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Advances in Detection of External Casing Cables During Perforating Operations

AUTHOR: Iain Maxted – Guardian Global Technologies; with acknowledgement and thanks to Halliburton Logging and Perforating
PROGRAMME

- Introduction
- System Description
- Technical Development
- Development Testing
- Real-World Results
- Future Direction
Introduction

- Metal Anomaly Tool – Why;
- Technical Issues;
- Project Objectives;
  - High Accuracy Detection;
  - Real-Time Output (Pseudo);
  - Minimise/Eliminate Expert User Interpretation;
  - Detect and Shoot in Single Run.
System Description

- Specification:
  - 3 \(\frac{1}{8}\)”; 15,000psi; 350\(^\circ\)F;
  - Casing Range: 4 \(\frac{1}{2}\)” – 7”;
  - Circumferential Resolution: 5\(^\circ\);
  - Detection Accuracy: +/- 7.5\(^\circ\) in Wells >5\(^\circ\) Deviation;

- System Operation:
  - MAT…..MPP…..PC…..Seeker.
Tool String Configuration

- Powered Swivel Joint/AOT
- Anchor
- Knuckle Joints
- Shock Absorber
- Metal Anomaly Tool
- Gun String
- Cable Head

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Technical Development

Eddy Current Sensor

- The Problem!

Static Magnetic Modelling

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### Technical Development

#### Sensor Configurations - 1

<table>
<thead>
<tr>
<th>Sensor name</th>
<th>Sensor description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECD-GMR-40-15</td>
<td>Eddy current detection GMR sensor with 40 mm OD coil bobbin (as designed for the test jig), 0.15mm wire diameter</td>
</tr>
<tr>
<td>ECD-GMR-18-15</td>
<td>Eddy current detection GMR sensor with 18 mm OD coil bobbin, 0.15mm wire diameter</td>
</tr>
<tr>
<td>ECD-GMR-18-50</td>
<td>Eddy current detection GMR sensor with 18 mm OD coil bobbin, 0.50mm wire diameter</td>
</tr>
<tr>
<td>ECD-GMR-18-15-2</td>
<td>Eddy current detection GMR sensor with 18 mm OD coil bobbin, 0.15mm wire diameter, double wound (two parallel wire strands)</td>
</tr>
<tr>
<td>ECD-GMR-DF40-15</td>
<td>Eddy current detection GMR sensor with 40 mm OD differential coil bobbin, 0.15mm wire diameter</td>
</tr>
<tr>
<td>ECD-GMR-DF18-15</td>
<td>Eddy current detection GMR sensor with 18 mm OD differential coil bobbin, 0.15mm wire diameter</td>
</tr>
<tr>
<td>FLD-GMR-DC-31</td>
<td>Flux leakage detection (remnant field), double core, single coil with 0.315mm diameter wire, GMR sensor</td>
</tr>
<tr>
<td>FLD-HAL-DC-31</td>
<td>Flux leakage detection (pulsed), double core, single coil with 0.315mm diameter wire, hall sensor</td>
</tr>
</tbody>
</table>
### Technical Development

#### Sensor Configurations - 2

<table>
<thead>
<tr>
<th>Sensor Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECD-DCA-40-15</td>
<td>Eddy current detection differential coil antenna sensor with 40 mm OD coil bobbin (as designed for the test jig), 0.15mm wire diameter</td>
</tr>
<tr>
<td>ECD-DCA-18-15</td>
<td>Eddy current detection differential coil antenna sensor with 18 mm OD coil bobbin (as designed for the test jig), 0.15mm wire diameter</td>
</tr>
<tr>
<td>ECD-DCA-18-50</td>
<td>Eddy current detection differential coil antenna sensor with 18 mm OD coil bobbin (as designed for the test jig), 0.50mm wire diameter</td>
</tr>
<tr>
<td>ECD-DCA-DF40-15</td>
<td>Eddy current detection differential coil antenna sensor with 40 mm OD differential driving coil bobbin, 0.15mm wire diameter</td>
</tr>
<tr>
<td>ECD-DCA-DF18-15</td>
<td>Eddy current detection differential coil antenna sensor with 18 mm OD differential driving coil bobbin, 0.15mm wire diameter</td>
</tr>
<tr>
<td>ECDCORED-1</td>
<td>Pot core - soft iron, h=24mm, D=5,22,34,42 mm, coil with 0.33mm wire, 16 layers of 39 turns, 12.7R. Differential coil sensor/driver wound onto ferrite core in the middle.</td>
</tr>
<tr>
<td>ECDCORED-2</td>
<td>Pot core - soft iron, h=24mm, D=11,22,34,42 mm, coil with 0.33mm wire, 16 layers of 39 turns, 12.7R. Differential coil sensor/driver wound onto ferrite core in the middle.</td>
</tr>
</tbody>
</table>
Technical Development

Sensor
Automated Evaluation – Labview

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Technical Development

Sensor Evolution
Technical Development

Conflicting Sensor Requirements:
1) High Power
2) High SNR

Pulsed Eddy Current - PEC
Technical Development

Preliminary Results

4 ½", 17lb Casing
Development Testing

Pulsed Eddy Current

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Development Testing
Casing and Target Characterisation

- Characterisation Runs in Sample of Specific Casing;
- Target Topology Input;
Development Testing

Casing and Target Characterisation

[Diagram showing Multi-Peaks and Cable Clamp with angular measurements]

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Development Testing
Opposite Crush Plates

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Development Testing

Opposite Back Channel

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Real-World Results

Software

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Real-World Results
Seven-Lobe Blast Protector

Result: 90 Deg target at 135 Deg

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Real-World Results

Data Accuracy, Repeatability and Consistency
Real-World Results

Data Accuracy, Repeatability and Consistency
Conclusions and Future Work

Conclusions

- ~1000 stations recorded to date;
- Reliable detection proven with various target forms;
- System requires little or no ‘expert’ input on the wellsite;
- Highly effective real-time QC;
- Results are available ‘real-time’;

Future Work

- Increase speed of scans;
- Machine learning to eliminate characterisation requirements;
QUESTIONS?
THANK YOU!