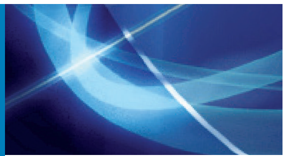
CROSSHOLE SONIC LOGGING



Crosshole Sonic Logging (CSL) Data Examples

Analyses to evaluate the integrity of the concrete include measurement of wave travel times between the source and receiver, calculation of corresponding wave velocities, and measuring receiver response energies. Longer travel times and corresponding slower velocities are indicative of irregularities in the concrete between the tubes, provided good bonding is present between the tubes and concrete.

The complete loss of signal is indicative of a significant defect in the concrete between one or more tube pair combinations. Desirable results show consistent pulse arrival times with corresponding wave velocities that are reasonable for concrete. In addition the energy plot should show relatively high energy with consistent values throughout the shaft. Figure 1 shows an example of data in a sound shaft with no defects.

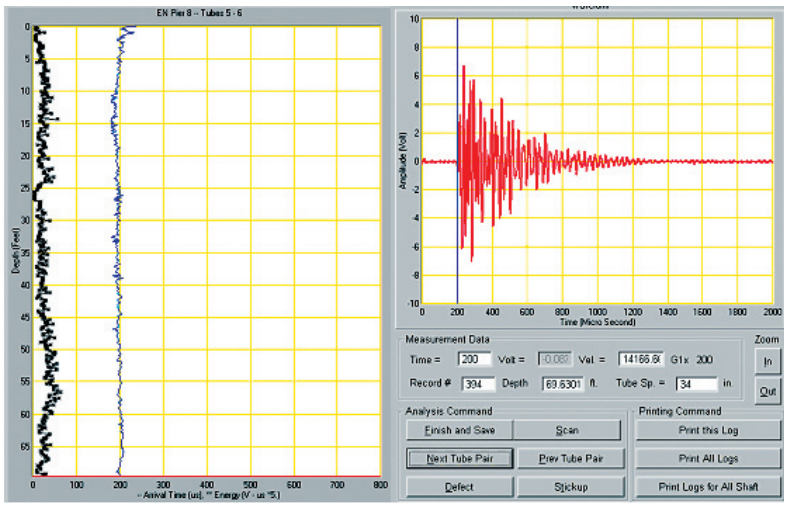


Figure 1. CSL results in a sound shaft

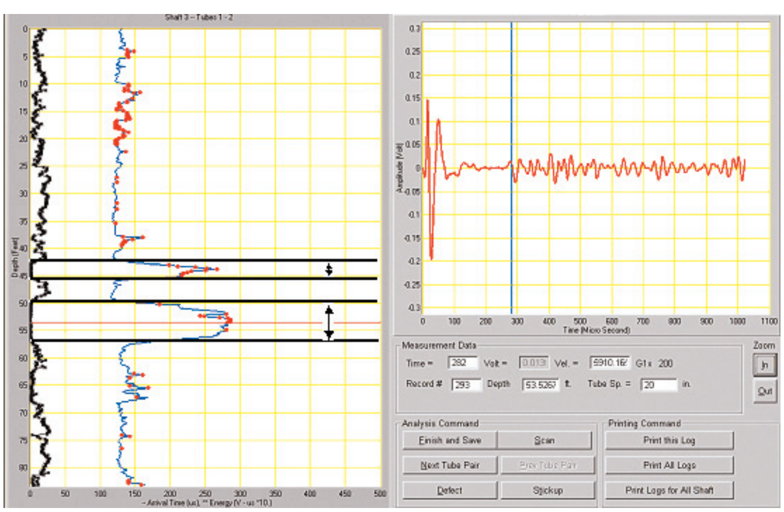


Figure 2. CSL results in a shaft with two defect zones

Defects such as contaminated, weak concrete and soil intrusions will result in delayed arrivals (slower velocity) or no arrivals in the defect zone. The signal energy is a secondary indicator of concrete quality with low energy indicating poorer quality concrete. Figure 2 shows an example of a shaft with 2 defect zones.

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A soft bottom defect occurs when the base of the concrete shaft is not poured properly allowing for intrusions of soil and/or water. An example is shown in Figure 3 where the soft bottom is characterized by slower velocities and low energy.

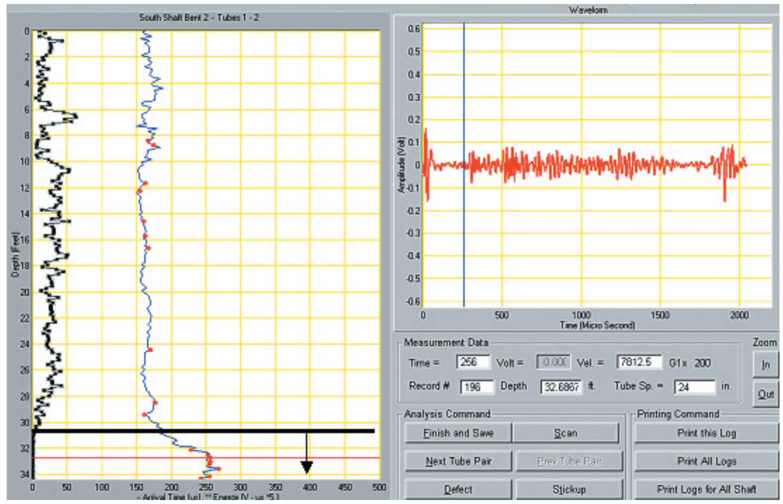

Figure 3. CSL data for a soft bottom defect

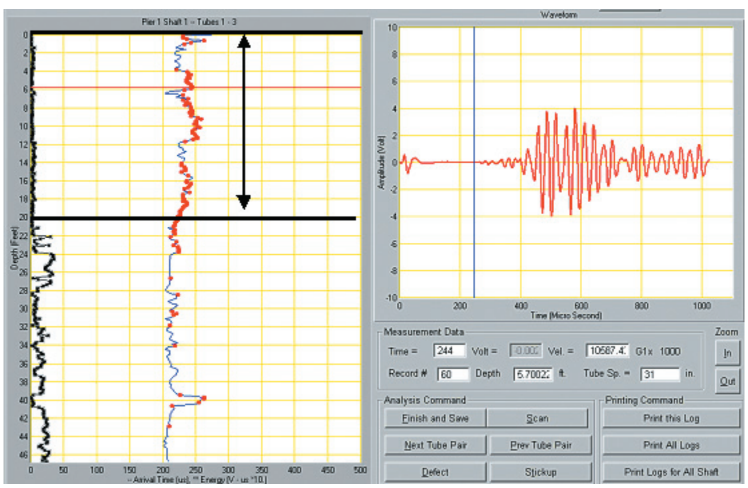

Figure 4. CSL data with debonding to a depth of 20ft

Debonding conditions between tubes and concrete can sometimes occur in a shaft. Tube debonding conditions can be due to various causes. The most common cause of tube debonding is initial tube expansion during the curing process due to heat from concrete hydration followed by contraction of the tube as the concrete cools. Tube debonding conditions are more common in PVC tubes than steel tubes because plastic is much more thermally expansive than steel or concrete. Figure 4 shows an example of CSL data in a shaft with debonding down to a depth of 20 ft. Debonding may be identified by low energy and erratic variation in pulse arrival times over short distances.

The quality of CSL log data is limited by the quality of the waveform. CSL data depends upon an accurate pick of the pulse arrival time, which thereby produces an accurate velocity estimation. High quality waveforms are characterized by a flat period with no incoming signal or noise, followed by a distinct spike in amplitude. This spike denotes the pulse arrival at the receiver. An example of a waveform with a distinct pulse arrival is shown in Figure 5.

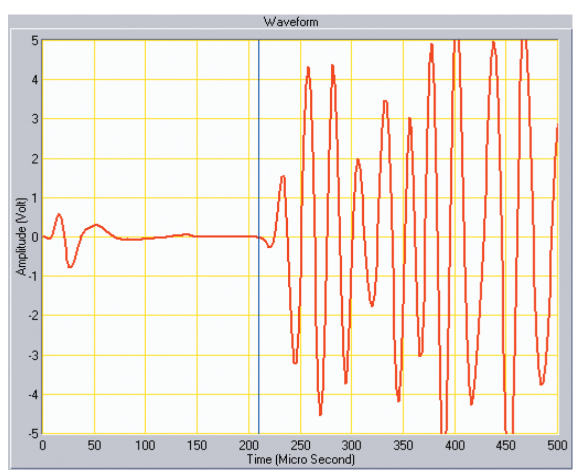

Figure 5. A waveform with a distinct pulse arrival shown by the vertical blue line