Increasing Safety by Advancing Perforating Technology

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- Abstract

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  - Electronic vs Mechanical Switches
  - Packaged Initiation Devices

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  - Plug & Play and Disposable Gun systems

- **Perforating Hardware**
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  - Improved/Disposable Downhole Hardware
  - Greaseless Coated Wireline

- Q&A
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Abstract

- Maximizing efficiency is the main objective of Perforating Technology
- Increased safety is a natural byproduct
- Technology Improvements -> Reliable operations -> Reduce human error
- Most safety incidents occur after a misrun
- Reliable Product(s) -> Less chance a rushed operator skips SOP or takes shortcuts
- New Technology transformed the industry by increasing efficiency, reliability and safety, while staying economically feasible in a cost-sensitive market
Select Fire Perforating
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Addressable Switches

- **Addressable Switch Technology**
  - Reduces misruns with its ability to skip over misfired guns
  - Reduces NPT with Real time switch communication downhole
  - Electrically unarmed at surface by default/design
  - Real time surface shot confirmation
  - Some systems are capable of running 100+ guns in a single run
  - Proven & Reliable technology
Addressable Switches

- **Electronic Switches vs. Mechanical Switches**
  - Most incidents occurred after a misrun or during troubleshooting and inspection
  - Increased reliability of addressable switches has reduced opportunities for safety incidents to occur
  - Increased market year after year due to safety benefits, operational advantages and price reductions
  - The implementation of addressable switches has improved industry ratio of runs-to-misruns from 40 to 100-300

<table>
<thead>
<tr>
<th>Year</th>
<th>Mechanical Switch</th>
<th>Electronic/Addressable Switch</th>
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<tbody>
<tr>
<td>2012</td>
<td>94%</td>
<td>6%</td>
</tr>
<tr>
<td>2013</td>
<td>86%</td>
<td>14%</td>
</tr>
<tr>
<td>2014</td>
<td>73%</td>
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<td>2015</td>
<td>63%</td>
<td>37%</td>
</tr>
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<td>2016</td>
<td>61%</td>
<td>39%</td>
</tr>
<tr>
<td>2017</td>
<td>59%</td>
<td>41%</td>
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<tr>
<td>2018</td>
<td>48%</td>
<td>52%</td>
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<tr>
<td>Est. 2019</td>
<td>~30%</td>
<td>~70%</td>
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Addressable Switches

- **Packaged Initiation Devices**
  - Fully encapsulated wires/connections reducing failure-prone points
  - Eliminate wiring issues in tandem subs
  - Eliminate wiring issues between bottom gun and plug switch
  - Increased reliability = less opportunity for a miss run and reduced exposure to live explosives at surface
Perforating Gun Systems
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Plug & Play and Disposable Perforating Gun Systems

- Engineered out root cause(s) of SQ failures
  - Failures analysis and tracking showed 32% due to pinched or nicked wire(s)
  - Less connections, enclosed wires, or No wire connections at all
  - No ports or port plugs
  - Reduced maintenance

- Case Study - A service company and operator in west Texas tracked efficiencies running a plug and play disposable Perforating Gun System for a 3 month period
  - Ran 500 stages totaling 2000+ guns before having a miss run. Prior, best run rate was 100 using conventional wired guns
  - 80% improved reliability and efficiency in gun loading, arming, and assembly operations compared to conventional select fire systems.
  - Safer operations as no opportunities were presented for bringing a live miss fired gun string out of hole
Perforating Hardware
Perforating Hardware

- **Improved/Disposable Downhole Hardware**
  - Uniform diameter, robust quick changes less prone to breaking
  - Disposable tandems and top subs eliminate maintenance
  - Disposable Setting Tools eliminate user error

- **Man-less Wellhead Connections**
  - Safe and quick connection of Wireline Pressure Control Equipment to wellhead
  - Remotely operated/controlled to remove individuals from dangerous and compromised positions under suspended loads
  - Reduces exposure/operation around pinch points to reduce hand injuries while making connections
  - Eliminates time consuming activities (man basket) to provide better wellsite efficiency
  - Reduces wellsite personnel/crew
  - Allows for gunstring/lubricator stabbing on/off during frac ops without getting into the hot-zone
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Perforating Hardware

- **Greaseless Coated Wireline**
  - No grease needed for pressure control – reducing operating cost significantly
  - No stranded armor procedures reducing risk of operating on pressurized vessels at close proximity
  - Jacketed cable reduces downhole friction, resulting in less tension during operation
  - Less tension reduces chances of wireline, sheave wheels, and/or rig-up equipment breakage on surface (attempts to free stuck tools/cable downhole) reducing injuries
  - Time saving for reheads – every 40 runs rather than every 5 runs
  - 5-10 gallons per stage and more for extended reach ($8 to $12 per gallon)

- **Case Study/Example (Standard):**
  - 120 stages job requires 23 reheads (35min.) = 805 minutes = 13.5 hours
  - 120 stages job requires 7 gallons/stage = 840 gallons = $8,400.00

- **Case Study/Example (Greaseless Wireline)**
  - 120 stages job requires 2 reheads (50min.) = 100 minutes = 1.66 hours
  - 120 stages job requires NO GREASE = $0.00
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Conclusion

- Reliability and efficiency are the primary objectives in advancing perforating technology

- Reliability -> reduced opportunity for handling miss run explosives -> Safer Operations

- Efficiency -> reduced human interaction with equipment -> reduced opportunity for human error -> Safer Operations

Let’s Increase Safety by Advancing Perforating Technology...
QUESTIONS?