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Designation: E 801 – 01

An American National Standard

Standard Practice for Controlling Quality of Radiological Examination of Electronic Devices[1]

This standard is issued under the fixed designation E 801; 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.

This standard has been approved for use by agencies of the Department of Defense.

ε[1] NOTE—Section 16 was added editorially in December 1995.

[1] This practice is under the jurisdiction of ASTM Committee E-7 E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.01 on Radiology (X and Gamma) Method.

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1. Scope

1.1 This practice relates to the radiological examination of electronic devices for internal discontinuities, extraneous material, missing components, crimped or broken wires, and defective solder joints in cavities, in the encapsulating materials, or the boards. Requirements expressed in this practice are intended to control the quality and repeatability of the radiological images and are not intended for controlling the acceptability or quality of the electronic devices imaged.

NOTE 1—Refer to the following publications for pertinent information on methodology and safety and protection: Guide E 94, and "General Safety Standard for Installation Using Non-Medical X Ray and Sealed Gamma Ray Sources, Energies Up to 10 MeV Equipment Design and Use," *Handbook No. 114*.[2]

1.2 If a nondestructive testing agency as described in Practice E 543 is used to perform the examination, the testing agency should meet the requirements of Practice E 543.

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:*

E 94 Guide for Radiographic Testing Examination[3]

E 543 Practice for Evaluating Agencies that Perform Performing Nondestructive Testing[3]

E 1000 Guide for Radioscopy[3]

E 1255 Practice for Radioscopy[3]

E 1316 Terminology for Nondestructive Examinations[3]

3. Terminology

3.1 *Definitions*—Refer to Terminology E 1316, Section D.

4. Direction of Radiation

4.1 When not otherwise specified, the direction of the central beam of radiation shall be as perpendicular (±5 %) as possible to the surface of the film.

5. Image Quality Indicators (IQI's)

5.1 The quality of all levels of radiological examination shall be determined by IQI's conforming to the following specifications:

5.1.1 The IQI's shall be fabricated of clear acrylic plastic with steel covers, lead spheres, gold or tungsten wires, and lead numbers. The steel covers serve as shims.

[2] Available from the National Institute of Standards and Technology, Gaithersburg, MD 20899.

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

5.1.1.1 The IQI's shall conform to the requirements of Fig. 1.

5.1.1.2 The IQI's shall be permanently identified with the appropriate IQI number as shown in Fig. 1. The number may be affixed by engraving, steel stamping, or by mounting a 0.125-in. (3.18-mm) tall lead number on the flat bottom of a 0.188-in. (4.78-mm) diameter hole. In any case, the identification shall be located as shown in Fig. 1 and shall be of sufficient contrast to be clearly discernible in the radiological image.

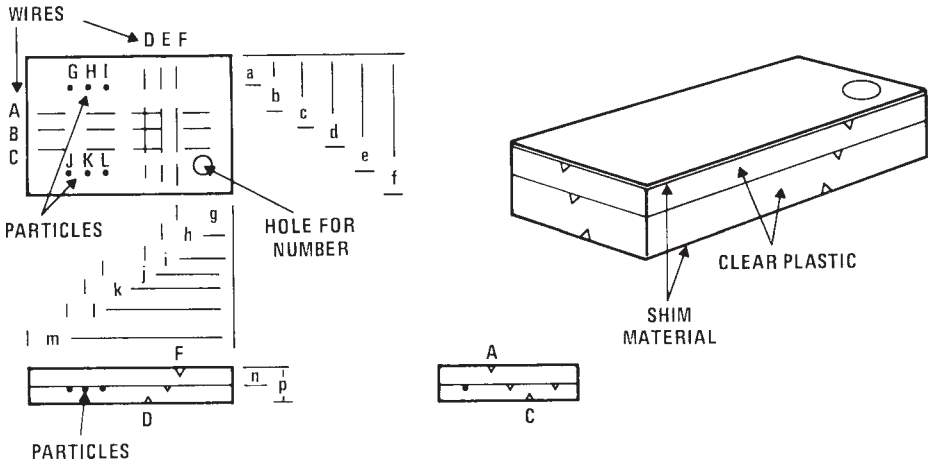


FIG. 1 Image Quality Indicator for Electron Devices

Dimensions, in. (mm)

a.	0.187 (4.750)	f.	1.00 (25.40)	k.	1.125 (28.575)
b.	0.375 (9.525)	g.	0.375 (9.525)	l.	1.313 (33.350)
c.	0.500 (12.700)	h.	0.500 (12.700)	m.	1.50 (38.10)
d.	0.625 (15.875)	i.	0.625 (15.875)	n.	0.125 (3.175)
e.	0.813 (20.650)	j.	0.938 (23.825)	p.	0.250 (6.350)

Particle Diameter, in. (mm)

G.	0.015(0.381)
H.	0.010(0.254)
I.	0.008(0.203)
J.	0.006(0.152)
K.	0.004(0.102)
L.	0.002(0.051)

Shim and Wire Specifications

Penetrameter Number	Shim Thickness, in. (mm)	Wire Diameters, in. (mm)					
		A	B	C	D	E	F
1	0 0	0.002 (0.051)	0.001 (0.025)	0.0005 (0.0127)	0.0005 (0.0127)	0.001 (0.025)	0.002 (0051)
2	0.002 (0.051)	0.002 (0.051)	0.001 (0.025)	0.0005 (0.0127)	0.0005 (0.0127)	0.001 (0.025)	0.002 (0.051)
3	0.005 (0.127)	0.002 (0.051)	0.001 (0.025)	0.0005 (0.0127)	0.0005 (0.0127)	0.001 (0.025)	0.002 (0.051)
4	0.007 0.178	0.002 (0.051)	0.001 (0.025)	0.0005 (0.0127)	0.0005 (0.0127)	0.001 (0.025)	0.002 (0.051)
5	0.010 (0.254)	0.003 (0.076)	0.002 (0.051)	0.001 (0.025)	0.001 (0.025)	0.002 (0.051)	0.003 (0.076)
6	0.015 (0.381)	0.003 (0.076)	0.002 (0.051)	0.001 (0.025)	0.001 (0.025)	0.002 (0.051)	0.003 (0.076)
7	0.025 (0.635)	0.005 (0.127)	0.003 (0.076)	0.002 (0.051)	0.002 (0.051)	0.003 (0.076)	0.005 (0.127)
8	0.035 (0.889)	0.005 (0.127)	0.003 (0.076)	0.002 (0.051)	0.002 (0.051)	0.003 (0.076)	0.005 (0.127)

NOTE 1—Use additional layers of shim material as required. The layers shall be 1 × 2 in. (25.4 × 50.8 mm). The addition shall be identified by the placement of lead numbers which denote the thickness immediately adjacent to the penetrameter numbers during exposure.

NOTE 2—Tolerance is ±0.001 in. (0.025 mm) where dimensions are 0.000 and ±0.003 in. (0.076 mm) where dimensions are 0.00.

NOTE 3—Bond materials together with cyanoacrylic or equivalent fast-drying epoxy.

NOTE 4—Particle holes are 0.031 in. (0.787 mm) nominal diameter.

NOTE 5—Tolerance on particle diameter is + 0.0003 in. (0.0076 mm).

NOTE 6—Wire grooves are 0.007 in. (0.178 mm) depth with 90° inclusive angle.

NOTE 7—The number hole is 0.25 in. (0.635 mm) nominal diameter and 0.125 in. (0.318 mm) deep.

5.1.1.3 Each semiconductor IQI will have a serial number permanently etched or engraved in the upper right-hand corner. Each serial number will be traceable to the calibration image supplied by the manufacturer. The manufacturer will radiograph the IQI with lead markers identifying the serial number. See Fig. 2.

6. Application of the Image Quality Indicator (IQI)

6.1 The application of the IQI's shall be made in such a manner as to simulate as closely as possible the device being examined. To accomplish this objective, a set of eight IQI's is provided. These provide a range of cover thickness (of steel shim stock) that is radiologically equivalent to the range of devices from glass diodes or plastic-encapsulated circuits (number one) to large power or hybrid circuit devices (number eight). Wire size increases with shim stock thickness because the higher power devices, which are radiologically compatible with the thicker coverings, normally use larger interconnecting wires than small signal devices which use the thin coverings. Particle size is normally independent of device type, so these remain constant.

6.2 The IQI used shall be the one whose image has a radiological density or grey level equal to that of the electron device ±10 %. The density or grey level is measured on an area of the IQI image that contains no wire or particle images. It shall be measured using a calibrated densitometer in the case of film, or by pixel grey level value in the case of radioscopic examination. If the IQI having the greatest density (number eight) does not produce a resultant image density within ±10 % of the electron device, additional shim stock shall be used. The shim shall be of the same type of steel as in the IQI and shall be placed under the IQI. The additional shim shall exceed the IQI outside dimensions by at least 0.125 in. (3.18 mm) on all sides. The thickness of the shims shall be noted with lead numerals placed adjacent to the shimmed IQI.

6.3 The distortion shall not exceed 10 % unless a higher or lower percentage is agreed upon between the purchaser and the supplier. Measurements for computation of distortion shall be made in the grid formed by the crossing wires.

6.3.1 Determine percent distortion (Note 2) as follows:

$$D = [(S_M - S_A)/S_A] \times 100$$

where:

D = percent distortion,
S_M = wire spacing as measured on the radiograph, and
S_A = actual wire spacing.

NOTE 2—Distortion may be positive or negative.

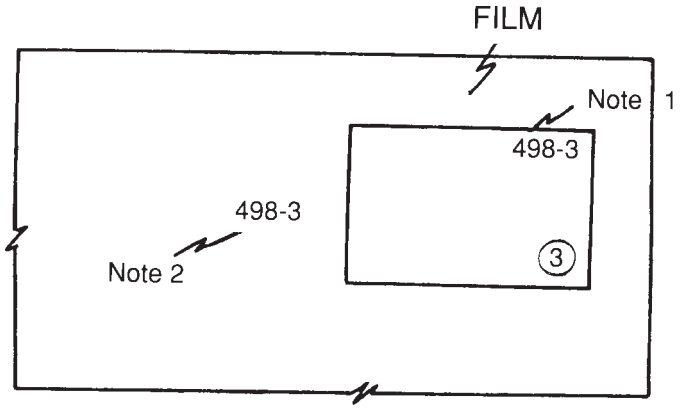
6.4 Particles *G* through *L* shall be visible in the image when IQI's 1 through 7 are used and particles *G* through *K* shall be visible in the image when IQI number 8 is used.

6.4.1 If shims are required, the number and size of particles that can be resolved shall be agreed on between the purchaser and the supplier.

7. Positioning of IQI's

7.1 The IQI's shall be positioned on the source side of the electronic device being imaged. They shall be placed so that the plane of the IQI is normal to the radiation beam if the same provision is made for the device(s) being examined.

7.1.1 The IQI's used for each exposure or field of view shall be positioned at the outer edges of the film or field of view but not impeding the area of interest being examined.



NOTE 1—Permanently etched or engraved serial number.
NOTE 2—⅛ in. lead markers corresponding to serial number.

FIG. 2 Arrangement of IQI and Lead Serial Number for Calibration Image

8. Number of IQI's

8.1 One IQI shall represent an area within which the radiological densities or grey fields do not vary more than ±10 % (Note 3). At least one IQI per field of view or film shall be exposed simultaneously with the specimen, except as noted in 8.1.1-8.1.3 and (Note 4).

8.1.1 When image density or grey level varies more than ± 10 % from that adjacent to the IQI, then an IQI to show acceptable sensitivity at the most dense part of the specimen image and a second IQI to show acceptable sensitivity at the least dense portion of the specimen image, will serve to qualify the image.

8.1.2 *Simultaneous Exposures*—In radiography, when a part or parts of the same design are exposed simultaneously under the same geometrical conditions in a 360° radiation beam, a minimum of one IQI shall be required in each quadrant. Where two IQI's are required, it is acceptable to use the radiographically equivalent IQI and one other IQI having the same wire size.

8.1.3 Two IQI's shall be used for each lot radiographed as shown in Fig. 3. The IQI's shall be located at diagonally opposite corners of the film as shown in Fig. 3. In radioscopic examinations, similar qualification of opposite sides of the field of view (FOV) is required once during examination of similar parts (that is, within ±10 % tolerance).

NOTE 3—Radiographic densities shall be measured with a calibrated densitometer. When films are exposed simultaneously in one film holder, density variations should be determined on the single or combined films, depending on the manner in which they are read and interpreted. Radiographic film density shall be in the range of 1.0 to 3.5.

NOTE 4—For parts of irregular geometry or widely varying thickness, it may be necessary to radiograph the first unit of a given design to determine proper placement of IQI's for subsequent radiography. Similarly, in radioscopic examinations, a dry run will assist with IQI positioning and scan plan development.

9. Part Identification

9.1 In radiography, the image of identification markers for the coordination of the part with the film shall appear on the film, so as not to interfere with the interpretation of the radiograph and so that it is evident that the complete part order was obtained. These marker positions shall coincide with the part number.

9.2 In radioscopy, the image header for each part image shall include a part serial number for traceability and to ensure that the complete part order was obtained.

10. Identification of the Image

10.1 In both radiography and radioscopy, a system of positive identification of the image shall be provided in addition to Section 8. Any or all of the following may appear: the name of the ~~inspecting~~ examining laboratory, the date, the part number, the view, and whether original or subsequent exposure.

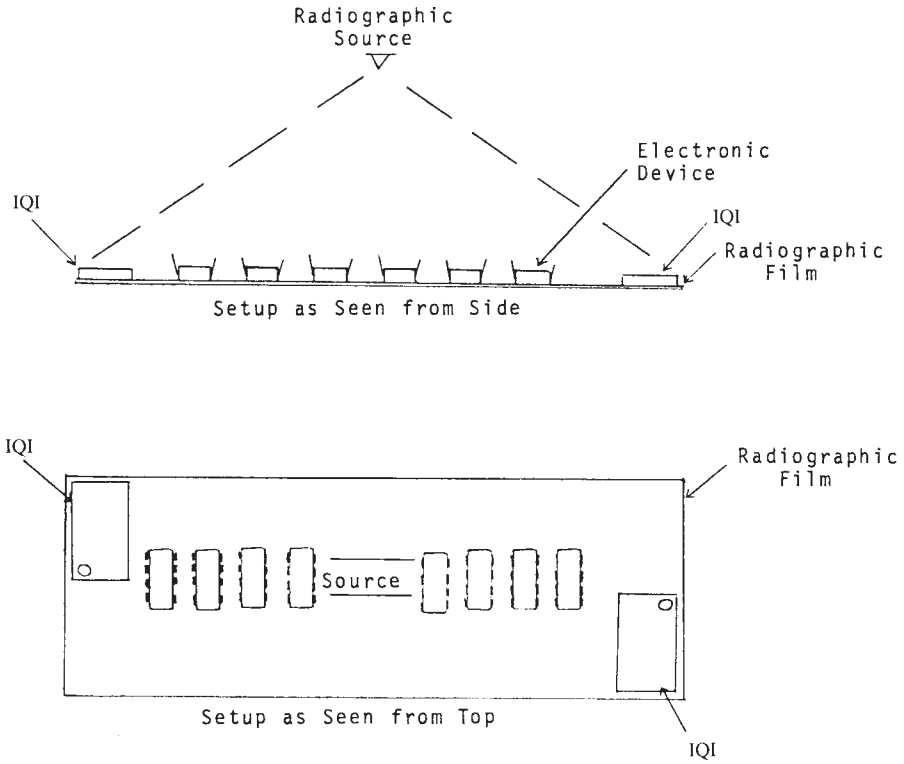


FIG. 3 Typical Image Quality Indicator Arrangement for Electronic Device

11. Multiple-Film Techniques

11.1 Film techniques with two or more films of equal or different speeds in the same holder will be permitted, provided that the appropriate wires and particles in the penetrameter for a specific area are demonstrated.

12. Non-Film Techniques

12.1 The use of non-film imaging techniques will be permitted, provided that the applicable penetrameter wires and particles are demonstrated in the resultant image.

13. Image Quality

13.1 The radiological image shall be free of blemishes that interfere with its interpretation.

14. Source-Film Distance

14.1 Any source-film distance will be satisfactory provided that the required quality level is attained.

15. Records

15.1 Complete records of the technique or scan plan details shall be maintained by the ~~inspecting~~ examining laboratory.

15.2 A calibration image shall be made by exposing the individual semiconductor IQI at the proper distance from the focal spot. The IQI shall be centered in the beam during this exposure. ~~Exposure factor shall be selected to provide a film density (*D*) of 1.0 to 2.0.~~ The certificate shall show the actual dimensions of the grids formed by the cross wires and the parallel variances within the grid. It shall also state the actual size of each particle.

16. Keywords

16.1 electronic devices; IQI's; radiography; radioscopy; shim; wire