Interpretation of Production Logs

KAPPA

INTERPRETATION THEORY

Module #10

Multiple Phase Conditions

Two phase flow:

Oil plus water	**- liquid + liquid**
Oil plus gas	**- liquid + gas**
Water plus gas	**- liquid + gas**

The questions are:

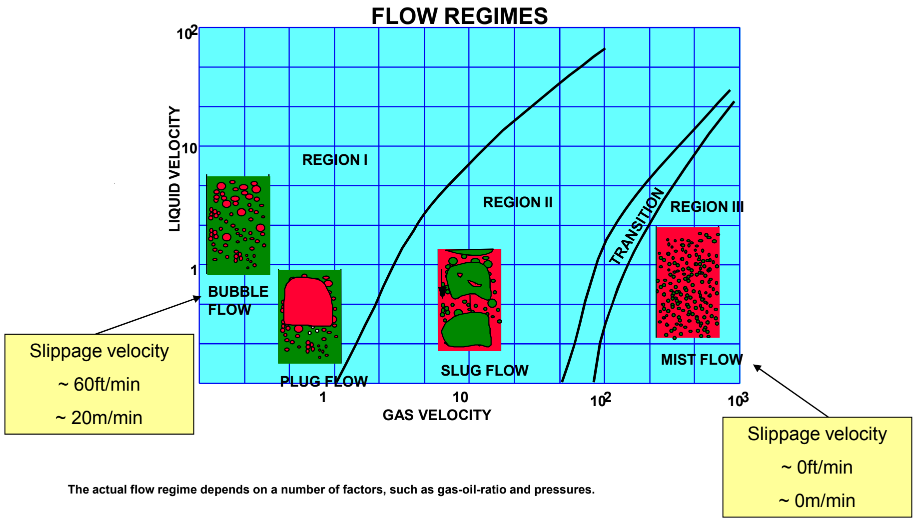
- what is flowing from which perforations
- is there any flow behind casing and if so which fluid
- is free gas being produced

Three phase flow there is:

Oil and gas plus water **- liquid + liquid + gas**

The questions are the same but the problem has an added unknown.

Flow In the Well - 2 Phase



The actual flow regime depends on a number of factors, such as gas-oil-ratio and pressures.

Definitions

Slip velocity, v_{slip}:

This is the absolute velocity difference between phases flowing together. No tool currently available to directly measure slip velocity.

Vslip = Vlight - Vheavy

Emeraude uses "Correlations" to assist in providing slip velocity.

Hold-up, Y:

This is fraction of the pipe cross-sectional area occupied by the phase of interest. The hold-ups must sum to unity

Yw + Yo + Yg = 1

Cut:

This is the ratio of the flowrate of the phase to the total flowrate. If there is no slip, then cut and hold-up are equal.

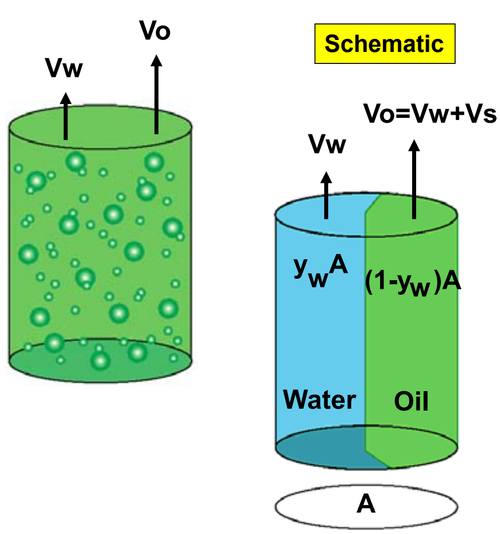
Water Cut = Qwater / Qtotal

Multiphase Solutions

- As with the single phase case the spinner will give an average total velocity, which will give an average total flow rate.
- Additional measurements are need to differentiate between the fluids.
- Here the fluid density and/or hold-up is used.
- In 3 phase both the density and hold-up are needed.
- An interpretation scheme making some assumptions can also be used, which is provided within Emeraude, with Flow Models and Correlations.

 5

Bubble Model



The bubble flow model used to be assumed in order to simplify the calculations as a quick look. A single slippage velocity Vs was required.

In computer based solutions a correlation is used to derive the flow regime and calculate a slippage velocity.

 6

Hold Up From Density

The solution for the rates needs an input of the hold up of any phase or the density

$\rho_M = \rho_H.Y_H + \rho_L.Y_L$

But $Y_L + Y_H = 1$ Therefore $Y_L = 1 - Y_H$

$\rho_M = \rho_H.Y_H + \rho_L.(1-Y_H)$

$Y_H = \frac{(\rho_M - \rho_L)}{(\rho_H - \rho_L)}$

ρ_L = light phase density
ρ_H = heavy phase density
ρ_M = mixture density

 7

2-Phase equal velocities

With the two phases flowing at the same velocity it would be sufficient to have a bulk rate and a way of measuring the holdups.

$$Q_t = 1.4 \times \left[0.83 \times V_{app}\right] \times D^2$$

(Units - Q [bbl/d]; V_{app}, V_m [ft/min]; D [inch])

$$\rho = Y_h \times \rho_h + Y_l \times \rho_l \quad \rightarrow \quad Y_h = \frac{\rho - \rho_l}{\rho_h - \rho_l}$$

$$Q_h = Y_h \times Q_t \quad ; \quad Q_l = Q_t - Q_h$$

NB: Vpcf and the friction correction (gradio) would require an iterative solution method

 8

2-Phase unequal velocities

Holdups: $Y_h + Y_l = 1$

Rates:

$$Q_h = V_h \times A \times Y_h \ ; \ Q_l = V_l \times A \times Y_l$$

$$Q_h + Q_l = Q_t$$

Slippage:

$$Vs = V_l - V_h = \frac{Q_l}{A \times Y_l} - \frac{Q_h}{A \times Y_h} \Rightarrow Vs = \frac{Q_t - Q_h}{A \times (1 - Y_h)} - \frac{Q_h}{A \times Y_h}$$

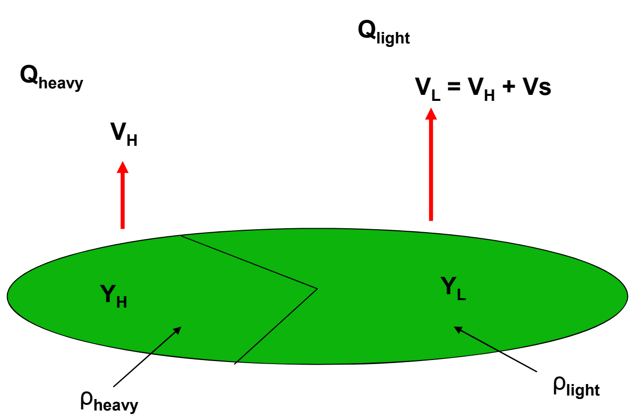
Rearranging:

$$Q_h = Y_h \times Q_t - Y_h \times (1 - Y_h) \times V_s \times A$$

$$Q_h = Y_h \times \left[Q_t - (1 - Y_h) \times V_s \times 1.4 \times D^2 \right]$$

(Units - Q [bbl/d]; V_{app}, V_m [ft/min]; D [inch])

2-Phase Model



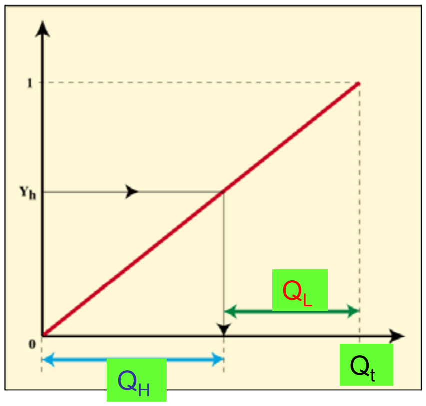
$Y_H + Y_L = 1$

$Q_H + Q_L = Q_t$

$V_s = V_L - V_H$

A = cross sectional area

Superficial Velocities

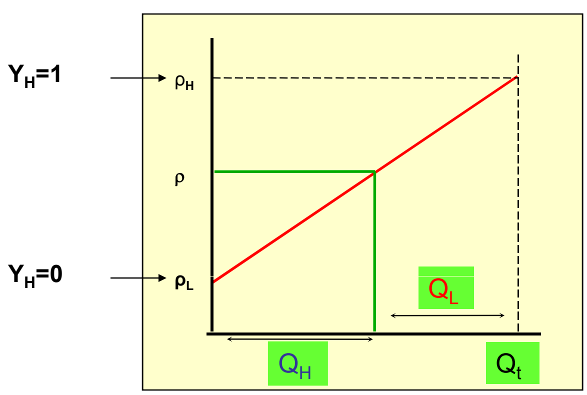


From the equations:

$Y_H + Y_L = 1$
$Q_H + Q_L = Q_t$

NOTE:
(No slippage velocity or flow regimes considered on this plot)

Densities



A similar solution is possible for the density, instead of holdups

Slippage Velocities

In the general case there is a difference between the two phases.

This term is called the Slippage Velocity, and will vary depending on the flow regime

The Slippage Velocity is the difference in velocities between the two phases.

$$V_{slippage} = V_{light} - V_{heavy}$$

The light phase generally rises faster than the heavy phase.

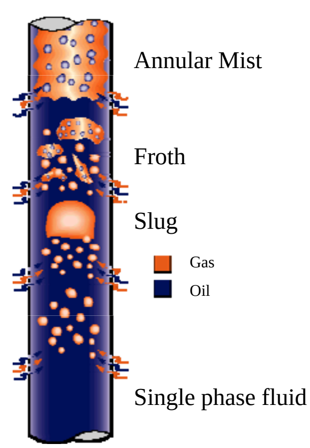
Slippage velocity correlations

Slippage velocity depends on the type of flow regime.

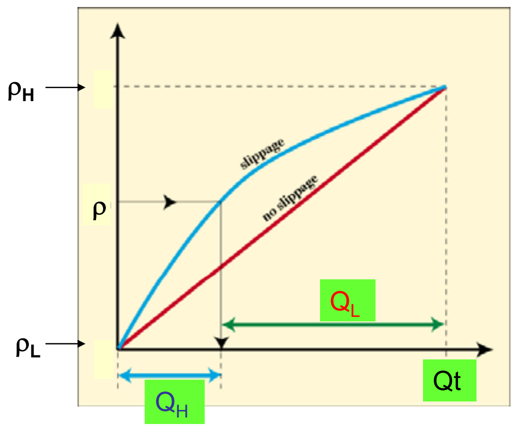
In Liquid-Gas a wide variety of regimes can occur

In Liquid-Liquid bubble flow is usually encountered (not near horizontal …)

A number of correlations exist, empirical or mechanistic, to determine the flow regime and calculate the slippage velocity Vs



Slippage Velocities

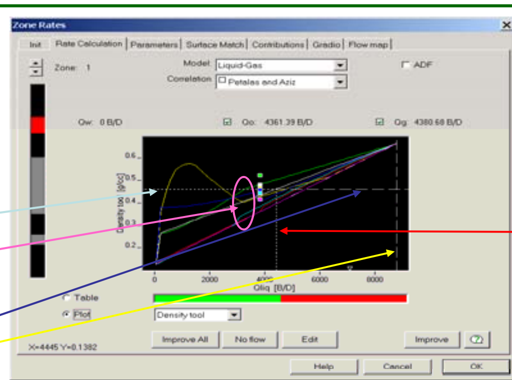


The slippage velocity implies that there will be less of the light phase seen in the pipe

The heavy phase hold up (Y_H) is larger, than would be predicted with no slip between the light and heavy phases.

The relationship becomes non-linear due to slippage and the changing nature of the flow regimes between the phases.

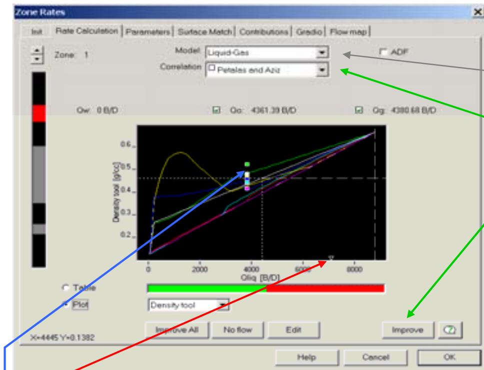
Zone Rates Calculation - 1



The default plot shows the density tool response vs possible values of Qh for the current Qt. Values on the X-axis are between 0 and Qt. The value Qt - Qh represents Ql (light)

- vertical dashed line: current value of Qt
- horizontal dashed line: measured density tool response for the zone
- coloured curves: simulated density tool responses for the applicable flow correlations
- vertical dotted line: Qh for the current solution
- horizontal dotted line : simulated density tool response for the current solution

Zone Rates Calculation - 2



• **Change Model** – Auto Improve

• **Change Correlation** – User must perform a "Manual Improve"

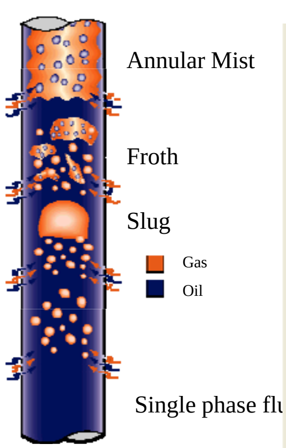
If the surface rates have been entered, (and the zone in view is the top calculation zone):

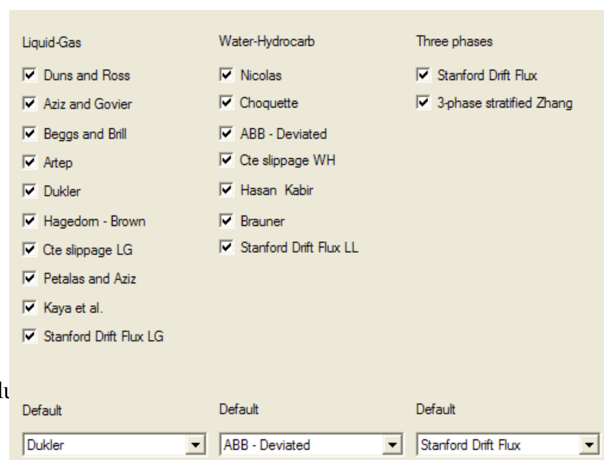
- white triangle pointing down on the X-axis:… downhole mixture rate as computed from the entered surface rates (and the PVT model Volume factors etc).
- colored squares:…. the density tool response the correlations would predict if the downhole rates were those corresponding to the entered surface conditions.

When a water holdup or a gas holdup measurement is available, it is possible to change the plot to a display of Water holdup or Gas holdup vs Qh. …replacing "density tool response" by "water holdup" or "gas holdup".

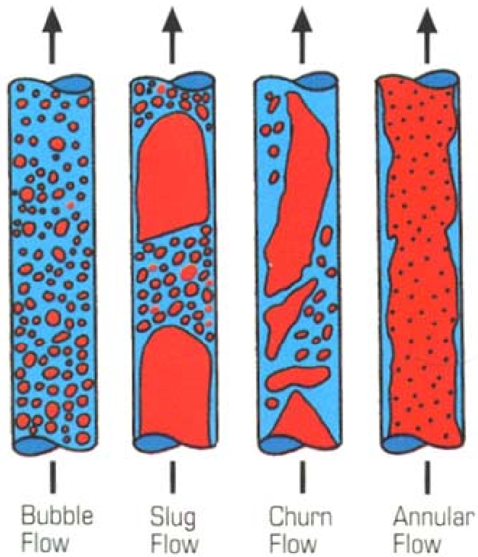
Flow Correlations

Flow Correlations

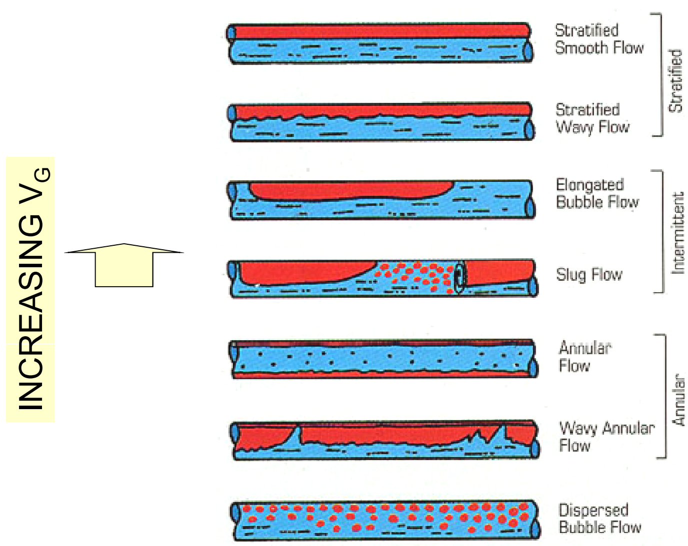




Flow Regimes in Vertical Pipes

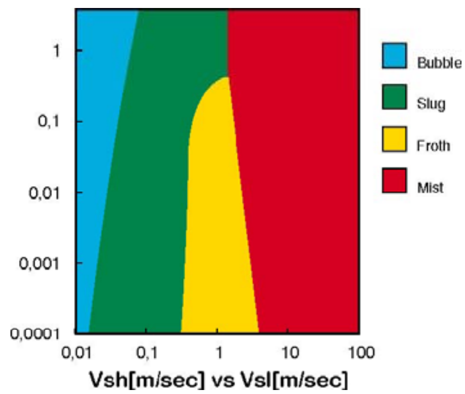


Flow Regimes in Horizontal Pipes

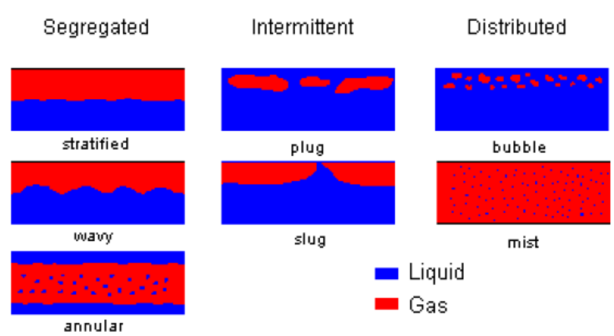


Aziz and Govier

- Mechanistic correlation for Liquid-gas flows.
- Only vertical flow is considered by the correlation
- Determination of the flow regimes is made using a single flow map plotted in terms of modified superficial velocities Y.Vsh vs X.Vsl, where X and Y are functions of the densities and interfacial tensions.



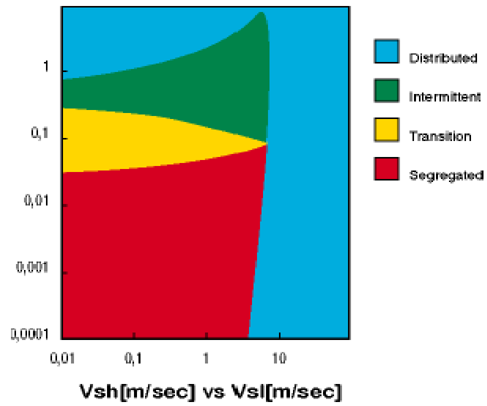
Beggs and Brill - 1



Correlation based on experiments with air-water flow for various pipe inclinations. The correlation distinguishes the flow regimes shown.

Beggs and Brill - 2

- Developed for tubing strings in inclined wells, and pipelines for hilly terrain, (but no negative Vs)
- From experiments using air and water over a wide range of parameters.
- Wide range of oil gravity
- Large errors for GOR>5000
- Accurate up to 10% water cut
- Not good in vertical oil flow
- Deviations 45 - 90deg

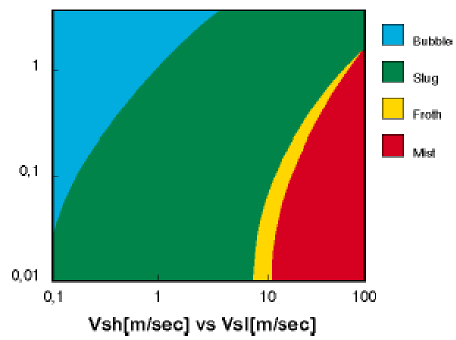


Artep

- No Flow Map
- Correlation for Liquid-Gas flow coupling a mechanistic derivation with a physical basis provided by experiments.
- The experiments were conducted in a flow loop at deviation between 0 and 90 degrees.
- The correlation does not handle a deviation of 90°.

Duns and Ross

- Only vertical upward flow is considered by the correlation.
- Handles mist better than slug flow.
- 1000 < GLR < 5000
- Wide range of oil gravity (13-56 API)
- Not suitable for wells with water cut
- Experimental correlation derived from laboratory data for vertical Liquid-Gas flow
- Good for Condensate wells
- Good for gas lift wells

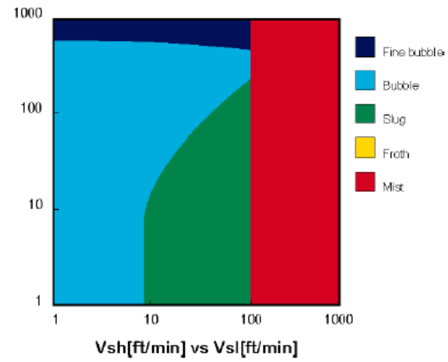


Hagedorn and Brown

- Experiment realised in a 1,500 ft vertical well.
- Tubing I.D: 1 in, 1¼ in, 1½ in.
- Oil viscosities between 10 and 110 cp (@ 80°F)
- Oil gravity from 25-40 °API
- GOR<5000
- Only vertical upward flow is considered by the model.
- No flow map.
- Single Holdup correlation provided for all conditions.
- Best choice for vertical wells with or without water cut.
- Poor in low rates
- Good in slug flows and high rate oil wells

Dukler - 1

- Based on experiments with air and water in 2.5 cm and 5.0 cm pipes.
- Mechanistic approach for the flow map determination.
- Only vertical flow is considered by the flow map, but slip deviation correction is applied in bubble flow (see next slide).



Dukler - 2

- Slug flow: The slippage correlation is given in the reference.
- Bubble flow: Slippage is based on (in ft/min)

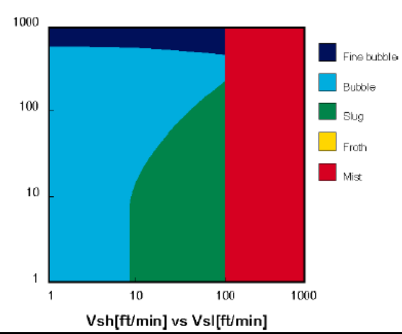
$$Vs = 60 \times \sqrt{(0.95 - (1 - Y_H)*(1 - Y_H))} + 1.50$$

- Pipe deviation: Taken into account by correcting the slippage velocity with a factor defined in the Interpretation Settings dialog as either linear for all angles:

$$Vs = Vs \times (1 + 0.04 \times \text{deviation})\ldots \text{ in bubble flow only.}$$

Or identical to the above until 45° and decreasing above this value (Ding et al.)

- The default setting is the linear correction.
- Probably the most widely-used flow correlation, although more-recent authors have questioned the physics of the correlation.



Petalas & Aziz

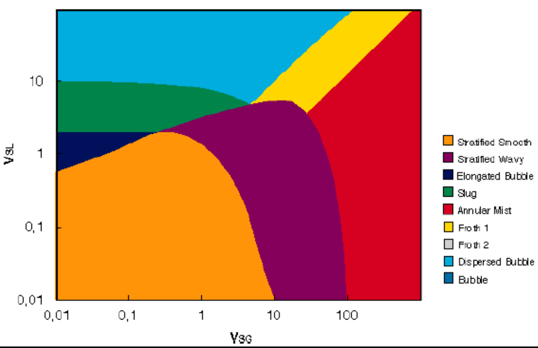
Mechanistic correlation for all pipe inclinations, geometries, and fluid properties. Empirical correlations involved in the model were developed based on the Multiphase Flow Database of Stanford University gathering 20,000 laboratory measurements and 1800 measurements from actual wells.

This correlation distinguishes the following regimes:

- Froth (transition between dispersed bubble and annular-mist).
- Froth II (transition between slug flow and annular-mist).
- Elongated bubbles
- Bubble
- Stratified smooth
- Stratified wavy
- Slug
- Annular-Mist
- Dispersed bubble

Stratified flow regimes are restricted to horizontal flow.

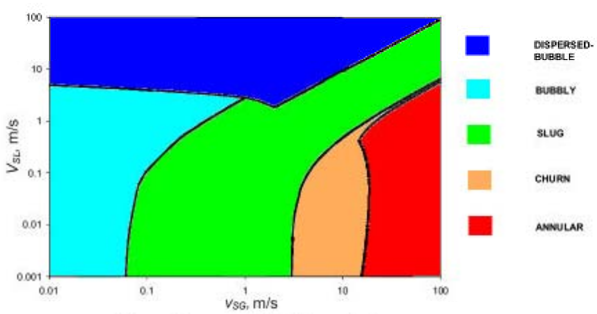
Air/Water system at atmospheric condition - Horizontal flow



Kaya et Al

A separate hydrodynamic mechanistic correlation is proposed for the different flow patterns.

The correlation includes five flow patterns: bubbly, dispersed-bubble, slug, churn, and annular flows in vertical and deviated wells



Flow-pattern map (90°, 5.08-cm pipe).

<u>Reference</u>: SPE 72998 : Mechanistic Modeling of Two-Phase Flow in Deviated Wells, A.S. Kaya, C. Sarica, and J.P. Brill

Stanford Drift Flux LG

Stanford Drift Flux Reference: SPE 89836 Drift-Flux Parameters for Three-Phase Steady-State Flow in Wellbores; H. Shi, J.A. Holmes, L.R. Diaz, L.J. Durlofsky, K. Aziz

The Drift-flux correlations represent multiphase flow in wellbores or pipes in terms of a number of empirically determined parameters. The great advantage of this correlation is that there is a continuity between the various flow regime type.

Two-phase correlation and parameter determination
i.e. The drift-flux correlation for two-phase **gas-liquid** flow is given by:
$Vg = Co \cdot Vm + Vd$
Where Vg is the average gas in situ velocity, Co is the profile parameter, Vm is the mixture velocity and Vd is the drift velocity.
The parameters determining Co, Vm, and Vd are experimentally determined.

Three-phase parameter determination
To model three-phase flow, a two-stage approach is first applied based purely on the two-phase flow correlations. The system is first treated as a gas-liquid flow to determine the gas hold up and then model the liquid as an oil-water system to determine the liquid hold ups.

Data used for the calibration were coming from cases with deviations from 0° to 88°.
The correlation should not be used outside this range.

Liquid-gas Correlations

Correlation	Year	Type	Application
Duns & Ross	1963	Emprical	Vertical flow, High GLR, Mist flows, Condensates, gas lift
Hagedorn & Brown	1965	Emprical	Vertical flow, slug flows
Aziz & Govier	1972	Mechanistic	Vertical flows
Beggs & Brill	1973	Emprical	All deviations
Duckler	1980	Mechanistic	Vertical flow
Artep	1988	Mechanistic	All deviations
Petalas & Aziz	1996	Mechanistic	All deviations (negative slippage)
Stanford Drift Flux LG	2004		0-88deg
Kaya et Al	2001	Mechanistic	Deviated & vertical flows (latest)

Nicolas

Nicolas, Choquette, and "ABB-deviated" are experimental correlations for Liquid-Liquid bubble flow. They all relate the slippage velocity to the bubble rise velocity in a static column.

Nicolas

Slip deviation correction in Emeraude:

Pipe deviation is taken into account by correcting the slippage velocity with a factor defined in the Interpretation Settings dialog as either linear for all angles:

$$Vs = Vs \times (1 + 0.04 \times deviation)$$

Or identical to the above until 45° and decreasing above this value (Ding et al.)

Note that changing the deviation correction mode in the Interpretation Settings will potentially affect all existing interpretations using the Nicolas correlation. It is left to the user to update calculations for zones/logs that are affected by the change.

Choquette, ABB-Deviated, Constant slippage

Choquette

This is a conventional slip velocity corelation in Water-Oil flow, represented as a chart giving the slippage versus the density difference for several values of water holdup .. (See next slide)

Slip deviation correction in Emeraude: as for Nicolas

ABB – Deviated

Variation of the Choquette correlation specifically derived from deviated wells data. Recommended for Liquid-Liquid calculations in deviated wells.

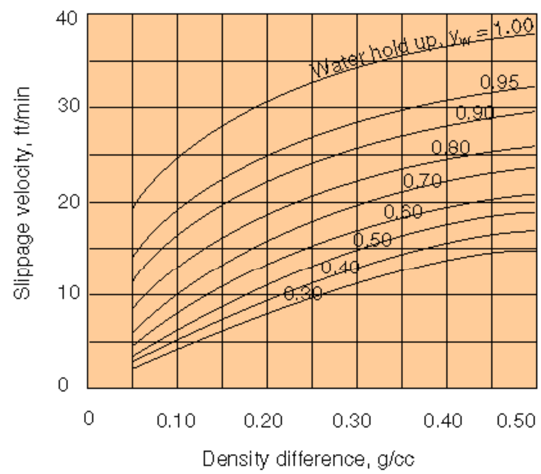
Constant slippage

The slippage value is entered manually on each zone.

When calculations are made using a differential pressure density tool, the pipe friction for all the above models is estimated using a Moody friction factor based for an Reynolds number representative of the mixture.

Choquette

The slippage velocity can be found using this chart. (Choquette)



Hassan & Kabir

SPE 49163:" A Simplified Model for Oil-Water Flow in Vertical and Deviated Wellbores", A. R. Hasan, SPE, U. of North Dakota, and C. S. Kabir, SPE, Chevron Overseas Petroleum Technology Company

The study focuses on water- dominated flow regimes, close to bubbly flow, pseudo-slug flow, and chum flow.

A drift-flux approach is taken to analyze the flow behavior of oil-water systems. Although simplistic, the proposed model appears to be quite robust in that it has reproduced a wide range of laboratory data from various sources.

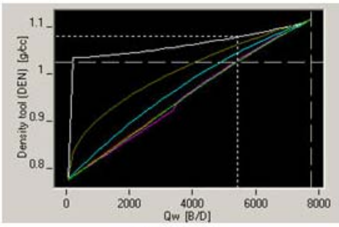
The model was validated versus different pipe sizes(1 to 8 in.), oil viscosity(1 to 150 cp) and production values(500 to 10,000 bpd).

Brauner

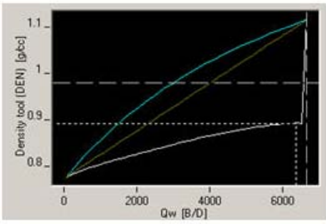
Reference: Modeling and Control of Two-Phase Flow Phenomena" Neima Brauner Ed. V Bertola, CISM Center, Udine, Italy, 2004.

Brauner is a combination of the Brauner stratified water-oil model, with the mechanistic model of Hasan & Kabir.
The option is given to force stratified flow (in the Edit dialog).

It is possible to force "on All" zones at once. Below are examples of the stratified flow predictions for upward and downward flows.



80 degrees



93 degrees

QAQC – Choice of correlations

Correlations can be selected based on a number of justifications:

- Based on a correlation used in pipe lift calculations.. Eg. PROSPER
- Chosen on local empirical experience – it worked for us in the past
- Whether the well is deviated or not.
- Based on the scientific principles the correlation was founded on.
- Used to match rate ratios of the surface rate measurements. (Choice of correlations does not change the total flowrate.. Only the ratio of the heavy and light flowrates)
- A particular correlation may be chosen because of failure of certain other correlations, say for example in low velocity regions where some correlations break down, predicting Vs > Vm
- A constant slippage correlation option can be selected where the slippage velocity is known in certain situations.

NOTE: Correlations were not designed specifically for PL intepretation

Superficial Velocities

The following slides are to introduce the concept of SUPERFICIAL VELOCITY and the relevance in the multiphase calculation process.

SUPERFICIAL VELOCITY is also referred to in the following topics in the online help:

- Apparent Downflow equation
- Viewing Correlation Flow Maps
- Mass weighted Spinner response equation
- Discussion of Multiphase Interpretation Theory

Superficial Velocities

The actual heavy phase velocity, $V_H = q_H / (Y_H.A)$
And actual light phase velocity, $V_L = q_L / (Y_L.A)$

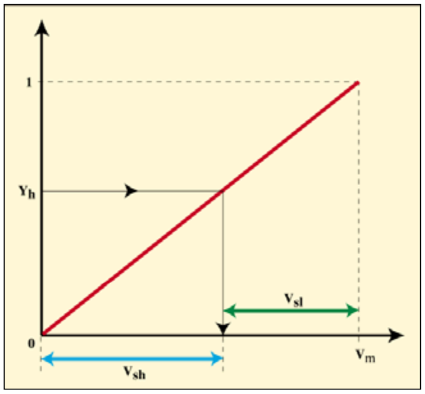
The superficial velocity of a given phase is the rate of the phase divided by the pipe area. (as if flowing in 100% of the pipe area!)

Superficial heavy phase velocity, $Vs_H = q_H/A$
Superficial light phase velocity, $Vs_L = q_L/A$

The total of the superficial velocities is the mixture velocity;

$$Vs_H + Vs_L = V_M$$

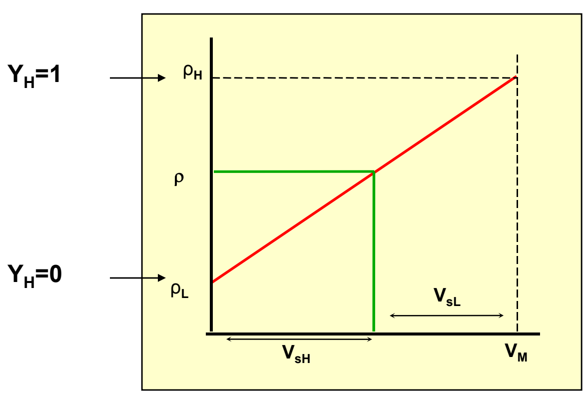
Superficial Velocities



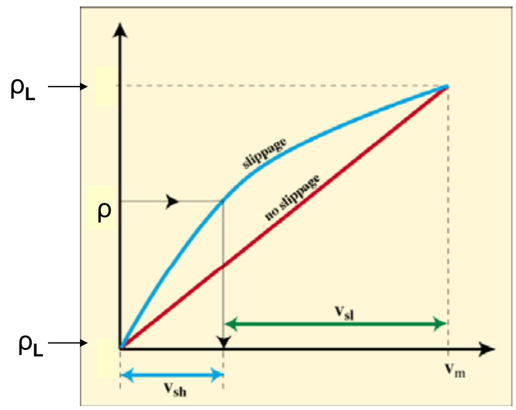
From this relation, if the hold up (e.g. Yh) is known, the superficial velocity can be found from the intercept on the line from 0,0 to 1, Vm

Densities

A similar solution is possible for the density



Slippage Velocities



The slippage velocity implies that there will be less of the light phase seen in the pipe

The heavy phase hold up (Y_H) is larger, than would be predicted with no slip between the light and heavy phases.

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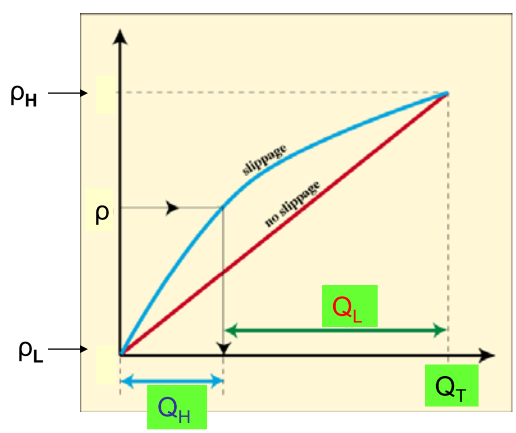
Slippage Velocities



Emeraude Models

KAPPA

INTERPRETATION THEORY

MODELS

Module #11

Emeraude Models

Use of the 2-phase flow models for 3-phase interpretation

2-phase model extended to 3-phase assuming there is no slippage between two of the three phases. (Version 2.00)

The mixed phase is either… oil and water,…. or oil and gas.

Introduction of additional parameters in order to split the superficial velocity of this mixed phase into the two components.. "fo" & "fg"

3-Phase flow model introduced with Version 2.10 incorporating 2 slippage velocities, and 2 correlations.

- Liquid - Gas
- Liquid - Liquid

3 Phases

- In 3 phase flow, the problem is extended with one more holdup and one more phase velocity
- We now have 3 phase velocities so there will be 2 slippage velocities to be considered
- 3-Phase flow is treated as the combination of two 2-phase situations.
- With a bulk rate measurement and the use of slippage models, the interpretation is made from 2 independent holdup measurements (e.g. density + water holdup, water holdup + gas holdup, etc).

Three Phases

Mixed phase is oil+water: (flowing with gas) Liquid-Gas

Introduce f_o, oil fraction in the liquid phase

$Q_{GAS} = Q_L$
$Q_{OIL} = f_o.Q_H$
$Q_{WATER} = (1-f_o).Q_H$

Mixed phase is oil+gas: (gas flowing with water) Liquid-Gas
(oil flowing with water) Liquid-Liquid

Introduce f_g, gas fraction in the hydrocarbon phase

$Q_{WATER} = Q_H$
$Q_{OIL} = (1-f_g).Q_L$
$Q_{GAS} = f_g.Q_L$

Two Phase - Liquid/Gas

LIQUID-GAS MODELS

"LIQUID-GAS"

Oil Water Gas

fo (Qh) (Ql)

(Qo + Qw) (Qg)

(No slippage between oil and water)

fo = volume fraction of oil
(from surface WOR)

Note: fo can be determined by non-linear regression if sufficient inputs are available.

"WATER-HYDROCARBON (G)"

Water Oil **GAS**

(Qh) (Ql) fg

(Qw) (Qo + Qg)

(No slippage between oil and gas)

fg = volume fraction of gas
(from PVT – CGR)

Hydrocarbons mainly gas
This model only available when Condensate in PVT

Two Phase – Liquid/Liquid

LIQUID-LIQUID MODEL

"WATER-HYDROCARBON (L)"

Water **OIL** Gas

(Qh) (Ql) fg

(Qw) (Qo Qg)

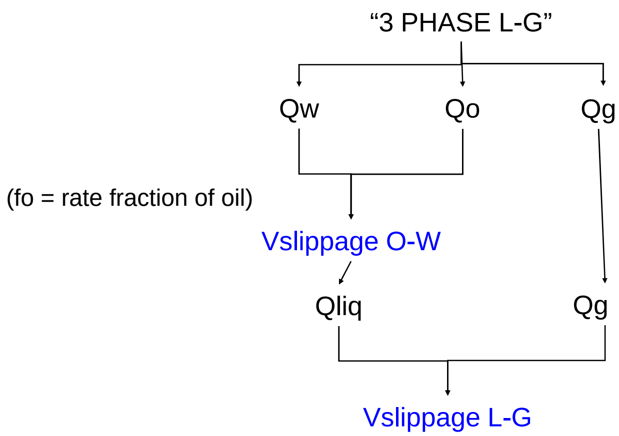
(No slippage between oil and gas)

fg = volume fraction of gas (from PVT – Rs)

Mainly oil (gas from solution)

Three Phase - Water/Oil/Gas

LIQUID-LIQUID-GAS MODEL



(Three Phase L-G model is combination of Liquid/Liquid and Liquid/Gas Models)

Models in Emeraude

Liquid-Gas
The liquid phase can comprise oil, water, or a mixture of both. There is no slippage between oil and water. In 3-phase, the fraction of oil in the Liquid phase, fo is introduced.
The initial fo value is based on the entered surface WOR. If the necessary measurements are available fo is a variable of the non-linear regression. In this case a green light will appear in front of the fo button in the Zone Rate dialog.

Water-Hydrocarbons (G)
Liquid-Gas situation where the heavy phase is water and the light phase is mainly gas possibly with some oil (or condensate). There is no slippage between the oil and gas phases.
If this model is used in 3-phase, the ratio of gas in the hydrocarbon phase, fg, is introduced. This value is fixed from the PVT CGR ratio.

Water-Hydrocarbons (L)
Liquid-Liquid situation where the heavy phase is water and the light phase is oil possibly with evolved gas. There is no slippage between the oil and gas phases.
If this model is used in 3-phase, the ratio of gas in the hydrocarbon phase, fg, is introduced. This value is fixed from the PVT Rs ratio.

3-Phase L-G
This is the combination of a Liquid-Gas and Water-Oil models. There is slippage between the oil and water phases within the Liquid phase. There is also slippage between the gas and the mixed liquid.
The oil fraction fo represents the ratio of the oil rate to the liquid rate. This model is only offered when there are enough measurements for fo to be a variable.

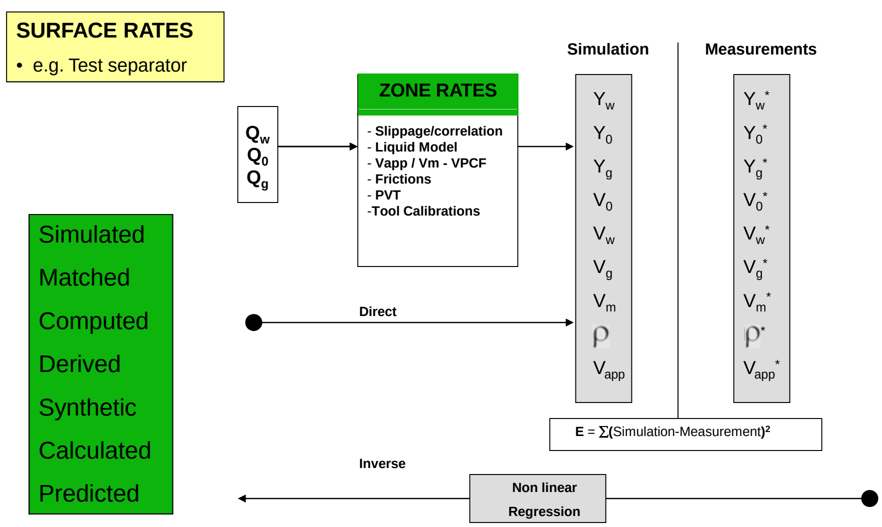
E03–15 Technical Reference

PVT	Flow model	Variable	Required Measurements
Single phase	Single phase	Vm	1 velocity (or temperature)
Oil-Gas	Single phase	Vm	1 velocity (or temperature)
	Liquid-Gas	Vsh, Vsl	2 including 1 velocity (or temperature)
Water-Gas	Liquid-Gas	Vsh, Vsl	2 including 1 velocity (or temperature)
Gas – Condensate	Single phase	Vm	1 velocity (or temperature)
	Liquid-Gas	Vsh, Vsl	2 including 1 velocity (or temperature)
Water-Oil-Gas	Liquid-Gas	Vsh, Vsl (fo fixed)	2 including 1 velocity (or temperature)
		Vsh, Vsl, fo	3 including 1 velocity (or temperature)
	Water-Hydrocarbons (L)	Vsh, Vsl	2 including 1 velocity (or temperature)
	3-Phase L-G	Vsh, Vsl, fo	3 including 1 velocity (or temperature)
Water-Gas-Condensate	Water-Hydrocarbons (G)	Vsh, Vsl	2 including 1 velocity (or temperature)

Page E03-15 Technical Reference

 9

Emeraude Process



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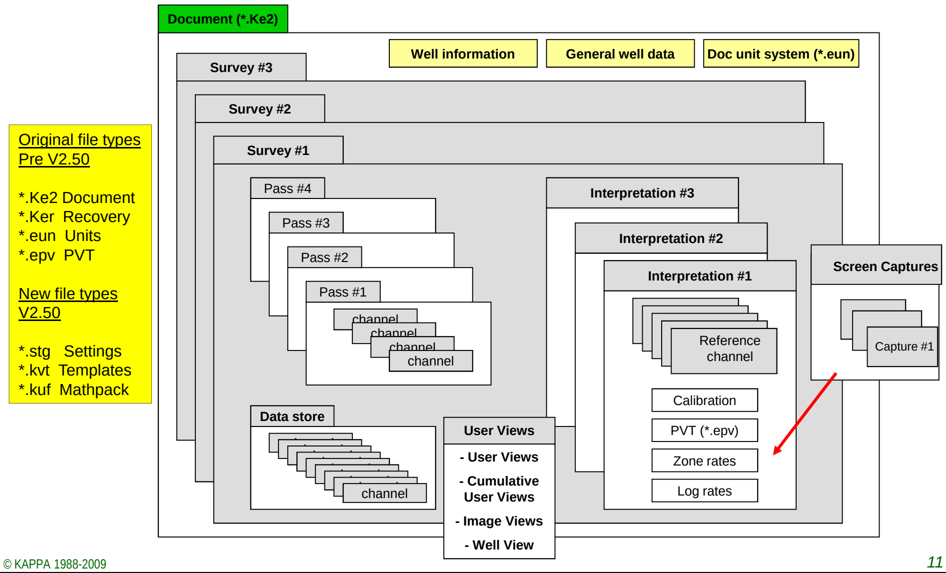
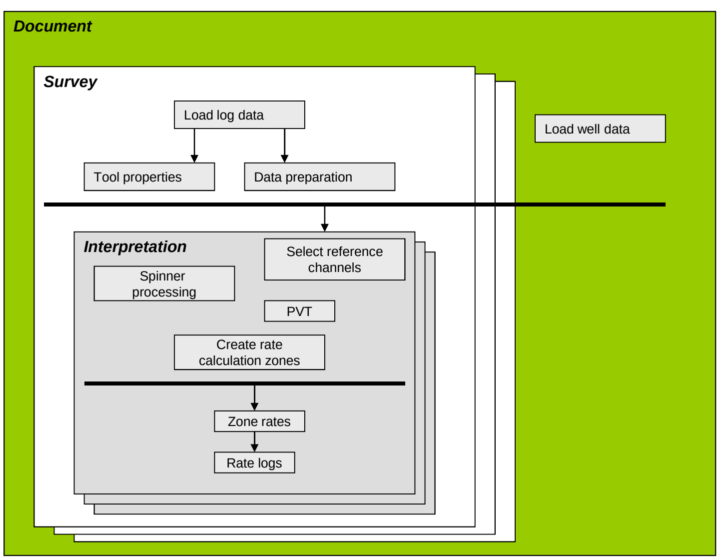
Emeraude Data Structure



Emeraude Roadmap



Technical Reading

SPE MONOGRAPH SERIES

Production Logging – Theoretical and Interpretive Elements, Vol.14 (A.D.Hill)

Cased Hole and Production Log Evaluation by James Smolen

Pennwell ISBN: 087814465X

SPE papers 1

Date	SPE No.	Title	Subject	Company	Authors
Apr-66	1245	Practical use of recent research in multiphase vertical and horizontal flow	Hagedorn & Brown		Hagedorn & Brown
Oct-69	2553	A comparison of existing multiphase flow methods for the calculation of pressure drop in vertical wells			Espanol & Holmes & Brown
Oct-72	4023	Measurements of multiphase fluid flow	Nicolas	Schlumberger	Nicolas & Witterholt
Nov-05	10186	Evaluation of Wireline Tractor Performance in Various Well Completions in Saudi Arabia		Aramco	Hashem & Zeybek
Oct-82	10208	Production Logging Tool Behavior in Two-Phase Inclined Flow			Hill, A.D
Nov-05	10248	Solutions To Challenges in Production Logging of Horizontal Wells Using New Tool		Baker Atlas	T. Chandran
Nov-05	10248	Solutions To Challenges in Production Logging of Horizontal Wells Using New Tool	MCFM Polaris	Baker Atlas	
Nov-05	10430	Identification of Water Entry with New Integrated Production Logging Tool in Challenging Horizontal Wells		Saudi Aramco	T.M. Al Beaiji
	10430	Identification of Water Entry with New Integrated Production Logging Tool in Challenging Horizontal Wells			
	10492	An Integrated Approach For Evaluating and Characterising Horizontal Well Inflow and Productivity in Heterogeneous Carbonate Reservoirs			
	11171	Production Logging Low Flow Rate Wells with High Water Cut			
	11265	Production Logging in Difficult Well Configurations			
	11433	Reduced Risk Alternatives for Water Entry Detection in High Water Producing Horizontal Wells			
	11567	Pushing The limits Of Tractor-Deployed Wireline Operations On Al Khalij Field In Qatar.			
Sep-85	14431	Research on Simultaneous Production Logging instruments in Multiphase Flow Loops	Basic PL Tools	Dresser Atlas	Davarzani & Roesner
Aug-88	14463	New Production Logging Technique for Horizontal Wells			Joly,E.L.
Oct-88	18216	A new model for two-phase oil/water flow: Production log interpretation and tubular calculations			Hasan & Kabir
May-94	20630	A comprehensive mechanistic model for upward two-phase flow in wellbores			Ansari & Sylvester
Sep-92	20632	A unified Model for predicting flowing temperature distribution in wellbores and pipelines	Ramey Enthalpy		Alves & Alhanati
Dec-93	20980	Production Logging as an Integral Part of Horizontal Well Transient Pressure Test		Schlumberger	Ahmed
Oct-90	21094	Production logging in horizontal wells: Applications and experience to date	Horizontal conventional PL	Schlumberger	Chauvel
Apr-92	24089	Acquiring Production Logging Data With Pulsed Neutron Logs from Highly Deviated or Non-Conventional Production Wells With Multiphase Flow in Prudhoe Bay, Alaska		Atlas	Barnette

SPE Papers 2

1992	25083	Stimulation and Production Logging of Horizontal Wells AGIP (NAME) Bouri Field, Offshore Libya			Hweg
May-03	26090	Planning a Coiled-Tubing-Conveyed Production Logging Job in a Horizontal Well		Atlas	Copoulos
Sep-93	26682	An evaluation of recent mechanistic models of multiphase flow for predicting pressure drops in oil and gas wells		BP	Pucknell & Mason
Aug-94	27959	Advances in two-phase flow modelling			Taitel
Nov-94	28757	Horizontal Well Production Logging in Australia		Schlumberger	Yves Chauvel
Mar-95	29815	New Fullbore Production Logging Sensor Improves the Evaluation of Production in Deviated and Horizontal Wells		Halliburton	Kessler
May-96	35669	Horizontal Well Production Optimization Using Production Logs Run on Coiled Tubing in the 26R Sand Reservoir, Stevens Zone, Elk Hills Field, California		Bechtel Petroleum	Walker
Oct-96	36560	Stratified flow model and interpretation in horizontal wells	Stratflo	Schlumberger	Theron & Unwin
Oct-96	36564	Production Logging Tool Developments for Horizontal Wells and Hostile Environments		Maritime	Gardner
Oct-96	36565	The Application of a New Radial Borehole Fluid Imaging Tool in Production Logging Highly Deviated Wells		Schlumberger	Vittachi
Oct-96	36625	Improved Production Log Interpretation in Horizontal Wells Using Pulsed Neutron Logs		ARCO Alaska	Brady
Nov-96	37127	Characterizing Horizontal Well Performance in a Tight Gas Sand Using Pressure Transient, Production Logging and Geological Data		PanCanadian Petroleum	Churcher
Nov-96	37147	Three phase hold up determination in horizontal wells using a pulsed neutron source	RST 3phase holdup	Schlumberger	Roscoe
Nov-96	37153	Oil and water velocity logging in horizontal wells using chemical markers	PVL	Schlumberger	Roscoe
Jun-97	38295	Diagnosing Horizontal Well Production in the Belridge Field with Downhole Video and Production Logs		Whittaker	Whittaker
Oct-97	38810	Characterisation of oil-water flow patterns in vertical and deviated wells			Flores & Brill
Nov-98	48851	Improved Production Log Interpretation in Horizontal Wells Using a Combination of Pulsed Neutron Logs, Quantitative Temperature Log Analysis, Time Lapse LWD Resistivity Logs and Borehole Gravity			Brady
Sep-98	49089	Horizontal well performance evaluation and fluid entry mechanisms	PVL, DEFT, RST Horizontal	Schlumberger	Lenn
Oct-98	49994	Wireline Tractor Production Logging Experience in Australian Horizontal Wells		ORAD-Ltd	Local
Oct-98	50178	Application of New Generation Technology to Horizontal Well Production Logging - Examples from the North West Shelf of Australia		Schlumberger	Carnegie
Nov-98	50395	Interpretation of Horizontal-Well Production Logs: Influence of logging tools			E. Ozkan

SPE Papers 3

Oct-98	51612	Wireline tractor production logging experience in Australian horizontal wells	Tractor	Sondex	Locul & Searight
Apr-99	54326	Advanced horizontal well production logging - an Australian offshore example - Carnegie A	Flagship Horizontal	Schlumberger	
	54652	Evaluating High-Angle Wells With Advanced Production-Logging Technology, North Slope Alaska			
	56650	Production Logging Problem Description in October Field, Gulf of Suez			
Aug-99	57415	Production Logging in Horizontal Wells by Use of Ultrasonics		IKU Petroleum Research	Fridtjof Nyhavn
Oct-99	57690	Evaluating high angle wells with advanced production logging technology	DEFT	Schlumberger	Hupp & Scnorr
Oct-00	63141	Applications of a new multiple sensor production logging system for horizontal and highly deviated multiphase producers	MCFM Polaris	Baker Atlas	Chace, Wang, Trycka
Oct-00	63188	Interpreting spinner response in multiphase bubble flow	Spinner	Baker Atlas	Chace & Giorgi
Oct-00	63262	A mechanistic model based approach to evaluate oil/water slip at horizontal or highly deviated wells	Horizontal slip	Chevron	Ouyang
	64405	Critical Wellbore Considerations for Successful Carbon-Oxygen Log Applications: Benefits of a Teamwork Approach			
Nov-00	65528	The Challenges of Detecting Gas Entries in Horizontal Well by Using Integrated Production Logging Tool, Case Study		Saudi Aramco	Hussein Ali
Mar-01	68468	Use of flow pattern based models for interpreting oil-water flow in production		Chevron	Kabir & Hoadley
	71727	Flow Diagnosis and Production Evaluation in High Flowrate Oil-Water Producers Using Optical-Fibre Holdup Sensors			
	71729	A New Statistical Method for Interpreting Production Logs			
Oct-01	72114	Reservoir monitoring methodology for a giant gas field	SIP	Total	Potapieff & De Witt
	72150	Evaluations of Sub Horizontal Well Performance with Optical and Electrical Probes			
	76749	Production Logging Advances in the Fractured Monterey			
May-02	77295	Interpretation of Horizontal-Well Production Logs: Influence of Logging Tool			Ozkan
Oct-02	77501	Mechanistic and simplified models for oil water countercurrent flow in deviated and multilateral wells	Apparent downflow	Chevron	Ouyang
Oct-02	77521	A case history on the use of downhole sensors in a field producing from long horizontal/multilateral wells	DTS		
Oct-02	77710	Installation of in-well fibre optic monitoring systems	DTS	Weatherford	Pruett
Oct-02	77782	Interpreting wellbore flow images with a conventional production log interpretation method	CAT	Halliburton	Frisch
Oct-02	77839	Advanced production logging technology for more accurate flow profiling - Case studies from the Gulf of Suez	RST/DEFT	Schlumberger	
Apr-03	81118	Horizontal production logging using tractor technology - a first for Trinidad	Schlum tools & tractor	BP	Allabar

SPE Papers 4

	81534	Multiphase Flowmeter and Production Logs Diagnose Well Response in an Onshore ADCO Field, Abu Dhabi			
	83969	Gas Holdup Imaging Identifies Complex Gas-Liquid Flow Regimes and Introduces a New Velocity Measurement In a Long, Cased Hole, Horizontal, Production Well			
Oct-03	84207	Production Logging In Horizontal Gravel-Packed Highly Viscous Oil Producers In The North Sea		Baker Atlas	Steve Riley
	84208	Better Flow Profiling Against Producing Zones Using a New Production Log Interpretation Technique			
Oct-03	84324	Brunei Field trial of a fibre optic distributed temperature sensor DTS system in a 1000m open hole horizontal oil producer	DTS	Sensa	Lauer & Brown
Oct-03	84379	Monitoring horizontal producers and injectors during cleanup and production using fibre optic distributed temperature measurements	DTS	Sensa	
Oct-03	84399	Production and injection profiling: a novel application of permanent downhole pressure gauges	Pressure gauges	Chevron	Ouyang
	84873	In-Situ Diagnosis of Inflow Behavior in Horizontal Wells			
	85667	Using Production Logging Technology for Reservoir Management in the Persian Gulf			
Oct-04	88705	Observations and Lessons Learned from a Set of Production Logging Data in Horizontal Barefoot Completions		Schlumberger	Mohamed Al Hamawi
Sep-04	89848	A Novel Approach To Production Logging in Multiphase Horizontal Wells		Schlumberger	D. Vu-Hoang
	90541				
Mar-05	93526	Expanding advanced production logging operations to short radius horizontal wells		Baker Atlas	O. Kelder
Oct-05	96980	Advances in Integrated Horizontal Production Logging in Openhole Completions		Saudi Aramco	M.S. Al-Ismail
	101721	Characterization of Multilayer Reservoir Properties Using Production Logs			
Sep-06	102198	The Role of Enhanced Production Logging Measurements in Challenging Openhole Horizontal Completions		Schlumberger	Mukerji
	102256	Integration of Borehole Imaging, Open Hole Logs, Nuclear Magnetic Resonance/Modular Dynamic Tester, and Advanced Production Logging as a Guide for Perforation Intervals Selection in Thin-Bedded Sands and Shales			
	102588	Characterization of Commingled Reservoir Properties With Production Logs			
	102894	Permeability From Production Logs - Method and Application			
	103069	Real-Time Fiber-Optic Distributed Temperature Sensing (DTS)-New Applications in the Oilfield			
	103097	Successful Flow Profiling of Gas Wells Using Distributed Temperature Sensing Data			

SPE Papers 5

Oct-06	103589	Pushing the Envelope for Production Logging in Extended Reach Horizontal Wells in Chayvo Field, Sakhalin, Russia – New Conveyance and Flow Profiling Approach		ExxonMobil	D.E. Fitz
	103589	Production Logging in Extended Reach (ERD) Horizontal Wells in Chayvo Field, Sakhalin, Russia - New Conveyance and Flow Profiling Approach			
	104013	Evaluation of Commingled Reservoir Properties Using Production Logs			
	104018	Characterization of Reservoir Properties Using Production Logs			
	105327	Horizontal Well Production Logging Experience in Heavy Oil Environment with Sand Screen: A Case Study From Kuwait			
	105700	Reservoir Characterization: Integrating Advanced Production Logging and Near Wellbore Modeling in a Maximum Reservoir Contact (MRC) Well			
	107070	Downhole Leak Determination Using Fiber-Optic Distributed-Temperature Surveys at Prudhoe Bay, Alaska			
Apr-07	108084	Production and Video Logging In Horizontal Low Permeability Gas Wells			D. Sask
	110412	Using Production Log to Calibrate Horizontal Wells in Reservoir Simulation			
	110693	Workover Successes in Deviated Wells Using Multispinner Production Log Data			
	111347	An Innovative Tractor Design for Logging Openhole Soft Formation Horizontal Wells			
	112863	First Production Log Run in a Heavy-Oil Long-Horizontal Well Through a Y-Tool and Premium Screens			
	114165	Tight Gas Surveillance and Characterization: Impact of Production Logging			
	1	Pressure Drop in wells producing oil and gas	Aziz & Govier		Aziz & Govier
May-73	2	A study of two phase flow in inclined pipes	Beggs & Brill		Beggs & Brill
Sep-88	3	Models for multiphase flow in oil wells	Artep		Ferschneider & Ozon
May-80	4	Modelling flow pattern transition for steady upward gas-liquid flow in vertical tubes	Dukler		Dukler & Taitel