API RP19B
Recommended Practices for Evaluation of Well Perforators

MENAPS

Presented by
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Shell
Chair API RP 19B Committee
API RP19B Background

1. Significant desire from the Operator and Contract perforating community to re-evaluate the current API RP19B Recommended Practices

2. 19B was due for renewal or reaffirmation this year

3. Agreement was finally reached in October 2010 for all Sections to be revisited

4. Individual working groups set up on all 6 sections

5. Section 4 working group have submitted revised section for approval by the SC19 and 19B committee

6. Addition of new section 6 for gun swell standard

7. Ongoing laboratory testing to identify possible candidate RPs for Penetration data
1. Current API RP19B standards overview & addition of Sect. 6

2. Background to requirement for an improved procedure for the standardised measurement of penetration and hole size

3. Possible solutions for consistent and repeatable measurement of penetration

4. How improved penetration measurement could improve modelling of perforator performance in reservoir conditions

5. Resolution of issue regarding stress profile in Section 2 and Section 4 test cells
Section 1: Evaluation under surface conditions in concrete targets

Section 2: Evaluation under stress conditions in rock targets

Section 3: Evaluation under elevated temperatures

Section 4: Evaluation of flow performance under simulated downhole conditions

Section 5: Debris Evaluation

Section 6 (new): Standard for measurement of gun swell
Section 1: Evaluation under surface conditions in concrete targets

- Provides a fit-for-purpose method of identifying – variability in charge data (LP & EHD) – charge interference – verified QC test – but also used as benchmark for charge penetration.
- Although designed to be consistent and arguably an improvement on API RP 43 Section 1 target – is know to be inconsistent and unsuitable reference for reservoir penetration benchmark.

“Penetration Data recorded in API RP19B Section 1 may not directly correlate to penetration downhole”.
Section 2: Evaluation under stress conditions in rock targets

- Basic test to measure stressed rock penetration profile and performance.
- Can be expanded to different rocks, diameters and stress conditions.
- Could be used as one of the systems for improved charge performance testing using a selection of outcrop rock or synthetic rock targets.
- Possibly look at different diameter target as standard.
Section 3: Evaluation under elevated temperatures

- Tests charge performance due to temperature
- But target is not corrected for temperature and test is expensive
- Committee is looking at potentially updating several aspects of the test.
Section 4: Evaluation of flow performance under simulated downhole conditions

- Suitable for evaluating flow, penetration and dynamic perforating event under simulated wellbore and reservoir conditions.

- Section 4 has been rewritten due to need to improve the correlation in performance between the different test cells in the market and has been submitted to vote this month.
Section 5: Debris Evaluation

- This is a relatively new standard and requires revisiting to ensure that the standard is fit-for-purpose.
- Committee agreed on reviewing the standard and are currently identifying significant changes to improve the RP.
Section 6 (new): Standard for measurement of gun swell

• Currently no standard for gun swell. Increased use of high performance small diameter carrier guns in Thru-Tubing operations has resulted in the requirement for a standard fit-for-purpose method of measuring swell.

• Committee agreed on preparing a new standard, currently suggesting the introduction of a set of standard 18in long drift gauges.
API RP19B 2. Penetration - Background

- As Operators – we like to know within reasonable limits the characteristics of the perf tunnel:– length, width, entrance hole, tunnel condition, crush zone etc.

- Unfortunately - there are a large number of factors that influence rock penetration and performance profile in the reservoir. For sandstones, these include but are not limited to:
  - Charge and gun design
  - Well bore conditions – (which includes everything between the gun and the reservoir)
  - Pore pressure, confining stresses and localized stress effects from the perforation itself
  - Rock properties – (strength/size/type/ and distribution of grains, porosity, density, cementitious matrix, pore fluid, bedding, calcite veins and fracture planes etc.)

- Current practice – only using data from Section 1 gives us the following level of inaccuracy:-
This shows that unstressed Section 1 concrete data provides little useful reference to stressed rock penetration or in-situ reservoir rock penetration.
3. Consistent Penetration

- Given that the current practice is not suitable for penetration measurements, need a:
  
  • consistent repeatable target material that is analogous to typical reservoir rocks
  
  • a set of test cell conditions that can provide an adequate representation of stressed conditions with consideration to cost of test and target material

- Materials that have been considered include stacked metal plates, Berea Sandstone, other consistent outcrop rocks, CIPs (Calcite In-situ Precipitation) and other synthetic rocks (synthetic rocks generally being a graded stressed quartz sand and quartz powder with a matrix partially filled with cementitious material to retain porosity)

- test cells considered vary from cardboard tubes, Section 2 cells, stone slab based triaxial frames and confinement steel clamps.
4. Penetration Modelling

- Given that it is possible to achieve agreement on penetration measurement – it is also necessary to look at how this stressed rock type data can be transferred meaningfully to a model for in-situ reservoir rock penetration.

- In addition – the ability to characterize the performance of a charge from a performance test or tests, is a necessary prerequisite to developing a useful model.

- While modeling itself is not within the remit of API RP 19B – it would be valuable to the industry to consider a standardized model.
API RP19B  4. Penetration Modelling

API Concrete penetration
Same gun & DP charge size

Required test points? - Defines slope and intercept

Rock Strength Indicator due to Confinement and Pore Pressure – psi.

Penetration in Stressed rock

Modified representative data not actual numbers
5. Stress Profiles in Targets

- When shooting targets in Sect. 2 & 4 under radial confinement – how confident are we that stress is reaching the core of the target and does it matter

- Stressed shots into big block targets and 7in rock cores with similar stress conditions indicate that radial stress applied to cores reaches the centre of the core

- Strain instrumented synthetic rock target – that is unlikely to have simulated actual stressed rock conditions – indicated only a relatively small portion of stress reached the centre of the target

- Need an alternative and definitive method of measuring stress in radially stressed cores – Ultrasonic Tomography
Planes to be imaged in CT and UT imaging

Ver 1

Ver 2

One plane above the perforation shot tip

hor 1

Perforation shot

hor 2

One plane across perforation diameter

Planned acoustic arrays for imaging samples under pressure

20 sensors in each vertical plane

20 sensors in each horizontal plane

Planned acoustic arrays for imaging samples under pressure

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20 sensors in each horizontal plane

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Rewriting and amending Recommended Practices is time consuming and requires significant expertise in the subject matter – appreciation is due to the volunteers who make this happen for our industry.

**Section 1, RP 19B**
Co-chairs - Rodger Anderson & Tim Sampson  
Committee - Tim Golian, Nathan Clark, Tony Grattan, Matthew Clay, Steve Barnes

**Section 2, RP 19B**
Co-chairs - David Atwood & John Hardesty  
Committee - Tim Sampson, Tim Golian, Doug Manning, Denis Haggerty, Brendan Grove, Kent Folse, Liam Mc Nelis

**Section 3, RP 19B**
Co-chairs - James Barker & Mark Sloan  
Committee - David Atwood, Rodger Anderson, Tim Golian, Andy Pettitt,

**Section 4, RP 19B** – Already submitted  
Co-chairs - David Atwood & John Hardesty

**Section 5, RP 19B**
Co-chairs - Rodger Anderson & Steve Zuklic  
Committee - Tim Golian, Alphie Wright, Jerry Walker

**Section 6, RP 19B, New section for gun swell**
Co-chairs – Jason McCann & Tim Golian  
Committee – Thilo Scharf, Andy Martin, Terry Widner, Jim Rollins, Cory Day, TBA

**RP-67**
Co-chairs - James Barker & Dan Pratt  
Committee – Alphie Wright, Andy Pettitt, Jim Ellis, Kent Folse, Phil Crabtree, Randy Evans, Bob Ference, Hanaey Ibrahim, Steven DeLozier, David Leidel,