Designation: E 1647 – 03

# Standard Practice for Determining Contrast Sensitivity in Radiology[1]

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## 1. Scope

1.1 This practice covers the design and material selection of a contrast sensitivity measuring gage used to determine the minimum change in material thickness or density that may be imaged without regard to spatial resolution limitations.

1.2 This practice is applicable to transmitted-beam radiographic and radioscopic imaging systems utilizing X-ray and gamma ray radiation sources.

1.3 The values stated in inch-pound units are to be regarded as standard.

1.4 *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.* For specific safety statements, see NIST/ANSI Handbook 114 Section 8, Code of Federal Regulations 21 CFR 1020.40 and 29 CFR 1910.96.

## 2. Referenced Documents

2.1 *ASTM Standards:*

B 139 Specification for Phosphor Bronze Rod, Bar, and Shapes[2]

B 150 Specification for Aluminum Bronze Rod, Bar, and Shapes[2]

B 161 Specification for Nickel Seamless Pipe and Tube[3]

B 164 Specification for Nickel-Copper Alloy Rod, Bar, and Wire[3]

B 166 Specification for Nickel-Chromium-Iron Alloys (UNS N06600, N06601, and N06690) and Nickel-Chromium-Cobalt-Molybdenum Alloy (UNS N06617) Rod, Bar, and Wire[3]

E 94 Guide for Radiographic Examination[4]

E 747 Practice for the Design Manufacture and Material Grouping Classification of Wire Image Quality Indicators (IQI) Used For Radiology[4]

E 1025 Practice for Hole-Type Image Quality Indicators Used for Radiography[4]

E 1316 Terminology for Nondestructive Examination[4]

E 1411 Practice for Qualification of Radioscopic Systems[4]

E 2002 Practice for Determining Total Image Unsharpness in Radiology[4]

2.2 *Federal Standards:*

21 CFR 1020.40 Safety Requirements for Cabinet X-ray Systems[5]

29 CFR 1910.96 Ionizing Radiation[5]

2.3 *NIST/ANSI Standards:*

NIST/ANSI Handbook 114 General Safety Standard for Installations Using Non-Medical X-ray and Sealed Gamma Ray Sources, Energies to 10 MeV[6]

2.4 *Other Standard:*[7]

EN 462 – 5 Duplex Wire Image Quality Indicator

EN 13068–1 Radioscopic Testing-Part 1: Qualitative Measurement of Imaging Properties

## 3. Terminology

3.1 *Definitions*—Definitions of terms applicable to this test method may be found in Terminology E 1316.

## 4. Summary of Practice

4.1 It is often useful to evaluate the contrast sensitivity of a penetrating radiation imaging system separate and apart from spatial resolution measurements. Conventional image quality indicators (IQI's), such as Test Method E 747 wire and Practice E 1025 plaque IQIs, combine the contrast sensitivity and resolution measurements into an overall performance figure of merit, other methods such as included in Practice E 2002 do not address contrast specifically. Such figures of merit are often not adequate to detect subtle changes in imaging system performance. For example, in a high contrast image, spatial resolution can degrade with almost no noticeable effect upon overall image quality. Similarly, in an application in which the imaging system provides a very sharp image, contrast can fade



[1] This practice 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] *Annual Book of ASTM Standards*, Vol 02.01.

[3] *Annual Book of ASTM Standards*, Vol 02.04.

[4] *Annual Book of ASTM Standards*, Vol 03.03.

[5] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

[6] Available from American Society for Nondestructive Testing, 1711 Arlingate Plaza, P.O. Box 28518, Columbus, OH 43228-0518.

[7] Available from British Standards Institute, 2 Park Street, London, England W1A2B5.

with little noticeable effect upon the overall image quality. These situations often develop and may go unnoticed until the system performance deteriorates below acceptable image quality limits.

## 5. Significance and Use

5.1 The contrast sensitivity gage measures contrast sensitivity independent of the imaging system spatial resolution limitations. The thickness recess dimensions of the contrast sensitivity gage are large with respect to the spatial resolution limitations of most imaging systems. Four levels of contrast sensitivity are measured: 4 %, 3 %, 2 %, and 1 %.

5.2 The contrast sensitivity gage is intended for use in conjunction with a high-contrast resolution measuring gage, such as the EN 462 – 5 Duplex Wire Image Quality Indicator. Such gages measure spatial resolution essentially independent of the imaging system's contrast sensitivity. Such measurements are appropriate for the qualification and performance monitoring of radiographic and radioscopic imaging systems.

5.3 Radioscopic/radiographic system performance may be specified by combining the measured contrast sensitivity expressed as a percentage with the spatial resolution expressed in millimeters of unsharpness. For the EN 462 – 5 spatial resolution gage, the unsharpness is equal to twice the wire diameter. For the line pair gage, the unsharpness is equal to the reciprocal of the line-pair/mm value. As an example, an imaging system that exhibits 2 % contrast sensitivity and images the 0.1 mm EN 462 – 5 paired wires (equivalent to imaging 5 line-pairs/millimeter resolution on a line-pair gage) performs at a 2 %–0.2 mm sensitivity level. A standard method of evaluating overall radioscopic system performance is given in Practice E 1411 and in EN 13068–1.

## 6. Contrast Sensitivity Gage Construction and Material Selection

6.1 Contrast sensitivity gages shall be fabricated in accordance with Fig. 1, using the dimensions given in Table 1, Table 2, and Table 3.

6.2 The gage shall preferably be fabricated from the examination object material. Otherwise, the following material selection guidelines are to be used:

6.2.1 Materials are designated in eight groupings, in accordance with their penetrating radiation absorption characteristics: groups 03, 02, and 01 for light metals and groups 1 through 5 for heavy metals.

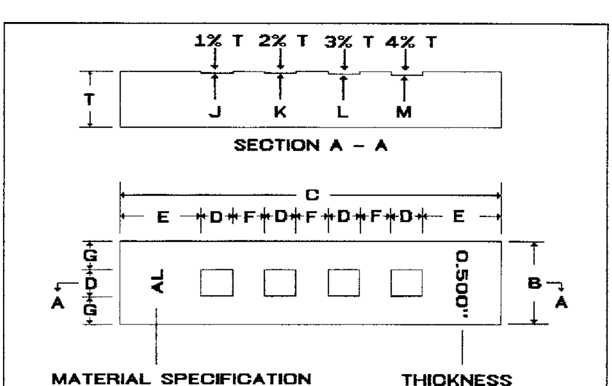


FIG. 1 General Layout of the Contrast Sensitivity Gage

TABLE 1 Design of the Contrast Sensitivity Gage

| Gage Thickness | J Recess | K Recess | L Recess | M Recess |
|---|---|---|---|---|
| T | 1 % of T | 2 % of T | 3 % of T | 4 % of T |

TABLE 2 Contrast Sensitivity Gage Dimensions

| Gage Size | B DIM. | C DIM. | D DIM. | E DIM. | F,G DIM. |
|---|---|---|---|---|---|
| 1 | 0.750 in. | 3.000 in. | 0.250 in. | 0.625 in. | 0.250 in. |
| | 19.05 mm | 76.20 mm | 6.35 mm | 15.88 mm | 6.35 mm |
| 2 | 1.500 in. | 6.000 in. | 0.500 in. | 1.250 in. | 0.500 in. |
| | 38.10 mm | 152.40 mm | 12.70 mm | 31.75 mm | 12.7 mm |
| 3 | 2.250 in. | 9.000 in. | 0.750 in. | 1.875 in. | 0.750 in. |
| | 57.15 mm | 228.60 mm | 19.05 mm | 47.63 mm | 19.05 mm |
| 4 | 3.000 in. | 12.000 in. | 1.000 in. | 2.500 in. | 1.000 in. |
| | 76.20 mm | 304.80 mm | 25.40 mm | 63.50 mm | 25.4 mm |

TABLE 3 Contrast Sensitivity Gage Application

| Gage Size | Use on Thicknesses |
|---|---|
| 1 | Up to 1.5 in. (38.1 mm) |
| 2 | Over 1.5 in. (38.1 mm) to 3.0 in. (76.2 mm) |
| 3 | Over 3.0 in. (76.2 mm) to 6.0 in. (152.4 mm) |
| 4 | Over 6.0 in. (152.4 mm) |

6.2.2 The light metal groups, magnesium (Mg), aluminum (Al), and titanium (Ti) are identified 03, 02, and 01, respectively, for their predominant constituent. The materials are listed in order of increasing radiation absorption.

6.2.3 The heavy metals group, steel, copper base, nickel base, and other alloys are identified 1 through 5. The materials increase in radiation absorption with increasing numerical designation.

6.2.4 Common trade names or alloy designations have been used for clarification of pertinent materials.

6.3 The materials from which the contrast sensitivity gage is to be made is designated by group number. The gage is applicable to all materials in that group. Material groupings are as follows:

6.3.1 *Material Group 03*:

6.3.1.1 The gage shall be made of magnesium or a magnesium alloy, provided it is no more radio-opaque than unalloyed magnesium, as determined by the method outlined in 6.4.

6.3.1.2 Use for all alloys where magnesium is the predominant alloying constituent.

6.3.2 *Materials Group 02*:

6.3.2.1 The gage shall be made of aluminum or an aluminum alloy, provided it is no more radio-opaque than unalloyed aluminum, as determined by the method outlined in 6.4.

6.3.2.2 Use for all alloys where aluminum is the predominant alloying constituent.

6.3.3 *Materials Group 01*:

6.3.3.1 The gage shall be made of titanium or a titanium alloy, provided it is no more radio-opaque than unalloyed titanium, as determined by the method outlined in 6.4.

6.3.3.2 Use for all alloys where titanium is the predominant alloying constituent.

6.3.4 *Materials Group 1*: