Data Requirements for DFIT™ Testing

The bulk of the data recorded by SPIDR® surface pressure gauges over the years has been for pressure transient analysis (PTA); At Halliburton we perform hundreds of PTA tests every year for our clients. We have made it our business to be PTA experts in this industry, and over the past 25 years we have learned a number of key factors related to obtaining useful data to be used in the PTA tests. A diagnostic fracture injection test or DFIT™ test is a relatively new type of PTA test being performed in the tight gas sand and shale plays so prevalent in the industry today, and as such is subject to the same data requirements as a more traditional test such as a pressure build-up (PBU) would be. The objective of this article is to highlight those data requirements as they pertain to DFIT™ testing and illustrate just how critical high quality data is for achieving the desired results of the test.

Pressure transient analysis is the analysis of change, namely the change in pressure over time. Thus it is critical to measure the pressure accurately, with high resolution and high frequency, and for that measurement to be repeatable. In traditional pressure transient testing of high permeability wells, high frequency and high resolution were critical to obtaining data that could be used for the analysis. This is due to the fact that in a high permeability reservoir, change happens very quickly, and the amount of change is small. If the gauge being used is of poor quality, the test data will be useless for analysis. But DFIT™ testing is done on low permeability reservoirs. While the same gauge quality concerns don't hold true for a traditional PTA test on a low permeability reservoir, for a DFIT™ test they do. This is because the pressure changes we are looking for in a DFIT™ test can be subtle, and they happen in a small window of time. By using a low quality gauge you run the risk of missing closure or picking the wrong closure time, or possibly not being able to detect closure because the gauge could not detect the subtle pressure change. Additionally, the after closure data which is used in determining reservoir permeability and pore pressure happens late in the fall-off when pressures are declining at a very slow rate. A low resolution gauge, 1 psi or lower resolution, would not be able to provide data that could be analyzed for permeability and pore pressure as it simply would not be able to detect the subtle pressure differences over time at the end of the test.

Another important aspect to consider concerning resolution and repeatability is noise in the data. Noise can also come in the form of poor temperature compensation of the gauge, as the case would be with day to night temperature swings or step functions that exist in the calibration of the gauge. Traditional PTA using type-curve matching uses computer software to generate a “model” of the reservoir based on user input, which then generates a derivative curve that is then “fitted” to the actual derivative curve generated from the test data. Noise in the test data is amplified when looked at in the first order derivative plot, so it is critical to have as little noise as possible in order to provide the best match. Several diagnostic derivative curves are used in DFIT™ test analysis in order to determine leak-off type, closure time/pressure, after-closure flow regime, etc. These are both first order and second order derivative curves, and second order derivative curves amplify noise even more than first order derivative curves. Even relatively low noise data can make the DFIT™ test analysis extremely difficult if not
impossible. Due to noise it may be impossible to determine if it is a closure event being seen in the data, or just noise. It may also be impossible to determine the slope of the after closure data to determine if pseudo-radial flow is being seen and if an after closure analysis should be performed. If an analysis were performed it would also be difficult to get the correct slope through the data to accurately determine permeability and pore pressure.

A final requirement to consider is the thermal compensation of the gauge in regards to the shape of the fall-off, or the rate of the pressure decline over time. Because DFIT™ test analysis is a pressure transient analysis, which is an analysis of the pressure change over time, it is critical that the data the gauge is providing is an accurate reflection of what is taking place in the reservoir, and is not a function of the temperature of the gauge. A gauge that has poor temperature compensation will provide pressure data that will change with gauge temperature and not what is happening in the reservoir. This is a separate issue from noise as the gauge may have a high resolution and the data may have very little noise, but over the duration of the test the rate of pressure decline is wrong due to the temperature influence in the gauge. The rate of pressure decline is critical for identifying leak-off type, the point at which the fracture closes, and the flow regime from the reservoir after closure has happened. If the gauge data is being affected by its ambient temperature, then any or all of these may be misidentified which would result in an incorrect analysis. The data may look fine, but it would not be an accurate representation of what is going on in the reservoir.

Pressure transient analysis is the most powerful tool available to the petroleum engineer, but it is only useful when quality data is combined with proper analysis technique. A small savings in the expense of a test by using a low quality pressure gauge may result in a test that cannot be analyzed, and a complete waste of the total test's costs. It may additionally waste the only opportunity that was available to test these ultra-low permeability reservoirs. Halliburton provides the means to obtaining the highest quality pressure data available in the oilfield, and the technical expertise that 25 years of experience in pressure transient analysis gives. We provide free consultation and well test planning, and are available 24 hours a day, 7 days a week.

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