Environmental Parameters for Cutters & Severing Tools – A Case for Industry Action

NAPS-49-18
AUTHORS: John Carminati - Shell
• Discussion limited to explosive cutters and severing tools
• Field examples
• Databases
  • Empirical performance under pressure and target
• API19PT proposal
## Cutter Selection Considerations

<table>
<thead>
<tr>
<th></th>
<th>Chemical</th>
<th>Explosive</th>
<th>RTC</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID Restrictions &amp; standoff</td>
<td>Large tool OD, most affected by standoff</td>
<td></td>
<td>Small tool OD, least affected by standoff</td>
</tr>
<tr>
<td>Temperature limits</td>
<td>45° - 300°F</td>
<td>Explosive dependent</td>
<td>O-ring material dependent</td>
</tr>
<tr>
<td>Fluid in the hole</td>
<td>ZnBr2, mud cake</td>
<td>&lt;18 ppg</td>
<td></td>
</tr>
<tr>
<td>Scales and GRE</td>
<td>Both</td>
<td></td>
<td>GRE</td>
</tr>
<tr>
<td>Metallurgy</td>
<td>22Cr &amp; higher</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wall thickness</td>
<td>Poor for thick wall</td>
<td>Good for thick wall</td>
<td>Poor for thick wall</td>
</tr>
<tr>
<td>Hydrostatic Pressure</td>
<td>&lt;12,500 psi</td>
<td>Important parameter</td>
<td></td>
</tr>
<tr>
<td>Stub condition</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possible casing damage</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Debris</td>
<td>Yes</td>
<td></td>
<td>Yes with slag</td>
</tr>
<tr>
<td>Anchor</td>
<td>Yes</td>
<td></td>
<td>No</td>
</tr>
</tbody>
</table>
Unreliable or misapplied?

- International asset with numerous pipe recovery operations during the 2016-2018 campaign
- One well (with several sidetracks) had 31 days of NPT attributable to severing tools
  - One in 10 runs was successful
  - Sever 8” x 2.812” drill collars at 12,000 psi static pressure at 5,000m (1.9 SG)
- Tender Scope of Work did not include sufficient environmental variables
  - Supplier tool information packs state survival, not operational pressures
    - The difference is often not caught because of roles within operating companies (contract vs well engineers)
    - Incomplete scope of work hinders knowledgeable tender clarifications
- Is functionality modeling good enough ($)? Or is a physical test needed ($$)?
  - Modeling must be calibrated to test or field data
    - Successful environmental data not captured in supplier supplied databases
- Tool was a supplier passthrough
  - Complicates environmental parameter knowledge flow
Shell database

• Shell began compiling a database in 1994
  • Contains 174 total job entries – with gaps
• Database captures 38 job attributes
• Not maintained since 2013
• Separate database exists for HPHT

• Database is to be searched against supplier recommendations
  • Historical databases can indicate what worked, but not the limits

• If in doubt, set up test which replicates downhole conditions
• Mixed results when hydrostatic pressure is greater than ~50% of cutter rating
Testing does add value

• Tubing cutter was not tested at Downhole pressure conditions – 14 days NPT
• Testing of different cutters prevented fishing operation saving 5+ days
• Success rate <65%
  • 1.55 attempts/cut in ‘02–’05 campaign
• Multivariant analysis
  • Standoff
  • Hydrostatic pressure
Temperature and Pressure Rating

<table>
<thead>
<tr>
<th>Tool OD</th>
<th>1-3/8”</th>
<th>1-3/4”</th>
<th>2”</th>
<th>2-5/8”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designed to Sever up to</td>
<td>3-1/2” OD DC’s</td>
<td>6-1/2” OD DC’s</td>
<td>8” OD DC’s</td>
<td>11” OD DC’s</td>
</tr>
<tr>
<td>Temperature and pressure rating</td>
<td>HMX - 400°F (204°C) 20,000 psi (138 Mpa) for 1 hour</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Operating Pressure</td>
<td>20,000 psi</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum operating temperature</td>
<td>238°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mud type or weight limitations</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Severing tools available for Supplier A, Supplier B, Supplier C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Definitions are not included with datasheets, so “inconstancies” are perceived.

Temperature and pressure ratings normally quoted at survival or initiation conditions.

During the RCFA, it was discovered that this severing tool was only effective to 12,000 psi.
RCFA findings

- Ballistic output has not been tested at all the various pressure and explosive weight combinations.
- Supplier qualification focuses on the ability of the firing mechanism to detonate at a given pressure.
  - Operators want to know performance limitations.
- Although some empirical testing has been performed, there is not a good understanding of the limitations of a given severing tool.
- Coupon penetration varies.
- Severing tool manufacturing QA may not include destructive testing of batch lots.
- Contingency with insanity – Repeat w/ a similar cutter.
- Compensating for generic design with more explosive.
Database issues

• Tool traceability
• Access to databases, knowledge networks, etc.
• Visibility to new engineers
• Database ownership and verification
• Difficult to fill a new data column in existing databases
• Specific cutter identification difficult – Supplier and size only
• Pass through cutters not identified correctly
• Supplier job histories do not contain results and environmental data
Proposal

• Discussed at API19B meeting in May
  • Recommendation made to 19SC for a new specification, API19PT (Perforating Tools)

• Propose that technical specs for cutters and severing tools be include in 19PT
  • Traceability
  • Manufacturing QA testing
  • Receipt inspections of outside purchased parts
  • Definition of temperature and pressure limits on data sheets
  • Suggest adding operational limits if known

• Consider adding Qualification Testing
  • Quantify penetration vs. environmental conditions (temperature & pressure)
  • Get Boundaries on lower, average, upper pressure limits
QUESTIONS? THANK YOU

NAPS-49-18
AUTHORS: John Carminati, David Moss - Shell