Avoiding Pitfalls with Measurement Uncertainties in Production Optimization Outcomes

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A Practical Approach

- Where Measurement Results are Used
- Plans for Improving Revenues
- Optimizing Wellbore Productivity and Reservoir Performance
A Practical Approach

• Where Accuracy Counts

• Unknown Cost of Measurement Uncertainties

• Where Potential Occurs for Uncertainties
Uses of Measurement Results

- Initial Production Rates from New Wells
- Managing Resource Development
- Effective Completion Designs
- Estimating Skin Damage from Well Tests
Uses of Measurement Results

- Effective Stimulation Treatment Designs
- Planning/Monitoring Waterfloods and Enhanced Recovery Applications
- Productivity Index
- Facility Equipment Designs
Optimizing Production to Improve Revenues

- Wellbore Deliverability and Productivity from Inflow Performance Predictions
- Stimulation Treatments
- Artificial Lift Equipment Selections
- Waterflood or Enhanced Recovery Schemes to Improve Recoveries
Optimizing Production to Improve Revenues

Valid Inflow Performance Predictions Depend on Accurate Oil, Water and Gas Flow Rates
Optimizing Production to Improve Revenues

Predicting New Flow Rates After a Stimulation Treatment:

<table>
<thead>
<tr>
<th>Old Rate</th>
<th>New Skin</th>
<th>Old Skin</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-4</td>
<td>10</td>
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Formula for Rate at New Skin

\[ \text{Rate at New Skin} = \text{Old Rate} \times \frac{8 + \text{Old Skin}}{8 + \text{New Skin}} \]

\[ = 4.5 \]
Where Accuracy Counts

- With Optimization Performance Claims
- Wells with High Watercuts
- In Fields with High Lifting Costs
- At Truck-in + Custody Transfer Points
Where Accuracy Counts

Well in a Mature Waterflood Netback Calculation Example with a 1% Watercut Error:

Oil Rate = 1 \text{ m}^3/\text{d}
Oil Price @ $90/\text{Bbl}
Processing @ $65/\text{d}
Royalties @ $160/\text{m}^3

Water Rate = 29 \text{ m}^3/\text{d}
Power Cost @ $71/\text{d}
Overhead @ $50/\text{d}
Trucking @ $125/\text{d}

Net Daily Revenue = $566/\text{m}^3 - $71/\text{d} - $65/\text{d} - $50/\text{d} - $160/\text{d} - $125/\text{d} = $95/day BIT

1% watercut error results in a Revenue variation of $164/day which can generate a loss of -$60K/Year
Where Accuracy Counts

In Fields with High Lifting Cost:

Profitable Pump Change/Workover
or
Uneconomic Due to Operating Expense

? Risk is Proportional to Measurement Uncertainty
Electronic Flow Information Path

- Operator entries for truck tickets, tank volumes, compressor readings, oil well tests, operating conditions and plant readings
- Raw EFM Volumes
- Validate: Use or Resample?
- Catch Lab Samples
- Electronic Flow Information via Field Data Capture (FDC)
- Pipeline Scheduling
- Daily Corporate Rollups and Facility Balance Reports
- Reporting + Allocations Program
- Receipt Volumes
  - Operating and G&A Expenses
  - Op Cost Savings with EFM
- Sales Revenues
- Rework Costs

Costly Rework and Revenue Losses without QM
- Repeat, time consuming phone calls to verify unreliable FDC records
- Audit issues and revenue settlements
- Corrections to erroneous meter details + lab analyses
- Amending report submissions and correcting misallocations
- Manual data (re)entries and Carrying out proration corrections
Electronic Flow Information Path

Operator entries for truck tickets, tank volumes, compressor readings, oil well tests, operating conditions and plant readings

Raw EFM Volumes

Validate: Use or Resample?

Order a Lab Resample if First is Unacceptable

Catch Lab Samples

Electronic Flow Information via Field Data Capture (FDC)

Pipeline Scheduling

Daily Corporate Rollups and Facility Balance Reports

Reporting + Allocations Program

Receipt Volumes

Operating and G&A Expenses

Op Cost Savings with EFM

Sales Revenues

Rework Costs

Costly Rework and Revenue Losses without QM

- Repeat, time consuming phone calls to verify unreliable FDC records
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Errors in Revenues and Expenses Originate with Measurement Uncertainties in:

- Proration Tests
- Watercut Determinations
Unknown Cost of Measurement Uncertainties

Emulsion Sampling Improvements

[Graph showing data with 'Oil' and 'Water' lines, with a period of improvements highlighted]

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Production history plot (Gas Rate [Mscf/D], Pressure [kPa] vs Time [hr])
Results

- Standard Model, Material Balance: 582 m
- Fracture - Finite conductivity: TMatch 0.475 1/hr, PMatch 1.16E-7 1/[psi2/ cp]
- Homogeneous Circle, No flow
- Tmin 24 hr
- Tmax 21144 hr
- Total Skin -3.38 k.h, total 2.71 md.m
- k, average 0.319 md
- Pi 11801.3 kPa
- STGIP 1.88 bscf
- STGIP 1.61 bscf
- Skin 0
- Geometrical Skin -3.38
- Xf 6.1 m
- Fc 152 md.m
- Pi 11801.3 kPa
- k.h 2.71 md.m
- k 0.319 md

Production history plot (Gas Rate [Mscf/D], Pressure [kPa] vs Time [hr])
Confidence in Results

Production history plot (Gas Rate [Mscf/D], Pressure [kPa] vs Time [hr])
Where Potential Occurs for Uncertainties with Oil Production

- Unrepresentative Sampling
- Entrained Gas
- Trucked-in Meter Errors
Well test volumes are prorated from satellite meter readings.

Proration Factors are reported using Actual battery volumes.
Error in Oil/Wtr/Emulsion Densities vs. %Watercut

- Oil Density
- Wtr Density
- %Error-Wtr
- %Error-Oil

Error Increases
Example Average Production Rate per Stage for Fractured Wells

- Desired Production Results

Oil m³/d
Example Average Production Rate per Stage for Fractured Wells
Data Scatter Reduces Effectiveness for Optimizing Completion Designs

Average Frac'd Well Oil Production Rate vs. Cumulative Oil
Implementing Lasting Solutions

- Check Proration Test Methods in the Field
- Communicate with Field Operations about Priorities for Accuracy
- Test Before and After Optimization Changes then Trend Results
- Explore Ways to Reduce Error Bands
Questions…