Overview - This 90 Minute Session #1 of 2

**Session #1**

a) General SNAP detailed work-through of two Base Case example problems
   - With about 10 sequential oil well sensitivity cases for completion design
     - The oil well example takes a naturally flowing oil well and ages the well to eventually become an artificial lift completion
   - Then, about 5 sequential sensitivity cases for a gas well completion design
     - *The gas well example takes a poorly designed gas well with gas liquids and resolves the completion*

b) Next, review several example SNAP cases / module exercise

c) Lastly, clearly describe and discuss the Oil & Gas Class Problems
   *Plus, address any relevant Q&A’s*
Overview – The 2nd 90 Minute Session #2 of 2

**Session #2 – at the end of the module**

a) Solicit presentation of the Oil & Gas Class Problems  
*Address any relevant Q&A's*

Overview – SUMMARY of this 90 Minute Session #1

**Session #1**

a) General SNAP detailed work-through of two Base Case example problems  
   • With about 10 sequential oil well sensitivity cases for completion design  
     – The oil well example takes a naturally flowing oil well and ages the well to eventually become an artificial lift completion  
   • Then, about 5 sequential sensitivity cases for a gas well completion design  
     – *The gas well example takes a poorly designed gas well with gas liquids and resolves the completion*

b) Next, review several example SNAP cases / module exercise

c) Lastly, clearly describe and discuss the Oil & Gas Class Problems  
   *Plus, address any relevant Q&A's*
Overview

Inflow Expression to Predict Q as $F(P_{\text{res}} - P_{\text{wf}})$

Recall... Inflow Summary

Empirical Methods

Oil
- Multi rate flow tests
- Vogel equation ($P_{\text{wf}} < P_{BP}$)
- PI equation ($P_{\text{wf}} > P_{BP}$)
- Fetkovich

Gas
- Multi rate flow tests
- C, n back pressure equation

Analytical Methods

Oil
- Darcy equation
- Forchheimer
- Other

Gas
- Darcy equation
- Forchheimer
- Jones
- Other

Reservoir Data

- NOT Required
- IS Required
Well Performance is about understanding how to optimize the “system.”

The system is comprised of components.

Each component can be individually modeled.

The components can be connected to create a “system” model.

$P_{wf} \quad \text{Below bubble point pressure}$

Well / Zone “A”

Gas breakout
Oil not shown

$P_{wf}$

$Q$
Inflow Performance

- **Curved Line Equation** (per Zone “A”):
  - A mathematical representation is provided by the Vogel IPR relationship:
    \[ Q = Q_{\text{max}} \times (1 - 0.2 \left( \frac{P_{\text{wf}}}{P_{\text{res}}} \right) - 0.8 \left( \frac{P_{\text{wf}}}{P_{\text{res}}} \right)^2) \]
  where \( Q_{\text{max}} = \text{AOF} \)

- Vogel developed this relationship by best fit from numerous reservoir simulation runs.
- The Vogel IPR has a long history of use in the industry with very good success.

The System

- \( P_{\text{wf}} \) **Above bubble point pressure**
**Inflow Performance**

- **Straight Line Equation** (per Zone “B”):
  - $\pi = \text{Straight line IPR (slope of line)}$

- **Productivity Index** ($\pi$ also given as $J$):
  - $Q = (P_{\text{res}} - P_{\text{wf}}) \times \pi$
    - Where $\pi$ is the linear slope

**Gas Inflow Performance**

*The Most Common Evaluation Method for Gas Wells*

- Many other curves to represent multi-phase inflow take the form of the gas equation:
  $$ Q = C (P_r^2 - P_{\text{wf}}^2)^n $$

  - The Bureau of Mines IPR, a.k.a. the Back Pressure equation (Rawlins & Schellhardt 1936).
  - The exponent ranges from 0.5 to 1.0
  - The exponent is derived from multiple rates by plotting $(P_r^2 - P_{\text{wf}}^2)$ versus rate and finding $n$, the inverse of the slope; then, find “C” by substituting one test point into the formula.
The Darcy equation requires many variables describing the reservoir, oil or gas.

- The "S" value represents wellbore skin, or pressure drop to due varied types of formation damage.
- The Darcy equation is an analytical equation to predict flow rate $Q$ (for oil or gas) as a function of pressure drop or drawdown.

$$Q = \frac{2 \pi \kappa h (P_{res} - P_{wf})}{\mu B_o (\ln \frac{r_o}{r_i})}$$

Inflow Expression to Predict $Q$ as $F(P_{res} - P_{wf})$

**Recall...**

**Inflow Summary**

**Empirical Methods**

- Multi rate flow tests
- Vogel equation ($P_{wf} < P_{BP}$)
- PI equation ($P_{wf} > P_{BP}$)
- Fetkovich

**Analytical Methods**

- Darcy equation
- Forchheimer
- Other
Inflow/Outflow Performance

- Nodal Analysis Summary of IPR / IPC Curves
  - The “Need to Know” Nodal Analysis Principle
  - Given any inflow, choose the tubing size that shows a “U” shape such that the minimum stable rate is to the left of the intersection with the inflow curve.
The System – Summary

- Combining Inflow and Outflow analyses provide a powerful tool for decision making.

![Graph showing Inflow and Outflow analyses](image-url)
The Excel worksheets provided may be used and data may be entered using either field units and/or metric units.

But Remember... Only enter data into the **yellow cells**.
Data entry is accomplished by clicking on the various screen tabs (General, PVT, Inflow, Wellbore, Sensitivities, and others that can be opened and used.)

Moving back and forth between metric units and field units is accomplished by clicking on the “Edit” tab.
Module Start Up Discussion

Clicking on the “Units Preference” tab within the “Edit” tab will then open the “Units Dialog” box. Simply select the desired field or metric units.

Now… time to work exercises