Designation: E1114 – 09 (Reapproved 2014)

Standard Test Method for Determining the Size of Iridium-192 Industrial Radiographic Sources[1]

This standard is issued under the fixed designation E1114; 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 covers the determination of the size of an Iridium-192 radiographic source. The determination is based upon measurement of the image of the Iridium metal source in a projection radiograph of the source assembly and comparison to the measurement of the image of a reference sample in the same radiograph.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E999 Guide for Controlling the Quality of Industrial Radiographic Film Processing

E1316 Terminology for Nondestructive Examinations

E1815 Test Method for Classification of Film Systems for Industrial Radiography

E2445 Practice for Performance Evaluation and Long-Term Stability of Computed Radiography Systems

E2597 Practice for Manufacturing Characterization of Digital Detector Arrays

2.2 *Other International Standards:*

EN 12679:2000 Industrial Radiography—Radiographic Method for the Determination of the Source Size for Radioisotopes[3]

3. Terminology

3.1 For definitions of terms relating to this test method, refer to Terminology E1316.

4. Significance and Use

4.1 One of the factors affecting the quality of a radiographic image is geometric unsharpness. The degree of geometric unsharpness is dependent upon the size of the source, the distance between the source and the object to be radiographed, and the distance between the object to be radiographed and the film or digital detector. This test method allows the user to determine the size of the source and to use this result to establish source to object and object to film or detector distances appropriate for maintaining the desired degree of geometric unsharpness.

NOTE 1—The European standard CEN EN 12579 describes a simplified procedure for measurement of source sizes of Ir-192, Co-60 and Se-75. The resulting source size of Ir-192 is comparable to the results obtained by this test method.

5. Apparatus

5.1 *Subject Iridium-192 Source,* the source size of which is to be determined. The appropriate apparatus and equipment for the safe storage, handling, and manipulation of the subject source, such as a radiographic exposure device (also referred to as a gamma ray projector or camera), remote control, source guide tube, and source stop are also required.

5.2 *Reference Sample (see* Figs. 1-3*)*—The reference sample shall be of material which is not radioactive. The recommended material is Iridium. However, substitutes such as platinum, tungsten or other material of similar radiopacity may be used. The sample should be of the same geometric shape as the subject source, should be approximately the same size as the subject source, and should be positioned on or within a shim or envelope to simulate the source capsule wall. The

[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 American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

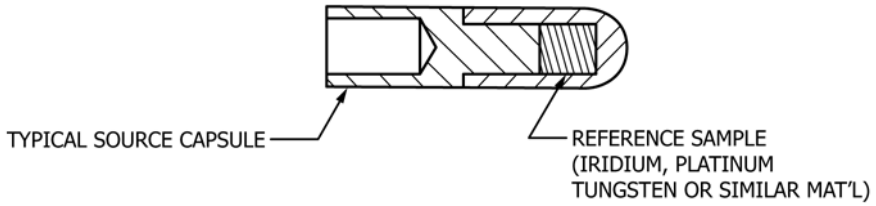

FIG. 1 Reference Sample in Standard Source Encapsulation

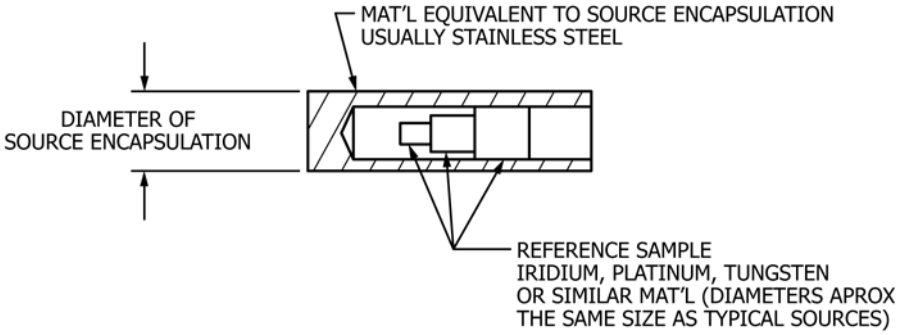

FIG. 2 Alternate Reference Sample Arrangement

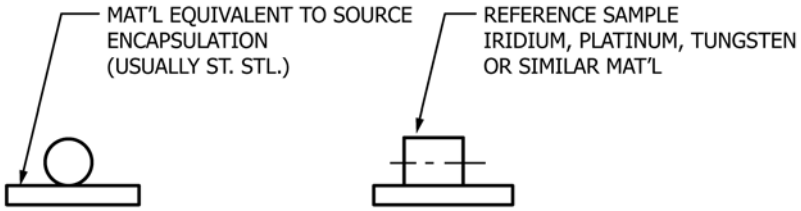

FIG. 3 Alternate Reference Sample Arrangement

resulting radiographic contrast, with reference to adjacent background density of the image of the reference sample, should be approximately the same as that of the subject source. The actual dimensions of the reference sample should be determined to the nearest 0.025 mm (0.001 in.).

5.3 *X-ray Generator,* capable of producing a radiation intensity (roentgen per hour at one metre) at least ten times greater than that produced by the subject source. Examples of typical X-ray generator output requirements that satisfy this criterion are presented in Table 1.

5.4 *Film systems*—Only film systems having cognizant engineering organization approval or meeting the system class requirements of Test Method E1815, for system classes I, II or Special, shall be used. Selection of film systems should be determined by such factors as the required radiographic quality level, equipment capability, materials and so forth. The film system selected shall be capable of demonstrating the required image quality. No intensifying screens shall be used. Radiographic films shall be processed in accordance with Guide E999.

TABLE 1 Examples of Typical X-ray Generator Output Requirements for Related Iridium^{192} Source Activities

Subject Iridium^{192} Source Radiation			Typical X-ray Generator Output Requirements	
Activity (Curie)	Output (R/h at 1 m)		Potential	Current
30	14.4		160 kV	5 mA
		or	200 kV	3 mA
100	48.0		160 kV	10 mA
		or	250 kV	4 mA
200	96.0		160 kV	20 mA
		or	250 kV	8 mA
		or	300 kV	6 mA

5.5 *Image Measurement Apparatus*—This apparatus is used to measure the size of the image of the spot. The apparatus shall be an optical comparator with built-in graticule with 0.1 mm divisions or 0.001 in. divisions and magnification of 5× to 10×.

5.6 *Digital Detectors*—Digital detectors, which are either imaging plates or digital detector arrays, may be used as film replacement. The digital detector shall possess a pixel pitch which is at least 40 times smaller than the nominal source size to measure and a basic spatial resolution smaller than 1/20 of the nominal source size. The basic spatial resolution shall be measured in accordance with the procedure of Practice E2597 for DDAs or Practice E2445 for the imaging plate scanner system or taken from manufacturer statements. In the area of free beam a detector $SNR_D > 100$ shall be achieved. The measurement procedure of the SNR shall be in accordance with the procedure of Practice E2597 for DDAs or Practice E2445 for the imaging plate scanner system.

5.7 *Evaluation of Digital Images*—Digital images shall be evaluated by an image processing software with contrast, brightness, profile and zoom function. The digital images shall be magnified at the monitor to a degree that allows the image viewing with at least one pixel of the image at one pixel of the monitor.

6. Procedure

6.1 Set up the exposure arrangement as shown in Figs. 4-7. Position the X-ray tube directly over the center of the film or digital detector. The film or detector plane must be normal to the central ray of the X-ray beam. The X-ray spot should be 0.90 m (36 in.) from the film or detector. Position the reference sample and apparatus used to locate the subject source (source stop) as close together as possible and directly over the center of the film or detector. The plane of the source stop and reference sample must be parallel to the film or detector and normal to the central ray of the X-ray beam. The source stop and reference sample should be 0.15 m (6 in.) from the film or detector. The source stop should be connected to the radiographic exposure device by the shortest source guide tube practicable in order to minimize fogging of the film or detector during source transit.

6.2 Place identification markers to be imaged on the film or detector to identify, as a minimum, the identification (serial number) of the subject source, the size of the reference sample, the identification of the organization performing the determination, and the date of the determination. Care should be taken to ensure that the images of the subject source and reference sample will not be superimposed on the image of the identification markers.

6.3 *Exposure*—Select the X-ray tube potential (kV), X-ray tube current (mA) and exposure time such that the density in the image of the envelope surrounding the reference sample does not exceed 3.0 and that the density difference between the image of the reference sample and the image of the envelope surrounding the reference sample is at least 0.10. In digital images the linear grey value difference between the image of the reference sample and the image of the envelope surrounding the reference sample shall be five times larger than the image noise σ(σ = standard deviation of the grey value fluctuations in an area of homogeneous exposure, measured in a window of at least 20 by 55 pixels) in a homogeneous neighbor area.

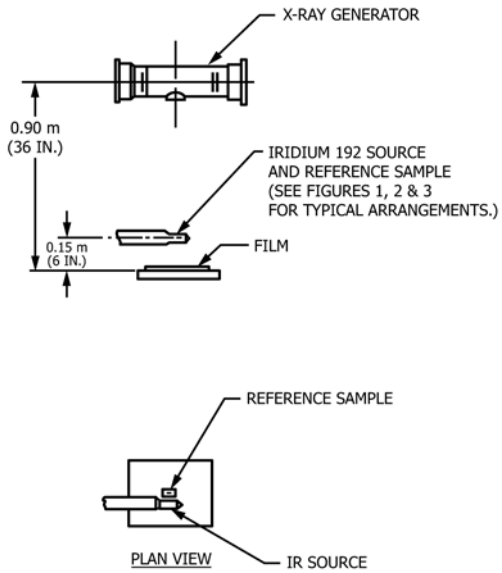

FIG. 4 Typical Exposure Arrangement

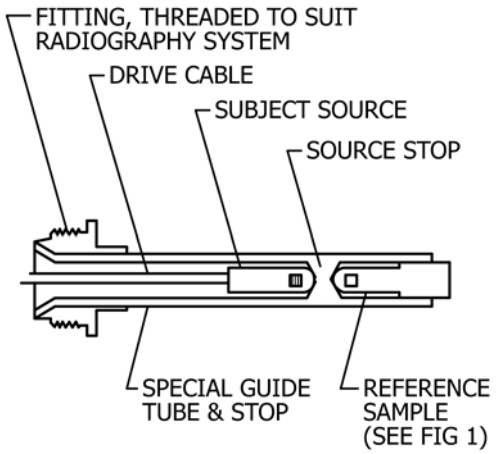

FIG. 5 Typical Arrangement Using a Specially Designed Guide Tube

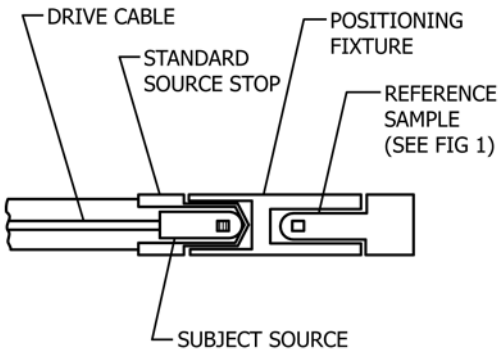

FIG. 6 Typical Arrangement Using a Standard Guide Tube and Special Positioning Fixture

NOTE 2—The actual parameters that will produce acceptable results may vary between X-ray units, and trial exposures may be necessary.

6.3.1 Energize the X-ray generator and, at the same time, manipulate the subject source into the exposure position in the source stop. It is important that this be performed as quickly as possible to minimize fogging of the film or detector.

6.3.2 At the conclusion of the exposure time, deenergize the X-ray generator and, at the same time, return the subject source to the proper shielded storage position.

6.3.3 Process the film or read out the digital detector array or scan the imaging plate.

7. Measurement of Source Dimensions

7.1 When viewing the film radiograpgh, view it with sufficient light intensity for adequate viewing. Using an optical comparator with built-in graticule as described in 5.5, measure the linear dimensions of the image of the spot size of the subject source and the reference sample. Take measurements

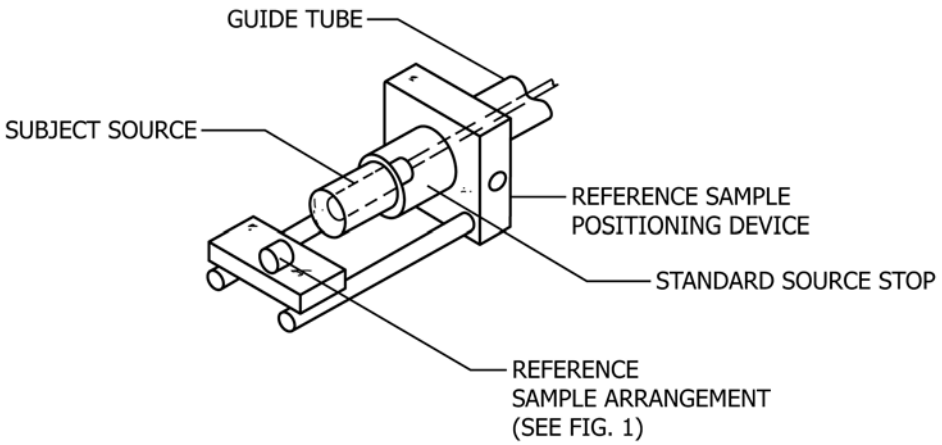

FIG. 7 Typical Arrangement Using Reference Sample Positioning Device

from the perceptible edges of the image. When performing the physical measurements with the optical comparator, the actual measured values shall be to the nearest graduation on the graticule scale being used.

7.2 When viewing the digital image, view it in a darkened room and use a bright monitor with at least 250 cd/m^2. Use the profile function of the image processing software for size measurement in digital images after proper brightness and contrast adjustment.

7.3 The source size for a given technique is the maximum projected dimension of the source in the plane perpendicular to a line drawn from the source to the object being radiographed. Therefore, sufficient measurements of the image of the Iridium must be made to determine the size of the source in any orientation. Sections 7.4 – 7.7 serve as examples.

7.4 *Uniform Right Circular Cylinder* (see Fig. 8)—Determine the source size of a uniform right circular cylindrical source by measuring the diameter, *d*, the height, *h*, and the diagonal, *m*, as illustrated in Fig. 8 and computing the actual dimensions as described in 8.1.

7.5 *Sphere* (see Fig. 9)—Determine the size of a spherical source by measuring the diameter, *d*, as illustrated in Fig. 9 and computing the actual dimension as described in 8.1.

7.6 *Nonuniform Stack of Right Circular Cylinders* (see Fig. 10)—Determine the size of a nonuniform stack of right circular cylindrical components of a source by measuring the intrinsic diameter, *d*, the height, *h*, and the effective maximum dimension, *m*, as illustrated in Fig. 10 and computing the actual dimensions as described in 8.1.

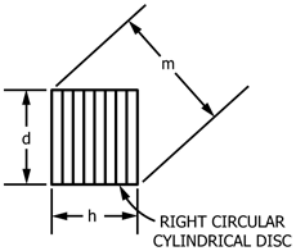

FIG. 8 Uniform Right Circular Cylinder

FIG. 9 Sphere

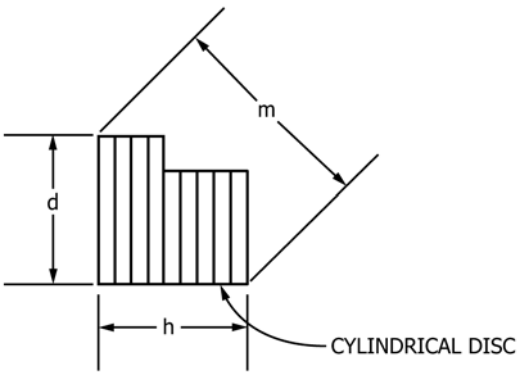

FIG. 10 Nonuniform Cylindrical Stack

7.7 *Separated Stack of Right Circular Cylinders* (see Fig. 11)—Determine the size of a separated stack of right circular cylindrical components of a source by measuring the intrinsic diameter, *d*, the effective height, *h*, and the effective maximum dimension, *m*, as illustrated in Fig. 11 and computing the actual dimensions as described in 8.1.

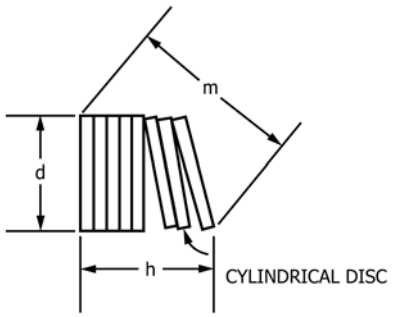

FIG. 11 Separated Cylindrical Stack

8. Calculation and Evaluation

8.1 Measure the linear dimension of interest in the subject source image and measure the same linear dimension in the reference sample image (that is, the diameter of each). The actual dimension of the subject source is computed from the following:

$$a = bc/d$$

where:

a = actual dimension of the subject source,
b = actual dimension of the reference sample,
c = measured dimension of the subject source image, and
d = measured dimension of the reference sample image.

9. Report

9.1 A report of the size of an Iridium-192 source should indicate the model number and serial number of the source, the name of the organization making the determination, the date the determination was made, a description of the shape of the source (or an appropriate sketch), and the calculated actual dimensions. The actual radiograph should accompany the report.

10. Precision and Bias

10.1 *Precision*—It is not possible to specify the precision of the procedure in this test method for measuring the size of Iridium-192 radiographic sources because round robin testing has not yet been accomplished.

10.2 *Bias*—No information can be presented on the bias of the procedure in this test method for measuring the size of Iridium-192 radiographic sources because round robin testing has not yet been accomplished.

11. Keywords

11.1 cylinder(s); Iridium 192; radiographic source; reference sample; source size; sphere