Remediation Services & Technology

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Agenda

- Near wellbore remediation
- Causes of formations damage
- Field deposits
  - Paraffin
  - Asphaltene
  - Scale
  - Emulsions
  - Water block
- RESTORE™- Remediation Services & Technology
- RESTORE Product Portfolio
- Case Histories
- Value Generated With RESTORE
- Summary
Near Well Bore Remediation

Remove Skin Damage
- Preferentially Removes Deposits from Oil Zones
- Cleans the Well-bore Area
- Restores Communication

Improve Permeability

Water-Wet the Formation

Increase Productivity/Injectivity
Causes of Formation Damages

- Fines Migration
- Change in Wettability
- Injected Solids
- Chemical Injection
- Kill Fluids
- Water Floods
- Scale Deposition
- Growth of Bacteria
- High Production Levels
- Low Bottom Hole Temperature

- Gas Expansion Cooling
- Oil Chemistry
- Pressure Drawdown Tests
- Cold Fluid Comp. & Frac Fluid
- CO2, NGL and Water Floods
- Hot Oiling Tubing and/or Casing
- Acid Jobs
- Condensate Treatments
- Bubble Point/Gas Separation
- Formation Minerals
Skin Damage Remediation – Traditional Field Techniques

- Jet Washing
- Scraping/Cutting
- Hot Oiling
- Cyclic Steam
- Acidizing
- Fracturing
- Perforating
Paraffinic or Asphaltenic Crude Oil

All Crude Are Not the Same (\( >C7+\))
## Crude Oil Properties – Paraffinic vs. Asphalitic

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<th>Temperature (°F)</th>
<th>Viscosity (centipoise)</th>
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- **Cloud Point**
- **Pour Point**

**Graph:**

- Red line: Crude B Asphalitic
- Blue line: Crude A Paraffinic

The graph illustrates the change in viscosity of Crude B Asphalitic and Crude A Paraffinic with temperature. The pour point and cloud point are indicated on the graph.
Paraffin Field Deposits
Properties of Paraffinic Crude Oil

- Mixture of high molecular weight alkanes
- Paraffin loses solubility in crude oil at a certain temperature (cloud point)
- Generally paraffin is present in higher gravity > 20°API
- Paraffin is soluble in both alkane and aromatic solvents
- Paraffin melts
Causes of Paraffin Deposition

Natural Causes

• Geological temperature gradient
• Gas expansion, separation from crude oil
• Underground aquifers
• Cold surface temperatures

Maintenance Causes

• Temperature losses
  - Water injection
  - Gas injection/lift
• Acid/fracture job
• Hot oiling
• Solvent loss
  - Heated equipment
  - Gas separation
Location of Paraffin Problems

- **Deposition**
  - Formation
  - Tubing
  - Flowline
  - Pipeline

- **Settling**
  - Tank bottoms
  - Interfaces in vessels
Identifying Paraffin Candidates

- Declines after well work
  - Immediate cause/effect relationship
- High GOR wells
- History of hot oiling
- Modeling
  - Sandia Hot Oil/JT Software
Asphaltene Deposits
Asphaltene Properties

- **Solubility class**
  - Insoluble in alkanes like pentane, hexane, heptane
  - Soluble in aromatics like benzene, toluene, xylene

- **Polar molecule**
  - Adsorbs to formation surfaces, especially clays
  - Oil wets formations

- **Decreases API gravity**
  - Increases viscosity

- **Amorphous black solid**
  - Does not melt
  - Provides black color to oil
Identifying Asphaltene Candidates

- Areas of high electrical potential
  - High gas flow across “chokes”
  - ESP

- Abrupt declines traced to recent well work
  - Immediate cause/effect relationship

- History of acidizing
  - Sudden drops after successful acid work
  - “Zero” fluid production
  - “Shows” of acid sludge
Inorganic - Scale

- Calcium carbonate (CaCO$_3$)
- Calcium sulfate (CaSO$_4$)
- Barium sulfate (BaSO$_4$)
- Strontium sulfate (SrSO$_4$)
- Iron carbonate (FeCO$_3$)
- Iron sulfide (FeS)
Inorganic Damage - Potential Causes of Scaling

- Pressure drops
- Temperature changes
- Incompatible waters
- pH changes
- Contact time
Identifying Scale Candidates

- **Samples**
  - Field tests
  - Analyses

- **Water analysis report**
  - Scaling indices
  - System DH conditions

- **Following hot water jobs (incompatibility)**

- **Pulling records**
  - Pump plugging
  - Tubing deposits
Identifying Emulsions Candidates

- Step Rate declines on production plots
  - Overall loss of fluid production
- Associated drops occur after
  - Pump changes
  - Circulations
  - Washbacks

Oil/Water Emulsion
Other - Water Blocks

- Change (increase) in water saturation in the near-wellbore area
  - Could lead to clay fine swelling (secondary)

- Causes
  - Drilling
  - Circulation
  - Washbacks
  - Jet washes
  - Steam cycles
Identifying Water Blocks Candidates

- Step Rate declines on production plots
  - Separation of Gross and Net production trends
  - Lost of crude oil production

- Associated drops occur after
  - Hot water jobs
  - Circulations
  - Washbacks
Wells Selection

- Reservoir properties:
  - Is there damage?
  - How can it be measured?

- Chemistry:
  - How much damage can be removed?
  - What type of treatment?
  - How long will the treatment last?

- Economics:
  - Would it be economic to treat?
  - What is the chance of success?
Target Wells

- High GOR wells
- CO₂ floods
- Nitrogen floods
- Steam floods
- Non-response to acid
- History of hot oil applications
- Acid sludge damage
- Severe DH scaling or iron sulfides
- High oil “cut” producers

- Abnormal production decline
  - Look for well decline > 20%
  - Look for wells experiencing deposition
- Wells with known/measured skin
  - Well Test/Deliverability Test
- Wells damaged by hot oiling & acidizing
Ideally, the formation face has little or no skin. Surfaces are water wet. Pore spaces are free of deposition.
Damage begins to occur. Surfaces have lost some water wetness.
More deposition. Pore spaces now have limited flow. Production is down substantially.
Some pore spaces have fully plugged. All water wettability has been lost. Production is now very low.
RESTORE Production Enhancement Program treatment injection starts.
RESTORE Production Enhancement Program treatment attacks the skin problem as it penetrates and disperses the damage.
Special solvents and surfactants work to dissolve damage and return the formation to a water-wet state.
After shut in period, production is resumed, carrying out deposits.
Identify candidate wells

- Involve production engineers, production foremen and account managers

Collect data

- Complete well surveys - RESTORE team
- Gather skin damage values

Characterize crude oil

- Identify damaging mechanism
RESTORE Program Service. . . (cont’d)

Generate proposal

• Review with customer
• Agree on benchmarks
• Make final adjustments

Initiate RESTORE applications

Evaluate results

• Record post-treatment skin value
• Track production increase vs. time
Case Study – Northeast 03: Results Gas Storage Wells

- **14 wells treated**
  - Total improvement (12 wells): 485%
  - 1 well not tested due to lack of pipeline

- **7 wells had before / after well tests**
  - 5 of 7 wells had additional improvement after PEP-4
    - 62% average improvement
  - Total improvement (7 tested wells): 415%
    - 353% after first blow (no chemical)
    - 415% after chemical and second blow
    - 62% due to Restore PEP 4
Midwest Case History – Gas Storage Field

Gas storage field: Aquifer
Bottom-Hole Temperature: 95 °C

Problem
- Poor injectivity and productivity
  - Water blocks and skin damage

Treatment – 12 wells treated with PEP-3

Results –
- Incremental increase 542.36 MMscf/season
- Increased production by 21%
- Value of incremental gas > $3,000,000!
- 605% ROI
Northeast Case History – Calcium Carbonate Scale

- Well Type: Gas Well
- Problem: Calcium Carbonate Damage
- Treatment: 250 to 350 gal. PEP-4 18” penetration
- Results: $2.2 million estimated 30-day withdraw benefit for the two wells
  - 220% increase in average well deliverability

![Well Deliverability Graph]

- Pre-treatment Condition
- After PEP 4

Well Deliverability

480% improvement
90% improvement

Well 1 Well 2
California Case History – Fine/RFE/Scale Damage

- Problem: Fine migration/RFE/Scale
- Treatment: PEP 2, DMO146, DMW 2336, SRW4808S
- Results - $384,000 revenue increase first three months
  - 2300% initial return on investment
  - 23 day average pay back time
  - 3-25% increase in rod pump efficiency
RESTORE - Summary

- Turn-key process
- Focus on skin damage
- Combines proven technology with proven chemistries
- Formulated solutions for your well-flow problems
  - Paraffin remediation
  - Asphaltene clean up
  - Scale removal
  - Multifactor damage remediation
  - Inorganic deposit clean up
- Delivers increased production and maximizes ROI
Thank you for your attention

Questions