SOUTH CASPER CREEK: Steamflood Pilot Implementation

By:
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2010 Wyoming EOR/IOR Conference
Jackson, WY
Sept 13-14, 2010
South Casper Creek (SCC) brief overview

- 59 Tensleep producers (North and South Domes).
- Average production 400 bopd x 42,000 bwpd (South Dome = 320 bopd x 28,000 bopd). +65 bopd from beginning 2009.
- Spacing 2-7 acres.
- Estimated OOIP (South Dome) = 78 MMBO (2004 MHA study)
- Est. cumulative production = 14.7 MMBO
- Remaining primary reserves = 2.6 MMBO (RF ~22%)
- Steamflood expansion reserves = 6.0 MMBO (RF ~30%)
Thermal Enhanced Oil Recovery

- Thermal Enhanced Oil Recover (TEOR) or Steamflood—consists of injecting (preferably) 80% steam into a reservoir which will lower the oil viscosity and increase the mobility of the oil. Steam/condensate will also displace reservoir fluids and steamflooding may also reduce residual oil saturations.
<table>
<thead>
<tr>
<th><strong>RESERVOIR</strong></th>
<th><strong>Tensleep</strong></th>
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</thead>
<tbody>
<tr>
<td><strong>Environment of Deposition</strong></td>
<td>Eolian Dune System</td>
</tr>
<tr>
<td><strong>Porosity (core)</strong></td>
<td>18 – 32%</td>
</tr>
<tr>
<td><strong>Permeability (core)</strong></td>
<td>370 – 3580 mD</td>
</tr>
<tr>
<td><strong>Secondary Porosity</strong></td>
<td>Dissolution of Anhydrite</td>
</tr>
<tr>
<td><strong>Ave Net Pay</strong></td>
<td>140’</td>
</tr>
<tr>
<td><strong>Depth</strong></td>
<td>2400 – 2600’</td>
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<tr>
<td><strong>BHT</strong></td>
<td>90 deg F</td>
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<tr>
<td><strong>Wettability</strong></td>
<td>Oil-wet</td>
</tr>
<tr>
<td><strong>OIL Gravity API deg @60°F</strong></td>
<td>13.7</td>
</tr>
<tr>
<td><strong>OIL Viscosity @90°F</strong></td>
<td>680 cp</td>
</tr>
<tr>
<td><strong>Pour pt</strong></td>
<td>15°F</td>
</tr>
<tr>
<td><strong>Sulfur Content (wt %)</strong></td>
<td>5.1%</td>
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<tr>
<td><strong>Cumulative Prod (Estimated 2010)</strong></td>
<td>14.7 MMBO</td>
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Brief SCC History

SCC Field discovered 1918. Produced gas from Canyon Springs

TS discovered 1923

Gas considered depleted 1925, began deepening wells to TS

Validated Thermal Recovery process (cyclic steaming) 1974

Initiated extensive drilling program in anticipation of steamflood 1980

Pilot steamflood 1981-85

Reactivated pilot steamflood, added 2nd injector 1988-89

Expanded steamflood. Peak 11 injectors ~ 1500 bopd 1990-93

Terminated steamflood 1993

Reactivated pilot steamflood 2009
Reactivate successful crestal #13-7-3 pilot.
- Previous & numerous studies of Tensleep reservoir have been performed (extensive log/core/lab analyses, seismic surveys, reservoir modeling).
- Citation focused studies on historical proven steamflooded areas.

Incorporate 7 front line producers in pattern.

Key indicators 6:1 steam/oil ratio and 8:1 oil/gas price ratio.

Estimated reserves = 491 MBO.
Project cost $1.9MM.
#13-7-3 Steamflood Pattern

South Casper Creek - Steamflood Pattern 13-6-3 & 13-7-3 Data
SCC #13-7-3 steam pattern
South Casper Creek Steamflood Operations

- Utilize a fresh water source to minimize water treating.
- Refurbish existing steam generator.
- Utilize mechanical deaeration to eliminate $O_2$ & $CO_2$.
- Minimize heat & friction losses.
- Tie in all front line producers to test header for monitoring performance.
SCC Steamflood Process

400 bbl soft water

20” x 54” twin softener

Charge pump w/ VFD

Cartridge filter (1 micron)

400 bbl raw water

Viking strainer

WSW #2 w/ Centrilift submersible & VFD

Charge pump w VFD

3’ x 8’ Deaerator

(2) Charge pumps

20” x 54” twin softener

20% Side stream of steam

Air intake

Triplex w/ VFD

OH-10

Expansion loop

#13-7-3 injector w/ Thermal Tube*

Gas inlet from Source Gas tie-in
WSW #2

- Lakota (755’-800’) open hole completion.
- Installed 21 stage Centrilift submersible with VFD.
- Well supplies water to ranch and office.
- Total hardness = 10 ppm.
- O&G = 1 ppm.
- *Previous steamflood utilized produced Tensleep water with Total Hardness = 1040 ppm.*
WSW #2 (Lakota)

Raw wtr tank

Wtr for ranch

Potable wtr for office
Water Softener

- 12” x 54” twin softener.
- OH-10 requirements less than 1 ppm total hardness.
- Cartridge filter upstream of softener.
- VFD installed on charge pump to match WSW #2 and OH-10 flow rates.
VFD
Brine tank
Filters
C-pump (feeds soft water tank)
Cartridge filters (1 micron)

Water softener
South Casper Creek Steamflood Deaerator

- 3’ x 8’ Precision Deaerator.
- Utilizes 11% side stream of steam to eliminate gases by heating water to saturation point \(\sim 190^\circ F\).
- Increases efficiency with higher temperature BFW.
- OH-10 requires less than 0.5 ppm O2
- Achieving 0.02 ppm O2 w/ deaeration.
- Eliminate hazardous O2 chemical scavenging.
- Protect investment.
Steam Feedwater

Deaerated water to OH-10

Vented gases

Baffles

Deaerated water to OH-10
Magnetic sight glass
South Casper Creek Steamflood OH-10

- Capable of producing 9600 lb/hr of 80Q steam. Maximum pressure 1500 psi.
- Installed Allen Bradley PLC. Minimizes constant supervision, precise control of fuel/air mixture for highest efficiency, troubleshooting.
- Calculated ~90% Fuel to Steam efficiency (stack loss method).
- Utilizes ~250 mcfd.
Herculine motor (fire rate output)

Linkages to control air/fuel mixture

Gas butterfly valve

Gas inlet
Radiant Section
Ceramic Fiber Refractory
2" sch 80 tubes
Steam Injection

- Insulated 2” schedule 80 injection line with 3” calcium silicate.
- Incorporate expansion loop with sliding shoes to accommodate temperature expansion/contraction.
- Installed #13-7-3 Thermal Tubing and thermal packer with expansion joint. Calculated reduction in heat loss 16,000 MMBTU/yr to wellbore.
- Injecting 250 MMBTU/day at 560 psi and 483 °F.
Expansion Loop
Sliding shoe
#13-7-3 injector w/ 3.5" x 2.375" Thermal Tube.

Injection Line insulated w/ 3" calcium silicate
Soft water tank

Raw water tank

Deaerator

OH-10
Test Header Facility

- Incorporates 7 first line producers.
- Header manifold has 10 spots (2 for expansion).
- 4’ x 12’ test separators.
- Strictly for testing (no treating capabilities).
- Temperature, oil production, water production.
Test Header
manifold
Results current to 9/1/2010

- Injecting for 16 months (15 months adjusted for downtime).
- 37.6 days of downtime (6.6 days in 2010).
- Injected ~255 Mbbls (CWE) of 76% steam.
- Consumed 103 MMCF of fuel gas.
- Temperature increase in 3 of 7 wells (+ 40°F).
- Monthly average expenses ~ $36,500 (85% purchased gas).
- ~30 bopd incremental oil. (Breaking even).
QUESTIONS??

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SOUTH CASPER CREEK

Caution
Hazardous chemicals may be present in this area. Failure to use caution may cause serious injury or illness. Contact Operator for hazard information & safety instructions.

DANGER
H₂S GAS MAY BE PRESENT

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