Designation: E1025 – 18

Standard Practice for Design, Manufacture, and Material Grouping Classification of Hole-Type Image Quality Indicators (IQI) Used for Radiography[1]

This standard is issued under the fixed designation E1025; 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 practice[2] covers the design, material grouping classification, and manufacture of hole-type image quality indicators (IQI) used to indicate the quality of radiologic images.

1.2 This practice is applicable to X-ray and gamma-ray radiology.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *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:*[3]

B139/B139M Specification for Phosphor Bronze Rod, Bar, and Shapes

B150/B150M Specification for Aluminum Bronze Rod, Bar, and Shapes

B164 Specification for Nickel-Copper Alloy Rod, Bar, and Wire

B166 Specification for Nickel-Chromium-Iron Alloys (UNS N06600, N06601, N06603, N06690, N06693, N06025, N06045, and N06696), Nickel-Chromium-Cobalt-Molybdenum Alloy (UNS N06617), and Nickel-Iron-Chromium-Tungsten Alloy (UNS N06674) Rod, Bar, and Wire

E746 Practice for Determining Relative Image Quality Response of Industrial Radiographic Imaging Systems

E747 Practice for Design, Manufacture and Material Grouping Classification of Wire Image Quality Indicators (IQI) Used for Radiology

E1735 Test Method for Determining Relative Image Quality of Industrial Radiographic Film Exposed to X-Radiation from 4 to 25 MeV

E1316 Terminology for Nondestructive Examinations

E2662 Practice for Radiographic Examination of Flat Panel Composites and Sandwich Core Materials Used in Aerospace Applications

2.2 *Department of Defense (DoD) Documents:*

MIL-I-24768 Insulation, Plastics, Laminated, Thermosetting; General Specification for[4]

2.3 *ISO Documents*[5]

ISO 17636-1 Non-Destructive Testing of Welds – Radiographic testing – Part 1: X- and Gamma-Ray Techniques with Film

ISO 17636-2 Non-Destructive Testing of Welds – Radiographic testing – Part 2: X- and Gamma-Ray Techniques with Digital Detectors

ISO 19232-2 Non-Destructive Testing – Image Quality of Radiographs – Part 2: Determination of the Image Quality Value Using Step/Hole-Type Image Quality Indicators

ISO 19232-3 Non-Destructive Testing – Image Quality of Radiographs – Part 3: Image Quality Classes

[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] For ASME Boiler and Pressure Vessel Code applications see related Practice SE-1025 in Section II of that Code.

[3] 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.

[4] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://dodssp.daps.dla.mil.

[5] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

*A Summary of Changes section appears at the end of this standard

2.4 *ASME Documents:*[6]

BPVC (Boiler and Pressure Vessel Code) Section V Nondestructive Examination, Article 2 Radiographic Examination

3. Terminology

3.1 *Definitions*—The definitions of terms relating to gamma and X-radiology in Terminology E1316, Section D, shall apply to the terms used in this practice.

4. Hole-Type IQI Requirements

4.1 Image quality indicators (IQIs) used to determine radiologic-image quality levels shall conform to the following requirements.

4.1.1 All image quality indicators (IQIs) shall be fabricated from materials or alloys identified or listed in accordance with 7.3. Other materials may be used in accordance with 7.4.

4.1.2 *Standard Hole-Type IQIs:*

4.1.2.1 Standard Hole-Type Image quality indicators (IQIs) shall dimensionally conform to the requirements of Fig. 1.

NOTE 1—Minimum hole diameters are used for standard hole type IQI numbers 1 through 9 where the hole diameters are 0.010 in. for the 1T hole, 0.020 in. for the 2T hole, and 0.040 in. for the 4T hole.

4.1.3 *Modified Hole-Type IQI:*

4.1.3.1 The rectangular IQI may be modified in length and width as necessary for special applications, provided the hole size(s) and IQI thickness conform to Fig. 1 or 4.1.4, as applicable.

4.1.3.2 The IQI's shall be identified as specified in 4.1.5 to 4.1.5.2, as applicable, except that the identification numbers may be placed adjacent to the IQI if placement on the IQI is impractical.

4.1.3.3 When modified IQI's are used, details of the modification shall be documented in the records accompanying the examination results.

4.1.4 *True T-hole Diameter IQI:*

4.1.4.1 It may be desirable for non-film applications to use true T-hole diameter IQI's for numbers 1 through 9.

4.1.4.2 Hole sizes for true T-hole diameter IQI's may be made by using laser or an electric discharge machining (EDM) process and shall be within ±10 % of 1T, 2T, and 4T (See Fig. 1, Note 3 for T)

4.1.4.3 When true T-hole-diameter IQI's are used, details of the modifications shall be documented in the records accompanying the examination results.

4.1.5 Both the rectangular and the circular IQIs shall be identified with number(s) made of lead or a material of similar radiation opacity. The number shall be bonded to the rectangular IQI's and shall be placed adjacent to circular IQI's to provide identification of the IQI on the image. The identification numbers shall indicate the thickness of the IQI in thousandths of an inch, that is, a number 10 IQI is 0.010 in. thick, a number 100 IQI is 0.100 in. thick, etc. Additional identification requirements are provided in 7.2.

4.1.5.1 *Alternative Identification Method*—It may be desirable for non-film applications to eliminate the lead number identifiers and replace them with either material addition or material removal methods as stated below:

(1) Material Addition Method—Numbers may be made of the same material as that of the IQI and of sufficient thickness to be clearly discernable within the radiologic image.

(2) Material Removal Method—Numbers may be cut into the IQI in such a manner as to be clearly discernable in the radiologic image. Processes such as laser etching, chemical etching, precision stamping, etc., may be used to create the numbers within the IQI.

4.1.5.2 Alloy-group identification shall be in accordance with 7.2. Rectangular IQI's shall be notched as shown in Fig. 2, except the corner notch for Group 001 is at a 45 degree angle. Round IQI's shall be vibrotooled or etched as shown in Fig. 3.

4.1.5.3 True T-hole diameter IQI identification numbers shall be rotated 90° as compared to Standard Hole Type IQIs. See Fig. 4.

5. IQI Procurement

5.1 When selecting IQI's for procurement, the following factors should be considered:

5.1.1 Determine the alloy group(s) of the material to be examined.

5.1.2 Determine the thickness or thickness range of the material(s) to be examined.

5.1.3 Determine the Image Quality Level requirements as described in Section 6 and Table 1.

5.1.4 Select the applicable IQI's that represent the required IQI thickness and alloy(s).

NOTE 2—This practice does not recommend or suggest specific IQI sets to be procured. Section 5 is an aid in selecting IQI's based on specific needs.

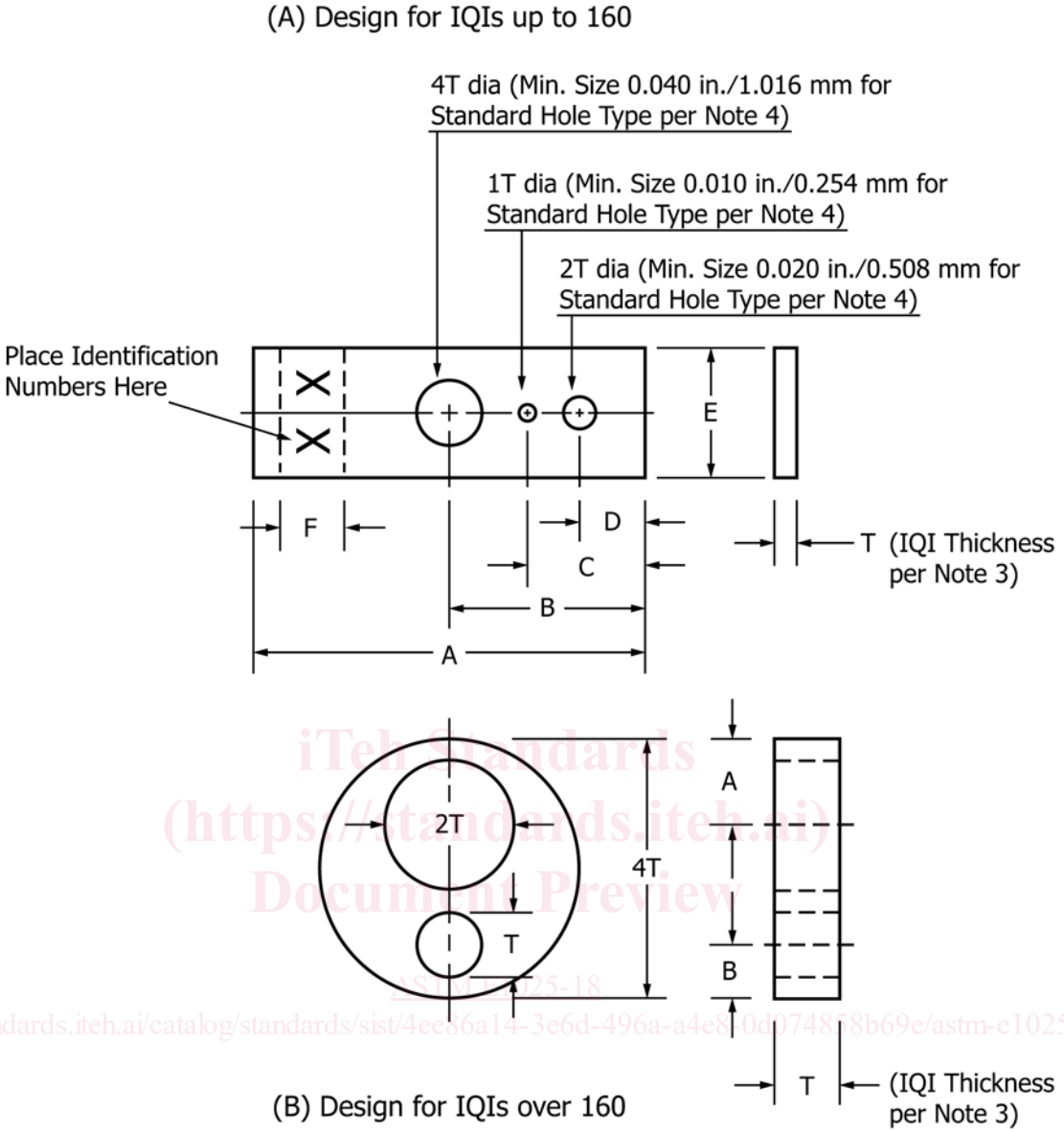
6. Image Quality Levels

6.1 Image quality levels are designated by a two part expression; *X-YT*. The first part of the expression, *X*, refers to the IQI thickness expressed as a percentage of the specimen thickness. The second part of the expression, *YT*, refers to the diameter of the required hole and is expressed as a multiple of the IQI thickness, *T* (for example, the image quality level 2-2*T* means that the IQI thickness, *T*, is no more than 2 % of the specimen thickness and that the diameter of the required IQI hole is 2 × *T*).

NOTE 3—Standard Hole Type Image Quality Indicators (IQI's) less than number 10 have hole sizes 0.010, 0.020, and 0.040 in. diameter regardless of the IQI thickness. Therefore, Standard Hole Type IQI's less than number 10 do not represent the quality levels specified in 6.1 and Table 1. The equivalent IQI sensitivity (EPS) can be calculated using the equation in Appendix X1.

6.2 Typical image quality level designations are shown in Table 1. The level of inspection specified should be based on service requirements of the product. Care should be taken in specifying True T-hole Diameter Type IQI's (4.1.4) and/or image quality levels 2-1*T*, 1-1*T*, and 1-2*T* by first determining that these levels can be maintained in production.

[6] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, http://www.asme.org.



NOTE 1—Tolerances for IQI thickness and hole diameter.
NOTE 2—Tolerances for True T-hole Diameter IQI thickness and hole diameter shall be ±10 %.
NOTE 3—*XX* identification number equals *T* in .001 in..
NOTE 4—IQIs No. 1 through 9 for Standard Hole Type IQI's (4.1.2) are not 1*T*, 2*T*, and 4*T*.
NOTE 5—Holes shall be true and normal to the IQI. Do not chamfer.

Identification Number *T* (Note 4)	A in. (mm)	B in. (mm)	C in. (mm)	D in. (mm)	E in. (mm)	F in. (mm)	Tolerances (Note 3)
1–4	1.500 (38.1) ±0.015 (0.38)	0.750 (19.05) ±0.015 (0.38)	0.438 (11.13) ±0.015 (0.38)	0.250 (6.35) ±0.015 (0.38)	0.500 (12.7) ±0.015 (0.38)	0.250 (6.35) ±0.030 (0.76)	±10%
5–20	1.500 (38.1) ±0.015 (0.38)	0.750 (19.05) ±0.015 (0.38)	0.438 (11.13) ±0.015 (0.38)	0.250 (6.35) ±0.015 (0.38)	0.500 (12.7) ±0.015 (0.38)	0.250 (6.35) ±0.030 (0.76)	±0.0005 (0.127)
21–50	1.500 (38.1) ±0.015 (0.38)	0.750 (19.05) ±0.015 (0.38)	0.438 (11.13) ±0.015 (0.38)	0.250 (6.35) ±0.015 (0.38)	0.500 (12.7) ±0.015 (0.38)	0.250 (6.35) ±0.030 (0.76)	±0.0025 (0.635)
51–160	2.250 (57.15) ±0.030 (0.762)	1.375 (34.93) ±0.030 (0.762)	0.750 (19.05) ±0.030 (0.762)	0.375 (9.53) ±0.030 (0.762)	1.000 (25.4) ±0.030 (0.762)	0.375 (9.53) ±0.030 (0.762)	±0.005 (0.127)
Over 160	1.330T ±0.005 (0.127)	0.830T ±0.005 (0.127)	...	...	...	...	±0.010 (0.254)

FIG. 1 IQI Design

6.3 In specifying image quality levels, the contract, purchase order, product specification, or drawing should state the proper two-part expression and clearly indicate the thickness of the material to which the level refers. In place of a designated

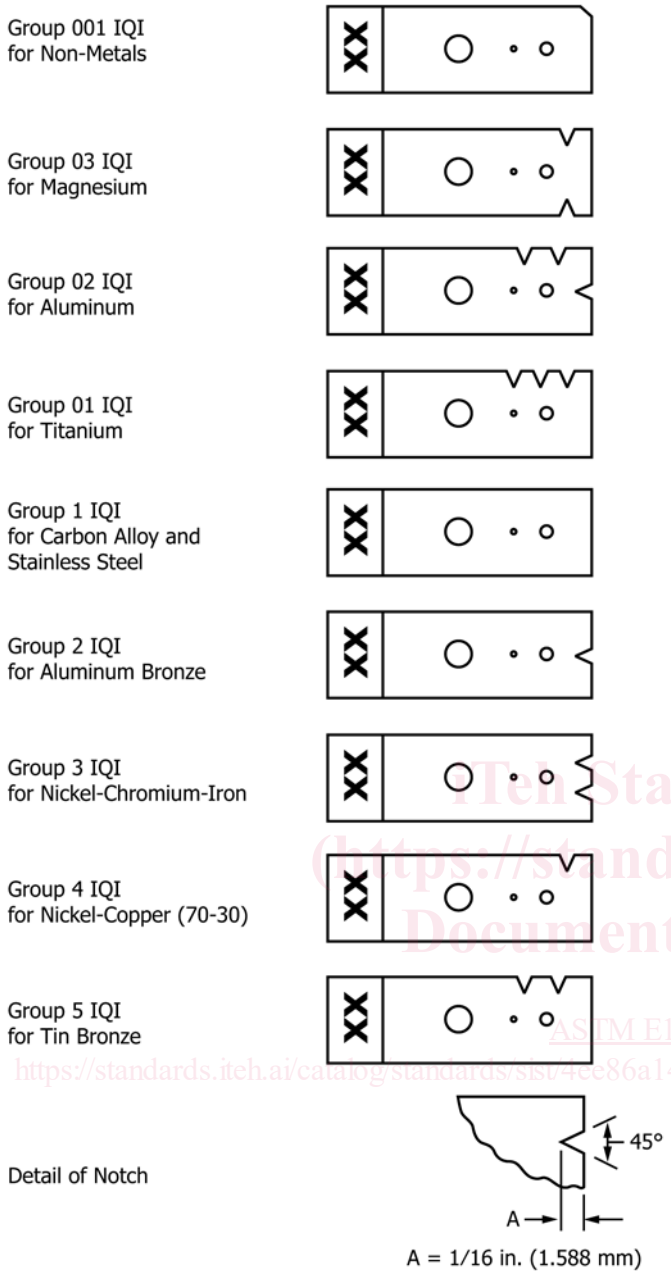


FIG. 2 Rectangular IQI Notch Identification and Material Grouping

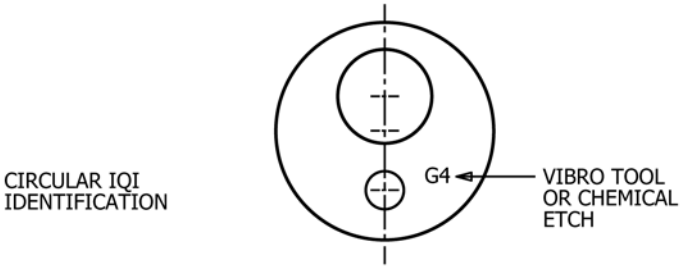


FIG. 3 Circular IQI Identification

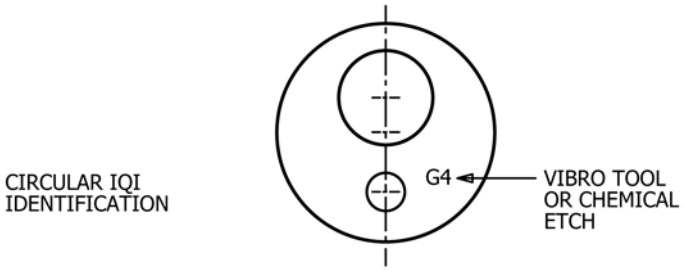


FIG. 4 True T-hole Diameter Type IQI Identification Orientation

TABLE 1 Typical Image Quality Levels

Image Quality Levels	IQI Thickness	Minimum Perceptible Hole Diameter	Equivalent IQI Sensitivity, %[A]
Standard Image Quality Levels			
2-1*T*	1/50 (2 %) of Specimen Thickness	1*T*	1.4
2-2*T*[B]		2*T*	2.0
2-4*T*		4*T*	2.8
Special Image Quality Levels			
1-1*T*	1/100 (1 %) of Specimen Thickness	1*T*	0.7
1-2*T*		2*T*	1
4-2*T*	1/25 (4 %) of Specimen Thickness	2*T*	4

[A] Equivalent IQI sensitivity is that thickness of the IQI, expressed as a percentage of the part thickness, in which the 2*T* hole would be visible under the same conditions.

[B] For *Level 2-2T Radiologic*—The 2*T* hole in an IQI, 1/50 (2 %) of the specimen thickness, is visible.

two–part expression, the IQI number and minimum discernible hole size shall be specified.

6.4 Appendix X1 of this practice provides a method for determining equivalent IQI sensitivity (EPS) in percent. Under certain conditions (as described within the purchaser-supplier agreement), EPS may be useful in relating a discernible hole size of the IQI thickness with the section thickness radiographed for establishing an overall technical image quality equivalency. This is not an alternative IQI provision for the originally specified IQI requirement of this practice, but may be a useful tool for establishing technical image equivalency on a case basis need with specific customer approvals.

6.5 Practice E747 contains provisions for wire IQI's that use varying length and diameter wires to effect image quality requirements. The requirements of Practice E747 are different from this standard; however, Practice E747 (see Table 4) contains provisions whereby wire sizes equivalent to corresponding 1T, 2T and 4T holes for various plaque thicknesses are provided. Appendix X1 of Practice E747 also provides methods for determining equivalencies between wire and hole type IQI's. This is not an alternative IQI provision for the originally specified IQI requirements of this practice, but may be useful for establishing technical image equivalency on a case basis need with specific customer approvals.

6.6 Test Methods E746 and E1735 provide additional tools for determining relative image quality response of industrial radiological systems when exposed to energy levels described within those test methods. Both of these test methods use the "equivalent penetrameter sensitivity" (EPS) concept to provide statistical image quality information that allows the imaging