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

API RP19B Contents

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

API RP19B 1. Current API Standards Overview

Section 1: Evaluation under surface conditions in concrete targets

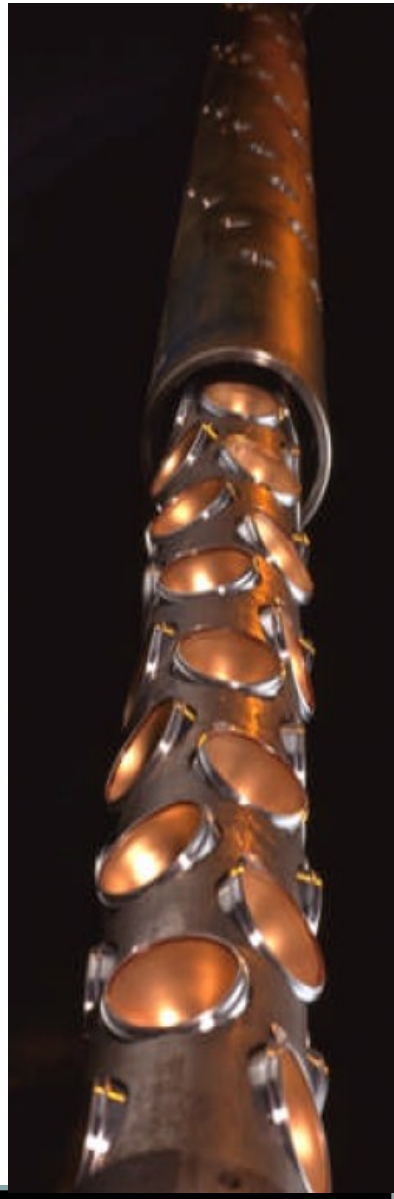
Section 2: Evaluation under stress conditions in rock targets

Section 3: Evaluation under elevated temperatures

Section 4: Evaluation of flow performance under simulated downhole conditions

Section 5: Debris Evaluation

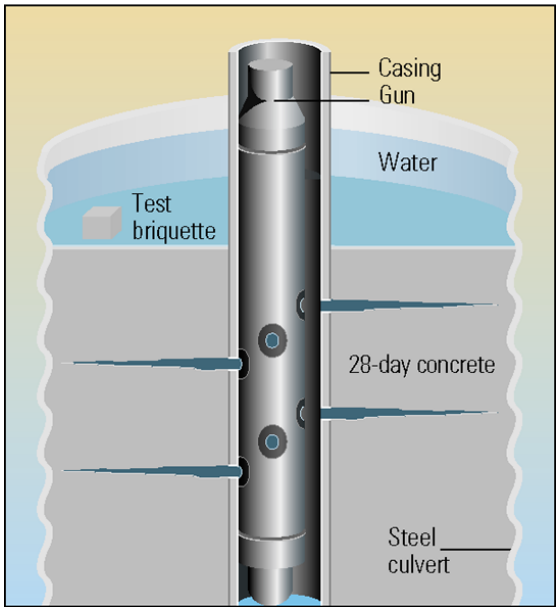
Section 6 (new): Standard for measurement of gun swell



API RP19B 1. Current API RPs Overview

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.

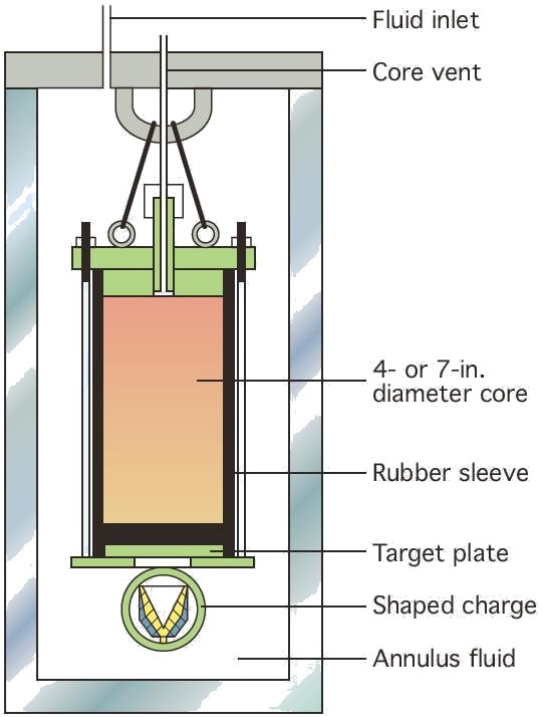


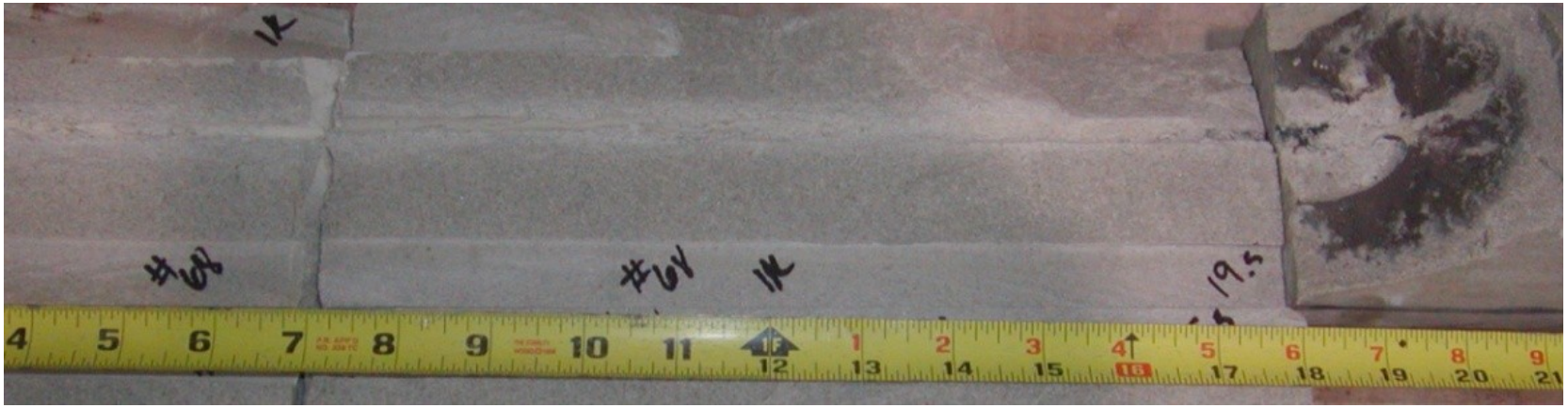
"Penetration Data recorded in API RP19B Section 1 may not directly correlate to penetration downhole".

API RP19B 1. Current API RPs Overview

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.*

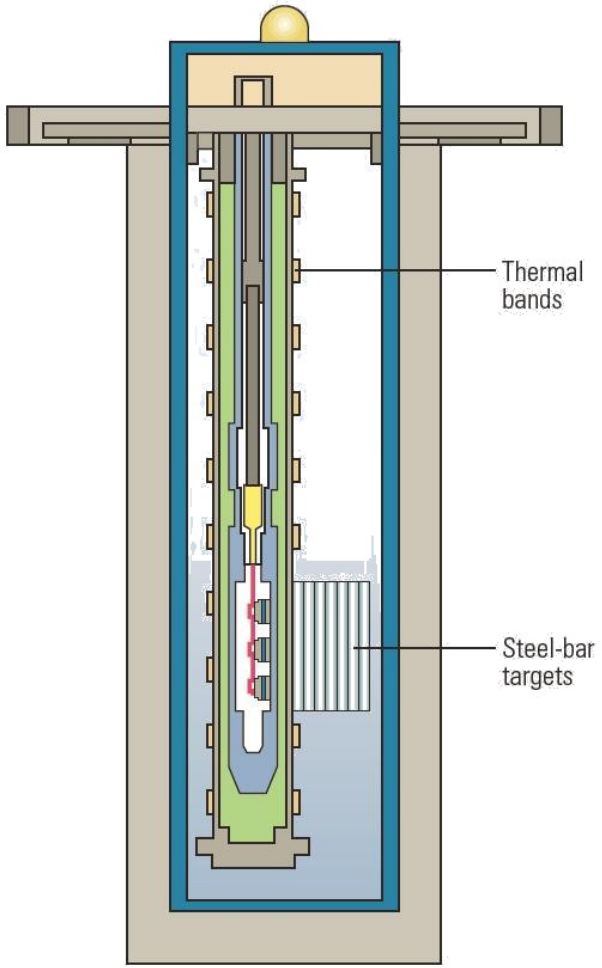




API RP19B 1. Current API RPs Overview

Section 3: Evaluation under elevated temperatures

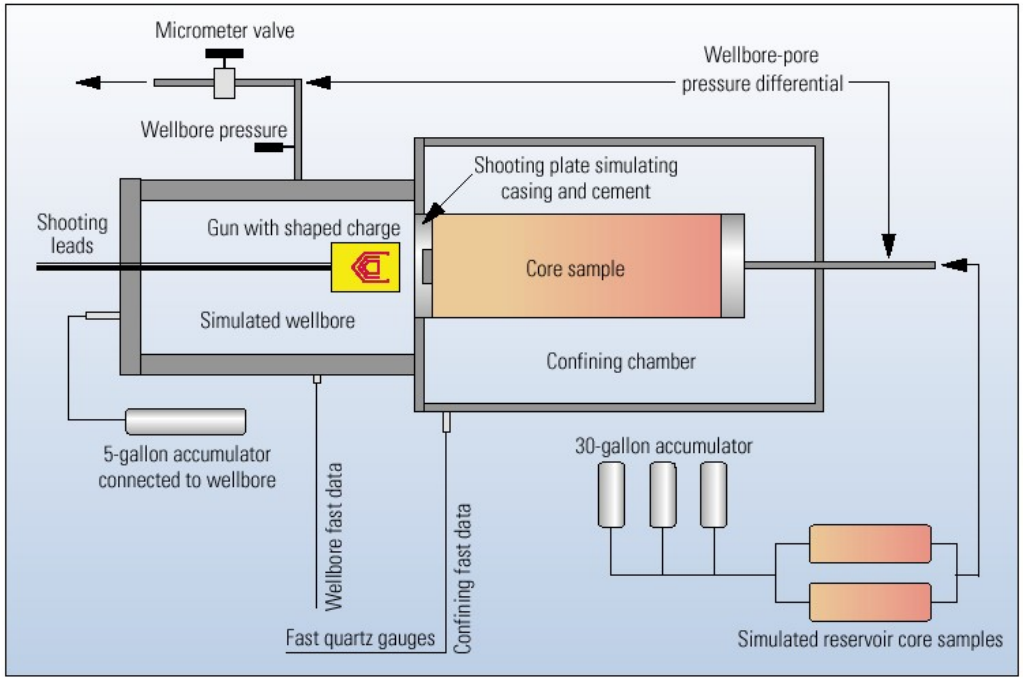
- Tests charge performance due to temperature
- But target is not corrected for temperature and test is expensive
- *Committee is looking at potentially updating several aspects of the test.*

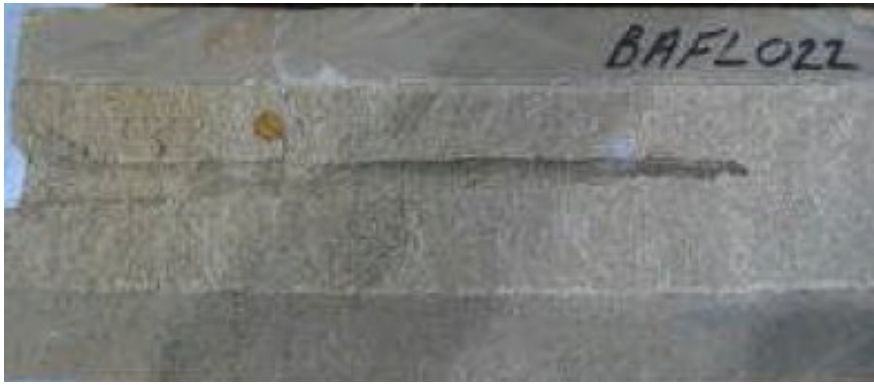


API RP19B 1. Current API RPs Overview

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.*





API RP19B 1. Current API RPs Overview

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.*

API RP19B 1. Current API RPs Overview

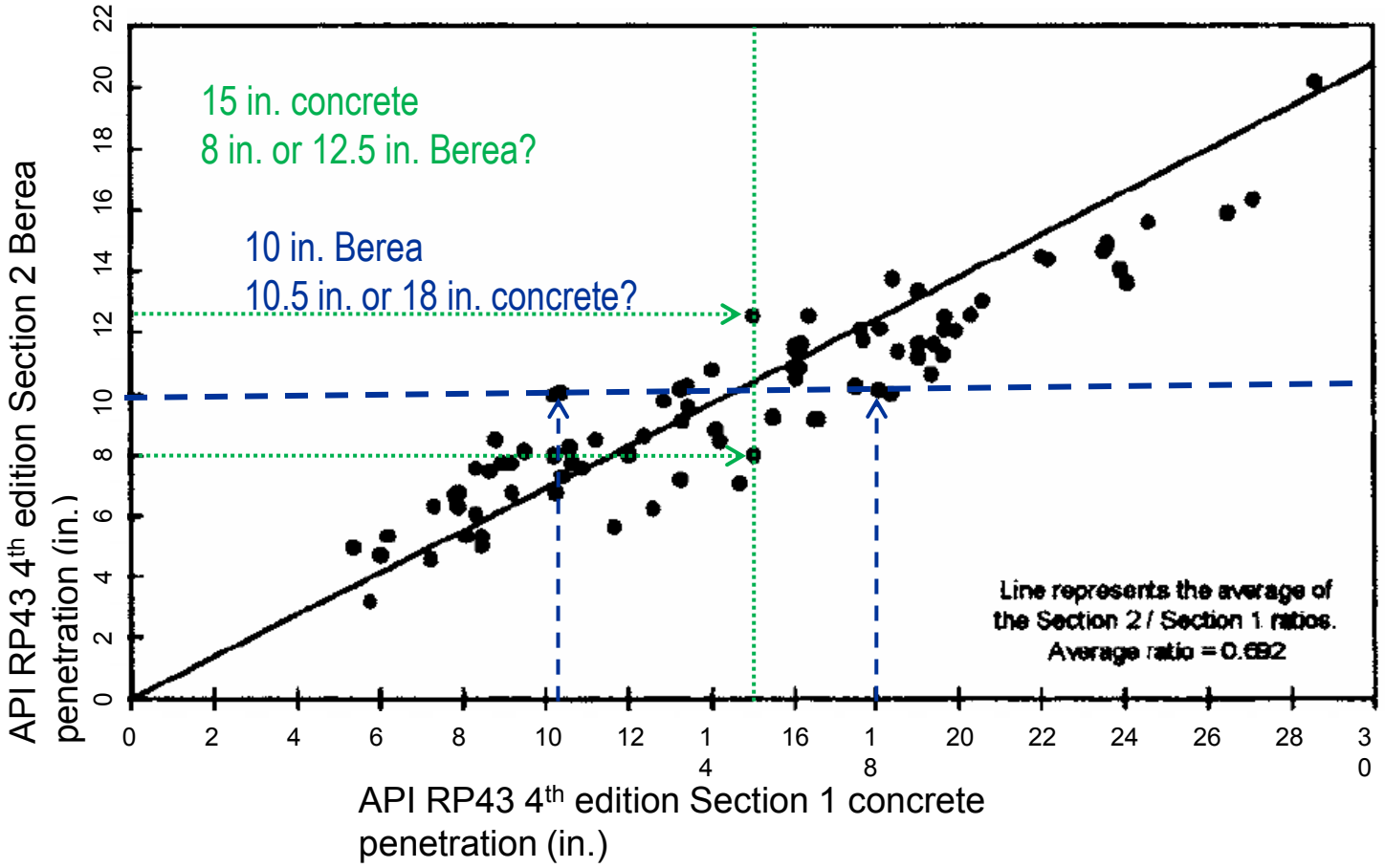
Section 6 (new): Standard for measurement of gun swell

- 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:-

API RP19B 2. Penetration - Background



- This shows that unstressed Section 1 concrete data provides little useful reference to stressed rock penetration or in-situ reservoir rock penetration

API RP19B 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.

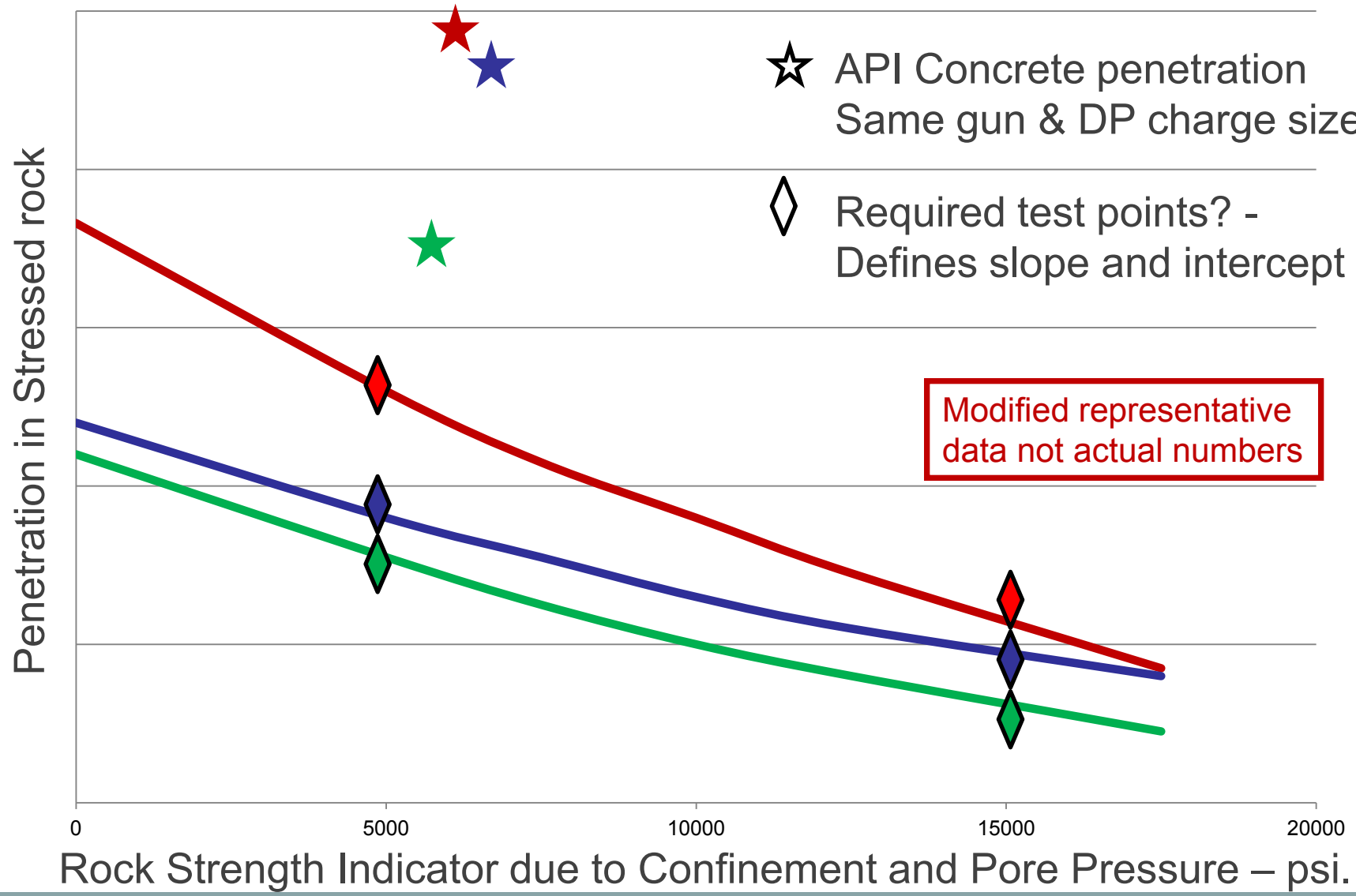
API RP19B 4. Penetration Modelling

- 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

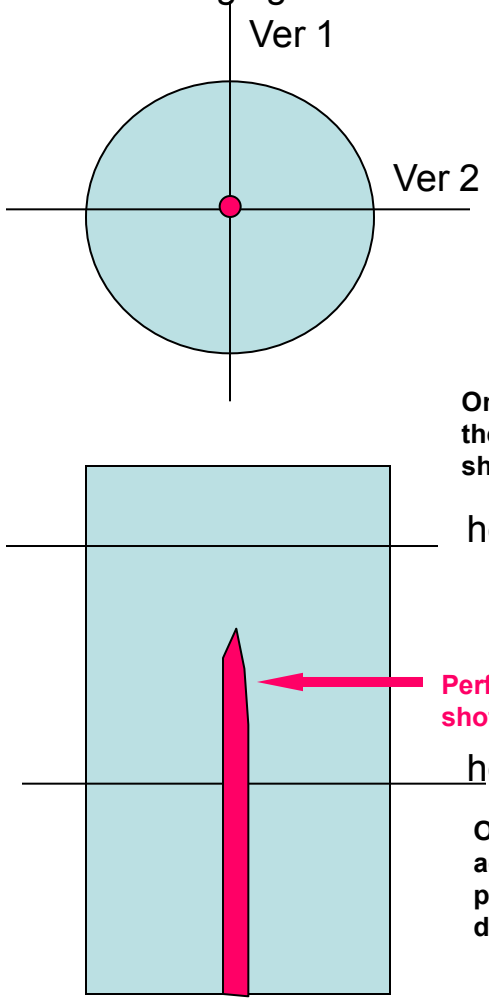


API RP19B 5. Stress Profiles in Targets

- 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

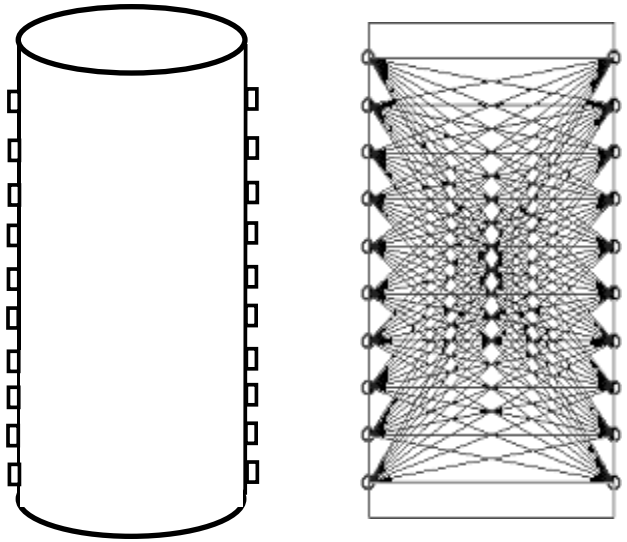
API RP19B 5. Stress Profiles in Targets

Planes to be imaged in CT and UT imaging

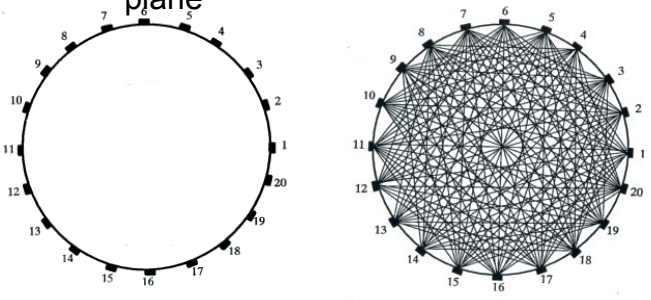


Planned acoustic arrays for imaging samples under pressure

20 sensors in each vertical plane



20 sensors in each horizontal plane



API RP19B Task Groups Appreciation

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,