



Hydro-Fracturing Monitoring Tool for Geothermal Reservoirs

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Reservoir Testing Technology

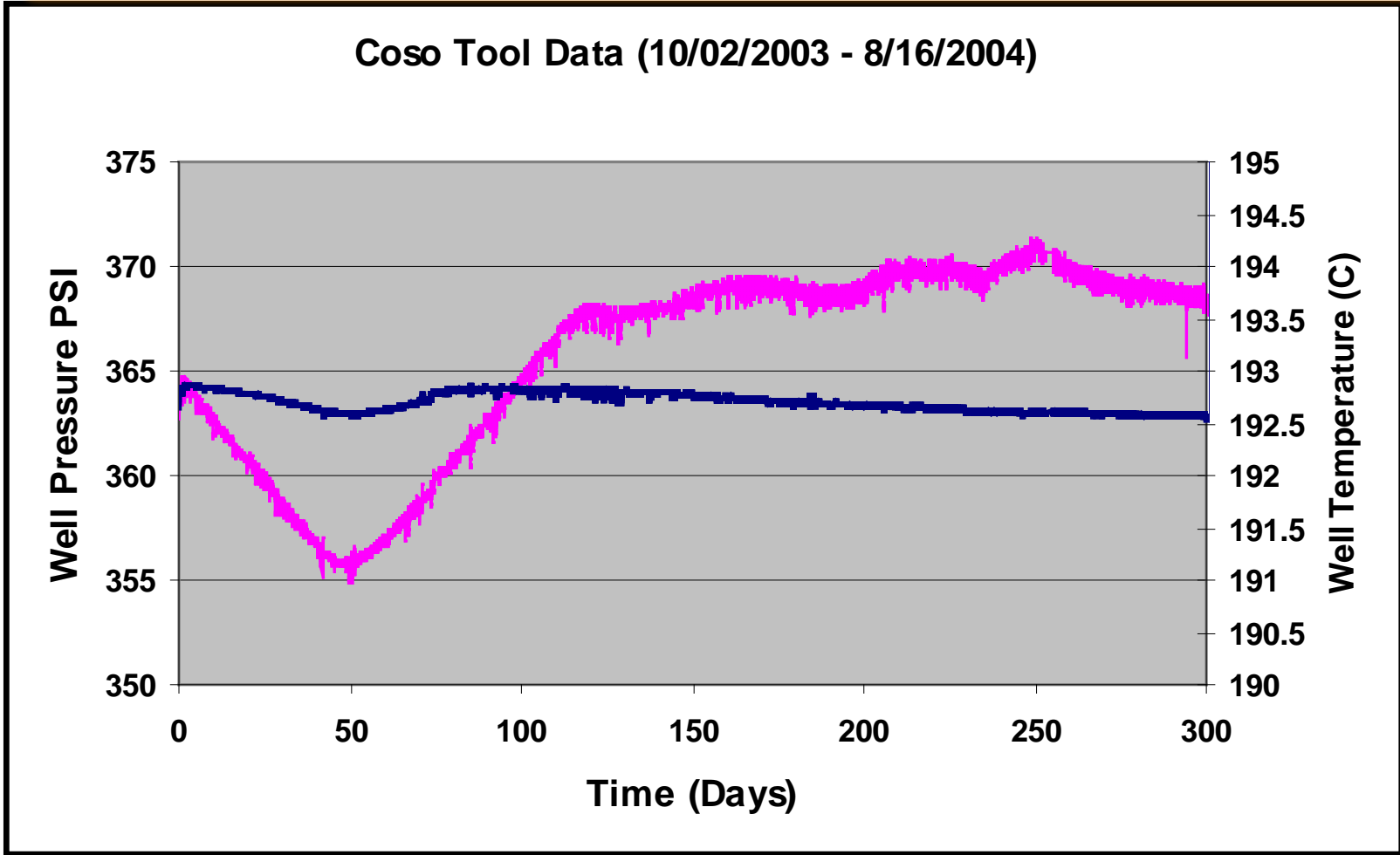
- The Perma Works PW-PT535A Tool Runs Barefoot -> No Heat Shield up to 275C/300C!
 - Tool enables unprecedented reservoir testing
 - Run reservoir tests for weeks/months/years without removing the logging tool
 - Test changing injection or production
 - Test well connectivity
 - Shut in testing reservoir recovery
 - Reservoir pull down test
 - Power Plant Maintenance!!





HT Electronics 2 Years at 193C

Sandia Labs Test: Perma Works Licensed Technology



What looks like noise is moon tides. This well has a small pressure cap at the surface.

Hydro-Fracturing Monitoring Tool

- New software and hardware is designed with well stimulation in mind
 - Two way communication allows operator control
 - Production logging as standard production logging tool

OR

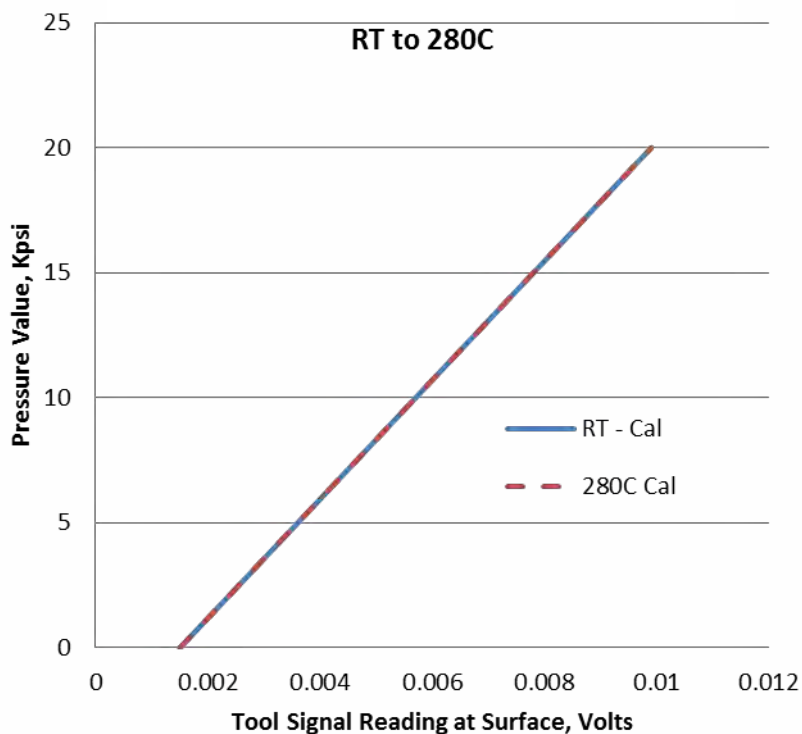
- High speed pressure only recording for capturing the fracture event
 - High speed is up to 100 readings a second
 - Capture pressure peak at the fractured zone in the well
 - Capture pressure fall off as fluid enters the well
 - On-the-fly mode switching; after fracture event, switch back to production logging operation
- Existing tool is HPHT 25Kpsi (1750 Bar)



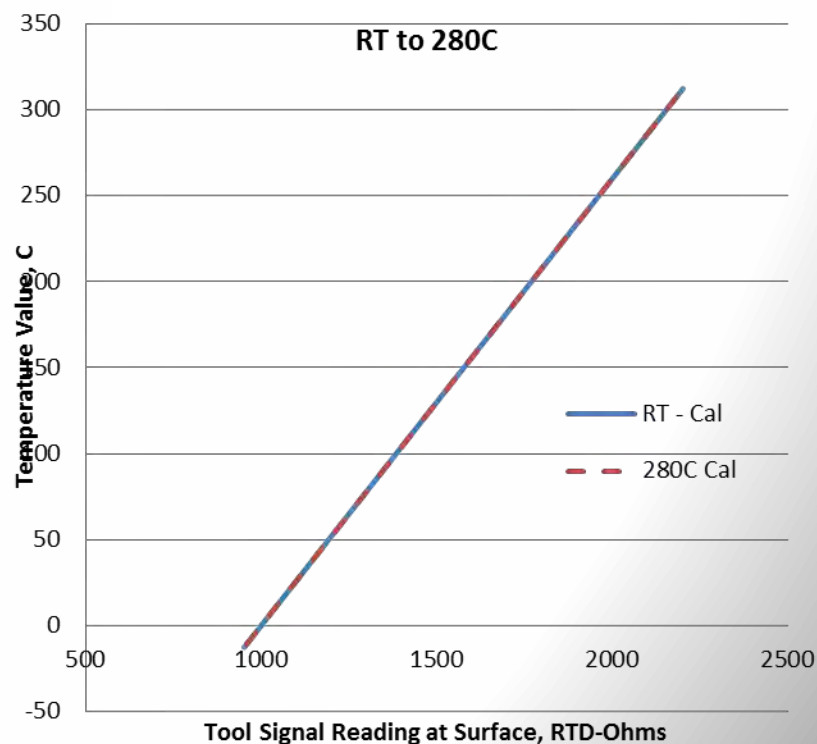
Breakthrough in Self-Compensation

No Computer Temperature Compensation was applied to the Calibration Data Below!

Calibration of Pressure over Temperature



Calibration of Temperature over Temperature



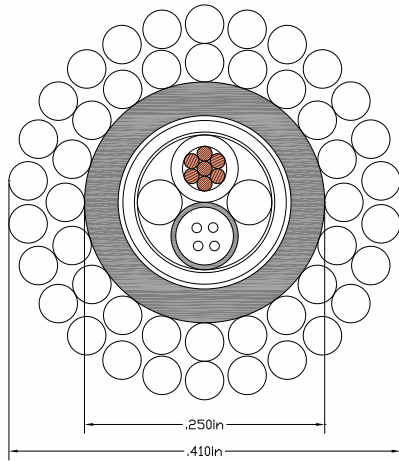
Even standard flasked tools use long polynomial temperature correction algorithms! Our self-compensation is done downhole allowing our tool to stay in calibration longer and over extreme temperatures found in Geothermal wells.

Lower Cost Reservoir Testing



- Permanent well monitoring using wire inside Incoloy tubing; designed for extreme temperatures (cable rated to 450C!)
 - Permanent installations enables tracking of reservoir changes over time. PWs new self-temperature compensation system reduces electronic drift over time!
- Low cost reservoir testing using standard HT logging cable
 - Recommended for short-term continuous well monitoring; more data at a lower cost.

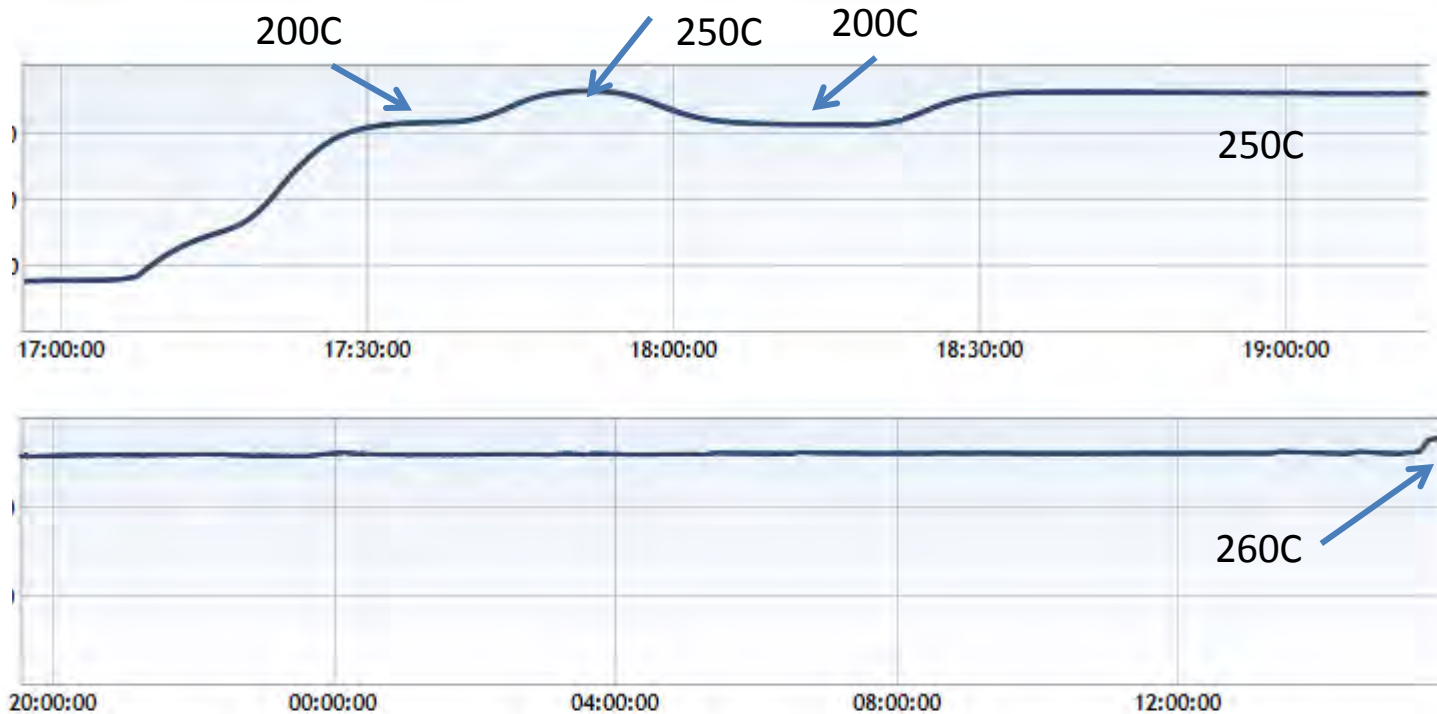
Combining PT & DTS



- The PW-PT535A tool can be coupled with the DTS fiber/wire combination cable sold by Draka, a member of the Prysmian Group.
- Draka's fluorine doped fiber has increased hydrogen resistance when tested at 300°C and 220 psi partial pressure H₂.
- Draka's research has been funded by Department of Energy under Award Number DE_EE0002786

- Having both DTS and electronic pressure/temperature measurements provides the best of both worlds
 - Bottom hole PT measurements tracks fluid changes and holds calibration on the DTS absolute temperature profile.

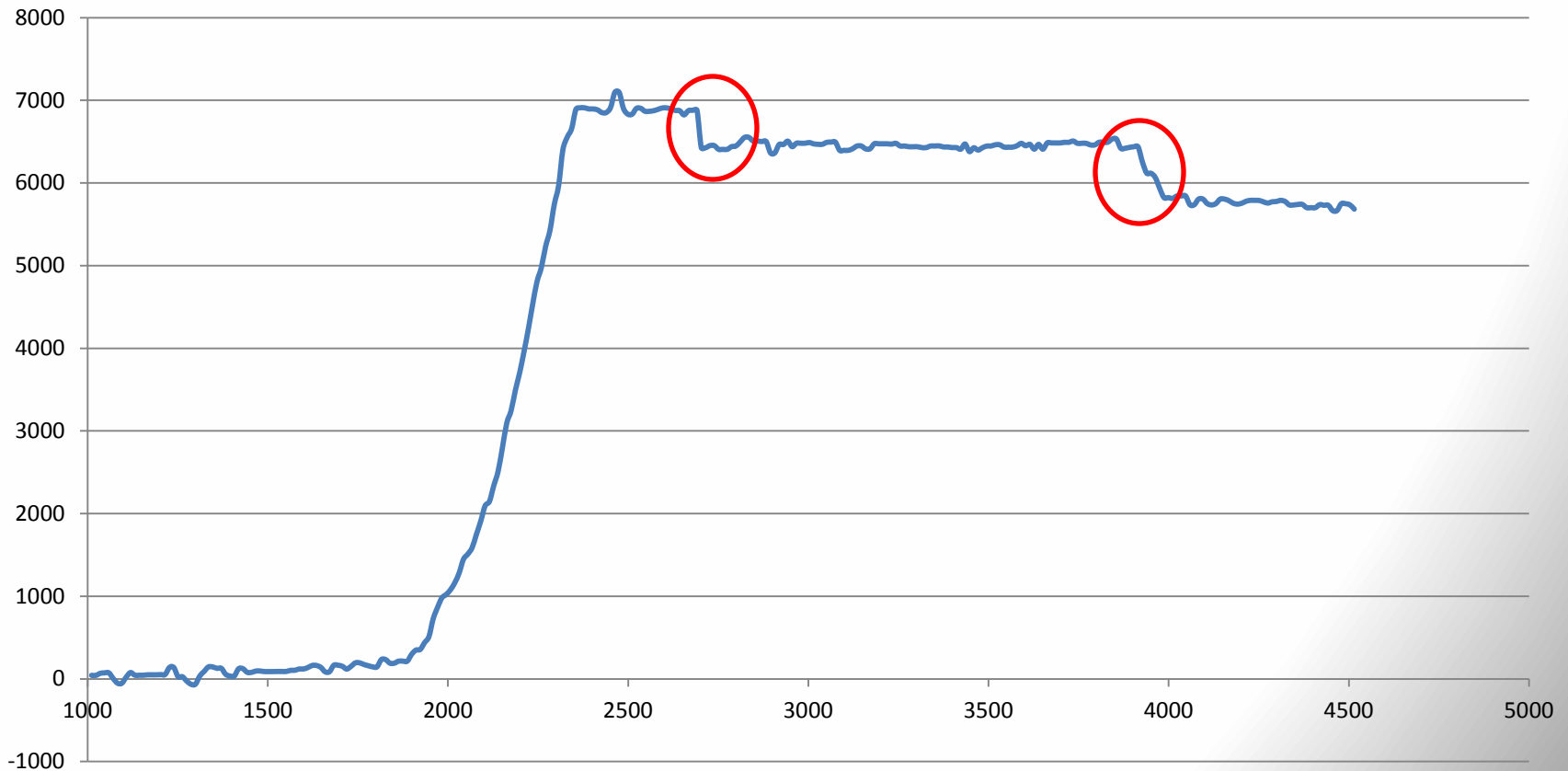
Example: 250C-24Hr Reservoir Test



Here the tool NEVER leaves the well for ~24 hrs. Using it's high-speed pressure or standard logging mode, this tool can support hydraulic fracturing up to 25,000 psi/275C. In permanent well monitoring, PW electronics have demonstrated 2 years at ~200C.

Example: Reservoir Flow Testing

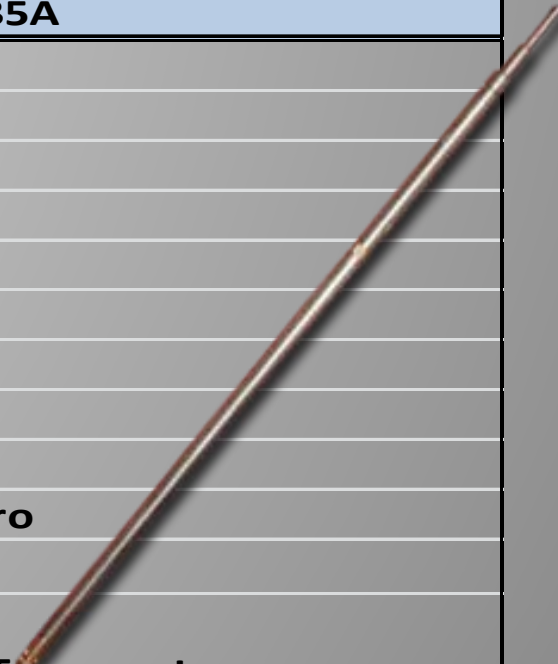
Flow Testing "Pressure"



Step changes in flow rates results in a change in pressure. This type of reservoir information is required by the reservoir engineer to adequately assess the reservoir.

PW-PT535A Tool is Unique

Attributes	PW-PT535A
Continuous Duty Temperature	535°F (280°C) 3% res. * Excursions to 575°F (300°C)
Expected Lifespan	400°F - 10 Years 450°F - 2 Years 500°F - 1 Year 535°F - 6 Months
Pressure	Up to 30,000 psi
Dimensions	6.5 ft. L x 1.75 in. OD
	Tool Voltage: 15-18VDC
Measurements	Pressure, Pres-Temp, Pres-Zero Temperature, Temp-Zero
Data Capture	24 bit Pressure and External Temperature 8 pressure readings per second in real time pressure only mode
Customizable Sensors	Choose pressure transducers from 500 psi (34 Bar) to 30000 psi (2000 Bar) Choose full range RTD for external temperature or a PW Zero Drift



Note: Upgrade underway to increase sampling rate to 100 readings per second



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Thank you,

Now if we have time, I will answer simple questions

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HT Magnetic Flow Sensor

- Replaces the spinner for longer well monitoring projects
- No moving parts -> Outlast spinners
- Prototype tool increase the diameter to 3 inches
- Flow moves through the center of the tool

**Preliminary
Data**

