



Environmental Field Geophysics

Magnetostrictive Borehole Seismic Source

Need

Seismic imaging using crosswell or three-dimensional surveys is a viable means of providing valuable subsurface characterization and monitoring information. While surface seismic sources can be used for reflection or vertical seismic profiling (VSP) surveys, it is often extremely advantageous to site the seismic source down hole, below the highly attenuating near-surface materials. Several types of borehole seismic sources have been developed, however most are not useful in environmental applications due to limitations in size (too large a diameter), frequency content (range not high enough), wave type (cannot generate significant shear wave energy), or fielding (only useable in cemented wells and/or in water-filled wells). Based on the need for a versatile downhole seismic source, Sandia initiated a program to develop a magnetostrictive seismic source specifically for environmental monitoring and characterization applications.

Description

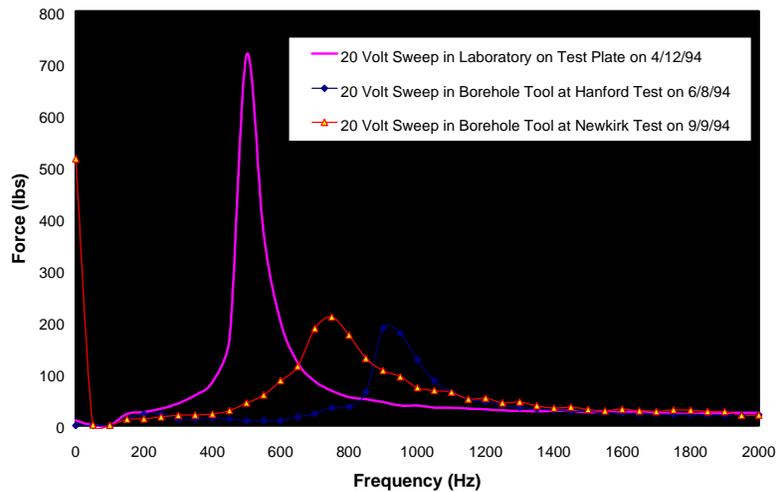
The magnetostrictive seismic source is a clamped, vertical-shear, swept frequency, reaction-mass shaker design consisting of a spring pre-loaded magnetostrictive rod with permanent magnet bias, drive coils to induce an alternating magnetic field, and an integral tungsten reaction mass. Several small commercially available magnetostrictive actuators were tested in order to determine their operating characteristics and establish requirements for the larger actuator needed for the seismic source. A large custom actuator was then fabricated and tested extensively in the laboratory. It was incorporated into an easily deployable clamped downhole tool capable of operating on a standard 7-conductor wireline in borehole environments to 10000' deep and 100°C. The tool is lightweight (50 lbs.), small (24" long), and has a small diameter (4" o.d.). It uses a clamp mechanism that couples it directly to the well casing, permitting the source to operate in dry wells as well as fluid-filled holes. Because the source is not volume expanding, tube-wave generation is minimized. It can be used in either PVC or steel cased wells.



Magnetostrictive seismic source



Actuator Output for 20 Volt Sweep in Laboratory, at Hanford, and at Newkirk



Force output vs. frequency for the source in laboratory and field tests

The magnetostrictive source has a usable frequency spectrum of 150 to 2000 Hz. The completed tool was successfully demonstrated in a crosswell test at a shallow environmental site at Hanford, Washington. The source transmitted signals with a S/N ratio of 10-15 dB from 150-720 Hz between wells spaced 239 feet apart in unconsolidated gravel. The source was also tested successfully in rock at an oil field test site, transmitting signals with a S/N ratio of 5-15 dB over the full sweep spectrum from 150 - 2000 Hz between wells spaced 282 feet apart. The maximum tested depth was 4550' on an 11000' wireline.

Reference

Cutler, R. P., G. E. Sleaf, and R. G. Keefe (1997)., Development of a Magnetostrictive Borehole Seismic Source, SAND97-0944, Sandia National Laboratories, Albuquerque, NM.

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