



Standard Practice for Ultrasonic Examination of Steel with Convex Cylindrically Curved Entry Surfaces¹

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1. Scope

1.1 This practice describes the selection of single element hard face ultrasonic search units for which flat-entry-surface calibration blocks can be used for examination of steel with convex cylindrically curved entry surfaces.

1.2 The scope of this practice includes the determination of search unit characteristics and radius of surface curvature of the material for which no gain correction is required, or, if a larger transducer is used, the computation of the additional gain required to allow calibration with a flat calibration block and examination on a curved surface.

1.3 This practice is intended for use during contact examination of convexly curved steel material using round flat face, piezoelectric search units for longitudinal ultrasonic wave generation in the frequency range from 1 to 10 MHz.

1.4 *This standard does not purport to address all of the safety problems, 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 1316 Terminology for Nondestructive Examinations²

3. Terminology

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

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *critical radius, R_c* —Smallest radius of curvature of the material that can be examined without a correction for curvature. The critical radius is calculated from properties of the transducer, couplant and material under examination. Values of R_c for various conditions can be determined from the equations in Annex A1.

3.2.2 *Discussion*—For contact examination using transducers with flat wear faces on convex surfaces, the width, W , refers

to the width of the ultrasonic beam generated by the search unit.

4. Summary of Practice

4.1 Three effects are produced by placing a flat faced search unit on a cylindrically curved convex surface:

4.1.1 *Cylindrical Plano*—A concave lens formed by the couplant defocuses the ultrasonic beam, reducing amplitude at the discontinuities.

4.1.2 Rays from the search unit strike the curved surface at non-normal incidence, producing a shear wave as well as a longitudinal wave. The shear wave extracts energy that could otherwise be used in the longitudinal component.

4.1.3 Except at the line of contact between the search unit and the curved surface, a finite varying thickness of couplant exists. This couplant layer transforms the impedance of the material undergoing examination, so that the impedance looking into the couplant no longer matches the search unit impedance. The impedance mismatch reduces the energy entering the curved surface.³

4.2 Of the three effects, the first two are negligible for typical search units, surface curvatures and properties of the couplant, transducer wear face and material being examined. The third effect predominates: a couplant layer $\lambda/20$ in thickness can result in an amplitude decrease of 50 % in the material being examined. Where the curvature and search unit size create a couplant thickness at diametrically opposite edges of the search unit that greatly exceeds $\lambda/20$, the ultrasound is effectively not transmitted. The effective transducer width is reduced, the total energy is reduced, and because of the reduced effective width, the beam spread increases.

5. Significance and Use

5.1 Standardization of ultrasonic equipment for examination of steel having surfaces with curved surfaces generally requires instrument calibration on calibration blocks of similar radius of curvature, surface finish, and material properties. A calibration procedure using flat-entry calibration blocks and conventional round transducers can result in equipment amplification errors if corrections are not made for the radius of curvature. This

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² *Annual Book of ASTM Standards*, Vol 03.03.

³ Substantial discussion of the basis of this practice is given in: Birchak, J. R. and Serabian, S., "Calibration of Ultrasonic Systems for Inspection from Curved Surfaces," *Materials Evaluation*, Vol 36, January 1978, p. 39.