Designation: E 797 – 95

An American National Standard

Standard Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method[1]

This standard is issued under the fixed designation E 797; 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 This practice[2] provides guidelines for measuring the thickness of materials using the contact pulse-echo method at temperatures not to exceed 200°F (93°C).

1.2 This practice is applicable to any material in which ultrasonic waves will propagate at a constant velocity throughout the part, and from which back reflections can be obtained and resolved.

1.3 The values stated in either inch-pound or SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.4 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*

E 317 Practice for Evaluating Performance Characteristics of Ultrasonic Pulse-Echo Testing Systems Without the Use of Electronic Measurement Instruments[3]

E 494 Practice for Measuring Ultrasonic Velocity in Materials[3]

E 1316 Terminology for Nondestructive Examinations[3]

2.2 *ASNT Document:*

Nondestructive Testing Handbook, 2nd Edition, Vol 7[4]

3. Terminology

3.1 *Definitions*—For definitions of terms used in this practice, refer to Terminology E 1316.

4. Summary of Practice

4.1 Thickness (T), when measured by the pulse-echo ultrasonic method, is a product of the velocity of sound in the material and one half the transit time (round trip) through the material.

$$T = \frac{Vt}{2}$$

where:
T = thickness,
V = velocity, and
t = transit time.

4.2 The pulse-echo ultrasonic instrument measures the transit time of the ultrasonic pulse through the part.

4.3 The velocity in the material under test is a function of the physical properties of the material. It is usually assumed to be a constant for a given class of materials. Its approximate value can be obtained from Table X3.1 in Practice E 494 or from the *Nondestructive Testing Handbook*, or it can be determined empirically.

4.4 One or more reference blocks are required having known velocity, or of the same material to be tested, and having thicknesses accurately measured and in the range of thicknesses to be measured. It is generally desirable that the thicknesses be "round numbers" rather than miscellaneous odd values. One block should have a thickness value near the maximum of the range of interest and another block near the minimum thickness.

4.5 The display element (CRT (cathode ray tube), meter, or digital display) of the instrument must be adjusted to present convenient values of thickness dependent on the range being used. The control for this function may have different names on different instruments, including *range*, *sweep*, *material calibrate*, or *velocity*.

4.6 The timing circuits in different instruments use various conversion schemes. A common method is the so-called time/analog conversion in which the time measured by the instrument is converted into a proportional dc voltage which is then applied to the readout device. Another technique uses a very high-frequency oscillator that is modulated or gated by the appropriate echo indications, the output being used either directly to suitable digital readouts or converted to a voltage for other presentation. A relationship of transit time versus thickness is shown graphically in Fig. 1.

5. Significance and Use

5.1 The techniques described provide indirect measurement

[1] This practice is under the jurisdiction of ASTM Committee E-7 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.06 on Ultrasonic Testing Procedure.

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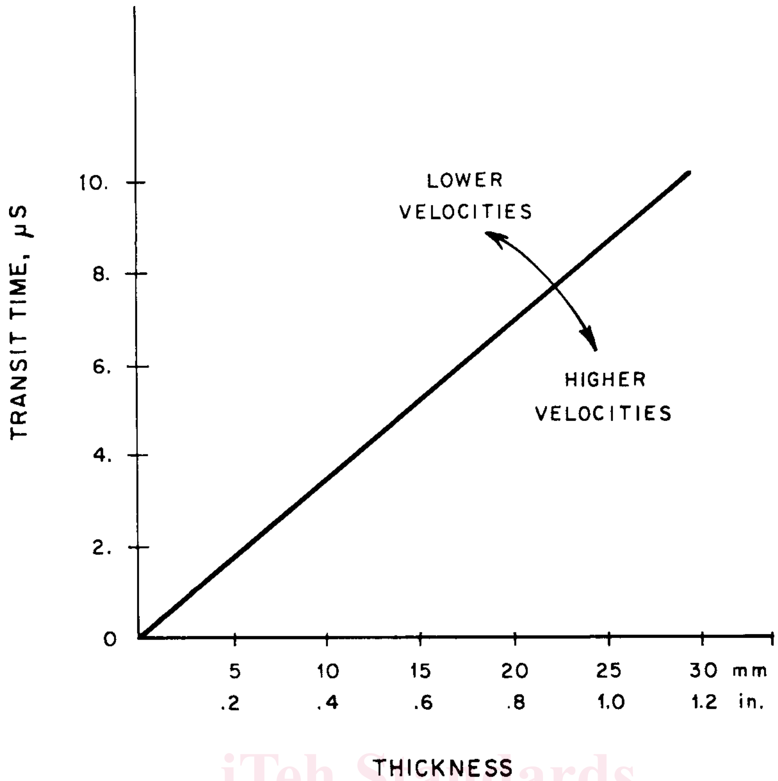
[2] For ASME Boiler and Pressure Vessel Code applications, see related Practice SE-797 in Section II of that Code.

[3] *Annual Book of ASTM Standards*, Vol 03.03.

[4] Available from the American Society for Nondestructive Testing, 1711 Arlingate Plaza, Columbus, OH 43228.



NOTE 1—Slope of velocity conversion line is approximately that of steel.

FIG. 1 Transit Time/Thickness Relationship

of thickness of sections of materials not exceeding temperatures of 200°F (93°C). Measurements are made from one side of the object, without requiring access to the rear surface.

5.2 Ultrasonic thickness measurements are used extensively on basic shapes and products of many materials, on precision machined parts, and to determine wall thinning in process equipment caused by corrosion and erosion.

5.3 Recommendations for determining the capabilities and limitations of ultrasonic thickness gages for specific applications can be found in the cited references.[5,6]

6. Apparatus

6.1 *Instruments*—Thickness-measurement instruments are divided into three groups: (*1*) Flaw detectors with CRT readout, (*2*) Flaw detectors with CRT and direct thickness readout, and (*3*) Direct thickness readout.

6.1.1 Flaw detectors with CRT readouts display time/amplitude information in an A-scan presentation. Thickness determinations are made by reading the distance between the zero-corrected initial pulse and first-returned echo (back reflection), or between multiple-back reflection echoes, on a calibrated base line of a CRT. The base line of the CRT should be adjusted for the desired thickness increments.

6.1.2 Flaw detectors with numeric readout are a combination pulse ultrasound flaw detection instrument with a CRT and additional circuitry that provides digital thickness information. The material thickness can be electronically measured and presented on a digital readout. The CRT provides a check on the validity of the electronic measurement by revealing measurement variables, such as internal discontinuities, or echo-strength variations, which might result in inaccurate readings.

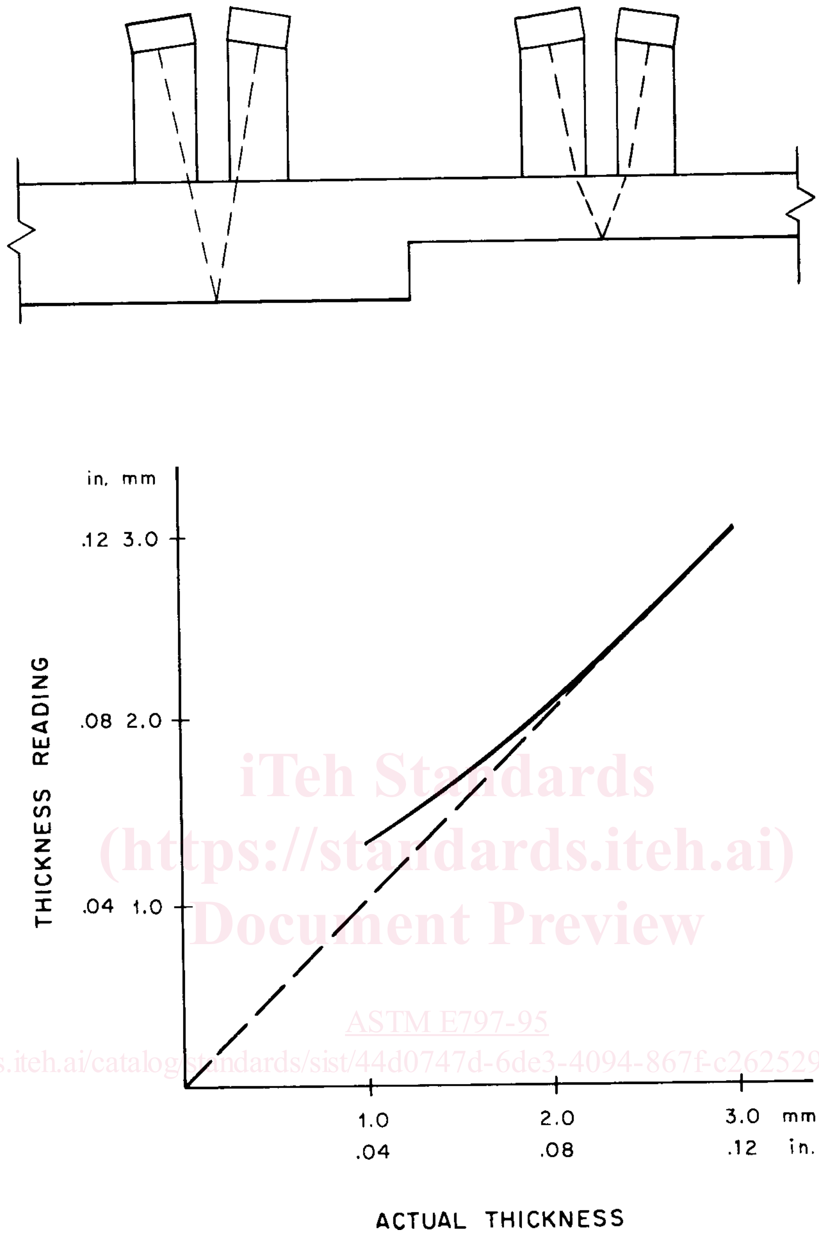
6.1.3 Thickness readout instruments are modified versions of the pulse-echo instrument. The elapsed time between the initial pulse and the first echo or between multiple echoes is converted into a meter or digital readout. The instruments are designed for measurement and direct numerical readout of specific ranges of thickness and materials.

6.2 *Search Units*—Most pulse-echo type search units (straight-beam contact, delay line, and dual element) are applicable if flaw detector instruments are used. If a thickness readout instrument has the capability to read thin sections, a highly damped, high-frequency search unit is generally used. High-frequency (10 MHz or higher) delay line search units are generally required for thicknesses less than about 0.6 mm (0.025 in.). Measurements of materials at high temperatures require search units specially designed for the application. When dual element search units are used, their inherent nonlinearity usually requires special corrections for thin sections. (See Fig. 2.) For optimum performance, it is often necessary that the instrument and search units be matched.

6.3 *Calibration Blocks*—The general requirements for appropriate calibration blocks are given in 4.4, 7.1.3, 7.2.2.1,

[5] Bosselaar, H., and Goosens, J.C.J., "Method to Evaluate Direct-Reading Ultrasonic Pulse-Echo Thickness Meters," *Materials Evaluation*, March 1971, pp. 45–50.

[6] Fowler, K.A., Elfbaum, G.M., Husarek, V., and Castel, J., "Applications of Precision Ultrasonic Thickness Gaging," *Proceedings of the Eighth World Conference on Nondestructive Testing*, Cannes, France, Sept. 6–11, 1976, Paper 3F.5.



(*a*) Proportional sound path increases with decrease in thickness.

(*b*) Typical reading error values

FIG. 2 Dual Transducer Nonlinearity

7.3.2, and 7.4.3. Multi-step blocks that may be useful for these calibration procedures are described in Appendix X1 (Figs. X1.1 and X1.2).

7. Procedure—Calibration and Adjustment of Apparatus

7.1 *Case I—Direct Contact, Single-Element Search Unit*:

7.1.1 *Conditions*—The display start is synchronized to the initial pulse. All display elements are linear. Full thickness is displayed on CRT.

7.1.2 Under these conditions, we can assume that the velocity conversion line effectively pivots about the origin (Fig. 1). It may be necessary to subtract the wear-plate time, requiring minor use of delay control. It is recommended that test blocks providing a minimum of two thicknesses that span the thickness range be used to check the full-range accuracy.

7.1.3 Place the search unit on a test block of known thickness with suitable couplant and adjust the instrument controls (material calibrate, range, sweep, or velocity) until the display presents the appropriate thickness reading.

7.1.4 The readings should then be checked and adjusted on test blocks with thickness of lesser value to improve the overall accuracy of the system.

7.2 *Case II—Delay Line Single-Element Search Unit*:

7.2.1 *Conditions*—When using this search unit, it is necessary that the equipment be capable of correcting for the time during which the sound passes through the delay line so that the end of the delay can be made to coincide with zero thickness. This requires a so-called "delay" control in the instrument or automatic electronic sensing of zero thickness.