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New Model to Analyze Nonlinear Leak-Off Test Behavior

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A leak-off test (LOT) is a verification method to estimate fracture pressure of exposed formations. After cementing each casing string, LOT is run to verify that the casing, cement and formation below the casing seat can withstand the wellbore pressure required to drill for the next casing string safely. Estimated fracture pressure from the test is used as the maximum pressure that may be imposed on that formation. Critical drilling decisions for mud weights, casing setting depths, and well control techniques are based upon the result of a LOT. Although LOT is a simple and inexpensive test, its interpretation is not always easy, particularly in formations that give nonlinear relationships between pumped volume and injection pressure. The observed shape of the LOT is primarily controlled by the local stresses. However, there are other factors that can affect and distort LOT results. Physically the LOT, indeed, reflects the total system compressibility, i.e., the compressibility of the drilling fluid, wellbore expansion, or so-called borehole ballooning, and leak (filtration) of drilling fluids into the formation. There is, however, no mathematical model explaining the nonlinear behavior. Disagreement on determining or interpreting actual leak-off pressure from the test data among the operators is common. In this paper, a mathematical model using a well-known compressibility equation is derived for total system compressibility to fully analyze nonlinear LOT behavior. This model accurately predicts the observed nonlinear behavior in a field example. The model also predicts the fracture pressure of the formation without running a test until formation fracture.

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