SURFACE LOGGING CAPABILITIES

Reducing geological uncertainty, maximizing drilling efficiency, and enhancing operational safety
GET THE WHOLE PICTURE

Start your drilling project off right with comprehensive knowledge about your wellsite. As an industry leader with more than 50 years of experience in mud logging, Weatherford has a comprehensive toolbox of technologies to build a full map of your field—from lithology to hydrocarbon content to porosity.

Mud Logging Services
Careful analysis of rock cuttings provides essential information about the lithology and hydrocarbon composition of your reservoir, and it helps to determine fluid type. Our mud logging services deliver timely interpretation of relevant drilling information to enhance safety and efficiency.

Advanced Gas Evaluation
As the industry leader in formation-gas analysis, we offer a suite of gas-extraction and gas-detection solutions that enable you to more accurately estimate reservoir fluid properties. Our combination of technology, personnel, analysis, and interpretation delivers high-quality data and insights in both open and closed-loop drilling environments.

Advanced Cuttings Analysis
Our RockWise® services bring advanced, laboratory-based formation evaluation techniques to the wellsite for faster and more informed reservoir decisions. Near real-time organic data, mineralogical analysis, and elemental rock compositions can help to optimize well completions and maximize production.

Wellsite Advisors
Integration of logging-while-drilling (LWD) and surface measurements enable our wellsite advisors to compare results to predrill models, which enhances safety and reduces nonproductive time (NPT). Providing highly qualified pore-pressure and fracture-gradient estimates at the wellsite and remote locations, the advisors perform real-time analysis to help you meet objectives throughout the drilling process.
DRILL WITH CONFIDENCE
Mud Logging Services

Effective mud logging is your first line of defense against unplanned wellsite events that can lead to borehole problems and NPT. Our experienced mud logging teams and quality measurement systems help to maintain safe and reliable operations. Innovative services—including early kick detection, advanced gas extraction/detection, and enhanced cuttings characterization—provide comprehensive drilling analysis to mitigate hazards.

Certified Cabins for Offshore and Onshore Use
Our mud logging units are certified for use in Zone 1 hazardous areas. We offer a range of sizes to accommodate onshore, offshore, and helicopter-lift applications. Standard units include basic mud logging capabilities and a data acquisition system. We can also custom build units for specific rigs and projects for even greater efficiency, comfort, durability, and safety and to accommodate additional offerings such as advanced gas systems, measurement-while-drilling (MWD)/LWD systems, and RockWise services.

Constant Volume Trap
The Weatherford constant volume trap (CVT) takes in mud through a continuous fluid-extraction device and routes it to a high-torque, constant-speed gas trap—a process that eliminates many of the issues associated with legacy gas traps. By reducing mud-volume fluctuation, the CVT delivers more accurate gas readings to enhance hydrocarbon detection and analysis. Two CVTs can be installed in a delta configuration for recycled gas evaluation.

Data Acquisition and Lithological Analysis
Better data enables you to make better operational decisions. At the core of our surface logging systems, we offer a range of highly innovative measurement tools and sensors that help you to build better datasets. Use our surface logging systems with our full support services or as standalone tools to facilitate your independent surface logging operations.

Suite of Gas Detectors
Collecting a representative gas sample is critical to accurate detection. Weatherford specialists help you to choose the optimal gas detection system for your drilling program from our suite of innovative options. We offer flame ionization detectors (FID) and catalytic combustion/thermal conductivity (CC/TCD) total gas detectors, as well as mass spectrometry and TCD gas detectors with two to four columns to enable detecting a variety of gases. We also provide a comprehensive suite of analytical devices to measure mud gas and isotopic compositions. To interpret these measurements, we offer dynamic software—including our internally developed and commercially offered Isologica™ software for geochemical integrated studies—and specialized training.
GAS EXTRACTION
- Constant volume trap
- Heated constant volume trap
- Quantitative gas measurement system
- GC-TRACER® surface gas detector

MUD-GAS COMPOSITION MEASUREMENTS
- Baseline FID 9000 total gas detector
- Anax CC/TCD total gas and CO₂ detector
- C₁ to C₅, C₂ to C₃⁺, BTEX, H₂, N₂, O₂, He, MCH, C₂H₄, and C₃H₆ TCD
- C₁ to C₅ FID

REAL-TIME ISOTOPIC COMPOSITION MEASUREMENT OR COLLECTION
- IsoTech RT® and Pro systems
  - δ¹³C methane, ethane, and propane
- IsoTube® AutoLoader system

INTERPRETATION AND DELIVERABLES
- Isologica software for detailed interpretations of gas samples
- Training and competency through in-house courses for employees and customers
  (Introduction to Mud Logging, Basic Gas Analysis, and Introduction to Pore Pressure)
- Internal technical team training on the integration and interpretation of mud gas
- Enhanced cuttings characterization with various detectors and analyzers
- Petrophysics integrated with advanced gas and rock analysis, when available

Pit-Volume Totalizer
If not properly monitored, an influx of formation fluid into the well can lead to a blowout. The pit-volume totalizer (PVT) provides an early warning of this hazard, which gives the wellsite crew time to take preventive measures. The PVT is equipped with a flowback monitor to detect kicks even when the mud pumps are off, and it is compatible with our electronic drilling recorder (EDR) and WellWizard® software.

In addition to enabling early kick detection, the PVT provides the following well and rig-safety data:
- Mud flow (in and out)
- Multiple mud-pit levels
- Mud weight (in and out)
- Trip tank levels
- Mud temperature (in and out)
- Mud-gas measurements
- Ambient gas, H₂S, and CO₂ measurements
Early Kick Detection
An unmonitored influx of formation fluid into the well can lead to a blowout. Our pressure-volume-temperature system provides an early warning of fluid influxes. By means of sensors and customized software, the system detects kicks and gives the wellsite crew time to take preventative measures.

Drilling-Hazard Mitigation Services
Our drilling optimization and hazard mitigation packages include drillstring-vibration control and hole stability, early kick detection, and advanced pore-pressure monitoring. These services incorporate an advanced data-acquisition system to enhance mud logging. Our fast and reliable early kick detection system improves well safety, reduces NPT, identifies unexpected events, and lowers environmental risk. Our systems can scale up to a full managed pressure drilling (MPD) system with the Microflux® control system.

Enhanced Flow Measurements
For precise monitoring of mud flow, pressure, pump strokes, and pit levels, we offer an advanced system that includes the PVT. By upgrading from the standard paddle-type detector with a sonic, electromagnetic, or Coriolis sensor, you can measure mud volume changes to within a single barrel.
When run in conjunction with the flowback application, our enhanced flow measurement system independently detects and alerts you to abnormal pit volume, flow, pump speed, and pressure for early identification of well anomalies before they become critical. This minimizes issues that can contribute to NPT.

Cuttings Volume Measurements
Especially in highly deviated or extended-reach wells, cuttings can clutter the hole and can lead to a stuck pipe or a lost bottomhole assembly. By measuring the volume of cuttings, we can track the removal of cuttings from the wellbore and monitor hole cleanliness.
Our field-proven system operates where cuttings fall—in the shale shaker area—one of the harshest environments on the rig. The system fits most shakers and can be fully integrated with our WellWizard software. The real-time measurements help to manage wellbore-stability challenges. At service level 1, a data engineer at the rigsite monitors hole cleaning and provides basic reports to the drilling team. At service level 2, a hole cleaning analyst reports on the hole status and makes recommendations to optimize cleaning.

Real-Time Drilling Monitoring
The WellWizard wellsite data hub uses standard industry communication protocols to enable on-site and remote access to your surface logging data. Coupled with our real-time data system, the WellWizard data hub enables you to make field decisions from anywhere in the world. The WellWizard software system also calculates more than 60 engineering and optimization parameters that can be modified to match your needs.
MEASURE WITH GREATER ACCURACY
Advanced Gas Evaluation

Weatherford is an industry leader in extracting and analyzing hydrocarbons entrained in drilling fluid. We offer tiered services ranging from total hydrocarbon gas detection to high-end, wide-spectrum compositional breakdowns and isotopic compositions. Our customizable installation methods enable you to accurately identify produced, liberated, recycled, and contamination gas.

Heated Constant Volume Trap
Our heated constant volume trap (HCVT) regulates the temperature and flow of fluids during mud sampling, which enhances the accuracy of gas readings. The HCVT is especially well suited for wells with extreme mud temperatures caused by high geothermal gradients and deepwater risers. With the highest fluid-sample flow rate in its class, the HCVT delivers timely, reliable data for improved gas analysis. A delta configuration is available to enable recycled gas evaluation.

Quad-Column Gas Chromatograph
The quad-column gas chromatograph cycles every 70 seconds to provide fast analysis and clear separation of gases, such as hydrocarbon compounds C₁ to C₁₀ and nonhydrocarbons carbon dioxide, nitrogen, helium, and oxygen. Using helium and nitrogen as carrier gases, the chromatograph accurately assesses combinations of gases in a single compact unit. The chromatograph is calibrated using Weatherford ChromatWizard software, and data from the chromatograph is displayed using the WellWizard data processor.

Isotech RT® System
The Isotech RT system collects gas samples during drilling and analyzes the isotopic composition of methane. Using separation technologies, the system isolates targeted chemical species from sampled gas while drilling and performs isotopic analysis using cavity ring-down spectroscopy (CRDS). By combining gas detection, collection, and analysis, the Isotech RT system provides an accurate gas dataset for your well.

IsoTube® AutoLoader System
The IsoTube AutoLoader system enables the automatic, mechanized collection of gas samples for compositional and isotopic analysis. Tube-mounted RFID tags store the date, time, coordinated universal time zone, depth, gas concentration, and serial numbers of the tube and device for easy and reliable tracking of samples.

Using an embedded control system, the system offers several triggering options, including independent triggers by time, depth, and total gas percentages. A web-based, WITS-integrated interface enables the user to remotely activate or disable triggers at any time.

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GC-TRACER Surface Gas Detector
The gas chromatograph tool for real-time analysis characterization and evaluation of reservoirs (GC-TRACER) system uses a patented membrane-based technology to extract light and heavy formation gas samples from drilling fluid. The system incorporates a high-speed gas chromatograph to analyze hydrocarbon compounds (C₁ to C₈, benzene, and toluene) and nonhydrocarbons (carbon dioxide and nitrogen) in a 55-second cycle time for each sample. Our experienced analysts then provide detailed interpretations using gas ratios and our dynamic Isologica software. This software platform can provide detailed data interpretations and visualizations. Our services help you determine hydrocarbon fluid types, contact points, and pay zones for effective geosteering.

Mass Spectrometry Detection
In 90 seconds, the mass spectrometer can analyze C₁ to C₁₀ hydrocarbons; BTEX compounds; inorganics, including N₂, Ar, O₂, H₂O, He, H₂, and CO₂; and sulfur-bearing compounds, including SO₂, COS, and CS₂. Using ratio interpretation techniques and Isologica software, our analysts can deliver valuable answers in time to make important decisions regarding your well.

ADVANCED GAS APPLICATIONS
· Identify net pay
· Estimate fluid type
· Identify fluid contacts
· Identify compartmentalization and connectivity
· Estimate seal integrity
· Estimate maturity
· Indicate fluid mobility
Wellbore placement and real-time formation evaluation are increasingly important in the development of hydrocarbon reservoirs. RockWise services use advanced methods to provide an improved understanding of reservoir and rock properties during the drilling process.

**APPLICATIONS**
- Chemostratigraphy and lateral wellbore positioning while drilling
- Identification of casing point/coring point
- Identification and evaluation of organic-rich zones in shale
- Correlation of stratigraphic and chemostratigraphic tops
- Optimization of frac-stage placement in lateral wells

**Organic Geochemical Parameters**
Our Source Rock Analyzer (SRA) delivers accurate data on critical organic parameters, such as total organic carbon (TOC), thermal maturity, free oil content, and source potential. As the first routine pyrolysis instrument for the wellsite, the rugged SRA can be used in active and previously drilled wells for applications such as identifying net pay zones and bypassed pay in a vertical well. The SRA is equally valuable when characterizing horizontal wells to optimize production.

**Elemental Composition**
Well suited for deployment at the wellsite, the energy-dispersive X-ray fluorescence (ED-XRF) instrument provides elemental data to enhance understanding of reservoir stratigraphy and rock properties. In a vertical wellbore, the XRF instrument can establish chemostratigraphic zonation and identify geological markers that serve as input to geosteering lateral wells. The data can also be used to validate rock attributes, such as mineralogy and organic geochemical parameters that have been modeled from core or log data.

**Fourier Transform Infrared Spectroscopy**
Fourier transform infrared spectroscopy (FTIR) is another method for the rapid quantification of formation mineralogy. FTIR can accurately determine clay type and measure total organic carbon in addition to other common sedimentary minerals during drilling.
Pore Pressure
Our pore-pressure specialists provide real-time geopressure analysis and prediction around the clock, and they alert your team to any abnormal conditions. We help you meet your targets while reducing risk, NPT, and operating costs throughout the drilling process. Our data analysis life cycle includes a predrill study, real-time monitoring during drilling, and a post-drill evaluation.

During drilling operations, we provide highly qualified pore-pressure and fracture-gradient (PPFG) estimates. We analyze pressures in real time to identify and mitigate pressure-related hazards. A combination of strong mud logging knowledge, advanced modeling software, and efficient and methodical processes enables us to deliver comprehensive data on schedule.

Monitoring Gas Events
To understand well behavior, our pore-pressure analysts track all gas events and compare them to the PPFG model. The analysts begin by identifying pump-off gas peaks and assessing their validity. Then they examine the behavior of all background gas—including drilling, circulation, and mud—in comparison to the model.

Estimating Pore Pressures from Gas
Determining the relationship between the gas and pore pressure in a well can help to provide estimates of increased pressure while drilling. For insights into these relationships, we observe various indicators:

- Flowback
- Active volume
- Torque and drag trends
- Temperature changes
- Cavings
- Gas ratios
- Total gas with gas ratios

When advantageous, this service can be integrated with other Weatherford service offerings such as the Drilling Advisor solution from Petroleum Consulting and MPD services.

Wellsite Geology
Our experienced team is equipped to give tactical support at the wellsite by providing a geologist to oversee all geological operations. Our experts manage coring, wireline logging, MWD/LWD, and mud logging to provide consistent, high-quality deliverables.

We match you with a team of advisors whose capabilities align with your drilling process to deliver safe, reliable, and efficient well operations.
At Weatherford, we train our mud logging teams to exacting standards to prepare them for any well challenge. We also offer in-house training for our clients to help them understand both the mud logging process and the critical data it can provide.

**Weatherford Mud Logging Specialists Training**
Our specialists must successfully complete rigorous competency-based training to join our team. The mud logging training program begins with hands-on classroom instruction and ends with additional tests at the wellsites. In fact, each mud logger must demonstrate proficiency on three different rigs to earn certification. The program includes courses for basic and advanced mud logging and for specialized tools.

Consistent, validated training equips every Weatherford mud logger to perform to the same high standards around the globe. In addition, better training helps to mitigate hazards and improve data accuracy.

**In-House Customer Training**
Our surface logging group provides industry training for mud logging and hydrocarbon gas evaluation. Compiled and delivered by industry experts, the courses provide in-depth knowledge on the positive impact mud logging can bring to drilling safety, drilling optimization, and formation evaluation. This training provides comprehensive insight into surface logging:

- Understanding drilling operations
- Performing quality control for mud logging services
- Interpreting various logs
- Understanding the importance of pore pressure predictions
Weatherford operates in more than 100 countries and has a network of approximately 1,350 locations, including manufacturing, service, research and development, and training facilities. To experience our surface logging services, visit weatherford.com/surfacelogging.