



Smart Plunger™

by PCS

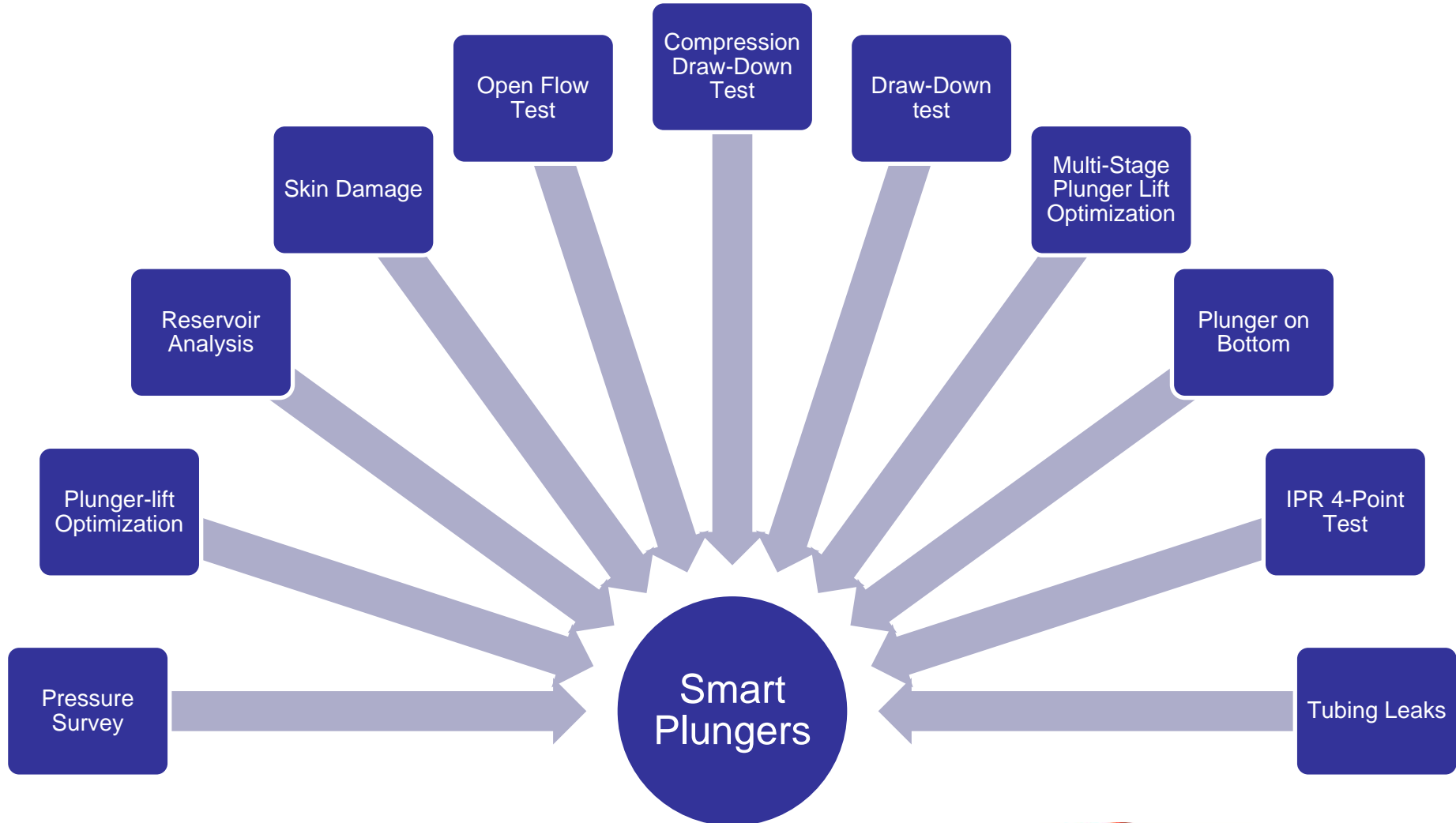


What they are

- Highly accurate downhole pressure & temperature gauge
- Contained inside stationary and traveling plunger styles
- Utilized in a traveling mode or stationary position
- Up to 15,000 psi
- Up to 300 °F
- Over 1,200,000 sample points
- 1 sample/ second minimum
- USB or serial interface for easy programming & downloads
- Low power consumption – single AA lithium battery



What they can do



Advantages

- Record real time pressures & temperatures for cycles covering entire well bore
- Detect tubing holes/ leaks and fluid levels
- Ensure plunger hits bottom
- Eliminates wireline costs – install & retrieve data loggers via plunger lift operation for reservoir studies, 4-point testing, etc.
- Immediate access upon plunger retrieval at well head
- Easily program and download data logger commands and data on location
- Combine TRAVELING & STATIONARY data logging
- Increase multi-tasking during tests –test plunger fall times, liquid level, bottom hole pressure survey, rising slug load & 4-point as a group
- Simple to use with no special training required – works like a conventional plunger

Programming



- Microprocessor settings can be programmed on location via laptop computer
- Sample rates of 1/second upward are set in a multi- or fixed-rate pattern for pressure & temperature
- Temperature only units can sample @ 3/second when looking for tubing holes
- Date & time are reset and battery installed
- Data logger probe placed in STATIONARY or TRAVELING plunger

Stationary

- Ensure there is a bottom stop assembly in the tubing
- The **DROP-OFF Tool** and transport plunger (left) attaches w/ collet to the fishneck of the **STATIONARY** plunger
- After plunger combination reaches bottom, **DROP-OFF Tool** thermal actuator activates at pre-determined temperature setting and separates from the fishneck of the **STATIONARY** plunger
- Well flows bringing **DROP-OFF Tool** and transport plunger to surface



Drop-Off Tool
on Transport
Plunger

Stationary
Plunger



Traveling

- Data logger programmed in the Traveling plunger housings
- Plunger is dropped and operated like a conventional plunger
- Plunger housings are available in:
 - dual pad
 - optional bar stock



Dual Pad



Bar Stock

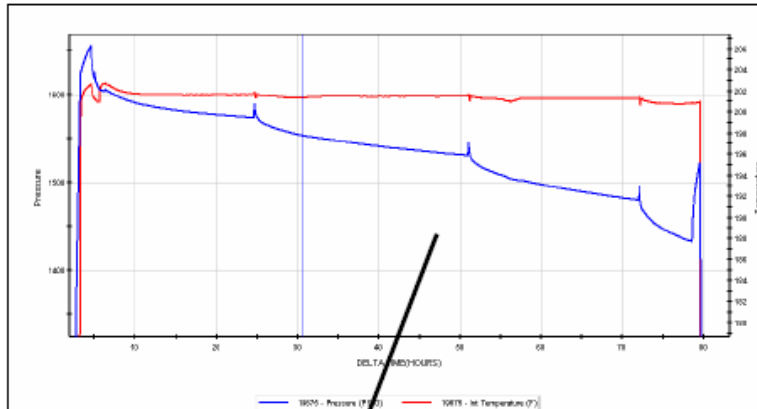
Retrieval

- Traveling Smart Plunger arrives in lubricator
- A Retrieval Tool on a transport plunger is used to bring up Stationary Smart Plungers
- The retrieval tool on a transport plunger is dropped in well and an overshot grabs the Stationary Smart Plunger
- Well is flowed bringing both plungers to surface and caught in the lubricator

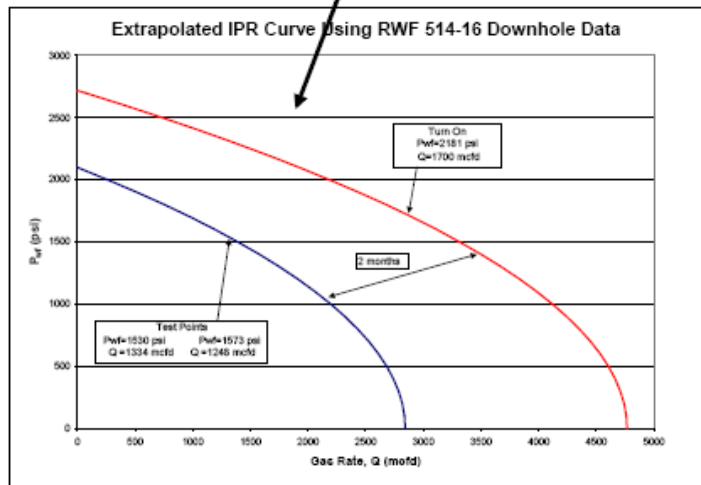


4-Point Isochronal Test – IPR Curve

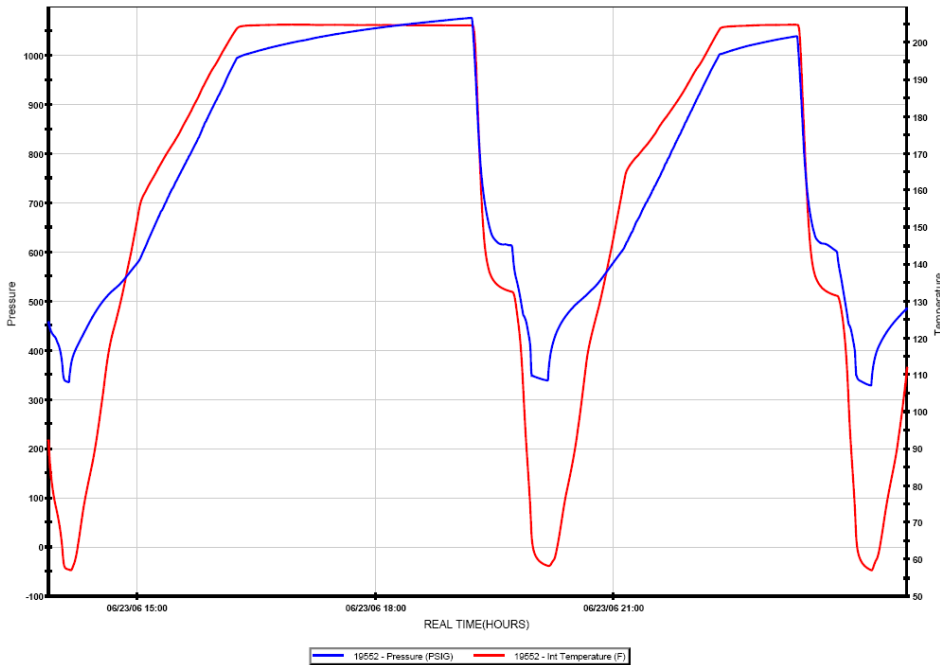
Smart Plunger Capabilities
Flow Testing



- A Stationary Smart Plunger is set at the bottom of the well
- The Drop-Off Tool and transport plunger is removed after surfacing
- The well is flowed for a pre-set time
- A surface choke is changed to pre-determined sizes during the flow test
- The Retrieval Tool and transport plunger brings the Stationary Smart Plunger to surface after the test
- Data from Stationary Smart Plunger and surface is extrapolated into an IPR curve



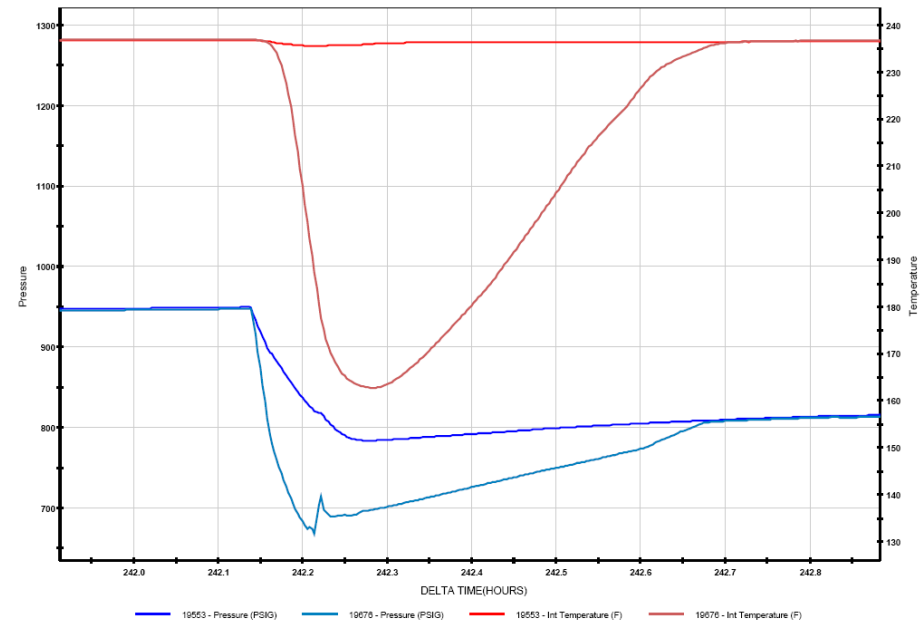
Plunger Lift Optimization



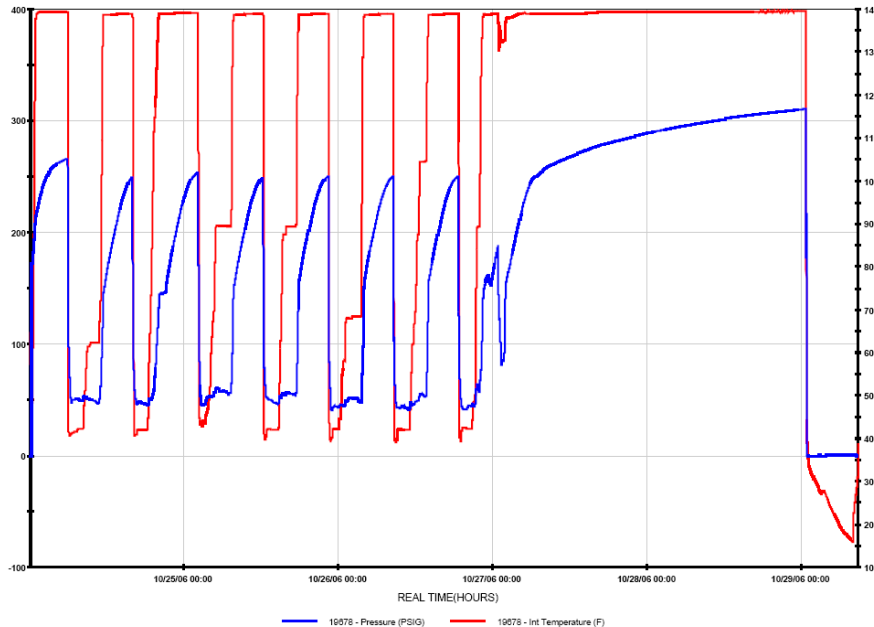
- Traveling Smart Plunger can be used to temporarily replace existing plunger
- Surface controller settings can be changed as required
- Compare data from each setting change
- Using data, make final adjustments
- Fall times and build-up requirements usually show the most dramatic changes

Plunger Lift Optimization

- A Traveling & Stationary Smart Plunger can be used together to track cycle information
- Corresponding conditions from the bottom hole & various tubing locations are recorded simultaneously
- Data trends are merged to help isolate and identify events and verify signatures of common occurrences
- Controller settings - times and pressures - can be adjusted to optimize accordingly



Pressure Build Up



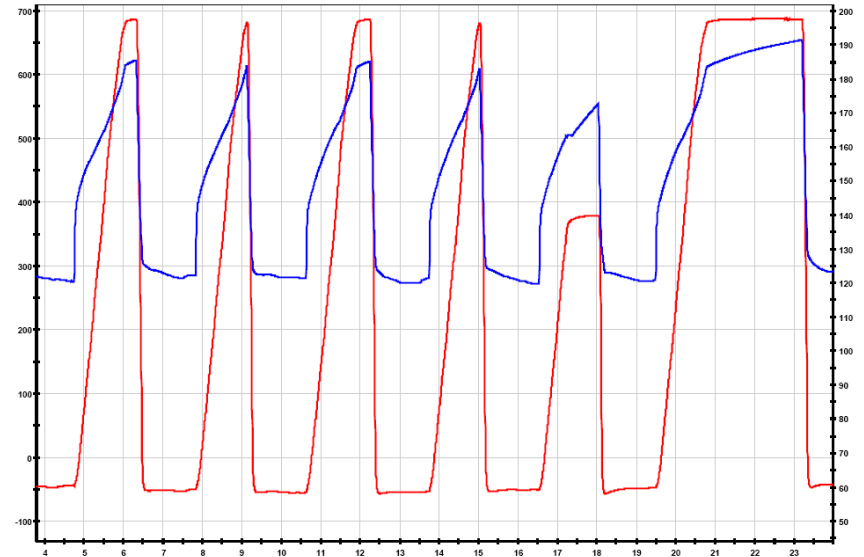
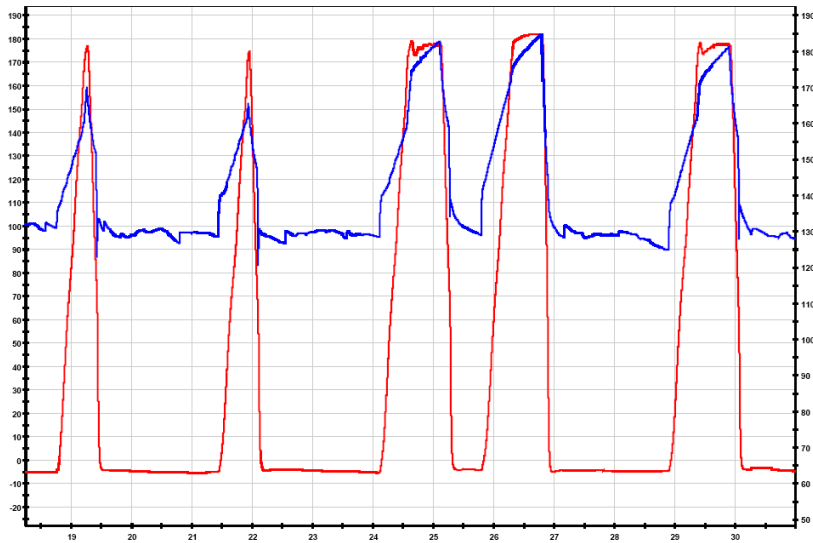
- A Stationary Smart Plunger is delivered to the bottom of the tubing via the Drop-Off Tool and transport plunger

OR

- A Traveling Smart Plunger is dropped and left at the well bottom
- Well is shut in, then plunger is removed at end of test
- Shown at left – typical example of plunger cycles followed by 48 hour build-up

Plunger on bottom

Smart Plunger tests discovered that some plungers were not hitting bottom – even with what was believed to be more than adequate shut in times

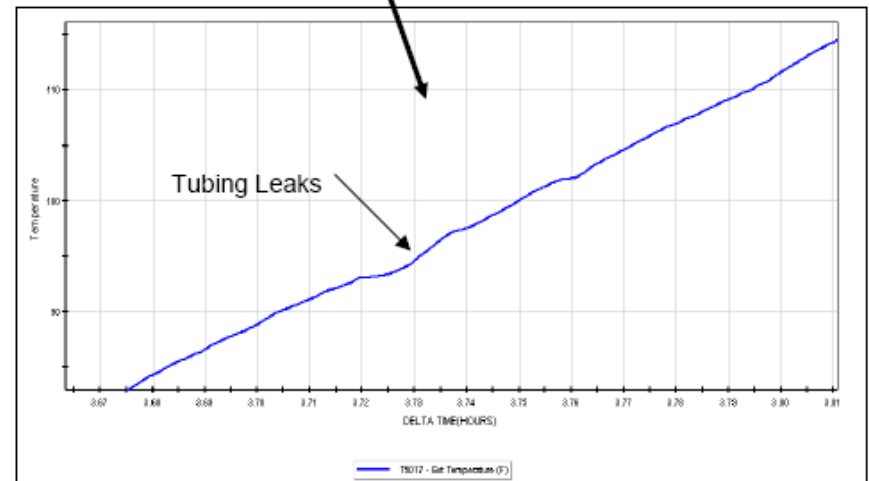
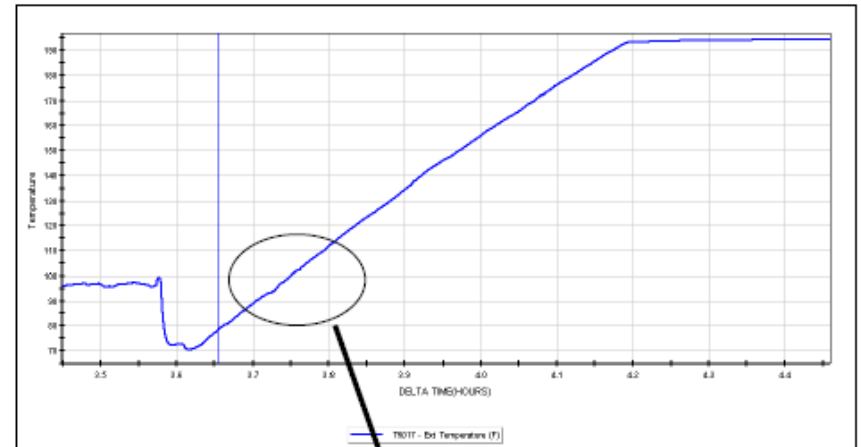


Both examples show the classic signature of being prematurely turned back on – no pressure build up.

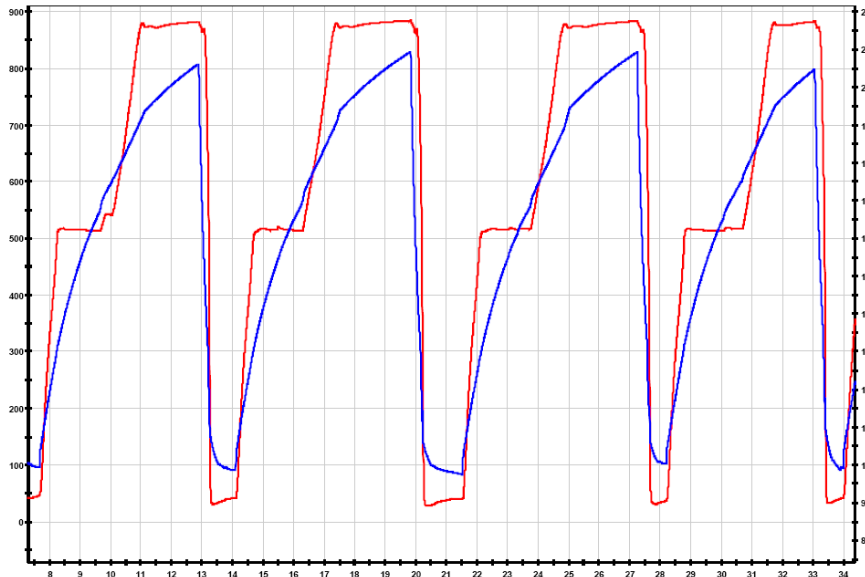
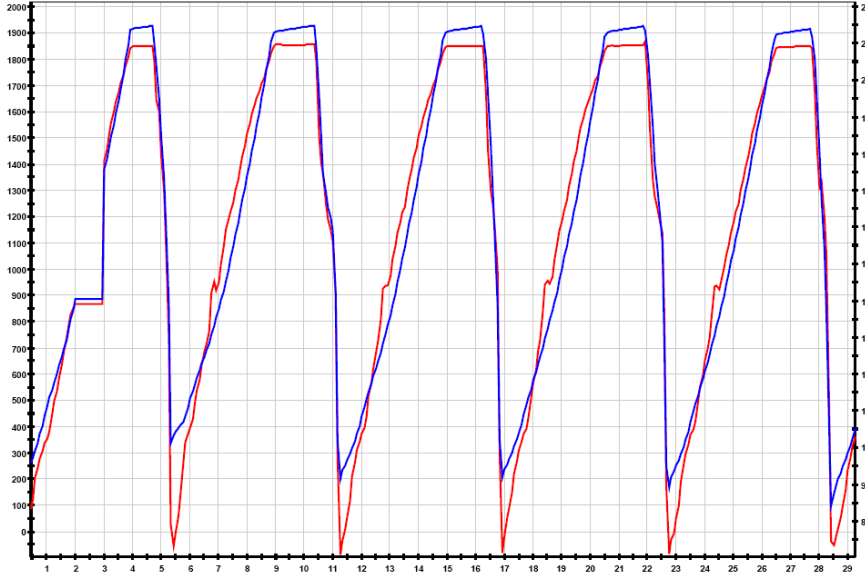
One case was suspected prior to testing – the other was completely unknown.

Detect tubing holes

- Williams has shared part of their extensive Smart Plunger usage in this case of detecting a tubing leak/hole
- Temperature only testing is done on 3 – sample/ second test settings in a dual pad plunger for slowest fall times & best results



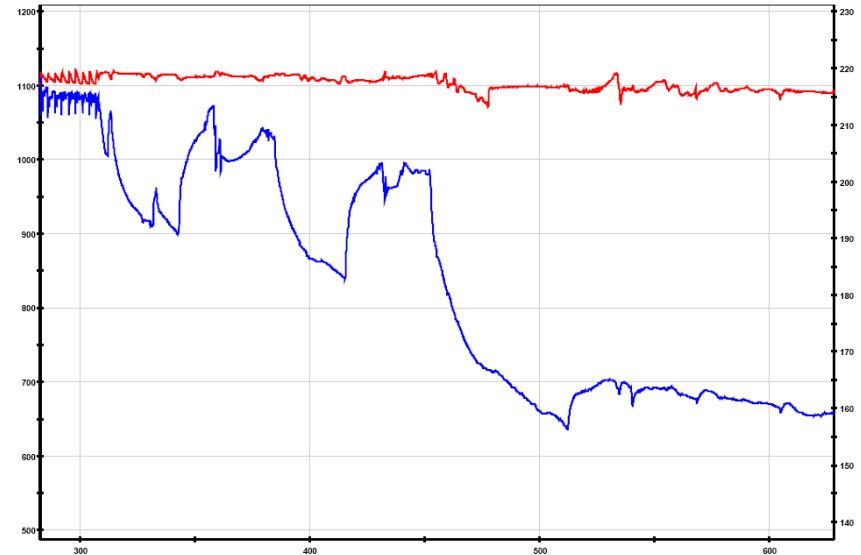
Detect tubing tight spots



- Plunger travel is measured in feet/minute and countless tests have given reasonable rates for various designs – padded and barstock
- Previously unseen in the industry, these graphs show what can only be detected by Smart Plunger data capture of pressure & temperature
- Both tubulars have definite plunger drag-hold-release points

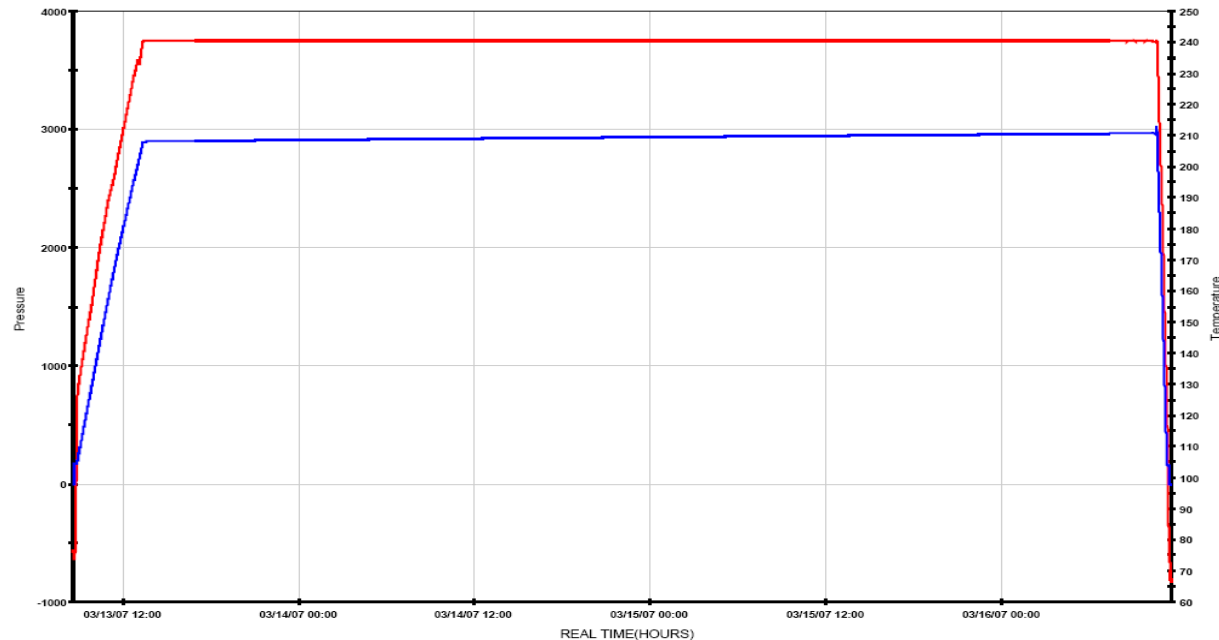
Compression drawdown

- A well using time control to open-close over time periods – stopcock– was targeted to test what would happen if field compression would be used
- Bottom hole flowing conditions were recorded during the process with a Stationary Smart Plunger
- Field compression was designed on the base test template

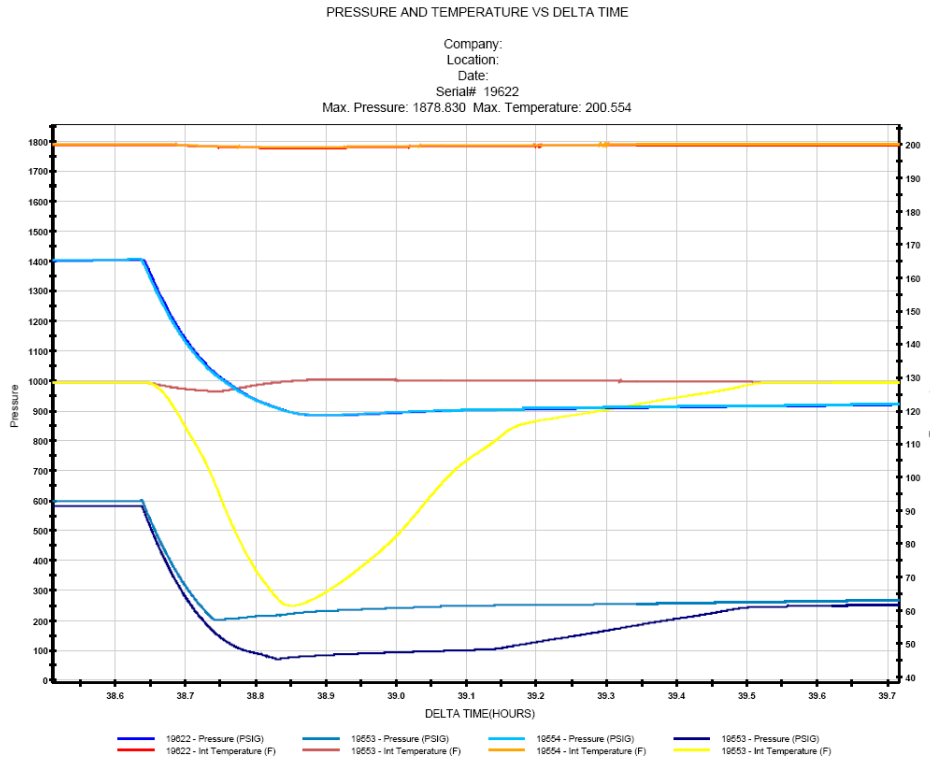


Reservoir analysis

- Smart Plungers use a high quality, extremely accurate data logger microprocessor to capture pressure & temperature data
- Reservoir support is available to analyze formation properties through build-up surveys (below) to evaluate depletion rates, permeability, material balance, skin damage and more



Multi-Stage Plunger Lift



- Recently new testing with four pressure & temperature points being recorded simultaneously – 2 Stationary, 2 Traveling – has shed light on Multi-Stage Plunger Lift operations
- New insight on where to set tools and boundaries
- Provides data to deal with Triple-Stage systems on a much more technical level
- Improved scheduling of service
- Better philosophy of how to run Multi-Stage controllers from surface