Laboratory Testing Of High-Pressure Coiled-Tubing Drilling System

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High-Pressure Drilling

- 1970s & 1980s High Pressure Bits
  - Drill 2 to 3 Time Faster
    - Exxon
    - Shell
    - Gulf Oil
    - Flow Drill
- Pressure - 10,000 to 15,000 psi
Exxon Jet Bit
Exxon HP Field Test

- **Conventional Bits** (2000 PSI)
- **Erosion Bits** (10,000 - 15,000 PSI)

**Graph:**
- Y-axis: Well Depth - Feet
- X-axis: Rotating Time - Hours

The graph illustrates the difference in well depth achieved by conventional and erosion bits over time.
Grooves Cut by HP Tests
High Pressure Problems

- Connections
- Joint Leaks
- Washouts
- High Maintenance
  - Pump
  - Rig
High Pressure Solutions

- Coiled Tubing
  - No Joints
  - Eliminates Washouts

- Improved Equipment
  - Pumps
  - Rigs
  - Motors
  - Bits
High Pressure Drilling Mechanism

- Bit
- PDC Cutter
- Jets
- Rock Ledges
Critical Components

- Coiled Tubing
  - Fatigue Life At High Pressures
- CT Rig
  - High Pressure Components
- PDM Motors
  - Bearing And Motor Loads
- Bits
  - Correct Nozzle Placement
CT Fatigue Life

(based on MEI CTLIFE model)

Fatigue Life (trips)

Internal Pressure (psi)

- 1.75"
- 2.00"

QT-1000
Fatigue Test Machine

- CT Sample
- Hydraulic Actuator
- Straight Bending Form
- Curved Bending Form
- Pressure Controller
- Pump
Fatigue Life of 1-1/2” Coiled Tubing
(R. Stanley, 2000)

Internal Test Pressure (psi)

Fatigue Life (cycles)

Actual Cycles for QT-1200
Model Cycles for QT-1000
Model Cycles for QT-800

(0.156” Wall)
Fiberspar Composite CT

- Production Tubing - *FS PT*
- Line Pipe - *FS LP*
- Coiled Tubing - *FS CT* (for Well Servicing)
Hydra-Rig High Pressure Swivel

Torque vs Pressure

Torque (ft. lbs) vs Pressure (PSI)

- Pressure ranges from 0 to 14000 PSI.
- Torque ranges from 0 to 500 ft. lbs.

Graph showing the relationship between torque and pressure for the Hydra-Rig High Pressure Swivel.
High Pressure CT Motor

- PDC Thrust Bearings
- PDM Multilobe Rotor/Stator (3 1/8”)
- 2 3/8” CT
- High Pressure Jet Bit
- Radial Bearings/Flow Restrictors
- Solid Titanium Flexshaft
- Solid Rotor
- Filter
Thrust Load on Bearing

10,000 PSI

Seal

Housing

34,000 lb

Force

Thrust Bearing

Bit
**Bearing Load Comparison**

Load Capacity

<table>
<thead>
<tr>
<th>Ball Bearing</th>
<th>PDC Bearing</th>
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<tr>
<td>5600</td>
<td>16,800</td>
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100 Hours @ 300 rpm
Damaged Ball Bearings
Labyrinth Seal

Outer Sleeve

Inner Sleeve
Motor Labyrinth Leakage

Flow Rate (gpm) vs. Leakage Clearance (w)

- Four 5” Labyrinths
- 10,000 psi

- Leakage Clearance (w):
  - 0.004” Flow Rate: 8.1 gpm
  - 0.006” Flow Rate: 12.1 gpm
Radial Bearing

Outer Sleeve

Inner Sleeve
High Pressure Jet-Drilling Rates

Jet Drilling Rate (ft/in)

- Texas Cream Limestone: 1500 ft/in
- Leander Limestone: 910 ft/in (WOB=1000 lbs)
- Glacier Bluff Dolomite: 68 ft/in
- Pecos Red Sandstone: 110 ft/in

Bit Weight = 2000 lbs
- Green = 10,000 psi
- Red = 1,000 psi

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Differential Pressure and Drilling Rate
(Moffit, 1991)

7-7/8 Tricone Bit
30,000 Lbs WOB
60 Rpm

Austin Chalk
Mancos Shale
Colton Sandstone

Differential Pressure (psi)

Drilling Rate (Ft/Hr)

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Cuttings Removal Screen

Choke

Borehole Pressure

Drilling Fluid Input

Shaft Seal

Pressure Chamber

Formation Pressure

Rock
Effect Of Wellbore Pressure

(Conventional Drilling)

Wellbore Pressure = 0 psi
Jet Pressure = 300 psi

Texas Cream Limestone
2000 lb Bit Weight

ROP (ft/hr)

0 psi

2000 psi

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Effect Of Wellbore Pressure

(High Pressure Drilling)

Texas Cream Limestone
2000 lb Bit Weight

Wellbore Pressure = 2000 psi
Jet Pressure = 9300 psi

ROP (ft/hr)

0 psi
1010
0
920
2000 psi

Wellbore Pressure

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Initial Bottom Hole Pattern
Modified Jet Bit
Final Bottom Hole Pattern
Additional Applications
Jet Slotting Stimulation

- Formation Damage
- Slots
- High Pressure Jets
Jet Slots In Glacier Bluff Dolomite

10,000 psi Jet Pressure

Slot
Drilling Cement

- Drillpipe or Casing
- High Pressure Jets

Cement

ROCK
Tubing After Drilling Cement
Cement Drilling Rates

- Conventional Motor: 60 ft/hr
- High Pressure Motor: 1420 ft/hr
Cement Drill Cuttings
(10,000 psi)
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The End

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