TGT

Platform

Cascade3

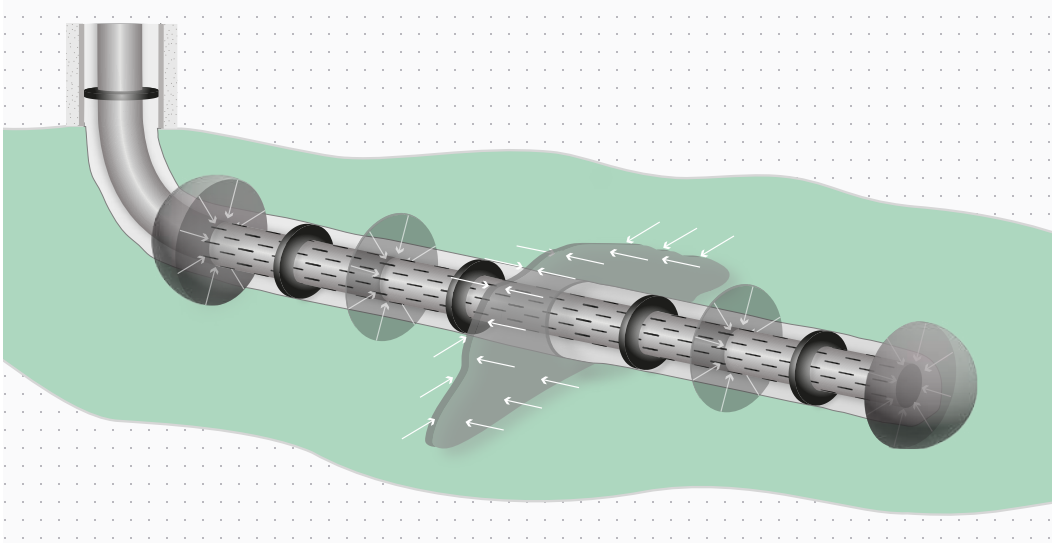
The most powerful flow analysis platform ever created for horizontal well systems

Made by experts for experts, the new Cascade3 flow analysis platform builds on two decades of knowledge and experience applying science and mathematics to solving the most complex downhole flow scenarios. Incorporating powerful modelling codes, Cascade3 transforms temperature and other well system data into continuous reservoir flow profiles. Crucially, Cascade3 flow profiles reveal flow activity in and out of the reservoir, delivering the truest picture of flow downhole in horizontal wells.

The new Horizontal Flow answer product enabled by Cascade3 overcomes the drawbacks of conventional surveys, delivering a more reliable assessment of flow in horizontal wells, and in a wider range of completion scenarios.

At the heart of Cascade3 is Torrent – a remarkable modelling engine that predicts the hydrodynamic and thermodynamic behaviour of fluids and their surroundings as they flow through the well system. Torrent features a 3D fine-grid framework and can solve three distinct flow patterns – radial, spherical, and linear flow in fractures. This immersive flow modelling environment delivers accurate continuous flow profiles in all completion and reservoir settings, including fractured formations.

Equipped with the right information from Cascade3, Production and Reservoir Engineers can take direct action to keep well and reservoir performance on track.



Flow inside the wellbore of a horizontal well can be challenging to decipher, but flow in the surrounding reservoir is equally complex. Cascade3 simultaneously resolves all three primary flow patterns that surround the well system – radial, spherical and linear flow in fractures, and combines thermodynamic and hydrodynamic science in an immersive 3D fine grid modelling architecture. The result is accurate reservoir flow profiles and unique insights that help asset teams keep performance on track.

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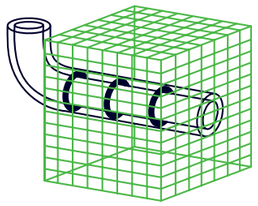
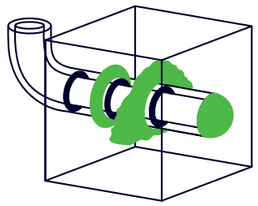
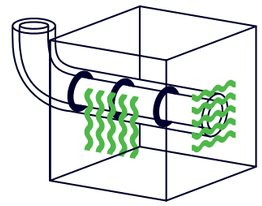
Cascade3 features
Many features combine to make Cascade3 the most powerful flow analysis platform ever created for horizontal well systems.



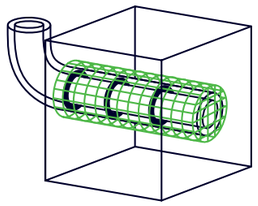
3D Fine grid
Flow moves in all directions through and around the well system. The 3D fine-grid modelling framework of Cascade3 provides a detailed workspace for accurate simulations that deliver clear and reliable flow modelling results.



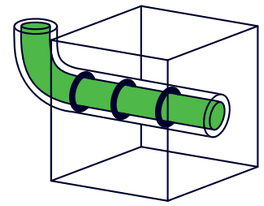
3x flow patterns
Flow moves in all directions through and around horizontal well systems has three main patterns: radial, spherical, and linear flow in fractures. Cascade3 is coded to handle all three to provide a robust computation of the real flow downhole, at all points along the well.



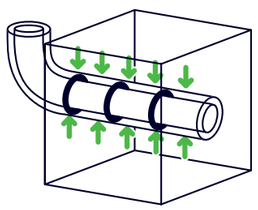
Hydrodynamics & Thermodynamics
Fluids in motion downhole are governed by the laws of hydrodynamics and thermodynamics. Cascade3 uniquely combines both, to decipher and quantify flow dynamics throughout the well system.



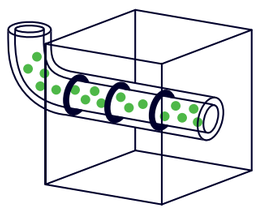
80 parameters
Horizontal well systems are impressively complex and dynamic. Cascade3 captures more than 80 input parameters, including well history, reservoir, and completion parameters to provide an immersive modelling environment for the well and the reservoir.



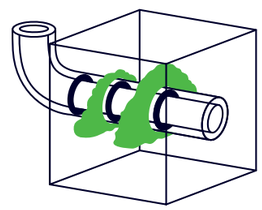
All completion types
Petroleum engineers design the well completion in harmony with the reservoir to maximise recovery. Cascade3 caters for all completion types, including uncemented liner, fracture ports, and barefoot, providing reliable flow profiles in all scenarios.



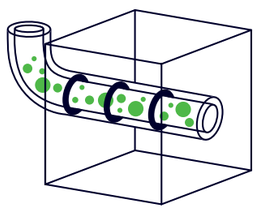
Actual reservoir flow
Conventional production surveys can only measure flow inside the liner, but flow in and out of the reservoir is what matters most. Horizontal Flow diagnostics delivers both, providing the most complete assessment possible of flow downhole.



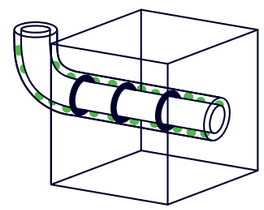
Continuous flow profile
Gaps or blind spots in the flow profile can lead to an incorrect assessment of well and reservoir performance. Horizontal Flow delivers a continuous flow profile to ensure that each zone is continuously assessed, without the gaps.



Fractures
Natural or induced fractures are a common feature in horizontal wells, and understanding how they affect performance is critical. Horizontal Flow reveals fracture locations and measures their flow performance.



Varied fluids & flows
Low flow rates and viscous fluids can confound conventional production surveys, causing gaps or ‘blind spots’ in the flow profile. Horizontal Flow cleverly combines temperature and acoustic measurements that work in all types of fluids and flow.



Flow behind liner
Conventional surveys are not equipped to locate or measure flow behind the liner, a common feature of horizontal wells. Horizontal Flow uses acoustics and Cascade3 to map and measure flow throughout the well system, even behind the liner.

Challenges

Cascade3 and Horizontal Flow are designed to help asset teams solve daily challenges with confidence and certainty.

Whether its locating water or gas breakthrough, understanding the influence of fractures, or maintaining an accurate reservoir model, Horizontal Flow with Cascade3 delivers the insights needed by asset teams to keep well and reservoir performance on track.

- Accessing reliable flow profiles
- Locating water/gas breakthrough
- Maintaining accurate reservoir model
- Measuring effective pay length
- Making accurate reserves assessments
- Revealing crossflow
- Assessing ICDs and packers
- Assessing fractures
- Making accurate production forecasts
- Optimising completion designs

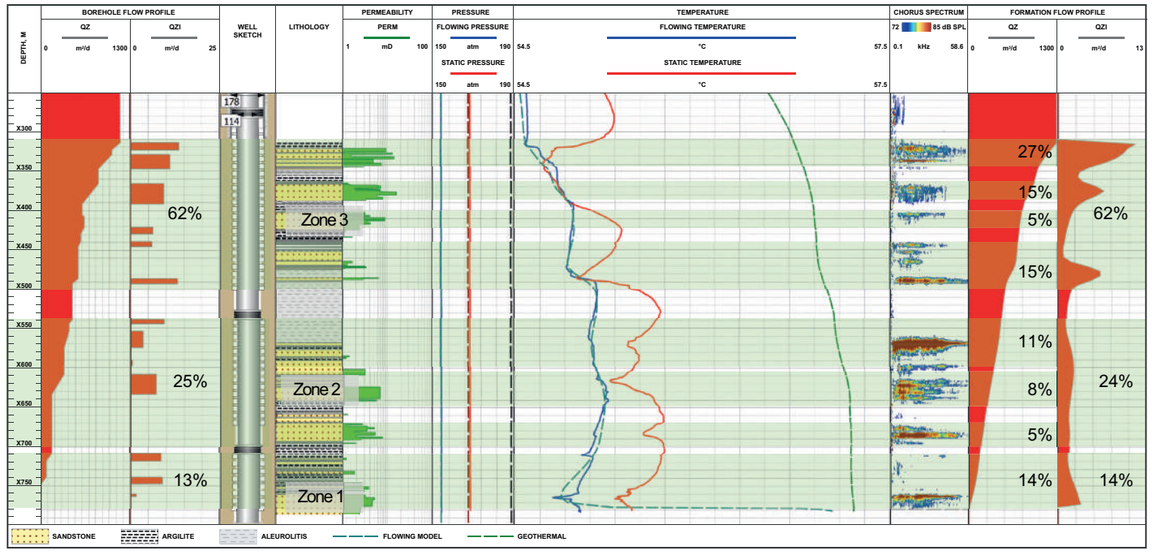
Benefits

Accurate reservoir flow profiles are fundamental to driving well and reservoir performance.

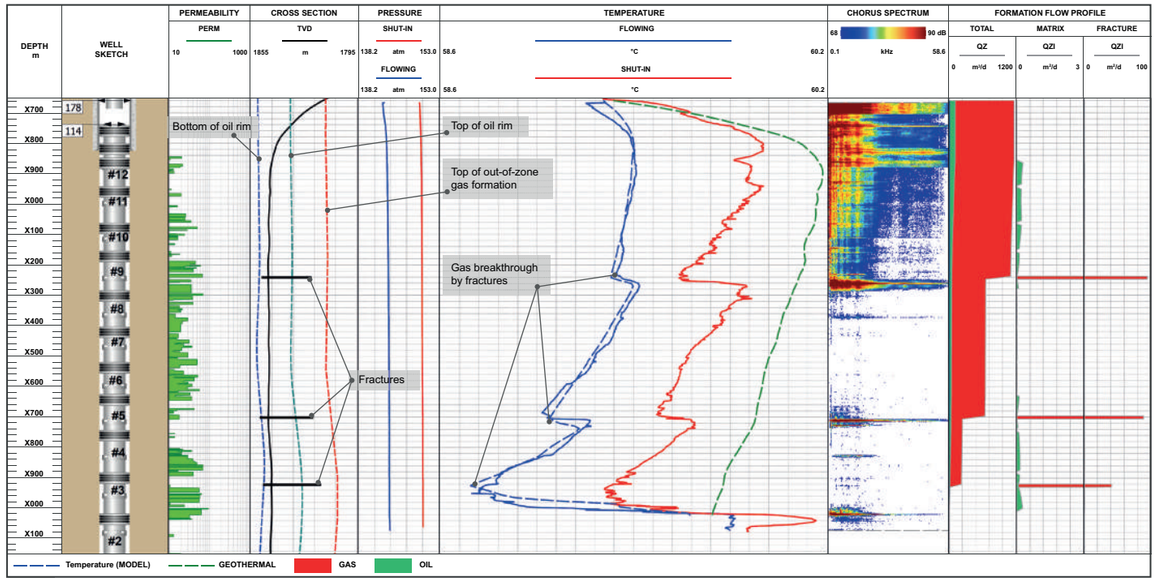
The flow profiles from Horizontal Flow with Cascade3 reflect actual flow activity in and out of the reservoir, delivering the truest picture of flow downhole and unlocking a host of valuable benefits.

- Increase ultimate recovery
- Reduce opex and unit cost per barrel
- Reduce CO2 emissions
- Optimise life-of-asset production
- Extend economic life of asset
- Maintain or increase production capacity
- Minimise water or unwanted gas production
- Improve dynamic reservoir model
- Improve sweep efficiency
- Optimise fracture programes

Horizontal Flow and Cascade3 are designed to help Production and Reservoir Engineers solve daily challenges with confidence and certainty.



Example 1. Accurate flow diagnostics for a horizontal gas well used to optimise development of a low-permeability reservoir
Horizontal Flow diagnostics with Cascade3 delivered an accurate gas production profile in a horizontal well drilled in a low-permeability, gas-bearing formation. The well was completed using a slotted liner across three zones separated by swellable packers. The contribution of each active permeable unit was accurately quantified with a continuous flow profile. The survey defined production contributions from each of the reservoir subunits, thereby improving the hydrodynamic reservoir model and making it possible to optimise subsequent wells in the ongoing field-development programme.



Example 2. Identifying gas breakthrough in a horizontal oil producer with multistage fractures helps to optimise fracture design
The Horizontal Flow survey identified three gas breakthrough zones responsible for the well's high gas/oil ratio, and estimated potential fracture growth, thereby indicating how far the fractures penetrated into the overlying gas-bearing formation. Fracture entry points behind the liner were assessed using the Chorus platform. This also revealed fractures in the target oil-bearing formation that were idle or nonproductive owing to the gas breakthrough. For future wells, the operator has redesigned the fracture programme so that production from the low-permeability oil rim can be maximised while preventing gas breakthroughs caused by out-of-zone fractures.

Cascade3 inputs

Well geometry
TVD well
Bottom TVD
Top TVD
Borehole diameter
Friction factor
Permeable zone
Active flow zone
Well flow profile
Liner diameter
Hydrodynamic
Matrix porosity
Matrix compressibility effect
Matrix flow anisotropy factor
Permeability
Mean piezo conductivity
Hydrodynamic external radius
Temperature external radius
Current reservoir pressure
Hydrodynamic per zone
Measured middle zone depth
Length
Normalized annulus permeability
Well conductivity
Sandface conductivity
Filter

Geothermal
Heat flux
Heel temperature
Lateral temperature gradient
Thermodynamic
Upper thermal conductivity
Matrix thermal conductivity
Lower thermal conductivity
Upper heat capacity
Matrix heat capacity
Lower heat capacity
Matrix thermal expansion
Thermo-physical anisotropy factor
Fractures
Measured depth
Distance from the bottom
Opening
Half-length
Height
Permeability
Skin
Injection / production history
Flow rate or pressure history of the well from beginning of well operation
Temperature history of injected fluid

Cascade3 inputs

Fluid properties (PVT)

Oil
Referenced oil density
Bubble point pressure
Rs background, correlation input parameter
Density at standard conditions
Oil formation volume factor at reservoir conditions
Reservoir pressure (pvt original)
Reservoir temperature (pvt orginal)
Bubble point pressure,
Bubble point temperature dependency factor
Adjustable parameter
Apparent dead oil density
Oil coefficients of thermal expansion
Oil compressibility
Oil viscosity at reservoir conditions
Surface tension
Oil-gas surface tension coefficient
Oil-water surface tension coefficient
Water-gas, surface tension coefficient

Water
Water density at reservoir conditions
Water coefficients of thermal expansion
Water compressibility
Water viscosity at resrvoir conditions, Pa*s
Adjustable parameter
Adjustable parameter
Gas
Gas molar mass, kg/mol
Latent heat of gas disssolution in oil J/kg
Gas formation volume factor at reservoir conditions
Adjustable parameter

Relative permeability (SCAL)

Oil
Residual saturation (oil-water system)
Corey oil-water
Residual saturation (oil-gas system)
Corey oil-gas
Power function of the gas saturation
Porous media type
Porous media type

Water
Irreducible saturation (oil-water system)
Corey water
Residual saturation (gas-water system)
Corey water-gas
Power function of the gas saturation
Gas
Residual saturation
Corey gas
Correction factor

Cascade3 outputs

Flow	Wellbore flow
	Matrix flow rate
	Annulus flow rate
	Fracture flow rate
	Fracture inflow rate along half-length
Temperature	Wellbore temperature
	Completion temperature
	Annulus temperature
	Sandface temperature
	Geothermal temperature
Pressure	Completion pressure
	Sandface pressure
	Reservoir pressure
	Fracture pressure
Output plots	Pressure distribution in reservoir - 3D plot
	Temperature distribution in reservoir - 3D plot

Cascade3 specifications

Model framework	3D Fine-grid
Flow profile type	Continuous
Modeling physics	Hydrodynamic and thermodynamic
Well inclination, deg	75 to 105
Fluid type	Low-compressible fluid
Phase mix	Multiphase with fixed phase proportions
No. of inputs	80
No. of outputs	16
Flow geometries	Radial, linear [fractures], spherical
Completion scheme	Barefoot, cased
Completion types	All (liner, slotted liner, sandscreen etc)