IPCOS

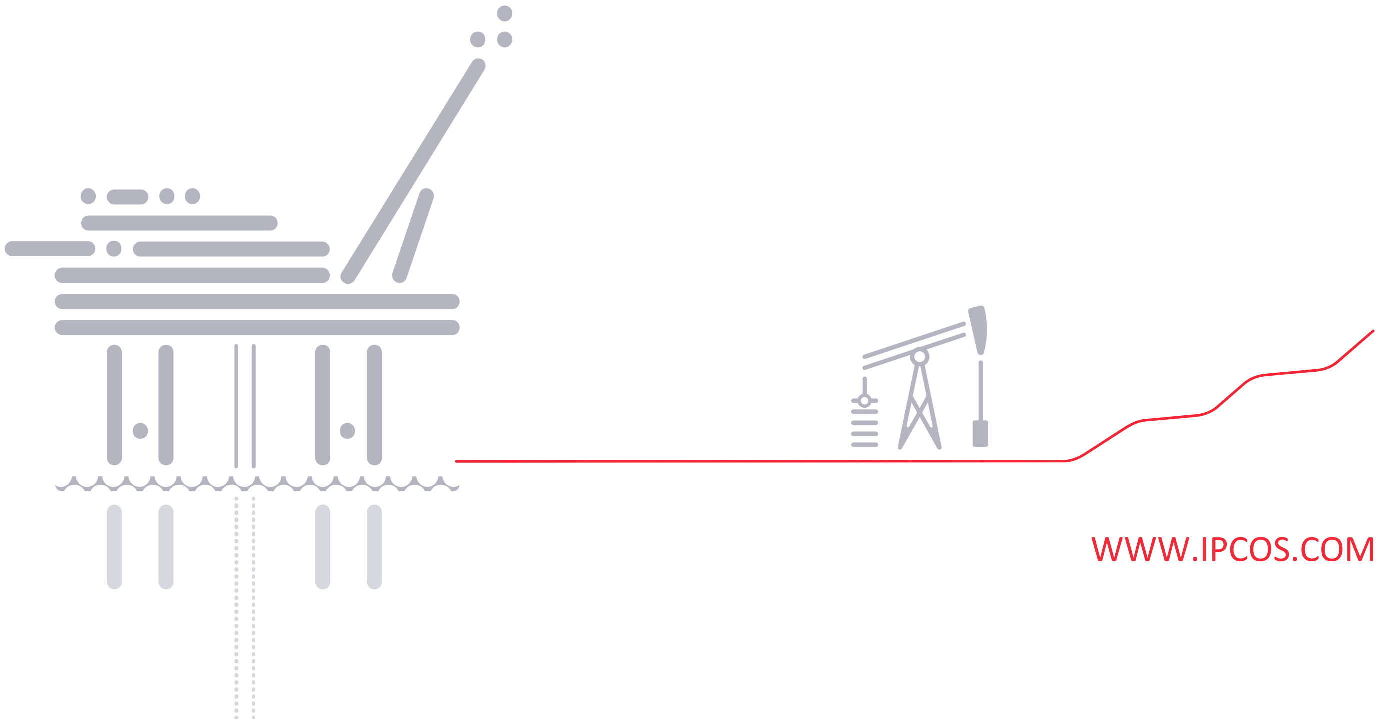
Allocating Commingled Flow

MONITORING

ALLOCATION

OPTIMIZATION

FORECASTING



WWW.IPCOS.COM

CONTACT

TITLE

Allocating Commingled flow

DATE	VERSION
19-May-2021	1.0

IPCOS TECHNICAL CONTACT

Filip Stroobant
Filip.stroobant@ipcos.com
Business Unit Manager Digital Oilfields

Business address:
Geldenaaksebaan 329,
3001 Heverlee, Belgium

Business Tel: +32 (16) 39 30 85
Mobile: +32 4 79 60 83 74

1. INTRODUCTION

There are many circumstances whereby wells or zones cannot be tested individually on a testing facility. This could be due to the unavailability of a single well flow line to a testing facility which is quite typical for subsea operations with a limited number of risers and manifolds at the seabed. Similar problems occur in smart well completions whereby production from the different zones commingles in a single production tubing, preventing individual zones to be tested without causing large deferment.

In most cases the lack of high-quality individual testing leads to additional uncertainty and challenges in the allocation process. Operators have tried to overcome this problem in a variety of ways with different levels of success. In this document the various methods will be evaluated and discussed. At the end of this document the reader should have a broad overview of how this problem is tackled and what the pros and cons are.

2. APPROACHES

2.1. SIMPLE TEST BY DIFFERENCE

In this approach it is assumed that a well which is commingled with several other wells is flowing for some time and subsequently closed or vice versa. Average production figures with the well closed are subtracted from average production figures with the well open to obtain a pseudo well test for the well. The two timeframes are typically very close to each other to ensure little changes have occurred to the production levels of the reference wells.

The main limitation of this approach is that this method assumes that all wells involved remain constant during the reference and the test period. Back pressure effects, which in some cases can be very significant, are ignored with this methodology. The below screenshot shows an example of user interface which was developed for simple test by difference. Reference periods can be selected by simple dragging and calculations are performed automatically.

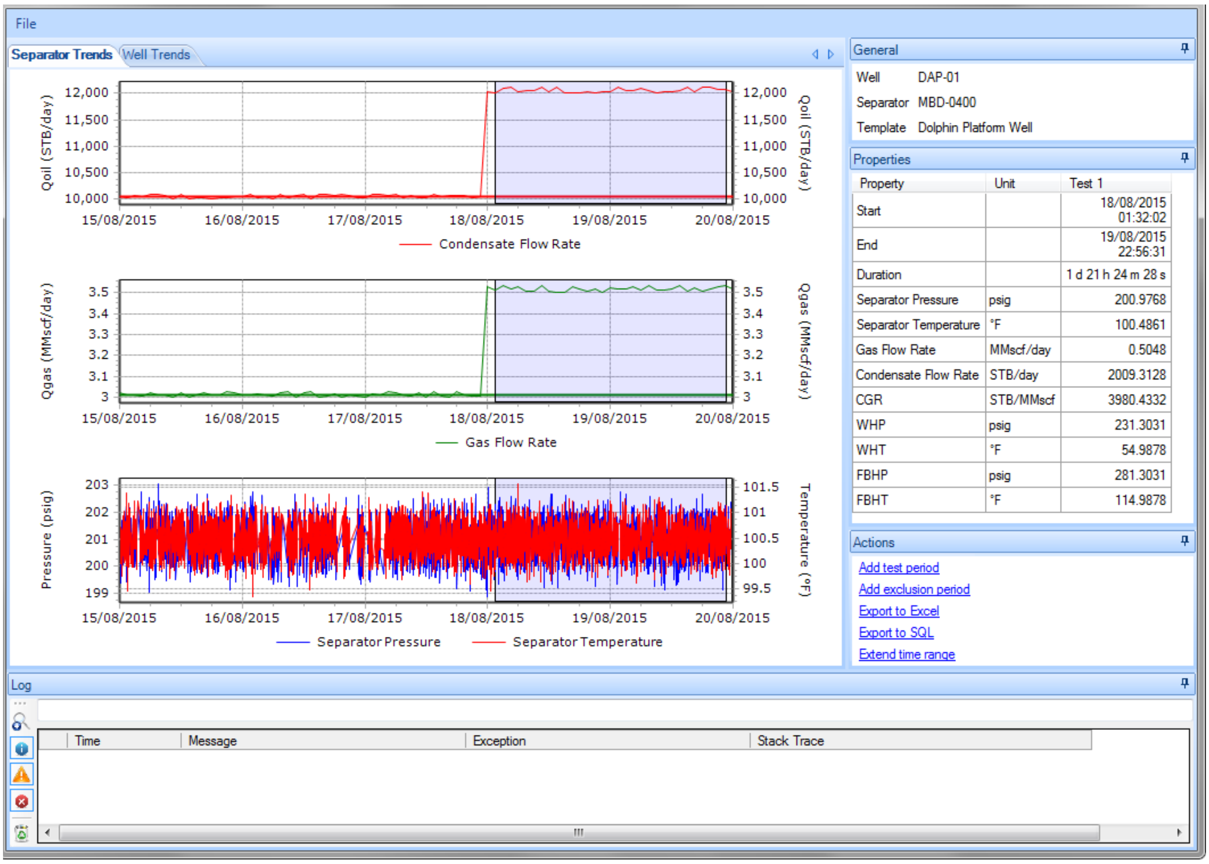


FIGURE 1 TEST BY DIFFERENCE APPLICATION

2.2. Virtual Metering Based Test by Difference

To improve the accuracy of the test by difference, virtual meters can be used. Virtual meters are based on a model for the well which accounts for actual operating conditions during the reference and test period. This method assumes that the well models for the wells which are subtracted are matched and accurate. This approach allows accounting for production variation of the wells not being tested as a consequence of back-pressure effects, and hence overcome one of the limitations of the previous approach.

The screenshot below shows a typical user interface whereby reference periods are selected and different virtual metering methods can be selected for subtraction. In case MPFM's are available these can also be considered. Note that there is also a stability indicator to evaluate the quality of the test.

FIGURE 2 VIRTUAL METERING BASED TEST BY DIFFERENCE

The models which are used for the virtual metering application can either be descriptive such as Prosper or Gap or purely data driven (statistical)

In the below screenshot a fully data-driven virtual metering application is shown. In this case the virtual meter is purely data driven and can also be used for test by difference purposes.

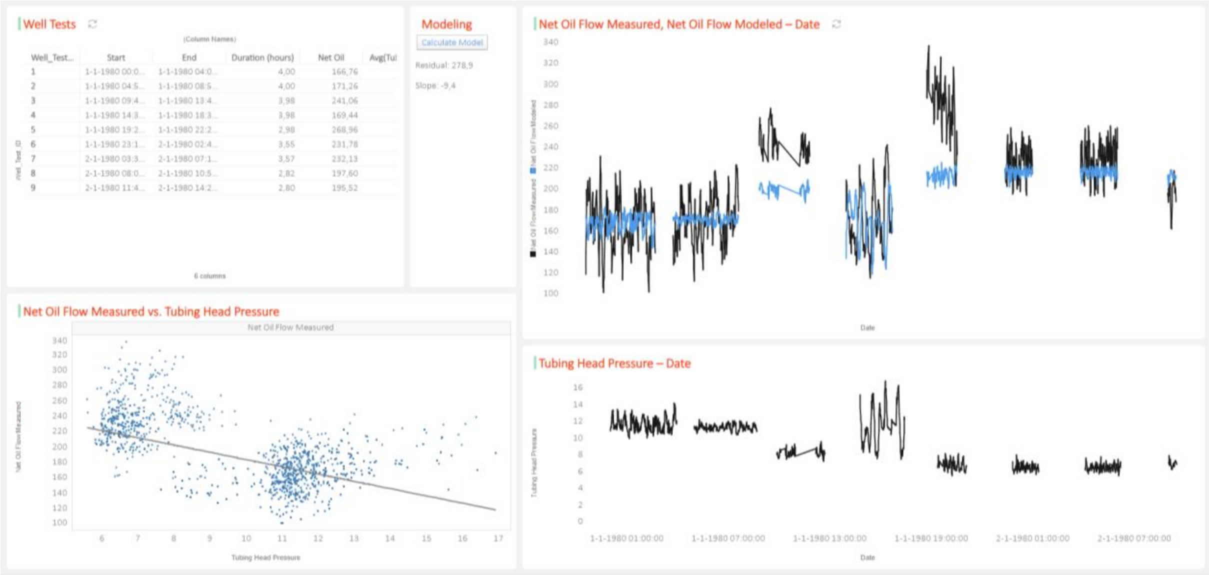


FIGURE 3 DATA DRIVEN VIRTUAL METERING APPLICATION

2.3. Commingled Well Model Matching

In some cases, it is not possible to match the models of the reference wells separately or there is no possibility to shut in wells to perform a test by difference. In this case commingled well test data needs to be used to match the models of multiple wells in one go. This method is complicated since the number of degrees of freedom is high and multiple solutions may be available to match the well test data.

Petroleum Experts has workflows available in this area which leverage different estimation methods (VLP, choke, IPR, pump, etc.) and force them to match by iterating the WC, GOR or other parameters of each well, subject to an overall mass balance constraint provided by the commingled test result. The below screenshot shows an early implementation of this workflow:

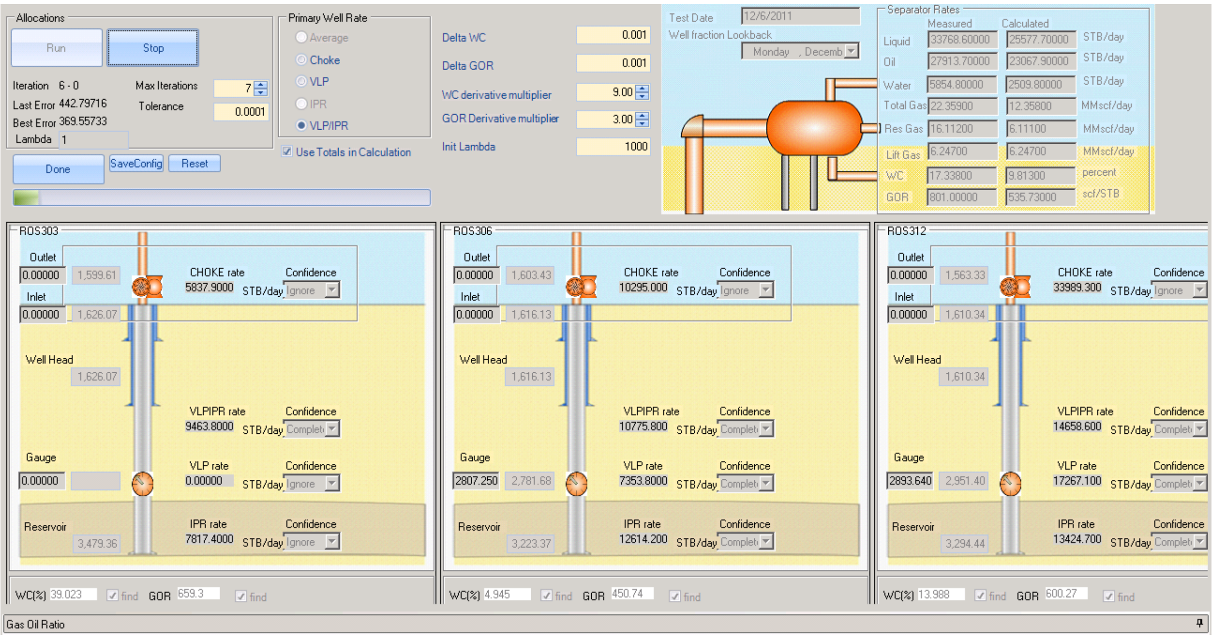


FIGURE 4 PETROLEUM EXPERTS MULTI-WELLTEST WORKFLOW

The main disadvantage of this class of workflows is that they operate in a black box manner and leave little room for the engineer to influence the calculation or interpret the result. Adoption of such workflows have therefore proven to be challenging.

An alternative approach to multi-well model matching has been implemented using data-driven methods. The below screenshot shows an example of a smart well with downhole inline choke (ICV) positions whereby zonal well models are derived from commingled test data. This approach is simpler and easier to grab compared to Prosper or Gap based methods but also has some limitations as the models are simpler.

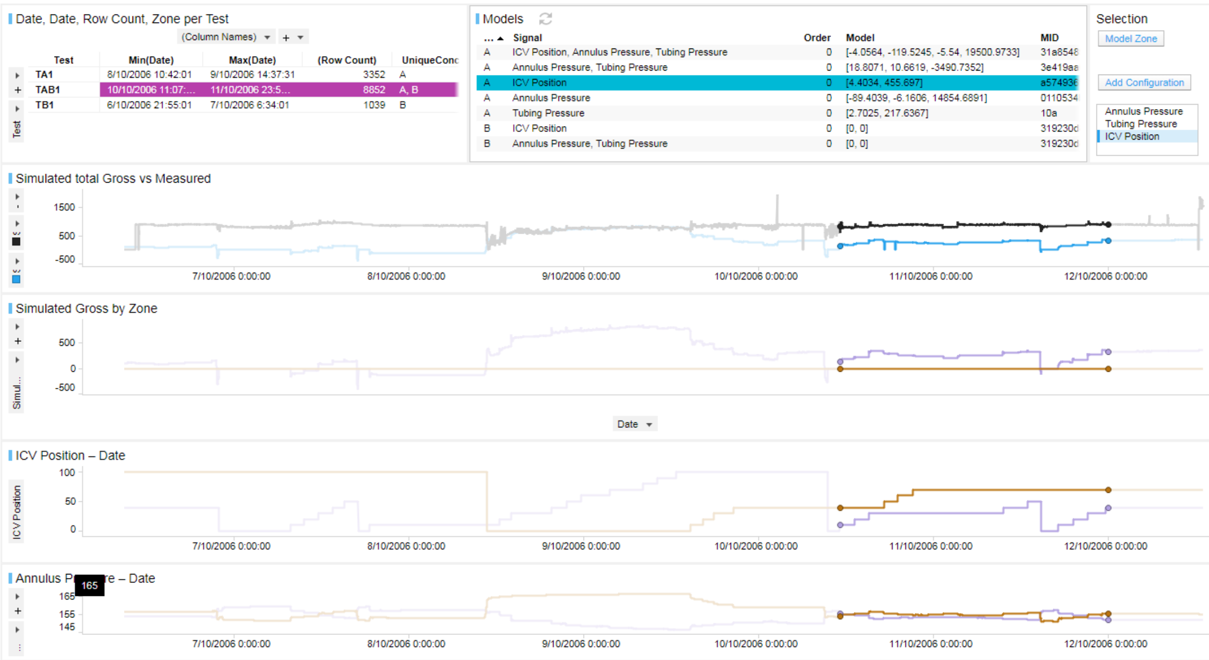


FIGURE 5 DATA DRIVEN MULTI-WELL MATCHING MODULE

In an attempt to achieve stronger involvement of the engineers, another approach was developed to help the engineers with the management of the data (automatically capture all the wells in test, gather the corresponding models, run some sensitivity analysis and offer an easy-to-operate user interface). The user is presented with the total production and ability to manually iterate on their selected well parameters, giving them final control of the match. While this approach seems very simple, it is arguably the one having produced the best results, since the engineers had no difficulty adopting the solution, and sufficient freedom was given so that they could endorse the result (e.g. in some case, the test separator was subject to bias, and a perfect mass balance was not required to be achieved, the important factor was more related to the steady evolution of the well parameters and the matching of measured bottom hole pressure). See screenshot below:

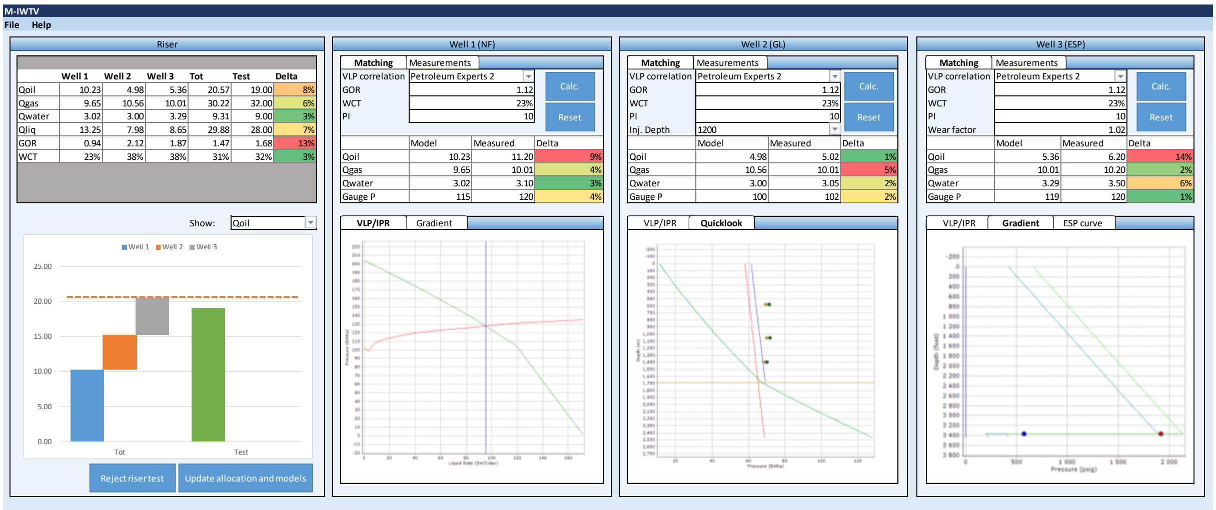


FIGURE 6 SEMI AUTOMATIC MODEL MATCHING

2.4. AUTOMATIC DETECTION OF TEST BY DIFFERENCE EVENTS

To further ease the analysis of commingled well tests for the engineer several techniques are available and have been implemented. The below module automatically looks for test by difference events in historical data and lists them for further analysis. Stability checks are performed and on/off status for the wells is incorporated from the historian.

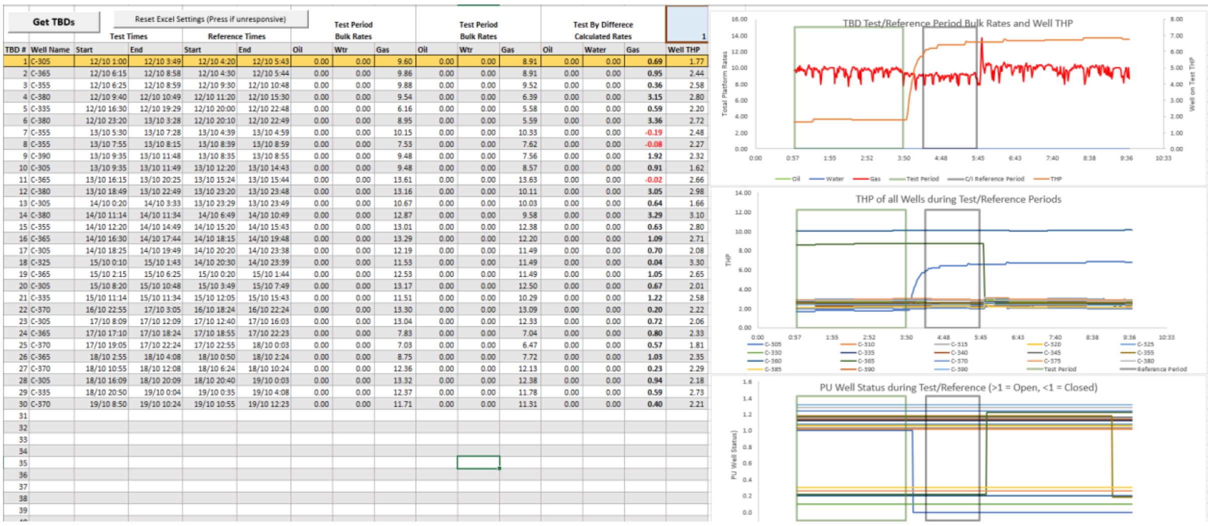


FIGURE 7 AUTO-TEST BY DIFFERENCE DETECTION

Other important elements include automatic stability detection. Robust on/off detection etc.

3. REFERENCES

As can be seen from this document IPCOS has been involved with several multi-well allocation problems using a variety of tools, technologies and approaches. IPCOS has published several papers in this space which are listed below. The ones which are specifically touching on test by difference have been put in bold.

N°	Title	Year
SPE-99963	Continuous Well Production Flow Monitoring and Surveillance	2006
SPE-108515	Implementing Real Time Production Optimisation in Shell Exploration & Production in Europe - Changing the way we work and run our business	2007
IPTC-11647	Production Surveillance and Optimization with Data Driven Models	2007
SPE-108957	**Combining Testing-By-Difference, Geochemical Fingerprinting and Data-Driven Models: an Integrated Solution to Production Allocation in a Long Subsea Tieback**	**2007**
SPE-112204	**Production Surveillance and Optimisation for Multizone Smart Wells with Data Driven Models**	**2008**
SPE-128654	Asset-Wide Reconciled Production Monitoring - A Key Enabler In Successful Real-Time Field Management	2010
SPE-145723	Real-Time Optimization of an Integrated Gas System	2011
SPE-150109	Successful Real-Time Optimization of a Highly Complex, Integrated Gas System: Intelligent Energy in the Real World	2012
SPE-172253	Detecting and Correcting Pipeline Leaks Before They Become a Big Problem	2014
SPE-174221	Early Detection of Gas Well Formation Damage, Water Breakthrough and Liquid Loading by Use of Surface Pressure Build-Up Data	2015
ITPC-18321	Innovative Integrated Asset Model including ESP Gas Handling and Power Supply Managements, Al Khalij Field case	2015
SPE-189047-MS	Practical Staged Implementation of Digital Field with Short Term Benefits	2017