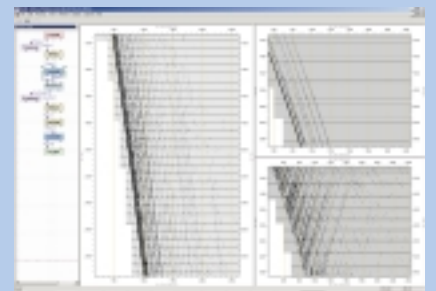


**Schlumberger**



# Efficient Acquisition of Quality Borehole Seismic



The Versatile  
Seismic Imager

## Applications

- Integrated processing for interpretation of borehole- and surface-seismic data
- Images for reservoir definition
- Images ahead of the bit
- Three-dimensional (3D) vertical seismic profiles (VSPs)
- Pore pressure predictions
- Planning for placement of future wells
- Simultaneous surface- and borehole-seismic recording for high-definition images

## Benefits

- Wellsite delivery of answer products for real-time decisions
- Schlumberger answer products with high-fidelity shear and compressional wavefields
- Fast and efficient acquisition

## Features

- Three-component (3C) borehole-seismic data acquisition
- Small sensor package with 3C omnitilt geophone accelerometers
- Excellent signal-to-noise ratio and tube wave rejection on 3C wavefields
- Acoustically isolated sensor package
- Relative bearing measurement on each shuttle
- Configuration using 1 to 20 shuttles
- Shaker in each sensor package
- Shuttle spacing adjustable using standard logging cable
- Integrated wellsite acquisition software for quality control (QC) and field processing
- Combinable with most wireline tools
- Choice of tool conveyance

## Quality, flexibility and speed

The VSI\* Versatile Seismic Imager tool uses Q-Technology\* single-sensor seismic hardware and software and advanced wireline telemetry for efficient data delivery from borehole to the surface. A tool design that focuses on data fidelity and quickly adapts to changing survey needs avoids the compromise in data quality that often results from efficiency limitations. The result is sharper, more accurate images and reduced operating logistics. These elements are fundamental to addressing complex surveys and cost-effectiveness and to delivering timely answer products.

The operating efficiency of the VSI tool is enhanced by

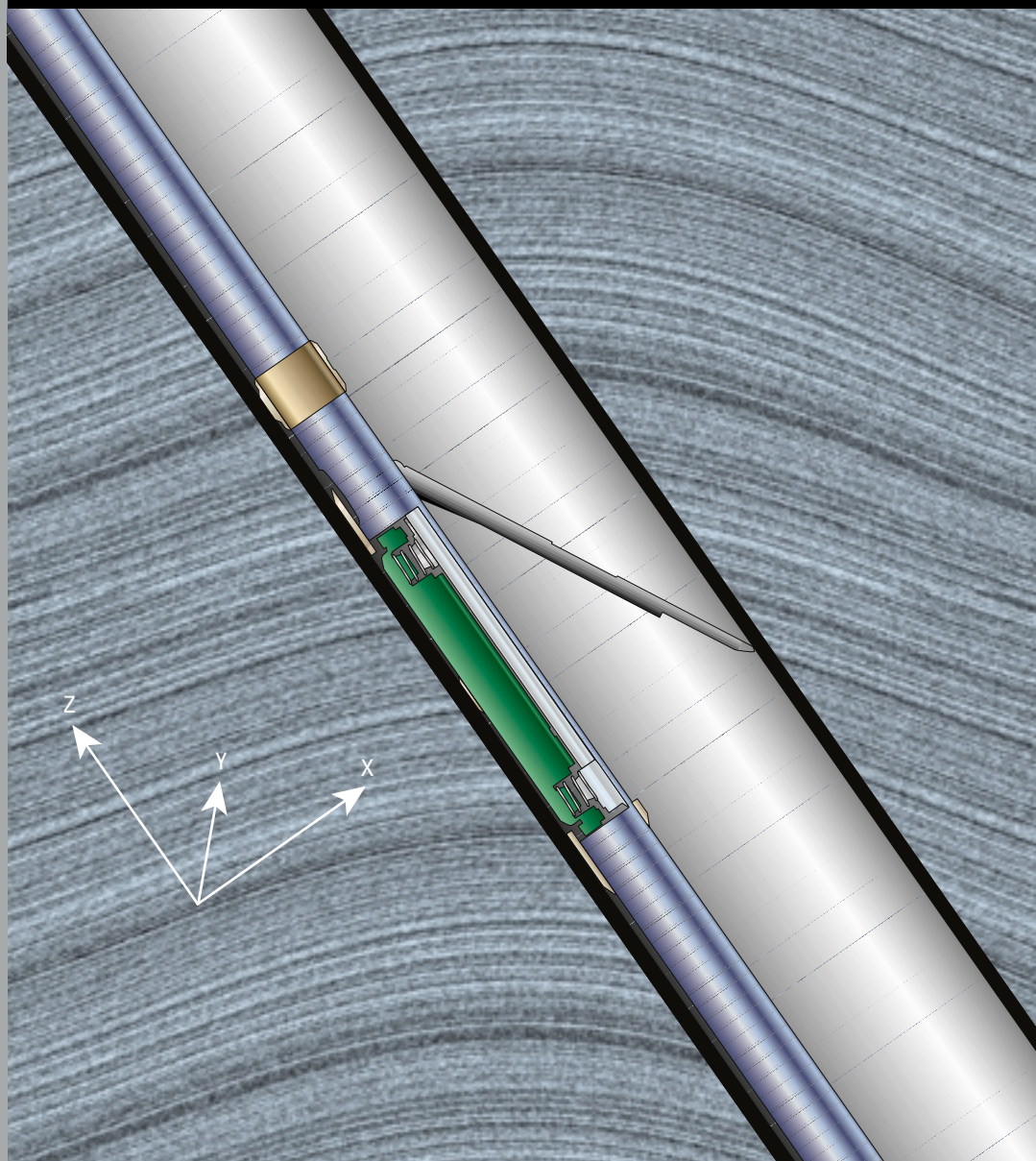
- rapid mechanical deployment
- very little time between stations

- short shot-cycle time during remote-source surveys (walkaways, offset VSPs)
- real-time data processing during acquisition, ensuring delivery of geophysical products when needed.

## Noise reduction by design

The VSI downhole seismic sensor measures particle motion of the formation at the wellbore. Positive anchoring of the sensor, sensor package size and acoustic isolation provide the primary means for removing tool harmonic noise and tube waves from the borehole-seismic band. Further innovation, such as digitization close to the sensor package, helps reduce signal distortion for superior clarity in interpretation answers. The VSI sensor package contains three-axis omnitilt geophone

*The VSI sensor package is decoupled from the main tool body, providing acoustic isolation and noise suppression. The caliper, shown in the extended position, can be used in either openhole or cased wells.*



accelerometers with flat response from 3 to 200 Hz. These provide excellent response within the borehole-seismic band and help with problems such as gimball lockup and the inconsistent axes inherent in conventional geophones mounted on gimbals.

### WAVE processing for QC

WAVE\* field processing encompasses wellsite acquisition, validation and evaluation for borehole seismic. It sets new standards in seismic processing and knowledge management by enabling wellsite delivery of high-quality data and answer products. It also facilitates seamless sharing of data for QC and processing without interrupting the acquisition process.

Advanced WAVE QC helps ensure the quality of answer products, and it optimizes workflow to shorten turn-around time. WAVE field processing and Schlumberger BorSeis\* processing center software share the same algorithm, strengthening confidence in using wellsite answers for crucial decisions.

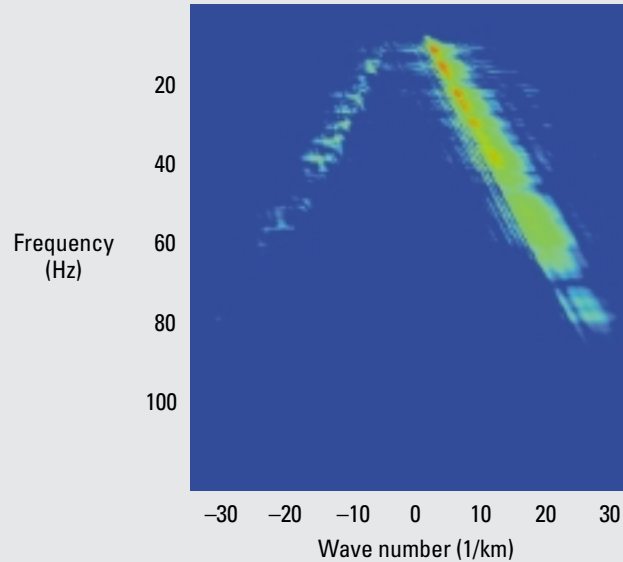
### WAVE borehole seismic reports

A WAVE reporting module enables generation of integrated high-quality geophysical reports with embedded QC plots. These reports are generated automatically during or after acquisition and include

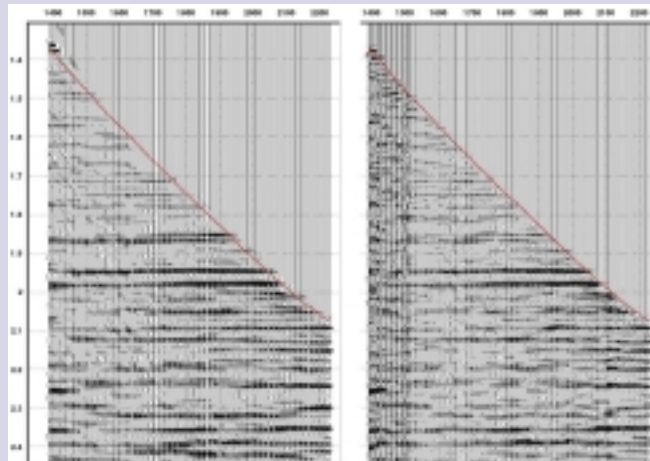
- final geophysical report in any standard printed format
- VSP plot scaled to match any surface seismic scale
- ASCII or bitmap image of transit times
- SEG-Y format file and verification listing
- PDF or bitmap file of VSP wavefields or corridor stack
- 3C polarization and hodograms
- full VSP processing.

The final geophysical report contains all survey-related information, including acquisition geometry, time-depth plots, amplitude plots, raw and processed wavefields, and general QC plots.

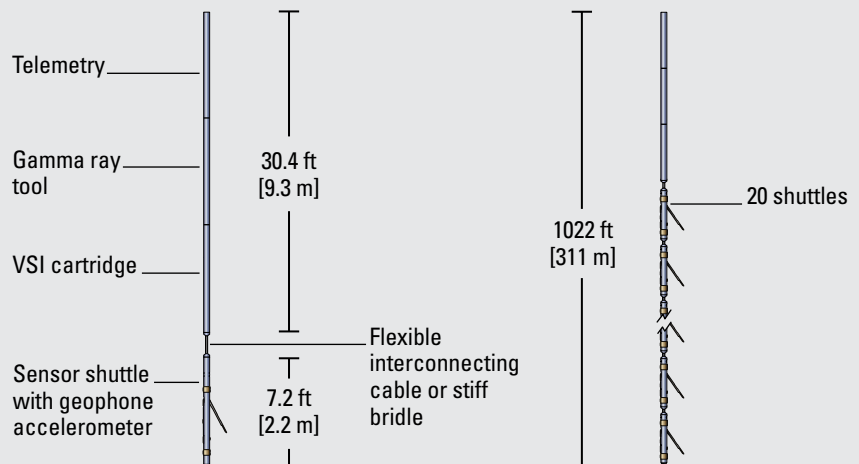
This WAVE QC plot shows excellent data fidelity.



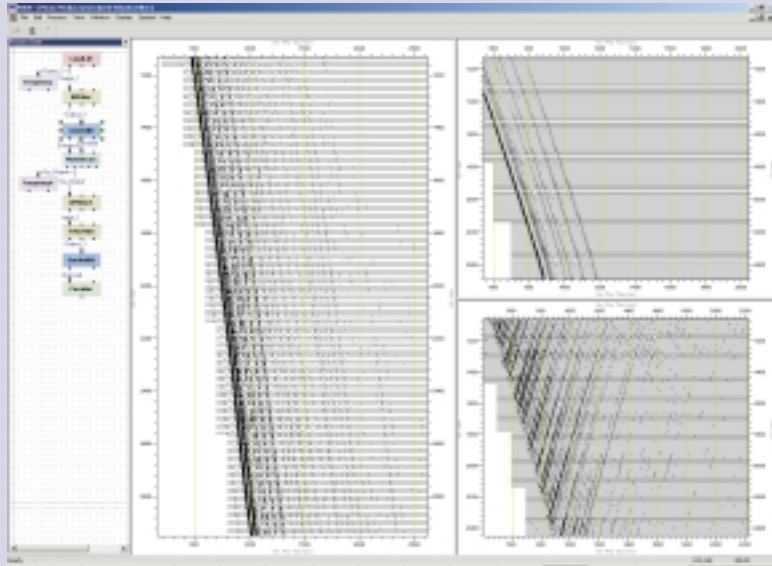
WAVE field processing (right) compares very favorably with the final product from the Schlumberger processing center (left). Field-processed stacks were only run through the WAVE default zero-offset VSP flow. (Data courtesy of Norsk Hydro Norway.)



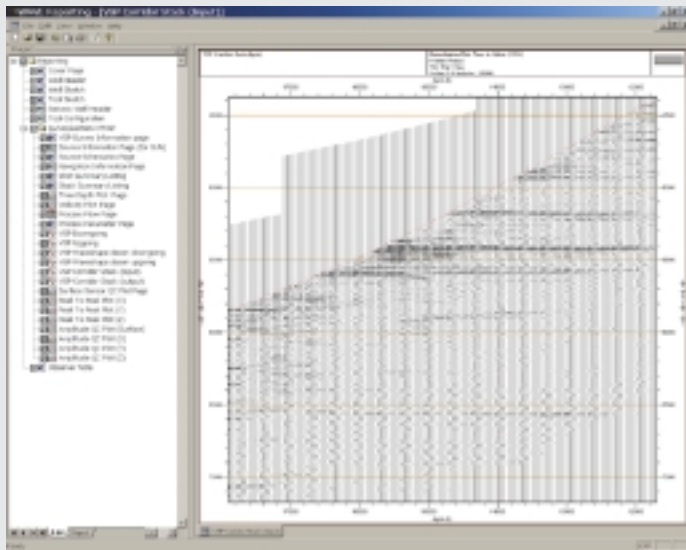
The VSI tool is extremely flexible and is field configurable to meet the survey goals. As many as 20 shuttles can be used to optimize the survey.



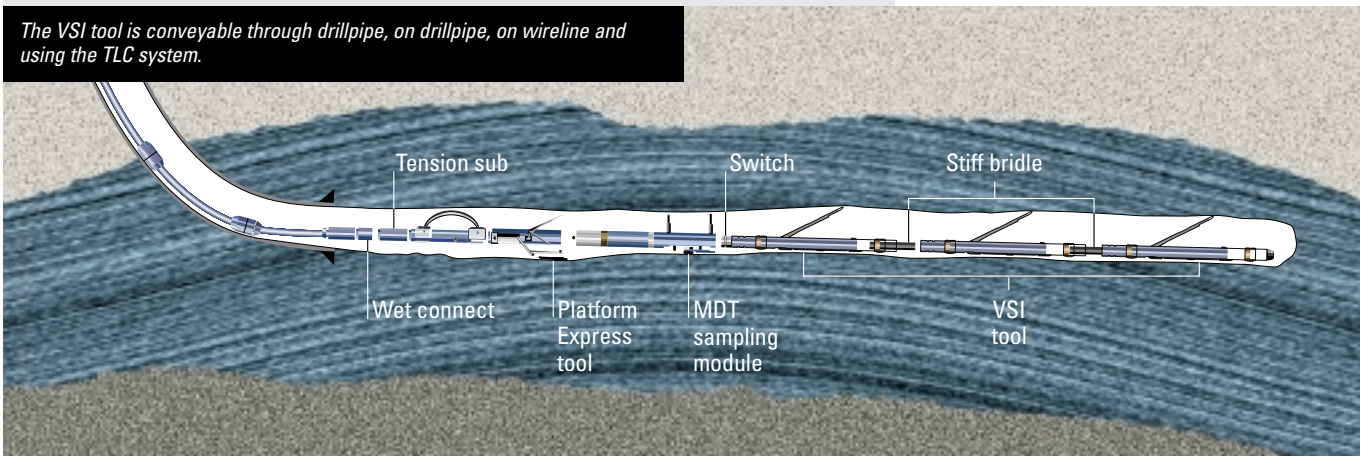
The processing flow of the WAVE interface is highly configurable.



The WAVE reporting module generates a display of the processed wavefield.



The VSI tool is conveyable through drillpipe, on drillpipe, on wireline and using the TLC system.



### Combinability

The decoupled design of the VSI tool enables use of long tool strings without acoustical degradation. As many as 20 VSI tools can be combined to obtain rapid, efficient multilevel seismic surveys.

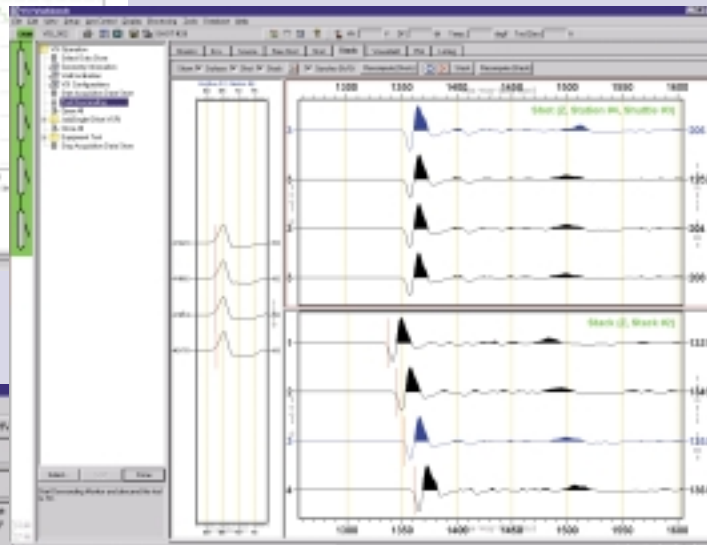
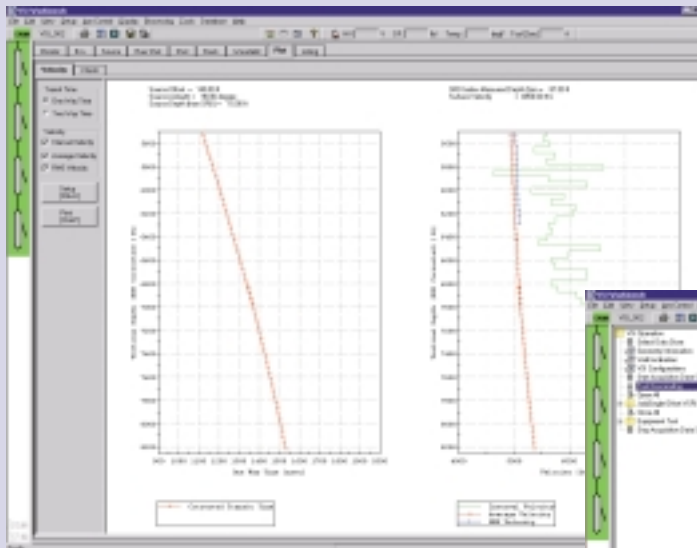
For positioning and correlation measurements, the VSI tool can be combined with a gamma ray tool for accurate depth control, an inclinometry tool for spatial orientation, and various other auxiliary sensor tools. Combinability with other wireline tools such as the MDT\* Modular Formation Dynamics Tester, DSI\* Dipole Shear Sonic Imager and Platform Express\* tools saves time and reduces costs.

### Conveyance

The VSI tool can be conveyed in vertical wells using standard wireline techniques.

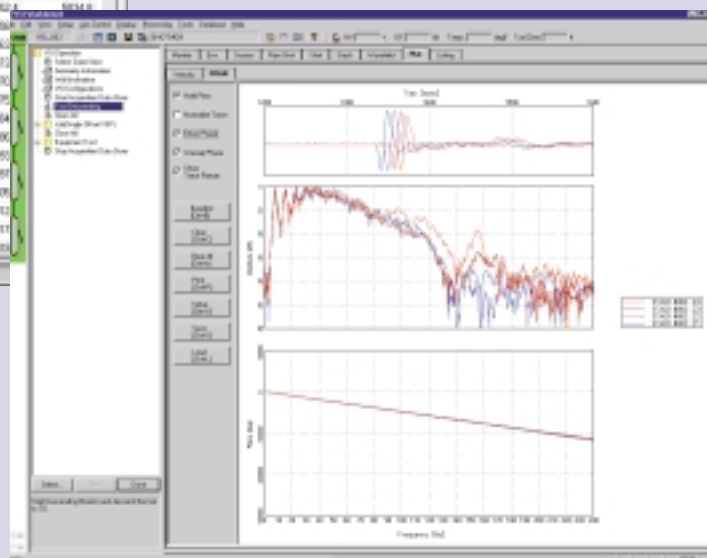
In highly deviated wells, it can be conveyed through drillpipe, with assist from a tractor or using the TLC\* Tough Logging Conditions system.

Data quality is monitored using acquisition QC and interactive data visualization, observer notes, job summary and frequency analysis (shown from top to bottom).



Stack Summary

Stack number	Well depth (ft)	TVD base (ft)	T1 (sec)	T1 (T10 Connected) (sec)	Interval Velocity (ft/s)	Average Velocity (ft/s)
1	4976.1	4999.1	887.1	882.9	22993.8	4924.7
2	5026.7	4989.7	889.3	886.1	17927.8	4983.1
3	5076.3	4980.3	892.1	887.9	1016.8	4986.0
4	5126.9	5007.9	1041.0	1008.8	5487.9	4912.9
5	5176.5	5007.5	1031.9	1037.7	5688.8	4982.7
6	5226.2	5129.2	1046.6	1048.4	5306.5	4986.2
7	5275.8	5166.8	1049.0	1055.7	5947.4	4910.0
8	5325.4	5226.4	1056.9	1064.7	5204.4	4910.2
9	5375.0	5296.0	1066.2	1074.8	5229.7	4921.9
10	5424.6	5356.6	1077.7	1083.9	5089.1	4934.5
11	5474.2	5396.2	1086.5	1092.7	5263.3	4939.5
12	5523.8	5436.8	1096.3	1102.1	5216.1	4931.3
13	5573.4	5486.4	1106.0	1111.6	5003.1	4935.0
14	5623.0	5536.0	1114.6	1120.9	5021.1	4939.0
15	5672.6	5605.6	1123.6	1129.4	5033.1	4943.7
16	5722.2	5655.2	1133.4	1138.2	5089.8	4949.1
17	5771.8	5689.8	1141.7	1147.6	5136.5	4954.2
18	5821.4	5729.4	1150.3	1156.1	5069.7	4959.6
19	5871.0	5769.0	1159.2	1165.0	6086.2	4965.0
20	5920.6	5808.6	1168.3	1174.5	4621.8	4971.0
21	5970.2	5848.2	1177.6	1184.3	5236.2	4977.0
22	6019.8	5887.8	1187.2	1194.2	6222.1	4983.0
23	6069.4	5927.4	1194.0	1199.9	5089.9	4989.0
24	6119.0	6000.1	1203.4	1209.2	5089.9	4995.0
25	6168.6	6075.8	1211.6	1217.6	5071.2	4999.0
26	6218.2	6151.4	1220.5	1226.4	6119.2	4997.0
27	6267.8	6179.0	1229.6	1234.9	6048.7	5000.0
28	6317.4	6254.6	1238.6	1242.7	5148.6	5011.0
29	6367.0	6276.2	1248.0	1251.3	5021.1	5011.0
30	6416.6	6351.8	1254.0	1259.1	5021.1	5011.0



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**VSI Tool Specifications**

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Max number of shuttles	20
Max temperature	300°F [150°C]
Max pressure	20,000 psi [1360 bar], standard; 25,000 psi [1700 bar] for high-pressure version
Tool OD	3 <sup>3</sup> / <sub>8</sub> in. [85.7 mm] standard; 2 <sup>1</sup> / <sub>2</sub> in. [63.5 mm] for slimhole version
Anchoring hole size	3 <sup>1</sup> / <sub>2</sub> –22 in. [88.9–558.8 mm]
Intershuttle spacing	8–40 ft [2.5–20 m]
Sampling rate	1, 2 and 4 ms
Combinability	Gamma ray and casing collar locator, standard; all other wireline tools by special switch
Cartridge length	20.9 ft [6.37 m]
Cartridge OD	2 <sup>1</sup> / <sub>2</sub> in. [63.5 mm]
Shuttle makeup length	6.4 ft [1.96 m]
Cartridge weight	190.8 lbm [86.5 kg]
Shuttle weight	70.6 lbm [32 kg]
Sensor package	Three omnitilt geophone accelerometers; one shaker
Sensitivity	> 0.5 V/G ± 5%
Natural frequency	20 Hz flat bandwidth in acceleration: 2–200 Hz
Dynamic range	> 105 dB (at 36 dB gain)
Distortion	< 0.15%
Digitization	24-bit ADC
Length	11.4 in. [290 mm]
Weight	6.4 lbm [2.9 kg]
Coupling force	63.9 ± 11.0 lbf [284.4 ± 49.0 N]
Coupling force-to-sensor weight ratio	10:1
VSI sonde mechanical strength	
Standard compressive	5,000 lbf [22,241.1 N] standard; 10,000 lbf [44,482.2 N] with TLC stiffener
Standard tensile	18,000 lbf [80,068 N]
VSI cartridge mechanical strength	
Standard compressive	10,000 lbf [44,482.2 N]
Standard tensile	43,000 lbf [191,273.6 N]
Well deviation	No limitation
Stiff bridle spacing	49.61 ft [15.12 m]
Stiff bridle OD	2 <sup>1</sup> / <sub>2</sub> in. [63.5 mm]
Stiff bridle mechanical strength	
Standard compressive	8000 lbf [5585.8 N]
Standard tensile	40,000 lbf [177,928.9 N]

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