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

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Agenda

- Discussion limited to explosive cutters and severing tools
- Field examples
- Databases
  - Empirical performance under pressure and target
- API19PT proposal

Cutter Selection Considerations

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

Unreliable or misapplied?

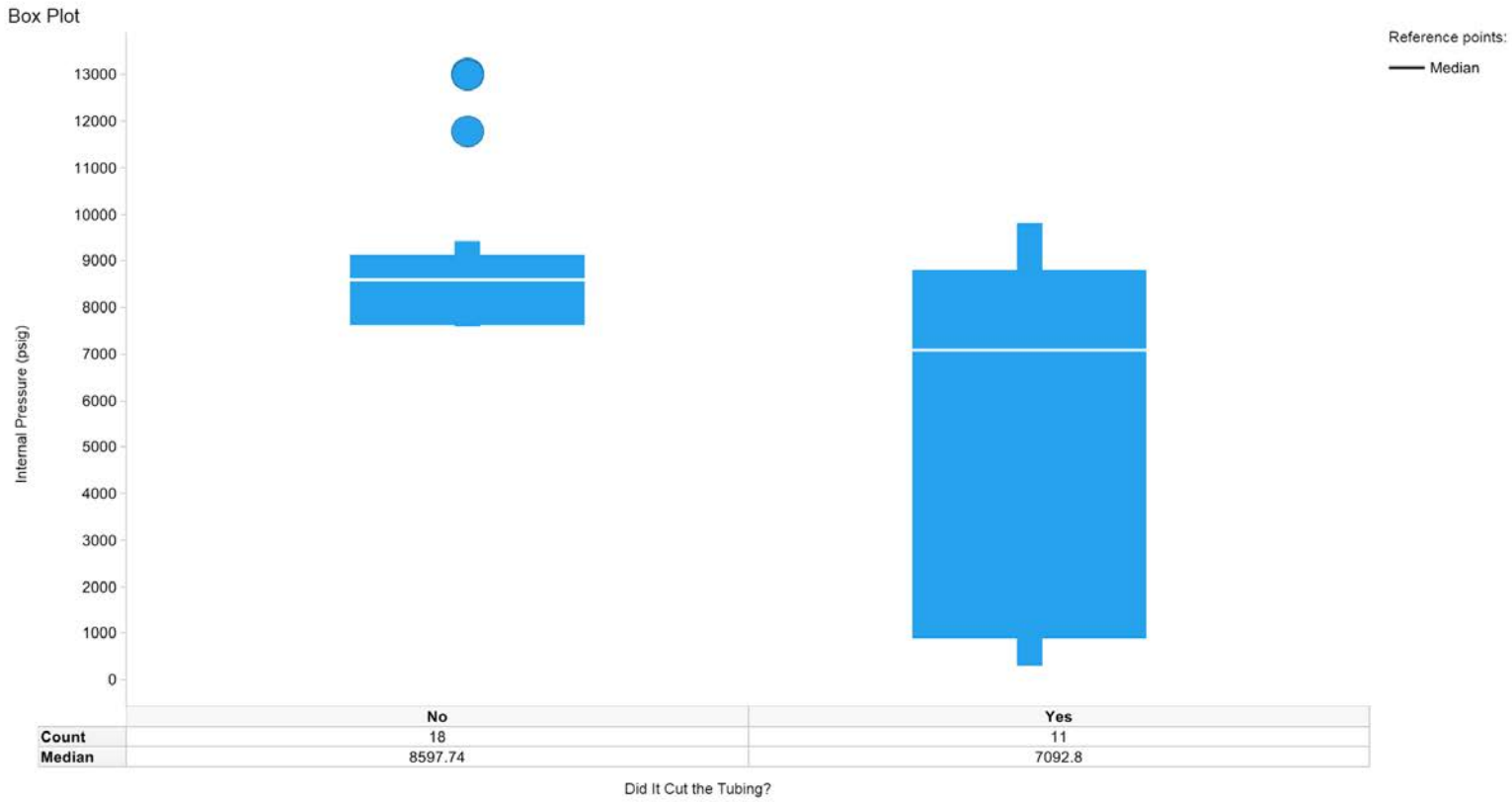
- International asset with numerous pipe recovery operations during the 2016-2018 campaign
- One well (with several sidetracks) had 31 days of NPT attributable to severing tools
  - One in 10 runs was successful
  - Sever 8” x 2.812” drill collars at 12,000 psi static pressure at 5,000m (1.9 SG)
- Tender 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

Cut Attempt #	Tubing Type	External Pressure (psig)	Tubular-Tool Clearance (in)	Did It Cut the Tubing?	Did Cutter Run as Designed?	Complete Tool Recovery (Also see comments)
1	2 7/8"			Yes	Yes	Yes
1	2 7/8"			Yes	Yes	Yes
1	3 1/2"			Yes	Yes	Yes
1	3 1/2"			No	No	Yes
2	3 1/2"			No	No	Yes
3	3 1/2"			Yes	Yes	Yes
1	2 7/8"			Yes	Yes	Yes
1	3 1/2"			No	No	Yes
2	3 1/2"			No	No	Yes
3	3 1/2"			Yes	Yes	Yes
1	2 7/8"			Yes	Yes	Yes
1	2 7/8"			Yes	Yes	Yes
1	2 7/8"			Yes	Yes	Yes
1	2 7/8"			Yes	Yes	Yes
1	4"					
1	3 1/2", 10.2#, 125k, 22 Chrome	9265.95	0.1485	Yes	Yes	Yes
1	3.5" 10.2# 13Cr-110		0.422			
1	3 1/2", 10.2#, 125k, 22 Chrome	9858.992	0.1485	Yes	Yes	Yes
1	3-1/2" 10.2#	8942	0.1485	Yes	Yes	Yes
1	mech cutter - did not function					
2	2 7/8"		0.316			
1	3.5", 15.1#, 110k, 13 Chrome	8518	0.367	Yes	Yes	Yes
1	2 7/8", 7.7#, 110k, 13 Chrome	9335.924	0.099	Yes	Yes	Yes
1	(no cut made)					
2	(cutter fired - no cut)		0.441			
3	3.5" 10.2# 22Cr		0.922			
1	4.5" 15.1# 13CR-110					
1	3 1/2", 10.2#, 125k, 22 Chrome	10150.344	0.1485	No	No	Yes

Shell database

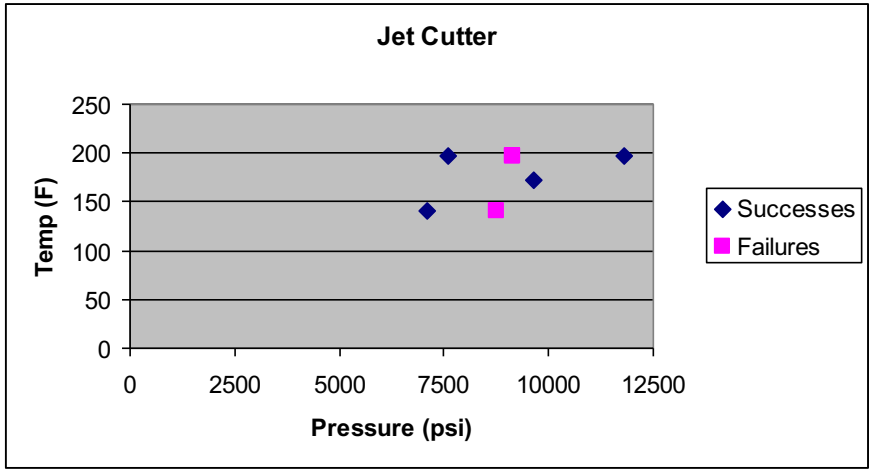


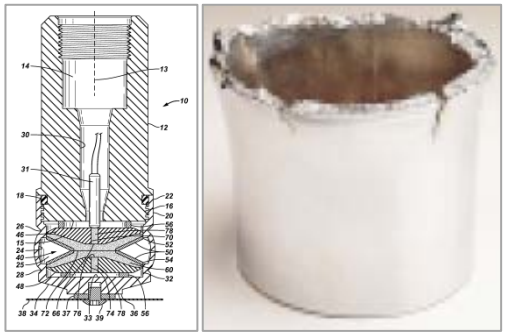
	No	Yes
Count	18	11
Median	8597.74	7092.8

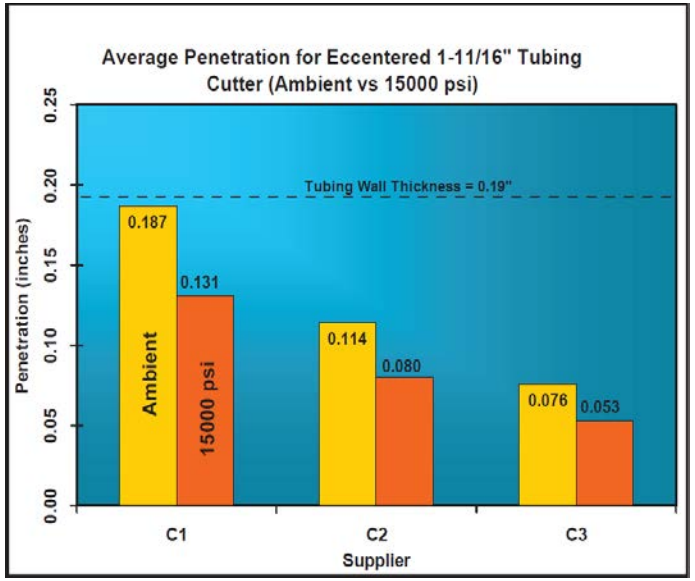
- Mixed results when hydrostatic pressure is greater than ~50% of cutter rating

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







WT Bell

Technical Data Sheets

Tool OD	1-3/8”	1-3/4”	2”	2-5/8”
Temperature and Pressure Rating	HMX - 400°F (204°C) 20,000 psi (138 Mpa) for 1 hour			
Designed to Sever up to	3-1/2” OD DC’s	6-1/2” OD DC’s	8” OD DC’s	11” OD DC’s

Maximum Operating Pressure	**20,000 psi**
Maximum operating temperature	**238°C**
Mud type or weight limitations	N/A
Severing tools available for Supplier A, Supplier B, Supplier C	

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

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