Driving Factor
Section Milling

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Perforate Wash Cement (PWC)
North Sea Experience

Case History Operational Times

- **Section Milling**: 10.5 days
- **Two Trip PWC**: 4.5 days
- **Single Trip PWC**: 3 days

Days
Critical Design Factors
The Beginning of the End

- Seafloor
- Depth
- TD
- Pressure
- Single Gradient Density at TD
- Fracture Pressure
- Seawater Hydrostatic
- Pore Pressure
The Initial Approach

Gram Weight vs EHD

Gram Load

Entrance Hole Diameter (mm)

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Engineered Approach

- Two deliverables
  - Diameter
  - Perforation Coefficient

- Four design Variables
  - Liner Material
  - Weight
  - Shape
  - Explosive

Equation for limited entry Frac

\[ \Delta P_{PERF} = \frac{MUD_{PPG} + Q^2}{12035 \times A_{PERF}^2 + C_d^2} \]
Design for the Future

Design Variables vs. Hole Size & Penetration

Entrance Hole Diameter (mm) vs. Penetration inches

- Entrance Hole Diameter (mm)
- Penetration

Design:
- 34 P3
- 34 P3
- 22 P1
- 22 P1
- 30 P3
- 22 P2
- 22 P1
Optimizing the System Performance

- Pressure
- Velocity
- Flow Rate
- Geometry

Source: Msc Dissertation Charles Nnaemeka Ukwuegbu, RGU University, Aberdeen
Designing Out NPT
Simple Formula for Calculating Strength Degradation of Well Casings and Pipelines Due to Corrosion Pitting

New Pipe Formula

\[ P_b = 0.875 \times 2\sigma_0 \left( \frac{t}{d_o} \right) \]

13 3/8 98 ppf N80 casing

\[ P_b = \frac{7.505}{2.67} \]

\[ P_b = 2.810 \text{ psi} \]

Stress Concentration Factor

2 < SCF < 3

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Source SPE 88572 by Kai Sun and Guo Boyun
Optimizing the System
Minimizing the Pressure Effects

Wellbore Pressure vs. Time

- Lowered Peak Pressure by ~ 8 Mpa (1200 psi)
- Max pressure ~ 12Mpa (1700 psi) over hydrostatic
Summary

- Developed a Safe, Efficient, and Reliable P&A system
  - Shaped charge Design – Consistent and targeted hole size
  - Gun System design lowers wellbore pressure
  - Low pressure auto-releasing firing system
Thank You !!!

- Questions ????