



# Standard Reference Radiograph for Evaluating the Performance of Radiographic Digitization Systems<sup>1</sup>

This standard is issued under the fixed designation E 1936; 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 ( $\epsilon$ ) 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. This is the first of three related standards. Subsequent standards will provide guidance on the use of the test targets and recommended system performance levels

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 ( $\mu$ )] 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 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.

1.4 *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.*

## 2. Referenced Documents

### 2.1 ASTM Standards:

E 1079 Practice for Calibration of Transmission Densitometers<sup>2</sup>

E 1254 Guide for Storage of Radiographs and Unexposed

### Industrial Radiographic Films<sup>2</sup>

E 1316 Terminology for Nondestructive Examinations<sup>2</sup>

E 1411 Practice for Qualification of Radioscopic Systems<sup>2</sup>

### 2.2 ASME Standard:

Section V, Article 2, Mandatory Appendix VI, Digital Image Acquisition, Display, Interpretation and Storage for Nuclear Applications<sup>3</sup>

### 2.3 ASTM Adjuncts:

Standard Reference Radiograph for Evaluating the Performance of Radiographic Digitization Systems<sup>4</sup>

## 3. Terminology

### 3.1 Definitions:

3.1.1 Refer to Terminology E 1316 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 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).

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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 03.03.

<sup>3</sup> Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990.

<sup>4</sup> Available from EPRI NDE Center, NDE Division, 1300 Harris Blvd., Charlotte, NC 28262.

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 E 1411, 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 between the cognizant engineering organization and purchaser of inspected components. 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 E 1079, 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 E 1254.

#### 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  $\approx 3.0$  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  $0^\circ$ ,  $45^\circ$ , and  $90^\circ$  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 will be used, one block series with an optical density of  $\approx 2.00$  OD on a background of  $\approx 1.95$  OD, an optical density change of 0.05. The second block series will have  $\approx 3.50$  OD on a background of  $\approx 3.40$  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 of 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 shall 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 shall be located in the horizontal as well as the vertical directions. The linearity targets, or measurement scale, divides the reference radiograph into three 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.

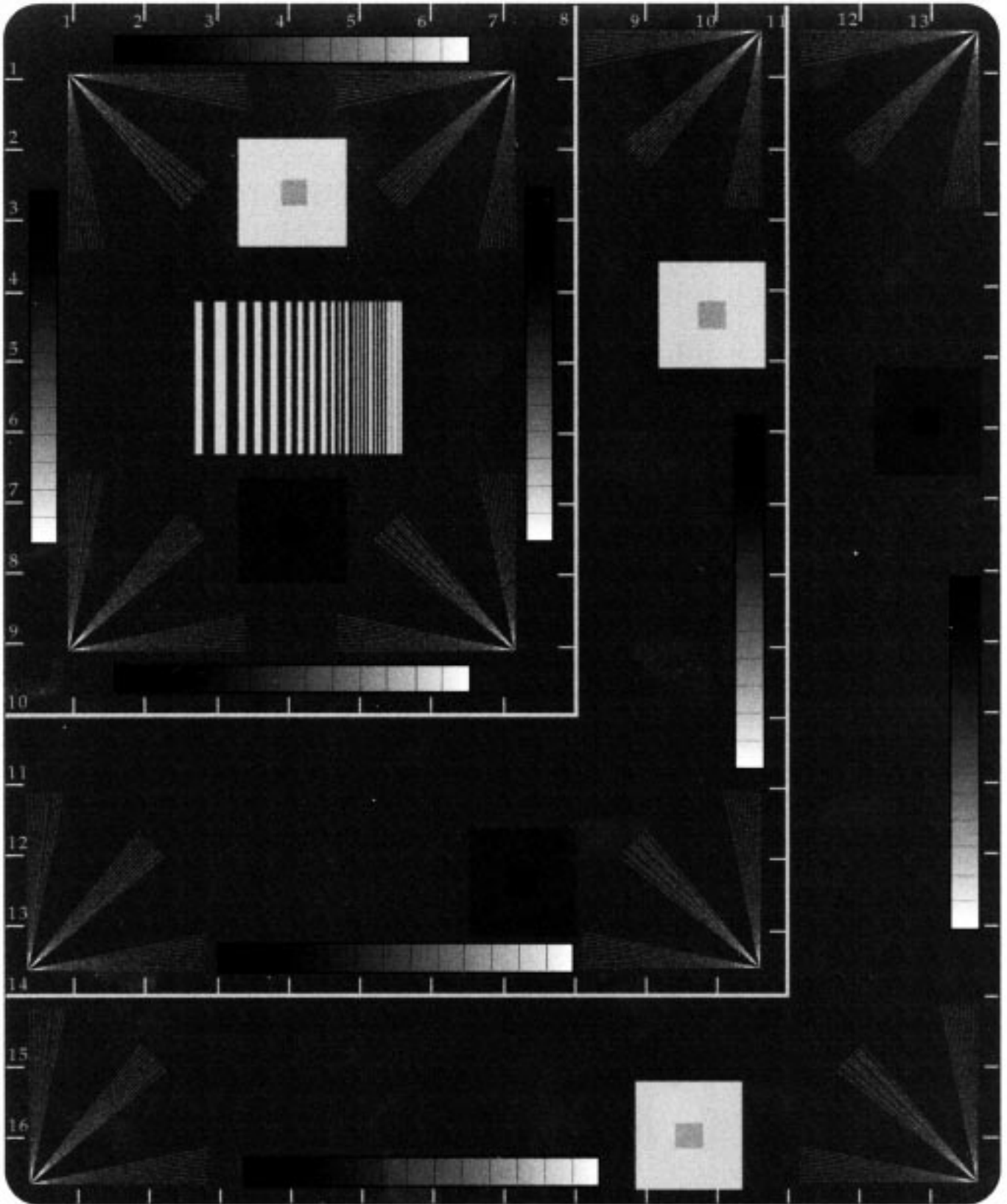


FIG. 1 Representation of the Adjunct

## 7. Keywords

system evaluation; target; X-ray

7.1 density contrast sensitivity; digitization; line pairs; reference radiograph; spatial linearity; spatial resolution;

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