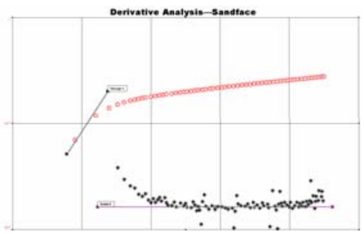
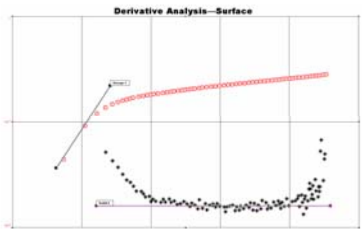
*i*REPORT

Information Report Surface Data Acquisition Useful and Economic for Well Testing Applications

Surface Pressure Data Accepted for Pressure Transient Testing

AEUB Approved!





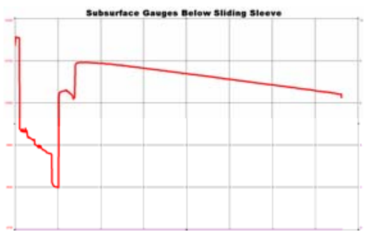
Alberta Energy Utilities Board (AEUB) G-40 states that surface pressure data are acceptable for testing dry gas wells less than 1500 m deep. This has proven economic for developing shallow gas reservoirs in the Western Canada Sedimentary Basin.

Validity of the technique is demonstrated by two illustrations. This example flow and buildup test was conducted on a 350 m deep low density sweet gas well with both subsurface and surface electronic pressure recorders installed. The first pressure derivative plot is from the *subsurface data*, the second from the *surface data*. Quantitative analytical results (kh, s', q_s, p_R) from the two methods were virtually identical.

Electronic surface pressure recorders have proliferated over recent years. Manufacturers offer a variety of units ranging from single channel stainless steel strain-gauges to multi-channel quartz-crystal transducers. Ambient temperature compensation algorithms have been incorporated successfully into most electronic gauges.

The only practical difference for evaluating surface data vs. subsurface data is an algorithm, such as Cullender & Smith, to convert surface measurements to sandface values.

Surface Data can be the Only Practical Method



Sometimes using surface pressure data is the only practical testing method available. This example illustrates a test where downhole gauges were set *below an open sliding sleeve* that was *above the perforations*. Valid pressure transient data were totally obliterated by liquid interference. Quiet-side (annulus) surface pressure data may very well have provided valid pressure transient data in this case.

An acoustic well sounder (AWS) survey is recommended at rig-off to confirm any fluid level.

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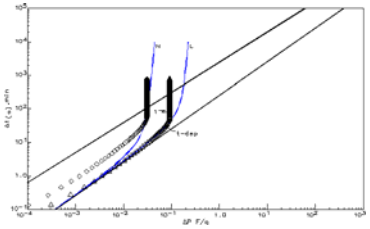
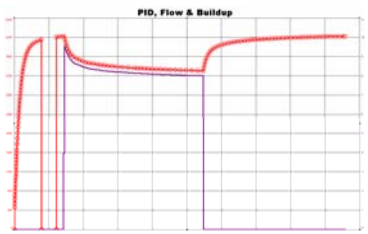
Closed-Chamber, Impulse & Perforation Inflow Diagnostic Tests



Closed-chamber tests have been utilized for many years as an alternative to drill stem tests. The technique is transferable to several alternative welltest solutions.

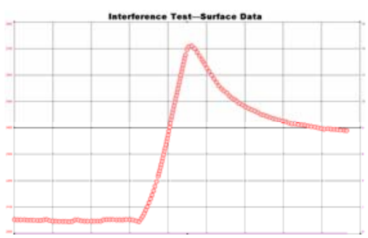
Pre-frac tests have been successful using the closed chamber method. Surface pressures are recorded during perforation. The surface pressure buildup is proportional to gas influx into the closed chamber (wellbore). Quantitative order-of-magnitude results (kh, s') can be estimated using either McKinley afterflow type-curve matching techniques (illustrated) or by associating a gas influx rate with pressure change and analyzing the pressure transient response as a drawdown. Analytical results are useful for deriving a permeability cutoff prior to frac'ing, weeding out high perm response from the frac program and sizing frac treatments.



Perforation Inflow Diagnostic (PID) tests are similar but conducted in higher permeability systems. Analytical results are useful for testing-on-the-fly decisions, tie-in decisions and facility infrastructure planning. For specific fields and pools, correlations can be developed whereby tie-in decisions can be made within minutes of perforating a wellbore. Regulatory AOF tests can then be conducted in-line, saving the cost of a production test plus the value of gas that would be flared.

Perforation Inflow Distribution Diagnostic (PIDD) tests can differentiate inflow ratios in multi-layer completions. By perforating subsequently better layers, an increase in surface pressure buildup slope is equal to an increase in gas inflow. It may be necessary to blow down the wellbore to maintain critical flow conditions across the perforations. Analytical results are analogues to production logging surveys and can be utilized for identifying movable gas, proving recoverable reserves, determining log cut-off values and identifying bypassed pay as well as non-performing layers.

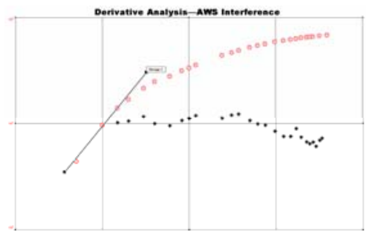
Surface Pressure Data Proves Useful for Interference Testing

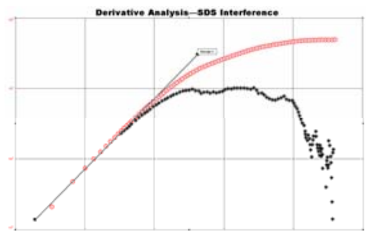


It appears only logical that surface pressure data could prove useful for interference testing in high permeability gas zones. Valid results have been derived from producing wells and injection wells.

This example illustrates the surface pressure data trace from a gas storage observation well. Subsurface pressures exhibited identical behaviour. Substantial savings were realized with future test operations by *not* requiring expensive electric wireline services for the surface readout of bottomhole pressure gauges.

Interference Testing, continued...

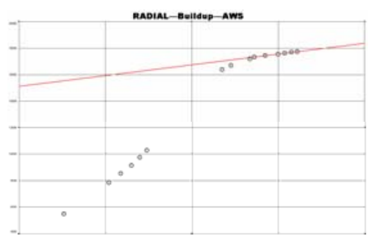


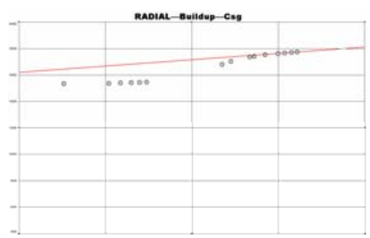


Valid results have also been obtained from water injection wells, flowing oil wells and pumping oil wells. For this second example, pressure buildup data were obtained on a pumping oil well using both an AWS and an electronic surface pressure recorder. There was no clear indication of interference from the AWS data set which, by nature, was quite sparse. The surface annular (casing) pressure data set, on the other hand, exhibited a definitive pseudo steady-state relationship through the late-time region, clearly identifying interference from the offset pumping well.

Electronic surface pressure gauges have several fundamental advantages over AWS instruments. First, the sampling rate is significantly higher. Acoustic instrument sampling rates are controlled by the liquid level shot frequency. Second, an electronic gauge can be left on, recording data, for a much longer time period than an AWS instrument due to significantly lower power consumption requirements and limited life of the nitrogen gas supply. Finally, manpower requirements for electronic instruments are significantly lower than for AWS instruments. Acoustic instruments must be checked regularly and nitrogen supplies have to be restocked if the test is designed to last any length of time.

Surface Casing Pressure Data Proves Valid for Pumping Oil Wells





It is common practice in pumping oil wells to use acoustic well sounder (AWS) instruments to obtain reservoir pressure buildup data without pulling rods and pump. With this method each pressure measurement is tied to a liquid level shot, which becomes the primary input signal. Sparse sample rates and noise (due to inaccuracy of the acoustic shot) are inherent problems. Both deficiencies can severely affect pressure derivative analysis techniques.

A number of historical AWS tests were reviewed, evaluating *only* surface casing pressure data. The analytical presumption was that the period of active liquid movement, after shut-in, was a function of wellbore storage (afterflow). The analyzable portion of the buildup was, therefore, after the liquid movement stabilized, in which case one final static liquid level measurement (AWS shot) should be sufficient.

The first example illustrates the conventional AWS data set while the second example illustrates casing pressures only, adjusted to the sandface by the final AWS shot only. Note the semi-log straight-line slopes are virtually identical. This is because the liquid level is constant throughout the valid radial flow regime.

Surface Data Useful for Several Other Applications

Well Test Alternatives — There are several other useful applications for surface pressure data instruments, besides those already described in this information sheet. Some of these include:

Well Test Optimization — Surveillance or optimization purposes for determining the running or pulling of subsurface pressure recorders or termination of critical well tests.

Surface Casing Vent Tests — Surface casing-vent tests can be conducted using the closed-chamber method.

Pressure Maintenance Surveys — Water injection well tests for pressure maintenance monitoring (to keep oil wells producing revenues).

Drill Stem Tests — Closed-chamber drill stem tests.

Under Balanced Drilling — Testing while under-balanced drilling (drill ahead, stop, test…drill ahead, stop, test…).

Segregation & Isolation — Segregation and isolation tests (packers, plugs, casing/tubing holes, surface casing).

Surface Data Qualification

Qualify Your Application — This information report on surface data is provided as a means of disseminating thoughts, information, knowledge and experience. The very nature of well testing is interpretative, as much art as science, such that there are no definitive answers. The magnitude of impact on quantitative results must also be qualified. Open discussion of the topics presented herein are encouraged.

Selected Reference

Information Source — Contents of this information report were derived from the technical paper CIM 1997–35 *"76 Examples of the Usefulness and Benefits of Surface Pressure Data for Well Testing Applications"* by Robert Hawkes, CET and David Leech, BTech.

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