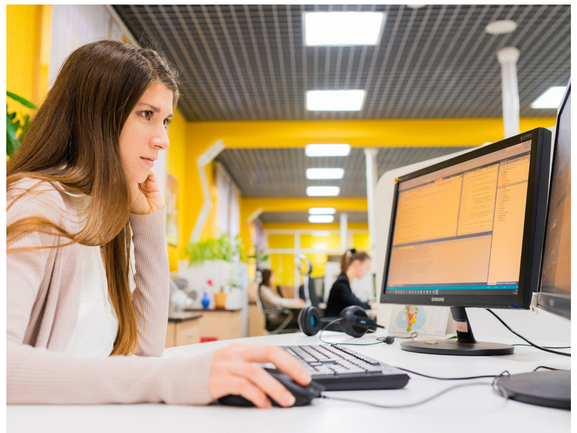
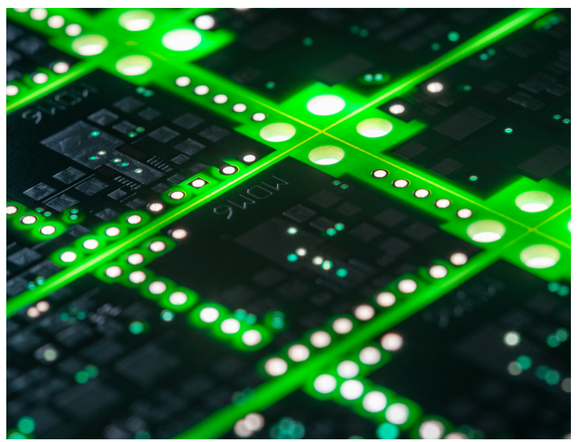
Cascade modeling	
Unique capabilities	
Methodology	Pre-modeling to evaluate the optimum programme and method for data acquisition, including stabilisation time estimation after well regime change.
Production/injection history	History is considered to properly model well/reservoir hydrodynamics and transient heat transfer between wellbore, reservoir units and rock formation; including daily and seasonal temperature variations at the wellhead in case of injection. To account for well workover, changing target units, and switching from production to injection.
Wellbore/reservoir thermo-mechanically coupled model (hydrodynamic and thermal sub-models)	Cross flows in tubing and behind casing, during flowing and/or shut-in, can be modeled and estimated (thief injection/ production evaluation). Stabilised and transient fluid flows in reservoir units with skin-factors. Heat exchange and thermal mixing between flows in tubing annulus, and cross flows behind casing. Transient heat transfer between wellbore, reservoir units and rock formation. Modeling thermodynamic (adiabatic and Joule-Thompson) effects developing over time.
Three phase (oil+gas+water) production mode	Three phase production mode is used to properly model multiphase flows and transient heat transfer in/between wellbore, reservoir units, and rock formation. To account for various thermodynamic effects, compressibility, gas liberation/ dissolution and interphase heat/mass exchange.
Autofitting	Explores the entire solution space to provide the best accuracy and perfect repeatability matching of model and measurements.
Profile accuracy	Profile accuracy figures are provided with every best-fit solution.

TGT

We remain dedicated to manufacturing our own products and technologies entirely in-house.



TGT has continued to advance our in-house production of key devices, components and electronic boards.



Platform Thermal

Cascade

Harnessing thermal energy to quantify flow, from the reservoir to the wellbore

Overview

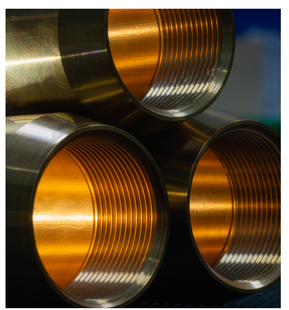
Fluids moving through the reservoir to the well system have thermal mass and can heat or cool the areas they touch. These temperature changes carry valuable information about fluid behaviour, particularly flow rates and profiles.

The trouble is, the physical laws of thermo-hydrodynamics are incredibly complex, and the interactions between them even more so. The 3D world of metal, concrete and earth we call the well system adds more complexity. Extracting accurate flow data from this environment may seem like an impossible task.

But not for Cascade.

TGT founded its business on transforming temperature changes into flow information, and since then we have taken this capability further than anyone.

Today, Cascade delivers that capability through our 'True Flow' products to reveal flow like never before.



Left: Where heat measurements become flow insights

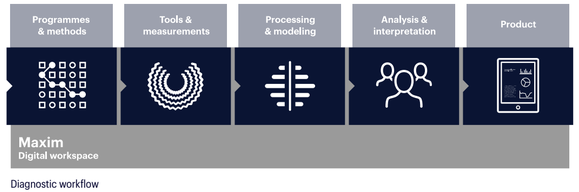
Right: Manned by a talented cadre of engineers, petrophysicists and geoscientists, we are continously improving our diagnostic capabilities to assert our position as global leader in through-barrier diagnostics.

Diagnostic system

Our approach
We recognise that delivering accurate diagnostics requires not only the highest fidelity measurements, but also a system-based approach. It is important to have the best sensors and measurements, but it also important to use them in the right way and then to filter, process and model the data into tangible answers.

We pursue a diagnostic system approach where multiple platforms come together, bringing their own unique diagnostic capability to be used in the framework of the proven workflow.

Cascade is our thermal platform, and when in the hands of our engineers and analysts can qualify and quantify any kind of flow event critically reservoir flow, and it reveals the relationship between the two.



Diagnostic workflow

Programmes & methods
Analysts customise proprietary diagnostic programmes—in our digital workspace, Maxim, activating well system behaviour to expose targeted thermal and fluid dynamics.

Tools & measurements
Cascade uses fast-response, high resolution temperature sensors from the Indigo platform to make accurate answers.

Processing & modeling
Powerful 3D thermo-hydrodynamic modeling code, unique to TGT, reconciles all critical well system elements including reservoirs, completion components and fluid types to produce accurate flow profiles.

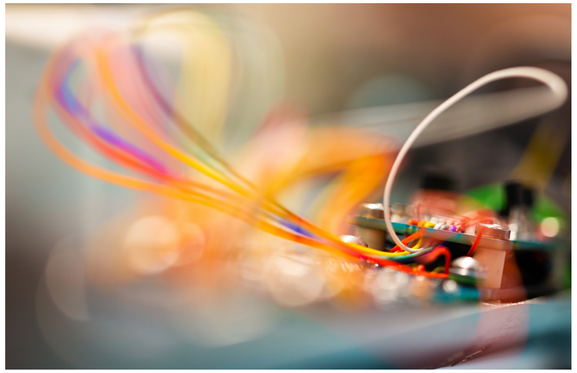
Automated modeling code rapidly resolves the 'answer' from inputted data.

Parallel processing makes thousands of calculations, accurately solving multiple thermo-hydrodynamic equations.

Analysis & interpretation
Analysts combine Cascade findings with information from Chorus and Indigo to provide accurate flow profiles across the reservoir.

Maxim, our digital workspace, provides analysts with a host of Cascade Apps and versatile visual displays to facilitate detailed analysis and confident interpretation.

Our True diagnostic systems and products extract accurate information from your well and turn it into unique actionable insights so you can manage performance safely, productively and profitably.



Pedigree
- Cascade diagnostic platform has been designed and engineered entirely in-house.
- More than 10-years of pioneering scientific research, ingenuity and direct field experience in applying thermal flow diagnostics to thousands of well systems globally.
- Advancing industry knowledge in temperature, hydrodynamics and 3D numerical modeling.
- Two confirmed patents (and pending) for specific data acquisition techniques required for reservoir flow quantification in producers and injectors.
- Tested and proven in more than a thousand well systems, servicing more than 70 international operators.
- More than 70 recognised industry publications.

TGT

Cascade specification

Mechanical

	Parameter Value
Maximum temperature	-4 – 302˚F | -20 – 150˚C
Maximum pressure	14 503psi | 100MPa
H_2S resistance	≤30%
Outside diameter	1.65in | 4.2cm
Housing material	Titanium
Pressure sensor	Sapphire gauge

Measurements

Operating envelope	Parameter Value
Relative pressure measurement error	0.15%
Pressure measurement range	0.5 – 100Mpa
Pressure resolution	0.0005Mpa
Absolute temperature measurement error	±0.1˚C
Temperature resolution	0.001˚C

tgtdiagnostics.com

Platform Cascade PCA001