TRIPLE & QUAD COMBO LWD

➢ iPCD™ ➢ Triple Combo
➢ Sonic ➢ Quad Combo
APS Technology has developed a new suite of Logging While Drilling (LWD) tools to complement our highly reliable Wave Propagation Resistivity (WPR™) tool, which was introduced in 2009. Like the WPR, these new integrated neutron Porosity, acoustic Caliper and azimuthal litho-Density (iPCD™) and Sonic tools operate seamlessly with the APS SureShot™ MWD platform. The introduction of these new porosity sensors allows APS’s customers, independent service companies and vertically integrated oil companies to provide higher-level “Triple Combo” or “Quad Combo” LWD services.

APS's advanced systems are powered by a turbine alternator in configurable combination with batteries to accommodate both LWD and Logging While Tripping (LWT). All LWD sensor subs can be used at typical flow rates (maximum 1,200 gpm or 76 l/sec) and to 347°F (175°C).

iPCD™ for Triple Combo LWD

The APS iPCD provides real-time bulk density (Δρ) and neutron porosity (Φn) data to characterize formation porosity and lithology while drilling. All nuclear measurements are borehole compensated using the standoff data provided by a novel acoustic caliper.

> Density sensor provides user-configurable formation imaging data with 4 or more sectors in real time and 24 sectors from memory.
> High-resolution images allow for structural/stratigraphic dip analysis.
> Photoelectric factor (Pe) data is stored in memory.
> All measurements include quality factors and standard log data.
> An array of rugged acoustic transducers provides a borehole shape/diameter log, permitting borehole breakout analysis.
> One set of transducers is aligned with the density neutron detectors for accurate real-time standoff measurement.

Radiation safety is of paramount importance with these types of tools. APS has made safety a priority, from tool design and international source licensing requirements to safety equipment and emergency procedures. Sources are doubly encapsulated with an industry-standard permanent mounting design featuring redundant mounting and retention schemes.
**APS m-Con System**

All APS LWD sensor subs connect via a modular connector (m-Con) system. This allows for quick, safe and reliable electrical and mechanical connection of LWD sensor subs, providing maximum flexibility for placement within the BHA.

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**Sonic Sensor for Quad Combo LWD**

The APS Sonic sensor is a full waveform sonic device that adds Δt (delta T) measurements to the Triple Combo LWD system. This sensor provides faster-than-fluid compressional wave (Δτc) and shear wave (Δτs) velocity data. In conjunction with APS WPR resistivity and iPCD sensors, the Sonic sensor enables operators to dispense with costly wireline logging operations and develop “insurance” formation evaluation logs during the drilling process.

- Sonic can be run in real-time MWD mode or standalone recorded data mode.
- Measurements provide data for a number of applications that are useful for several of the disciplines found on most asset teams.

Geophysicists can use APS Sonic sensor data to minimize uncertainty by tying time-based seismic data directly in with depth-based well log data. The rock’s mechanical properties can also be calculated using APS Sonic and iPCD density data, for use in a borehole stability analysis and in the completion design of the well.

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**Additional Applications:**

- Provide an additional correlation log and a non-nuclear porosity device to use in the hydrocarbon saturation calculation.
- Establish fluid type and distinguish gas and oil contacts within a reservoir.
- Provide telemetered Δt compressional data for real-time pore pressure evaluation and mud weight/casing point selection optimization during the well construction process. This is an invaluable tool for establishing a safe and effective drilling operation.
- As a digital full waveform sensor, Sonic can acquire data to identify natural fractures in the formation.
- Waveforms can also be used in cased holes to identify the top of a cement location behind casing and help confirm a good cement job.