



Standard Test Methods for Crosshole Seismic Testing¹

This standard is issued under the fixed designation D 4428/D 4428M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope *

1.1 These test methods are limited to the determination of horizontally traveling compression (P) and shear (S) seismic waves at test sites consisting primarily of soil materials (as opposed to rock). A preferred test method intended for use on critical projects where the highest quality data must be obtained is included. Also included is an optional method intended for use on projects which do not require measurements of a high degree of precision.

1.2 Various applications of the data will be addressed and acceptable interpretation procedures and equipment, such as seismic sources, receivers, and recording systems will be discussed. Other items addressed include borehole spacing, drilling, casing, grouting, deviation surveys, and actual test conduct. Data reduction and interpretation is limited to the identification of various seismic wave types, apparent velocity relation to true velocity, example computations, effective borehole spacing, use of Snell's law of refraction, assumptions, and computer programs.

1.3 It is important to note that more than one acceptable device can be used to generate a high-quality P wave or S wave, or both. Further, several types of commercially available receivers and recording systems can also be used to conduct an acceptable crosshole survey. Consequently, these test methods primarily concern the actual test procedure, data interpretation, and specifications for equipment which will yield uniform test results.

1.4 The values stated in either SI units or inch-pound units are to be regarded as standard. Within the text, the inch-pound units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

¹ These test methods are under the jurisdiction of ASTM Committee D18 on Soil and Rock and are the direct responsibility of Subcommittee D18.09 on Dynamic Properties of Soils.

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2. Significance and Use

2.1 The seismic crosshole method provides a designer with information pertinent to the seismic wave velocities of the materials in question (1).² This data may be used as input into static/dynamic analyses, as a means for computing shear modulus, Young's modulus, and Poisson's ratio, or simply for the determination of anomalies that might exist between boreholes.

2.2 Fundamental assumptions inherent in the test methods are as follows:

2.2.1 Horizontal layering is assumed.

2.2.2 Snell's laws of refraction will apply. If Snell's laws of refraction are not applied, velocities obtained will be unreliable.

3. Apparatus

3.1 The basic data acquisition system consists of the following:

3.1.1 *Energy Sources*—These energy sources are chosen according to the needs of the survey, the primary consideration being whether P -wave or S -wave velocities are to be determined. The source should be rich in the type of energy required, that is, to produce good P -wave data, the energy source must transmit adequate energy to the medium in compression or volume change. Impulsive sources, such as explosives, hammers, or air guns, are all acceptable P -wave generators. To produce an identifiable S wave, the source should transmit energy to the ground primarily by directionalized distortion. For good S waves, energy sources must be repeatable and, although not mandatory, reversible. The S -wave source must be capable of producing an S -wave train with an amplitude at least twice that of the P -wave train. Fig. 1 and Fig. 2 show examples of impulse and vibratory seismic sources.

3.1.2 *Receivers*—The receivers intended for use in the crosshole test shall be transducers having appropriate frequency and sensitivity characteristics to determine the seismic wave train arrival. Typical examples include geophones and accelerometers. The frequency response of the transducer must not vary more than 5 % over a range of frequencies from $\frac{1}{2}$ to

² The boldface numbers in parentheses refer to the list of references at the end of this standard.

*A Summary of Changes section appears at the end of this standard.