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5.5 ULTRASONIC TESTING

5.5.1 Introduction

Ultrasonic Testing (UT) is used to evaluate the internal (volumetric) condition of materials. Specifically, it is used to confirm suspected discontinuities or cracks, as well as check questionable material thicknesses or lengths. Typical discontinuities, which are detectable by use of UT, include laminations, surface cracks, and many surface and subsurface weld related discontinuities (lack of fusion, porosity, etc).

The use of sound to determine the internal properties of a member is not new; audible sound has been used as a nondestructive method for centuries. For instance, striking a porcelain bowl to listen for either a ring or dull tone is an old way to detect a crack. Today, shear stud connectors used for composite bridge beams are still crudely tested by striking them with a hammer and listening to the change in ringing note.

With Ultrasonic Testing, the transducer can be thought of as replacing both the hammer and ear. The transducer directs a wave of high frequency vibrations, inaudible to the human ear, into the test specimen and then receives the returning echoes. The ultrasonic instrument provides the necessary electronics to produce these waves and display the returning echoes for interpretation.

A transducer is a device that is capable of converting energy from one form to another. In the case of UT, electrical energy is changed to mechanical energy and vice versa. Ultrasonic testing transducers convert electrical energy into mechanical vibrations, which in turn produce high frequency sound waves. They also convert high frequency sound back into electrical energy upon receiving the return echoes.

The most common ultrasonic technique currently in use in the United States is called pulse echo. The pulse echo method employs short bursts, or pulses, of waves, which are transmitted into the specimen by the transducer which must be in integral contact with the specimen. This is typically accomplished through the use of a substance called coupling gel. Any returning unexpected echo from these pulses is evaluated for the determination of reflector location and size.

With pulse echo, a single transducer can be utilized as both the emitter and receiver. This type is commonly used in steel inspection applications. Another method utilizes two transducers. One acts as the emitter and the second, located very close to the emitter, acts solely as the receiver. This method is called “pitch-catch” and is more commonly used in the evaluation of other materials such as concrete.

The signal height or amplitude is related to the amount of reflected sound energy. Large reflectors, causing total reflection of sound, produce signal responses of higher amplitude than smaller reflectors, which only reflect a portion of sound energy. Larger return echo amplitudes suggest larger sized flaws. Echo indications are normally retested from another position to confirm flaw size and position. Refer to Figure 5.5.1-1 for an illustration of pulse echo ultrasonic testing.

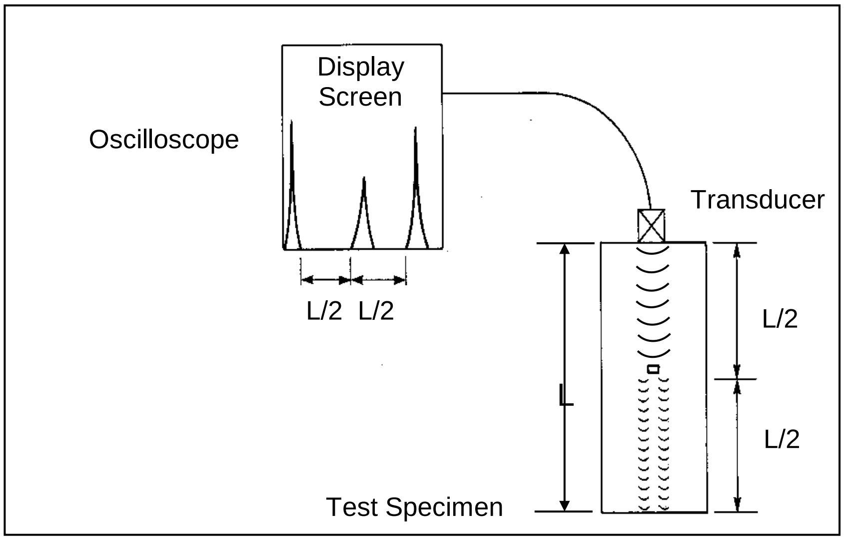

Figure 5.5.1-1: Illustration of Pulse Echo Ultrasonic Testing.

Basic ultrasonic pulse echo systems include the following functions:

1. Power Supply
2. Pulser
3. Receiver/Amplifier
4. Oscilloscope (Cathode Ray Tube) (CRT)
5. Timer (Clock)
6. Transducer

Power for the testing equipment is supplied by portable battery packs or by an external AC source. The pulser, also called the pulse generator, produces the short duration burst of voltage, which is applied to the transducer. The rate of these voltage bursts is controlled by a clock or timer. Sound echoes returning to the transducer are relayed to the receiver, amplified, filtered and sent to the cathode ray tube for display on the screen. Pulse echo methods include compression, shear, and surface wave modes.

1. Compression Wave Testing, (also called straight beam testing), is used for flaw detection, particularly laminations, and for thickness measuring. It directs waves into the material perpendicular to the specimen's surface. Refer to Figure 5.5.1-2 for a schematic of the Compression Wave mode.

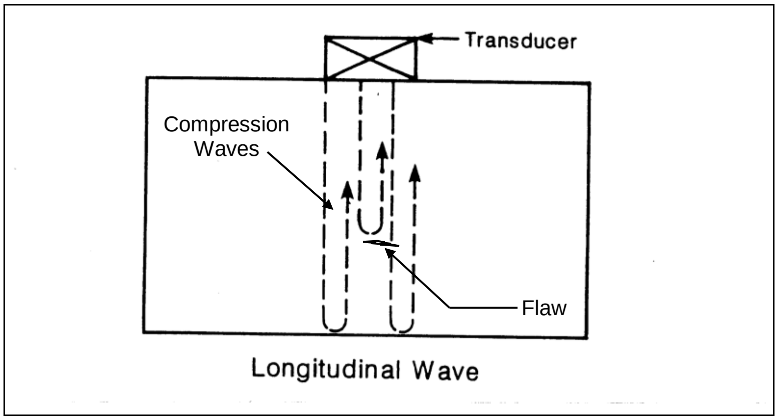

Figure 5.5.1-2: Pulse Echo UT Compression Wave Schematic.

2. Shear Wave Testing, (also called angle beam testing), is ideally suited for weld testing. Waves are directed into the material at an angle other than 90 degrees to the specimen surface. The shorter wavelength (lower velocity) increases sensitivity, and angular capability allows for weld examination at predetermined angles. Refer to Figure 5.5.1-3 for a schematic of the Shear Wave mode.

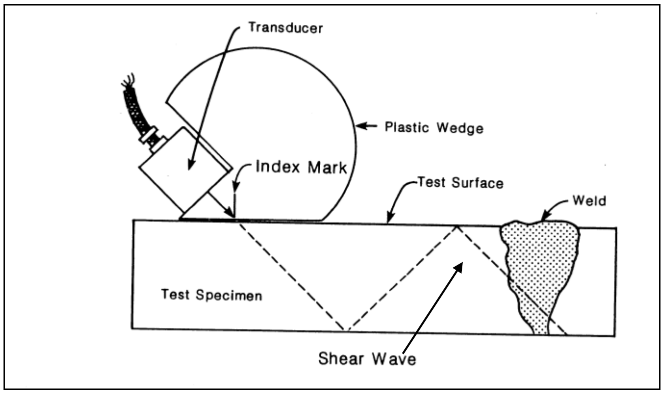

Figure 5.5.1-3: Pulse Echo UT Shear Wave Schematic.

3. Phased Array Testing is an advanced ultrasonic method that uses several elements within a single transducer to "steer" the stress beam. Phased Array combines both straight and angled beam testing by emitting a stress beam at several angles from one location. The stress beam covers a much larger area and allows the inspector to view an internal defect from more perspectives through the use of different displays. Phased array provides better volumetric coverage and is especially advantageous for weld inspections. Phased Array is typically used in steel inspection however there is technology used in concrete inspection that performs similarly.

A variety American Society for Testing and Materials (ASTM) Standards cover ultrasonic testing methods dependent on the material and type of structural component. American Welding Society (AWS) Standards cover ultrasonic testing of welds.

5.5.2 Applications

Perhaps the most advantageous aspect of Ultrasonic Testing (UT) is its ability to examine the internal structure of a material when accessibility is limited to one side. It is an ideal method for the detection of flaws, which are generally not readily detectable by visual means. Because of the basic characteristics of UT, it is used to inspect a variety of both metallic and nonmetallic members such as welds, forgings, castings, plastics, ceramics, concrete, steel sheeting, aluminum tubing, fiberglass, timber, etc. Since UT is capable of economically revealing subsurface discontinuities (variation in material composition) in a variety of dissimilar materials, it is an extremely effective and useful tool. Furthermore, relatively thick specimens can also be examined. Used on bridge decks, slabs, and foundations, UT results are definitive for both bare and covered concrete decks. Penetration of asphalt thicknesses of up to 6 inches has been quite successful. Used on caissons and piles, the length and integrity of piles and caissons can be determined. Ultrasonic tests on concrete, wood, and steel piles have been generally successful to lengths of 100 inches.

UT is most successful for detecting discontinuities, which are oriented perpendicular to the direction of the propagating stress beam. It is also often used as a complimentary method to other nondestructive evaluation (NDE) procedures such as radiography.

The method is readily adaptable to field testing, as portable lightweight units containing a rechargeable battery having a typical 8-hour battery life. Refer to Figure 5.5.2-1 for a view of an inspector conducting UT in the field.

Figure 5.5.2-1: Inspector Conducting UT on a Sign Structure Anchor Bolt.

5.5.3 Limitations

Ultrasonic testing (UT) should not be performed on rough surfaces, on parts with complicated geometries, on highly attenuated materials, or where the discontinuity size is expected to be smaller than one half of the wavelength. Rough surfaces may require grinding in the surface preparation. Other factors, which limit the successful application of UT are: lack of properly trained personnel, over estimation of the accuracy of flaw locating and sizing, and poorly written testing procedures. Typically a certified Level III nondestructive evaluation (NDE) specialist should evaluate and develop written testing procedures for uncommon applications.

Furthermore, it is important that the UT equipment be calibrated prior to each use.

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