Designation: E1165 – 20

Standard Test Method for Measurement of Focal Spots of Industrial X-Ray Tubes by Pinhole Imaging[1]

This standard is issued under the fixed designation E1165; 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 The image quality and the resolution of X-ray images are especially sensitive to the characteristics of the focal spot. The imaging qualities of the focal spot are based on its two dimensional intensity distribution as seen from the detector plane.

1.2 This test method provides instructions for determining the effective size (dimensions) of standard and mini focal spots of industrial X-ray tubes for focal spot dimensions from 100 µm up to several mm of X-ray sources up to 600 kV tube voltage. Smaller focal spots down to 50 µm could be evaluated with less precision. This determination is based on the measurement of an image of a focal spot that has been radiographically recorded with a "pinhole" technique. An alternative method with a plaque hole IQI may be found in the Annex A, which covers the same focal spot sizes.

1.3 Smaller focal spots should be measured using Test Method E2903 using the projection of an edge.

1.4 This test method may also be used to determine the change in focal spot size that may have occurred due to tube age, tube overloading, and the like. This would entail the production of a focal spot radiograph (with the pinhole method) and an evaluation of the resultant image for pitting, cracking, and the like.

1.5 *Units*—Values stated in SI units are to be regarded as the standard.

1.6 *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.*

1.7 *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:*[2]

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

E999 Guide for Controlling the Quality of Industrial Radiographic Film Processing

E1000 Guide for Radioscopy

E1025 Practice for Design, Manufacture, and Material Grouping Classification of Hole-Type Image Quality Indicators (IQI) Used for Radiography

E1255 Practice for Radioscopy

E1742 Practice for Radiographic Examination

E1815 Test Method for Classification of Film Systems for Industrial Radiography

E2002 Practice for Determining Total Image Unsharpness and Basic Spatial Resolution in Radiography and Radioscopy

E2033 Practice for Radiographic Examination Using Computed Radiography (Photostimulable Luminescence Method)

E2339 Practice for Digital Imaging and Communication in Nondestructive Evaluation (DICONDE)

E2698 Practice for Radiographic Examination Using Digital Detector Arrays

E2736 Guide for Digital Detector Array Radiography

E2903 Test Method for Measurement of the Effective Focal Spot Size of Mini and Micro Focus X-ray Tubes

2.2 *European Standards:*[3]

EN 12543-2 Non-destructive testing—Characteristics of focal spots in industrial X-ray systems for use in non-destructive testing—Part 2: Pinhole camera radiographic method

[1] This test method is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.01 on Radiology (X and Gamma) 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 European Committee for Standardization (CEN), Avenue Marnix 17, B-1000, Brussels, Belgium, http://www.cen.eu.

EN 12543-5 Non-destructive testing—Characteristics of focal spots in industrial X-ray systems for use in non-destructive testing—Part 5: Measurement of the effective focal spot size of mini and micro focus X-ray tubes

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *actual focal spot, n*—the X-ray producing area of the target as viewed from a position perpendicular to the target surface (see Fig. 1).

3.1.2 *effective focal spot, n*—the X-ray producing area of the target as viewed by a detection device from a position perpendicular to the electron beam in the center of the resulting X-ray beam (see Fig. 1).

3.1.3 *effective size of focal spot, n*—focal spot size measured according to this test method.

4. Summary of Test Method

4.1 This test method is based on a projection image of the focal spot using a pinhole camera. This image shows the intensity distribution of the focal spot. From this image the effective size of the focal spot is calculated. Using digital tools, an integration of the profile across the pinhole image transforms the pinhole image into an edge response curve. The X- and Y-dimension of the edge unsharpness is used for calculation of the size of the focal spot. This method provides similar results as the method described in Test Method E2903 using an edge target instead of a pinhole camera. The measured effective spot sizes correspond to the geometrical image unsharpness values at given magnifications as measured with the Practice E2002 duplex wire gauge in practical images using equation:

$$U_G = \varphi(v - 1) \quad (1)$$

with geometrical unsharpness, U_G, focal spot size, φ, and magnification, v (see Guide E1000 for details of this equation). For a full description, see the WC-NDT 2012 paper cited in Footnote 4.[4]

4.2 Additionally, a simplified test method is described in Annex A for users of X-ray tubes who may not intend to use a pinhole camera. This alternative method is based on the edge method according toTest Method E2903 using a plate hole IQI as described in Practices E1025 or E1742 instead of a pinhole camera.

5. Significance and Use

5.1 One of the factors affecting the quality of radiologic images is the geometric unsharpness. The degree of geometric unsharpness is dependent on the focal spot size of the radiation source, the distance between the source and the object to be radiographed, and the distance between the object to be radiographed and the detector (imaging plate, Digital Detector Array (DDA) or film). This test method allows the user to determine the effective focal size of the X-ray source. This result may then be used to establish source to object and object to detector distances appropriate for maintaining the desired degree of geometric unsharpness or maximum magnification for a given radiographic imaging application, or both. Some ASTM standards require this value for calculation of a required magnification, for example, Practices E1255, E2033, and E2698.

[4] Klaus Bavendiek, Uwe Heike, Uwe Zscherpel, Uwe Ewert, and Adrian Riedo. "New measurement methods of focal spot size and shape of X-ray tubes in digital radiological applications in comparison to current standards," WC-NDT 2012, Durban, South Africa, http://www.x-ray-forum.de/WCNDT_Paper346_WE_MR21_A_BavendiekEtAl.pdf.

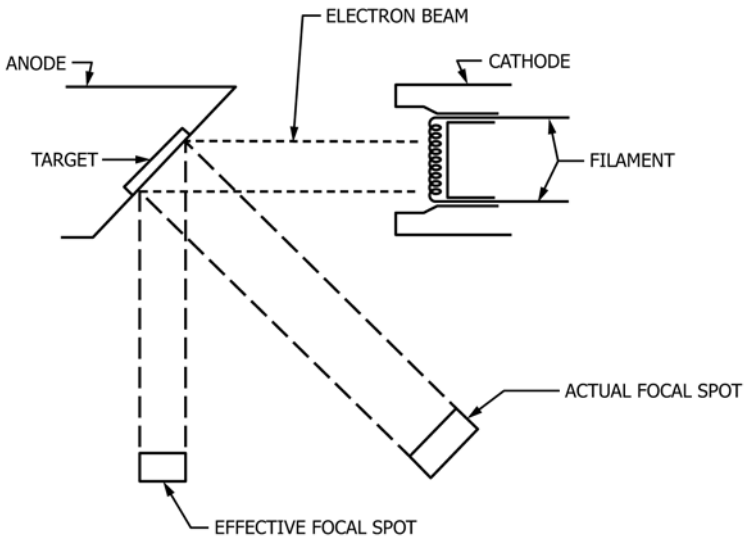

FIG. 1 Actual/Effective Focal Spot