



**Weatherford**<sup>®</sup>

# MatBal<sup>™</sup> Software

Reservoir Analysis and Production Forecasting Software



Material balance techniques provide a dynamic measure of hydrocarbon volumes and a critical estimate of key reservoir parameters.



# Reservoir Analysis and Production Forecasting Software

## Introduction

Weatherford's *MatBal* product allows the analysis, evaluation and prediction of the response of hydrocarbon reservoir systems using fundamental material balance principles.

The ease with which material balance techniques can be applied results in an efficient and cost-effective alternative to more complex and expensive simulation techniques.

By using material balance techniques engineers can:

- Estimate the volume of fluids initially present in the reservoir
- Examine the effects of changes resulting from produced and injected fluids

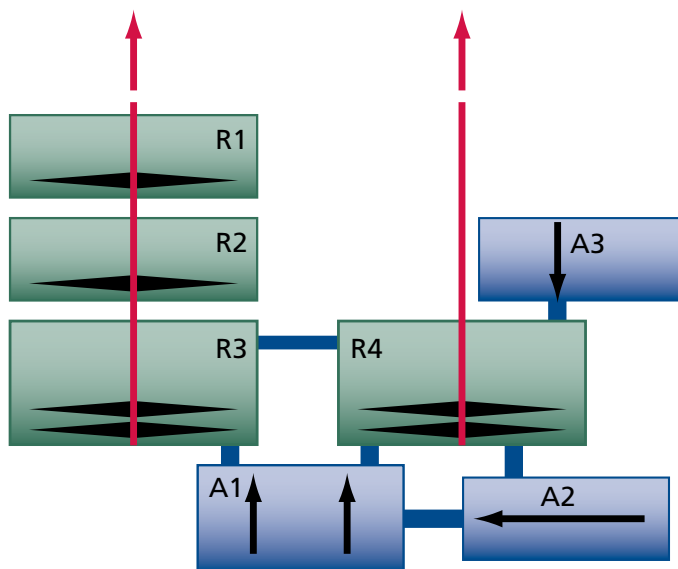
The program helps the reservoir engineer to perform each stage of a material balance study quickly and efficiently. These stages include:

- Building an appropriate material balance model
- Matching to historical data
- Generating production forecasts

Unlike many standard material balance applications, *MatBal* software does not limit models to single reservoirs supported by single aquifers but allows multiple reservoirs, aquifers and wells producing from more than one reservoir layer with crossflow between layers.

Weatherford International's production optimization division provides solutions to increase production and lower lifting costs in green and brown fields. We deliver agile, well-supported products and services that foster innovative optimizing approaches for flowing wells and all forms of artificial lift. The software, hardware and completions solutions help you work better, smarter and faster.

Material balance techniques are widely used throughout all phases of field development, providing a dynamic measure of hydrocarbon volumes and an estimate of key reservoir parameters.

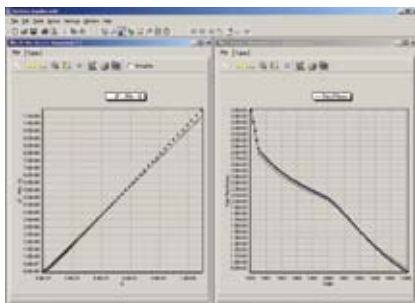


- Multi-layer well completions
- Reservoirs connected to:
  - Reservoirs
  - Multiple aquifers
- Aquifers connected to:
  - Multiple reservoirs
  - Aquifers

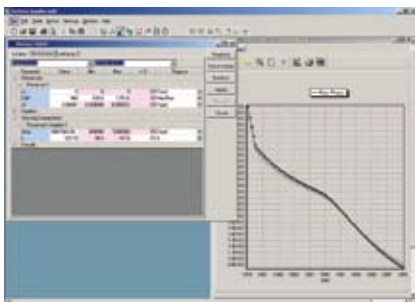
# Reservoir Analysis and Production Forecasting Software

The application has an up-to-date, easy-to-use interface designed to streamline all stages of a material balance analysis.

The program is integrated with other Weatherford production engineering products. PVT data, well models and performance information can be directly imported from **WellFlo™** software. The application is also integrated with **ReO Forecast™** software to form part of an application suite that allows the modeling of hydrocarbon production systems from reservoir to delivery point through full field surface network optimizer.



**Linear history match—classic straight line fit to date (left); simultaneous display of diagnostic plots (right).**



**Non-linear history match.**

Principal *MatBal* modes are history matching and forecasting.

## History Matching

Calibration of a *MatBal* model is achieved through the following history matching functions.

### Allocation

Production data can be entered either for reservoirs or for wells.

- When historical reservoir production data is entered, *MatBal* software re-samples the historical production data to a common time-basis
- When historical well production data is entered, the program allocates historical well production to the individual producing layers and re-samples to a common time-basis

### History Match

Historical production and pressure data is used to calibrate the field model using a combination of linear and non-linear regression methods in conjunction with diagnostic plots for water influx and pressure comparison.

- **Linear Regression**—the linear regression facility performs straight line fits to the classic material balance equations (e.g.  $P/Z$  for gas reservoirs,  $F-We$  vs.  $E$  for aquifer supported reservoirs)
- **Non-Linear Regression**—the non-linear regression facility varies key model parameters (e.g. OIIP, aquifer strength, reservoir-reservoir transmissibility) to obtain an optimum match to historical data and provides a simultaneous best-fit to all reservoirs in the model

### Simulation

The simulation option takes the entered historical production data as input and calculates the pressure, saturations and fluid properties for each reservoir in the model as output. These simulation calculations are performed automatically on entering the simulation mode and users can view the simulation results, generate plots and perform manual simulations in this mode.

### Relative Permeability Tuning

In this mode, the relative permeability model (Corey functions) can be tuned to observed data for reservoirs and/or well-reservoir connections.

# Reservoir Analysis and Production Forecasting Software

## Forecasting

The history matched field model can be used as a basis for forecasting future reservoir performance using off-take or pressure schedules. Forecasting can be performed at the reservoir or well level and four forecasting models are available.

### Reservoir Rate Control

The user specifies field oil production and injection rates. The program calculates reservoir pressures, saturation and secondary phase rates and cumulative production.

### Well Control

Wells can be controlled in one of three ways.

- Tubing head pressure controlled (all well types)
- Rate controlled on main fluid phase (all well types)
- Liquid rate controlled (only for oil producers)

The type of control for individual wells can be changed over the period of the forecast.

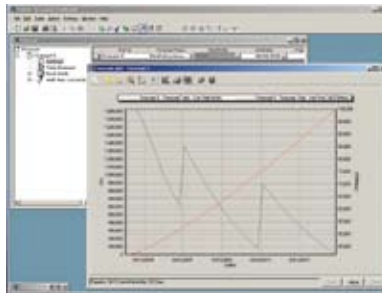
### Manifold Rate Control

This option is similar to the well control option but in this case the user defines an oil production rate, minimum and maximum manifold pressures and a maximum gas lift rate. The algorithm will try to produce the well at the specified rate and determine the manifold pressure required to achieve that rate.

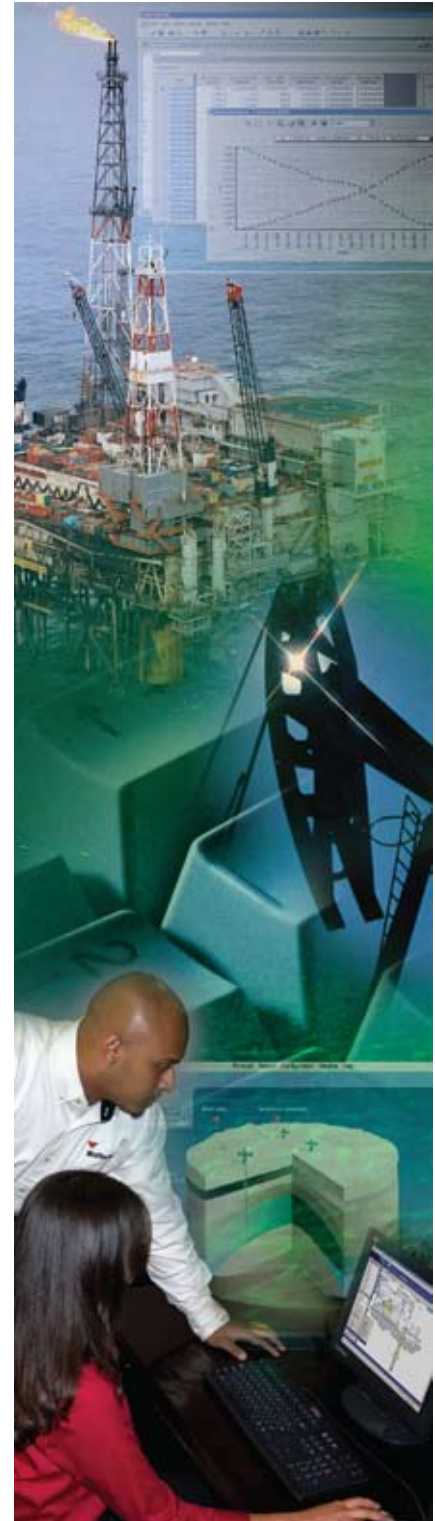
### Manifold Pressure Control

For this option the user specifies a manifold pressure, minimum and maximum production rates (oil, gas, water and liquid) and a maximum gas lift rate and the program will produce the well at the specified pressure (if possible).

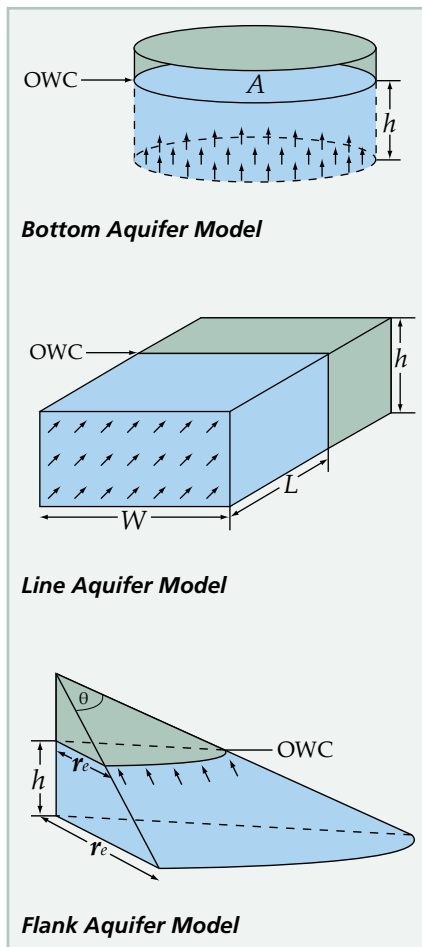
Production and abandonment constraints can be applied to individual wells and for gas-lifted systems, *MatBal* software determines the optimum allocation of lift gas to individual gas lifted wells.



**Key results are plotted as forecast progresses.**



# Reservoir Analysis and Production Forecasting Software



## MatBal Technology

*MatBal* software allows the user to model multiple reservoir and aquifer systems, with inter-reservoir, inter-aquifer and reservoir-aquifer fluid flow. Wells can be completed in more than one reservoir, allowing for cross flow via the wellbore.

## Reservoir Data

The *MatBal* application can model the following types of reservoir:

- Oil (with or without gas-cap)
- Condensate (with or without oil rim)
- Dry or wet gas
- Volatile oil

Injection of water and/or gas is allowed. Reservoir-reservoir pressure communication is modeled by transmissibilities. Formation compressibilities are entered either as single values or as functions of pressure.

## PVT

Tabular PVT data is used for each reservoir. For volatile oil and gas-condensate reservoirs a modified black-oil model (i.e. vaporized condensate in gas-phase) is used for a more accurate representation of phase changes. Links to *WellFlo* software allow the PVT data to be imported from tuned black-oil correlations.

## Aquifer Models

The program's aquifer models range from simple pot aquifers to line, bottom and flank geometries for which the following type of aquifer solution methods are available.

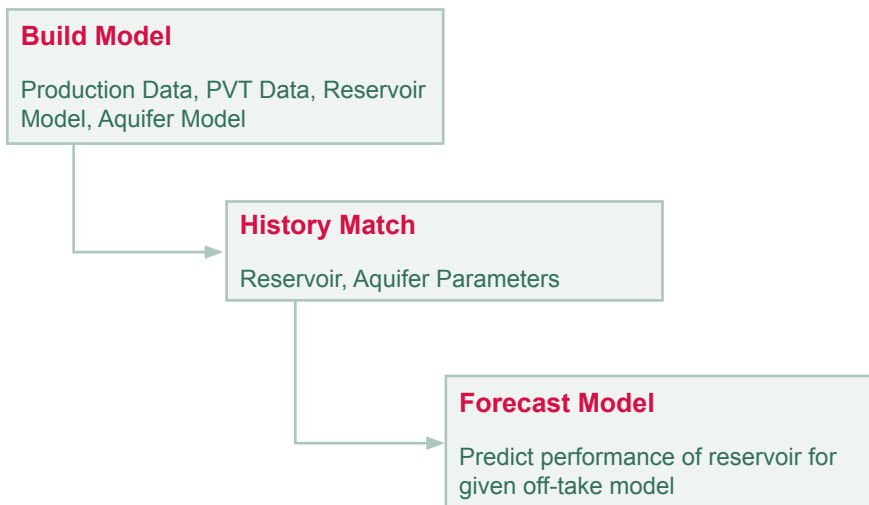
- Fetkovitch
- Modified Fetkovitch
- Carter-Tracey
- Hurst and Van Everdingen
- Model building

# Reservoir Analysis and Production Forecasting Software

## Well Models

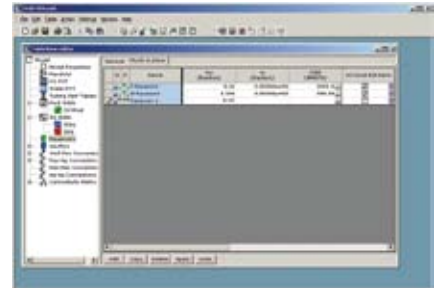
The *MatBal* well model is based on parameterized inflow performance relationships (including straight-line, Vogel and normalized pseudo-pressure) and tubing performance characterized by vertical flow performance (VFP) tables. Both the inflow performance and the VFP data can be generated directly from *WellFlo* software and imported into the program. It is possible to enter pseudo-relative permeability curves (parameterized by Corey functions) for wells to predict water cut/WGR and producing GOR/CGR development as a function of average phase saturations. Regression facilities exist within the software to tune the well-reservoir model to historical water cut/WGR and GOR/CGR evolution.

Individual well constraints such as maximum water cut, maximum drawdown or maximum rate can also be specified.



## Conclusion

*MatBal* software is a material balance application that can contain multiple wells, reservoirs and aquifers with complex interconnectivity in a single model. This makes the software a comprehensive alternative to more detailed reservoir simulation models, especially for reservoir management problems within the scope of a material balance application. At the same time, the program retains the simplicity and application speed of the material balance approach. In this context *MatBal* software is now being used by an increasing number of customers throughout the world.



**Model building.**



**Weatherford**<sup>®</sup>

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