Well Monitoring and SureFLO™ Virtual Flow Metering (VFM)

The Baker Hughes SureFLO™ Virtual Flow Metering (SureFLO™-VFM) System combines flow and reservoir data into a single, efficient modeling platform. This solution brings together knowledge about the reservoir and completions with real-time flow data to provide operators with production performance monitoring (oil, gas and water rates estimation) and near real-time guidance on how to best optimize well and reservoir performance. The Baker Hughes SureFLO™-VFM model uses measurements from downhole devices to estimate model input and unknown parameters, automatically narrowing the gap between predicted and measured data. The model is then updated in real time, as new downhole pressure, temperature, and surface rate measurements are incorporated in the formulas.

As the information constantly updates, it enables operators to identify the flow at the wellbore, and to better understand the dynamics of the reservoir before an event occurs, get real-time insight to the reservoir’s behavior and near real-time guidance to help control cross flow, delay water breakthrough, and improve production performance. Providing useful well surveillance information, serves in a primary well rate metering role or as a backup to multiphase meters. This gives the operator an opportunity to be proactive and respond before production can be negatively impacted. In addition, the accuracy of the validated and reconciled data (corrected measurements, and unmeasured data, including KPIs) is determined based on sound statistical principles.
**The Baker Hughes Solution**

Main Objective of the SureFLO™ Virtual Flow Metering (SureFLO™-VFM) system

- Provide a monitoring of all the zones in a well based on the SureFLO™-VFM models
- Provide backup values for any defect instrument
- Provide flow measurements where there are no physical meter (Virtual Meter)
- Generate alarms when deviations are detected between validated and measured data or when discrepancies are detected between measured data
- Reconcile all the data by using rigorous data reconciliation techniques
- Provide daily coherent mass balances of the complete production system with the higher possible accuracy. (Fig.1)

**Figure 1: Validated and reconciled data**
In the SureFLO™-VFM workflow, bottomhole pressure and temperature data are used to allocate production rates to their respective zones using the SureFLO™-VFM estimation (inversion) algorithms, while ensuring that the total measured oil/water/gas production rate ($Q_T$) is honored (constraints). As pressures, temperatures and the total rates ($Q_T$) are continuously measured, the optimal zonal flow rates and water cuts are calculated by minimizing error associated with series of measured and predicted variables in order to produce estimates of unknown variables in the high ranking objective functions (manipulated/estimated variables) constraints to temperature, pressure and total rates ($Q_T$) data histories over a specified time horizon. The updated calibrated SureFLO™-VFM allocation model can then be used for probabilistic forecasting and dynamic optimization of downhole valve set points over time to achieve optimal ICS performance and improved oil recovery. Essentially, real-time sensor data is processed and analyzed using multiple instances of SureFLO™-VFM for a wide range of applications (Figure 2).

**SureFLO™-VFM system:**
- Provides superior data validation and reconciliation process for secure, reliable and accurate raw and calculated data
- Interfaces with various well architectures equipped with instrumentations, downhole inflow control valves and active flow control devices and data sources from multiple vendors (vendor neutrality)
- Provides cutting-edge data assimilation technology for integrating past records and dynamic measurements to extract important information about field connectivity and compartmentalization
- Detects malfunction of any components of the sensor data transport infrastructure that has failed other than noticing inability of bringing new sensor measurement into the system using hybrid intelligence system
- Alerts users on exceptions and abnormal conditions for the generated key performance indicators (KPIs)
- Provides more precise data for large scale reservoir model validation which is only possible at very few points where well testing data are available
- Provides facility for visualization and analysis of data, and generate key performance indicators (KPI) dashboards
- Monitors in real-time completion key performance indicators (KPIs) - sudden water influxes, water breakthrough time, water cut, cross flow, etc. for optimizing field wide performance
- Integrates production and injection well performance monitoring and optimization
- Monitors more wells with fewer personnel
- Optimizes the decision making process and provide a conduit for closed loop production optimization and control