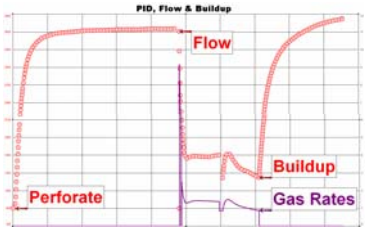
WELLTEST SPECIALISTS

*i*REPORT

Information Report

Impulse, Perforation and Closed Chamber Testing; Snapshots of Reservoir Inflow Characteristics

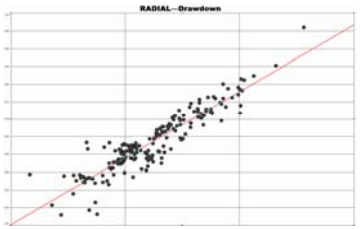
Surface Data Recorders Modernize Underutilized Techniques



Impulse testing has been around for some time and analytical theory is well documented. Modern electronic surface data acquisition equipment has made impulse testing practical and economic in the Western Canada Sedimentary Basin. Issues advancing usage include under-balanced perforating, coiled tubing frac's, by-passed pay, ultimate recovery in low deliverability systems, flaring, secrecy and general exploitation. Two methods are currently available to quantify reservoir flow characteristics (kh, s, q, p_R), with order-of-magnitude accuracy; a multi-rate drawdown/buildup approach or Fekete's WellTest™ impulse model.

Perforation Inflow Diagnostic (PID) Tests

For this test, a surface data recorder is rigged in, the well is perforated and the resulting buildup pressures are recorded. As per accepted closed-chamber theory, gas inflow rates are calculated based on the change in pressure with time ($\Delta p/\Delta t$). This process can be generalized over a fixed time period (i.e. 5, 10, 30 minutes) to generate an instantaneous AOF value or rigorously applied to each positive Δp increment. Nevertheless, rate calculations are terminated at one-half (½) of the static reservoir pressure, defined as the critical flow cut-off point.



Using conventional welltest analysis software, then, data before the critical flow cut-off can be analyzed as a pressure drawdown. Data following the cut-off point can be analyzed as a pressure buildup. Conventional pressure derivative and radial flow (semi-log) analytical techniques can be employed. Analytical models can also be employed with either regime. Corresponding analysis of conventional flow and buildup test data (as per illustration) has demonstrated validity of the PID analysis technique for generating quantitative results with order-of-magnitude accuracy.

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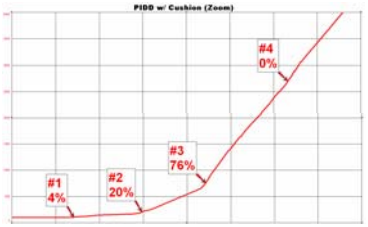
⇉ *Perforation Inflow Distribution (PID) Tests*

PIDD Without Cushion



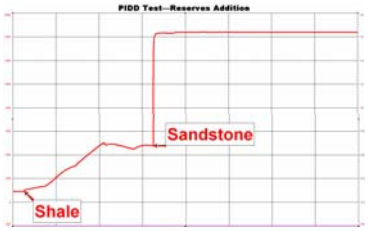
PIDD With Cushion

The PID test is analogous to production logging when two or more intervals are perforated. Based on changes to the $\Delta p/\Delta t$ slope, gas inflow and AOF ratios can be estimated. Starting with the interval of least anticipated influx potential, multiple perforation runs are conducted. Subsequent to each perforation run, pressures are allowed to build up for a set period of time, being a function of permeability and rate of pressure increase. It may be necessary to blow down the well if pressures exceed the critical flow cut-off point of one-half (½) the static reservoir pressure.

The first example illustrates four intervals perforated with no cushion. Perforated intervals two and three obviously exhibited an increment in slope, contributing subsequently higher inflow ratios. Perforation interval number four did not exhibit an increment in slope and thus contributed negligible gas.

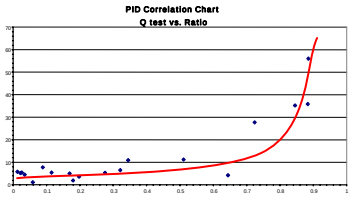
The second example illustrates four intervals perforated with a cushion. Again, perforated intervals two and three exhibited an increment in slope, contributing subsequently higher inflow ratios. Perforation interval number four did not exhibit an increment in slope and thus contributed negligible gas.

⇈ *Proving Movable Reserves*



In this example a high permeability sandstone overlaid a shale zone. Decline curve analysis indicated reserves greater than volumetrics could justify. It was hypothesized that the gas shale reserves migrated vertically, due to pressure differential, to be produced with the sandstone reserves. The shale was perforated first and exhibited a pressure increase, thus proving additional movable gas reserves. The second perforation response was from the high permeability sandstone. The PID has also proven incremental by-passed reserves in Alberta's east-central tight gas sands (Milk River/Medicine Hat/Second White Specks).

$ *Exploitation Correlations*



Exploitation correlation plots can be developed for specific fields and pools. Enough tests and end-results need to be monitored so correlations can be observed. Eventually these plots are used for making on-site real-time tie-in or fracture treatment decisions. In some documented cases tie-in decisions were literally being made five minutes after perforating a well by plotting a hand-held pressure point (dimensionless) on the correlation chart. In-line deliverability tests were conducted later for AEUB regulatory compliance. This not only saved thousands of dollars by not testing, but also the value of gas not flared.

Impulse Tests Useful for Other Applications

Surface Casing Vent Tests	Surface casing-vent tests can be conducted using the closed-chamber method.
Drill Stem Tests	Closed-chamber drill stem tests.
Fracture Stimulations	Pre-frac evaluations and frac falloff tests.

Impulse Test Data Qualification

Qualify Your Application	This information report on impulse tests 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 2000–80 *"Impulse, Perforation and Closed Chamber Testing: Simple, Quick Cost-effective Snapshots of Reservoir Inflow Characteristics"* by David Leech, Robert V. Hawkes, Paul Storey and Sharyda Brown.

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