



Standard Reference Radiograph for Evaluating the Performance of Radiographic Digitization Systems¹

This standard is issued under the fixed designation E1936; 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 reference radiograph covers a series of test targets suitable for evaluating, quantifying, and documenting performance parameters of the radiographic digitization process or the electronic image reconstruction process, or both. This reference radiograph can be used for visual and electronic analysis of digitization systems.

1.2 This reference radiograph provides a series of test targets to provide a vehicle for the evaluation of spatial resolution, density contrast sensitivity, dynamic range, and spatial linearity as well as other aspects of a digitization system. The test targets are suitable for evaluating a digitization system with a spatial resolution down to $\sim 1/1000$ in. (25 micrometres (μm)), a density contrast sensitivity down to 0.02 optical density (OD), a density range of 0.5 to 4.5 OD, and a film size capacity of 14 in. (355 mm) wide by 17 in. (431 mm) long.

1.3 From time to time, there may be minor changes to the process for manufacturing of the reference adjunct film. These changes could include changes in the films or processing chemistry used, text designation on the film, etc.; however, in all cases, these changes are reviewed by the Illustration Monitoring Subcommittee to ensure that there are no changes to the functional use of the reference image. Therefore, the adjunct reference films remain valid for use with this standard regardless of the date of production or the revision level of the text standard.

1.4 The values stated in inch-pound units are to be regarded as the standard, with the exception of the spatial resolution targets (6.2 and 6.7) which are stated in SI units.

1.5 *This standard does not purport to address 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.*

¹ This reference radiograph is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.02 on Reference Radiological Images.

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2. Referenced Documents

2.1 ASTM Standards:²

E1079 Practice for Calibration of Transmission Densitometers

E1254 Guide for Storage of Radiographs and Unexposed Industrial Radiographic Films

E1316 Terminology for Nondestructive Examinations

E1411 Practice for Qualification of Radioscopic Systems

2.2 ASME Standard:

Section V, Article 2, Mandatory Appendix VI, Digital Image Acquisition, Display, Interpretation and Storage for Nuclear Applications³

2.3 ASTM Adjuncts:

Standard Reference Radiograph for Evaluating the Performance of Radiographic Digitization Systems⁴

3. Terminology

3.1 Definitions:

3.1.1 Refer to Terminology E1316 for definitions of terms used in this guide.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *converging line pairs*—the targets located on the reference radiograph that are used to determine the spatial resolution of the digitization system.

3.2.2 *parallel line pairs*—the targets located on the reference radiograph that are used in conjunction with the converging line pairs to determine the spatial resolution of the digitization system.

3.2.3 *reference radiograph*—the single piece of industrial radiographic film containing all of the reference targets described in this document.

3.2.4 *scan line*—it is a path that is one pixel high (vertical) by the number of pixels wide (horizontal), that is captured by

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 Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

⁴ Available from ASTM Headquarters. Order RRE1936.

the digitization system. The scan lines are added, one on top of the other, to electronically reproduce the physical (analog) data in the horizontal (film width) and vertical (film length) directions on the display monitor.

3.2.5 spatial linearity—the accuracy to which a digitization system reproduces the physical dimension. It is assessed within a single scan line and from one scan line to the next (horizontal and vertical directions).

3.2.6 spatial resolution—it is measured as the minimum distance detectable between two physically spaced lines (see **6.2 spatial resolution targets**). It is determined by the sampling rate in physical two-dimensional space and the system unsharpness.

3.2.7 targets—the physical patterns on the reference radiograph that are used to evaluate the radiographic film digitization system.

4. Significance and Use

4.1 This reference radiograph may be used to quantify the performance characteristics of a radiographic digitization system or to provide periodic evaluations of a digitization system in a production mode to verify that appropriate operating characteristics are being maintained. This reference radiograph provides a means for verifying the performance of a digitization system in much the same way that the tests described in Practice **E1411**, provide for the verification of a radioscopic imaging system. It may be used to evaluate the performance of a digitization system in accordance with the requirements contained in ASME Section V, Article 2, Mandatory Appendix VI, or other documents invoking requirements of this reference radiograph.

4.2 This reference radiograph provides a tool that allows the user to determine the performance of their radiographic digitization system. This reference radiograph may be used, where there is no other applicable document, for establishing records of quality and acceptable levels of performance of the film digitization system. This reference radiograph does not provide guidance on use of the test targets or recommend system performance levels.

5. Preparation of Reference Radiograph

5.1 The optical densities specified in **6.3** and **6.4** of this document are ascertained using densitometry equipment and techniques in accordance with Practice **E1079**, and are supplied with the adjunct reference radiograph. Optical densities are recorded in the center 0.12 in. (3 mm) of each of the density targets in **6.3** and **6.4**.

5.2 Film Deterioration—Radiographic film is subject to wear and tear from handling and use. The extent to which the image deteriorates over time is a function of storage conditions, care in handling, and amount of use. Reference radiographic film is no exception and may exhibit a loss of image quality over time. The reference radiograph should therefore be examined each time it is used for signs of wear and tear, including scratches, abrasions, stains, and so forth. A reference radiograph that shows signs of excessive wear and tear, which could influence the interpretation and use of the

reference radiograph, should be replaced. A guide for the storage of the reference radiograph is described in Guide **E1254**.

6. Description of Targets

6.1 The reference radiograph has five types of targets that may be used to evaluate various parameters of the digitization system. The targets are located within a background density of approximately 3.0 OD. The reference radiograph is divided into three areas with sizes of 8 in. (203 mm) by 10 in. (254 mm), 11 in. (279 mm) by 14 in. (355 mm), and 14 in. (355 mm) by 17 in. (430 mm). These have been created for digitization systems unable to accommodate film sizes up to 14 in. by 17 in. The reference radiograph may be cut to custom fit a particular digitization system and still contain all of the necessary targets within each of these areas that are represented on the illustration in **Fig. 1**.

6.2 Spatial Resolution Targets—These consist of three identical groups of at least 6 converging line pairs. The targets have a maximum resolution of no less than 20 line pairs per millimetre (lp/mm) and a minimum resolution of no greater than 1 lp/mm. The three line pair groups are oriented in the 0°, 45°, and 90° positions. The maximum resolution is oriented toward the corners of the reference radiograph. Reference marks are provided to indicate spatial resolution at levels of 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, and 20 lp/mm.

6.3 Density Contrast Sensitivity Targets—These consist of 0.4 in. (1 cm) by 0.4 in. fields centered in 1.6 in. (4 cm) by 1.6 in. blocks of a slightly lower density. Two series of blocks are used, one block series with an optical density of approximately 2.00 OD on a background of approximately 1.95 OD, an optical density change of 0.05. The second block series will have approximately 3.50 OD on a background of approximately 3.40 OD, an optical density change of 0.10. The relative density change is more important than the absolute density. These 2 block series are grouped in no less than six areas on the reference radiograph.

6.4 Stepped Density Targets—These targets are to be used to determine dynamic range and density contrast sensitivity. They shall consist of a series of 0.4 in. (1 cm) by 0.4 in. blocks with densities ranging from 0.5 to 4.5 OD. There shall be no less than 13 blocks aligned in a row with the following approximate densities: 4.5, 4.02, 4, 3.5, 3.02, 3, 2.5, 2.02, 2, 1.5, 1.02, 1, and 0.5 OD. These blocks are grouped in no less than eight areas on the reference radiograph.

6.5 Sharp Edge Target—Each stepped density target (corresponding to **6.4**) with the density 0.5 OD shall have sharp edges to the background of 3.0 OD. The unsharpness of the sharp edges shall be less than 10 micron (<0.0004 in.). This sharp edge may be used to measure horizontal and vertical line spread functions by differentiation of step profiles. The normalized magnitude of the Fourier transform of a line spread function yields the Modulation Transfer Function (MTF).

6.6 Linearity Targets—These targets provide 1.0 in. (25.4 mm) units of measure. They are located in the horizontal as well as the vertical directions. The linearity targets, or measurement scale, divides the reference radiograph into three

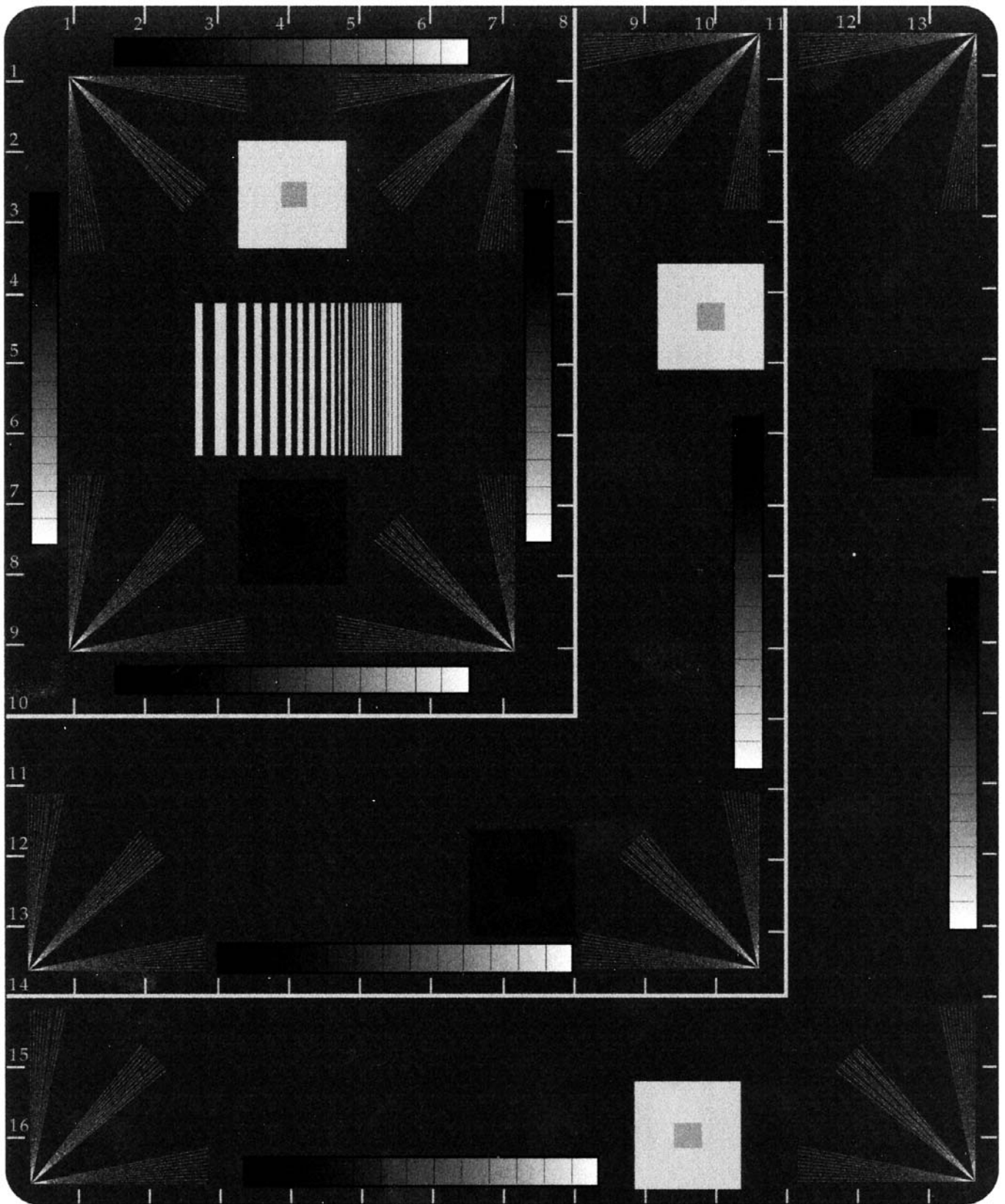


FIG. 1 Representation of the Adjunct

distinct film sizes 8 by 10 in. (203 by 254 mm), 11 by 14 in. (279 by 355 mm), and 14 by 17 in. (355 by 430 mm).

6.7 *Parallel Line Pair Target*—This target consists of a parallel line pair gage with a resolution starting at no greater

than 0.5 lp/mm and increases to a resolution of no less than 20 lp/mm. This target may be used to determine spatial resolution. It is positioned near the center of the 8 by 10 in. (203 by 254 mm) area on the reference radiograph.

6.8 Additional targets may be located on the reference radiograph as long as they do not interfere with the digitization, or interpretation, of the targets located in 6.2 through 6.7.

7. Keywords

7.1 density contrast sensitivity; digitization; line pairs; reference radiograph; spatial linearity; spatial resolution; system evaluation; target; X-ray

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