

Spartek Systems Inc

Providing our Customers with Best in Class Technology



SPARTEK SYSTEMS
GEOPHYSICAL INSTRUMENTATION

Production Logging Technology

AFES – April 2016

Spartek Systems - A Leading OEM



- Founded in 1994, Spartek Systems is a leading developer & manufacturer of leading edge surface and subsurface instrumentation.
- Product Lines
 - Gauges, Carriers & Shut-In Tools
 - **Cased Hole Logging Systems**
 - Permanent Downhole Monitoring
 - Intelligent Electronic Firing Heads
 - Wireless Rf Short-Hop



PLT Contribution to Reservoir Evaluation



SPARTEK SYSTEMS
GEOPHYSICAL INSTRUMENTATION

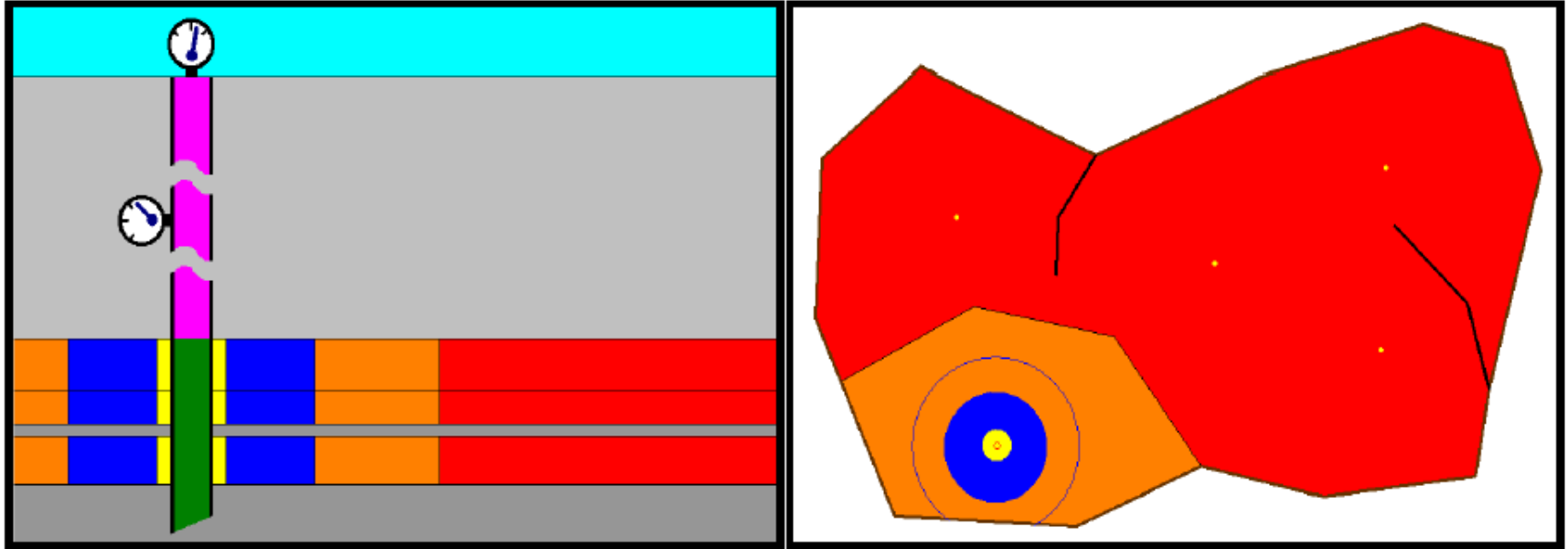


Fig. 1.B.5 – Schematics in the X-Y and X-Z planes of Dynamic Data Analysis

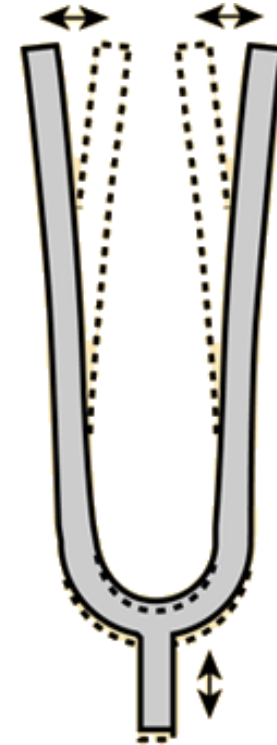
Green: production Logging addresses the **flow in the wellbore** at the sand face, with the ability of identifying **phase contribution of the different producing zones** (* courtesy KAPPA DDA 4.30)

Fluid Density Measurements

- Differential Pressure (bulk measurement)
 - Gradio-manometer & Dual/Differential Pressure Tools
 - Depth Derived from Single Pressure
 - * **Deviation correction, & horizontal well limitations**
- Radioactive Source-Detector (localized/bulk)
 - * **Radioactive source licensing, transport, loss**
- Buoyancy & Mass Balance (localized/bulk)
 - * **Tool design, packaging, reliability**
- Acoustic Methods (localized)
 - * **No deviation correction, Non Radioactive**

ADT - Principle and Theory

- The density of a sample of a material is defined as the quantity of mass of the material to a given volume of the sample.
- The natural frequency of Vibrating tubes and Tuning Forks are a function of the **mass**, stiffness, and geometry of the vibrating element.
- The **effective mass** of these vibrating elements change when sampling a “fluid”.
- Density of the sample is related to **resonant frequency** by the following equation (simple damped harmonic oscillator)

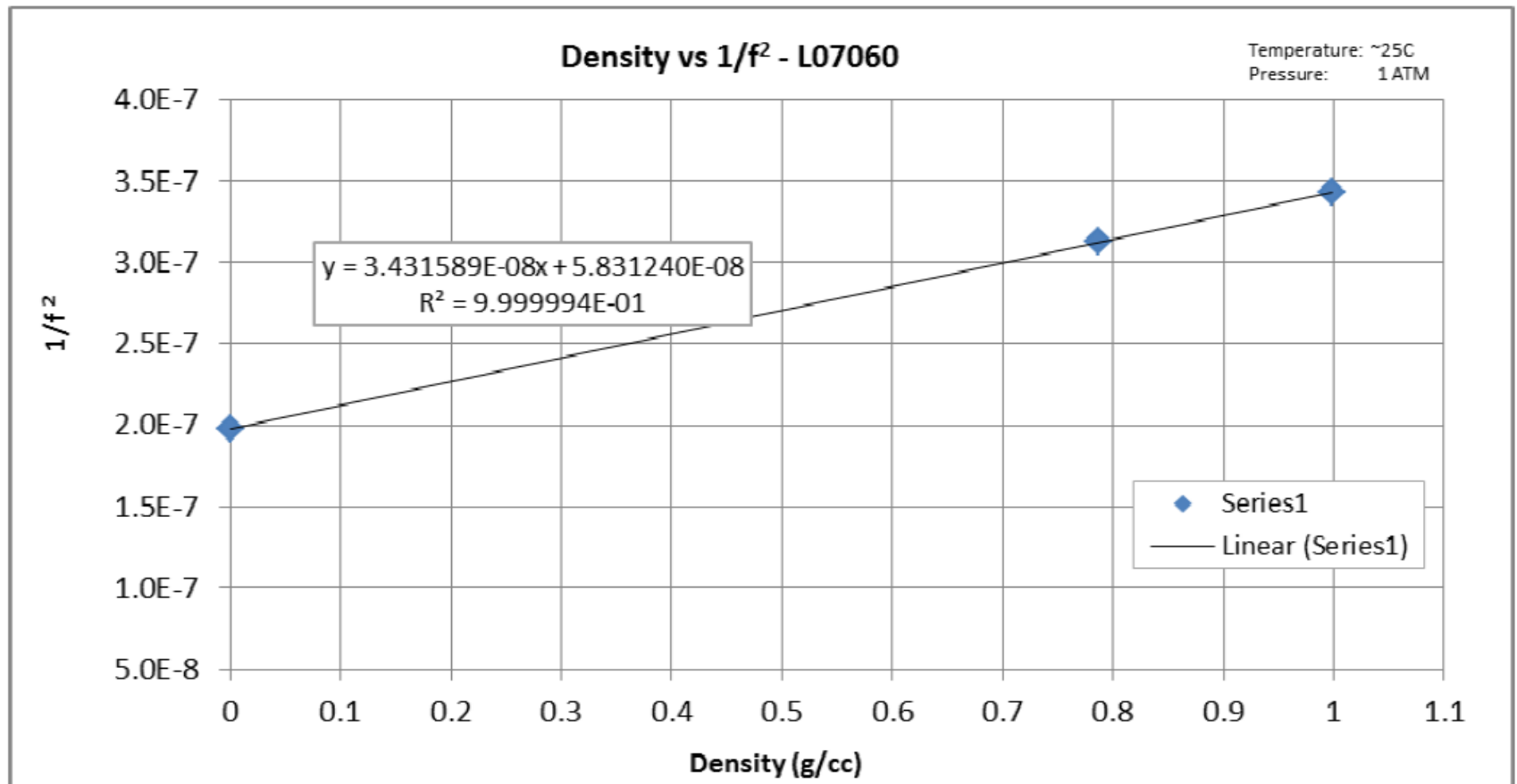


$$\rho = C0 + C1 * T^2$$

Where

ρ = Density of fluid
 $C0$ & $C1$ = Constants
 T = Period ($1/F$)

ADT Response: Density vs Frequency



.. curve fit of measured frequency vs known fluid density

ADT Calibration – Reference Data

Density Calibration Data Points

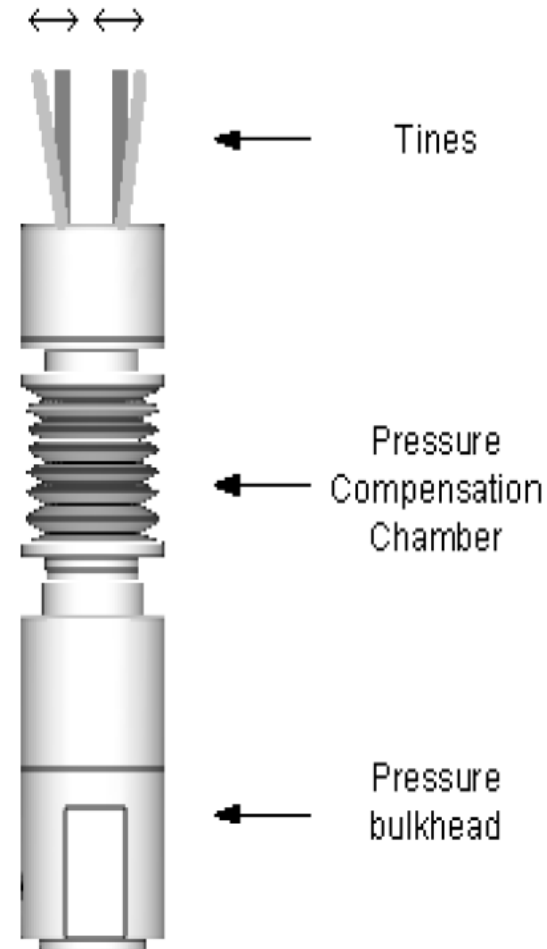
Pressure = 1 ATM

Medium	Density g/cc	Temperature deg C	Frequency Hz
Air	0.001275	3.77	2257.326
Air	0.001185	24.81	2245.596
Air	0.001089	51.09	2229.747
Air	0.001009	76.73	2214.779
Air	0.000939	102.62	2200.4
Air	0.000879	128.46	2184.691
Air	0.000826	154.18	2169.574
Air	0.000788	174.53	2157.479
Isopropyl alcohol	0.787	22.39	1787.104
Distilled water	0.998	22.82	1707.067

.. calibration data points across a range of density values

Acoustic Densitometer – Gen 1

- First Generation Tool ~ 2009
 - Tines driven at Resonant Frequency
 - Oil Filled Bellows for Pressure Comp
 - Temperature from Adjacent Tool
 - Pressure Bulkhead & Sealing Elements
 - Option for Cavity Shield



Tuning-Fork Transducer

ADT Early Tool Configurations



1 3/8" Tool with Open Cavity

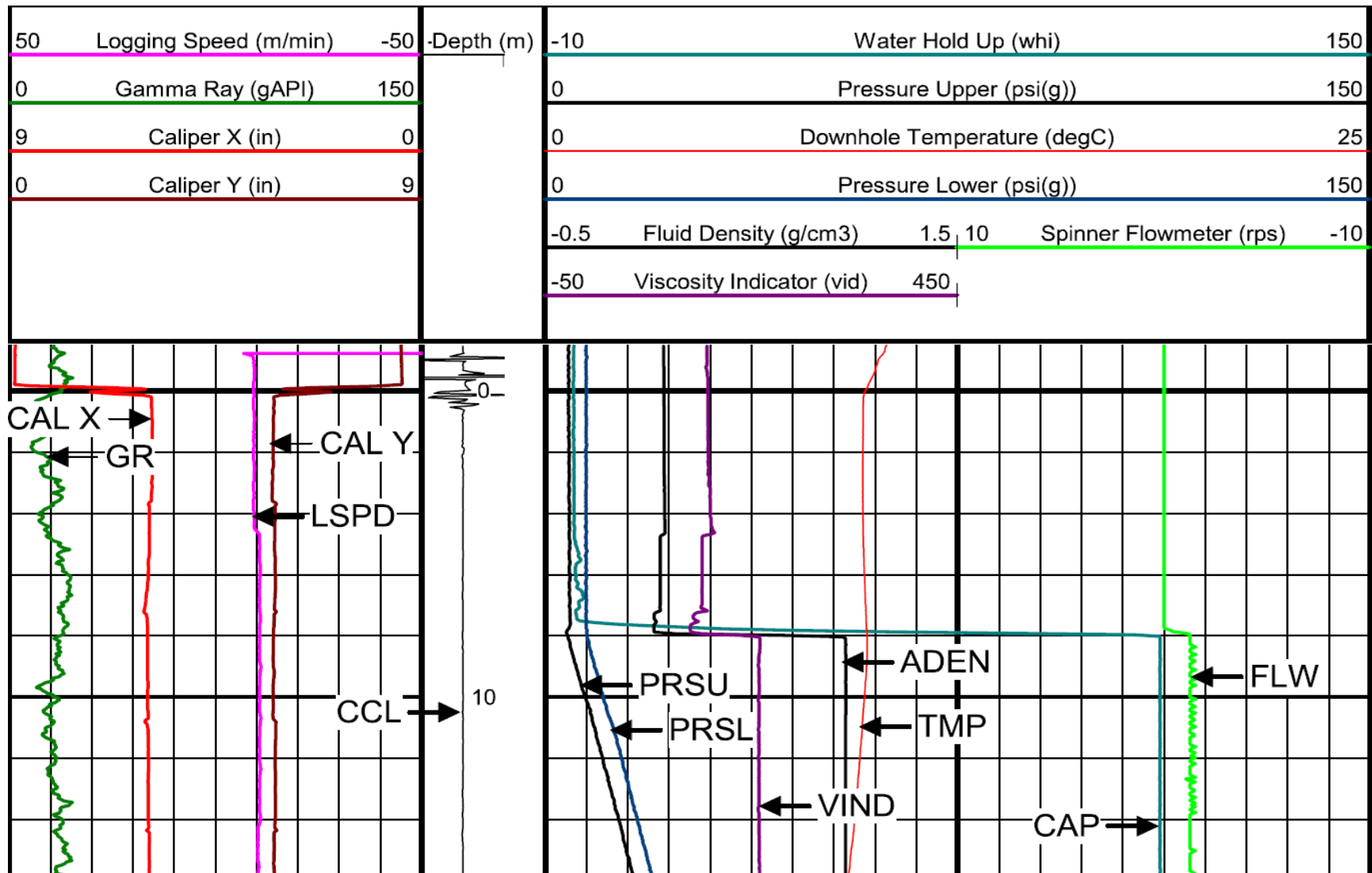


1 3/8" Tool with Cavity Shield

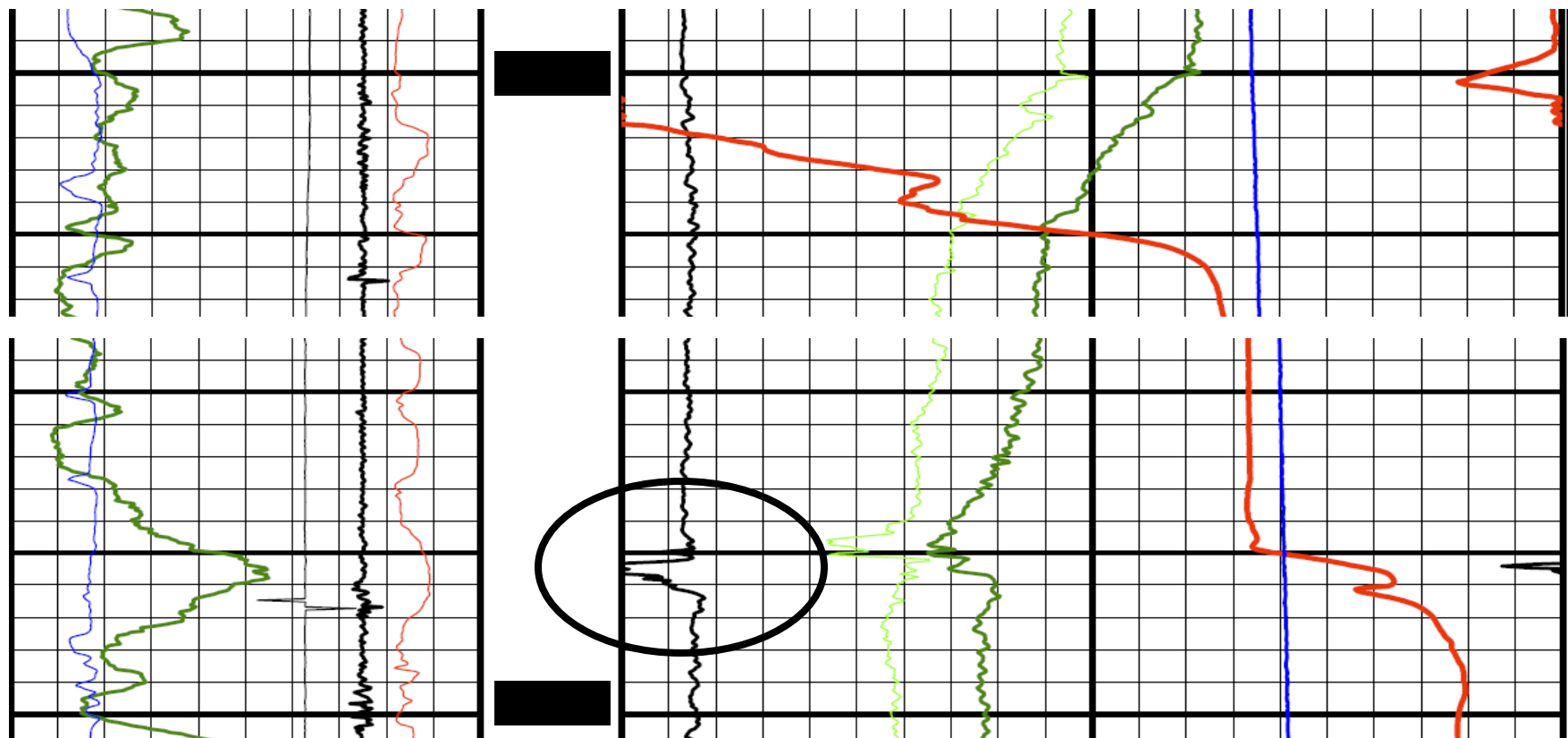
LOG DATA EXAMPLES (GEN I & II)

ACOUSTIC DENSITOMETER

Log Example – Testwell

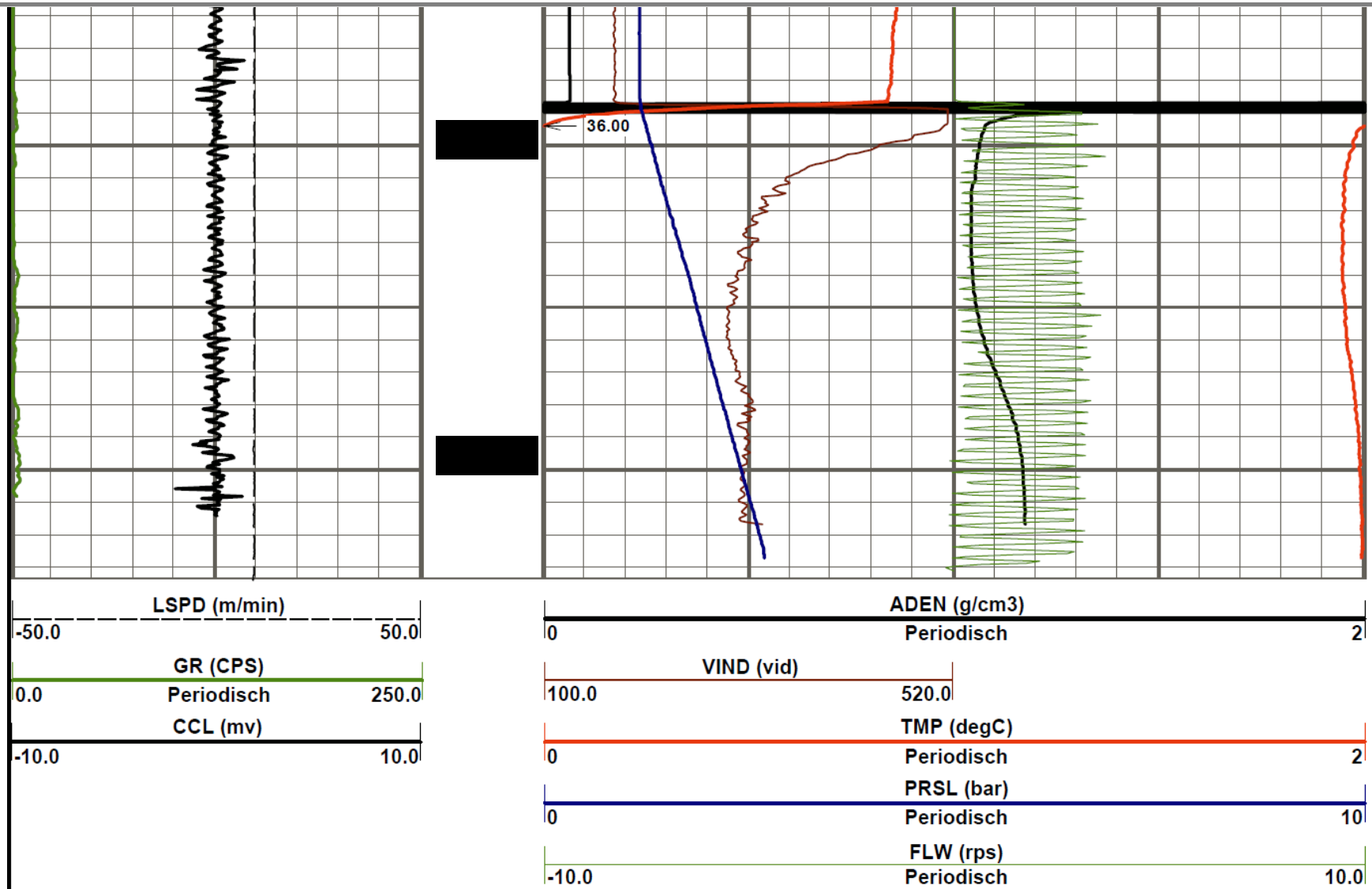


Log Example – Europe

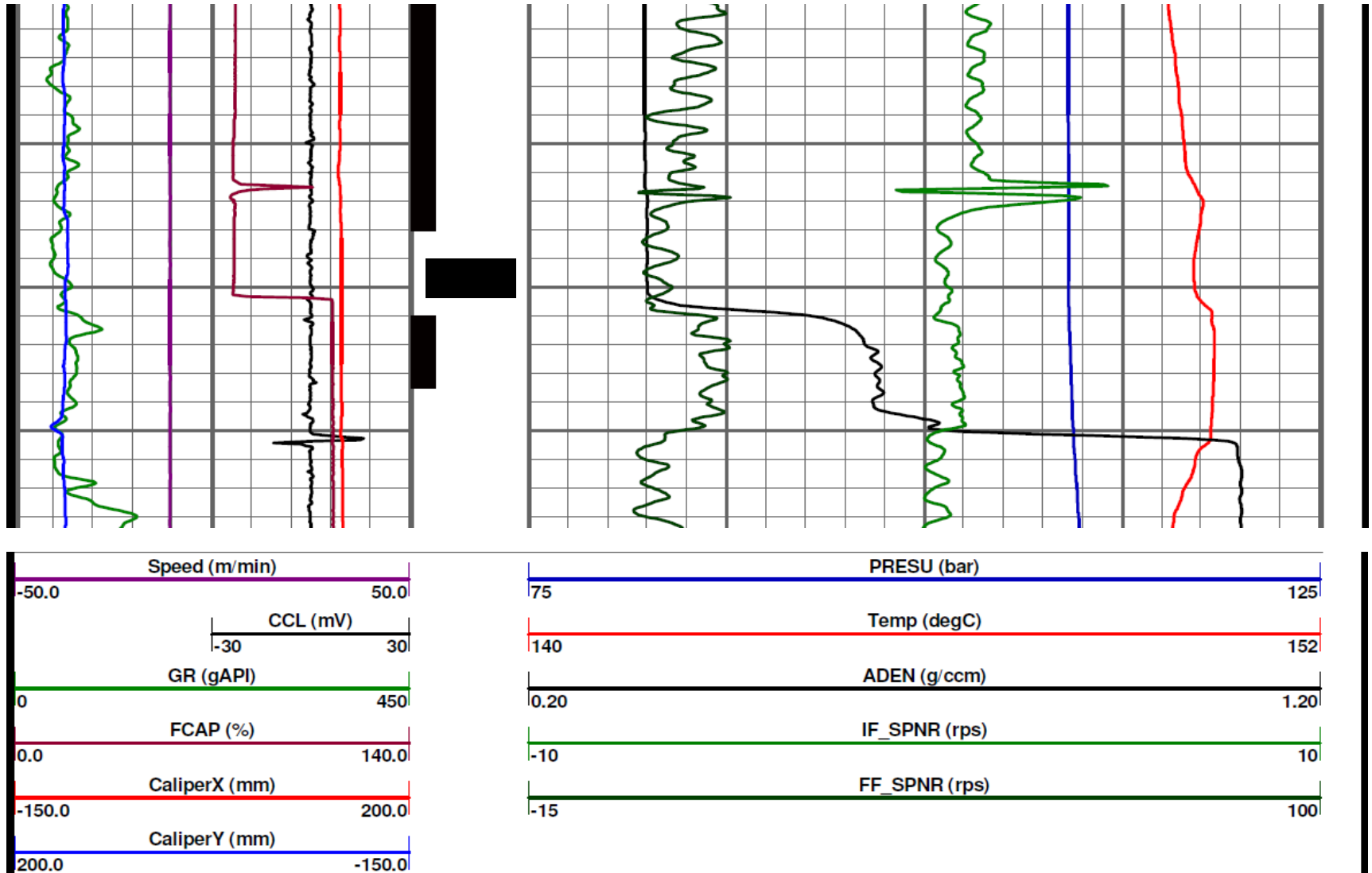


-50	Logging Speed (m/min)	50	Depth (m)	0	Fluid Density (g/cm3)	2
0	Gamma Ray (gAPI)	150		0	ILS (rps)	100
	Cas-50 Collar Locatc50mv)			0	FBS (rps)	200
50	Caliper X (mm)	250		140	Downhole Temperature (degC)	145
250	Caliper Y (mm)	50		170	Pressure Lower (bar)	180

Log Example – Europe



Log Example – Europe



Acoustic Densitometer – Gen 3

- Larger Tines
 - Less sensitivity to entrained gas
 - Increase surface area (better averaging)
- Lower Frequency 2100 Hz Air, 1660 Hz Water
 - Increase power
 - Operates in higher viscosity fluids
- No bellows or oil filling
- Integrated RTD for temperature compensation
- Proprietary Ceramic based PTFE Coating to minimize fluid coating anomalies.
- Oct 1, 2014 Commercial



G2
bellows/seals



G2
no bellows
no seals
blue

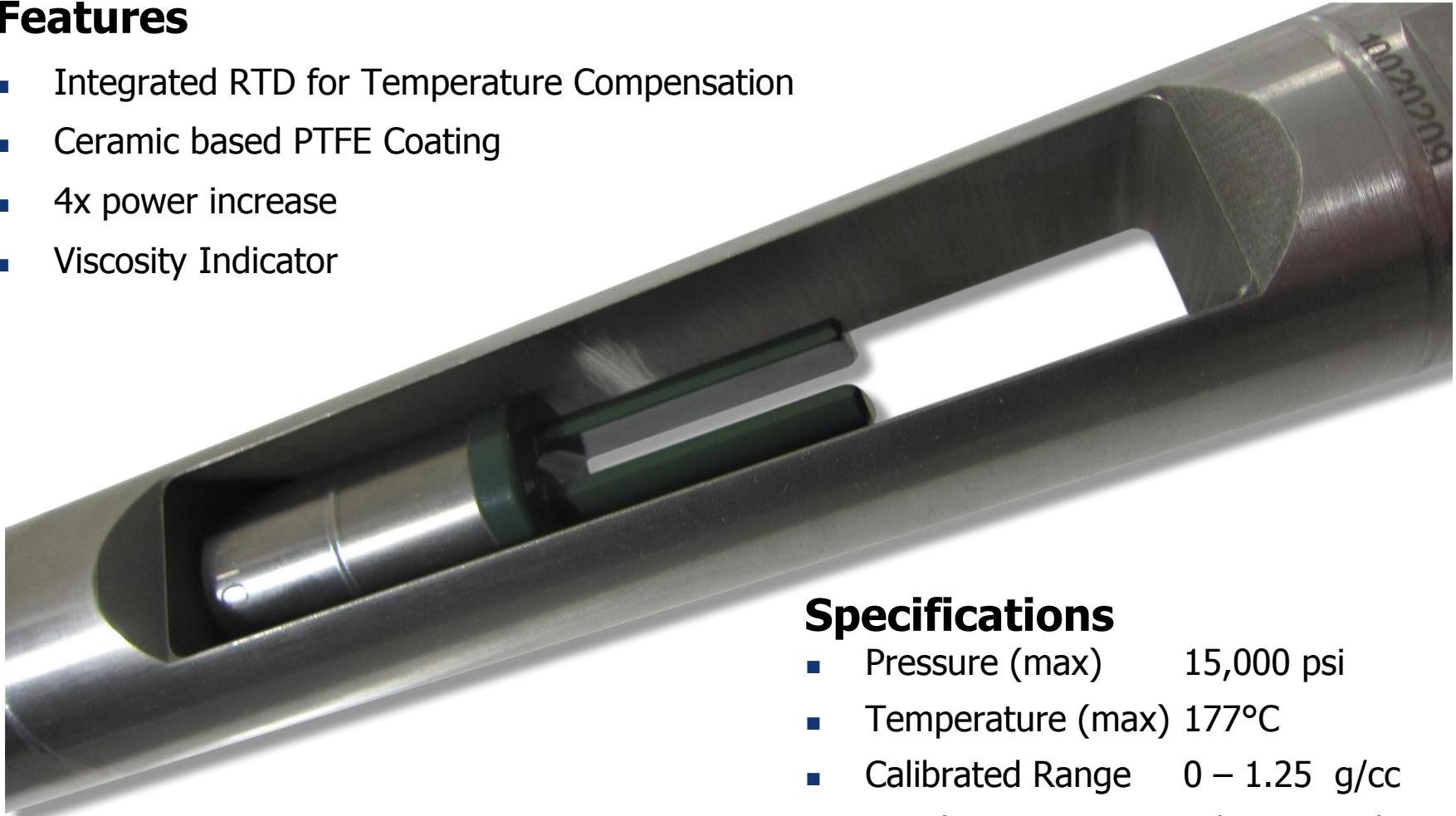


G3
no bellows
no seals
green

Acoustic Densitometer – Gen 3

Features

- Integrated RTD for Temperature Compensation
- Ceramic based PTFE Coating
- 4x power increase
- Viscosity Indicator



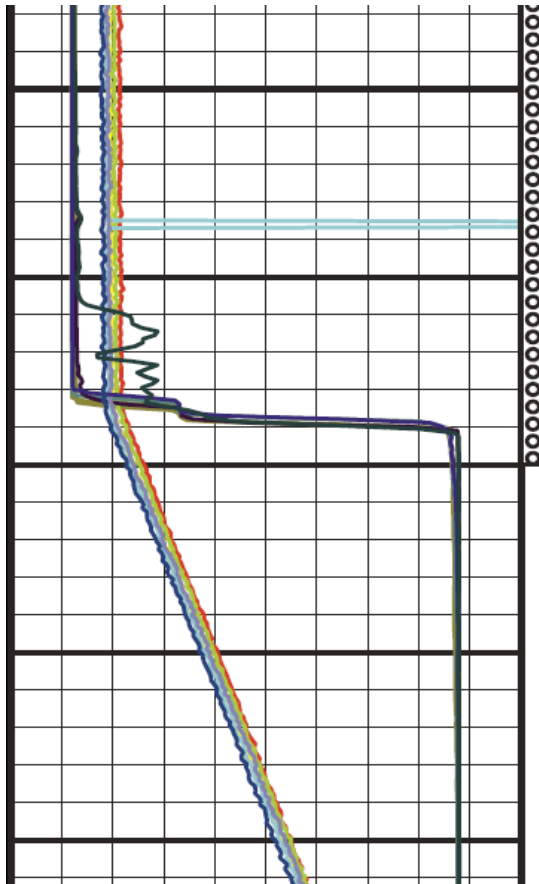
Specifications

- Pressure (max) 15,000 psi
- Temperature (max) 177°C
- Calibrated Range 0 – 1.25 g/cc
- Resolution +/- 0.01 g/cc
- Accuracy +/- 0.03 g/cc

LOG DATA EXAMPLES (GEN III)

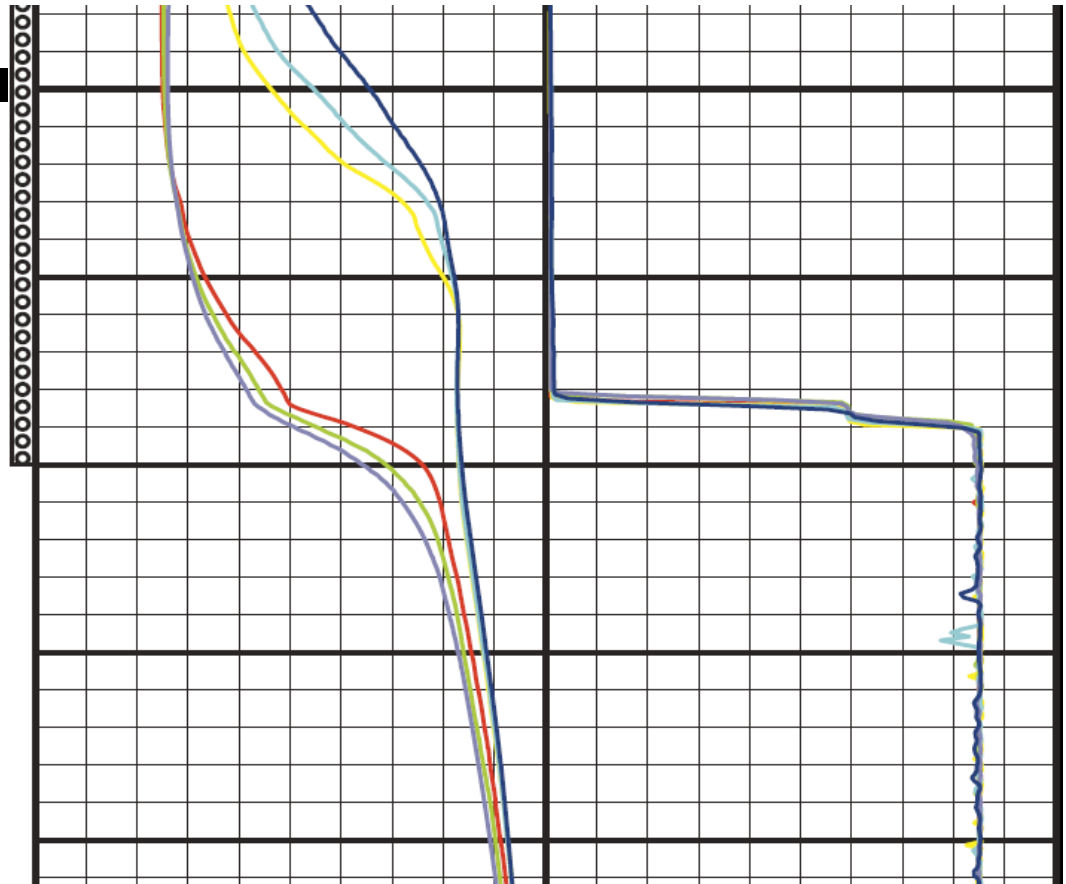
ACOUSTIC DENSITOMETER

Log Example – Europe



260 Pressure 10m/min Up (psi) 310

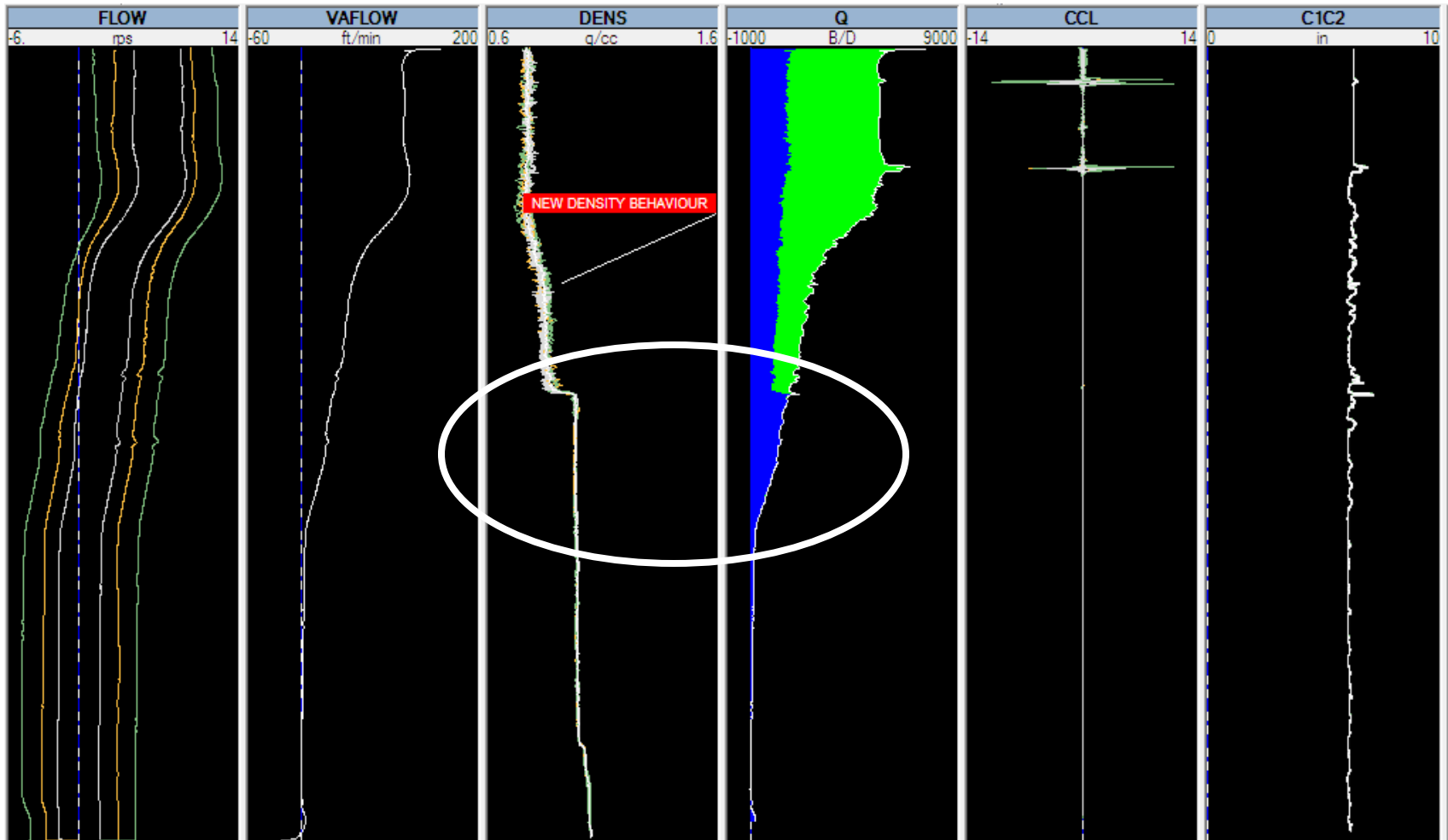
-20 Water Hold Up 10m/min Up (whi) 120



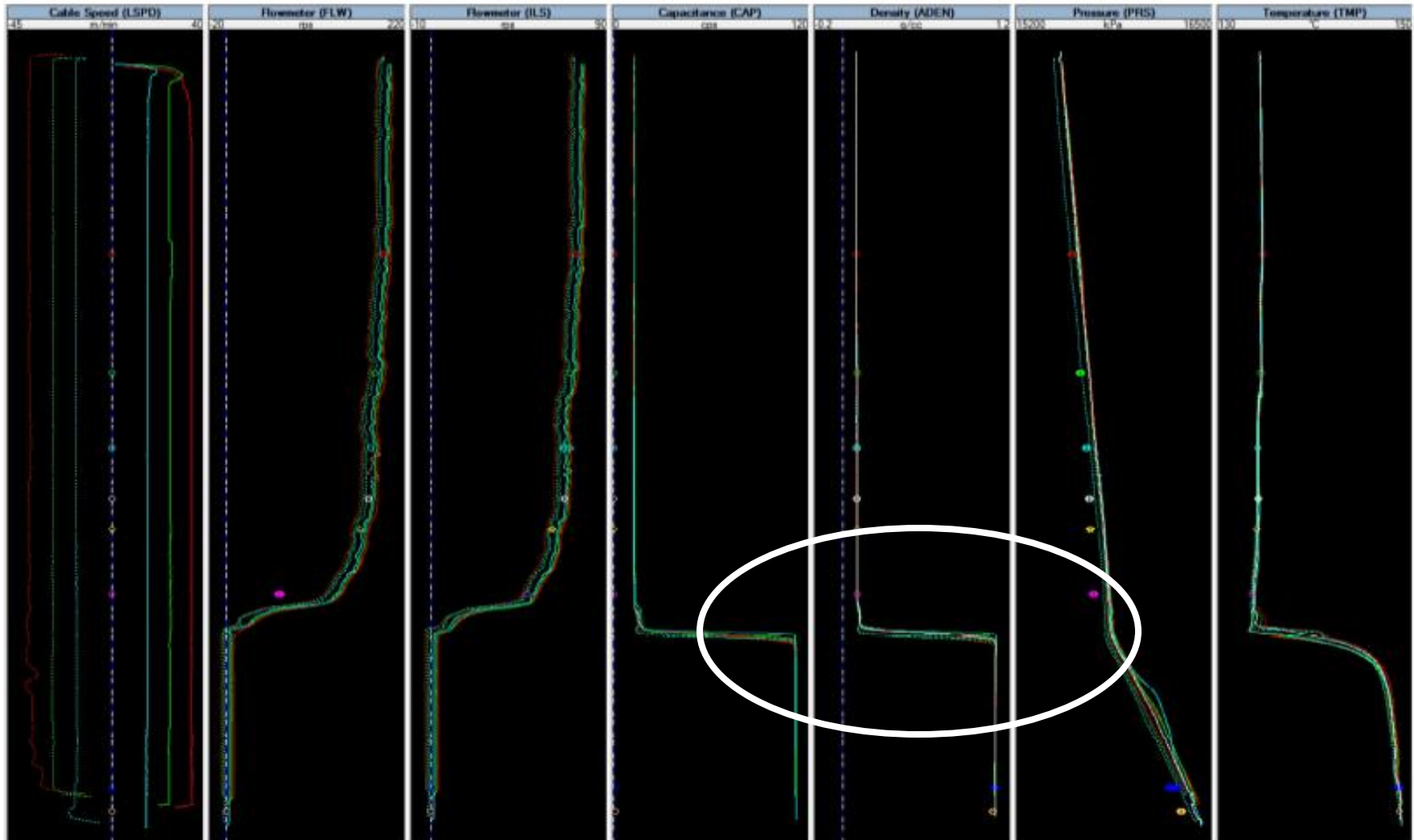
64 Temperature 20m/min Down (degC) 74 0 Density 20m/min Down (g/cm3) 1.2

64 Temperature 20m/min Up (degC) 74 0 Density 20m/min Up (g/cm3) 1.2

Log Example – Middle East



Log Example – Middle East

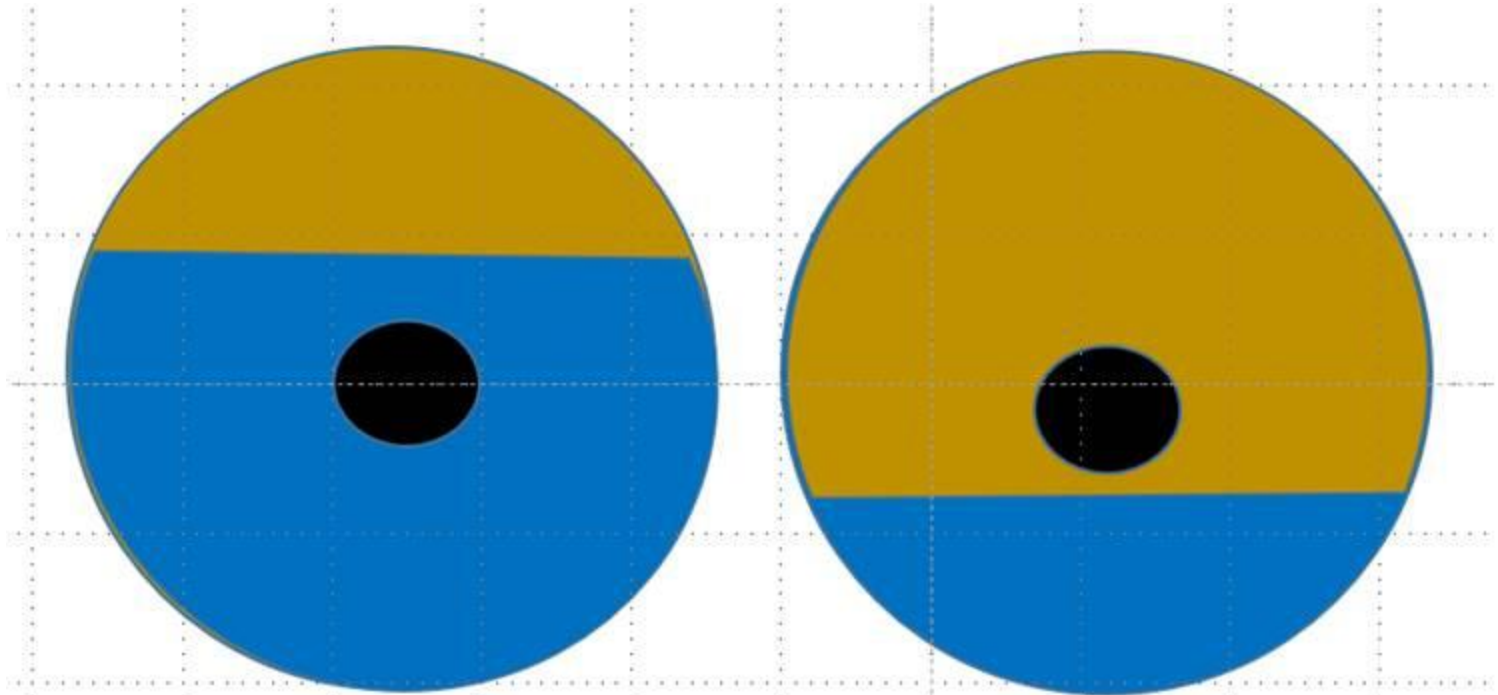


ADT Log Response Factors

- Tuning Fork is a high resolution localized measurement.
- The tool responds to fluid on and near the tines.
 - Vertical resolution is ~ 5 cm for the new low frequency fork
- Fluid coating the tines will impact the measurement.
- Rapid changes in fluid can create anomalous readings (they should be ignored, eg a spike in f , V_{ind} goes low).
- Readings are temperature dependent (must be corrected)
- Readings are independent of pressure (fork properties)
- More to learn ...

<https://www.linkedin.com/groups/3965168/3965168-5812577946312916995>

ADT Log Response Factors

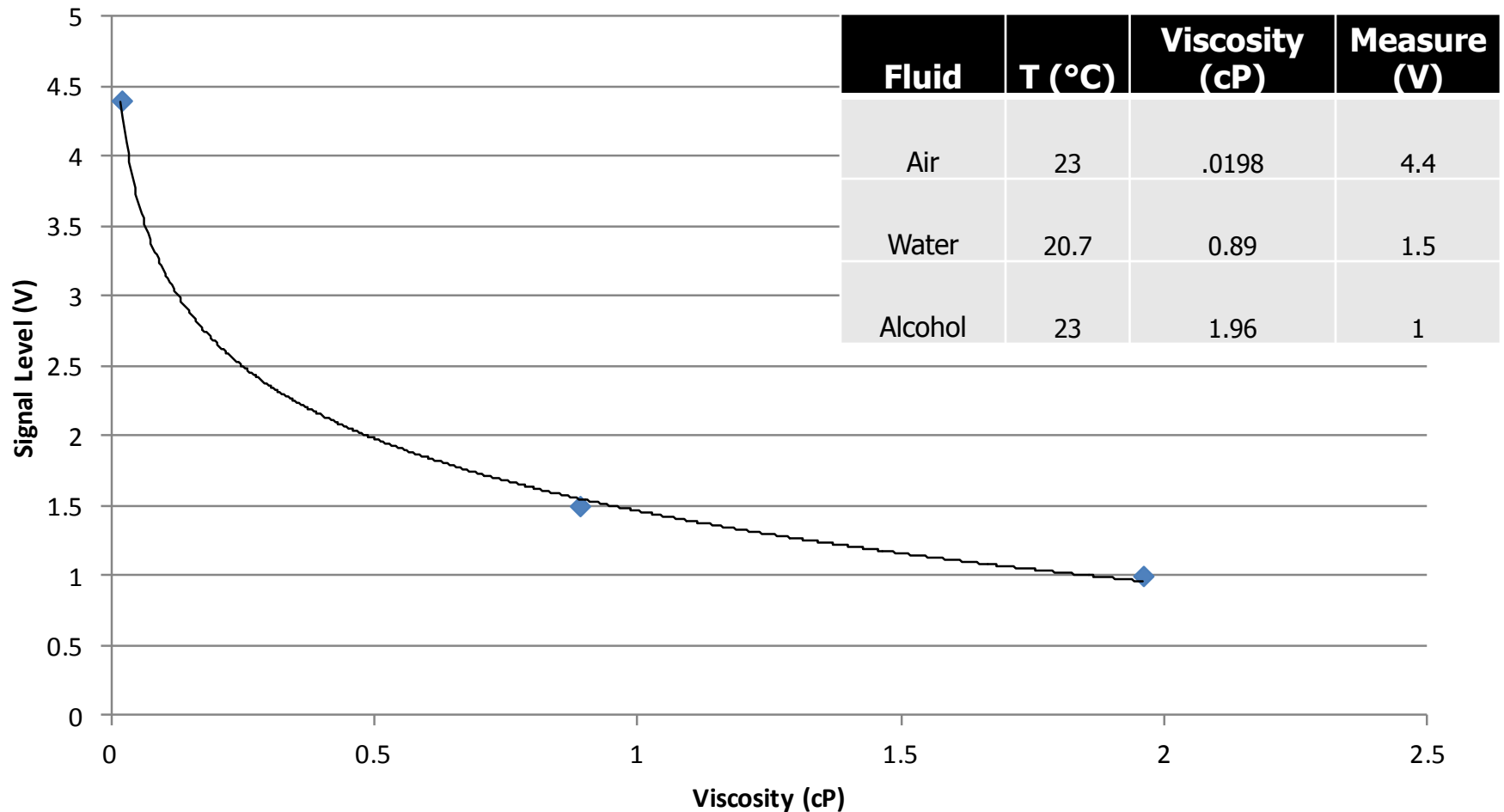


The measurement is localized so it will only see the fluid it is in ... so ... Left water density ... Right Oil density ... measurement resolution is ~ 5 cm

You would expect a similar response from a radioactive density The difference being related to potential coating of tines, as you go from one fluid to the other This could create some in between measurements as the fluid comes off the tines...

ADT Viscosity Indicator / QC

Viscosity Indicator

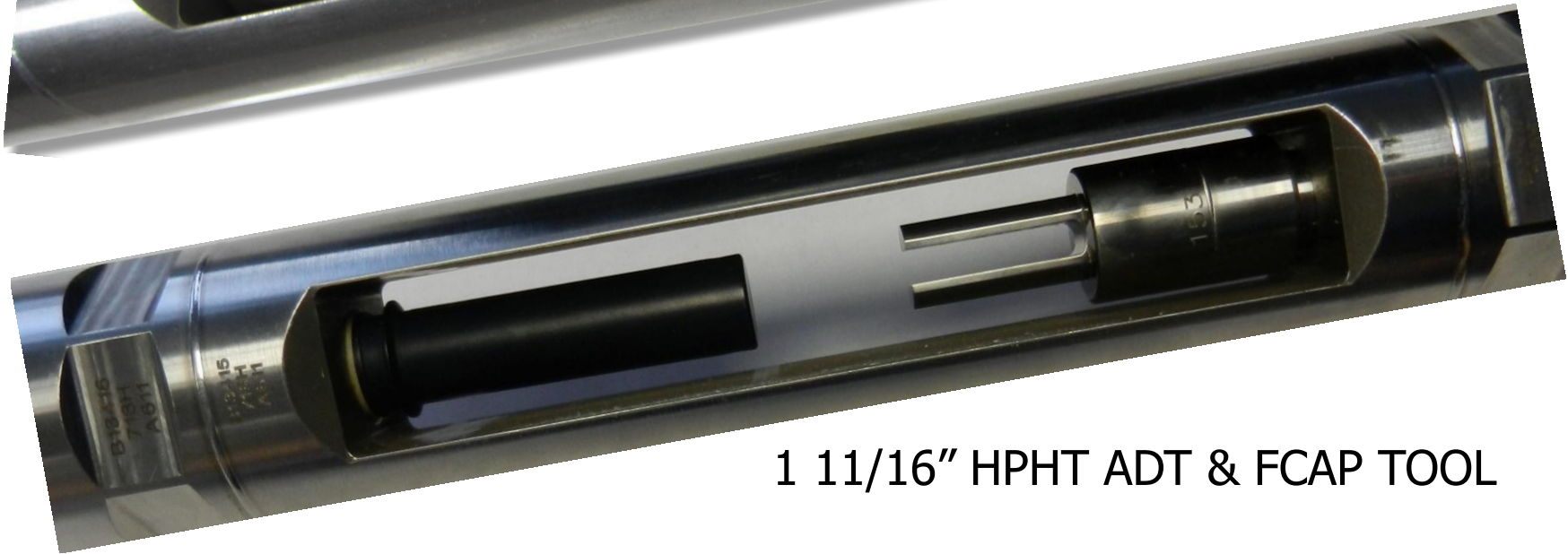
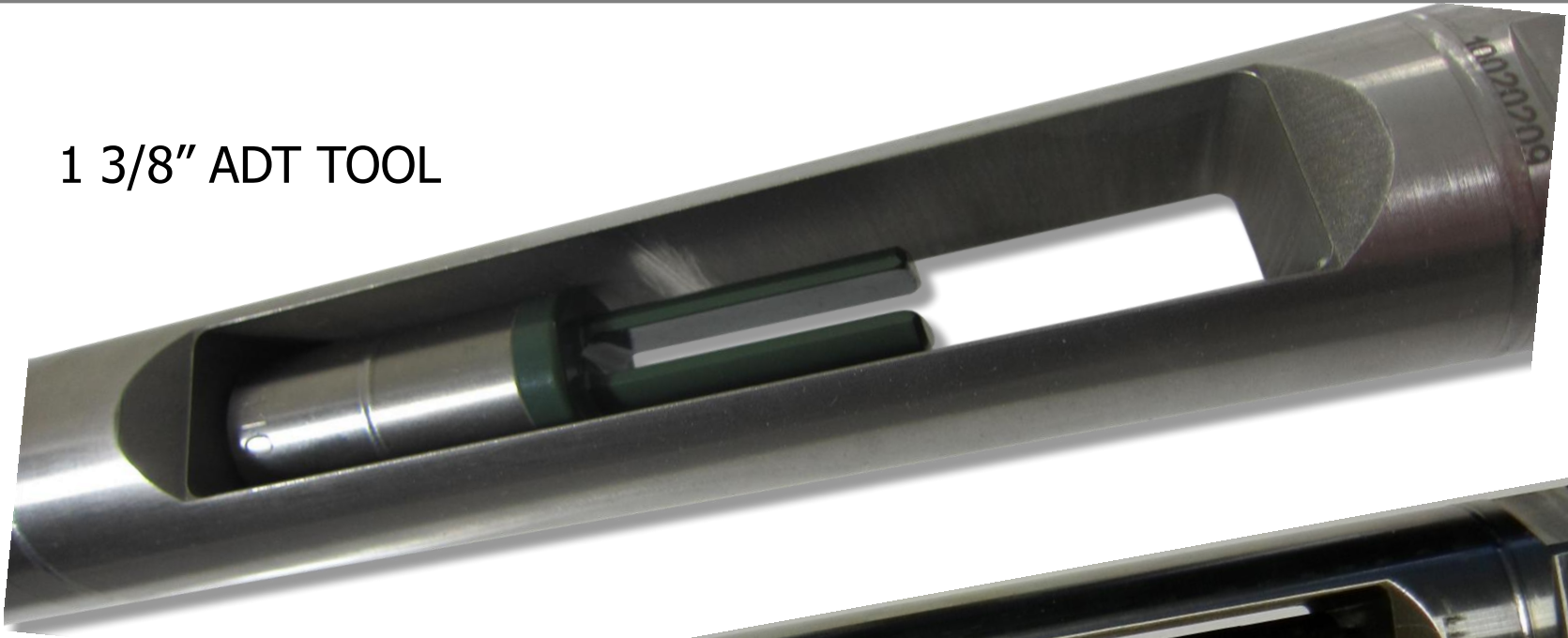


TECHNOLOGY DEVELOPMENT

HPHT & ARRAY PLT TOOLS

Acoustic Densitometer G3 Tool Assy

1 3/8" ADT TOOL



1 11/16" HPHT ADT & FCAP TOOL

HPHT Production Logging

- Operating Temperature **300°C ~ 6 hrs**
- Pressure Rating **20,000 psi**
- Outer Diameter **1 11/16"**
- Overall Length (SRO/Flow) **15ft**
- HT Sealing Technology **Metal-to-metal with HT Elastomer**
- Heat Shield **Thin Wall Flask**
- Tool Joints **10 Pin Non-Rotating**
- Sensors:
 - Gamma, CCL
 - Quartz Pressure
 - External Temperature
 - Continuous Flow
- **Fluid ID (220°C max)**
 - Acoustic Density
 - Capacitance



Multi-Sensor Array Technology

■ Operating Specifications

- Maximum OD Tool: 2 1/8 inch
- Length: 1.8m [6.2 ft]
- Operating Temperature 177°C (max)
- Operating Pressure 15,000 psi (max)
- Casing / Tubing Size 3 inch to 7 inch
- Sensors (across borehole) 6

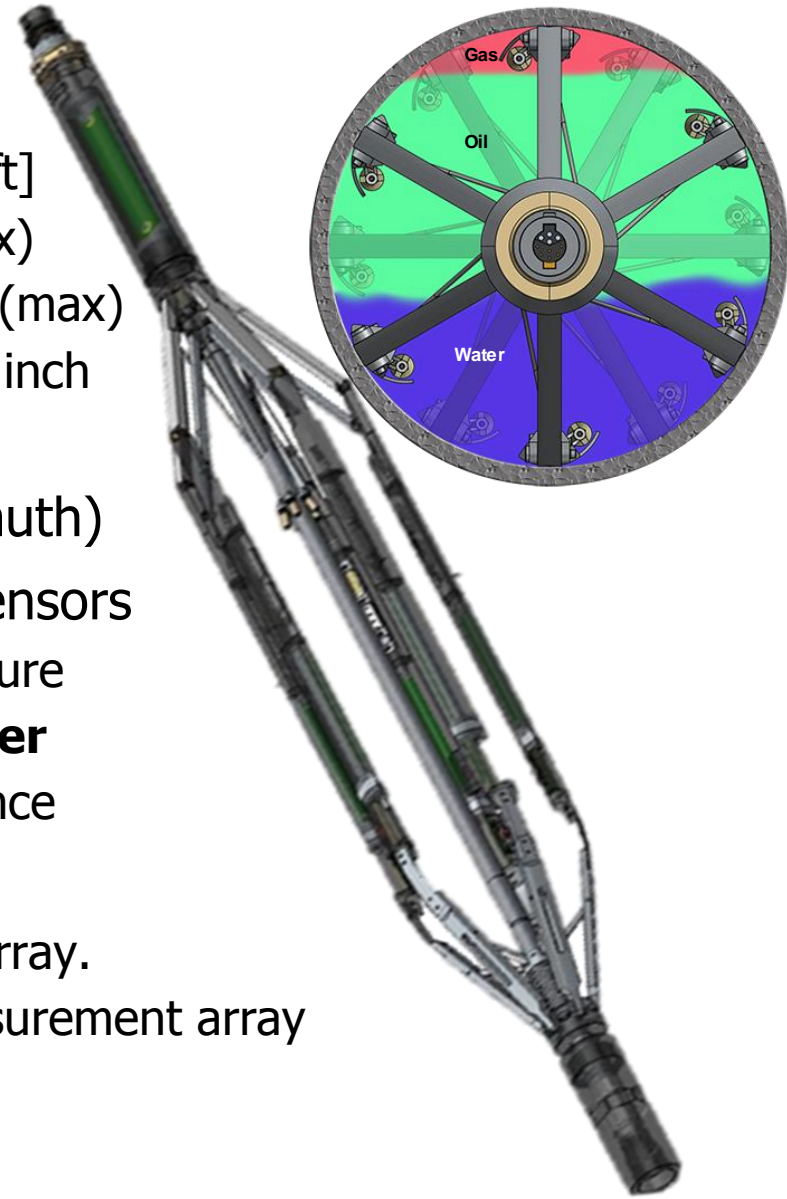
■ Orientation Module (Deviation and Azimuth)

■ Circumferential Array with Combined Sensors

- Flow: Spinner, Fast Response Temperature
- **Liquid / Gas – Acoustic Densitometer**
- Water Holdup – Capacitance, Conductance

■ Benefits

- All sensors located in single multi-arm array.
- Modules can be combined for 12+ measurement array
- Robust design



Multi-Sensor Array Technology

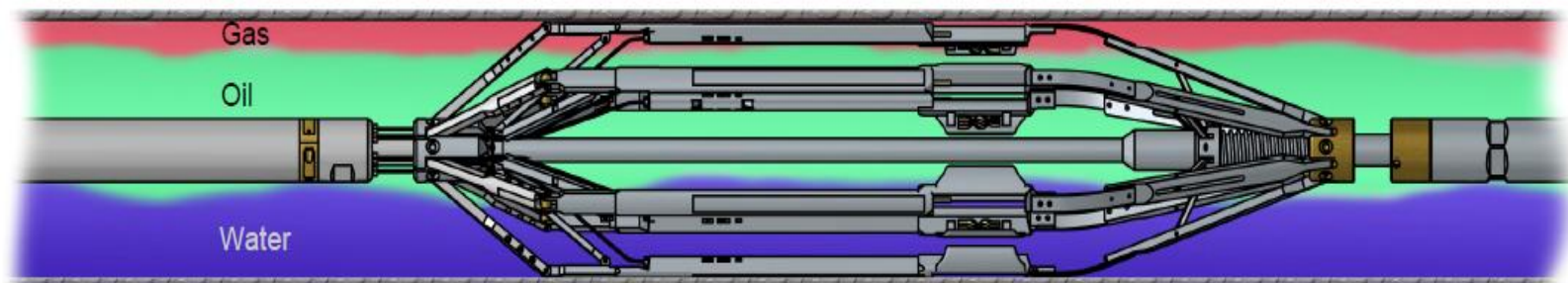
- Flow – Miniature Turbine Spinner
- Temperature – Fast Response RTD
- Water Cut – Capacitance, Conductance
 - 2 Port Capacitance
 - Range 5pF to 100pF
 - 4 Electrode Conductivity Probe
 - Range: .01 to 10000 (ohm-m)
- Gas Hold-Up – Acoustic Densitometer
 - Proven technology
 - High Resolution
 - Range 0 – 1.25 g/cc



Multi-Sensor Array Technology

- All sensors are located on the same Arm
 - Digital Single Wire Communication to Main tool body
 - Sensor(s) design optimized for configuration
- Can run one or more Multi-Sensor Array PLT's on the same run
 - Additional Redundancy
 - Sensor can be offset to provide equivalent of 10 arm device
- High Sample Rate Capable
 - 460.8 kbits tool bus
 - Hybrid Memory/SRO
- Prototype Build Stage

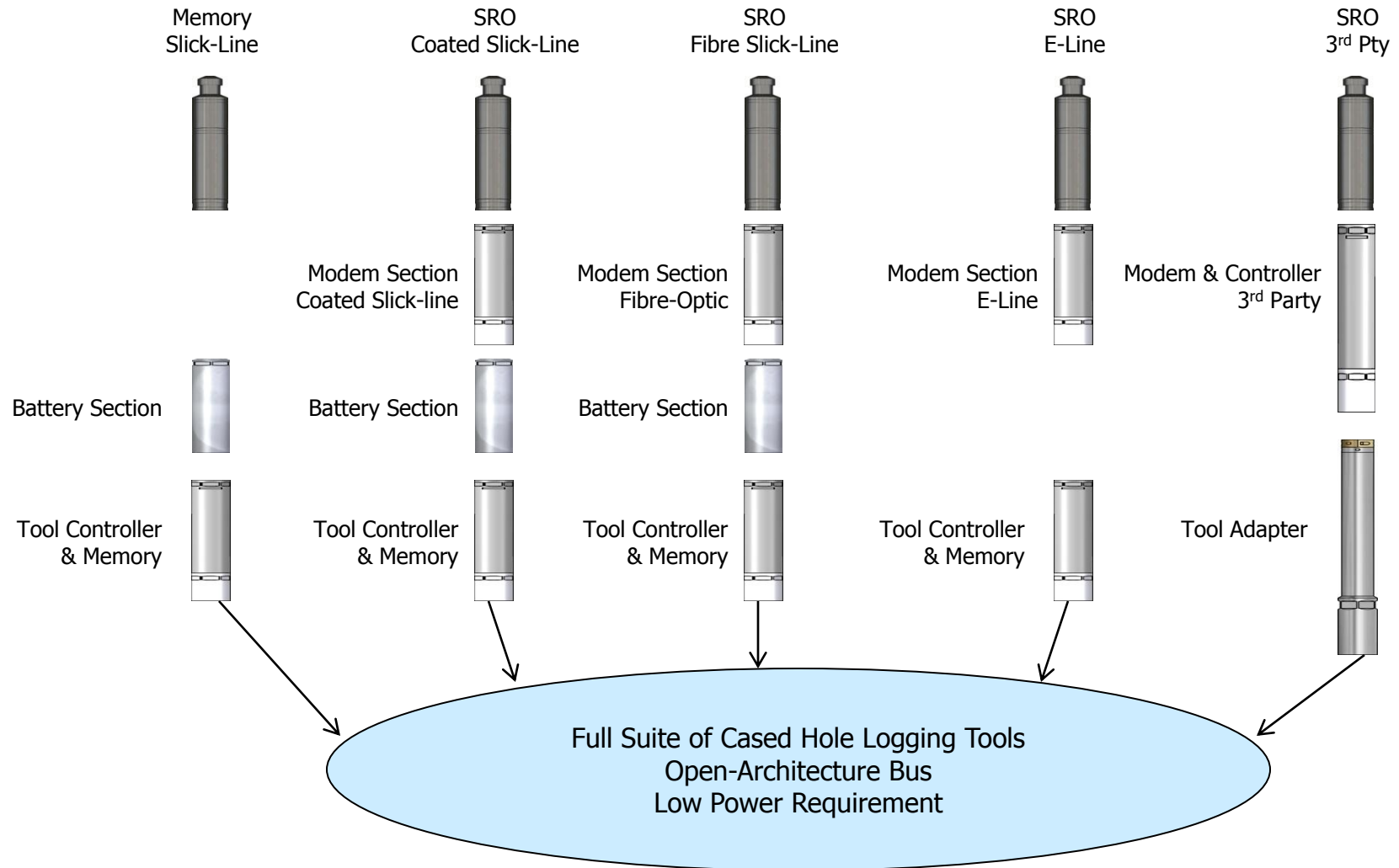
- A New Generation of Fluid Density Sensors
 - Direct Non-Radioactive Measure of Fluid Density
 - Linear Response over Wide Range
 - Very Good Accuracy & Resolution
 - Not Sensitive to Borehole Deviation
- Technology Can be Packaged for Sub-Surface
 - Conventional PLT
 - HPHT PLT
 - Horizontal PLT (using Array Packaging)
- Field Trials ongoing in 2016



CH LOGGING TECHNOLOGY

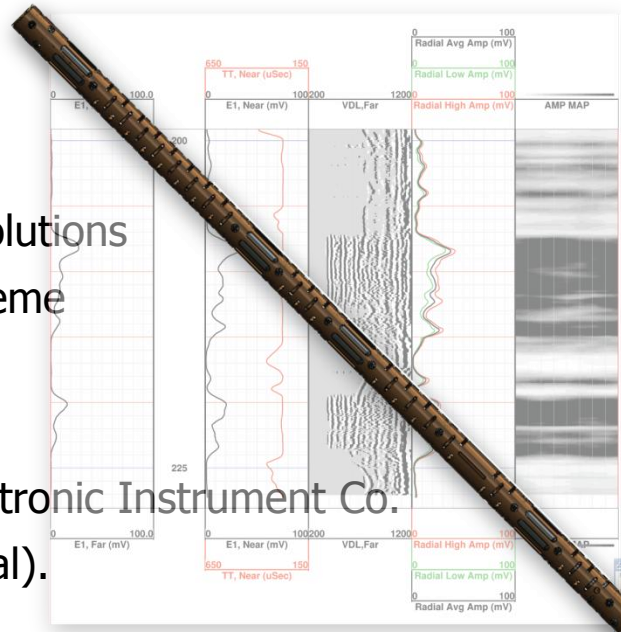
OPEN ARCHITECTURE PLATFORM

Deployment Options



Cased Hole Platform - Partners

- Baker Hughes
- FMC/Pure Energy
- Welltec
- Micro-g Lacoste
- Downhole Sonic Solutions
- Antares Datensysteme
- TecWell/Archer
- Hunting Titan
- Xi'an Well-sun Electronic Instrument Co.
- Others (Confidential).



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Thank You