

Information Report **Wireline (Slickline) Reporting and Data Validation**



Wireline in General

- Principals** Wireline is one method of running various measuring instruments and tools into petroleum wells. Basically, devices are attached to the end of a long spool of wire and are reeled down hole and back up with a winch. See wireline nomenclature at the end.
- Lubricator** A lubricator (several sections of pipe) is attached to the top of a wellhead BOP. A grease valve and pulley are mounted on top of the lubricator to run the wire through. Tool strings are then pulled up into the lubricator, before running in and out of the wellbore.
- Winch** The winch is usually mounted on a truck but can be skid mounted for remote operations. A drop spool can also be employed if instruments need to be hung down hole (i.e. inside casing, no tubing in which a collar stop can be landed).
- Wire** Four basic types of wire are employed. Also called slickline, solid steel wire is for normal use while solid stainless steel wire is for sour service. Braided wire comes in either solid core, for heavy duty use, or e-line in which the braid is wrapped around a coaxial cable for electric control of downhole tools and instruments (i.e. logs).
- Welltesting** This **iREPORT** will focus on operations, quality control, data reporting and data validation topics related specifically to the use of pressure recorders for well testing purposes.



Instruments in General

- Electronic Data** Run on e-line are open hole logs and production logs which include flow spinners, pressure, temperature and gradiometer recorders or even video cameras. For welltesting, pressure recorders (bombs) are the primary wireline instrument. Data reporting and validation topics will herein be focused on pressure instruments.

✂ **Tools in General**

- Casing Tools Down the casing, bridge plugs, packers and perforating guns can be run by wireline.
- Tubing Tools In the tubing, gauge rings are run to tag fill or fluid or to be sure there are no obstructions before running plugs (and their equalization prongs), collar stops (darts), sliding sleeve shifting tools or any instrument. Overshots are run to retrieve tools. Jars are run to apply upward or downward striking forces, sometimes to set tools but also to shear safety pins and get out of the hole, leaving a stuck tool (fish) behind. Impression blocks have a facing of lead and are run to evaluate obstructions and fish but can be good for locating a liquid level. There are many fishing tools, including wire catchers, overshots, junk baskets and magnets. Swabbing is also done with wireline and wax cutters are run on wire. These are just a few of the basic tools, there are far too many to get specific.

💧 **Subsurface Pressure Recorders**

- Gauge Types Pressure recorders are available in two basic types: strain gauges for general usage and quartz gauges, with higher resolution, where better accuracy is required. Strain or quartz elements provide a *primary amplitude signal*, from which *pressure is inferred*.
- Calibration Recorders are calibrated in an oil bath, where temperature and pressure are applied by a certified source. Any gauge deviations are corrected employing a calibration equation.
- Pressure Range Electronic recorders measure absolute pressures and are available in a variety of ranges (i.e. 93–20 000 kPa_a). Try to choose gauges so pressures will fall between 20 % and 80 % of the range. Gauges are far less accurate below 10 % of their range (regardless of what the salesman says!).
- Clock A clock is required to obtain a data sequence. Clocks last as long as the batteries, but do malfunction once in a while, for various reasons (slow down or speed up, stop).
- Sample Frequency Clock sample frequency can be set on electronic recorders. Rapid sampling is fine for short tests or during times of rapid pressure change but can lead to excessive data file sizes in long tests. Slower sample rates can miss important data points, such as the final flowing pressure, but can allow for longer tests as memory and battery power will last longer.
- Temperature Sensor Temperature of the strain or quartz element must be known, so a thermometer is installed and provides another *primary input signal*. Note, then, that *calculated pressure is actually a secondary product*.

↓ Recorder Run-In

Liquid Level When recorders are run into a well they are measuring pressure vs. time ($\Delta p/\Delta t$). Liquid levels can be observed based on changes in the $\Delta p/\Delta t$ slope. Approximate liquid levels can be calculated assuming a constant running speed ($\Delta d/\Delta t$). This is close enough to qualify possible pressure gradients and magnitude of the initial measured pressure (i.e. the measured pressure may be low due to a liquid column between gauge RRD and MPP).

↪ Recorders On Bottom

Initial Pressure With recorders on bottom for a time it is important to note the trend. If pressures are still building, stabilized conditions have yet to be achieved. Pressures may drop if the zone is still over charged by a fracture treatment or if there is interference or communication. The best condition, for analytical purposes, is a flat, stabilized, pressure trend yielding a valid estimate of initial or average reservoir pressure.

≡ Purging Production Facilities

Wellbore Fluids Most often the initial pressure is just *before purging* portable production test facilities. This operation usually causes one of two patterns. If the wellbore is gas filled, a characteristic drawdown spike occurs (∇). If there is liquid in the hole, the pressure may spike upwards (\wedge) due to increasing the liquid head between gauges and MPP. Pattern is a good indicator of wellbore fluid composition.

🕒 Flow Testing

Important Events The production flow test, or drawdown, is what sends the pressure transient out into the reservoir. The flow test may be designed as a *single point* or *multi-point*. The final flowing pressure, before the extended buildup, is always important. Multi-point tests may be done as a *modified isochronal*, with equal flow/shut-in sequences, or *flow-after-flow*, with equal flow sequences but no shut-in periods (i.e. for high permeability systems). The flowing (and shut-in) pressures, at each step, are also important events for multi-point tests.

Flowing Trends Flowing pressures *increasing* might be due to the near wellbore region cleaning up or liquid loading. Flowing pressures *decreasing* usually indicates that stabilized conditions have yet to be achieved. Be cognizant of counteracting effects by comparing surface flowing data.

➔ **Pressure Buildup**

- Quality Control Pressure buildup data should always be examined for quality control and anomalies. If data are smooth, great!
- Early-Time Several phenomena might cause data anomalies shortly after shut-in. Phase redistribution (gas going back into solution) can cause a *hump* in the early-time data. Liquid fill-up can cause a *drop* in pressures (changing from gas above MPP to a liquid head). A falling liquid level may cause a sudden *increase* in pressures, as the column between recorders and MPP changes from liquid to gas.
- Middle-Time One might also observe liquid shifts well into the buildup. Other completion operations (i.e. on an up-hole zone) may affect the buildup, which could suggest communication behind pipe, across a packer or a leaking plug.
- Late-Time Longer term one might see shut-in pressures start to *decline*, suggesting communication or interference from offset producing wells or isobaric pressure gradients due to drainage.

📄 **Temperature Data**

- Quality Control Temperature data should also be examined for quality control and anomalies. Temperature data are a good indicator of wellbore and reservoir characteristics.
- J-T Cooling Joule-Thompson cooling usually dominates flowing temperatures in gas wells as a function of gas expansion through the perforations. If the magnitude of this cooling *decreases* (less cool) then the near wellbore region might be cleaning up.
- Warming With recorders usually landed above the perforations, temperatures *warming* above landing temperature usually indicates liquid loading (i.e. liquid from the formation warms the gauges up). One anomaly to watch for immediately after shut-in is a spike in temperature indicating adiabatic heating (a gas compression phenomenon).

⚡ **Differentials**

- Diagnostic Differentials should be created for both pressure and temperature traces, for quality control and data validation. Liquid shifts are most clearly exhibited by differential diagnostics. Drift is also evident from the differential. Every effort should be undertaken to identify an erroneous or malfunctioning gauge.

Purging the Lubricator

Final Pressure The final test pressure should be taken immediately *prior to purging the lubricator*, since this operation causes a slight flow, effectively ending the buildup. Purging the lubricator at the end of the test is very much like purging production facilities: in a gas filled wellbore a downward spike (v) occurs but if liquids are present an upward spike may occur (^).

Run-in & Reverse Gradients

Incomplete Data Sometimes a static gradient survey is conducted while running gauges into the well, before they are left on bottom. Pulling a static gradient survey, at the end of the buildup, while recovering the recorders, is known as a reverse gradient. While these practices save a bit of money and time, they often miss critical information on wellbore fluid composition. The fluid gradient between recorder run depth (RRD) and mid-point of perforations (MPP) remains unknown. This can result in only a *partial liquid gradient being measured*.

Conventional Static Gradients

Definitive Data Conventional static gradient surveys are run to MPP, often to PBSD, and definitively measure wellbore fluid interfaces and gradients. Conventional gradients are the preferred method for welltest engineering.

Tubing & Casing Pressures

Hand-Held Gauge Initial and final tubing and casing pressures are important for welltest engineering. These measurements help with quality control and can suggest annular liquid levels or possible gas composition differences between tubing and annulus (i.e. air in the casing— a volatile situation which must be rectified before tie-in).

Government Regulations

Regulatory Boards In Canada, petroleum well testing is controlled by provincial boards, each with a variety of rules, regulations and submission requirements:

- Alberta Energy and Utilities Board (AEUB)
- British Columbia Oil and Gas Commission (BC-OGC)
- Saskatchewan Industry and Resources (SIR)

Alberta Requirements

- Act & Regulations Alberta has the most stringent requirements and one should be thoroughly familiar with Oil and Gas Conservation Act 151/71, AEUB published guides G3, G5, G40 and G60 as well as General Bulletins 2003-01, 2003-05 and especially 2003-15 (the PAS file mnemonic guide).
- AEUB.pas Files All wireline data, reports and pressure transient analyses (PTA) are required to be submitted to the AEUB, in electronic format, via their web site, as PAS files (pressure ASCII standard). The GRD.pas file supports gradient surveys while the TRG.pas file supports extended or flow and buildup tests (with or without PTA).
- 2 kPa/h Rule There are numerous checks to validate the data. In particular, there is a check to verify if data can be submitted with or without PTA, known as the “2 kPa/h Rule”.
- Note that, to be submitted without PTA, G40 requires pressures building less than 2 kPa/h — but the Board’s computer has built-in leniency, and checks for pressures building less than 2.5 kPa/h, to pass submission requirements.
 - Stand-alone static gradient surveys are checked over the last 2 h on-bottom time for compliance with the 2 kPa/h rule.
 - Extended tests and buildup tests are checked over the last 6 h on-bottom time for compliance with the 2 kPa/h rule.
- Data Quality Despite the Board’s attempts to ensure data quality, through computer validation checks, there are loopholes allowing false representation. All purchased AEUB.pas files should thus be reviewed by a qualified welltest interpretation and pressure transient analysis expert.

British Columbia Requirements

- Regulations All test data and applicable analyses must be submitted, as per requirements of Section 95 of the *Drilling and Production Regulation*. Well testing requirements are further detailed in Section 6.7 of the *British Columbia Oil and Gas Handbook*.
- Submissions Welltest submissions to the BC-OGC are still via paper copy. Reports should be prepared by qualified welltest interpretation experts. Wireline data are documented on the Reservoir Pressure Survey Test Report (OGC-061-PST form).



Saskatchewan Requirements

Submissions Welltest submissions to the SIR are still via paper copy. Absolute Open Flow (AOF) reports should be prepared by qualified welltest interpretation experts, with the accompanying AEUB-EG-32 form (predating AEUB.pas electronic files).



Contact

david@welltestspecialists.com

David Leech, BTech, Welltest Specialists Inc., 403-256-5767



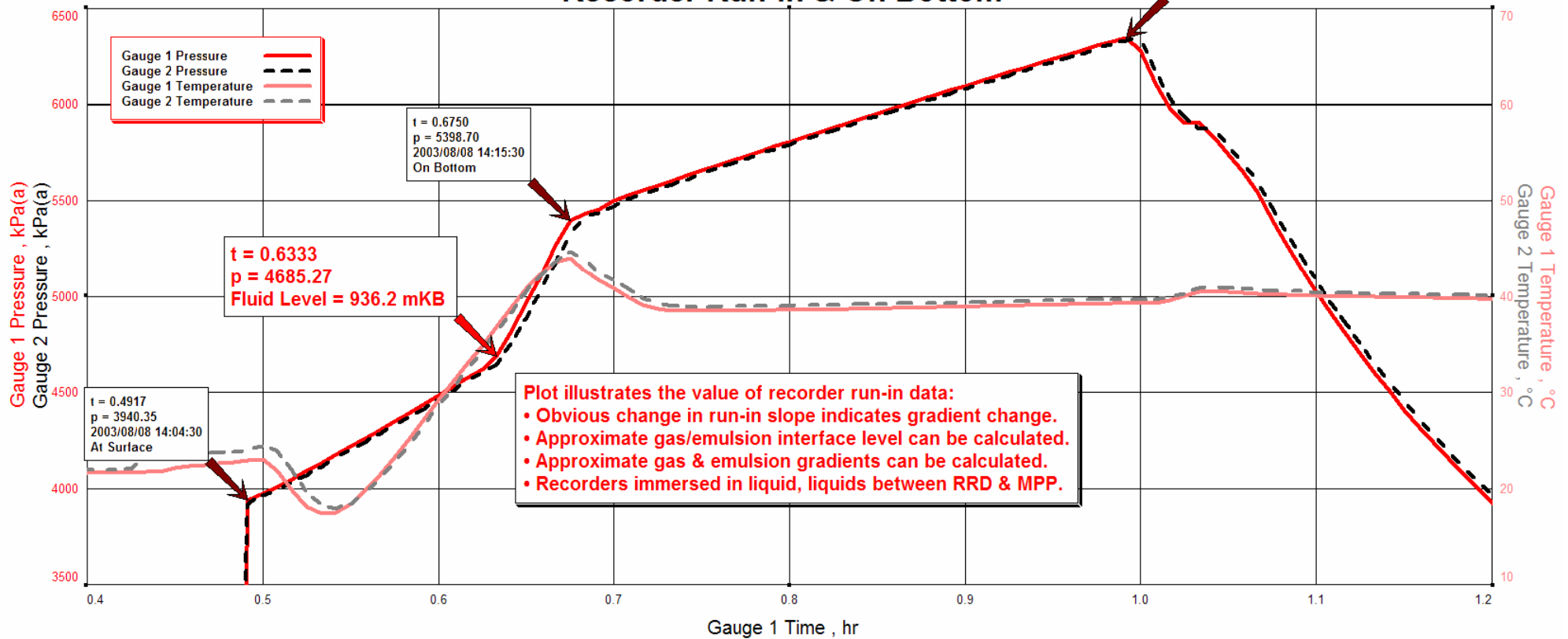
Wireline Nomenclature

Tubing	Tools run on the tubing string by the service rig
BHA	Bottom Hole Assembly, the collection of tools run at the end of the tubing string (packer, nipples, etc.).
Collar	Short, threaded, link, connecting two sections or lengths of tubing together.
Packer	Isolates upper and lower zones, in dual completions. Includes a profile in the on/off mechanism.
Sliding Sleeve	Can be opened or closed, allowing fluids to flow from the annulus up the tubing. Includes a profile.
Nipple	A short tool with an internal profile that specific tools (plugs, darts, etc.) can latch or lock in to.
Profile	Designated such as D, S, W, R, X, XN, etc. For matching wireline tools (plugs, darts, etc.)
No-Go	The last item on the tubing string, with a narrow internal diameter, to prevent tools falling through.
Testing	Wireline tools run into tubing for well testing purposes
Gauge Ring	Hollow, open ring tool with specific diameter, run before any other tools, to be sure tubing is clear.
Collar Stop	Will lock into the space between tubing sections to hold or retain pressure recorders at run depth.
Dart	Will lock into a matching profile, to hold or retain pressure recorders at run depth.
Plug	Used to isolate lower and upper zones. Will lock into profiles or collars. See prong.
Prong	Part of the plug, pulled first to open smaller holes to equalize, before pulling full-bore plug.
Recorders	Tools run with the pressure recorder string
Fishing Neck	At the top of the tool string, for separating from and leaving tools, or attaching to and recovering tools.
Bomb Wells	Secondary encasements, to hold recorders and protect them from sour gas, filled with inhibited fluid.
Hold-down	Attached above the tool string, to prevent high gas flow rates from blowing recorders up-hole.
Miscellaneous	Other wireline tools used for running and recovering
Sinker Bars	Heavy sections used simply for weight, to help lower tools into wellbores.
Jars	Hydraulic or mechanical tools that can exert upward or downward “hammer-like” striking forces.
Overshot	Latches on to the top of the fishing neck to retrieve tools.
Wellhead	Equipment attached to the wellhead
BOP	Blow Out Preventer, to shut-in and control well flow, shearing the wire, if problems occur.
Lubricator	Several sections of pipe, above the BOP. For pulling tool strings into, before running down-hole.
Stuffing Box	At the top of the lubricator, with packing nut and pulley, through which the wire runs.
Weight Gauge	With pulley to direct wire to the stuffing box, measures weight on the tool string.
Truck	Equipment on board the truck
Counter	Measures wire length, to determine depth. Zeroed with tool string touching casing flange.

C1 Hydrocarbons Inc.
 10A/10-11-012-13W6/03
 Start Test Date: 2003/08/08
 Final Test Date: 2003/08/08

C1 Fort St. Nick
 Formation: Cecilia
 Pool: 1217.2-1219.2 mKB
 Job Number: TRG

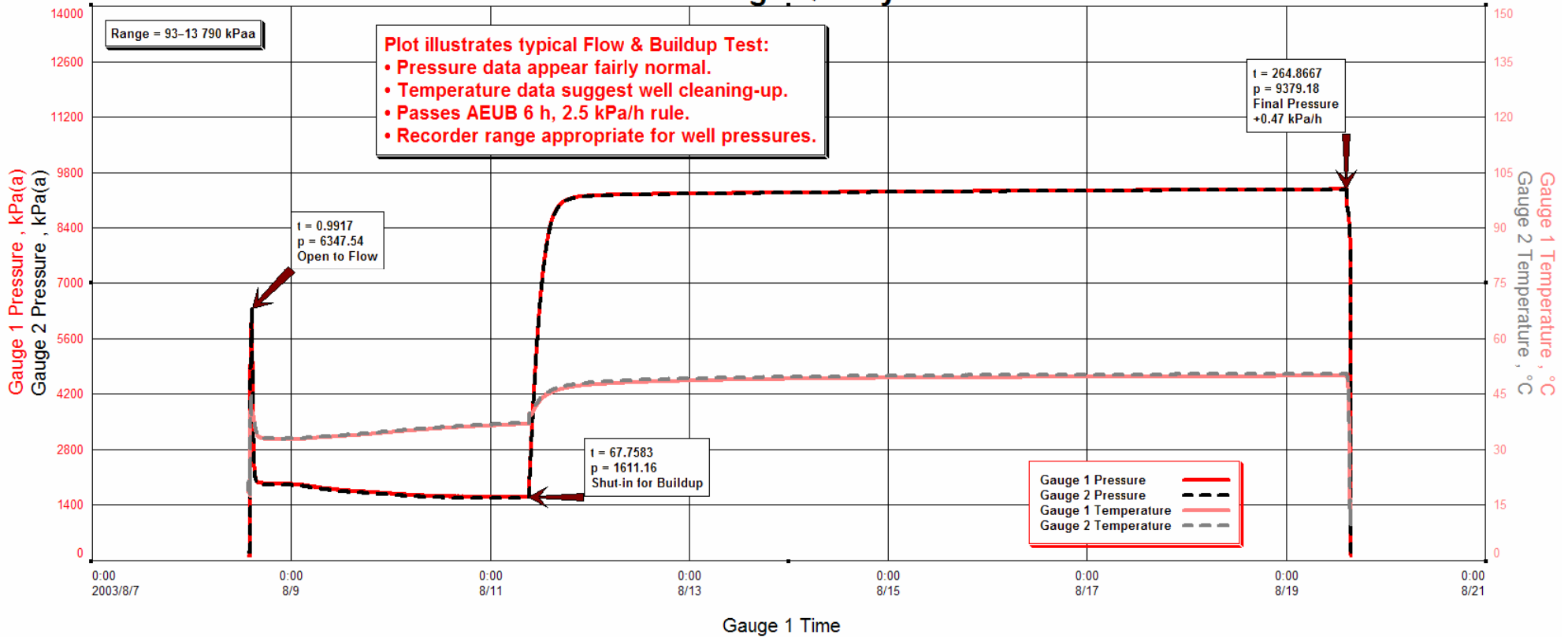
Recorder Run-In & On Bottom



C1 Hydrocarbons Inc.
 10A/10-11-012-13W6/03
 Start Test Date: 2003/08/08
 Final Test Date: 2003/08/08

C1 Fort St. Nick
 Formation: Cecilia
 Pool: 1217.2-1219.2 mKB
 Job Number: TRG

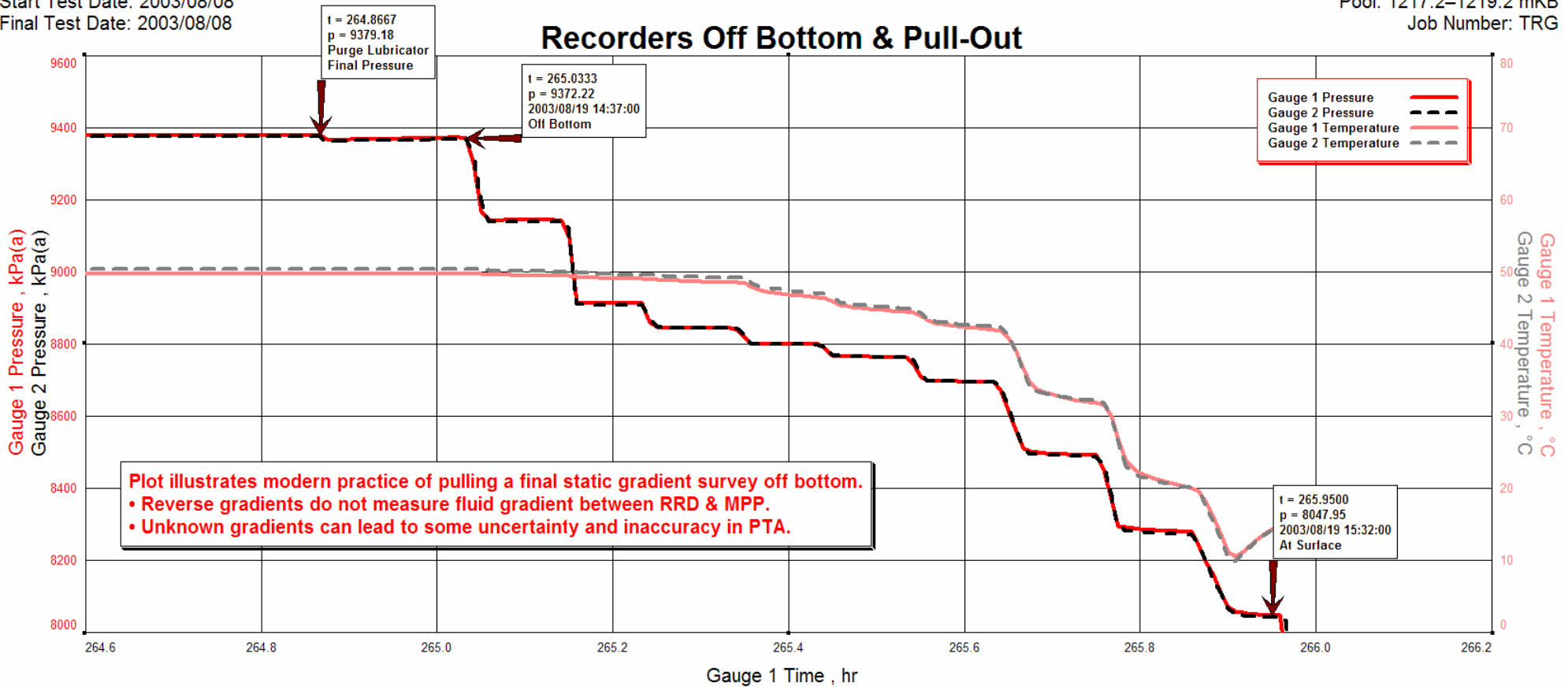
Recorder Range Quality Control



C1 Hydrocarbons Inc.
 10A/10-11-012-13W6/03
 Start Test Date: 2003/08/08
 Final Test Date: 2003/08/08

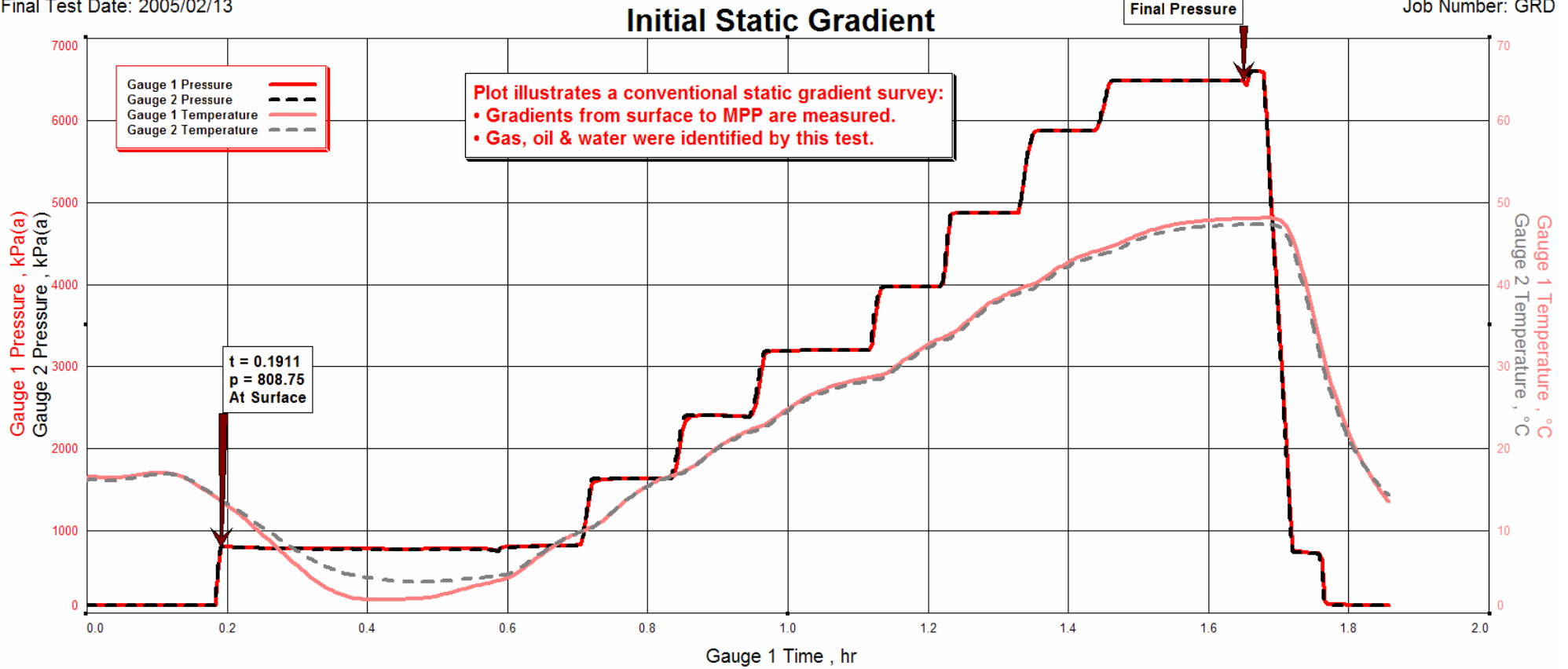
C1 Fort St. Nick
 Formation: Cecilia
 Pool: 1217.2-1219.2 mKB
 Job Number: TRG

Recorders Off Bottom & Pull-Out



XYZ Energy Canada
 200/b-060-A/090-H-09/00
 Start Test Date: 2005/02/13
 Final Test Date: 2005/02/13

XYZ Chimichanga
 Formation: Charlie B
 Pool: 960.5 - 967.0 mKB
 Job Number: GRD



XYZ Energy Canada
 200/b-060-A/090-H-09/00
 Start Test Date: 2005/02/13
 Final Test Date: 2005/02/13

XYZ Chimichanga
 Formation: Charlie B
 Pool: 960.5 - 967.0 mKB
 Job Number: GRD

