WELLTEST SPECIALISTS

iREPORT

Welltest 104: **Surface Pressure Data**

Welltesting & Surface Pressure Data

Responsibility Chain Management

Petroleum Reservoir and Production Engineering teams initiate hydrocarbon welltests. Well testing is about measuring and recording flow rate and pressure data. Surface pressure data are also a valuable resource. Responsibility chain management of data requires an integrated team: from wellsite acquisition or collection; to field-office processing, data validation, and technical reporting; to engineering analysis (PTA, AOF, IPR) and legal submissions (AER, SEC). Corporate directors, managers, and stakeholders depend on reliable, traceable, advice from testing wells.

Welltesting Team

Talented and experienced wellsite equipment operators are always appreciated for safe running, installation, and recovery of scientific instruments. Knowledgeable and particular field-office technicians are valued for accurate, timely technical reporting. Engineers need to know what standards to expect, and to do whatever data processing might be required to achieve professional acceptance.

Surface Team

Surface pressure data recorders are deployed by the same team that runs Acoustic Well Sounders (AWS – Welltest 103), often in conjunction. Surface data recorders can also have channels for Production Testing gauges (static and differential pressures, and temperature, Welltest 102). Surface data recorders can be rigged for live viewing and streaming from remote locations.

Engineering Team

Engineering is quirky: words are different, acronyms are strange, expectations are high, accuracy and precision are standard protocols. All staff in the responsibility chain need an awareness of equipment, tools, and operations. Practical knowledge about quality control, data validation, and technical reporting ensures consistent, reliable deliverables. Literacy with oil patch nomenclature (words, acronyms, subscripts, superscripts) is requisite for effective communication and comprehension.

Bridging Technical Gaps

Welltest Specialists technical training material has been written to bridge technical gaps and help new staff get up to speed with welltest engineering workflow and workspace.

Pressure Data

This *i*REPORT will focus on topics related to deployment of surface pressure recorders (gauges) for welltesting purposes.

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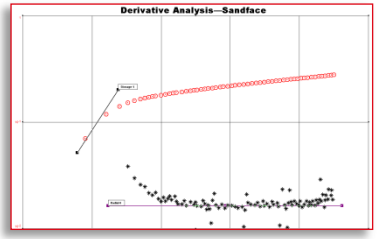
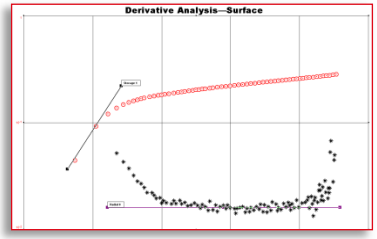
Surface Pressure Data

Well Documented

Surface or wellhead pressure data (tubing, casing) have always been vital for safe production operations. Oil well testing with acoustic well sounders is well documented and very useful for reservoir pressure and production optimization. Dry gas well testing is also common for annual requirements and to test for skin damage. Surface data recorders monitor Mini-Frac', DFIT, and Step-Rate tests. Waterflood injection and waste disposal wells are often tested from surface. Streaming surface pressure data to an engineer's laptop wherever is efficient test supervision.

Validity for Pressure Transient Analysis





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 from the two methods (kh, s', q_s, p_R) 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.

Unfortunately, after decades of accepting surface tests for Initial Pressure Gas requirements for shallow, low deliverability wells, Alberta AER issued Directive 2010-38 abolishing the practice.

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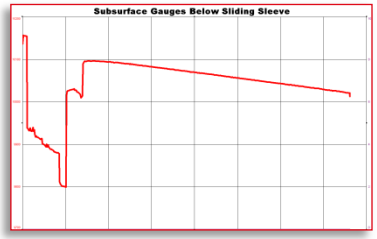
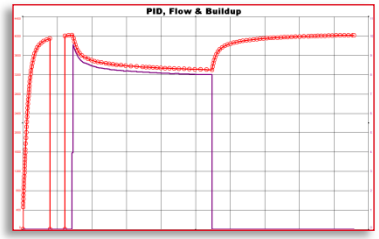
Only Practical Method

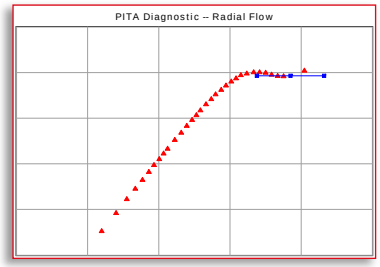


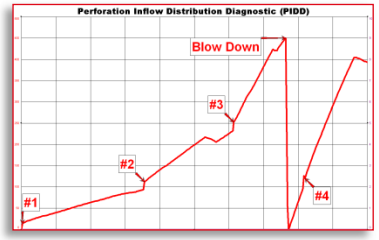
Sometimes using surface pressure data is the only practical testing method available. This example illustrates a test where downhole gauges were set *below an open sliding sleeve* that was *above the perforations*. Valid pressure transient data were totally obliterated by liquid interference. Quiet-side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

Closed-Chamber & Impulse Testing







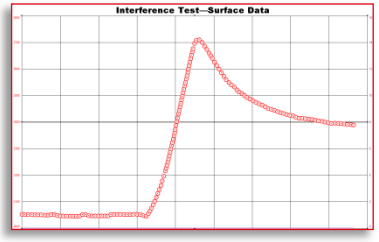
Closed-chamber tests have been utilized for many years as an alternative to drill stem tests. The valve open impulse technique is transferable to several alternative welltest solutions.

Pre-frac' tests have been successful using closed chamber methods. Surface pressures are recorded during underbalanced perforation. Surface pressures build up proportionally to gas influx into the closed chamber (wellbore). Quantitative order-of-magnitude results (p*, kh, s') can be estimated using Perforation Inflow Test Analysis (PITA & Slug) methods. Analytical results are useful for deriving a permeability cutoff prior to frac'ing, weeding out high perm' response from the frac' program, or 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.

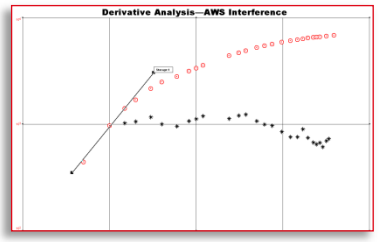
Perforation Inflow Distribution Diagnostic (PIDD) tests can differentiate inflow ratios in multi-layer completions. By perforating subsequently better layers, an increase in surface pressure buildup slope is equal to an increase in gas inflow. It may be necessary to blow down the wellbore to maintain 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, or identifying bypassed pay as well as non-performing layers.

Interference Testing

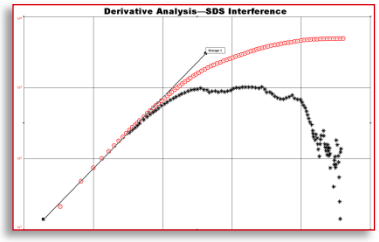


It appears only logical that surface pressure data could prove useful for interference testing in high permeability gas zones. Valid results have been derived from oil and gas producing wells as well as water injection wells.

This first 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.



Valid results can also be 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 obvious indication of interference from the AWS data set which, by nature, was quite sparse. Surface annular (casing) pressure data, on the other hand, clearly exhibited a pseudo steady-state relationship through the late-time region, identifying definitive interference from the offset pumping well.



Electronic surface pressure gauges have several fundamental advantages over acoustic well sounders (AWS). First, sampling rate is significantly higher. Acoustic instrument sampling rates are controlled by the liquid level gas gun 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 gun supply. Finally, manpower requirements for electronic instruments are significantly lower than for AWS. Acoustic instruments must be checked regularly, and nitrogen supplies have to be restocked if the test is designed to last any length of time.

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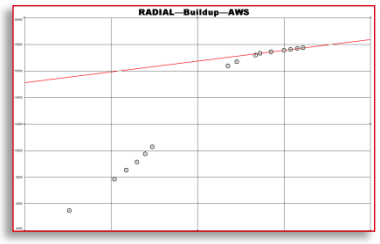
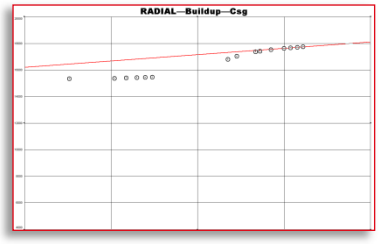
Pumping Oil Wells





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.

Testing a hypothesis, a number of historical AWS tests were reviewed, evaluating *only* surface casing pressures. Analytically it was presumed that the period of active liquid movement, after shut-in, was a function of wellbore storage (afterflow). The analyzable portion of the buildup was, thus, after liquid movement stabilized, in which case one final static liquid level measurement (AWS shot) should be sufficient.

The first plot shows conventional AWS data while the second plot shows casing pressures only, adjusted to the sandface by the final AWS shot only. The semi-log straight-line slopes deriving permeability and p*, are virtually identical. This is because the liquid level is constant throughout the valid radial flow regime. Skin, however, will not be resolved correctly.

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	Live surveillance or optimization purposes for determining the running or pulling of subsurface pressure recorders or termination of critical well tests.
Surface Casing Vent Tests	Regulatory surface casing-vent tests can be analyzed using the closed-chamber method.
Pressure Maintenance Surveys	Water injection 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 ¿REPORT 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 is encouraged.

Selected Reference

Information Source

Contents of this ¿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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