THERMOCHEM®
Empowering Energy Industries since 1985

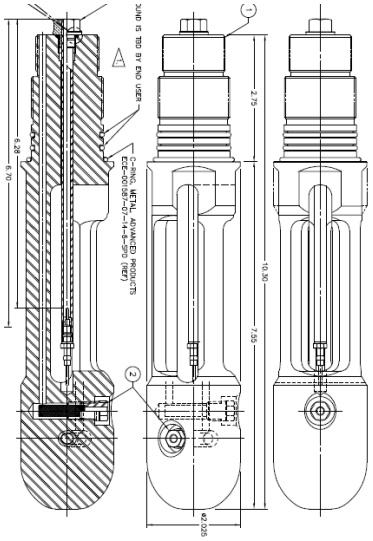
HIGH TEMPERATURE 2-PHASE DOWNHOLE SAMPLING / PTS TOOL

Wellhead vs. Downhole Sampling

Geothermal wells are typically sampled for geochemistry at the wellhead, which only provides an average composition of the fluids from depth. Unless the well is pumped, sampling occurs after flashing and scale deposition. Downhole sampling allows vertical profiling of geochemistry with depth, so that each entry can be defined for reservoir model development and simulations. It can also identify specific problematic fluid zones such as high gas, acidic brine or incompatible fluids that cause scaling upon mixing in the wellbore. Pre-flash fluids can be collected before calcium and trace metals have deposited for an accurate reconstruction of the original reservoir fluids.

However, traditional downhole sampling tools have several shortcomings:

- The brine flashes as it enters the sample chamber, causing loss of constituents to deposition.
- Sample capacity is severely limited for two-phase fluids and steam zones as sample chamber fills and pressurizes with low-density steam.
- Sample valves are exposed to extreme environments (~250 °C to 350 °C) and often leak and fail.
- Sampler components are not inert and react with the small volumes of sample collected (high reactive surface to sample volume).
- Difficulty in extracting samples and inability to collect representative NCG samples, limited to liquid chemistry only.



Thermochem's Two-Phase Downhole Sampling Solution

Thermochem has designed an advanced high-temperature two-phase downhole sampling (DHS) tool that is able to withstand temperatures up to 350°C and can recover large sample volumes of 400 ml.

Key design features and benefits of the Thermochem DHS tool include:

- Internal high-tech sample cooler condenses steam and cools brine before the sample chamber and inlet valve, enabling 400 ml of sample to be recovered, even in 100% steam zones.
- The pre-cooling of brine before entering the sample chamber eliminates flashing and loss of trace species to deposition.

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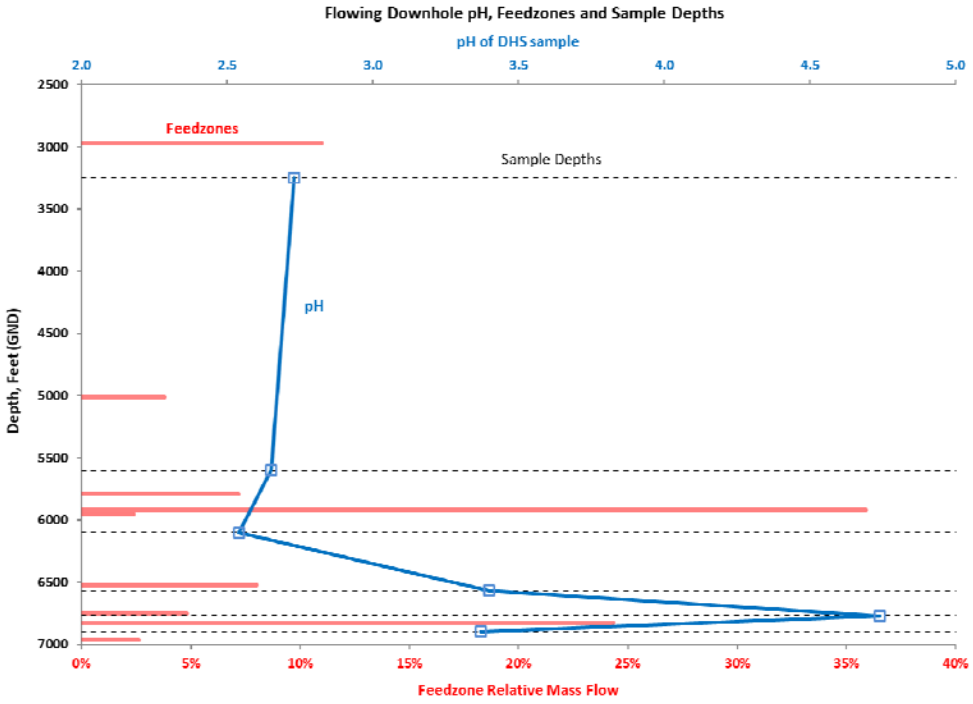
- Pre-cooled fluids allow the use of highly-reliable, leak-tight sample valves.
- The sample cooler is filled with a eutectic material that has a higher heat capacity per volume than ice.
- The pre-cooler also functions as a total heat calorimeter, enabling measurement of the steam to brine ratio, so that samples collected in the two-phase zone can be reconstructed to wellbore conditions.
- Titanium flow-path and sample chamber with low surface area to sample volume ratio minimizes deposition or contamination. Simple design, minimal moving parts reduces maintenance needs.
- Evacuated or inert-gas charged sample chamber allows high-accuracy NCG sample recovery.
- Sample valve opens at pre-set times, temperatures or pressures to target specific zones.
- Wellbore fluid conductivity measurement for TDS logs as a function of depth or time.
- PTS capability for Pressure/Temperature/Spinner logs during sampling.

Applications

The Thermochem DHS tool performs a full spectrum of reservoir characterizations:

- Vertical profiling of gas and liquid chemistry.
- Pre-flash sample collection without loss or contamination.
- Detect and characterize corrosive fluid entry zones.
- Locate reinjection or and other cool-fluid intrusion zones.
- Profile zones of tracer recovery during interwell tracer tests.
- Sample dry steam wells, single-phase brine, two-phase fluids.
- Collection of trace metals and gases (titanium sample path).
- Temperature, pressure, spinner (PTS), conductivity logging.



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The table below lists the current specifications for Thermochem DHS-PTS tool with the new high-pressure valve and sample chamber assembly.

Current Specifications for Thermochem DHS - PTS Memory Tool

General Tool	Specification
Temperature rating	350°C for 4 hours
External Heat Shield maximum pressure	72.4 MPa
External Heat Shield Material	17-4 PH SS
Outer diameter	59.4mm
Weight	55 kg
Overall Length, standard sub (PT)	4356 mm
Internal Components	
Sample Chamber Material	Titanium
Computer Sample control	Adjustable sampling duration, validation of sample
Sample volume	430mL
Fluid type	Two-phase, Single-Phase Steam or Water
Sample Chamber Pressure rating	35.0 Mpa @ 20°C, 34.5 MPa @ 80°C
Applicable pH range	2 - 11 pH units
Applicable Salinity range	0 - 250,000 ppm
Sample Transfer Method	Transfer under gas pressure and manual control
PT / PTS Data	
Pressure	Strain Gage, 0-5000 psia (7500 proof), +/- 0.15% of FSO
Temperature	Platinum RTD sensor, +/- 0.3 +(t*.005) °C
Spinner (Optional)	2 reed switches, 2 pole magnet – 4 pulses per
Pressure transducer rating	34.5MPa standard, available up to 72.4MPa
Data Sampling rate	5 sec, programmable
Data Capacity	1,000,000 data points

ABOUT THERMOCHEM

Thermochem is a vertically integrated consultancy, service, and OEM instrument firm empowering energy industries since 1985. Our mission is to protect the assets and resources of our clients, ensuring the most efficient use of equipment and resources, through preventing corrosion and scale damage to valuable equipment and providing early detection and solutions to resource problems. We service clients in more than 30 countries, providing chemical engineering solutions and equipment for geothermal energy, oil and gas, combined cycle, cogeneration, fossil fuel and nuclear power plant projects from our offices and laboratories based in the USA and Indonesia.

We provide solutions to our clients from the ground up: exploration through operations. Our extensive range of products and services includes greenfield exploration, well testing, geochemical modeling, chemical process engineering, analytical chemistry, reservoir engineering, permit support, due diligence and specialized instrumentation such as two-phase wellbore samplers, pH-modification equipment and on-line steam quality and purity meters.