ALD™ Azimuthal Lithodensity Service

PROVIDING HIGH-QUALITY DENSITY MEASUREMENTS AND FORMATION IMAGES

OVERVIEW

The ALD™ service provides fit-for-purpose, reliable measurements that are suitable for a wide range of petrophysical and geological applications. The service not only provides accurate density and Pe logs for reservoir evaluation, but also provides high-quality borehole images for structural dip interpretation, geosteering, and hole stability applications. As the ALD tool rotates, the density, Pe, and acoustic standoff data are acquired in 16 azimuthally oriented sectors or bins, referenced to either the high side of the borehole or magnetic north. The azimuthal data can be presented as conventional log curves (top, right, bottom, and left quadrants) and as borehole image logs. Azimuthal density curves and image data are also available in real time.

ALD image logs reveal borehole shape features such as hole spiraling and stress-induced breakout. In addition to the density and Pe image data, an acoustic standoff sensor, mounted in line with the scintillation detectors in the 6-3/4-, 8-, and 9-1/2- in. ALD tools, provides direct measurements of standoff, borehole diameter, and borehole geometry, for better evaluation of log and borehole quality.

The ALD service features a proven rapid-sampling statistical technique for optimizing density and Pe data quality. This technique identifies and segregates the highest-quality count-rate samples acquired with minimum standoff, and operates even in vertical wells where high-side azimuthal binning is not possible.

ALD™ SERVICE APPLICATIONS

» Accurate density and Pe logs, even in enlarged boreholes or with bi-center bits
» Formation imaging for:
  – Geosteering
  – Structural dip in high-angle wells
  – Borehole breakout, washout, and spiraling
» Porosity
» Lithology
» Pore pressure
» Gas detection (with CTN™ neutron porosity tool)
» Formation mechanical and seismic properties (with the QBAT™ or XBAT™ sonic tools)

ALD™ SERVICE FEATURES

» The first and only LWD density service for larger borehole sizes.
» Azimuthally oriented density, Pe, and acoustic standoff measurements
» Rugged detectors and electronics for greater reliability
» Real-time formation imaging in oil-based and water-based mud systems
» Three independent techniques for optimizing density and Pe log quality:
  – Azimuthal imaging
  – Rapid sampling
  – Conventional
» Operates in SOLAR™ conditions of up to 175°C / 347°F and 30,000 psi / 207 MPa on certain sizes

ALD™ SERVICE BENEFITS

» Reduces cost and time by eliminating wireline conveyance even in SOLAR conditions
» Optimizes wellbore placement through geosteering
» Reduces geological uncertainty and refines the earth model by measuring structural dip in real time
### ALD™ Sensor Technical Specifications

<table>
<thead>
<tr>
<th></th>
<th>4-3/4 inch</th>
<th>6-3/4 inch</th>
<th>8 inch</th>
<th>9-1/2 inch</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nominal Tool OD</strong></td>
<td>4-3/4 in. / 121 mm</td>
<td>6-3/4 in. / 171 mm</td>
<td>8 in. / 203 mm</td>
<td>9-1/2 in. / 241 mm</td>
</tr>
<tr>
<td><strong>Available Stabilizer Diameters</strong></td>
<td>5-3/8, 5-1/2, 5-3/4, 6, 6-3/8 in.</td>
<td>8 in. / 203 mm</td>
<td>8-1/16 in. / 207 mm, 210 mm, 238 mm</td>
<td>12 in. / 305 mm</td>
</tr>
<tr>
<td><strong>Hole Size Range</strong></td>
<td>5-1/2 to 6-3/4 in. / 140 to 171 mm</td>
<td>5-1/2 to 6-3/4 in. / 140 to 171 mm</td>
<td>8 in. / 203 mm</td>
<td>12 in. / 305 mm</td>
</tr>
<tr>
<td><strong>Collar ID</strong></td>
<td>1.25 in. / 31.8 mm</td>
<td>1.25 in. / 31.8 mm</td>
<td>1.92 in. / 48.8 mm</td>
<td>2.36 in. / 61.0 mm</td>
</tr>
<tr>
<td><strong>Length</strong></td>
<td>14.35 ft / 4.37 m</td>
<td>14.54 ft / 4.43 m</td>
<td>16.31 ft / 4.97 m</td>
<td>18.90 ft / 5.75 m</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>654 lbf / 297 kg</td>
<td>1,517 lbf / 688 kg</td>
<td>2,973 lbf / 1,349 kg</td>
<td>4,687 lbf / 2,117 kg</td>
</tr>
<tr>
<td><strong>Connections</strong></td>
<td>3-1/2 IF (NC 38) box up x pin down</td>
<td>4-1/2 IF (NC 50) box up x pin down</td>
<td>6-5/8 REG box up x pin down</td>
<td>7-5/8 REG box up x pin down</td>
</tr>
<tr>
<td><strong>Make-up Torque</strong></td>
<td>9,940 to 10,900 lbf-ft / 1350 to 1480 daN-m</td>
<td>31,500 to 34,700 lbf-ft / 4280 to 4700 daN-m</td>
<td>52,500 to 57,700 lbf-ft / 7120 to 7830 daN-m</td>
<td>84,200 to 92,600 lbf-ft / 11,800 to 12,400 daN-m</td>
</tr>
<tr>
<td><strong>Maximum Dogleg Severity (surcharge for higher doglegs)</strong></td>
<td>14° per 100 ft (30 m)</td>
<td>10° per 100 ft (30 m)</td>
<td>8° per 100 ft (30 m)</td>
<td>8° per 100 ft (30 m)</td>
</tr>
<tr>
<td><strong>Maximum Temperature</strong></td>
<td>302°F / 150°C</td>
<td>302°F / 150°C</td>
<td>302°F / 150°C</td>
<td>302°F / 150°C</td>
</tr>
<tr>
<td><strong>Maximum Pressure</strong></td>
<td>20,000 psi / 138 MPa</td>
<td>25,000 psi / 172 MPa</td>
<td>25,000 psi / 172 MPa</td>
<td>25,000 psi / 172 MPa</td>
</tr>
<tr>
<td><strong>Maximum Mass Flow Rate</strong></td>
<td>5,000 lbf x ppg / 2300 kg x m</td>
<td>10,000 lbf x ppg / 4500 kg x m</td>
<td>20,000 lbf x ppg / 9000 kg x m</td>
<td>20,000 lbf x ppg / 9000 kg x m</td>
</tr>
<tr>
<td><strong>Maximum Sand Content</strong></td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td><strong>Maximum Lost Circulation Material</strong></td>
<td>No Restrictions</td>
<td>No Restrictions</td>
<td>No Restrictions</td>
<td>No Restrictions</td>
</tr>
<tr>
<td><strong>Maximum RPM</strong></td>
<td>180</td>
<td>180</td>
<td>180</td>
<td>180</td>
</tr>
<tr>
<td><strong>Maximum Weight on Bit</strong></td>
<td>25,000 lbf / 11 000 daN</td>
<td>45,000 lbf / 20 000 daN</td>
<td>60,000 lbf / 27 000 daN</td>
<td>75,000 lbf / 33 000 daN</td>
</tr>
<tr>
<td><strong>Lateral Vibration</strong></td>
<td>10 min at a Peak Shock Level of 90g</td>
<td>10 min at a Peak Shock Level of 90g</td>
<td>10 min at a Peak Shock Level of 90g</td>
<td>10 min at a Peak Shock Level of 90g</td>
</tr>
<tr>
<td><strong>Axial Vibration</strong></td>
<td>10 min at a Peak Shock Level of 40g</td>
<td>10 min at a Peak Shock Level of 40g</td>
<td>10 min at a Peak Shock Level of 40g</td>
<td>10 min at a Peak Shock Level of 40g</td>
</tr>
</tbody>
</table>

#### Measurement Specifications

- **Density / Pe Sensor Type**: PMT Scintillation Detectors
- **Acoustic Standoff Sensor Type**: N/A
- **Acoustic Standoff Accuracy**: ±0.025 g/cc
- **Density Measurement Accuracy**: ±0.025 g/cc
- **Density Statistical Repeatability (1σ)²**: ±0.005 g/cc
- **Pe Factor Measurement Range**: 1 to 20
- **Pe Factor Measurement Accuracy**: ±0.05 (1 to 20)
- **Pe Factor Statistical Repeatability (1σ)³**: ±3% (1 to 5)
- **Acoustic Standoff Measurement Range**: N/A
- **Acoustic Standoff Accuracy**: ±0.05 in.
- **Density Measure Point from Pin End of Tool**: 5.28 ft / 1.61 m
- **Standoff Measure Point from Pin End of Tool**: 6.26 ft / 1.91 m

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* High temperature (347°F / 175 °C) tools may be available on special request.
** High pressure tools are available on special request (25,000 psi / 172 MPa for 4 3/4" tools and 30,000 psi / 207 MPa for 6 3/4" and 8" tools)
1 Tool will operate in larger borehole sizes but some functionality may be limited. Suitability to be evaluated on a case-by-case basis.

For more information, contact your local Halliburton representative or visit us on the web at www.halliburton.com

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