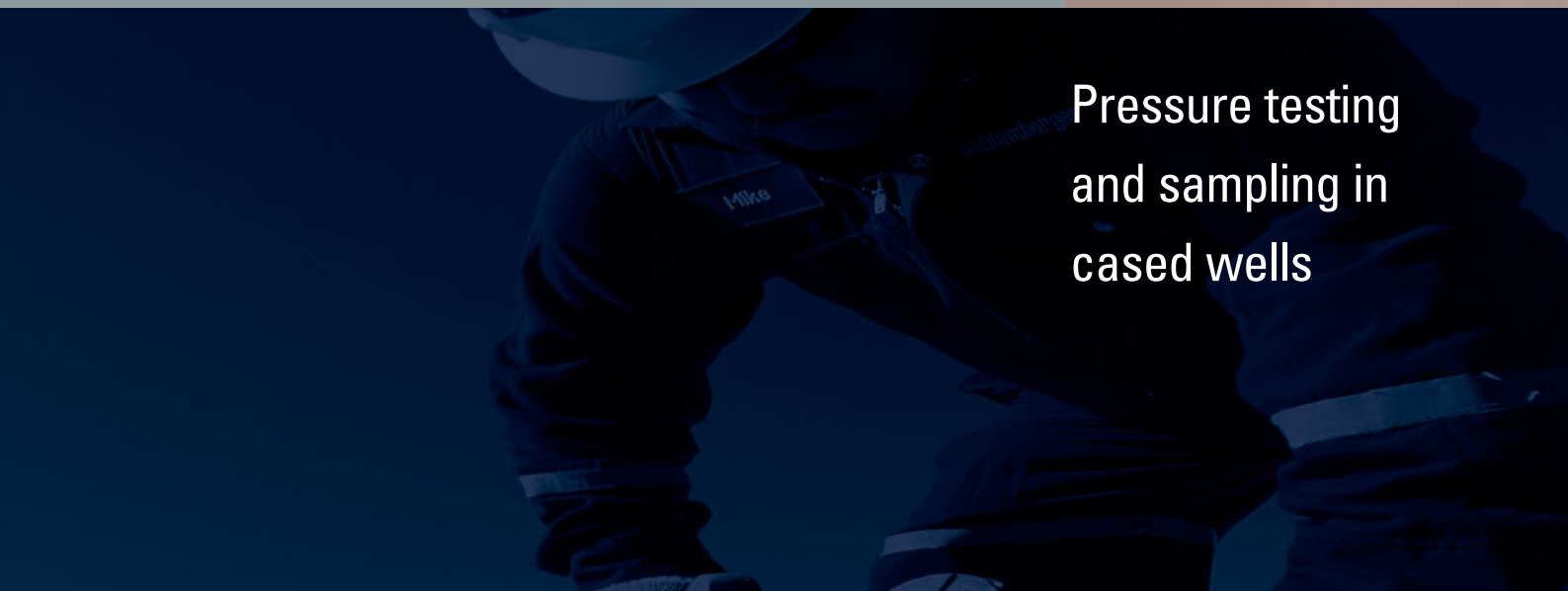
Schlumberger

CHDT Cased Hole Dynamics Tester



Pressure testing and sampling in cased wells

Applications

- Evaluation of old wells for bypassed hydrocarbons
- Development of critical economic data for well evaluation
- Reduced-risk alternative to openhole formation testing under difficult conditions
- Pressure monitoring during water, steam and CO_2 injection
- Identification of collector zones in gas-storage wells
- Stress testing and leakoff evaluation in cased hole
- Production and injection through precise holes

Benefits

- Complete resealing of the casing after pressure or sampling operations
- Avoidance of difficult openhole conditions
- Supplement to incomplete openhole data
- Elimination of explosives, perforation damage and casing burrs
- Compatible with ABC* Analysis Behind Casing solutions
- Safer access to overpressured or H_2S zones

Features

- Corrosion-resistant plugs to isolate tested zones and restore pressure integrity
- Combinable with MDT* Modular Formation Dynamics Tester modules for advanced sampling and fluid characterization
- Controlled drilling depth for mobility profiling and enhanced flow area
- Large pretest volume for additional testing flexibility
- Enhanced flow area for pressure testing in tight formations
- Input to fracture and stimulation programs
- Capability of maintaining an underbalance while drilling

Cased Hole Dynamics Tester

The Schlumberger CHDT* Cased Hole Dynamics Tester is a technologically advanced tool capable of measuring multiple pressures and sampling fluids behind a cased wellbore. Developed with support from the Gas Technology Institute (GTI), the CHDT tool has the unique ability to drill through a cased borehole and into the formation, perform multiple pressure measurements, recover fluid samples and then plug the hole made in the casing.

Downhole technology

Since logging its first well in 1927, Schlumberger has used advanced technology to acquire essential reservoir data for the oil and gas industry.

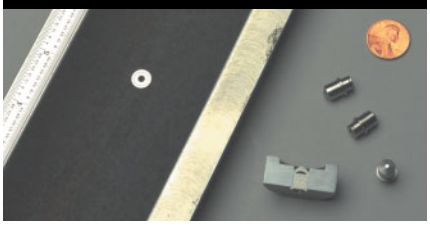
For new wells, formation testers provide critical information for the overall economic evaluation of a reservoir, including formation pressure profiles, formation fluid samples and permeability calculations in openhole environments.

For old wells, evaluation data for economic modeling and planning can be even more important and more difficult to acquire. Formation pressures and fluid samples acquired from be- hind the casing can be used to evaluate the potential for recovery from bypassed hydrocarbon zones.

Knowledge of the reservoir pressure, fluid type and mobility can be combined with saturation monitoring surveys and production history to model the dynamic response of the reservoir—crucial for optimizing hydrocarbon recovery.

Traditional cased hole formation testers have disadvantages, including the limited number of tests that can be performed on each trip and the need for costly remedial work to repair the casing after testing.

With a pressure rating of 10,000 psi, CHDT downhole plugs eliminate the need for remedial casing repair or cement-squeeze operations.



CHDT service

This unique service provides a cost-effective method to optimize recompletion plans, enhance old or incomplete log data, assess unknown pay zones, and evaluate wells for economic potential. The CHDT service is the first purpose-built, cased hole formation testing service that can acquire multiple formation pressures, retrieve high-quality downhole samples and restore pressure integrity—all in a single, cost-effective trip.

The unique ability of the CHDT tool to restore pressure integrity to the casing after drilling eliminates costs associated with conventional plug-setting runs, cement-squeeze operations, pressure tests and scraper runs, as well as the rig costs associated with these operations. During the life of a well, the CHDT tool can provide information that could eliminate the need for perforating or expensive remedial cementing operations and allow cost-effective testing of a zone before workover or well abandonment.

The innovative CHDT tool seals against the casing and uses a flexible drill shaft to penetrate through both the casing and the cement and into the formation. As the drill penetrates the target, a built-in instrument package simultaneously monitors pressure, fluid resistivity and drilling parameters. This additional information about the casing-cement-formation interfaces allows real-time quality control.

The CHDT tool is also combinable with the MDT modules. These modules enable quality single-phase sampling, enhanced fluid identification and contamination monitoring, which were previously available only with openhole applications.

The CHDT tool can be combined with other through-casing formation evaluation tools such as the CHFR* Cased Hole Formation Resistivity tool and the RSTPro* Reservoir Saturation Tool. The resulting comprehensive formation evaluation, performed through casing, eliminates the guesswork that can result in irreversible, expensive or less-than-optimal decisions.

The CHDT tool is fully combinable with MDT modules such as the multisample module, the pumpout module and the OFA* Optical Fluid Analyzer module.

Improved safety

Traditional cased hole formation testers rely on explosive charges to penetrate the casing and cement in order to establish communication with the formation. The explosive shock often eliminates the seal between the formation tester and the casing, which prevents any valid pressure monitoring, pretesting or sampling.

Since explosive charges are also limited in size and their penetration depth cannot be controlled, the pretest can be difficult to analyze or the interpretation can be invalid. Since the CHDT tool accesses the formation by drilling, the use of explosives is eliminated.

Reduced formation and casing damage

The CHDT drilling operation ensures minimal casing, cement and formation damage and provides accurate control of penetration depth. In some cases, explosive charges can cause enough damage to the cement integrity to compromise zonal isolation. These charges create casing burrs that reduce the effective internal diameter of the casing and interfere with downhole hardware required on subsequent runs. The CHDT drilling process eliminates casing burrs and the resulting downhole interference.

The drilling process also reduces the formation skin damage associated with explosive charges and perforating. The pressure response at different penetration depths can be used for mobility profiling, detecting microannulus and increasing the effective flow area in low-permeability formations.

In newly cased wells, it is also beneficial to drill into the formation to reach beyond the invaded or damaged zone.

Increased run efficiency

Traditional cased hole formation testers are limited to two pressure tests and two samples per trip. The CHDT tool can drill up to six holes (one per station), perform multiple pressure tests and acquire multiple, high-quality samples per station—all in a single run. Sample quality and fluid properties can also be monitored when the tool is combined with the OFA, LFA* Live Fluid Analyzer and pumpout modules of the MDT tool. When the sampling and testing have been completed, the CHDT tool plugs the holes in the casing.

Combined services

To acquire representative pressures and samples at the desired depth, it is important to verify that there is an adequate cement bond for zonal isolation. This bond eliminates the possibility of fluid communication with nearby zones.

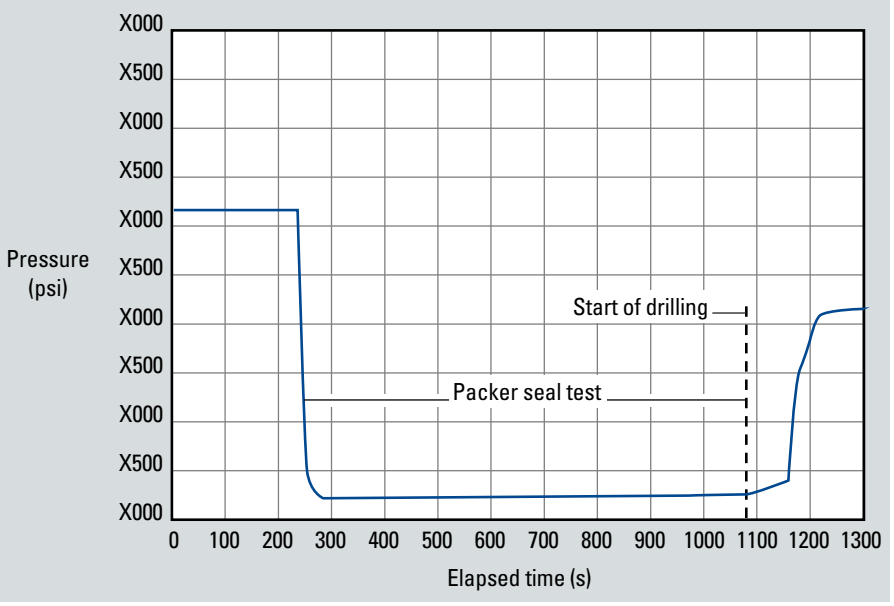
To optimize the planning and test-point selection for the CHDT service, the Schlumberger USI* UltraSonic Imager tool can simultaneously provide information about the casing thickness, ovalization, cement quality and the location of external centralizers. The USI tool will also give an indication of the casing's internal condition, eliminating the need for a separate corrosion log.

CHDT operations

The CHDT tool is first run to the desired depth. Anchor shoes push the tool packer against the casing to provide a seal between the inner surface of the casing and the tool. A packer seal test ensures that the seal is properly established before drilling.

After the seal is verified, the drilling process starts, with pressure and drill bit position monitored at the surface. As the drill bit advances through the casing into the cement, small pressure variations result from the difference in pore pressure of the cement and volumetric changes. As the drilling continues into the cement, the cleaning cycles effectively remove debris from the tunnel and pull it into the tool. This procedure enhances drilling performance and reduces torque at the bit.

The integrity of the packer seal is verified prior to the drilling operation by reducing flowline pressure of the CHDT tool.



Once the formation is reached, the pressure will stabilize and the drilling can be terminated. The flowline pressure can be reduced prior to drilling to enhance the pressure response when communication is made with the formation.

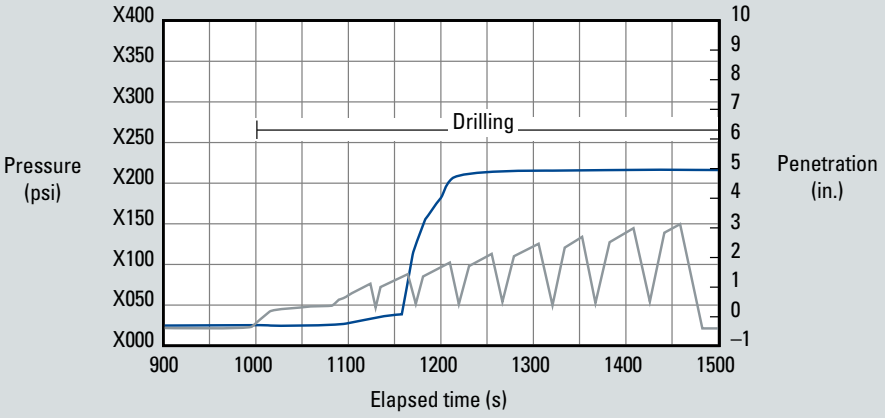
For drawdown analysis, the CHDT tool can perform multiple pretests with volumes to 100 cm^3 and at various rates. Multiple pretests, performed at different penetration depths, can detect the presence of a microannulus and ensure formation pressure measurement repeatability. The wellsite pretest interpretation includes the depth of penetration in the analysis and can be performed using either the strain gauge or the CQG pressure responses. For low-permeability formations, the flow area can be increased by extending the drilled tunnel into the formation.

CHDT samples are acquired when proper communication is established between the tool and the formation. The CHDT tool monitors resistivity for fluid typing and can be combined with the OFA or LFA fluid analyzer modules for advanced fluid typing and contamination monitoring.

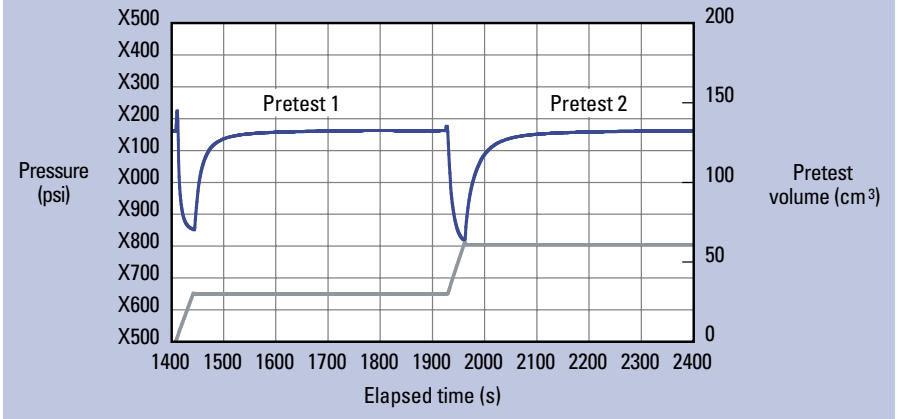
One-gallon H_2S-rated sample chambers, which are suitable for standard 5½-in. casing, are available for the CHDT tool. MDT sample chambers are also available for operations in 7-in. or larger casing. They include the multisample module with six 450-cm^3 bottles; 250-cm^3 single-phase multisample chambers; and 1-, 2¾- and 6-gal sample chambers. To increase efficiency, the CHDT tool can run several chambers simultaneously.

After performing the required pressure testing and sampling, the CHDT tool uses corrosion-resistant plugs to seal the hole in the casing. The unique CHDT capability to restore pressure integrity to the casing results in a mechanical metal-to-metal seal that is rated to a differential pressure of 10,000 psi. The change to the original internal casing diameter after the plug is set is only 0.03 in., and the upset can be removed without interfering with the pressure rating of the plug.

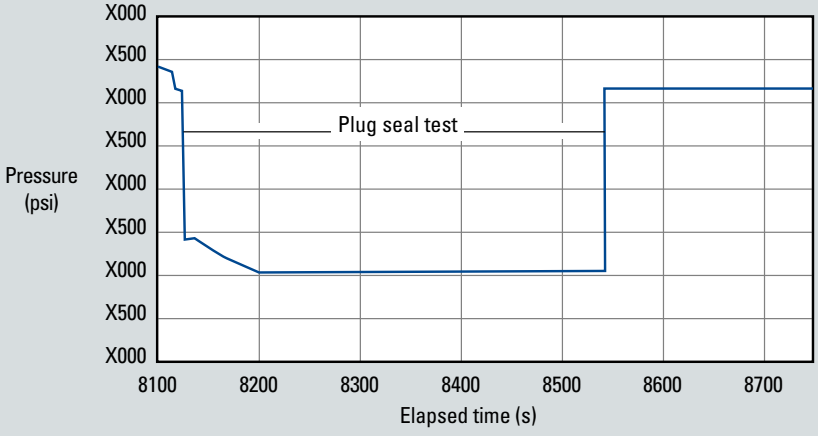
Two pressure gauges, the CQG Crystal Quartz Gauge (blue) and a strain gauge (not shown), record pressure during the drilling operation. At the same time, the drill bit position (gray) is noted for quality control.*



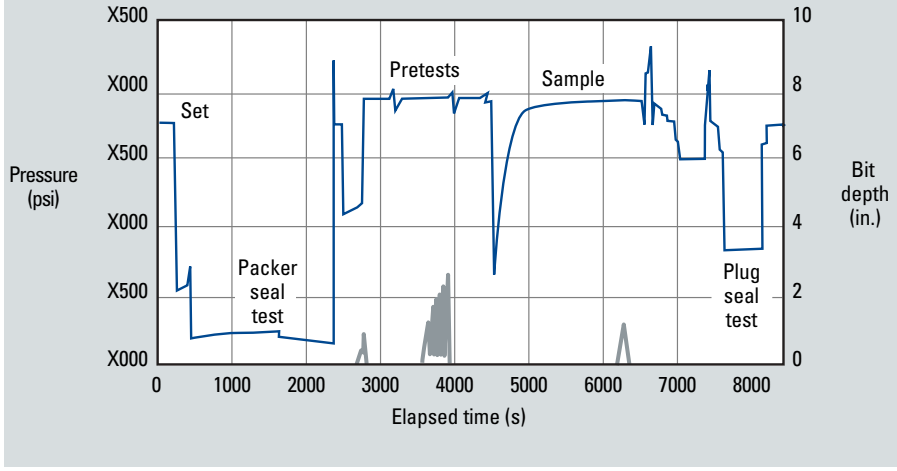
The CQG pressure response (blue) is shown, along with the pretest piston position (gray) indicating the volume of the test. The pretest rate can also be displayed.



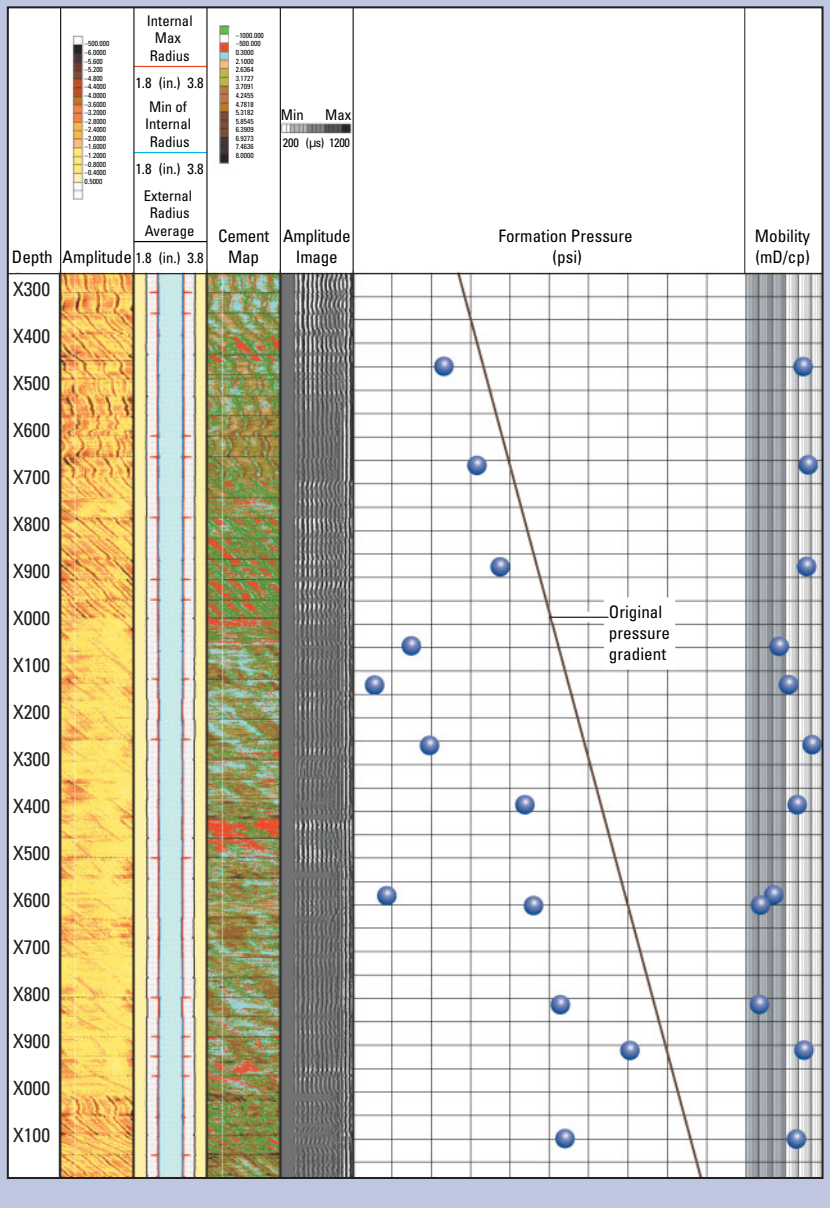
To verify integrity of the plug after the plugging operation, the pressure is reduced below the formation pressure and monitored to check the plug seal.



The log below shows one CHDT station, which includes two pressure tests and one sample operation.



The cased hole USI log is shown in conjunction with the CHDT pressure profile and drawdown mobility profile.



Bypassed hydrocarbons

The CHDT tool was used in a South Texas well that had been drilled in 1941. Although the operators suspected bypassed hydrocarbons, the available data were limited to an old spontaneous potential log and resistivity survey.

A through-tubing RST* Reservoir Saturation Tool identified multiple zones with potential hydrocarbons. A USI tool was run to evaluate the casing condition and the cement quality. The CHDT tool was subsequently run to measure the reservoir pressure and confirm the fluid type.

Seven formation pressures were acquired, and four samples confirmed hydrocarbons. All holes were successfully plugged with the CHDT tool. Based on the data acquired by the CHDT tool, the operator was able to plan a recovery program for the bypassed hydrocarbons.

Depletion and fracture program

An operator on the West Coast of the United States wanted to determine the formation pressure in potentially bypassed zones prior to planning a fracture stimulation program.

The CHDT tool was run in five wells with casing sizes varying from 5½ to 7 in. Six or more tests were conducted in each of the wells. Pressure gradients were acquired in each well to identify the bypassed zones and ascertain zonal connectivity. Each pretest was analyzed to estimate drawdown mobility. Good repeatability was observed on successive pretests conducted at the same depths.

A comparison of the measured pressure profile with the initial pressure profile illustrates zones with significant to little depletion. The mobility profile provided valuable information on the potential drainage strategy for these and other planned wells.

The CHDT tests provided information that was used to formulate a secondary recovery strategy and to help refine economic decisions for fracture stimulation.

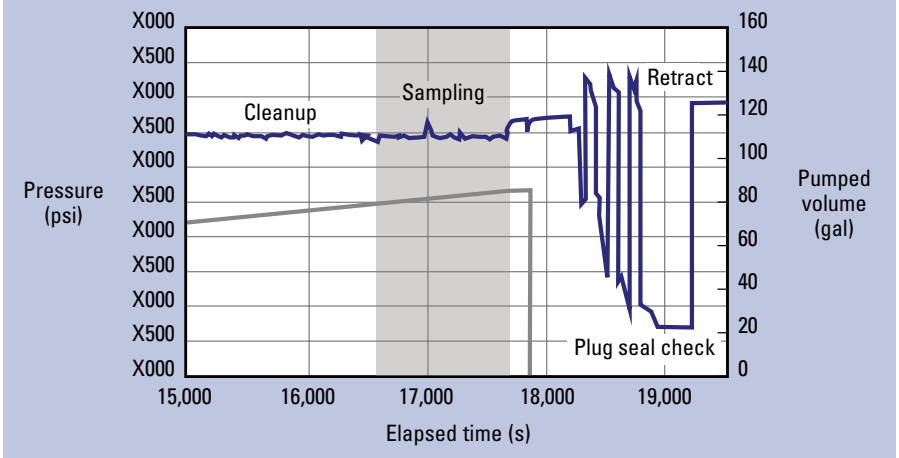
New well with difficult conditions

In a vertical openhole exploration well for Phillips, several attempts were made to acquire fluid samples for geochemical analysis. Formation pressures and fluid gradients were also required. As a result of adverse hole conditions, formation tester operations were discontinued after three attempts to acquire the data.

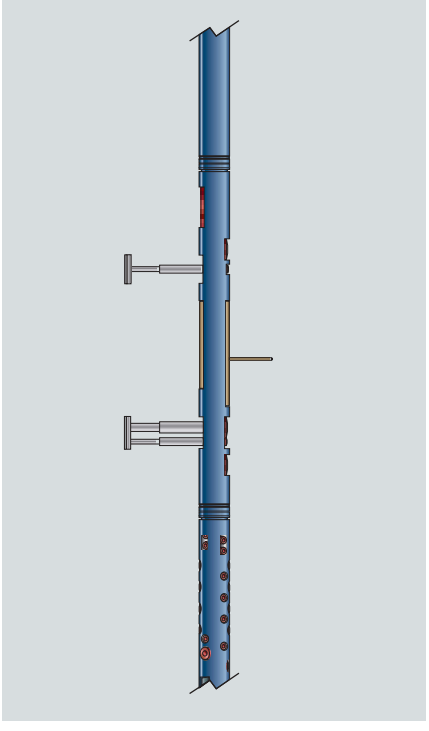
After casing was run, the CHDT tool acquired five pressures, three pressure-volume-temperature (PVT) samples and two 1-gal samples for wellsite validation. A total of 185 gal [700 L] was pumped to clean up the filtrate invasion prior to capturing the samples. All holes were successfully plugged, and the well was pressure tested at surface to 3,500 psi [24,130 kPa] for 30 min with no leaks detected.

The PVT samples were acquired by combining the CHDT tool with the OFA module, the MDT pumpout module and MDT multisample module.

The CHDT station log shows the pressure response (blue) during a low-shock sampling job. The log also details the pumpout volume response (gray).



The CHDT tool seals against the casing and uses a flexible drill shaft to penetrate through the casing and into the formation.



Tool Specifications

OD	4.25 in. [108 mm]
Length (pressure measurements only)	31.2 ft [9.5 m]
Optional sample chamber	9.7 ft [2.9 m]
Casing size	5½ to 9⅝ in.
Max casing thickness (standard probe)	0.5 in.
Max temperature	350°F [176°C]
Max pressure	20,000 psi [137,900 kPa]
Max underbalance	4000 psi [275 bar]
H_2S service	Yes
Max holes drilled and plugged†	6 per run
Plug pressure rating	10,000 psi [68,950 kPa] (bidirectional)
Max drilled depth	6 in. [152 mm]
Drill hole diameter	0.281 in. [7.137 mm]
Pressure sensors	Quartz gauge, CQG gauge and strain gauge
CQG accuracy	(±1 psi ± 0.01% reading)
CQG resolution	0.003 psi [0.020 kPa]
Pretest volume	6.1 $in.^3$ [100 cm^3]
Pressure tests per hole	Unlimited
Sampling	PVT and conventional
MDT service combinability‡	Yes
Fluid identification	Resistivity, OFA, LFA

† Formation dependent

‡ Combinable with MDT modules (including OFA, LFA, multisample chamber, etc.) in 7-in. and larger casing

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