New Perforating Switch Technology Advances Safety and Reliability for Horizontal Completions

SLAP-16-5

2016 LATIN AMERICA PERFORATING SYMPOSIUM, BUENOS AIRES

OCTOBER 18, 2016

PRESENTER: Gerardo Arguello, Allied-Horizontal Wireline Services
AGENDA/INTRODUCTION

New Perforating Switch Technology Advances Safety and Reliability for Horizontal Completions

- Opening Remarks
- Evolution of Oil & Gas Perforation
- Operation of an EB Switch
- Disadvantages of an EB Switch
- Addressable Switch Technology
- Step change in Reliability
- Closing Remarks
- Q&A
Opening Remarks

WL – the decisive factor

- Increased Importance on Safety, Reliability and Efficiency in Oil & Gas
- Safety, Reliability and Efficiency is instrumental in lowering the overall Drilling & Completion Cost
- For Wireline Horizontal Completion:
  - Obsolete technologies are hindering in achieving superior safety and wellsite performances
  - Critical component which determines Safety, Reliability and Efficiency is the Perforation Switch
Evolution of Oil & Gas Perforation

- Explosive shaped charge perforating introduced in 1950’s
- EB Switch Technology introduced in 1970’s to allow multiple guns and select-fire perforating (Combination of diodes and pressure switches)
- Inception of Wireline Horizontal Completion (Plug and Perf) with pump-down method uses perforation guns, setting tool and composite bridge plugs

NEW PERFORATING SWITCH TECHNOLOGY ADVANCES SAFETY AND RELIABILITY FOR HORIZONTAL COMPLETIONS
Operation of EB Switch

- Positive (+) and negative (-) EB switches are available for selective firing.

- A diode is connected to each switch – only one gun will initiate per firing sequence as the desired depth.

- For sequence firing, dependent on pressure shock wave from detonation of the perforation guns.
Disadvantages of EB Switch

- Inadvertent detonation - Sensitive to Stray Voltage
- Personnel Dependency – Room for Error: Safety and Reliability
- Perforating the wrong interval
  - Inadvertent pressure (leaking subs/guns) can activate pressure switch
  - Repair requires costly resources
  - Lost production or sub-optimization
- Reliability Issues
  - Unable to check gun-string until at desired depth
  - When misrun occurs, operation halted – unable to skip guns
Addressable Switch technology

- **Surface control system**
  - Software application
  - Shooting Panel
  - Two-way communication

- **Electronic Switch device**
  - Single use, one per gun
  - IP address / Current + Gates
  - Mechanical deterrent optional

- **Initiation device**
  - Conventional deto
  - High Explosive RF Safe deto
  - Bridge Wire RF Safe deto
Step Change in Safety & Reliability

Addressable Switch – The Game Changer in Perforation

- Intrinsically-Safe Perforation System
  - Safety:
    - Intelligent electronic circuitry
    - Block inadvertent current
    - Redundancy of RF-Safe perimeter
  - Reliability and Efficiency:
    - Ability to check gun-string multiple times – surface and downhole
    - Real-time shot detection
    - Ability to skip guns
    - Simplified Wiring reduces human error
    - Robust components

- Trouble-shooting for Continuous Improvement
  - Real-time event file recorded (assists troubleshooting)

### EB Switch

<table>
<thead>
<tr>
<th>EB Switch</th>
<th>Addressable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Mechanical parts</td>
</tr>
<tr>
<td>No</td>
<td>Gun skipping</td>
</tr>
<tr>
<td>No</td>
<td>Test at surface</td>
</tr>
<tr>
<td>No</td>
<td>Test downhole</td>
</tr>
<tr>
<td>No</td>
<td>Shot verification</td>
</tr>
<tr>
<td>No</td>
<td>Fails safe</td>
</tr>
<tr>
<td>1-4</td>
<td>Misruns/100 runs</td>
</tr>
</tbody>
</table>
Closing Remarks

Safety:
Unintentional Detonation can result in loss of life.

Reliability & Efficiency:
Reduce Human Dependency
Mediocre performances is no longer accepted

Overall Cost:
Increase Efficiency > Decrease Non-Productive Time

Off depth Perforation

Obsolete Technology:
EB Switches are almost 50 Years Old

% Efficiency

Introduction of Addressable Switches
QUESTIONS?
THANK YOU!

<table>
<thead>
<tr>
<th>What are the odds...</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rolling a pair of sixes</td>
<td>1: 35</td>
</tr>
<tr>
<td>Killed in a road accident</td>
<td>1: 8,000</td>
</tr>
<tr>
<td>Getting hole in one</td>
<td>1: 12,000</td>
</tr>
<tr>
<td>Getting an injury from fireworks</td>
<td>1: 19,000</td>
</tr>
<tr>
<td>Date a supermodel</td>
<td>1: 19,556</td>
</tr>
<tr>
<td>Struck by lightning</td>
<td>1: 750,000</td>
</tr>
<tr>
<td>Spotting a UFO today</td>
<td>1: 3,000,000</td>
</tr>
<tr>
<td>Killed in a tornado</td>
<td>1: 5,000,000</td>
</tr>
<tr>
<td>Struck by lightning – twice</td>
<td>1: 9,000,000</td>
</tr>
<tr>
<td>Killed in an airplane crash</td>
<td>1: 11,000,000</td>
</tr>
<tr>
<td>Killed by a falling coconut</td>
<td>1: 250,000,000</td>
</tr>
<tr>
<td>Killed by a shark</td>
<td>1: 300,000,000</td>
</tr>
<tr>
<td>Unintended initiation of Addressable Switch detonator</td>
<td>1: 72,000,000,000,000,000,000</td>
</tr>
</tbody>
</table>