Selective Perforation: A Game Changer in Perforating Technology - Case Study

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Layout

- Background
- Selective Perforation: Past / Present
- Selective Perforation: Future
- Selective Gun: Future
- Gun–Assembly, Application
- Case Study
Perforation engineering is a key element in successful well stimulation / production / injection.

Selective perforation gun is required when multiple zones have to be perforated in a single run.
Selective Perforation

- Significant hardware
- Reliable equipment
- Engineer competency
- Minimize failure modes
- Maintain high safety standard
Selective Technology: Past
Selective Technology: Present
Downhole Switch Communication

396830 (tWitmCons): T7:0x1072D34 - Top ASFS(72D3), receives communication voltage and responds “Normal”
396830 (tWitmCons): T7:0x00000022 - Internal WAFE code setting up firing sequence
396830 (tWitmCons): T7:0x1072D34 - WITM sends “Turn on W/L FET” command
396830 (tWitmCons): T7:0x0072D34 - Switch responds “Wireline FET” on
396830 (tWitmCons): T7:1

396830 (tWitmCons): T7:0x100F65 - 2nd ASFS from top, (0F65) now receives voltage and responds “Normal”
396830 (tWitmCons): T7:0x100F65 - WITM sends “Turn on W/L FET” command
396830 (tWitmCons): T7:0x100F65 - Switch responds “Wireline FET” on

396830 (tWitmCons): T7:1
396830 (tWitmCons): T7:0x100E00 - 3rd ASFS from top, (08E0) now receives voltage and responds “Normal”
396830 (tWitmCons): T7:0x100E01 - WITM sends “ARM” command
396830 (tWitmCons): T7:0x100E01 - Switch Responds “Armed” (ARM FET on)
396830 (tWitmCons): T7:-202
396830 (tWitmCons): T7:7
396830 (tWitmCons): T7:0x1108E02 - WITM sends “FIRE” command
396830 (tWitmCons): T7:0x1108E03 - Switch responds “FIRING” (Deto FET is turned on) At this point the user turns the variac up, and the power is routed to the detonator.
Selective Technology: Risk

- Manual handling
- Mistakes while crimping connections
- Possibility of pinch wire
- Adaptors
- Time-consuming operation
  - Typically every gun ~ 5 connection
  - Assume 1 min per connection
  - Considering 17 guns per run
    - Time required for making connections
    - 17*5 ~ 85 mins
Selective Technology: Future

SafeJet - A gun system that is transported in the fully assembled form from the gun shop to the well location and is ready to run in hole.

- Fully addressable and RF safe (up to 40 guns/run)
- 3 1/8" diameter
- 16" makeup length
SafeJet: Reliability & Efficiency

Pre-assembled with wiring and detonator cord - no booster, no crimping

SafeJet board (ASFS* + Secure* Technology)

Disposable bulkheads
SafeJet: Rig up

<table>
<thead>
<tr>
<th>Perforation using TuffTRAC + 2&quot; guns</th>
<th>Perforation using TuffTRAC + SafeJet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part</td>
<td>Length (m)</td>
</tr>
<tr>
<td>Tuff TRAC</td>
<td>3 drive section 0.40</td>
</tr>
<tr>
<td>CCL / ATPS/ Logging head/Head Tension</td>
<td></td>
</tr>
<tr>
<td>Electrical release</td>
<td></td>
</tr>
<tr>
<td>Swivel</td>
<td>0.60</td>
</tr>
<tr>
<td>CCL-Gun Adaptor</td>
<td>0.13</td>
</tr>
<tr>
<td>Firing Head</td>
<td>0.14</td>
</tr>
<tr>
<td>HSD gun</td>
<td>0.61 5.49</td>
</tr>
<tr>
<td>Selective firing adaptor</td>
<td>0.63 9.57</td>
</tr>
<tr>
<td>Spacer + Male Male end to end adapter</td>
<td>0.42</td>
</tr>
<tr>
<td>End to End adapter</td>
<td>0.14</td>
</tr>
<tr>
<td>Bottom gun</td>
<td>1 0.61</td>
</tr>
<tr>
<td>INDEXING FIRING HEAD</td>
<td>0.17</td>
</tr>
<tr>
<td>MPD*1</td>
<td>1.00</td>
</tr>
<tr>
<td>MPD*2</td>
<td>1.00</td>
</tr>
<tr>
<td>CCL-MPD ADAPTOR</td>
<td>0.02</td>
</tr>
<tr>
<td>Bottom Nose</td>
<td>0.08</td>
</tr>
<tr>
<td>(m)</td>
<td>21.87</td>
</tr>
<tr>
<td>Total gun sections</td>
<td>10 (ft) 71.72</td>
</tr>
</tbody>
</table>

| Part                                 | Length (m)                           |
| CCL-Gun Adaptor                      | 0.13                                 |
| Firing Head                          | 0.14                                 |
| SafeJet Gun                          | 0.45 10.80                           |
| WPFD + Adaptors                      | 4.20                                 |
| Bottom Nose                          | 0.08                                 |
| (m)                                  | 22.35                                |
| Total gun sections                   | 24 (ft) 73.28                        |

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Case Study

Perforating Heavy-Wall Pipe in a Horizontal Well, Offshore Norway

TuffTRAC tractor multiple runs convey 180 single-shot SafeJet perforating guns

**CHALLENGE**

Perforate a 4,100-ft pay zone in a horizontal well through 9¼-in heavy-wall liner at one shot every 25 ft.

**SOLUTION**

Convey 180 selective single-shot SafeJet perforating guns delivering the specified entry hole size on the TuffTRAC downhole wall tractor system in multiple runs.

**RESULTS**

Successfully perforated the 4,100-ft zone as specified in two phases.

Perforating a 4,100-ft pay zone in a horizontal well

An operator needed to perforate a horizontal production well offshore Norway with a reservoir pay zone of approximately 4,100 ft. Perforating was to be conducted in two phases of the toe half and then the heel half of the pay zone. A particular entry hole size was specified for the perforations in the 9¼-in heavy-wall liner with one shot approximately every 25 ft. At 90 holes per phase, a total of 180 shots was required.

![Diagram showing depth and location of perforations](image)
SafeJet: Value

![SafeJet Value Chart](chart.png)

- X-4: 3 Runs Saved
- X-3: 2 Runs Saved
- X-2: 5 Runs Saved
- X-1: 4 Runs Saved

Legend:
- 2” Alternative
- SJ Actual Runs*
- SJ Planned Runs
Thanks for your time

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