



“The New STANDARD in Well Logging”

Open Hole Logging Technical Catalogue

2015

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Primary to the completion of any well, is the requirement to obtain the maximum amount of information necessary to determine not only the possibility of the presence of hydrocarbons, but also definitive and quantitative information for the evaluation of formations and lithologies in order to expand database information on fields and regions. The physical measurements acquired through the use of Open Hole Logging tools provides information on borehole environment, geometry, porosity, permeability, resistivity/conductivity and depth control, and provides the basis on which detailed formation evaluation is performed.

## APPLICATIONS

- primary depth control correlation
- lithology determination
- porosity
- permeability
- shale volume
- formation evaluation
- borehole geometry
- hydrocarbon indication
- borehole environmental information
- multi-well integration
- dip meter
- formation testing

## DESCRIPTION

Through the use of a variety of down-hole tools, each providing quantitative information on specific parameters of the borehole environment and geology encountered, specific determinations regarding the producibility of the well and other lithologic, stratigraphic and structural information can be determined.

By combining the specific information from Open Hole Logs with subsequent petrophysical, geophysical, regional and adjacent well data, definition of reservoir and regional parameters can be established.

## BENEFITS TO YOU

Our dedication to quality, consistency and competence, along with a long established commitment to research and development of new and innovative technology to enhance data acquisition capabilities will ensure that your company can make the necessary decisions based on precise and accurate data. These services are provided to your company at the highest standards the industry has to offer.

## SERVICES

- STANDARD High Resolution quality data recorded at 10 samples per foot / 33 samples per meter, logged at 30 feet per minute (1,800 feet per hour, 9 meters per minute)\*
- HDD<sup>TM</sup> (High Definition Data) of actual recordable 40 samples per foot / 132 samples per meter, logged at 25 feet per minute (1,500 ft per hour, 7 meters per minute)\*
- Depth capacities to 20,000 ft / 6,000 m.
- Temperature capabilities to 350 °F / 176 °C
- Hole size capabilities from 6" to 16" / 152 to 406 mm
- Hostile environment (eg. H<sub>2</sub>S, CO<sub>2</sub>, etc) available on request
- Deviated hole logging up to 60° (on gravity descent)
- High Angle and Horizontal Logging via Tractor deployment
- Tool String can be configured and stacked in various configurations

\* Speeds dependant on hole conditions

**DOWNHOLE SERVICES AVAILABLE**

- Conductivity/Resistivity: Dual Induction-Shallow Focussed Laterolog  
Micro-Electric Log  
4 Arm Dipmeter
- Porosity: Compensated Litho-Density – X-Caliper  
Compensated Neutron (Thermal) – Y-Caliper  
Borehole Compensated Sonic Log
- Seismic Integrated: Transit Time
- Correlation: Gamma Ray
- Lithology Pe
- Environmental Temperature, Fluid Resistivity, Digital Telemetry  
X, Y and M Calipers (Litho, Neutron, Microlog, Dipmeter)
- Pressure Formation Tester (Fluid Sample also available)

## Gamma Ray (GR)

Primary depth correlation must begin with the first log run. This log must also be the primary lithology and reservoir indicator. Calibrated to A.P.I. standards and able to be used for accurate shale volume indicators, this tool provides the foundation of information required for detailed formation evaluation.

### APPLICATIONS

- Primary depth correlation
- Formation lithology indicator
- Provides primary shale volume

### DESCRIPTION

The calibrated Gamma Ray tools are used with every Open Hole evaluation survey log run in the hole. Used as the primary depth control device, the Gamma Ray log provides the basis for all future log and depth correlations, open or cased hole, for the life of the well.

A high sensitivity Scintillation type detector combined with a photomultiplier and amplification electronics, when calibrated with an A.P.I. Standard calibrator, provide a highly repeatable and statistically accurate log, delineating formation and lithological changes within the strata.

Natural radioactive materials, primarily Potassium, Uranium and Thorium (K.U.T), collect in the strata in various proportions dependent on lithology. Shales, due to their composition, tend to contain much more of these elements than do sandstones or carbonates (limestone and dolomite). The result is that on logs, shale will read higher A.P.I. counts and the presentation curve of the Gamma Ray will tend to the right of the logging track. The "cleaner" reservoir rock, such as sandstone and limestone, will read much lower and to the left of the logging track.

Formations are not strictly defined as "clean" or "shale"; sandstones and carbonates may contain some percentage of shale through deposition. Initial and then detailed shale volume (percentage of shale in sand etc..) are accomplished by determining the cleanest formation reading (minimum shale) and the most predominant shale, adjacent to the interval being considered, and assuming the cleanest is 0%, and the shaliest is 100%. Everything in between will then be some combination of both.

### BENEFITS TO YOU

Consistent and accurate depth control combined with lithology and shale volume indication will provide the basis for a detailed and accurate evaluation when combined with more specific tools. Combined with a Spontaneous Potential log, which responds also to reservoir type formations with some water content, location of potentially productive formations are indicated and can be identified.

**SPECIFICATIONS**

<b>API Calibration</b>	<b>2 point linear API cal.</b>
<b>Detector</b>	<b>Scintillation (NaI crystal)</b>
<b>Diameter</b>	<b>3 3/8" (86 mm)</b>
<b>Length</b>	<b>3 1/4" (0.99 m)</b>
<b>Weight</b>	<b>60 lbs (27.2 kg)</b>
<b>Temperature</b>	<b>300 ° F (150 °C)</b>
<b>Pressure</b>	<b>20,000 psi (138 MPa)</b>
<b>Vertical Resolution*</b>	<b>0.5-0.75 ft (15 -20 cm)*</b>
<b>Depth of Investigation</b>	<b>0.98-1.48 ft (30 - 45 cm)</b>

**COMBINATIONS**

**DUAL INDUCTION - LL3 - SP  
 COMPENSATED NEUTRON  
 COMPENSATED LITHO-DENSITY  
 MICRO-ELECTRIC LOG  
 DIPMETER  
 MULTI-FORMATION TESTER  
 BOREHOLE COMPENSATED SONIC**

<b>First reading GR</b>	<b>(from Bottom) 24" (0.6 m)</b>	<b>Maximum Range 0-1000 API (Accuracy: 1 API)</b>
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\* At STANDARD Data Resolution (10 samples/ft, 33 samples/m)

## Dual Induction–Laterolog (DIL-LL3), Spontaneous Potential (SP)

A primary property inherent to any formation is its ability to conduct or resist electricity. The measured values for  $R_{ILD}$  (deep induction),  $R_{ILM}$  (medium induction) and  $R_{LLS}$  (short laterolog) can be corrected for environmental and tool factors, to provide accurate True Resistivity ( $R_T$ ) of the uninvaded, invaded and flushed zones. This allows for the determination of  $R_W$ ,  $R_I$ ,  $R_{XO}$  (water, invaded and flushed zone resistivities, respectively), Formation Factor, water saturations and permeability.

### APPLICATIONS

- Primary and secondary depth correlation
- Formation resistivity/conductivity,  $R_T$ ,  $R_I$ ,  $R_{XO}$ ,  $R_W$ ,  $R_{WA}$
- Reservoir and permeability indication from SP
- Shale volume indication from SP

### DESCRIPTION

By inducing an electromagnetic field (EMF) into the formations through the use of high voltage transmitter coils, the resulting eddy currents formed in the formations can be measured at the receiver coils and the conductivity / resistivity of the formation established. Coil spacing and arrangements are designed to maximize tool efficiency and to provide maximum depth of investigation.

This particular Dual Induction – Laterolog - SP configuration is constructed with the laterolog (LL3) situated at the bottom of the tool, which allows for a tool first reading within 12 -14" (0.3 - 0.35 m) of the actual bottom of the hole, as. No significant "rat hole" or overhole drilling is required, as is the case with most other resistivity type tools.

Individual tool curve responses on the field log will provide initial insight into formation potential, by the relationship of each of the three curves to each other. For example, in wet formations with high porosity, the deep and medium induction curves will generally track each other with the laterolog curve reading lower or higher depending on the well fluid resistivity. Tighter or less porous formations will generally see all three curves track, such as is the case in most shales. Lower, but still porous and wet formations will sometimes have all three curves separating as a function of fluid invasion, where the laterolog sees only the part of the formation which has been flushed by well fluid filtrate, the medium sees formation which although not flushed, has been invaded to some degree by well fluid filtrate, and the deep sees uninvaded formation whose resistivity is a function of matrix and formation water.

### BENEFITS TO YOU

"Quick Look" methods of reservoir identification, using the curve response. By combining the resistivity/conductivity information of the Dual Induction - LL3 with one or more porosity devices and a Gamma Ray and SP log, definitive formation evaluation techniques can be carried out.

**SPECIFICATIONS**

**COMBINATIONS**

Calibration	Zero and 500 mmho loop Cal	<b>GAMMA RAY BOREHOLE COMPENSATED SONIC MICRO-ELECTRIC LOG COMPENSATED NEUTRON COMPENSATED LITHO-DENSITY</b>
Coil Configuration	6FF40	
Diameter	4" (101.6 mm)	
Length	22' (6.4 m)	
Weight	290 lbs (132 kg)	
Temperature	300 °F (150 °C)	
Pressure	20,000 psi (138 MPa)	
Vertical Resolution*	S: 0.49-0.66 ft, M: 1.41 ft, D: 2.5 ft	S: 15-20 cm, M: 43 cm, D: 76 cm
Depth of Investigation	S: 0.98-1.48 ft, M: 2.82 ft, D: 5.0 ft	S: 30-45 cm, M: 86 cm, D: 152 cm

<b>First Reading</b>	<b>(from Bottom):</b>	<b>Maximum Range:</b>
Deep (ILD)	12' (3.65 m)	0.2 to 2000 ohm/m (Accuracy: 2 ohm/m)
Medium (ILM)	16' (4.87 m)	0.2 to 2000 ohm/m (Accuracy: 2 ohm/m)
Shallow (LL3)	1' (0.3 m)	0.2 to 2000 ohm/m (Accuracy: 2 ohm/m)
SP	12' (3.65 m)	n/a (Accuracy: 1 mV)

\* At STANDARD Data Resolution (10 samples/ft, 33 samples/m)

## Compensated Neutron Log (CNL)

The establishment of an additional Porosity value obtained from an independent and/or different method, such as neutron capture, provides greater accuracy as well as a reference for cross-plotting of porosities in formation evaluation techniques. The Compensated Neutron Log, by using the thermal capture cross-section of induced neutron radiation from a chemical source, provides a porosity determination from the amount of hydrogen contained within the formation, usually denoted by the presence of water.

### APPLICATIONS

- Formation porosity from neutron radiation ( $\Phi_n$  or NPHI)
- Evaluation of "gas effect" in reservoirs
- Borehole geometry from Y-Caliper
- Indications of fluid contact levels within the reservoir
- Secondary depth control

### DESCRIPTION

Also considered a primary porosity device, using neutron rather the gamma radiation (as with density porosity) to determine the porosity of a formation or reservoir, the Compensated Neutron Log provides a porosity value which when compared to Density porosity, provides more accurate determination of true formation porosity.

This tool uses a pad-mounted dual He-3 detector system and a chemical Neutron source ( $\text{Am}^{241}$ - Be) to investigate the formations during logging. The counts detected are converted to a ratio which is referred back to known calibration values for porosity, and again mathematically, through comparison to the values calibrated prior to running the log, the porosity is determined.

Environmental corrections are made during logging, if requested, for borehole rugosity (by the Y-Caliper); salinity, weight and composition of borehole fluids, borehole temperature, pressure and mud cake.

Pad mounting of the detection system allows the detectors to be placed as close to the wall of the borehole as possible, thereby reducing the effects of well fluids and other environmental factors from introducing error into the readings. In addition, the use of a caliper also allows measurement of actual borehole geometry in the Y-axis along which the pad runs while logging. The resulting caliper log can be used for correction of readings in rugose holes, as well as an overall borehole geometrical presentation for total well volume which when combined with the X-Caliper provides additional accuracy.

### BENEFITS TO YOU

By combining the Compensated Neutron Porosity with the Bulk Density and Density Porosity, Gamma Ray, Resistivities, SP and other porosity devices, detailed analysis of formations and potential reservoirs can be made for water saturation and hydrocarbon occurrence.

The Y-Caliper log from the Compensated Neutron provides hole volume and geometry while simultaneously providing environmental correction parameters.

**SPECIFICATIONS**

<b>A.P.I. Calibration</b>	<b>3 Point Ratio to Porosity</b>
<b>Detectors</b>	<b>Dual He-3</b>
<b>Diameter</b>	<b>4" (101.6 mm)</b>
<b>Length</b>	<b>10.25' (3.125 m)</b>
<b>Weight</b>	<b>280 lbs (130 kg)</b>
<b>Temperature</b>	<b>350 °F (177 °C)</b>
<b>Pressure</b>	<b>20,000 psi (138 MPa)</b>
<b>Caliper (Y orientation)</b>	<b>6" - 16" (152 mm - 406 mm)</b>
<b>Caliper Range</b>	<b>4" - 18" (100 mm - 460 mm)</b>
<b>Vertical Resolution*</b>	<b>0.66 ft (20 cm)</b>
<b>Depth of Investigation</b>	<b>0.98 – 1.25 ft (30 – 38 cm)</b>
<b>Accuracy</b>	<b>0-30% <math>\Phi</math>: 1 pu, 30-60% <math>\Phi</math>: 3 pu</b>

\* At STANDARD Data Resolution (10 samples/ft, 33 samples/m)

**COMBINATIONS**

**DUAL INDUCTION - LL3 - SP  
COMPENSATED LITHO-DENSITY  
GAMMA RAY  
BOREHOLE COMPENSATED SONIC  
MICRO-ELECTRIC LOG**

## Borehole Compensated Sonic Log (BHCS or BHS)

The establishment of an additional Porosity value obtained from an independent and/or different method such as formation travel time, provides greater accuracy, as well a reference for cross-plotting of porosities in formation evaluation techniques. The Borehole Compensated Sonic Log uses the acoustic properties of the rock to determine the porosity of formations. Along with porosity RECON's BHCS is also configured to capture the complete waveform of the sonic pulse. The acquisition of which allows for processing of Cement Bond Logs in the cased section of the wellbore during the same logging run. More importantly it allows for the processing of the Compressional and Shear wave arrival times, allowing for Seismic integration and Rock Mechanics quantification.

### APPLICATIONS

- Formation transit time Delta T (DT or  $\Delta T$ )
- Formation porosity from Delta T
- Evaluation of secondary porosity in formations
- Lithology determination from acoustic properties
- Cement Bond Logs (CBL - VDL) derived from Full Waveform Sonic (FWS)
- Compressional ( $\Delta t_c$ ) and Shear ( $\Delta t_s$ ) Acquisition Modes

### DESCRIPTION

Providing additional porosity information, the unique aspects of the acoustic properties of rock also enable specific assumptions on lithology as well as porosity to be made. The Sonic porosity when cross-plotted with Density and Neutron porosities provides for even more accurate formation evaluation.

The Borehole Compensated Sonic log (BHCS) utilizes the determination of Delta T, the difference in arrival times at multiple receivers from multiple transmitters located on the tool, this value is then mathematically converted to a porosity value using standard matrix values in the porosity equation.

Several variations on the distance from transmitter to receiver exist, from very short to very long, to allow for a variety of applications. Fracture finding, lithology determination, secondary porosity determination and cement bond logs are all additional data sets that can be determined.

### BENEFITS TO YOU

Normally run in combination with the Dual Induction or other tools, the porosity and lithology information provided by the Borehole Compensated Sonic combined with other porosity devices and resistivity information allow for detailed formation evaluation including water saturation and hydrocarbon indication.

Lithology determination by cross-plotting against other logs, as well as shale volume calculation, makes this tool a valuable companion to other porosity devices and in many cases can provide porosity information on a "stand alone" basis.

The BHCS employs a full-time Full Waveform Sonic function (FWS) which allows for increased versatility in the use of acoustic data. As the signal is not digitized downhole, the full waveform is recorded uphole for use in data processing with minimal signal loss due to analog-digital conversion.

This allows for the generation of CBL-VDL (Cement Bond Log / Variable Density Log) in intermediate or surface casing environments through a simple playback process without having to re-run the tool or requiring a special acquisition mode.

The Digital acquisition of the FWS also allows for the post processing of the Compressional and Shear arrival times. The use of these travel times allows for the integration with all forms of Seismic data as well as the calculation of Rock Mechanics properties such as Young's Modulus, Poissons Ratio etc.

## SPECIFICATIONS

<b>Calibration (Free Pipe)</b>	<b>57 <math>\mu</math>sec/ft (187 <math>\mu</math>sec/m)</b>
<b>Transmitters/receivers</b>	<b>Piezoelectric crystal</b>
<b>Diameter</b>	<b>3 3/8" (86 mm)</b>
<b>Length</b>	<b>15.9' (4.85 m)</b>
<b>Weight</b>	<b>180 lbs (75 kg)</b>
<b>Temperature</b>	<b>300 °F (150 °C)</b>
<b>Pressure</b>	<b>20,000 psi (138 MPa)</b>
<b>Tranceiver Arrangement</b>	<b>Dual 3ft, 5ft</b>
<b>Full Waveform Capture</b>	<b>OH-CH VDL capable</b>
<b>Vertical Resolution*</b>	<b>1.97 ft (60 cm)</b>
<b>Depth of Investigation</b>	<b>0.98 -1.48 ft (30 - 45 cm)</b>
<b>Accuracy</b>	<b>3.3 <math>\mu</math>sec</b>

\* At STANDARD Data Resolution (10 samples/ft, 33 samples/m)

## COMBINATIONS

**DUAL INDUCTION - LL3 - SP  
COMPENSATED LITHO-DENSITY  
COMPENSATED NEUTRON  
GAMMA RAY  
MICRO-ELECTRIC LOG**

## Litho-Density Tool (LDT)

A primary reservoir characteristic sought from any formation encountered during drilling is the density. By measuring Bulk Density, some assumptions as to lithology and porosity can be made with comparison to known properties. The addition of photoelectric effect or Pe, a lithology indicator, aids in determination for correction of matrix values used in porosity calculation algorithms. The determination of a quantitative porosity value can then allow more detailed evaluations to be made of a formation's productive potential.

### APPLICATIONS

- Bulk Density determination ( $\rho_b$  or RHOB)
- Calculated Density Porosity from Bulk Density ( $\Phi_{den}$  or DPHI)
- Lithology determination from Pe curve (Pe)
- Density Correction, quality curve ( $\Delta\rho$  or DRHO)
- Borehole geometry from X-Caliper

### DESCRIPTION

Considered a primary porosity determination device, the Compensated Photo-Litho Density log uses known properties and a calibration technique which provides definitive Bulk Density determinations. This tool uses a pad mounted dual scintillation detector system and a chemical Gamma Ray source (Cesium 137,  $Cs^{137}$ ) to investigate the formations during logging. The counts detected are mathematically converted to a bulk density determination, through comparison to the values calibrated prior to running the log for materials of known density. The determined bulk density is then converted to a Porosity by another mathematical relationship which incorporates known lithological information such as the density values for matrix.

Matrix and lithology (Pe curve) determination is made from a four window comparator system which measures low energy level gamma rays to determine the photoelectric effect of formations. This is presented as the Pe curve.

Pad mounting of the detection system allows the detectors to be placed as close to the wall of the borehole as possible, thereby reducing the effects of well fluids and other environmental factors from introducing error into the readings. In addition, the use of a caliper for this purpose also allows measurement of actual borehole geometry in the X-axis along which the pad runs while logging. The resulting caliper log can be used for correction of readings in rugose holes, as well as an overall borehole geometrical presentation for total well volume.

### BENEFITS TO YOU

By combining the Pe, Bulk Density and Density Porosity with the Gamma Ray, Resistivities, SP and other porosity devices, detailed analysis of formations and potential reservoirs can be made for water saturation and hydrocarbon occurrence.

The X-Caliper log from the Compensated Photo-Litho Density provides hole volume and geometry while simultaneously providing environmental correction parameters.

**SPECIFICATIONS**

<b>A.P.I. Calibration</b>	<b>Al, Mg and Sandstone Cals</b>
<b>Detectors</b>	<b>Dual Scintillation</b>
<b>Diameter</b>	<b>4" (101.6 mm)</b>
<b>Length</b>	<b>9.35' (2.85 m)</b>
<b>Weight</b>	<b>280 lbs (130 kg)</b>
<b>Temperature</b>	<b>300 °F (150 °C)</b>
<b>Pressure</b>	<b>20,000 psi (138 MPa)</b>
<b>Bulk Density</b>	<b>1.0-3.0 g/cc (1,000–3,000 kg/m<sup>3</sup>)</b>
<b>Caliper (X orientation)</b>	<b>6" to 16" (152 mm to 406 mm)</b>
<b>Caliper Range</b>	<b>4" to 18" (100 mm to 460 mm)</b>
<b>Vertical Resolution*</b>	<b>0.66 ft (20cm)</b>
<b>Depth of Investigation</b>	<b>0.98 – 1.25 ft (30 – 38 cm)</b>
<b>Accuracy</b>	<b>RHOB: 0.015 g/cc (15 kg/m)</b>

\* At STANDARD Data Resolution (10 samples/ft, 33 samples/m)

**COMBINATIONS**

**DUAL INDUCTION - LL3 - SP  
COMPENSATED NEUTRON  
GAMMA RAY  
BOREHOLE COMPENSATED SONIC  
MICRO-ELECTRIC LOG**

## Micro-Electric Log (MEL)

A primary property inherent to any formation is its ability to conduct or resist electricity. The Micro-Electric Log/Caliper measures the Conductivity/Resistivity of a very small area of the borehole wall through the use of a short spaced series of electrodes which induce current and measure the return at a short distant reference. This shorter current return path gives the tool both a fine vertical resolution and shallow depth of investigation. The values measured determine the micro-resistivity of the formation and indicate, along with the caliper, the presence of mud cake (filter cake) which is an indication of permeability. The Micro and Inverse readings of the tool are also correlatable to the primary Resistivity devices such as the Dual Induction. As this tool has very small spacing, thin bed definition to 1" is possible. This information can be used for thin bed corrections on macro tools.

### APPLICATIONS

- Formation micro-resistivity/conductivity, micro-normal, micro-inverse
- Qualitative indication of permeability (including comparison to SP)
- Correlation of micro-resistivity/conductivity with  $R_{ILD}$ ,  $R_{ILM}$  and  $R_{LLS}$
- Borehole geometry and filter cake buildup from caliper
- Moved oil estimation by comparison to invasion profile

### DESCRIPTION

By inducing current into the formation through the use of button electrodes, the current will follow the path of least resistance to a distant reference return and the conductivity of the formations and the flushed zones can be measured. The conductivity or resistivity of the formation at the borehole can be established through Ohms Law. Electrode spacing and arrangements are designed to allow the tool to investigate at very shallow depths into the formation so that in most cases, where porosity exists, the formation investigated is flushed with borehole fluid filtrate. This allows for comparison of true  $R_{XO}$  to  $R_{ILD}$  to determine corrections for thin bed effects and other factors.

The Micro-Electric Logging Tool also is a caliper type tool with the electrodes mounted in a soft pad on the caliper arm. Decreases in hole diameter adjacent to formations which show a shaded "crossover" effect of the micro-normal and inverse curves is usually an indication of permeability in the formation. For example, in wet formations with permeability, the micro-normal and the inverse curves will generally crossover. The readings of this tool, as are all Resistivity tools, are dependant to some extent on the Resistivity of the borehole fluid. It is the filtrate of the borehole fluid which invades formations with permeability and also causes borehole effects on the logs.

### BENEFITS TO YOU

"Quick Look" method of reservoir identification using the curve responses. By combining the micro resistivity/conductivity information of the Micro-Electric Log with other macro type resistivity, porosity and lithology devices, definitive formation evaluation techniques can be carried out to determine more specifically the productive capability of a formation, or to further define formation parameters.

**SPECIFICATIONS**

<b>Calibration</b>	<b>Zero and 50 OHM Cal</b>
<b>Electrode Configuration</b>	<b>1" and 2"</b>
<b>Diameter</b>	<b>4" (101.6 mm)</b>
<b>Length</b>	<b>8.65' (2.64 m)</b>
<b>Weight</b>	<b>180 lbs (75 kg)</b>
<b>Temperature</b>	<b>300 °F (150 °C)</b>
<b>Pressure</b>	<b>20,000 psi (138 MPa)</b>
<b>Caliper Range</b>	<b>4" - 18" (100 mm - 460 mm)</b>
<b>Vertical Resolution*</b>	<b>0.16 ft (5 cm)</b>
<b>Depth of Investigation</b>	<b>0.16 – 0.5 t (5 -15 cm)</b>

**COMBINATIONS**

**GAMMA RAY  
 DUAL INDUCTION - LL3 - SP  
 BOREHOLE COMPENSATED SONIC  
 COMPENSATED NEUTRON  
 COMPENSATED LITHO-DENSITY**

<b>First Reading</b>	<b>(from Bottom):</b>	<b>Maximum Range:</b>	
<b>Micro-Normal (1")</b>	<b>24" (0.6 m)</b>	<b>0 to 2000 ohm/m</b>	<b>Accuracy: 1%</b>
<b>Micro-Inverse (2")</b>	<b>24" (0.6 m)</b>	<b>0 to 2000 ohm/m</b>	<b>Accuracy: 1%</b>

\* At STANDARD Data Resolution (10 samples/ft, 33 samples/m)

## Formation Dipmeter (DIP)

The acquisition of complex formation dip and strike can greatly assist in correlation of formation information such as seismic and petrophysical evaluations. Using a combination of Micro-Resistivity measurements of a very small area of the borehole wall, this tool can provide highly accurate dip and strike measurements, as well as specific Micro-Shallow resistivity of the flushed zone. Pad mounted and short-spaced focussed arrangements of electrodes induce current into the side of the borehole and measure the micro-Resistivity of the formations. Directional Survey information is acquired through a built-in high resolution directional package of accelerometers. Along with the caliper, which can provide indications of the presence of mud cake (filter cake), specific indications of permeability can be quantified. Comparisons of the micro-resistivity readings of each pad can also show anomalies in dip/strike of specific formations as well as specific characteristics of the formations, especially thin beds.

### APPLICATIONS

- Borehole Survey via azimuth, deviation and relative bearing (Directional Package)
- Borehole geometry via 4 independent calipers (4-Arm Caliper)
- Overall dip accuracy to  $\pm 5\%$
- Formation micro-resistivity/conductivity, qualitative indication of permeability, resistivity pseudo-imaging
- Correlation of micro-resistivity/conductivity with  $R_{ILD}$  and  $R_{LLS}$
- Borehole geometry and filter cake build-up from calipers

### DESCRIPTION

The Formation Dipmeter uses a focussed electrode arrangement on the pads of each of the 4 arms, combined with a directional electronics package using accelerometers. By inducing current into the formations through the focussed electrodes the measurements of each pad, when compared to the others and correcting for spin and deviation, can provide specific information as to the Dip/Strike of formations measured.

Computation of the data acquired allows for standard arrow plots, Tadpole plots, geo-dip sets etc., borehole profile, borehole geometry and true vertical depth.

### BENEFITS TO YOU

"Quick Look" method of reservoir identification using the curve response. By combining the borehole deviation, along with Dip/Strike interpretations, micro resistivity/conductivity information of the Formation Dipmeter tool and with other macro type resistivity, porosity and lithology devices, definitive formation evaluation techniques can be carried out to determine more specifically the productive capability of a formation, or to further define formation and field parameters.

**SPECIFICATIONS**

<b>Calibration</b>	<b>Zero, 50 and 500 ohm Cal</b>
<b>Electrode Configuration</b>	<b>Four Arm w/ 1 button / arm</b>
<b>Diameter</b>	<b>5" (127 mm)</b>
<b>Length</b>	<b>16' (4.9 m)</b>
<b>Weight</b>	<b>240 lbs (110 kg)</b>
<b>Temperature</b>	<b>300 °F (150 °C)</b>
<b>Pressure</b>	<b>20,000 psi (138 MPa)</b>
<b>Vertical Resolution*</b>	<b>0.16 ft (5 cm)</b>
<b>Depth of Investigation</b>	<b>0.16 – 0.5 t (5 -15 cm)</b>

**COMBINATIONS**

**GAMMA RAY  
 SP  
 BOREHOLE COMPENSATED SONIC  
 COMPENSATED NEUTRON  
 COMPENSATED LITHO-DENSITY**

<b>First Reading</b>	<b>(from Bottom):</b>	<b>Maximum Range: 0 to 2000 ohm/m</b>
<b>Micro-Shallow</b>	<b>24" (0.6 m)</b>	
<b>Caliper Range</b>	<b>4" - 18" (100 mm - 460 mm)</b>	
<b>Directional Package</b>	<b>3 axis inclinometer</b>	

\* At STANDARD Data Resolution (10 samples/ft, 33 samples/m)

## Formation Tester (Selectable/Multiple Pressure & Sample)

The acquisition of complex formation pressure and fluid samples can greatly assist in determining the productive potential of a formation. Using the sample taking abilities of a caliper type formation tester which allows multiple samples of fluids and "no-limit" sampling of pressure, this tool can provide highly accurate formation fluid and pressure measurements.

### APPLICATIONS

- Multiple formation pressures with precision quartz gauge accuracy
- Formation fluid sample in 2.6 and 5.0 USGAL (9.8L and 18.9L) volumes per run, if required
- Specific formation pressure (shut-in pressure) at specified depths
- Qualitative indication of permeability
- Draw-Down and Build-Up Pressure Transient Analysis

### DESCRIPTION

Using a extendable caliper type arm, which provides positive contact with the borehole wall while the tool is stationary, multiple pretest and/or an actual single sample of formation fluid can be obtained depending on the sample chamber sizes and numbers. Any number of formation pressures can be obtained by a high resolution quartz pressure gauge within the tool. A single fluid sample may be collected in a single run for analysis at surface; multiple sample chambers in 2.6 and 5.0 USGAL (9.8L and 18.9L) volumes, allow for flexibility in fluid sample volume. Multiple samples can be obtained through additional runs.

### BENEFITS TO YOU

"Quick Look" method of reservoir identification using the curve responses. By combining the formation fluid sample and pressure information, along with Dip/Strike interpretations, micro resistivity/conductivity information of the Formation Dipmeter tool and with other macro type resistivity, porosity and lithology devices, definitive formation evaluation techniques can be carried out to determine more specifically the productive capability of a formation, or to further define formation and field parameters.

### SPECIFICATIONS

<b>Calibration</b>	<b>Presision Quartz up to 34 MPa</b>
<b>Pad Configuration</b>	<b>Single extendable</b>
<b>Diameter</b>	<b>5" (127 mm)</b>
<b>Length</b>	<b>30' (9.5 m), varies with sample tanks</b>
<b>Weight</b>	<b>400 lbs (165 kg), varies with tanks</b>
<b>Temperature</b>	<b>300 °F (150 °C)</b>
<b>Pressure</b>	<b>20,000 psi (138 MPa)</b>
<b>Pad Extension Range</b>	<b>4" - 18" (100 mm - 460 mm)</b>
<b>Pressure Guage type</b>	<b>Quartz</b>
<b>Angular Deviation</b>	<b>to maximum 35°</b>
<b>Sample Volumes</b>	<b>2.6 or 5.0 USGAL (9.8L or 18.9L)</b>

### COMBINATIONS

**GAMMA RAY**