Quantifying reservoir inflow contribution with RESMAN's Flush Out model

The Flush Out model

RESMAN has developed two patented techniques to quantitatively determine the inflow distribution across the reservoir interval — the Flush Out model and the Arrival Time* model.

The Flush Out model is a proprietary mathematical technique that models the transient response of tracer concentrations generated during a well start up. The model is based on the rate of change in tracer concentration as a function of cumulative production.

The Flush Out modeling process compares the measured concentrations from field samples to simulated data to identify the most representative percent of total inflow for each monitored zone.

How it works

In the Flush Out technique, RESMAN Intelligent Tracers are deployed in an annular area of a reservoir compartment that is connected to the main flow stream.

The Intelligent Tracers are designed to release their molecules in controlled rates that are independent of flow conditions. This feature allows a small volume of oil with a high concentration of tracer molecules to form in the annular area during shut-in periods (Fig. 1).

When the well is started, initial production from the zone flushes out the fluids containing the high concentration of tracer molecules from the annular area to the main flow stream (Fig. 2).

The zones with high inflow rates flush out the annular area faster than zones with low inflow rates, thereby preserving the high concentration of tracer molecules and generating a profile with steep rates of decline.

Alternatively, the concentration of tracer molecules in the fluid that is flushed out from a low-performing zone becomes more diluted as it enters the main flow stream and travels to the surface. Consequently, the tracer concentration profile presents a noticeably less steep rate of decline when compared to a high-performing zone (Fig. 3).

The RESMAN Flush Out model analyzes and compares the rate of decline in tracer concentration between each monitored zone and quantitatively determines the respective relative inflow rates.

Fig. 1 - After deployed in the well, the intelligent tracers release a unique molecule signature into the surrounding fluids.

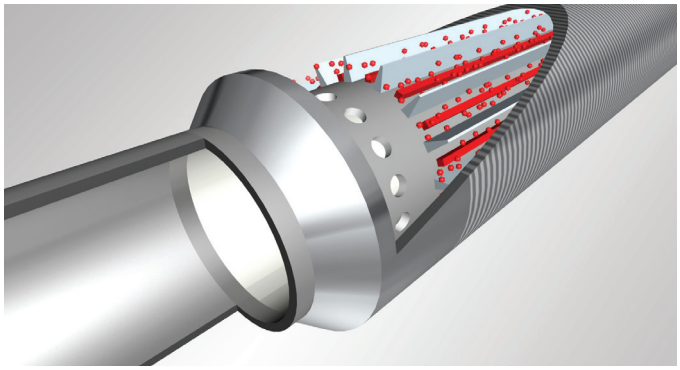


Fig. 2 - Initial production from the zone flushes out the high concentration of molecules. Efficiency of this flush out is proportional to zonal performance.

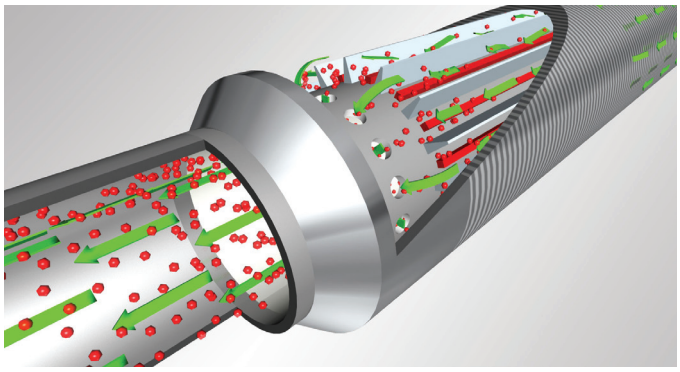
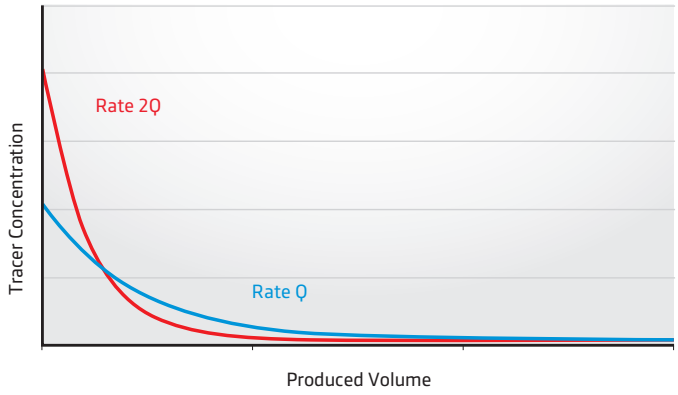


Fig. 3 - With RESMAN's Flush Out model, profiles with steeper rates of decline in concentration (Rate 2Q, red) indicate more efficient displacement of tracer molecules and thus higher inflow rates.



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Model verification

The validity of the Flush Out model was verified in a full-scale, flow-loop test with joint industry project (JIP) partners Eni and Statoil (Fig. 4).

The flow-loop test provided RESMAN with an in-depth understanding of the flow physics associated with the complexities of tracer flow in modern well completions.

The results of this test demonstrated that RESMAN's analytical model can predict flow within 5% accuracy.

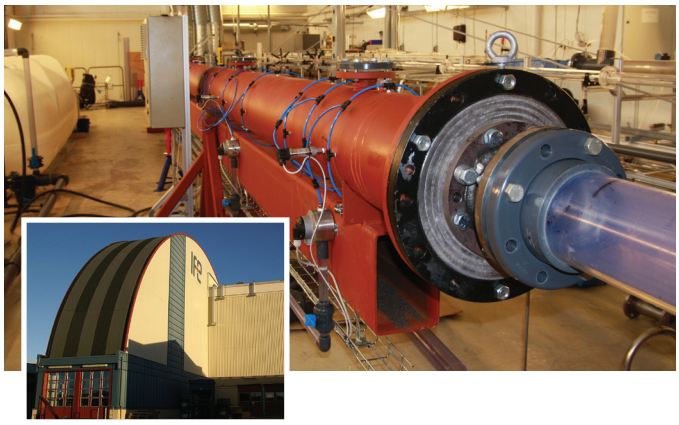
Field proven

The Flush Out model has been successfully applied in several projects with RESMAN systems, mostly in complex subsea environments with up to 10 miles of production tie back from the subsea wellhead to the production facility.

In addition, the model has been used to understand the inflow contribution in multistage hydraulic fracturing applications, thereby enabling the operator to optimize well drilling and fracturing strategies.

For field data examples, see the RESMAN case studies and papers at www.resman.no/knowledge.

Fig. 4 - RESMAN's proprietary inflow models have been verified in a full-scale, flow-loop test with JIP partners Eni and Statoil at the Institute for Energy Technology (IFE) facilities near Oslo, Norway.



* Refer to Technical Bulletin 3 for more information about RESMAN's Arrival Time model.