Full Wave Sonic Tool (FWS™)

The FWS™ tool provides compressional wave, refracted shear wave, and Stoneley wave properties of downhole formations for a wide range of petrophysical, geological, and geophysical applications. To minimize the number of logging trips required for complete formation evaluation, the FWS tool is compatible with all DITS™ logging tool strings. A liquid-filled borehole is required for sonic logging, and can be used in fresh-, salt-, or oil-based mud systems.

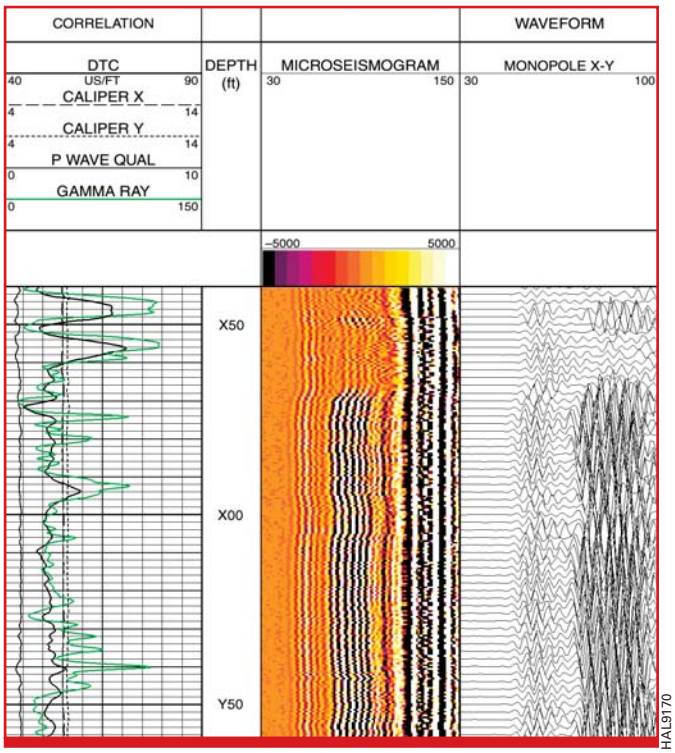
The long transmitter-to-receiver offset allows for the acquisition of borehole sonic data beyond the effects of any near-wellbore altered region. This long offset also allows for the acquisition of high-quality sonic data in enlarged boreholes where critical angle effects would affect sonic tools with short transmitter-to-receiver offsets.

The information obtained from the FWS tool is plotted in three separate log presentations:

- **Slowness Presentation.** Compressional slowness and refracted shear slowness, velocity ratio, and time-depth integration of the compressional and shear travel times, and other logging data such as gamma ray and caliper
- **Quality Presentation.** Indicators which establish confidence levels for the slowness processing, including compressional slowness and semblance coherency and refracted shear and semblance quality gain curves for each receiver
- **Waveform Presentation.** Waveforms from all four receivers can be presented in either X-Y or X-Z (MicroSeismogram™) formats. Gain curves reflecting the gain applied to the waveform by the Automatic Gain Control (AGC) circuit, and correlation curves, including gamma ray and caliper information

The FWS tool can be run in the cased hole environment to obtain sonic properties through casing.

Acoustic coupling of the pipe-to-formation is required for cased hole applications.



The natural gamma ray, X-X caliper, Y-Y caliper, P-wave travel time and P-wave semblance quality are presented in Track 1. The monopole waveform data is presented in Track 2 in the MicroSeismogram™ format (X-Z) and in an X-Y waveform presentation in Track 3.

HLS ASIA LIMITED

HALLIBURTON

FWS Tool Features

The Full Wave Sonic tool contains the following features:

- Advanced system design and software processing with long transmitter-to-receiver offsets and one-foot receiver-to-receiver spacings
- Detection of signals at all receivers for each transmitter pulse ensures constant source characteristics
- Automatic gain control of each receiver preserves signal amplitude
- Downhole digitizing helps eliminate transmission noise and allows broadband frequency response
- Low-frequency response allows detection of low frequency Stoneley waves and multiple Δt measurements per depth interval
- Continuous uninterrupted recording of full waveform signals
- Ability to record various types of information including tool data, quality curves, and final results
- Operator-selectable multiple modes of tool operation, digitally recorded waveform data, and improved porosity estimates using both $\Delta t_c / \Delta t_s$
- Lithology identification by means of velocity ratio, $\Delta t_s / \Delta t_c$ and location of gas zones, even in poor hole conditions and cased holes
- Indication of permeability variations with depth from Stoneley wave attenuation and slowness
- Detection of naturally fractured zones, determination of rock elastic constants, and estimation of formation strength and least horizontal stress
- Prediction of vertical extent of hydraulic fractures

FWS Tool Benefits

The Full Wave Sonic tool offers the following benefits:

- Provides P-wave slowness for petrophysical, geological, and geophysical applications
- Measurements in both open and cased hole, with a potential for deeper investigation
- Long transmitter-to-receiver offset virtually eliminates problems in large boreholes
- Improved vertical resolution for detection of thinner beds (Beds as thin as three inches can be identified with the t curves)
- Accurate amplitude and velocity determinations, and provides reliable data in all types of formations, with more high-quality data
- Simultaneous digitizing of all four receivers after each transmitter pulse helps ensure constant source characterization
- Customer-selectable log presentations and sophisticated processing techniques
- Tool can be configured for operation in different environments and for different applications
- Calculates sonic porosity from P-wave slowness and can determine secondary porosity by combining sonic porosity with neutron and density porosity data
- Time-to-depth correlation for seismic correlation
- Combining sonic slowness data with formation density data is the required input information needed for synthetic seismograms

Full Wave Sonic Tool (FWS™)

Length		Diameter		Maximum Pressure		Maximum Temperature		Weight	
(ft)	(m)	(in)	(mm)	(psi)	(Mpa)	(°F)	(°C)	(lb)	(kg)
28.6	8.7	3.625	92.1	20,000	137.9	350	176.7	460	208.7

HLS ASIA LIMITED

HALLIBURTON