ASME

ISO International Organization for Standardization

American Petroleum Institute

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API RP 11v11
Recommended Practice for The Use of Dynamic Simulation of Gas Lift Wells and Systems

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CONTENT

- **This presentation describes dynamic simulation and its current applications for gas-lift wells and systems.**
- **It gives an overview of the plans for a new API Recommended Practice for Dynamic Simulation of Gas-Lift Wells and Systems: API RP 11V11.**

API 11V Gas-Lift Task Group

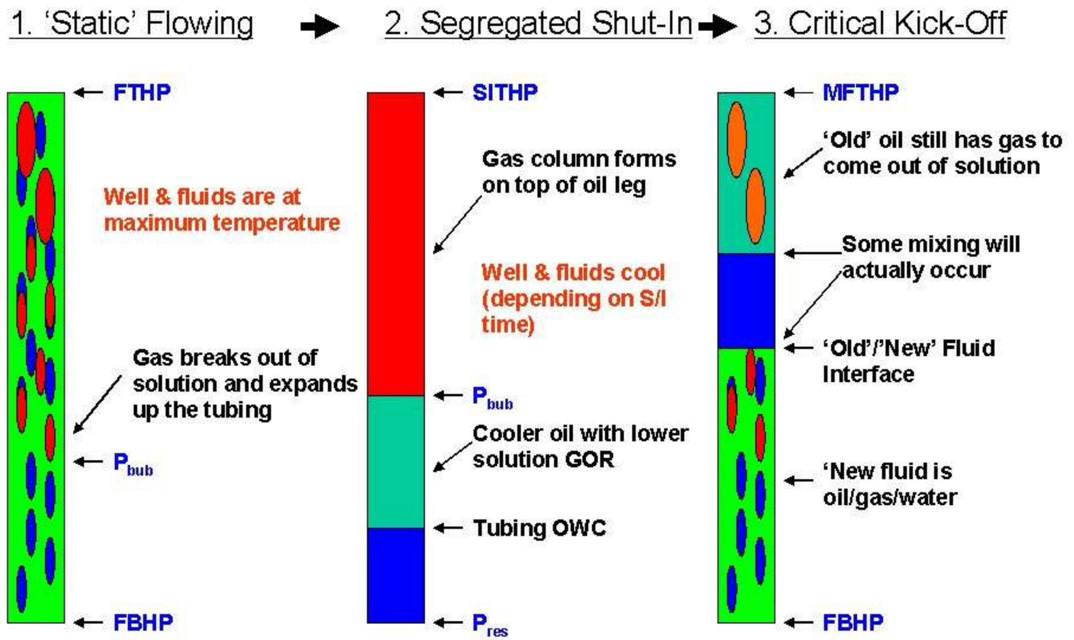
APR-RP-11

Although our primary focus is currently on gas-lift, we intend to address a broad range of artificial lift systems and topics

NODAL® vs. DYNAMIC SIMULATION

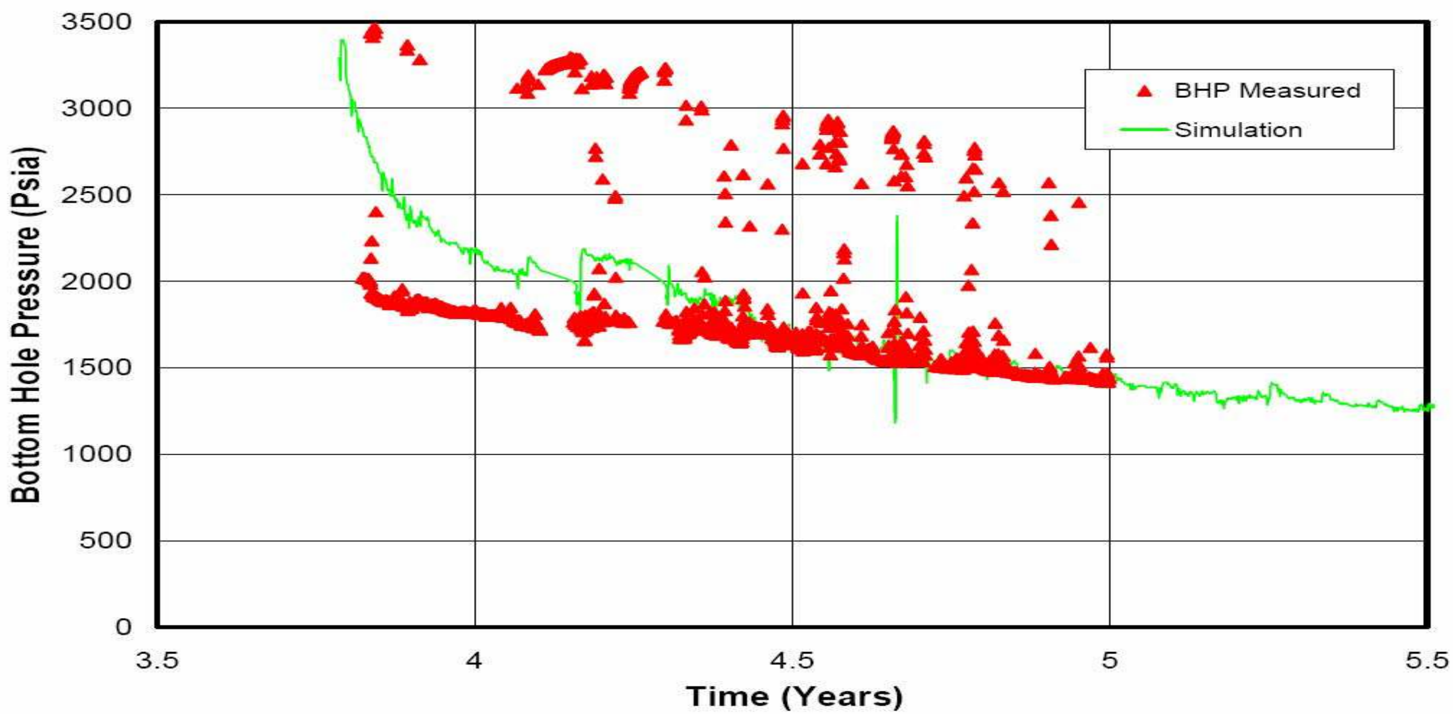
The weak points of NODAL S.S. analysis comparing with dynamic (transient) simulation are:

- **Unable to predict severe slugging introduced by riser / flowline or HL / ML / sinusoidal wellbores**
- **Unable to perform instability analysis**
- **Unable to performance gas-lift unloading analysis**
- **Unable to predict dynamic behaviour of plunger lift**
- **Unable to look at gas/condensate gas well liquid load-up issues**
- **Unable to performance flow assurance study, e.g., start-up / shut-down, corrosion / chemical injection**



NODAL® vs. DYNAMIC SIMULATION

- **Steady state simulation tools (Prosper, etc.) are inappropriate for dynamic (transient, change with time) multi-phase flow in wellbores.**
- **An example of discrepancy btw. S.S. model and measured results for a CVX gas-condensate well (Britannia, North Sea).**

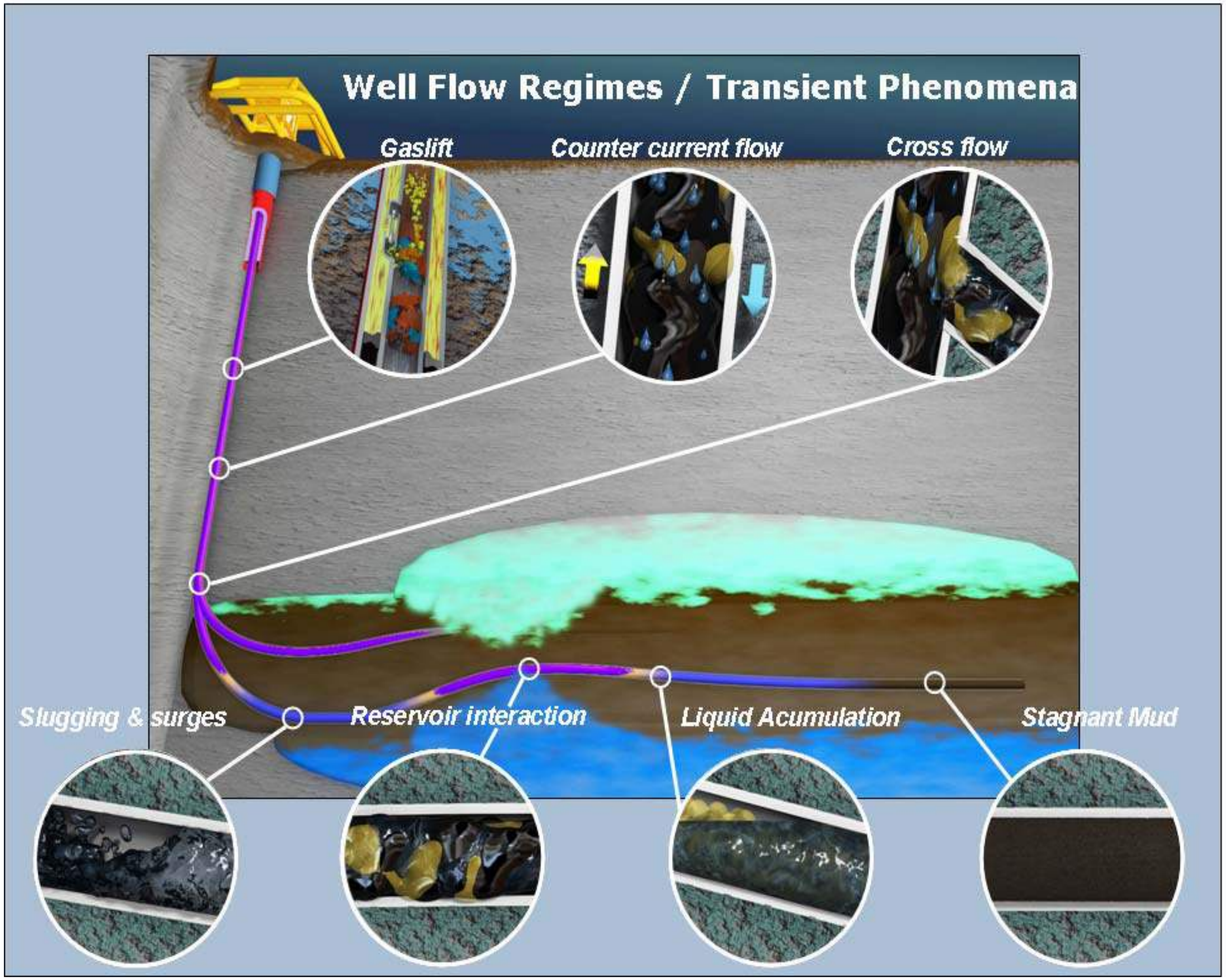


DYNAMIC SIMULATION

- Dynamic simulation can be used at any stage of a field's life cycle to build a virtual model of a well and/or production system.
- It can help to understand transient well behaviour and determine the optimum process to eliminate or minimize instability problems.
- It can be used to analyse "what if" scenarios and predict results.
- It does not replace NODAL® analysis but fills gaps where steady-sate analysis techniques cannot provide adequate solutions.

Dynamic Simulation
Recommended Areas of Use

- Gas-lift unloading / plunger lift
- Instablility / Severe Slugging
- Gas-lift design and optimisation
- Cross-flow analysis
- Gas well Liquid load-up
- Well Clean-up / start-up
- Well Testing: Wellbore Storage effects / Segregation effects
- Wellbore thermal calculations
- Flow Assurance



DYNAMIC GAS LIFT APPLICATIONS

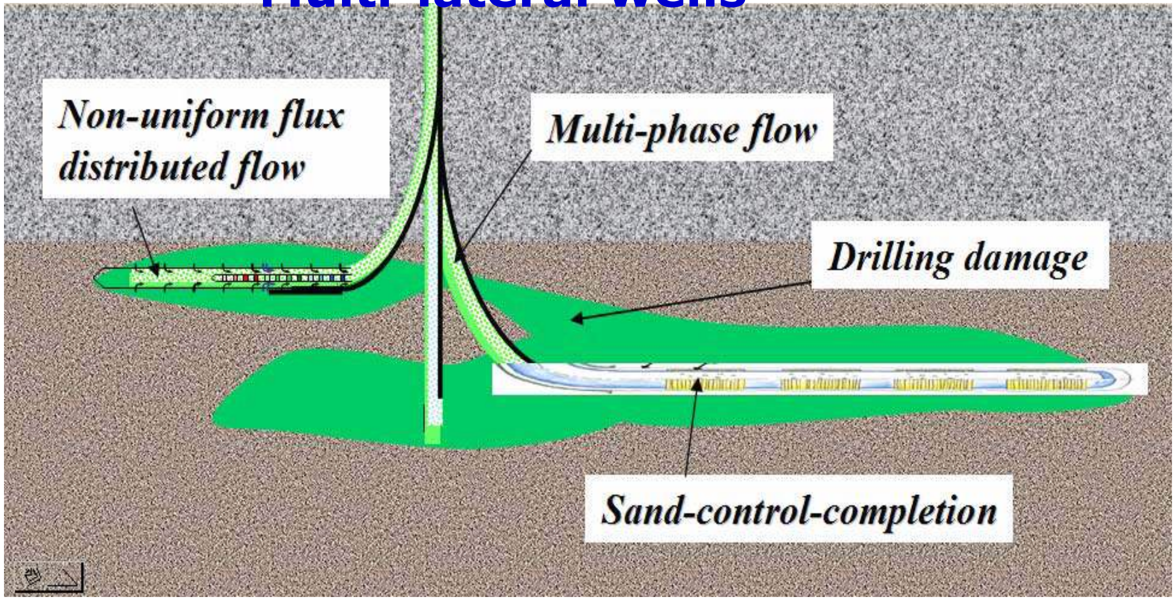
- Continuous gas-lift / Gas-lift valve performance
- Intermittent gas-lift
- Gas-assisted plunger lift
- Dual gas-lift
- Single-point gas-lift
- “Auto” gas-lift (gas from one zone is used lift other zones)
- Riser gas-lift
- Gas-lift for gas well deliquification
- Gas-lift unloading
- Kick-off of gas-lift wells
- Use of gas-lift for wellbore clean-up
- Gas-lift system distribution with various types of system configurations
- Use of un-dehydrated gas
- Use of non-hydrocarbon gases such as CO2 and N2.

DYNAMIC SIMULATION for WELL DESIGN

<u>Well design:</u>

Understand effects of well design & associated dynamic
effects on well operations, including:

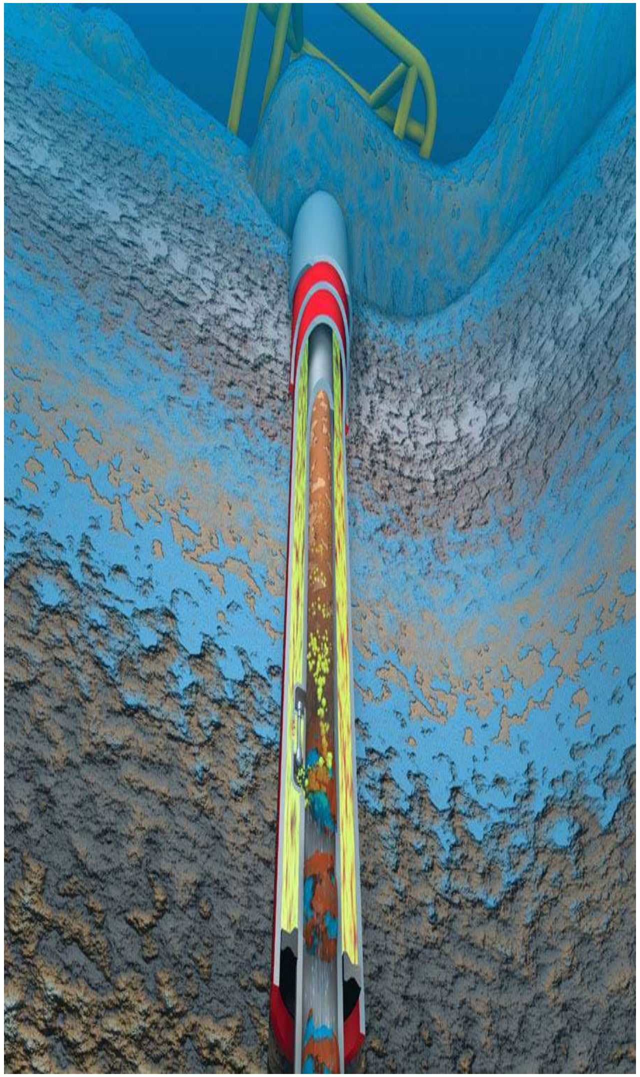
- **Vertical wells**
- **Horizontal / Sinusoidal wells**
- **Multi-lateral wells**



Example 1: Dynamic Simulation for Dry-Tree Gas-Lift (injection at the mud line)

- An example for subsea deepwater G-L, where transient issues relates to flow assurance, complex wellbore. Long flowlines / risers play significant roll in G-L system design and optimization.

•10,000' vert. well (5 ½" tb x 9 5/8" cs) from reservoir to riser base (mud line), drill water fills well annulus.
•5,000' riser (1.5" insulate layer) to dry tree.
•Gas injected downward from surface (125F) to the 9 5/8" riser annulus. Riser-base is a merge node where well & annulus converge into the riser.

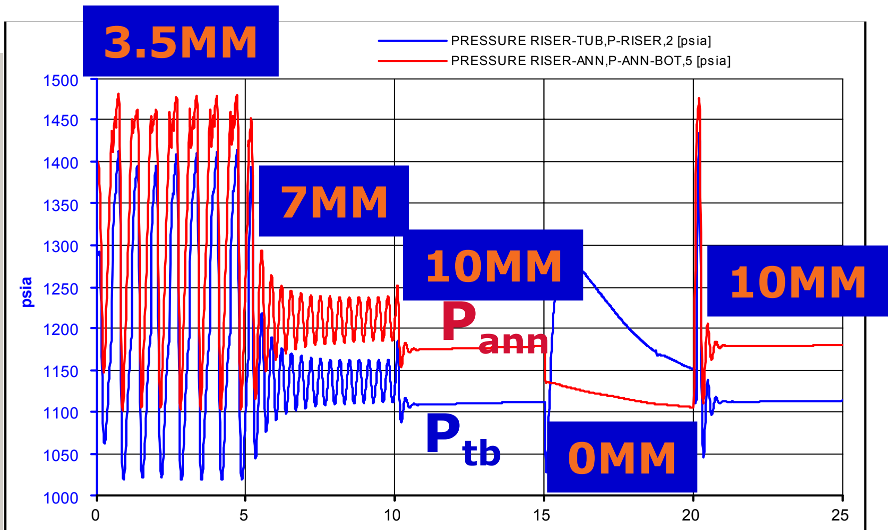


Example 1: Dynamic Simulation for Dry-Tree Gas-Lift (injection at the mud line) (courtesy to Lee Norris)

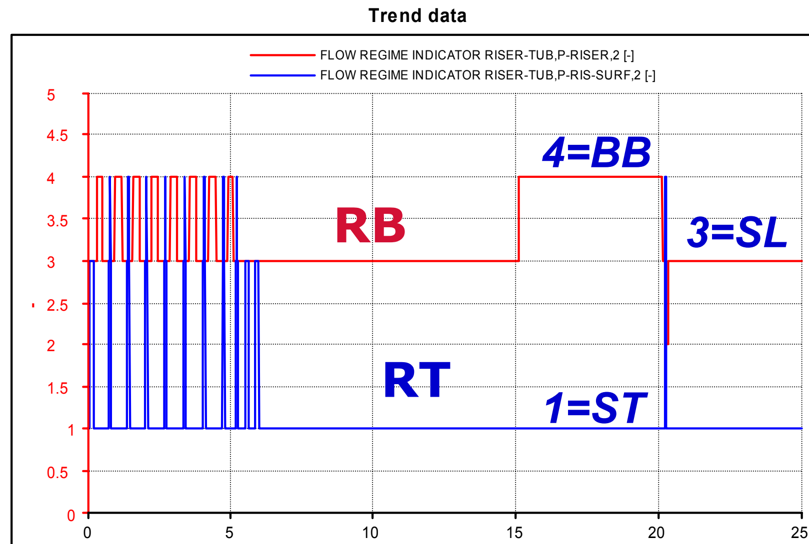
- Simulate unstable and stable production by injecting different quantities of gas, U-shaped temperature profiles due to counter-current flow and heat exchange through annulus and riser, the effect of downtime of injection operation and the restart of gas-lift.

- **0 ~ 5 hr.: 3.5 MMscf/d gas injection**
- **5 ~ 10 hr.: 7.0 MMscf/d gas injection**
- **10 ~ 15 hr.: 10.5 MMscf/d gas injection**
- **15 ~ 20 hr.: gas injection stopped**
- **20 ~ 25 hr.: resume 10.5 MMscf/d gas injection**
- **Sea Water@ riser top=76 F, Sea water@ mud-line=43 F**

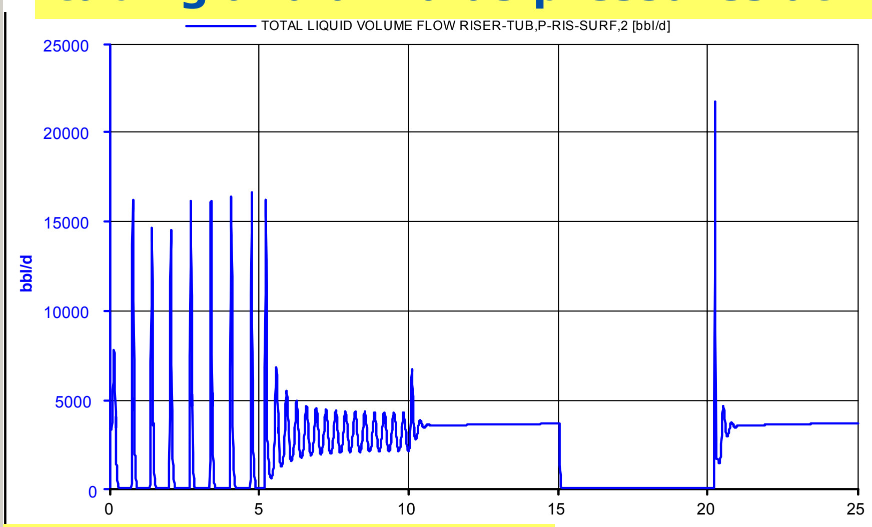
Example 1: Dynamic Simulation for Dry-Tree Gas-Lift (injection at the mud line)



tubing and annulus pressures at RB

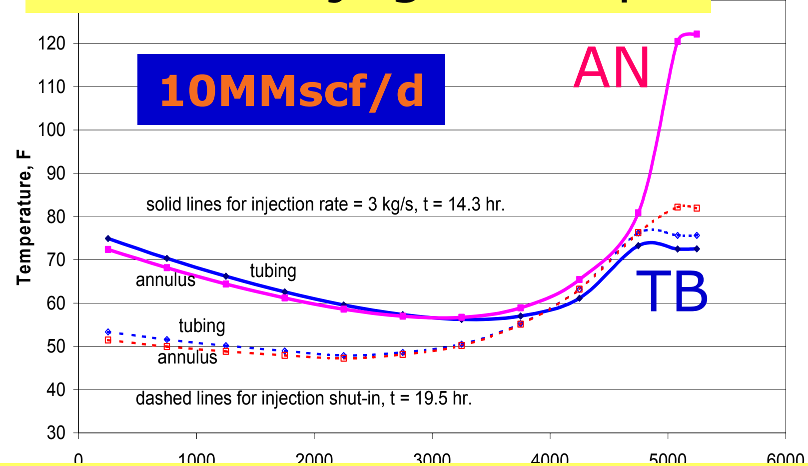


Flow Pattern in Riser Base &Top



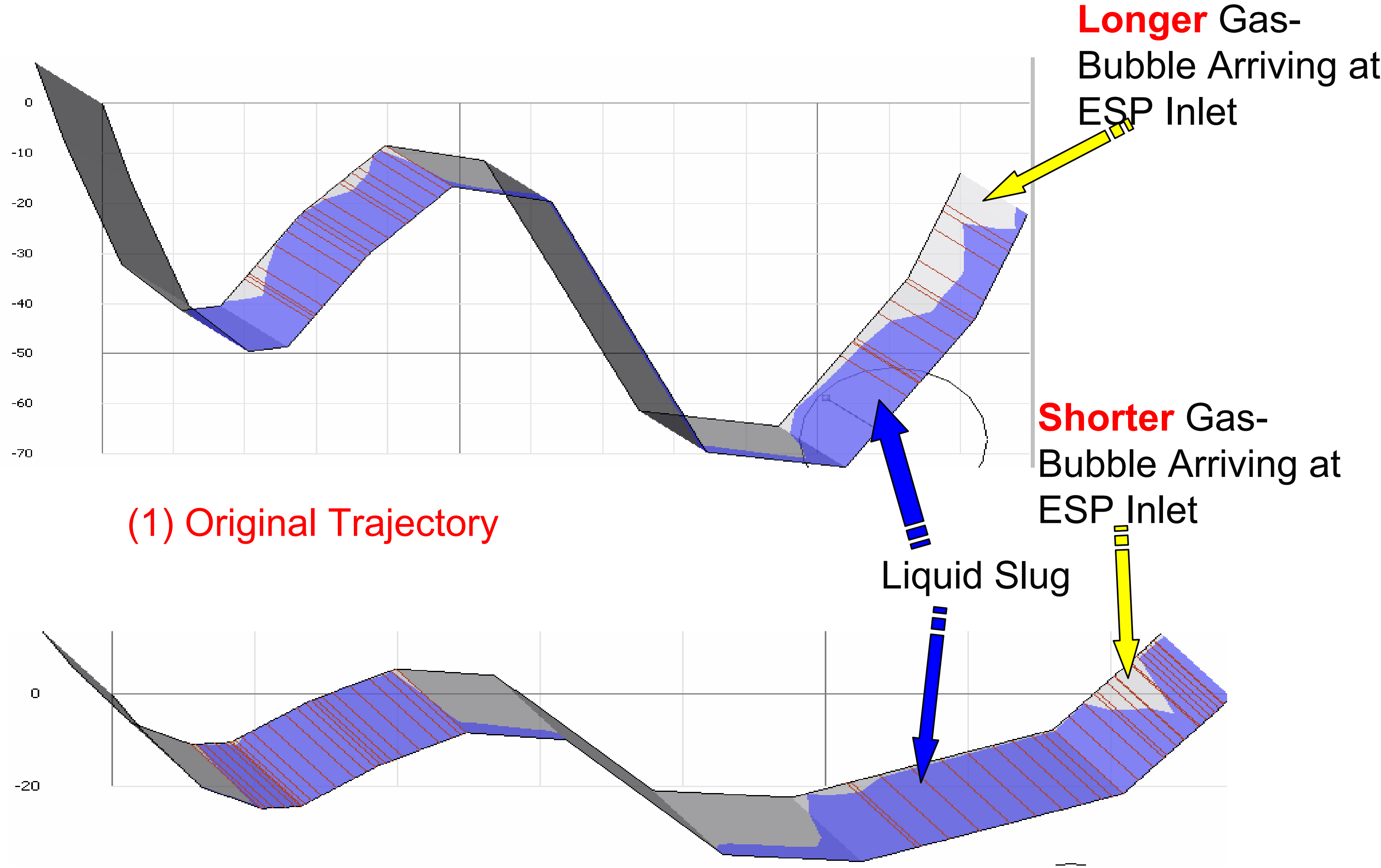
total liquid rate at RT

warmer inj. gas temp.



U-shaped tubing& ann. Temp

Application Example 2: CVX Sinusoidal Wells Trajectory Design to Reduce Instability

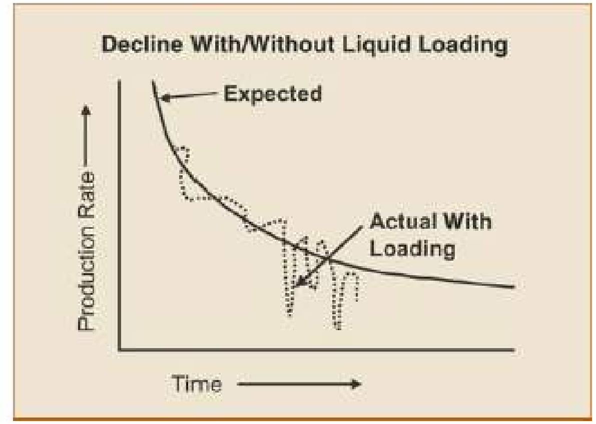


(1) Original Trajectory

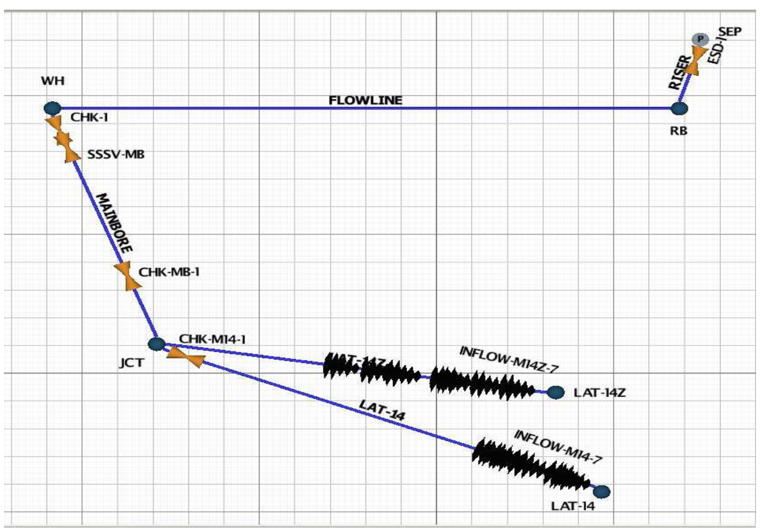
(2) Improved Trajectory: Higher Entrance Angle and half amplitude

Application Example 3: CVX Dual Laterals Liquid Load-up Study

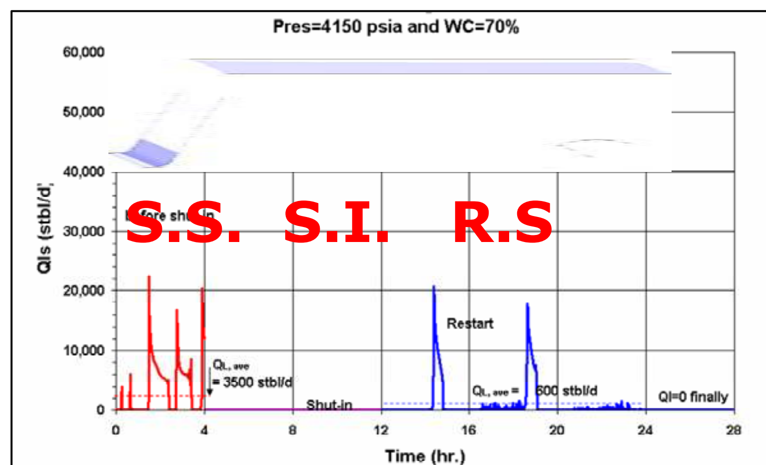
A dual-lateral well was completed in a cvx subsea condensate field with high peak rate (77 MMscf/d and 6300 stbo/d). Within one year, the production significantly declined with high water-cut (WC=90%).



- **After a shut-in the well came on-line at a much reduced rate and over a period of 3 days stopped producing.**

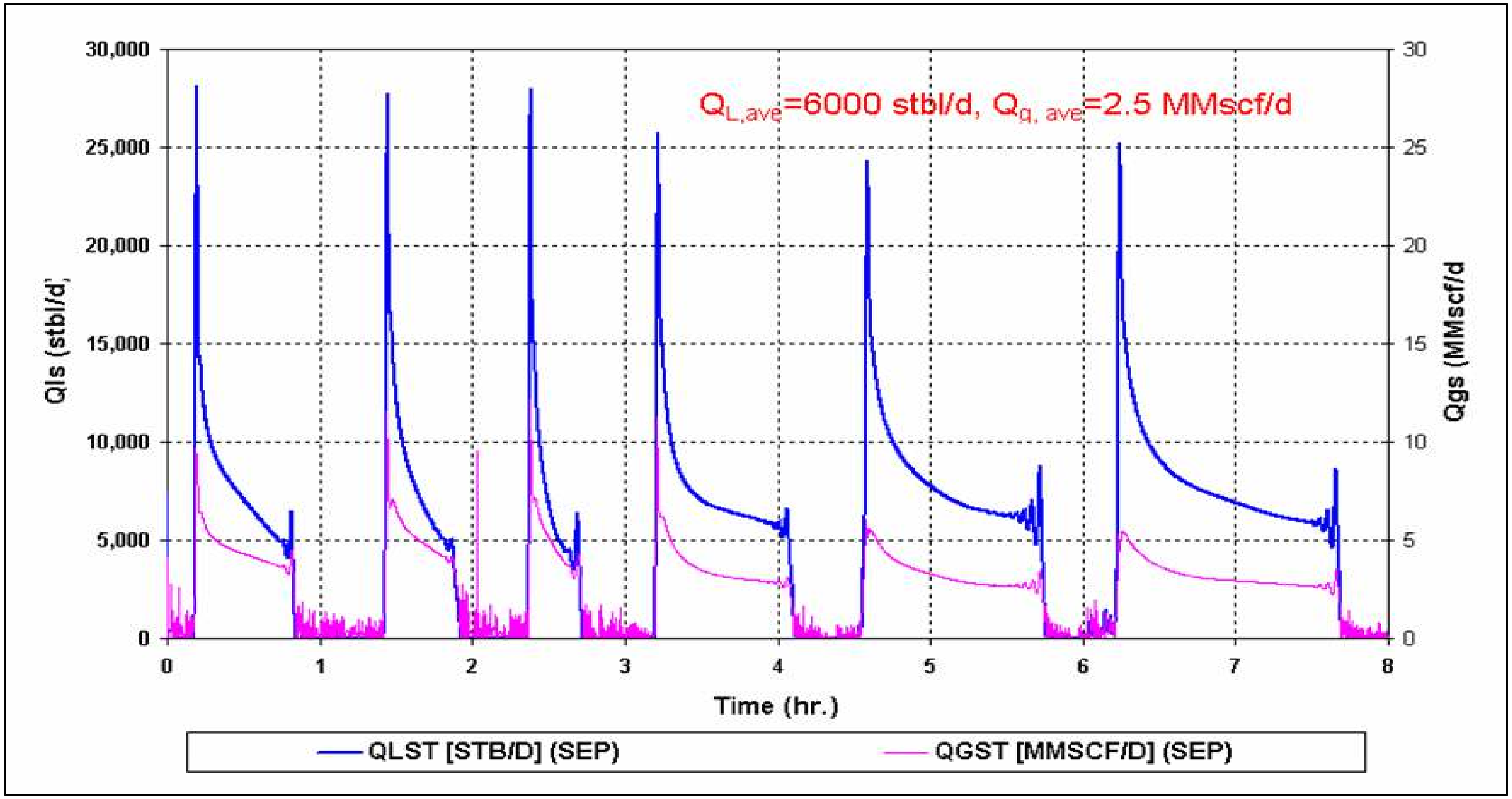


Liquid Flow Rate



Application Example 3:
CVX Dual Laterals Liquid Load-up Study

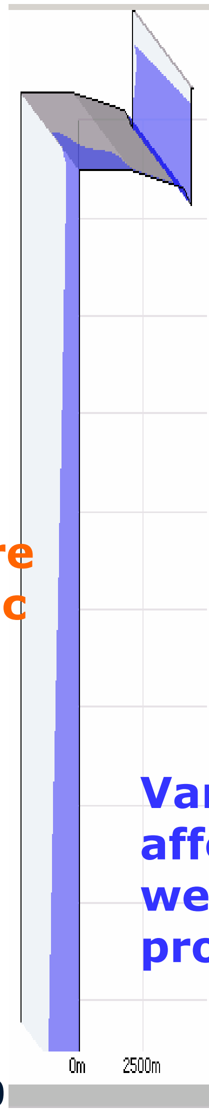
Flow Rate at Separator, Gas-Lift has been stopped



Well becomes intermittent after gas-lift stop

Application Example 4:
Integrated Wellbore-Reservoir Dynamic Simulation

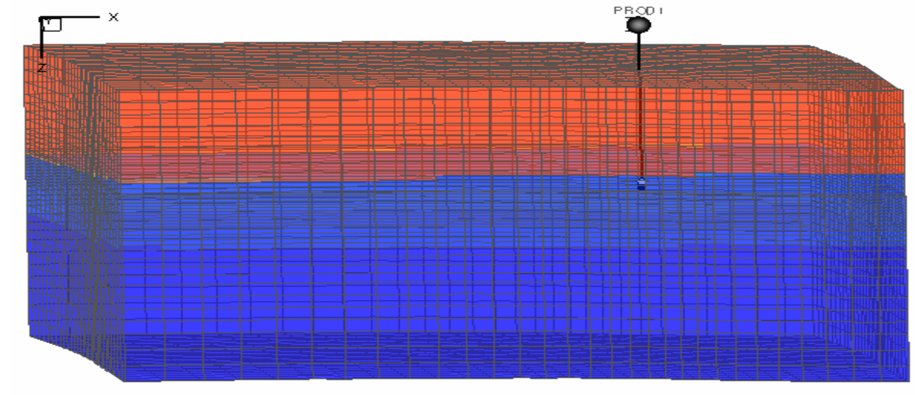
WHP = 290 psi



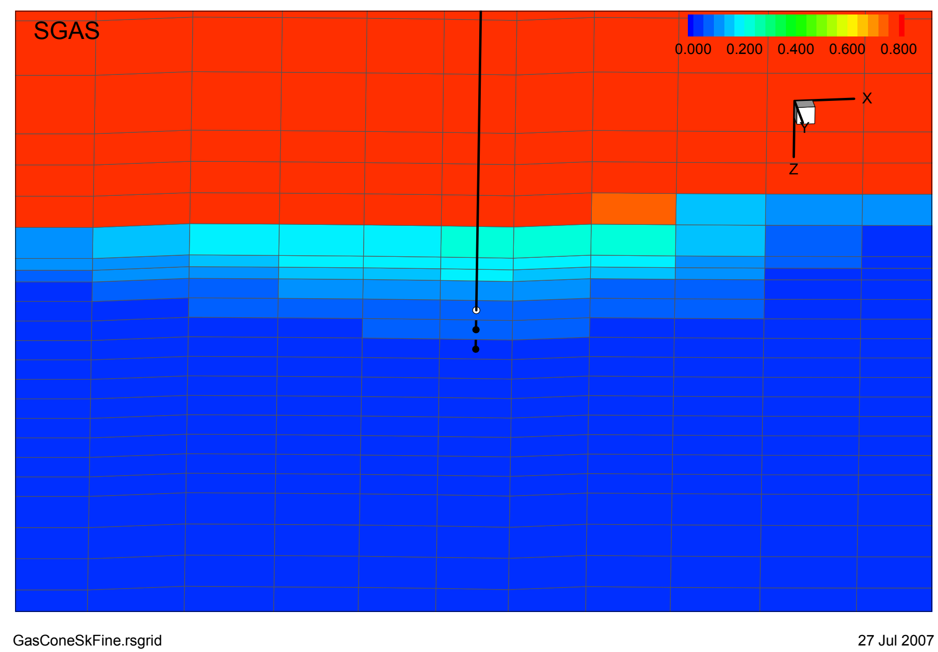
Wellbore Dynamic Model

Variable BHP affects near wellbore productivity

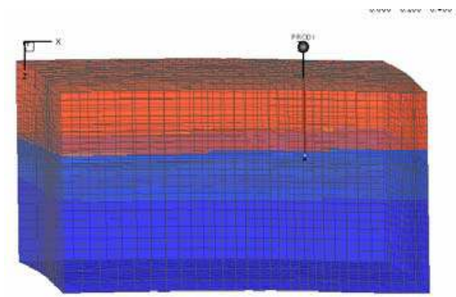
MD= 7790



Reservoir Model



Application Example 4:
Integrated Wellbore-Reservoir Dynamic Simulation



OLGA

Matlab toolbox

One Time Step Explicitness

CHEARS

DLL

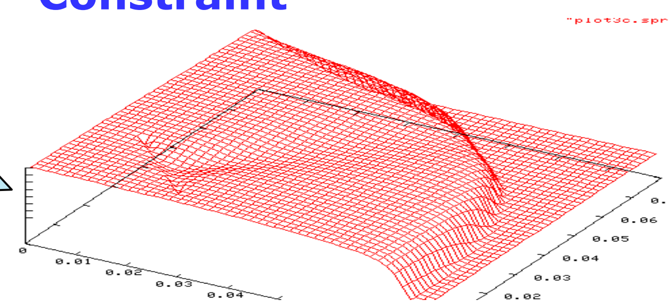
Inflow Source

Rates

BHP

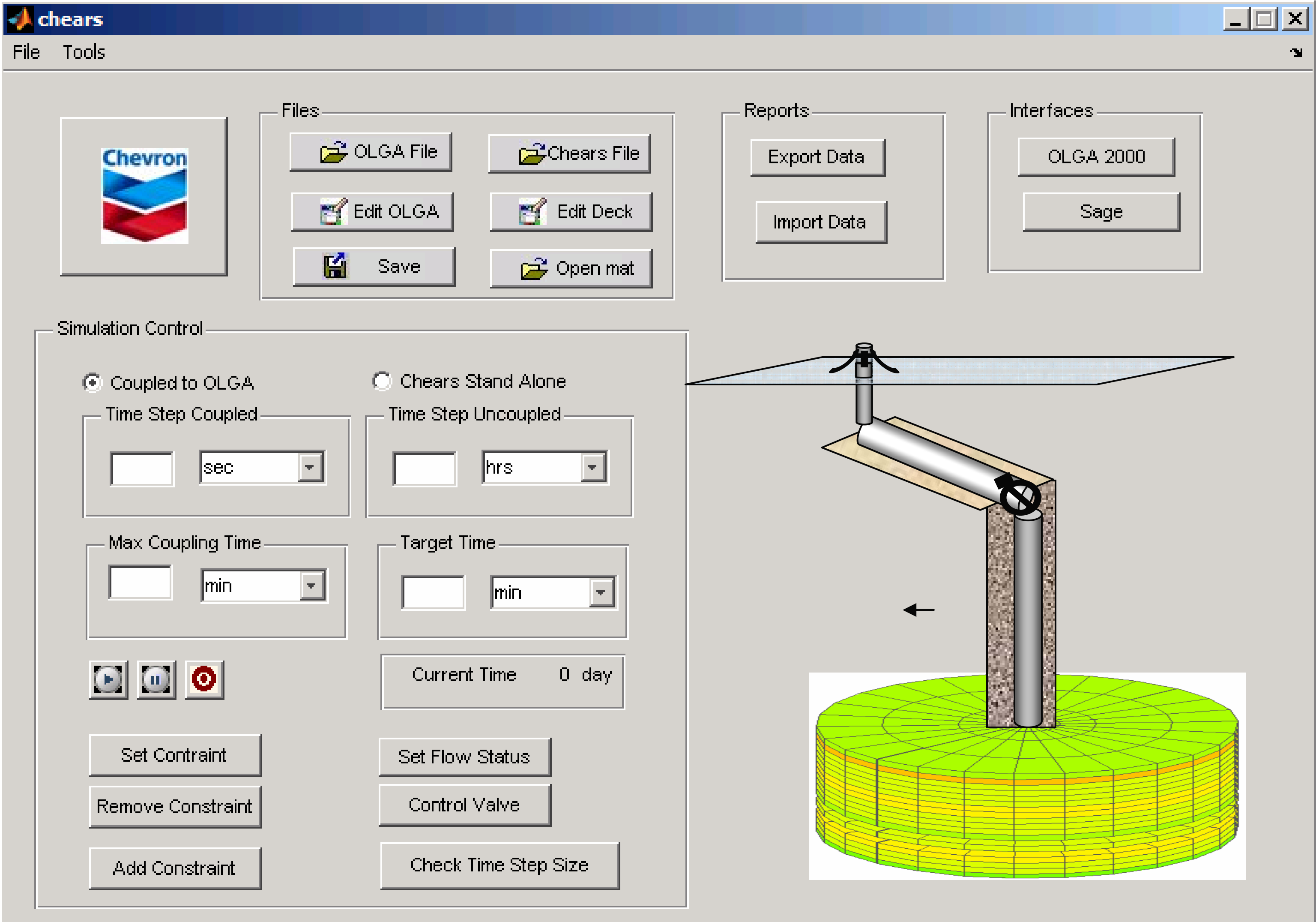
Set BHP as Constraint

MATLAB



*We are not recommending the use of only mentioned tools

Application Example 4: Integrated Wellbore-Reservoir Dynamic Simulation



*We are not recommending the use of only mentioned tools

DYNAMIC SIMULATION PRACTICES

- Currently, there are no industry-accepted recommended practices for the application of dynamic simulation for gas-lift.

- The industry recognizes the needs for a API RP for Dynamic Simulation of Gas-Lift Wells and Systems: API RP 11V11.

API RP 11v11 TEAM MEMBERS

- Following the API Standards Development procedures, we formed a working team committee to develop written recommendations and guidelines for dynamic simulation techniques.
- We would like to invite you to be a member of the committee and participate in shaping these global standards to contribute your experience and to represent your company.
- Our next meeting is scheduled to be held on Friday 8/02/08

API RP 11v11
TASK GROUP MEMBERS

16 members representing 14 companies and one university

Juan Mantecon, SPT Group - Chairperson
Cleon Dunham, Oilfield Automation - Secretary
Adam Ballard, BP
Arne Valle, StatoilHydro
Boots Rouen, Schlumberger
Dan Dees, AppSmiths
Fernado Ascencio Candejas, PEMEX
Dr. Fernando Samaniego, UNAM (Mexico Autonomous Nacional University)
Galileu Paulo Henke A. Oliveira, Petrobras
Greg Stephenson, eP-Solutions
Kallal Arunachalam, ConocoPhillips
Ken Decker, Decker Technology
Knud Lunde , StatoilHydro
Murat Kerem, Shell
Shanhong Song, Chevron
Yula Tang, Chevron