Designation: E545 – 19

Standard Test Method for Determining Image Quality in Direct Thermal Neutron Radiographic Examination[1]

This standard is issued under the fixed designation E545; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This test method covers the use of an Image Quality Indicator (IQI) system to determine the relative[2] quality of radiographic images produced by direct, thermal neutron radiographic examination. The requirements expressed in this test method are not intended to control the quality level of materials and components.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

E543 Specification for Agencies Performing Nondestructive Testing

E748 Guide for Thermal Neutron Radiography of Materials

E803 Test Method for Determining the *L/D* Ratio of Neutron Radiography Beams

E1079 Practice for Calibration of Transmission Densitometers

E1316 Terminology for Nondestructive Examinations

E2003 Practice for Fabrication of the Neutron Radiographic Beam Purity Indicators

E2023 Practice for Fabrication of Neutron Radiographic Sensitivity Indicators

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, see Terminology E1316, Section H.

4. Summary of Test Method

4.1 The judgment of the quality of a neutron radiograph is based upon the evaluation of images obtained from indicators that are exposed along with the test object. In cases of limited film size or extended object size, the indicators may be exposed on another film immediately prior to or following exposure of the test object under exactly the same conditions (refer to Process Control Radiographs, Section 10). The IQI values must be determined from films with an optical density between 2.0 to 3.0. Two types of IQIs are used.

4.1.1 *Beam Purity Indicator (BPI)*—The BPI is a device used for quantitative determination of radiographic quality. It is a polytetrafluoroethylene block containing two boron nitride disks, two lead disks, and two cadmium or gadolinium wires. A key feature of the BPI is the ability to make a visual analysis of its image for subjective information, such as image unsharpness and film and processing quality. Densitometric measurements of the image of the device permit quantitative determination of the effective value for the thermal neutron content, gamma content, pair production content, and scattered neutron content. The BPI shall be constructed in accordance with Practice E2003. Optionally, any BPI fabricated prior to publication of Practice E2003 which conforms to Test Method E545 - 81 through 91 may be used.

4.1.2 *Sensitivity Indicator (SI)*—The SI device is used for qualitative determination of the sensitivity of detail visible on a neutron radiograph. The SI is a step-wedge device containing gaps and holes of known dimensions. Visual inspection of the

[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] The numerical values obtained in the calculations described herein may vary between different film processing systems, film types, and within one processing system if processing variables change.

[3] 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.

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

image of this device provides subjective information regarding total radiographic sensitivity with respect to the step-block material. The SI shall be constructed in accordance with Practice E2023. Optionally, any SI fabricated prior to publication of Practice E2023 which conforms to Test Method E545-81 through 91 may be used.

4.2 Neutron radiography practices are discussed in Guide E748.

5. Significance and Use

5.1 The BPI is designed to yield quantitative information concerning neutron beam and image system parameters that contribute to film exposure and thereby affect overall image quality. In addition, the BPI can be used to verify the day-to-day consistency of the neutron radiographic quality. Gadolinium conversion screens and single-emulsion silver-halide films, exposed together in the neutron imaging beam, were used in the development and testing of the BPI. Use of alternative detection systems may produce densitometric readings that are not valid for the equations used in Section 9.

5.2 *The only truly valid sensitivity indicator is a reference standard part. A reference standard part is a material or component that is the same as the object being neutron radiographed except with a known standard discontinuity, inclusion, omission, or flaw. The sensitivity indicators were designed to substitute for the reference standard and provide qualitative information on hole and gap sensitivity.*

5.3 The number of areas or objects to be radiographed and the film acceptance standard used should be specified in the contract, purchase order, specification, or drawings.

6. Basis of Application

6.1 *Qualification of Nondestructive Agencies*—If specified in the contractual agreement, NDT agencies shall be qualified and evaluated in accordance with Specification E543. The applicable revision of Specification E543 shall be specified in the contractual agreement.

6.2 *Procedures and Techniques*—The procedures and techniques to be utilized shall be as described in this test method unless otherwise specified. Specific techniques may be specified in contractual documents.

6.3 *Extent of Examination*—The extent of examination shall be in accordance with Section 7 unless otherwise specified.

6.4 *Reporting Criteria/Acceptance Criteria*—Reporting criteria for the examination results shall be in accordance with Section 11 unless otherwise specified. Acceptance criteria (for example, for reference radiographs) shall be specified in the contractual agreement.

7. Procedure

7.1 The direction of the beam of radiation should be as perpendicular as possible to the plane of the film.

7.2 Use Conversion screens that respond to neutrons of thermal energies, such as metallic gadolinium.

7.3 Each radiograph shall include a beam purity indicator and a sensitivity indicator or a Process Control Radiograph shall be used (refer to Section 10 for details on Process Control Radiographs).

7.4 The indicators shall be located no less than 25 mm from any edge of the exposed area of the film when feasible.

7.5 The indicators shall be located such that the image of the indicators on the film do not overlap the image of the object.

7.6 The SI should be oriented parallel to and as close as possible to the film.

7.7 The SI should be oriented such that its thickest step is not adjacent to the BPI or the objects being radiographed.

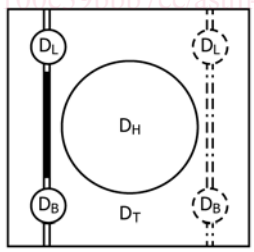
7.8 The BPI surface must be parallel against the film cassette face during exposure or density readings will be invalid.

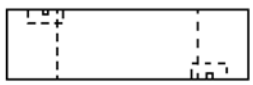
7.9 The cadmium or gadolinium wires in the BPI shall be oriented such that their longitudinal axis is perpendicular to the nearest film edge.

7.10 Measure the film densities using a diffuse transmission densitometer. The densitometer shall be calibrated according to Practice E1079.

7.11 For the purpose of determining image quality, the background optical density shall be between 2.0 and 3.0 measured at the hole in the center of the BPI.

7.12 Determine the thermal neutron content (NC), scattered neutron content (S), gamma content (γ), and pair production content (P) by densitometric analysis of the BPI image. Make a determination of the constituents of film exposure by measuring the densities in the BPI image as shown in Table 1.





Beam Purity Indicator

TABLE 1 Definitions of Density Variables

higher D_B	Larger film density measured through the images of the boron nitride disks.
lower D_B	Smaller film density measured through the images of the boron nitride disks.
higher D_L	Larger film density measured through the images of the lead disks.
lower D_L	Smaller film density measured through the images of the lead disks.
D_H	Film density measured at the center of the hole in the BPI.
D_T	Film density measured through the image of the polytetrafluoroethylene.
ΔD_L	higher D_L - lower D_L
ΔD_B	higher D_B - lower D_B