Designation: E1496 – 05 (Reapproved 2010)

Standard Test Method for
Neutron Radiographic Dimensional Measurements[1]

This standard is issued under the fixed designation E1496; 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 test method provides a technique for extracting quantitative dimensional information on an object from its neutron radiograph. The technique is based on the identification of changes in film density caused by material changes where a corresponding discontinuity in film density exists. This test method is designed to be used with neutron radiographs made with a well-collimated beam. The film densities in the vicinity of the edge must be in the linear portion of the density versus exposure curve. The accuracy of this test method may be affected adversely in installations with high-angular-divergence neutron beams or with large object-to-film distances.

1.2 *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:*[2]

E94 Guide for Radiographic Examination
E543 Specification for Agencies Performing Nondestructive Testing
E748 Practices for Thermal Neutron Radiography of Materials
E803 Test Method for Determining the *L/D* Ratio of Neutron Radiography Beams
E1316 Terminology for Nondestructive Examinations

2.2 *Other Documents:*

SNT-TC-1A Recommended Practice for Nondestructive Testing Personnel Qualification and Certification[3]
ANSI/ASNT CP-189 ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel[3]
NAS-410 Nondestructive Testing Personnel Qualification and Certification[4]

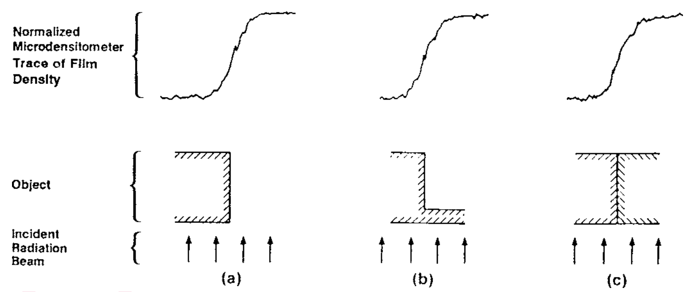

FIG. 1 Typical Microdensitometer Film Density Traces Associated with Three Rectangular Material Discontinuities: (a) Edge of Object, (b) Thickness Variation, and (c) Dissimilar Material Boundary

3. Terminology

3.1 *Definitions*—Definitions of the many terms relative to radiography (for example, X, gamma, and neutron radiography) can be found in Terminology E1316.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *extremum*—the point on the linear response portion of the curve of smoothed density versus location at which the slope is a maximum.

3.2.2 *extremum slope criterion*—the criterion that specifies the edge of a discontinuity or an object, located at the spatial position corresponding to the extremum as determined from examination of a radiograph.

3.2.3 *linear response*—a radiographic response where the film density across an edge within an object is contained in the linear part of the density versus exposure curve.

3.2.4 *traveling-stage microdensitometer*—a densitometer with a small aperture (typically between 10 to 25 μm by 200 to 300 μm) that has the capability of scanning a radiograph in a continuous or stepped manner and generating either a digital or an analog mapping of the film density of the radiograph as a function of position.

[1] This test method is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.05 on Radiology (Neutron) Method.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from The American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518.

[4] Available from Aerospace Industries Association of America, Inc. (AIA), 1250 Eye St., NW, Washington, DC 20005.

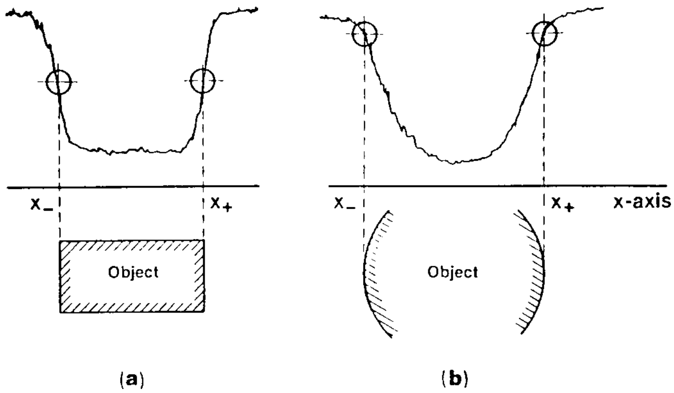

FIG. 2 Typical Microdensitometer Traces of Film Density for (a) Rectangular Objects and (b) Cylindrical Objects; Note Placements of Edges x_+ and x_- on the Traces

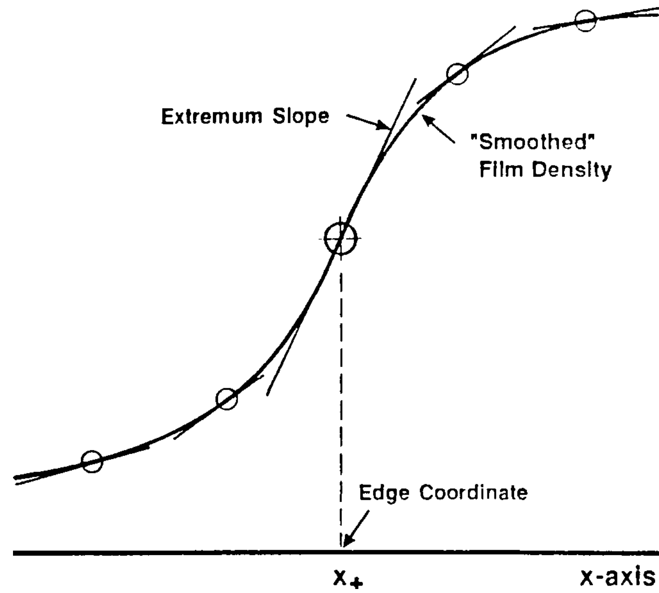

FIG. 3 Depiction of Various Slopes on a Smoothed Microdensitometer Trace; The Object Edge Coordinate, x_+, Corresponds to the Extremum Slope Point on the Trace

4. Summary of Test Method

4.1 All radiation used in radiography is attenuated in its passage through an object according to its thickness and magnitude of the material attenuation properties appropriate to the type and energy of radiation. Additionally, significant spatial spreading occurs due to the system imperfections, nonsymmetric radiation transport, and image formation process. Significant variations in the recorded radiation near edges and material discontinuities therefore occur and manifest themselves by film density variations in the radiograph, as illustrated in Fig. 1.

4.2 A graph of detector response (film density) versus location across an interface is similar in form for many different types of interface, provided that the detector responds linearly to increased exposure over the entire region of interest. Typical radiographic responses are shown in Fig. 2 (a) and (b).

4.3 Both theoretical and experimental studies in neutron radiography have established that under commonly encountered high-quality linear-response radiographic conditions, the edge of an object corresponds to that point on the smoothed experimentally obtained microdensitometer trace at which the slope is a maximum, as illustrated in Fig. 3. This point is called the extremum, and the relationship between the spatial position of the extremum and location of the edge is called the extremum slope criterion. These have been confirmed by careful experimentation (**1-3**).[5]

5. Significance and Use

5.1 Many requirements exist for accurate dimensional information in industrial quality control. Frequently, this information cannot be measured directly, may be very uncertain, or is expensive to obtain. If a radiograph of the object in question displays a sufficient film density variation near the edge of interest, however, dimensional radiography methods may be applied. This test method provides a technique for extracting quantitative dimensional information from the neutron radiograph of an object. Guide E94 and Practices E748 are helpful for understanding the principles involved in obtaining a high-quality neutron radiograph.

5.2 Dimensional radiography appears to be particularly relevant in determination of the following: (*1*) diameters of spent radioactive fuel, (*2*) gap sizes in contact-circuit mechanisms of shielded components, and (*3*) prescribed spacings between distinct materials.

5.3 While this test method addresses dimensional measurements using neutron radiography, the methods and techniques of dimensional radiography are also equally applicable to various types of radiography, such as x-ray, γ-ray, and neutron.

5.4 A fundamental assumption of this test method is that the user will have access to a system that permits the attainment of data describing the density response of the radiograph. Although a system may include any digitization equipment capable of providing the spatial resolutions recommended in 6.1.1, a typical system will include a high-resolution traveling-stage microdensitometer and a neutron radiograph of the object.

5.5 An object with accurately known dimensions must be available to calibrate the equipment used to measure the radiographic response, that is, the traveling-stage microdensitometer (or other digitization system capable of spatial resolution comparable to that of the detector).

6. Basis of Application

6.1 The following items are subject to contractual agreement between parties using or referencing this test method.

6.1.1 *Personnel Qualification*—If specified in the contractual agreement, personnel performing examinations in accordance with this test method shall be qualified in accordance with a nationally or internationally recognized NDT personnel qualification practice or standard such as ANSI/ASNT CP-189, SNT-TC-1A, NAS-410, or a similar document and certified by the employer or certifying agency, as applicable. The practice

[5] The boldface numbers in parentheses refer to the list of references at the end of this test method.