IN-SITU PERMEABILITY TESTING FROM EXPLORATION HOLES

Drill Stem Test

Sigra can provide in-situ measurements of permeability and pore-fluid pressure in rocks and soils by using Sigra's own Drill Stem Test (DST) equipment and software. The DST yields greater accuracy of permeability, barriers to flow and recharge boundaries compared with traditional falling-head and lugeon test techniques normally used in civil engineering applications. Testing is normally undertaken in HQ size (96mm) exploration holes, however they can be performed in larger diameter holes.

Fluids can be drawn from, or injected into the formation; the basis of the analysis is independent of the flow direction. The most successful and unambiguous testing involves drawing fluid from the formation so as to avoid contamination of the wellbore with foreign fluids and clay particles which can change the near-field formation permeability characteristics.

Sigra DST Cube

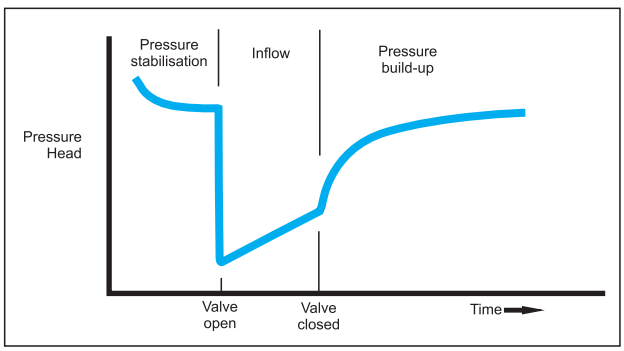
The Drill Stem Test involves lowering the fluid column in the drill string to create a hydrostatic head differential between the drill string and the isolated formation test zone. A valve connecting the drill string to the test zone is opened, allowing formation fluid to enter the drill string. After this period of fluid inflow, the valve is closed and a pressure is allowed to build back up in the isolated test zone. Throughout the test, pressures are continually logged and analysed at surface. The procedure maybe repeated to confirm formation behaviour.

Monitoring the formation response to the test process at surface allows Sigra engineers to adapt testing to meet in-hole behaviour. Surface readouts permit viewing of the well test progress in both numerical and graphical forms. Plots of the total test, the pressure derivative with respect to Agarwal time, and the Horner build-up are available on surface. The ability to view these plots in real-time ensures all tests Sigra controls and undertakes with its own equipment produce valid results, provided an adequate seal can be created between the inflated packers and the borehole wall.

The DST system developed by Sigra comprises a steel framed cube containing data logging equipment and control systems. Sigra also supplies downhole tools which come in two forms; a through-the-bit tool and an end-of-string tool.

The through-the-bit tool is designed to be run through an HQ or HRQ drill string utilising the drill rig's wireline winch. The tool can be run as a bottom test with a single packer positioned above the target formation, or in a straddle configuration with packers placed above and below the target formation. The through-the-bit tool allows a test to be performed quickly without requiring the driller to trip out drill pipe, thus reducing rig time. The through-the-bit tool can be used in holes up to 105mm in diameter.

The end-of-string tool is also used in a bottom test or straddle configuration. The tool is designed to be screwed onto the bottom of the drill string then lowered into position. Packer inflation and communication lines are lowered inside the drill pipe on a wireline to connect with the tool. The end-of-string tool can perform multiple tests along a borehole simply by adding or removing drill pipe, provided the test zone straddle spacing requirement remains the same.



DST Build-up plot

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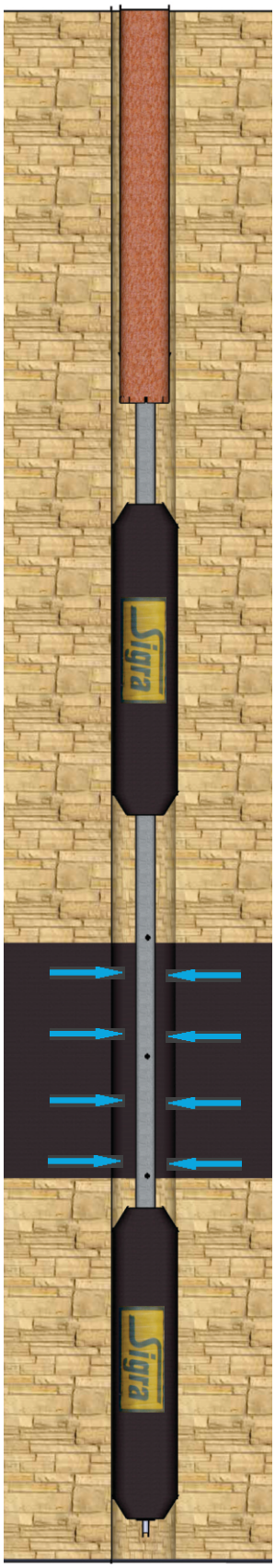


Both tools use compressed air or nitrogen to lower the hydrostatic head in the drill string prior to a test. Each system contains a zero volume change valve which controls connection between the test zone and the inside of the drill string. The valve is operated by raising or lowering the drill string once the packers are inflated. Three pressure transducers in the tool monitor the test zone pressure, drill string pressure and packer inflation pressure.

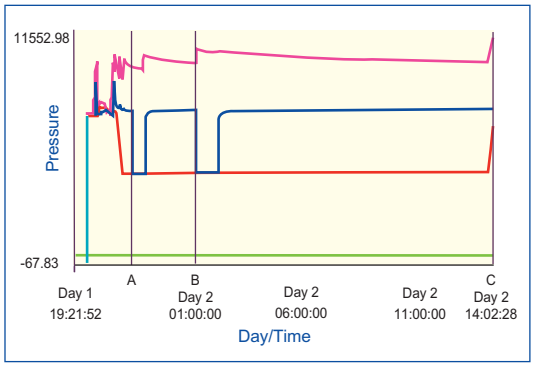
The DST cube contains a regulator to control the rate at which compressed air lowers the fluid column in the drill string. The air pressure is regulated so as not to blow air out the bottom of the drill string and into the annulus. Once the fluid column in the drill string is at the desired level, the packers are set. The packers are inflated to the required sealing pressure by using water or compressed air. At greater depths the packers may only be inflated using water. The packer inflation lines and communication lines are secured at points along the rig's wireline winch from the DST tool to surface.

After the packers are set and a seal is confirmed, the test zone is isolated from the drill string by closing the valve. Excess air pressure in the drill string is then bled off. The valve is then opened again, allowing formation fluid to enter in to the drill string. The rate of fluid in-flow is determined by a change in head measured by the drill string pressure transducer. Any gas flow is detected by high and low flow gas meters.

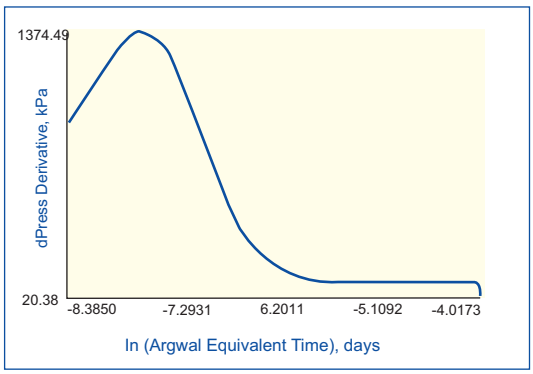
At the end of testing, the drill string is filled with water from surface. Once the pressure in the drill string and test zone has equalised, the packers are then deflated. The through-the-bit tool is pulled to surface through the drill string. In the case of the end-of-string tool, the electronics are detached from the tool and pulled to surface, allowing the driller to add or remove drill pipe.

A water regulation system is also installed in the cube which allows for fluid injection into the formation at a controlled pressure or flow rate should it be required. Formation fluid samplers may also be used with the DST system.

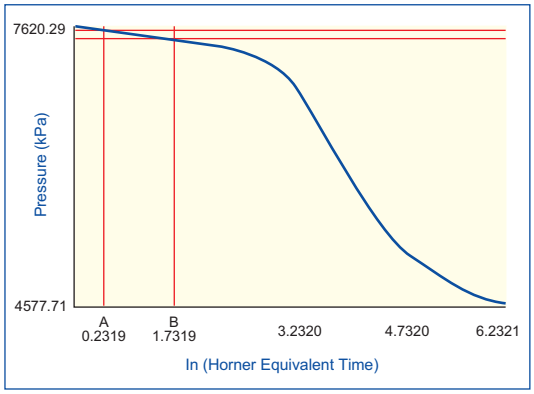
Sigra also has the capability to determine anisotropy and inhomogeneity using pulsed DST in place of a full pumping test. The Pulsed DST involves sequentially testing individual boreholes and placing piezometers in these after each borehole test is finished. The next borehole to be tested sends a pressure transient to those boreholes drilled before and fitted with piezometers. The most convenient way to test each well is by conducting a DST in the test zones. Hence the name “pulsed DST”.



Example Total Plot of Sigra Drill Stem Test (DST)



Example of Plot of Derivative with Respect to Agarwal Time



Example of Horner Build-Up Plot