Successful Deployments of an Electro Hydraulic Firing Head in Norway

IPS 16-15

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Agenda

• Tool Description
• Tool Features
• Tool Function
• Case History
Electro-Hydraulic TCP Firing Head

• Very compact design
• 400°F (204°C) 30,000 psi (2,070 Bar) rated
• Requires specific series of pre programmed pressure cycles to function.
• Based on true TCP firing system technology rather than capacitors and electric detonators used in most other electronic firing heads.
• Can be run with another electro-hydraulic head, a pure hydraulic firing head, and a slickline or wireline deployed firing head for additional redundancy.
• Up to 14 weeks firing delay with auxiliary battery pack
## Intelligent Firing System Safety

<table>
<thead>
<tr>
<th>Design Feature</th>
<th>Initial Pick-Up</th>
<th>Running In-hole</th>
<th>Laying Down Guns</th>
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<tbody>
<tr>
<td></td>
<td>Prevents</td>
<td>Prevents</td>
<td>Valve actuated or leaked</td>
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<td>Hammer placement</td>
<td>Prevents detention via</td>
<td>Prevents detention via</td>
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<td>within tool</td>
<td>impact from foreign object</td>
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<td>actuated from drop</td>
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<td>Activated: lacks travel for</td>
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<td>minimum detonation impact</td>
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<td>Shear Pin / Hammer</td>
<td>Prevents</td>
<td>Prevents</td>
<td>Leak: prevents detonation</td>
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<td>Size*</td>
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<td>mechanical drop</td>
<td>from drop</td>
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<td>Pulsar Pressure Switch</td>
<td>Prevents actuation until</td>
<td>Prevents actuation until</td>
<td>Prevents actuation when</td>
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<td>Labyrinth seal</td>
<td>n/a</td>
<td>Prevents leak in valve from</td>
<td>Fully disables firing head.</td>
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<td>detonating guns by fully disabling firing head</td>
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Basic Tool Layout

Electronics section
Valve section
Hydraulic firing system
Perforating gun

Hydraulic firing system
Back-up firing head(s) above

FIRE
Electro-Hydraulic with Redundancy Feature

- Allows the use of a redundant Hydraulic Firing Head
- A second Electro Hydraulic
- A wireline retrievable firing head
Surface Pressure
1000
0

Downhole Pressure
30000
29000
28000

Pulsar Intelligent Firing System Actuation

Graph showing pressure changes over time with peaks at different intervals.
Pulsar Intelligent Firing System Actuation

Delay between receiving fire signal and actually firing

Time to Hold Pressure

How many times to apply pressure

Surface Applied Pressure

Surface

Downhole

Pressure

1000

4000

3000

2000

0

1000

2000

3000

4000

Surface

Downhole

Pressure

7:12

14:24

21:36

28:48

36:00

43:12

Time Elapsed

Applied Pressure

Time to Hold Pressure

How many times to apply pressure

Surface Applied Pressure

Delay between receiving fire signal and actually firing
Case History
Norwegian Case History

- Deploy gun oriented gun string
- Set 2 hydraulic packers
- Function test SSSV
- Pressure test both packers and tubing
- Cycle Electro-Hydraulic Firing Head
- 4 ½” MAGR automatically releases, leaving fullbore tubing string
Tool Settings

Firmware Version  T
SN: 150224-002

Arming Delay 45 Min  1 Min
Arming Temperature 158.4 °F  66 °C
Arming Pressure 1500 PSI  103.421 BAR
Hold Duration 6 Min  0 Sec
Applied Pressure 1537 PSI  103.972 BAR
Cycles 3
Firing Delay 0 Min  1 Min
TVD: 8135 ft

Mud Weight: 8.6 lb/gal
Temperature at TD: 254.2 °F

Sequence Timing

Start
Min  Sec  PSI
08  00  1537+/−384.25
12  00  0+/−384.25
16  00  1537+/−384.25
20  00  0+/−384.25
24  00  1537+/−384.25
28  00  0+/−384.25
32  00  0+/−384.25
36  00  0+/−384.25

End
Proof of Concept
Proof of Concept
Conclusion

- Reliable and Robust Design
- Adaptable to changing wellbore conditions
- Based on proven TCP technology
QUESTIONS? THANK YOU!