Schlumberger

MDT Modular Formation Dynamics Tester

Quality fluid samples and highly accurate reservoir pressures

Applications

- Formation pressure measurement and fluid contact identification
- Formation fluid sampling
- Permeability measurement
- Permeability anisotropy measurement
- Mini-drillstem test (DST) and productivity assessment
- In-situ stress and minifrac testing

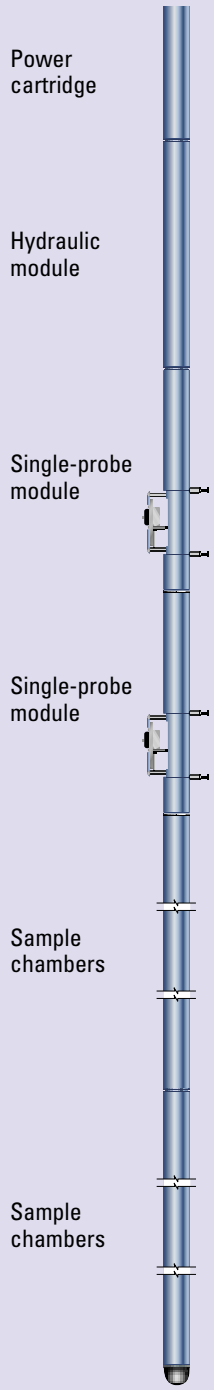
Benefits

- Testing and sampling in low permeability, laminated, fractured, unconsolidated and heterogeneous formations
- Fast, repeatable pressure measurements
- Faster tests in low permeability—reduced seal losses and probe plugging
- Pressure, volume and temperature (PVT) formation fluid samples
- Downhole fluid differentiation
- Real-time fluid gradients, permeability and contamination assessment

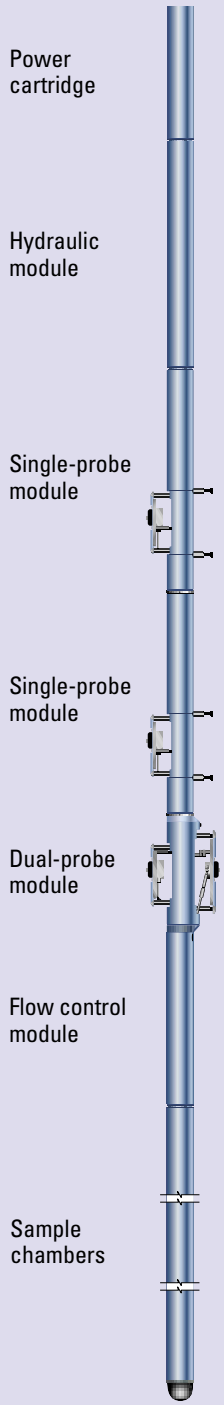
Features

- Modular, custom-design capability
- Multiple samples in one trip
- Multiprobe and inflatable dual packer module options
- Efficient integration with other tools
- Accurate pressure measurements using a CQG* Crystal Quartz Gauge
- Programmable pretest pressure, rate and volume
- Filtrate pumpout prior to sampling
- Fluid resistivity and temperature measurements at the probe
- Quantatative sample contamination measurement with optical spectroscopy techniques
- Low-shock and single-phase sampling
- Field-proven database for accurate pumpout time

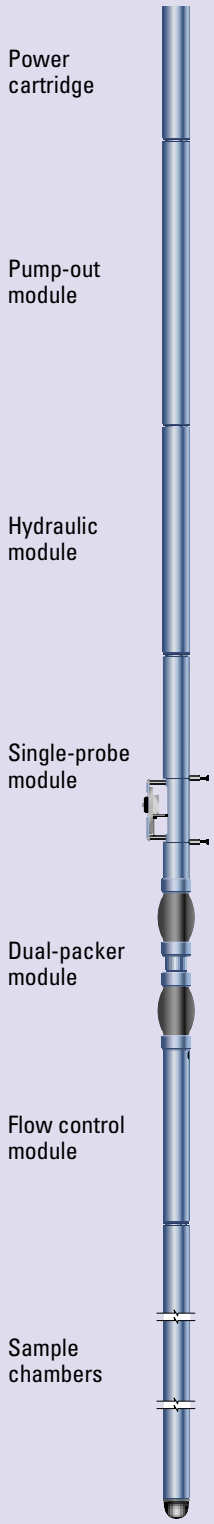
The MDT tool can be customized and efficiently assembled on-site to meet exact requirements depending on the needs of a particular well evaluation.



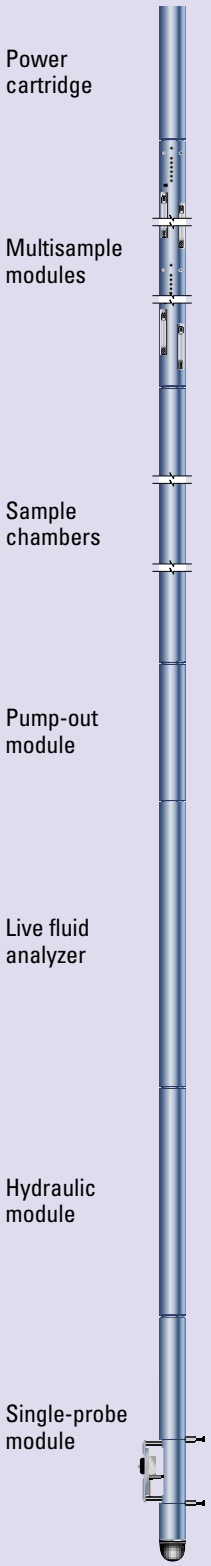
Basic MDT configuration for pressure, permeability and sampling



Multi-probe vertical interference testing



Vertical interference test with probe-packer



Low shock PVT-quality sampling

Real-time measurements

The Schlumberger MDT* Modular Formation Dynamics Tester tool provides fast and accurate pressure measurements and high-quality fluid sampling. It can also measure permeability anisotropy. In a single trip, the MDT tool is able to acquire most of the data requirements needed for accurate and timely decision making.

Flexibility

The key to this remarkable tool is an innovative, modular design that lets you customize the tool for the required applications. MDT modules combine to meet the exact needs and goals of the data acquisition program. This designed flexibility makes the tool compatible with almost all Schlumberger measurement technologies and allows the MDT tool to evolve as new measurement techniques, technologies and options evolve.

Quick, accurate pressure and permeability measurements

Reservoir pressure measurements using a wireline tester require inserting the probe into the reservoir and withdrawing a small amount of fluid. Since the pressure gauge is exposed to many temperature and pressure changes, these measurements require accurate gauges with high resolution that can dependably react to the dynamic conditions.

The MDT tool uses highly accurate gauges with best-in-class resolution, repeatability and dynamic response for pressure measurements. These pressure gauges exhibit excellent response with no compromise in accuracy or resolution. Precise flowline control during testing and sampling ensures monophasic flow. These innovative features provide the most efficient and accurate permeability determination available.

MDT modules

Electronic power module

The power cartridge (MRPC) converts AC power from the surface to provide DC power for all modules in the tool. It is an essential part of any MDT configuration.

Hydraulic power module

The hydraulic power module (MRHY) contains an electric motor and hydraulic pump to provide hydraulic power for setting and retracting the single- and dual-probe modules. The MRHY module features an accumulator that allows the test probes to autoretract and prevent a stuck-tool situation in the event of a power failure.

Single-probe module

The single-probe module (MRPS) contains the probe assembly, (with packer and telescoping backup pistons), the pressure gauges, fluid resistivity and temperature sensors, and a 20-cc pretest chamber. The MRPS also contains a strain gauge and an accurate, high-resolution, quick-response CQG gauge. The volume, rate and drawdown of this chamber can be controlled from the surface to adjust to any test situation, especially in tight formations.

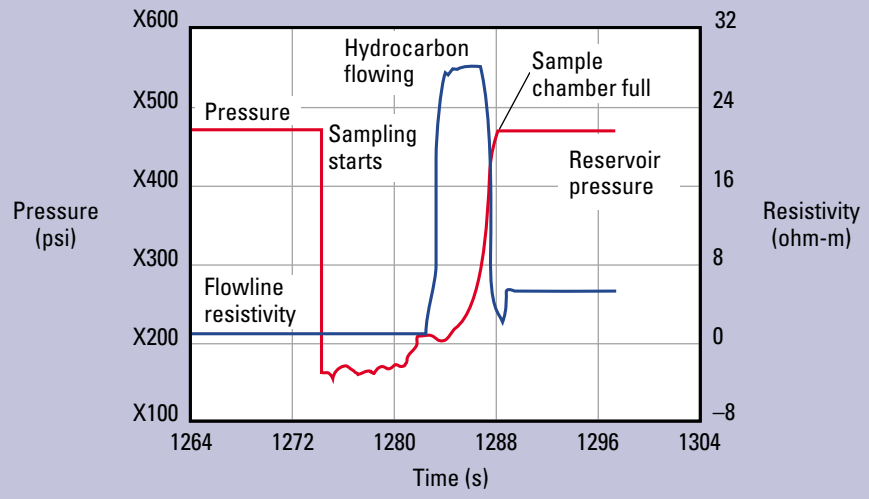
Dual-probe module

The dual-probe module (MRPD) contains two probes mounted back-to-back, 180° apart on the same block. When combined with an MRPS module, it forms a multi-probe system capable of determining horizontal and vertical permeability.

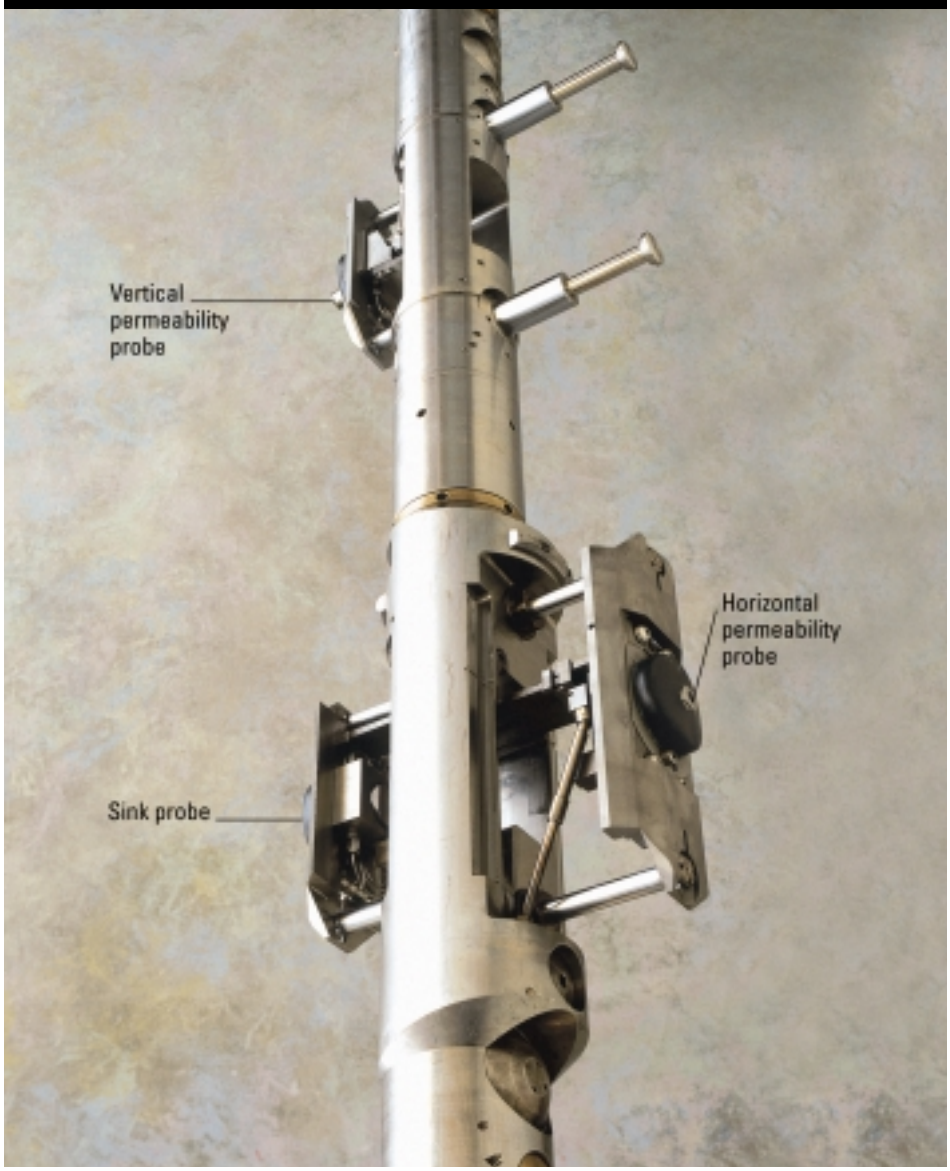
During a typical test with the MRPD module, formation fluid is diverted through the sink probe to a one-liter pretest chamber in the flow control module. The MRPD module, in conjunction with the pressure measured at the vertical probe from the MRPS module, measures the pressure at both probes. These measurements are used to determine near-wellbore permeability anisotropy.

Flexible probe configurations are a unique feature of the MDT tool. By running multiple probe modules, pressure communication between adjacent formations can be monitored during an interference test. The MDT multi-probe configuration also allows in-situ verification of gauge quality and utilization of two different probe assemblies for redundancy in difficult conditions.

In a water-based mud environment, the MDT flowline resistivity measurement helps discriminate between fluid contaminated by mud filtrate and formation oil or fresh water.



The multiprobe configuration of the MDT tool measures the pressure response at two or more locations in addition to the single probe data. Data from the MDT multiprobe configuration provide an evaluation of horizontal and vertical permeabilities and formation heterogeneity.



The MRPA module employs two inflatable packers to isolate a borehole interval for testing. Tests in low-permeability formations are greatly enhanced, because the cross-sectional area of the isolated interval is many times greater than that of the standard MDT probe.

Dual-packer module

The dual-packer module (MRPA) uses two inflatable packers, set against the borehole wall, to isolate a 3 to 11 ft. section of the formation and provide access to the formation over a wall area that is thousands of times larger than the standard probe area. This allows fluids to be withdrawn at a higher rate without dropping below the bubble point, and it provides a permeability estimate with a radius of investigation in the range of tens of feet. The MRPA is useful for making pressure measurements and taking fluid samples in difficult conditions (tight, vuggy, fractured and unconsolidated formations) and has also been used in cased holes after a perforation operation. In addition, the MRPA module can be used for in-situ stress testing and mini-frac testing.

Modular sample chamber

The Modular Sample Chamber (MRSC) is available in three sizes: 1 gal, 2.75 gal and 6 gal. The upper block of each chamber contains a throttle valve that can be operated fully open, fully closed or in throttle mode. The 1-and 2.75-gal chambers exist in both H_2S and non-H_2S versions. The 6-gal chamber can be expanded in 6-gal increments to act as dump chambers by adding more 6-gal cylinders.

Multisample module

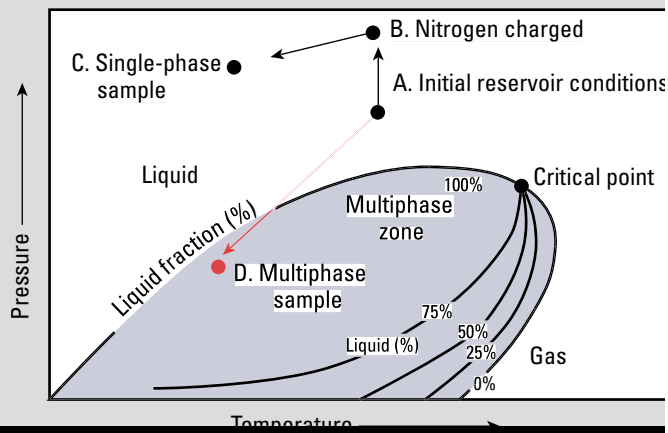
The Multisample Module (MRMS) allows the collection of high-quality samples for PVT analysis. The module is designed to retrieve six formation fluid samples, 450-cc each, during a single trip into the well. Sample bottles detach easily from the tool for transport to a PVT laboratory. The bottles meet transportation regulations for shipping pressurized vessels, so no wellsite transfer is necessary.

Since multiple MRSC and MRMS modules can be combined, the total number of sample modules is limited only by cable strength and well conditions. For longer tool strings, as well as highly deviated and horizontal wells, the MDT tool can be combined with the TLC* Tough Logging Conditions system for efficient sampling operations.

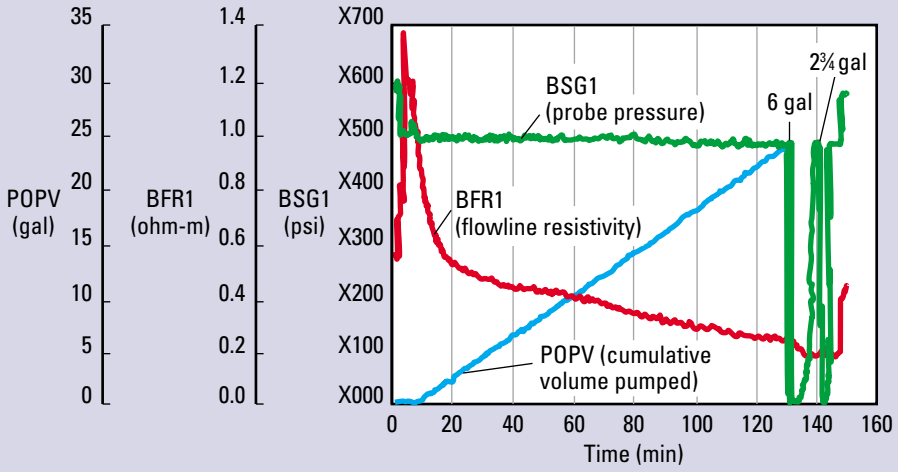
Multiple MRMS modules—each capable of collecting six high-quality PVT samples—can be combined in one run to meet sampling requirements.

Chemical analysis of MDT-acquired samples helps to characterize the reservoir fluid and facilitates optimal completion and surface facilities design.

As they are brought to the surface, samples taken at reservoir temperature and pressure (A) can change phase at lower temperatures and pressures (D). Overpressuring the sample downhole (B) will maintain its initial phase as it is brought to the surface (C) at a lower temperature.



In oil-based mud environments, flowline resistivity may also aid in formation water sampling.



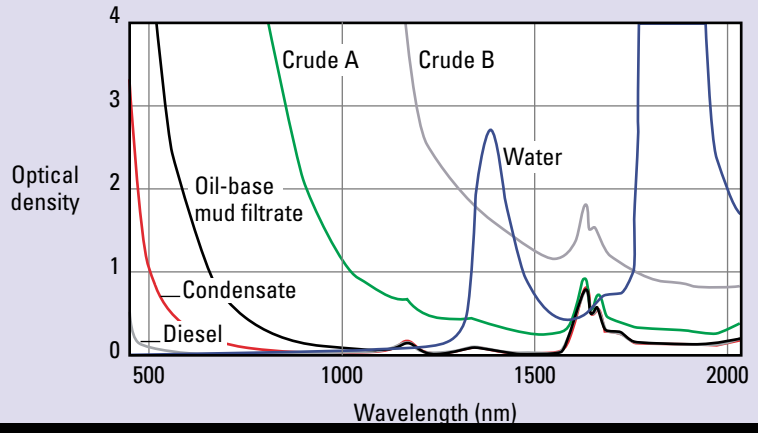
Single-phase multisample chamber

The single-phase multisample chamber ensures collection of monophasic fluid samples by overpressuring samples after they are taken at reservoir conditions. Sample chambers are pressurized with a nitrogen gas chamber across two pistons. This compensates for the temperature-induced pressure drop as the samples are returned to the surface.

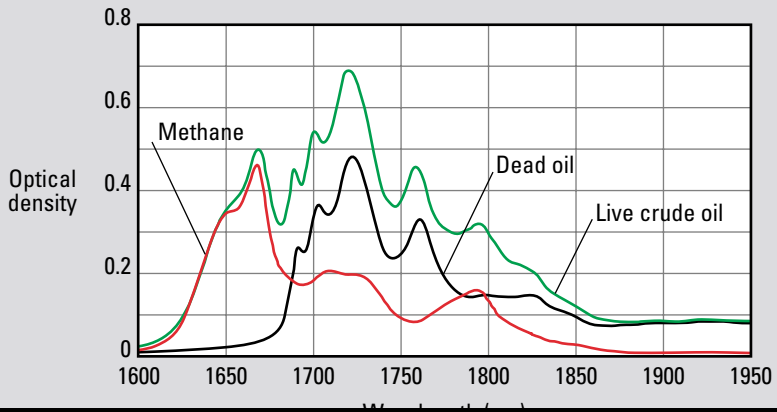
Pump-out module

The Pump-Out Module (MRPO) is used to pump unwanted fluid (mud filtrate) from the formation to the borehole, so representative samples can be taken. It is also used to pump fluid from the borehole into the flowline for inflating the packers of the MRPA module. In addition, the module can pump within the tool, for example, from a sample chamber to the inflatable packers.

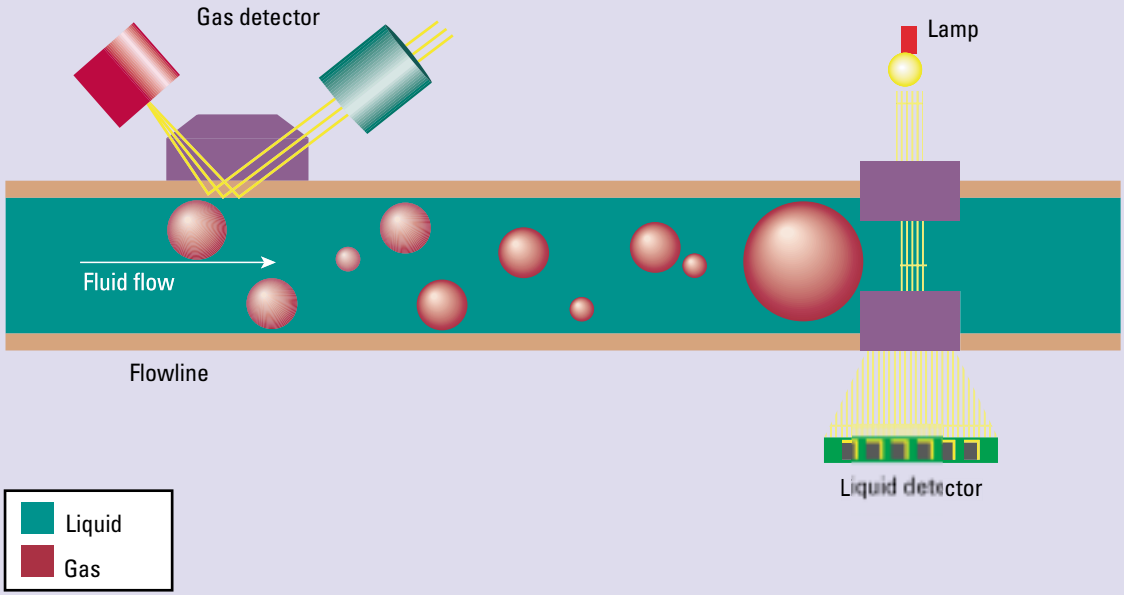
Optical density spectra can be used to uniquely identify different fluids.



The graph below illustrates the optical density (OD) of methane, dead oil and live crude oil. An OD of zero means there is full transmission (no absorption) of light. An OD of 1 means that 10% of the light is transmitted, and 90% is absorbed. Methane and dead oil peaks are prominently shown in the live crude oil spectrum.



The LFA module provides real-time downhole fluid analysis by measuring multiple optical properties of the fluid to quantify the amount of reservoir and drilling fluids in the flowline.



Live fluid analyzer module

Downhole fluid analysis in real time, as provided by the LFA* Live Fluid Analyzer module, enhances the usefulness of new techniques like pumpout and dual inflatable packers. The LFA module measures optical properties of the fluid in the flowline.

The LFA module employs an absorption spectrometer that utilizes visible and near infrared light to quantify the amount of reservoir and drilling fluids in the flowline. Light is transmitted through the fluid as it flows past the LFA spectrometer. The amount of light absorbed by the fluid depends on the composition of the fluid. Water and oil are reliably detected by their unique absorption spectra. A second sensor in the LFA module is the gas refractometer, which can be used to differentiate between gas and liquid.

Optical absorption in the visible and near infrared region is used for fluid discrimination and quantification; the change in index of refraction is used for free gas detection; and methane presence is used for both contamination monitoring and gas detection.

Flow control module

The Flow Control Module (MRCF) is a 1-liter pretest chamber where the flow rate can be accurately measured and controlled. The MRCF can also be used during sampling that requires a controlled flow rate. The volume is limited to 1 liter. The module creates a pressure pulse in the formation large enough for multiprobe measurements.

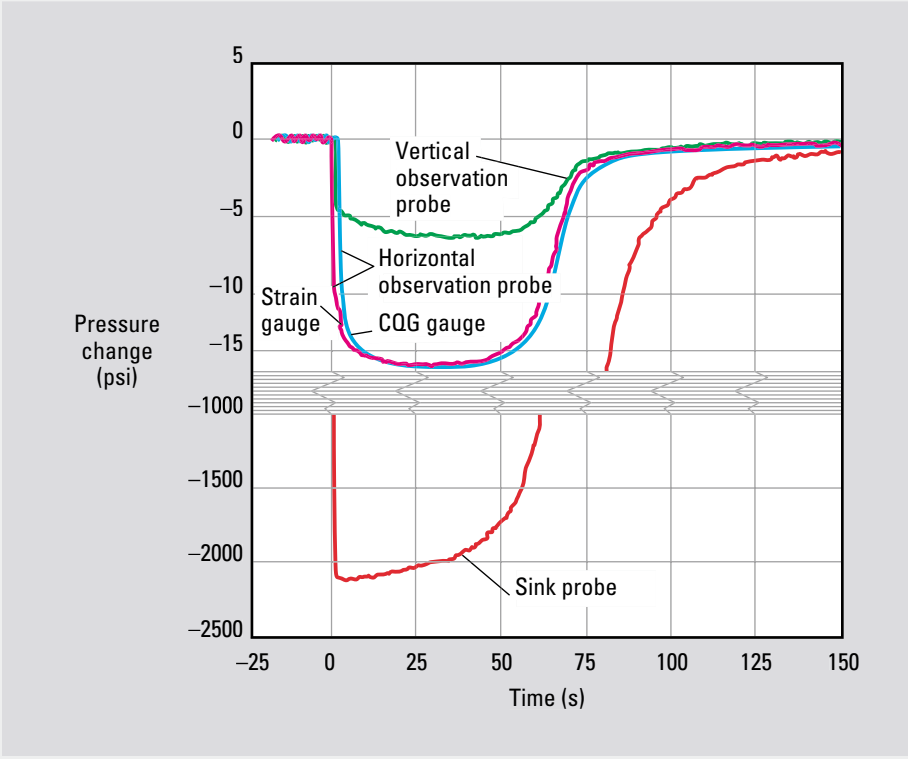
Prejob modeling and real-time answers

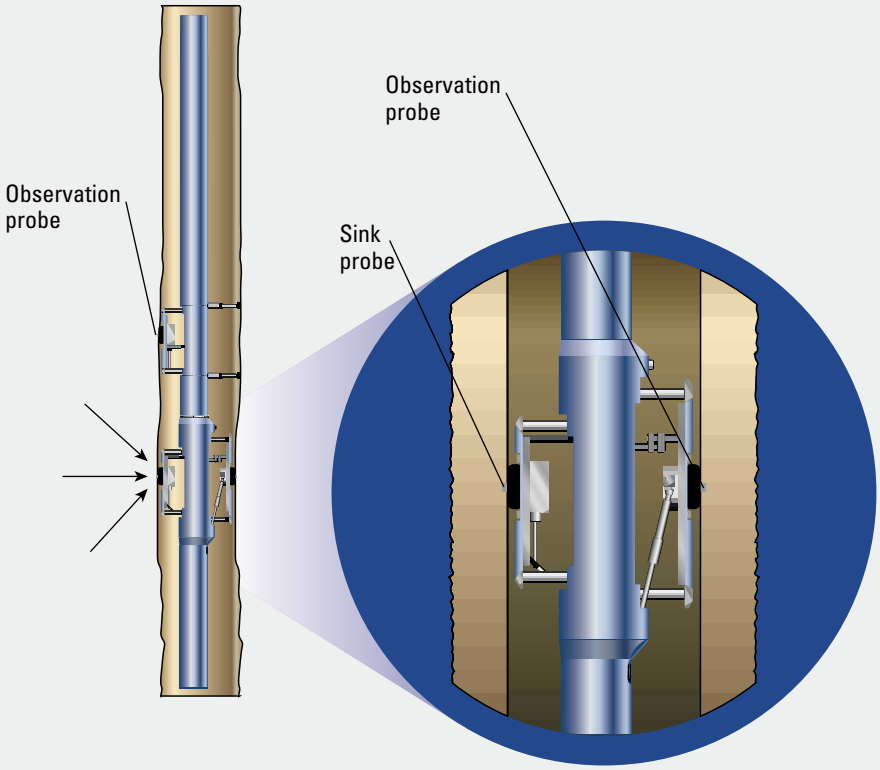
The software capabilities of the MDT tool enhance its hardware capabilities. Drawing on experience based on the vast number of MDT projects that have been completed over the past decade, programs are available to accurately plan and execute new MDT jobs. Highly sophisticated interpretation programs generate accurate pressure gradient, permeability and fluid sampling answers when they are needed.

Planning programs are also available to predict the response of the different gauges under any given environment and for any tool configuration. These programs also predict the duration of required pumping time and the likelihood of sticking in any given situation. These expert systems, based on the huge MDT job database, help optimize the running of the job. In the unlikely event that sticking does occur, the LWF* logging while fishing technique can be used to simultaneously complete the survey on drillpipe and safely retrieve the stuck string.

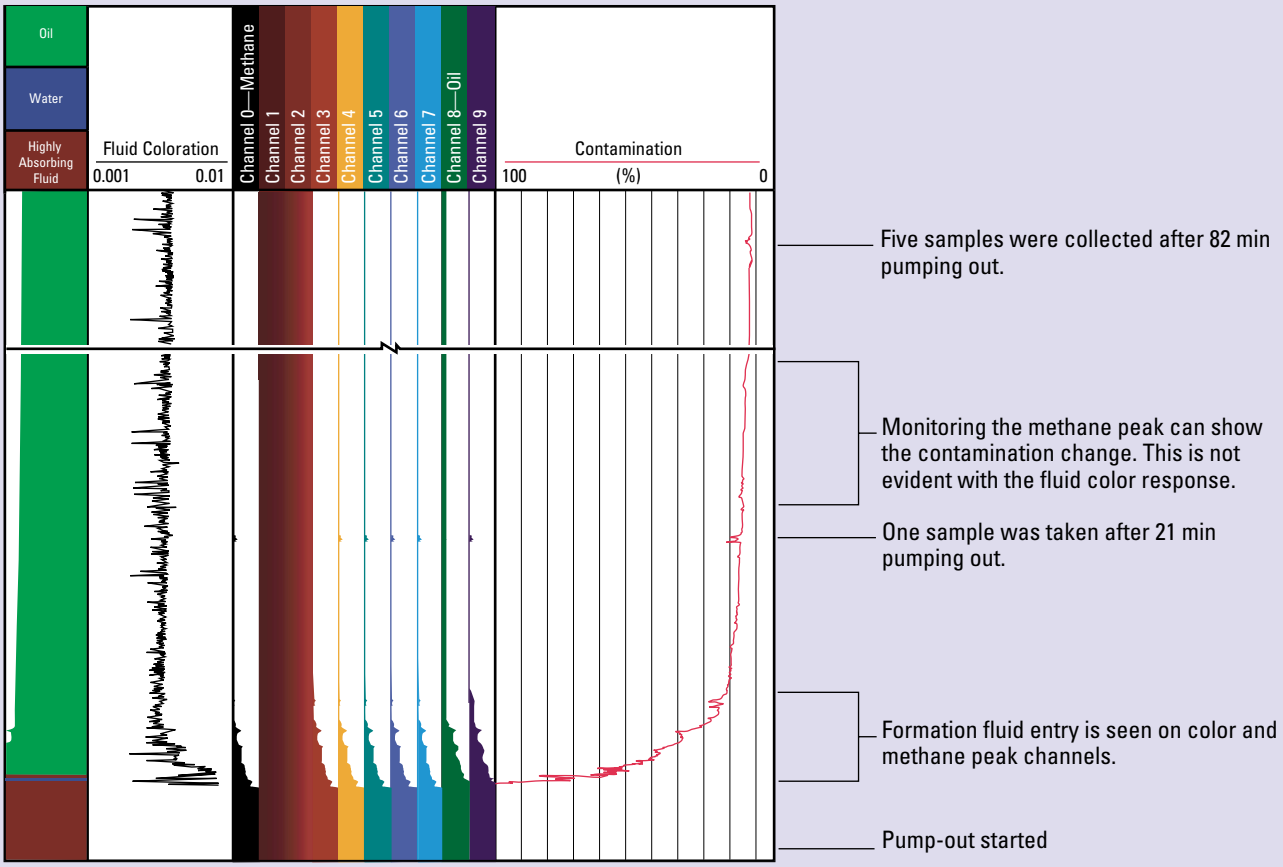
MDT interpretation software provides real-time plotting of pressure, resistivity and optical properties versus time. These plots generate derivatives and perform interpretation at the wellsite. This capability is essential for real-time quality control and ongoing optimization of the job. Using the InterACT* wellsite monitoring and control system for real-time data transfer to remote sites, Schlumberger and customer experts can simultaneously apply more sophisticated and elaborate modeling and interpretation software offsite.

The Flow Control Module contains a one-liter pretest chamber and metering valves capable of producing finely tuned drawdowns.





The LFA module monitors oil-based mud contamination by analyzing fluid color and methane content to ensure quality fluid sampling. Color and methane curves indicate the percentage of fluid contamination.



Fluid identification example

The purpose of fluid sampling is to obtain a representative sample of the virgin reservoir fluid. To obtain the sample, the unwanted fluid must be discarded prior to collecting the formation fluid sample. There also must be a method to analyze and determine the nature of the fluid in real time. The MDT tool with the pump-out module, LFA module and the flowline resistivity measurement identifies and collects high-quality reservoir fluid samples suitable for further laboratory analysis.

Flowline resistivity measurements taken by the probe module help discriminate between formation fluids and filtrate from water- and oil-base muds. Equipping the MDT tool with a pump-out module makes it possible to sample fluid, while monitoring the flowline resistivity, by pumping filtrate-contaminated fluid into the mud column. Fluid removed from the formation is excluded from the sample chamber until an uncontaminated sample can be recovered.

MDT Specifications	
Single-probe configuration	
OD	4.75 in. [120.6 mm]
Min hole size	5⅞ in. [149. 2 mm][†]
Max without kits	14.25 in. [361.5 mm]
Max with kits	24 in. [610 mm]
Pressure rating	25,000 psi [17,235 kPa][‡]
Max temperature rating	400°F [205°C][§]
Multiprobe tool configuration	
OD	6.00 in. [152.4 mm]
Min hole size	7.62 in. [193.6 mm]
Max without kit	13.75 in. [336.5 mm]
Max with kit	15.00 in. [381.00 mm]
Max pressure rating	25,000 psi [17,235 kPa]
Max temperature rating	400°F [205°C]
Dual-packer configuration	
OD	5.00 to 10.00 in. [127.0 to 254 mm][††]
Min hole size	5⅞ in. [149.2 mm][††]
Max hole size	14.75 in. [374.6 mm][††]
Pressure rating	25,000 psi [17,235 kPa]
Max temperature rating	325°F [163°C][††]
LFA module	
OD	4.75 in. [120.6 mm]
Length	5.83 ft [1.7 m]
Weight	161 lbm [73 kg]
Range	0 to 5 optical density
Accuracy	0.01 optical density
Pressure rating	25,000 psi [17,236 kPa]
Temperature rating	350°F [176°C]
Pressure gauge specifications	
Strain gauge	
Range	0 to 25,000 psi [0 to 17,236 kPa][‡‡]
Accuracy	0.10% full scale
Repeatability	0.06% full scale
Resolution	0.1 psi [0.689 kPa]
Temperature rating	400°F [205°C][‡‡]
CQG gauge	
Range	0 to 25,000 psi[‡‡]
Accuracy	2.0 psi [13.8 kPa]+ 0.01% of reading
Repeatability	< 1.0 psi
Resolution	0.01 psi
Temperature rating	400°F [205°C][‡‡]

[†] If wellbore conditions are favorable, the tool can be run on TLC in holes with an ID as small as 5½ in. [14 cm].

[‡] 25,000 psi [172.5 mPa] for the high pressure MDT and 20,000 psi [138 mPa] for the normal MDT tool

[§] 350°F [175°C] with some CQG types

[††] Functional rating based on the actual packer installed and type of mud used.

[‡‡] Actual pressure/temperature combination will depend on specific type of gauge. For the CQG, HCQG-A is rated 175°C/25,000 psi, HCQG-B/D 200°C/18,000 psi or 180°C/20,000 psi and CQG-C/G 175°C/15,000 psi.

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