Introduction to API 19b Section IV testing on sandstone cores and shaped charge testing for 2“ and 2 1/8“ systems

European and West African Perforating Symposium (EWAPS)
7-9th November 2012

Presenter - Liam Mc Nelis, DYNAenergetics.
Co-Author - Christian Eitschberger, DYNAenergetics.
Outline:

1. Introduction to Section IV testing
2. Sandstone targets & test outline
3. Results & analysis
4. Summary & looking forward
1. Introduction

• Simulate downhole conditions
• Use natural rock targets instead of concrete
• Pressures & stress in rock cores
• Flow through cores
Section IV Vessel
2. Sandstone Targets

Mainsandstein
Permeability 3-10mD
Porosity 14%
UCS: 7540psi (parallel)

Sander Schilfsandstein
Permeability 120-150mD
Porosity 19%
UCS: 6700psi (parallel)
Test Outline: 2" and 2 1/8"

- 2" Expendable Retrievable Hollow Gun Carrier versus 2 1/8" Encapsulated

- Overburden Pressure 5800 psi
  Pore Pressure 1900 psi (Effective Stress 3900 psi)
  Wellbore Pressure: 2900 psi

- Shot on 7" Diameter x 15" Length Sandstone Cores
Vessel Configuration

- 2 1/8” Encapsulated Charge in Section IV Vessel

Confining 5800 psi

Pore 1900 psi

Wellbore 2900 psi

1/2” Casing Plate, 3/4” Cement axially flowed with OMS
3. Test Results

TTP & Open Tunnel for 6.5g DP HMX/St

Penetration (""")

Shot Nr #

EHD Casing: 0,18" - 0,22"
Sander Schilfsandstein: 7“ x 15“

6,5 DP HMX/St
Mainsandstein: 7“ x 15“

6,5 DP HMX/St
Pre & Post Shot Permeability: 6.5g DP HMX/St

**Sander Schilf**

Permeability (mD) vs Shot #

**Main Sandstein**

Permeability (mD) vs Shot #
Sander Schilf Sandstone: 7“ x 15“

- 13g DP Encapsulated HMX/St
Mainsandstein: 7" x 15"

13g DP Encapsulated HMX/St
Pre & Post Shot Permeability: 13g DP Encapsulated HMX/St

**Sander Schilf**

- Pre-Shot permeability data for Sander Schilf.
- Post-Shot permeability data for Sander Schilf.

**Mainsandstein**

- Pre-Shot permeability data for Mainsandstein.
- Post-Shot permeability data for Mainsandstein.
High Speed Gauge Data (5 kHz):

6.5g DP HMX/St in Sander Schilfsandstein

Dynamic Underbalance
(Gun Volume 13.5 inch³ - 223 cm³)
High Speed Gauge Data (5 kHz):

13g DP HMx/St (Encapsulated) in Sander Schilfsandstein

Pressure Peak

- Pore Pressure (psi)
- Wellbore Pressure (psi)

Time (ms)
Summary

Performance Comparison of 6.5g DP HMX/St & 13g DP HMX/St

- **Average Open Tunnel**
  - **6.5g DP**
    - Average Open Tunnel Sander: Average PR 1.11
    - Average Open Tunnel Mainsandstein: Average PR 1.15
  - **13g DP**
    - Average Open Tunnel Sander: Average PR 1.23
    - Average Open Tunnel Mainsandstein: Average PR 1.24
Summary

- Sander Schilfsandstein: 2 1/8" charges visibly better perforation tunnels & PR.
  Mainsandstein: Not a huge difference in perf. tunnel between 2" & 2 1/8" results (DUB effect?) PR ~10% better with encapsulated charge.

- Need more high speed data and more realistic testing configurations.

- Need to model the comparative downhole performance of 2 1/8" encapsulated charges vs 2" carrier and using high speed gauges to confirm pressure spike data.

- Penetration in concrete (API 19b Section I) is not an accurate reflection of downhole performance.

- Rock optimized charges for optimal performance.
Thank you for your attention!