each other. It should also be noted that the downhole data was gauge pressure and the surface data was absolute, so there is a ~15 psi difference to be expected.
Figures 3 and 4 are regression analyses on the surface and downhole data to determine closure pressure and time, net pressure, and fluid efficiency, and use the square root of shut-in time. As before, the
downhole pressures in the surface data plot are computed based on the depth and fluid gravity input into the software, and the surface pressures in the downhole data are likewise computed. Once again as can be seen, the results compare very well with each other.

**Figure 3 - Surface Data Regression Analysis using square root of shut-in time**

**Figure 4 - Downhole Data Regression Analysis using square root of shut-in time**
As can be seen from the previous plots, the surface data gives the same result as the downhole gauge data as far as determining closure pressure, ISIP, net pressure, and fluid efficiency are concerned. However it can be observed in the plots that there is a key difference between the downhole and surface data later on into the fall-off. This is due to the reservoir being under-pressured and the well going on vacuum at surface. When this happens, the surface pressure is no longer a reflection of what is happening downhole, and analysis results will be different. If the reservoir is under-pressured and the fall-off is of a short enough duration so that the well has not gone on vacuum at the surface, the results between downhole data and surface data will be the same. However for long fall-offs where the well has gone on vacuum at the surface before a full analysis can be done then only downhole gauge data can provide true, accurate results. For normally pressured or over pressured reservoirs the surface data will give the same results as the downhole data at all times. This is important to understand and plan for prior to performing minifrac or DFIT™ testing work. It can mean the difference between saving money and risk and getting useful results and simply wasting money and time on poor results.

The conclusions to be drawn from this comparison are that surface data is a much safer, less expensive way to obtain minifrac data on a majority of tight sand and shale wells. The results from the analyses match up very well, and the shape of the data during the fall-off prior to going on vacuum at the surface is the same for both datasets. Any future work could be planned based on the analyses of either of the two datasets. It is important to understand the limits of testing under-pressured reservoirs from the surface, and to plan ahead to avoid wasted time and money on tests that yield poor results. Halliburton offers free consultation and well test planning for all your pressure transient testing needs, including minifracs or DFIT™ testing services. We offer a complimentary analysis when a SPIDR® gauge is used to capture the surface DFIT™ test data, and are available 24/7 to assist in all your well testing needs.

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