ABC Analysis
Behind Casing

Evaluate, reevaluate, and monitor reservoirs through casing
The value of analysis behind casing
Since logging its first openhole well in 1927, Schlumberger has used advanced technology to acquire essential reservoir data for the oil and gas industry. Today we can make quality formation evaluation measurements in cased holes. We offer ABC* analysis behind casing services to satisfy three primary industry requirements:

**Obtaining essential well log data under any conditions**—If the well being drilled has, or is expected to have, hole stability problems, operators may want to case the well as soon as it is drilled. Formation evaluation, which until recently had to be performed exclusively in open hole, can now be performed in cased hole.

**Finding and evaluating bypassed pay**—Large amounts of bypassed hydrocarbons exist in old wells. It is considerably more cost effective, and often more environmentally friendly, to explore for those hidden hydrocarbons in old wells rather than to drill new wells.

**Optimizing reservoir management**—Formation evaluation measurements made in representative old wells in a reservoir, whether one time or in a time-lapse mode, can greatly assist in efficient management of the reservoir.

ABC services do not end with optimal data acquisition. Rather, data are processed and interpreted to provide a total solution for efficient operations, enhanced production, and extension of the economic life of an asset.

Multiple services to satisfy multiple objectives
ABC services can provide comprehensive formation evaluation under most conditions. Because they are a suite of services rather than a single platform, measurements can be chosen based on objectives, type of formation, type of completion, borehole environment, lithology, reservoir dynamics, and the availability of primary evaluation data.

Analysis behind casing lets you search for new zones and identify bypassed zones after casing is set. These innovative services measure porosity, resistivity, lithology, shale content, fluid saturations, and pressure; and they enable you to recover formation fluid samples from cased holes.

**Determination of water saturations in many formation conditions**
Accurate determinations of water saturations can be made in a wide range of formation porosities, water salinities, and formation resistivities.

**Formation resistivity through casing**—The CHFR-Plus* Cased Hole Formation Resistivity tool makes direct deep-reading formation resistivity measurements through casing and cement. The concept of measuring resistivity through casing is not new, but it is only recent breakthroughs in downhole electronics and electrode design that have made these challenging measurements possible. Now the same basic measurements can be compared in open and cased holes, thereby eliminating the errors caused by comparing different types of measurements.

**Pulsed neutron measurements**—The RSTPro* Reservoir Saturation Tool makes both formation sigma and carbon/oxygen ratio (COR) measurements. In formations with high formation-water salinity, the sigma measurement has been used for several decades to determine saturations. Now, the COR measurement is providing an accurate means to evaluate formation water saturation in moderate- to high-porosity formations.

The correct measurement technique depends on formation properties, borehole environment, and well completion details, as described in the table on the next page.

Time-lapse formation-water saturation measurements can be used to monitor the performance of a well or reservoir over time.
Reservoir petrophysical evaluation

ABC services allow evaluation of formation petrophysical properties such as formation density, porosity, and acoustic properties in cased wells. This is even more significant in wells where primary evaluation data were lost, were of poor quality, or were never acquired.

In old wells, an operator may want to reevaluate the formation with measurements that were unavailable at the time the well was drilled. ABC services allow the latest formation evaluation technology to be applied in wells that were drilled decades ago. It is no longer necessary to drill new wells in existing fields solely for the purpose of data gathering.

Formation porosity—The CHFP® Cased Hole Formation Porosity service makes accurate formation porosity and sigma measurements in wells that are cased. The CHFP measurement, based on an electronic neutron source instead of a chemical source, uses borehole shielding and focusing to obtain porosity measurements that are affected only minimally by borehole environment, casing standoff, and formation characteristics such as lithology and salinity.

The CNL® Compensated Neutron Log has traditionally been run as a porosity indicator in cased wells. Even though it provides a good estimation of formation porosity in most conditions, the unfocused nature of the CNL log does not allow correction for environmental effects, such as thickness of casing and cement, nor effects due to positions of the tool and casing in the borehole. When the highest possible accuracy is desired, the CHFP service is the measurement of choice.

Formation density—The CHFD® Cased Hole Formation Density service makes accurate formation density measurements in cased wells. The CHFD service, which is based on a chemical gamma ray source and a three-detector measurement system, makes measurements in a wide range of casing and borehole sizes. The three-detector system makes a density measurement corrected for casing and cement thickness.
**Formation acoustics**—The DSI* Dipole Shear Sonic Imager, now coupled with the BestDT* automated sonic waveform processing for best slowness, provides accurate formation compressional and shear slowness measurements in cased wells. The BestDT processing is based on optimally designed frequency filters and advanced signal processing. These significantly attenuate casing arrivals, as seen on the log at right.

**Lithology**—In many complex lithologies and clays, a better understanding of the matrix is necessary to produce a credible fluid analysis. SpectroLith lithology processing of spectra from neutron-induced gamma ray spectroscopy tools is a quantitative, mineral-based lithology interpretation derived from single-tool elemental yields. A modified geochemical oxides-closure model transforms capture yields into elemental concentrations.

An exclusive core database was used to develop the lithology interpretation that converts concentrations to fractions of clay, carbonate, and framework quartz. The SpectroLith service is available with the RSTPro service, which makes a below-tubing and behind-tubing measurement of capture elemental yields.

**Reservoir fluid identification and dynamics**

The CHDT* Cased Hole Dynamics Tester provides a technique for determining formation pressures in old or new cased wells, and it enables efficient, cost-effective fluid sampling without the inherent risks of standard sampling techniques.

The innovative CHDT tool seals against the casing and uses a flexible drill shaft to penetrate through the casing and cement into the formation. It eliminates the use of explosives altogether. Downhole sensors measure formation pressure, pressure transients, and formation fluid resistivity.

Combining the CHDT tool with various modules of the MDT* Modular Formation Dynamics Tester enables enhanced fluid identification, contamination monitoring, and high-quality sampling. After all measurements and samples have been taken, the tool inserts a corrosion-resistant metal plug into the hole drilled in the casing, thereby preserving casing integrity and eliminating the need for costly repair procedures.

Oil and gas companies can use this technology to identify zones with bypassed hydrocarbons and to monitor depletion of reservoirs, effectiveness of water or gas injection, and changes in fluid contacts.
ABC measurements save $40,000 in perforating and testing costs

The lowest section of a Canadian well, through the Elkton formation, could not be logged in open hole because of unstable hole conditions. Further, the upper section of the well, through the Rock Creek formation, had not been fully evaluated in open hole. The operator, Big Horn Resources, decided to evaluate both formations fully in cased hole using ABC services.

The Elkton formation was evaluated using CHFR, CNL, and DSI services. In the Rock Creek formation, the same data were acquired for comparison with existing openhole data, and the CHDT tester was run to determine reservoir pressure and permeability.

ABC logs and analyses confirmed the Elkton formation was dry. In the Rock Creek formation, CHFR data agreed with openhole deep-resistivity measurements, and cased hole DSI and CNL measurements confirmed openhole porosity measurements. The CHDT tester was then used to make pressure measurements to establish a fluid gradient and permeabilities.

Based on ABC measurements of resistivity and porosity, the operator completed the well in the Rock Creek formation. Accurate evaluation through casing saved $40,000 in perforating and testing costs.

ABC services prove a viable alternative to openhole logging in risky wells

The Dorine field in Ecuador poses significant risk and expense to openhole logging operations. Schlumberger acquired ABC density, porosity, and sonic data for an Alberta Energy Corporation well that had been logged in open hole. Open and cased hole data matched closely.

Two wells logged subsequently using ABC services have shown equally good results.

CHFR and CHDT services were run to acquire data in the Elkton and Rock Creek formations that could not be obtained in open hole. CHFR data overlaid deep-reading openhole resistivity, and the CHDT tester acquired formation pressures and fluid samples, allowing the well to be completed successfully in the Rock Creek formation.
Rapid, trouble-free data collection in a high-risk environment

Snorre, a mature field in the Tampen area of the Norwegian North Sea, presents a challenging environment for well construction. Oil is produced from a variety of geologically complex reservoir units through horizontal production wells. Hydrocarbon recovery is maximized through water-alternating-gas (WAG) injection, creating a number of different pressure regimes and further adding to the complexity of producing the field.

Accurate reservoir pressure information is crucial for reservoir modeling to enable Norsk Hydro to manage the field effectively.

Openhole logs had been acquired using memory logging while drilling. The risk of conveying an openhole formation tester on a TLC* Tough Logging Conditions system was deemed to be too great. Acquiring pressure data quickly and accurately was critical. Borehole conditions are known to deteriorate rapidly, sometimes to the degree that casing cannot be run successfully and zonal isolation is suboptimal, so the well was cased and cemented immediately after the drillstring was pulled out of the hole.

A USI* UltraSonic Imager was run to evaluate the quality of the cement bond. A CHDT tester was then conveyed in this highly deviated well on a wireline tractor, pressure measurements were made, and fluid samples were recovered from all the reservoirs.

Norsk Hydro was able to obtain valuable reservoir data, while virtually eliminating the risk associated with conventional openhole formation testing. Particularly important were the pore pressure data on which the completion-fluid weight was based. Without actual pressure measurements, the completion-fluid weight would have been based on the maximum pore pressure prognosis for well control. If the reservoir pressure had been considerably lower than the prognosis, the well would not have flowed, production would have been delayed, and the well would have required an intervention for stimulation operations.

ABC services were run in this North Sea well offshore Norway to complement the initial LWD petrophysical evaluation after conventional openhole formation testing was deemed high risk. The ABC answer product illustrates LWD, CHDT, and USI data in a composite display.