DFIT™ Test Analysis When On Vacuum At The Surface

A diagnostic fracture injection test (DFIT™) is an optimal type of test to perform using surface acquired pressure data. This is because the fluid being injected into the formation is incompressible; the surface pressure data will mirror the downhole pressure data so long as the well doesn’t go on vacuum at the surface. The fluid column will be continuous from the perfs up to the surface gauge, and the only difference between the downhole pressures and surface pressures will be that of the hydrostatic head of the fluid column. The data requirements are high resolution (0.01 psi) and high frequency (1 sample/sec), and it is important that the gauge is also not influenced by external temperature fluctuations that may distort the shape of the fall-off data. Our SPIDR® gauge is the industry leader in regards to surface pressure testing, and we’ve seen a large increase in the number of DFIT™ testing services being performed over the past year. For the majority of these, the well does not go on vacuum at the surface and the surface pressure data acquired is an exact representation of the downhole pressures. However, we have seen some tests where after a period of time the well does go on vacuum at the surface. After that point, the surface pressure is no longer representative of the downhole pressures, and analysis on the data after that point is not possible. This does not, however, mean that a well cannot be tested from the surface if it goes on vacuum. Depending on how quickly the well goes on vacuum, valuable formation characteristics may still be determined from the surface data. This article will present a recent test performed on a well that went on vacuum a few hours after shut-in. Both the SPIDR® surface pressure data and downhole pressure data were recorded and analyzed and it will be seen that the analyses from the two tests yielded the same results.

Figure 1 below shows the SPIDR® surface pressure data (pressure scale on left y-axis) and the downhole pressure data (pressure scale on the right y-axis) overlaid with each other so that the shapes of the curves may be compared. The y-axes cover the same span of 1,100 psi in 100 psi increments. It can be seen that at about 35 hours the shape of the surface pressure starts to differ from the shape of the downhole gauge data, and that after about 38 hours the well is on vacuum at the surface. It can be seen that prior to 35 hours, the surface data is a direct representation of the downhole gauge data. Thus the only question is did we capture enough useful information prior to the well going on vacuum to perform an analysis and get meaningful results?
The following six plots show the pre-closure analysis performed on the surface and downhole pressure data. It is important to note that the downhole pressure data is gauge pressure and the surface data is absolute pressure, so 14.7 psi needs to be added to the downhole gauge results when comparing with the surface results. Also, only the surface data up to where the well goes on vacuum was used for analysis, however the full downhole gauge data file was used for the downhole data analysis. It can be seen in the plots below that the analyses are very similar; they yield the same closure time, closure pressure, net pressure, stress gradient, and efficiency.

This well took enough time to go on vacuum to get useful data for a pre-closure analysis, and permeability can also be estimated from this pre-closure data as well. The after closure surface data however was not suitable for analysis for $P^*$ and permeability due to the well being on vacuum.
It is important to understand that the length of time it may take for a well to go on vacuum is dependent on reservoir pressure and permeability of the formation, and thus it may not be possible to use surface pressures for the DFIT™ tests on all wells. But it is an incorrect assumption to say any well that goes on vacuum at the surface cannot be tested from the surface. The vast majority of wells we have tested do not go on vacuum at all at the surface, and the after closure data provides valuable reservoir information for future modeling work. In the cases where the well does not go on vacuum, downhole gauge data has no advantage to surface data, and is in fact simply more costly and comes at a much higher risk.

One other alternative should you be concerned about your well going on vacuum is to consider running a nitrogen fracture injection test (NFIT). Instead of using water or brine as the injection fluid, nitrogen is instead used to help reduce the weight of the hydrostatic column, thus allowing you to perform a DFIT™ Test on an underpressured reservoir. Halliburton can assist in designing a test that will work for any reservoir.

Our DFIT™ analysis is complementary when the SPIDR® gauge is rented for the purpose of capturing DFIT™ test data. 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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