CO₂ Application Guide and Market Analysis for the Permian Basin GFE Project

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Agenda

Personal Introduction
Project Introduction
Application Guide
- CO₂ Challenges
- Three Tiered Approach – Material Selection; Product; and Real-Time
- Midland Result
Benefits: Customer and Schlumberger
Way Forward
Project Introduction

Why CO₂ as a method of enhanced oil recovery (EOR)?

- What is CO₂ injection?
- Drivers for CO₂ floods vs other EOR methods
- CO₂ ESP market in the Permian = $53MM Annually

![Growth of CO₂ EOR Projects](chart.png)
Application Guideline
CO₂ Challenges

Reservoir Characteristics
- Low temperature < 130F
- Carbonate or sandstone geology
- Corrosion, scale, asphaltene and paraffins

Operating philosophy
- Scenario 1 – Minimize intake pressure
- Scenario 2 – Maintain intake pressure
- WAG – Water alternating gas
Application Guideline
Three Tiered Approach – Material Selection

Applies to all ESP components

Metallurgy - CO$_2$ vs H$_2$S

Carbon steel housings
Monel trim and coating
Redalloy heads and bases
HSN elastomers

<table>
<thead>
<tr>
<th>Component</th>
<th>Standard Material</th>
<th>Upgraded Material</th>
<th>Cost Difference (+)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump</td>
<td>Carbon Steel</td>
<td>Redalloy</td>
<td>59%</td>
</tr>
<tr>
<td>Protector</td>
<td>Carbon Steel</td>
<td>Redalloy</td>
<td>23%</td>
</tr>
<tr>
<td>Motor</td>
<td>Carbon Steel</td>
<td>Redalloy</td>
<td>11%</td>
</tr>
<tr>
<td>Cable</td>
<td>Galvanized</td>
<td>Monel</td>
<td>169%</td>
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</tbody>
</table>
Application Guideline
Three Tiered Approach – Product

Pump selection
- Mixed flow stages – 20-25% free gas
- Compression pump stages – wide operating ranges - WAG
- Mixed flow stages – DN1750 and D1050N
- Sizing – Current rules of thumb → DesignPro Module

Gas separation and/or handling
- Scenario 1 allows the use of either
- Scenario 2 allows only the use of gas handling equipment
Pump Selection – D1050N vs DN1750

[Graph showing performance curves for REDA Production Systems]

Pump Performance Curve
1 Stage(s)
3500 RPM - 60 Hz

Fluid Specific Gravity 1.00

- Hp
- Eff

Capacity - Barrels per Day

- D1050N
- DN1750
Application Guideline
Three Tiered Approach – Product

Protector selection
- Labyrinth on top – SS tubes in upper chamber
- High-load thrust bearing

Motor selection – Maximus advantages
- Tape in vs Plug in
- Benefits for CO₂
- Impact on well control → HSE considerations
Application Guideline
Three Tiered Approach – Product

Cable selection
- Size dependent on motor amps
- Lead barrier

Actual Client experience
- 37 pulls from 1996-1999
- 17 for downhole ground
- 13 total were cable related

Application Change to lead barrier
Application Guideline
Three Tiered Approach – Real Time Monitoring

Utilize Phoenix Sensor
Recording and trending of Phoenix data
Kinder Morgan KSU 263A intervention
- Increasing intake pressure
- Xylene flush

% Daily Average Pump Intake Pressure (psi)
Maximum Motor Temperature (°F)

ESP Data for KSU 263A

- Daily Avg Pump Intake Pressure
- Daily Maximum Motor Temp


180.0 185.0 190.0 195.0 200.0 205.0 210.0 215.0 220.0

1,400 1,500 1,600 1,700 1,800

Schlumberger
Application Guideline
Midland Results – Client Field Experience

Client Field

- 1996-Present
- Circa 100 ESPs installed by YE 2011

12 Month Rolling Failure Rate Comparison
Application Guideline
Midland Results – Client Field

Client Field
- ES Pump Configuration
- BOI – Bolt on intake → Scenario 2 (Maintain intake pressure)
- 3 Chamber Protector, Labyrinth on top
- EZLine and Maximus motors
- Lead Cable
- 2010 - YE 2011 – 39 total pulls
  - No equipment failures related to application error
Market Analysis

CO₂ First implemented in the 1970s in the Permian

- Estimated that 70 billion bbls of additional oil are technically recoverable in US
- 1300+ ESPs in CO₂ projects with competitor equipment
- Total CO₂ ESP market in the Permian is $53MM annually
- Estimate of available CO₂ market - $47MM annually

<table>
<thead>
<tr>
<th>Customer</th>
<th>ESP Spend (kUSD)</th>
<th># of ESPs in CO₂ Floods</th>
<th>CO₂ SLB ESPs</th>
<th>Available CO₂ ESPs</th>
<th>Estimated CO2 ESP Revenue (kUSD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxy</td>
<td>$ 50,000.00</td>
<td>600</td>
<td>30</td>
<td>570</td>
<td>$ 25,000.00</td>
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<td>Chevron</td>
<td>$ 25,000.00</td>
<td>250</td>
<td>13</td>
<td>238</td>
<td>$ 7,812.50</td>
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<td>Kinder Morgan</td>
<td>$ 15,000.00</td>
<td>480</td>
<td>31</td>
<td>449</td>
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<td>Apache</td>
<td>$ 12,500.00</td>
<td>85</td>
<td>28</td>
<td>57</td>
<td>$ 2,361.11</td>
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<tr>
<td>Hess</td>
<td>$ 3,000.00</td>
<td>90</td>
<td>90</td>
<td>N/A</td>
<td>$ 3,000.00</td>
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<tr>
<td><strong>Total =</strong></td>
<td><strong>$ 105,500.00</strong></td>
<td><strong>1505</strong></td>
<td><strong>192</strong></td>
<td><strong>1,314</strong></td>
<td><strong>$ 53,173.61</strong></td>
</tr>
</tbody>
</table>
Advantage of working with an established ESP supplier of CO$_2$ solutions in the Permian Basin
Application of lessons learned from previous clients to size and select ESPs correctly for this environment
Minimize ‘learning phase’ associated with operating ESPs in new CO$_2$ floods
Reduced spend attributed to ‘learning phase’
Client example – estimated 10% reduction on ESP spend alone
CO₂ Application Guide for the Permian Basin
InTouch best practice - 5809240
Consolidated summary of important lessons learned
Quantified the CO₂ ESP market in the Permian
Locate future opportunities and targets for new business
$47MM spent annually on competitor equipment in CO₂ floods
$2MM potentially available within the next year
CO$_2$ floods are an expanding market for ESPs in the Permian Consistent Application Guide for material selection and sizing → Using this to develop DesignPro Module
Maintain best practices for Permian equipment selection
Target the customers identified with the largest amount of CO$_2$ potential
Questions?