The Society of Petroleum Evaluation Engineers
SPEE Denver Chapter announces its October Luncheon Meeting.
(Members and Guests are cordially invited to attend.)

Wednesday, October 10, 2018

Gary J. Gonzenbach
Principal, CG Petroleum Consulting

Will be speaking on:
SPEE Monograph 5  Update on Type Well Profiles

LUNCHEON STARTS AT 11:30 A.M.
(A plated lunch will be served.)
PRESENTATION BEGINS AT NOON

The Denver Athletic Club
3rd Floor, Petroleum Room
1325 Glenarm Place (14th and Glenarm) Denver CO 80204
Parking flat rate $7.00 on space available basis

Cost: $25.00 per person online registration

Sponsored in part by Quorum Software, creators of
Mosaic, a comprehensive software application for reserves management,
petroleum economics, and decline analysis www.quorumsoftware.com
Please RSVP by Noon Monday, October 8, 2018

RSVP and simultaneously pay by credit card online at:
https://secure.spee.org/civicrm/event/info?reset=1&id=195

If the above link does not work, alternatively go to www.spee.org then select ‘Local Chapters’, then ‘Denver’, then ‘Register Now’.

**Abstract:** SPEE Monograph 5: A Practical Guide to Type Well Profiles  Type wells are one of the most critical tools used in reserve estimation for both conventional and unconventional plays. Yet to date, there are no concise or commonly accepted industry guidelines on the subject. The SPEE Monograph 5 committee has been hard at work exploring the differences in the way Type Well Profiles (aka “Type Curves”) are constructed. The Monograph explores the appropriateness of those methods in different situations, and whether or not they adhere to basic reservoir flow principles. The Monograph also seeks understanding (by BOTH developers and consumers) as to the uncertainty of the developed profiles and clarity on the construction methods. This presentation is an update on the status of this project and its critical issues.

**Speaker Bio:** Mr. Gary Gonzenbach is a registered Petroleum Reservoir Engineer with 30+ years’ experience in the industry. His career experience includes acquisition and divestiture, software development, expert witness, third party evaluation reports, senior industry advisor, and unconventional basin studies concentrating in the Delaware, Permian, and Eagle Ford resource plays. Gary has served on panel discussions, has written technical papers on Standardized Reserve Reconciliations and is co-author of SPEE Monograph 3 Guidelines for the Practical Evaluation of Undeveloped Reserves in Resource Plays. More recently, Gary is a past president of the Society of Petroleum Evaluation Engineers. He has served many years at the local chapter level offices for both SPE and SPEE. He is the chairman of the SPEE Monograph 5 committee on Type Well Profiles, which will be publishing industry guidelines on Type Well Curve construction and uncertainty. Mr. Gonzenbach is the founder of CG Petroleum Consulting.

**About SPEE:** [http://www.spee.org](http://www.spee.org)  SPEE was formed in 1962 as a professional, non-profit organization bringing together specialists in the evaluation of petroleum and natural gas properties. SPEE continues today to be strongly committed to providing educational and other services to its members and to the oil and gas industry, and to promoting the profession of petroleum evaluation engineering.

**For additional information, please contact:**
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Monograph 5: A Practical Guide to Type Well Profiles

Society of Petroleum Evaluation Engineers

Gary J. Gonzenbach: gary@cgpetroleum.com
Public data set generously provided by IHS Markit

SPEE Monograph 5 Committee Members

- Vitaliy Charkovskyy, Ryder Scott Company – Consultant
- Jorge Faz, Occidental Petroleum Corporation – E&P
- Jennifer Fitzgerald, Anadarko Petroleum Corp – E&P
- Randy Freeborn, 3esi Enersight – software
- David Fulford, Apache Corporation – E&P
- *Gary Gonzenbach, CG Petroleum Consulting, PLLC – Consultant
- Russell Hall, Russell K. Hall & Associates, Inc – Consultant
- Steve Hendrickson, Hendrickson Engineering – Consultant
- Dilhan Ilk, Degolyer and MacNaughton - Consultant
- Rick Krenek, Netherland, Sewell & Associates, Inc – Consultant
- John Lee, PHD, Texas A&M University, 3esi Enersight advisor – Academic
- Rod Sidle, 3esi Enersight advisor – Consultant
- John Wright, Wright Consulting Company – Consultant
# SPEE Monograph 5 Committee - Disclaimer

- **Opinions are not final!**

## Audience

<table>
<thead>
<tr>
<th>Category</th>
<th>Example</th>
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<tbody>
<tr>
<td>Consumers (Investors, Banks)</td>
<td></td>
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<tr>
<td>Producers (Consultants, E&amp;P)</td>
<td></td>
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<tr>
<td>Software Vendors</td>
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</tbody>
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## Reaches Final Publication in 2020

## Needs more non-public Data!!
<table>
<thead>
<tr>
<th>Type Well Profiles (TWP)</th>
<th>Not</th>
<th>Type Well Curves</th>
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<tbody>
<tr>
<td>method for constructing either (1) the &quot;average well&quot; performance or (2) the &quot;average monthly&quot; performance in a developmental program over time</td>
<td></td>
<td>such as methods for analyzing pressure drawdown (flow) and buildup tests, diffusivity equation</td>
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<tr>
<td>Results can be directly applied to Cash Flow Analysis</td>
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</table>
Why Type Well Profiles?

- Forecasts of New Wells with Limited History
- Forecasts of Undrilled Wells
- Development Planning
- Unconventional and Conventional
What is the Committee trying to Accomplish?

• Establish **Practical** Industry Guidance
  *Adherence to Fluid Flow Principles*

• Methods of Construction
  • Public Data vs Proprietary Data
  • Fit for Purpose

• Analogous Bin Selection
  • Survivor Bias
  • Scaling

• Validation of Results

• Communication of Uncertainty
Methodology

- Create a practical, working outline
- Pick different areas and apply
- See what works and record observations, any changes to outline methodology
- Feedback and suggestions from industry peers along the way
- Coordinate with other industry groups
Before you start

- What’s the Purpose?
- Is it Multi-phase?
- Do you understand the geology?
- **Data, data, data!**
  - How will you bin?
  - How will you scale?
  - How will you accumulate and update data in the process?
  - Do you have enough samples?
Focus Area 1
Permian Basin (Howard Co)

- **Analogous Data Sets** are difficult to find
  - Multiple Benches (Wolfcamp A)
  - Completion differences
  - Small data sets
- **Multiphase, primarily oil**
- **Flow Regime Information** is limited
  - No frac spacing information
  - No perm information
  - No daily data
  - Limited pressure data
  - Very short linear flow period
  - Most data exists in BIF (Boundary Influenced Flow)
  - Some BDF (Boundary Dominated Flow)
- **Validation of Results**
  - Not enough history to hindcast
Focus Area 2
Barnet Shale
(Johnson Co)

• **Dry Gas Window** (Lower Barnett)
  • Large Data Set
  • Single Phase

• **Historical Data**
  • Publicly available Monthly data, no daily
  • Assumed Constant Pressure
  • Oldest wells drilled in 2007
  • Field wide event that changed performance

• **Established Diagnostic Techniques**
  • Long period of linear flow
  • Short Transient period
  • Boundary Dominated Flow, maybe

• **Straightforward Validation**
  • Enough history to validate results with hindcasting
Other Focus Areas

Montney

Niobrara (Codell)
TWP Construction 1

Iterative Selection

- **Well selection (bins)**
  - Geologic area, formation, permeability, height
  - Well type, lateral length, spacing between clusters, landing depth, number of stages
  - Multi-phase, flow regime
  - Vintage, Proppant, Frac Fluids
  - Months of history, interference, allocated data

- **Forecast Focus and surrounding wells**
  - *First pass can be normalized forecast of sum if needed for familiarity*
  - Individual well forecasted to Technical EUR
  - Eliminate Survivor Bias

- **Verification**
  - Examine P10/P90 ratios, EUR Distribution
  - Look for Outliers and why
  - Spatial analysis
  - Sample Size

- **Rinse and Repeat**
  - Re-bin
TWP Construction 2 Application

- Scaling
  - Lateral length, kH, proppant
- Fitness Metrics
  - Discounted Volume
- Uncertainty
  - Probability of Outcome
  - Commerciality
  - Success / Fail decision tree
- Communication of purpose
Type Well Profiles - Fluid Flow Principles

Flow Regime Theory

- Transient Linear Flow
- (until fracture interference, b=2)
- Boundary Influenced Flow
- (BDF of Stimulated Reservoir Volume b < 1, Linear beyond SRV b=2)
- Boundary Dominated Flow (b < 1)

Goals:

- Establish Start of Boundary Influenced Flow
- Establish Decline rate and B
• Diagnostic Methods
  • Pressure normalized Log(q) versus Log(MBT) sometimes effective
    • Absence of Daily Data makes it difficult to pick unique half-slope and unity slope solutions
    • Absence of Pressure data for rate normalization can make for misleading interpretation

• Log(q) versus Log(t) Plots
  • assumes constant pressure, single phase
  • Workable with monthly data

• GOR change method in multi-phase environment (based on some observations):
  • During Linear flow, if Flowing pressure is constant, GOR is constant
  • GOR starts to increase under Boundary Influenced Flow
Flow Regime Identification

Log(q) versus Log(t)
Forecast - Diagnostics
Practical Decline Models

• **Single Segment Arps** – intended for BDF only, difficult or impossible to fit multiple flow regimes and usually overstates reserves

• **Two Segment Arps** – Linear & BIF, or BIF and BDF flow regimes
  • Two different B Factors
  • Need to determine end of Linear Flow

• **Three Segment Arps** – Linear, BIF, and BDF flow
  • Three different B Factors
  • Determination of the end of Linear flow
  • Determination of the end of Boundary Influenced flow
Tendency to bias towards the longest surviving wells when averaging production

- Forecast all wells individually first
- Separate TWPs by Vintage if you see a performance trend
- Divide by a constant well count (even as wells go off-line)
Survivor Bias - declining well count, no individual forecast
Survivor Bias - constant well count, individual forecasts
Binning

Grouping wells into analogous categories so that a TWP is meaningful and predictive, while keeping the number of samples per bin statistically meaningful.

- Multi-variate
  - Separate into regions of significant differences
- Correlate
  - Variables which show definite influence on performance results
- Anomalies may shed most light on differentiators
Binning – Completion Differences

- Well Type (H vs V)
- Lateral Length
- Vintage
- Number of Frac Stages
- Type of Frac Fluid
- Volume of Frac fluid
- Pounds of Proppant
- Clusters per Stage
- Mesh Size
- Pump Type
- Pump Size
- Choke Size
- Artificial Lift
- Proppant type
- Choke management
Binning – Geologic Differences

Porosity

Structure Thickness

Organic Content

phi*h

Vshale

Permeability

Fracture length

Vlime

Vcarbonate

Vdolomite

Formation

Dual porosity

Fracture Orientation

Vquartz

Matrix density

Vlime

Vdolomite

Formation

Matrix density
Binning – Reservoir Differences

- Thermal Maturity
- Initial Water Saturation
- Initial Reservoir Pressure
- GOR
- Flow Regim
- B factor
- Initial Potential
- Performance
Bins - Distribution

Quantile-Quantile Plot

- oil_cum_180
- Lognormal

Empirical Quantiles

Theoretical Quantiles
Bins
- Distribution
Bins
- EUR / 1000'
Probit
Scaling – Tradeoff versus Bin Size

- Scaling
- Establish Correlations
  - IP versus Lateral Length
  - EUR versus Lateral Length
- Note Decline rate and Qi are both changing
- Note that EUR per foot decreases with increasing length

- Possible new techniques on scaling to curve shape using permeability and calculated fracture half-length
Commerciality – Risked Probability of Success

*SPE 179996 -(David S. Fulford) – Unconventional Risk and Uncertainty: Show Me What Success Looks Like
## Uncertainty

### Sources of Uncertainty

- Uncertainty of the Individual Forecasts
- clean data
- sufficient history
- Is Sample set “truly” analogous
- Is Sample set large enough for high statistical confidence

### Clarity of Purpose

- Analogy of input area wells to intended use area
- For single well or developmental program

### The level of Uncertainty does not preclude the use of a TWP or not, what is important is that the Level of Uncertainty is adequately communicated from the producer to the consumer.
Closing

Monograph 5 is a work in progress. If you would like to contribute comments, suggestions, ideas, or data, please contact me at

Gary J. Gonzenbach
gary@cgpetroleum.com

Thank you!