~~Designation:E1161–03~~

~~Standard Test Method for~~ Designation: E 1161 – 09

Standard Practice for Radiologic Examination of Semiconductors and Electronic Components[1]

This standard is issued under the fixed designation E 1161; 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

~~1.1This test method provides a standard procedure for nondestructive radiographic examination of semiconductor devices, electronic components, and the materials used for construction of these items. This test method covers the radiographic examination of these items for possible defective conditions such as extraneous material within the sealed case, improper internal connections, voids in materials used for element mounting, or the sealing glass, or physical damage.~~

~~1.2The quality level and acceptance criteria for the specimens being examined shall be specified in the detail drawing, purchase order or contract.~~

~~1.3~~

1.1 This practice provides the minimum requirements for nondestructive radiologic examination of semiconductor devices, microelectronic devices, electromagnetic devices, electronic and electrical devices, and the materials used for construction of these items.

1.2 This practice covers the radiologic examination of these items to detect possible defective conditions within the sealed case, especially those resulting from sealing the lid to the case, and internal defects such as extraneous material (foreign objects), improper interconnecting wires, voids in the die attach material or in the glass (when sealing glass is used) or physical damage.

1.3 The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this practice.

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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E 94 Guide for Radiographic Examination

E 431 Guide to Interpretation of Radiographs of Semiconductors and Related Devices

E 543 ~~Practice~~Specification for Agencies Performing Nondestructive Testing

E 801 ~~Practice for Controlling Quality of Radiological Examination of Electronic Devices[2]~~ Practice for Controlling Quality of Radiological Examination of Electronic Devices

E 666 Practice for Calculating Absorbed Dose From Gamma or X Radiation

E 999 Guide for Controlling the Quality of Industrial Radiographic Film Processing

E 1000 Guide for Radioscopy

E 1079 Practice for Calibration of Transmission Densitometers

E 1254 Guide for Storage of Radiographs and Unexposed Industrial Radiographic Films

E 1255 Practice for Radioscopy

E 1316 ~~Terminology for Nondestructive Examinations[2]~~ Terminology for Nondestructive Examinations

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[1] This ~~test method~~ 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) ~~Methods.~~Method.

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[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* ~~, Vol 03.03.~~volume information, refer to the standard's Document Summary page on the ASTM website.

E 1390 Specification for Illuminators Used for Viewing Industrial Radiographs
E 1411 Practice for Qualification of Radioscopic Systems
E 1453 Guide for Storage of Media that Contains Analog or Digital Radioscopic Data
E 1475 Guide for Data Fields for Computerized Transfer of Digital Radiological Examination Data
E 1742 Practice for Radiographic Examination
E 1815 Test Method for Classification of Film Systems for Industrial Radiography
E 1817 Practice for Controlling Quality of Radiological Examination by Using Representative Quality Indicators (RQIs)
E 2339 Practice for Digital Imaging and Communication in Nondestructive Evaluation (DICONDE)
E 2597 Practice for Manufacturing Characterization of Digital Detector Arrays

2.2 ~~*ASNT Standard:*~~*ANSI Standards:*[3]

ANSI/ESD S20.20 ESD Association Standard for the Development of an Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)

2.3 *ASNT Standard:*[4]

ANSI/ASNT CP-189 Standard for Qualification and Certification of Nondestructive Testing Personnel
SNT-TC-1A Personnel Qualification and Certification

~~2.3~~

2.4 *AIA Documents:*[5]

NAS-410~~Certification and Qualification of Nondestructive Test Personnel~~

~~2.4 *Federal Standard:*~~ *Certification and Qualification of Nondestructive Test Personnel*

2.5 *Department of Defense (DOD) Documents:*[6]

MIL-PRF-28861 Performance Specification—General Specification for Filters, Capacitors, Radio Frequency/Electromagnetic Interference Suppression
MIL-STD-202 Test Method Standard Electronic and Electrical Component Parts
MIL-STD-202, Method 209 Radiographic Inspection
MIL-STD-750 Test Method Standard Test Methods for Semiconductor Devices
MIL-STD-750, Method 2076 Radiography
MIL-STD-883 Test Method Standard Microcircuits
MIL-STD-883, Method 2012 Radiography
MIL-STD-981 Design, Manufacturing and Quality Standards for Custom Electromagnetic Devices for Space Applications

2.6 *Federal Standard:*[6]

FED-STD-595~~Color (Requirements for Individual Color Chits)~~ Color (Requirements for Individual Color Chits)

2.7 *NCRP Documents:*

NCRP 116 Limitation of Exposure to Ionizing Radiation
NCRP 144 Radiation Protection for Particle Accelerator Facilities

3. Terminology

~~3.1*Definitions*—For definitions of terms used in this test method, see Terminology E1316~~

3.1 *Definitions*—Definitions relating to radiological examination, which appear in Terminology E 1316, shall apply to the terms used in this practice.

3.2 *Abbreviations:*

3.2.1 *controlling documentation* —The document or standard that is specified by contractual agreement and lists such items as the examination requirements, number of views, and acceptance criteria. Controlling documentation may be in the form of a purchase order, engineering drawing, Military Standard, etc. or a combination thereof.

3.2.2 *device(s)*—For the purpose of this practice, the term “device” and “devices” shall be used to describe microcircuits, semiconductors, electromagnetic devices, electronic and electrical component parts. Microcircuits include such items as, monolithic, multichip and hybrid microcircuits, microcircuit arrays, and the elements from which these circuits are made. Semiconductors include such items as diodes, transistors, voltage regulators, rectifiers, tunnel diodes and other related parts. Electromagnetic devices include such items as transformers, inductors and coils. Electronic and electrical components include such items as capacitors, resistors, switches and relays. This is not an all inclusive list, therefore, the term “device” or “devices” will be used throughout this practice to refer to the items which are the subject of the radiological examination process.

~~[3] Available from the American Society for Nondestructive Testing, 1711 Arlingate Plaza, P.O. Box 28518, Columbus, OH 43228.~~
[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.
~~[4] Aerospace Industries Association (AIA), 1050 Eye St., NW, Washington, DC 20005.~~
[4] Available from American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518, http://www.asnt.org.
~~[5] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.~~
[5] Available from Aerospace Industries Association of America, Inc. (AIA), 1000 Wilson Blvd., Suite 1700, Arlington, VA 22209-3928, http://www.aia-aerospace.org.
[6] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://www.dodssp.daps.mil.

3.2.3 *micro-bubbles*—A film defect where tiny bubbles in the film's emulsion create white dots on the processed radiograph. Micro-bubbles are unacceptable when they show up in the area of interest of a device because they can be interpreted as extraneous matter (foreign material).

3.2.4 *parallax error effect*—For the purpose of this practice, the term "parallax error effect" will refer to a double image on the radiograph of the device's internal features such as wires or ball bonds. This is caused by the device being too far from the central X-ray beam where the angle of the X-rays creates a double image on double emulsion film.

3.2.5 *pick-off*—An automatic film processing artifact where tiny spots of emulsion are "picked off" of the radiograph as it is moving through the dryer. Pick-off artifacts are unacceptable when they show up in the area of interest of a device because they can be interpreted as extraneous matter (foreign material).

3.2.6 *pre-cap*—Prior to capping or encapsulation.

3.3 *Abbreviations:*

3.3.1 *AWG*—American Wire Gauge

3.3.2 *CEO*—Cognizant Engineering Organization. The company, government agency, or other authority responsible for the design, or end use, of the device(s) for which radiological examination is required. This, in addition to design personnel, may include personnel from electrical engineering, material and process engineering, nondestructive testing (usually the certified Radiographic Level 3), or quality groups, as appropriate.

3.3.3 *DDA*—Digital Detector Array. DDAs are described in Practice E 2597.

3.3.4 *DPA*—Destructive Physical Analysis

3.3.5 *ESD*—Electrostatic Discharge

3.3.6 *ESDS*—Electrostatic Discharge Sensitive

3.3.7 *FDD*—Focal spot to Detector Distance

3.3.8 *FFD*—Focal spot to Film Distance

3.3.9 *FOD*—Focal spot to Object Distance (always measured to the "source side" of the object)

3.3.10 *PIND*—Particle Impact Noise Detection

3.3.11 *RAD*—Radiation Absorbed Dose, the dose causing 100 ergs of energy to be absorbed by one gram of matter

3.3.12 *TLD*—Thermoluminescence Dosimetry

4. Significance and Use

~~4.1This test method is useful for determination of voiding in semiconductor element to header mounting material, glass seal, and lid seal areas. It is also useful for examination of the internal cavities of devices for extraneous material, wire dress, and bond placement for unattached elements.~~

4.1 This practice establishes the basic minimum parameters and controls for the application of radiological examination of electronic devices. Factors such as device handling, equipment, ESDS, materials, personnel qualification, procedure and quality requirements, reporting, records and radiation sensitivity are addressed. This practice is written so it can be specified on the engineering drawing, specification or contract. It is not a detailed how-to procedure and must be supplemented by a detailed examination technique/procedure (see 9.1).

4.2 This practice does not set limits on radiation dose, but does list requirements to limit and document radiation dose to devices. When radiation dose limits are an issue, the requestor of radiological examinations must be cognizant of this issue and state any maximum radiation dose limitations that are required in the contractual agreement between the using parties.

5. ~~Basis of Application~~

~~5.1The following items are subject to contractual agreement between the parties using or referencing this standard.~~

~~5.1.1~~*Qualification*

5.1 *Personnel Qualification*—If specified in the contractual agreement, personnel performing examinations to this ~~standard~~ practice shall be qualified in accordance with a nationally or internationally recognized NDT personnel qualification practice or standard such as ~~ANSI/ASNT-CP-189~~ANSI/ANST CP-189, SNT-TC-1A~~, NAS-410, or a similar document and certified by the employer or certifying agency, as applicable. The practice or standard used and its applicable revision shall be identified in the contractual agreement between the using parties.~~

~~5.1.2*Qualification of Nondestructive Testing Agencies*—If specified in the contractual agreement, NDT agencies shall be qualified and evaluated as described in Practice E543. The applicable edition of Practice E543 shall be specified in the contractual agreement.~~

~~5.1.3*Surface Preparation*—The pre-examination surface preparation criteria shall be as specified in the contractual agreement.~~

~~5.1.4*Timing of Examination*—The timing of examination shall be as specified in the contractual agreement.~~

~~5.1.5*Extent of Examination*—The extent of examination shall be in accordance with paragraph 9.2.1.1 or 9.2.1.2 unless otherwise specified.~~

~~5.1.6*Reporting Criteria/Acceptance Criteria*—Reporting criteria for the examination results shall be as specified in the contractual agreement. Since acceptance criteria (for example, for reference radiographs) are not specified in this standard, they shall be specified in the contractual agreement.~~

~~5.1.7*Reexamination of Repaired/Reworked Items*—Reexamination of repaired/reworked items is not addressed in this standard~~

~~and if required shall be specified in the contractual agreement.~~ , NAS-410, or similar document and certified by the employer or certifying agency, as applicable. The practice or standard used and its applicable revision shall be identified in the contractual agreement between the using parties. When examining devices to DOD requirements (see 2.5), NAS-410 shall be the required standard.

5.2 *Qualification of Nondestructive Testing (NDT) Agencies*—When specified in the contractual agreement, Nondestructive Testing agencies shall be qualified and evaluated as described in Practice E 543.

5.2.1 *Safety*—The NDT facility shall present no hazards to the safety of personnel and property. NCRP 144, NCRP 116 may be used as guides to ensure that radiological procedures are performed so that personnel shall not receive a radiation dose exceeding the maximum safe limits as permitted by city, state, or national codes.

6. ~~Apparatus~~ Equipment

6.1 *Radiation Source*—~~Only X-radiation generating equipment shall be used. It shall provide the proper quality level and film density when used in accordance with this test method.~~ —Only X-ray generating equipment shall be used. Such factors as focal spot size, inherent filtration, accelerating voltage and tube current shall be considered when choosing the proper X-ray source. The X-ray source and exposure parameters shall not cause damage to the device(s) under examination. The suitability of these exposure parameters shall be demonstrated by attainment of the required radiological quality level and compliance with all other requirements stipulated in this practice.

6.1.1 *Focal Spot*—The focal spot size shall be such that the ~~resolution~~ radiological quality level specified in ~~9.4~~10.3 can be achieved.

6.2 ~~*Radiographic Viewer*, capable of resolving a flaw of 0.025 mm at a density of 1.0 to 2.0.~~ Non-Film Systems—Radioscopy systems designed specifically for the examination of electronic devices are generally the alternative to film based radiography. However, DDA based systems may also be used.

6.2.1 The suitability of any non-film radiological system shall be demonstrated by attainment of the required radiological quality level and compliance with all other applicable requirements stipulated in this practice.

6.2.2 When specified in the controlling documentation, non-film radioscopy systems shall be operated in accordance with Practice E 1255 and qualified in accordance with Practice E 1411. Other types of non-film systems operaating procedures and qualification procedures shall be agreed upon between the using parties.

6.2.3 X-ray systems shall be characterized for their radiation dose rate using a calibrated dosimeter. The dose rate shall be identified at distances to be used during examination so safe limits can be established to ensure devices under examination are not subject to excessive levels of radiation. Dose rate characterization shall be performed with and without filters (see 6.13) to establish best practices between radiological quality levels and total dose during examination. All exposure information shall be tracked and recorded in the examination record (see 11.1).

6.3 *Film Viewers*—Viewers used for film interpretations shall meet the following minimum requirements:

6.3.1 The light source shall have sufficient intensity to enable viewing of film densities in the area of interest.

6.3.2 Film viewers procured to or meeting the requirements of Guide E 1390 are acceptable for use.

6.3.3 Low intensity film viewers such as fluorescent 14 by 17-in. illuminators, shall be equipped with daylight fluorescent bulbs.

6.3.4 All film viewers shall be tested for and posted with the maximum readable density in accordance with Practice E 1742, Figure 2 and subsection 6.27.4.

6.3.5 Film viewers shall be kept clean and viewing surfaces shall be free of scratches or other defects that will interfere with proper film interpretation.

6.4 *Holding Fixtures*, ~~capable of holding specimens in the required positions without interfering with the accuracy or ease of interpretation.~~

~~6.4*Lead-Topped Tables*—Perform all semiconductor and electronic component radiographic examination on a lead-topped table. The lead shall be at least 1.5 mm thick.~~ —Holding fixtures shall be capable of holding specimens in the required positions without interfering with the accuracy or ease of image interpretation. Holding fixtures shall not be made of materials that will create undesirable secondary radiation that will reduce image clarity. Holding fixtures shall be clean of debris that can interfere with image interpretation by appearing on the radiograph or radiological image and be confused with that of any defect. Holding fixtures shall not cause damage to the devices under examination and shall be compliant with any special handling requirements including ESD precautions.

6.5 *Lead-Topped Tables*—When performing film radiography, a lead-topped table with at least 0.062 in. of lead shall be used. The lead shall be smooth, and with out any gouges or scratches that will cause undesirable image artifacts. Lead vinyl or lead rubber may be used in lieu of lead. Tape or other low density materials used to cover the lead topped table shall not be allowed unless directly related to ESD protection.

6.6 *Film Holders*—~~Film holders and cassettes shall be light tight. They may be flexible vinyl, plastic, or other durable material.~~

~~6.6*IQI's*, shall be in accordance with Practice E801.~~ —Film holders and cassettes shall be light tight. They may be flexible vinyl, plastic, or other durable material. Vacuum cassettes are preferred in order to keep the device(s) as close to the film as possible. The suitability of any film holder shall be such as to comply with any special handling requirements including ESD precautions and their suitability shall be demonstrated by attainment of the required radiological quality level and compliance with all other requirements stipulated in this practice.

6.7 ~~*Density Measurement Apparatus*— Use a densitometer capable of repeatable measurements within 0.02 density units and step wedge comparison films.~~ Lead Foil Screens—When ESD mats are used on top of the lead topped exposure table, the film holder shall be equipped with a lead foil back screen of adequate thickness to protect the film from backscatter. Lead foil backing screens shall be 0.010 in. minimum thickness. Lead foil screens shall be free of blemishes such as cracks, creases, scratches or foreign material that will cause undesirable non-relevant image artifacts on the radiograph.

6.8 *Image Quality Indicators (IQIs)*— IQIs shall be in accordance with Practice E 801. RQIs may be used in place of IQIs and shall comply with 6.9.

6.8.1 *Shims*—Shims shall be used with IQI's in order to achieve the density requirements in 10.1 and 10.4. Shims shall be made of stainless steel or radiographically similar material.

6.9 *Representative Quality Indicators (RQIs)*—When RQIs are used in place of IQIs, they shall be similar in construction to the device being examined. RQIs may have natural or artificial defects similar to those that are expected to occur in the device being examined, or may be of acceptable construction with an AWG number 48 (0.001 in.) tungsten wire mounted across the body. RQIs that conform to Practice E 1817 are acceptable for use. Details of the design of RQIs and all features that must be demonstrated on the radiological images shall be documented and these records shall be kept on file and available.

6.10 *Densitometer*—Where film radiography is performed, a densitometer shall be available to check film densities. The densitometer shall be capable of measuring the light transmitted through a radiograph with a film density up to the maximum allowed by 10.4 or any higher film densities determined suitable for use by the CEO. Densitometers shall be operated and calibrated in accordance with Practice E 1079.

6.11 *Magnifiers*—Magnifiers shall be available to provide magnification between 6× to 25× to aid in interpretation and determine indication size, as applicable.

6.12 *ESD Equipment*—ESD equipment such as ESD monitoring systems, wrist straps and grounding cords, lab coats, and ESD work surfaces shall be available to comply with all ESD precautions and requirements.

6.13 *Filters*—Filter material used for X-ray beam hardening shall have an atomic number (Z) in the range from 29 to 35. Pure copper (Z=29) or pure Zinc (Z=30) are preferred. Other materials may be used when approved by the Radiographic Level 3 and/or CEO. Layering of these materials may be used as well; however, the order in which the materials are layered shall be documented in the radiological examination technique procedure (see 9.1).

7. Materials

7.1 ~~*Films*—Films used for radiographic examination of semiconductors and electronic components must be very fine grain. The grain must be fine enough to permit resolution of discontinuities that are 0.025 mm.~~

~~7.2*Non-Film Techniques, When Specified*—The use of non-film techniques is permitted if agreed upon between purchaser and supplier and the equipment is capable of producing results of equal quality when compared with film techniques, and all requirements of this test method are complied with, except those pertaining to the actual film. Types of permanent records using non-film techniques if required are, for example, digital magnetic tape or disc, video tape, and photograph of video image.~~ ESD Materials—ESD materials such as electrically conductive bags, ESD compliant tape, and other ESD approved materials shall be available as required to aid in the radiological examination process and comply with all ESD handling and storage requirements.

7.2 *Film*—Only film systems meeting the Class I (or better) requirements of ASTM E 1815 shall be used. Radiographic film may be single or double emulsion; however, single emulsion film is preferred and required when parallax error effects cause double images of very small features (for example, interconnecting wires). Radiographic film shall be free of inherent defects, such as micro-bubbles, that will interfere with film interpretation or could be confused as defects in the device under examination.

7.2.1 *Non-Film Recording Media*—The use of recording medium such as CD-ROMs and DVDs are allowed, provided the proper image clarity and definition can be demonstrated. Media storage and handling, when in accordance with Guides E 1453 and E 1475, is acceptable for use.

7.3 *Film Processing Solutions*—Radiographs shall be processed in solutions specifically formulated for industrial radiographic film systems and shall be capable of consistently producing radiographs that meet the requirements of this practice. The time and temperature for film immersion shall be within the manufacturer's recommended range.

8. ~~Calibration~~

~~8.1The step wedge comparison films used for densitometer calibration shall be currently calibrated with traceability to the National Institute of Standards and Technology.~~ Precautions

8.1 *Electrostatic Discharge*— – Unless otherwise specified, all devices (except those identified for DPA testing) shall be treated as ESDS. The NDT Agency shall have an ESD program that complies with ANSI/ESD S20.20. ESD protocol shall be used when performing radiological examinations to this practice. A procedure shall be established and recorded that will protect the device(s) from ESD damage during radiological examination. The ESD radiological procedure shall be approved by the ESD CEO.

8.1.1 When performing examinations on a lead topped table, the table top shall meet the requirements for an ESD work surface. An approved ESD mat may be used on the lead topped table; however, the film holder shall contain sufficient back screens to protect the film from backscatter as required in accordance with 6.6.

8.1.2 When performing film based examinations, when the film holder is not an approved ESD material, the film holder may

be placed in an approved ESD bag such that the device(s) are never placed on non-conductive material. Other methodologies are allowed when approved by the ESD CEO.

8.1.3 When performing non-film based radiology, the system shall be designed such that the device(s) is never placed on a non-conductive surface that would violate ESD protocol.

8.2 *Radiation Dose Control*—Unless otherwise specified, all silicon based devices shall be considered radiation sensitive, precautions shall be taken to minimize radiation dose during radiological examinations to reduce the possibility of radiation damage. A general rule is that "active" devices are radiation sensitive and "passive" devices are not radiation sensitive (for example, active devise=microcircuit, passive device=transformer). When in doubt, always treat devices as radiation sensitive. Devices are exempt from this Section's requirements only when noted on the controlling documentations.

8.2.1 *Filters*—Filters shall be used to harden the X-ray beam to reduce total radiation dose to the device(s). As a minimum, a thickness of 0.005 in. pure copper or pure zinc filter shall be placed at the X-ray tube window to harden the X-ray beam when performing film radiography. When performing geometric enlargement techniques with the device very close to the focal spot (for example, micro-focus X-ray tube/DDA), secondary radiation from the filter may increase the dose to the device; in such cases proper filtering shall be determined prior to the actual examination by the Radiographic Level 3 or CEO. Other materials and thicknesses may be used when it is demonstrated that improvement in the radiological quality level is attained or further reduction in radiation dose is an overriding factor.

8.2.2 *Shielding*—When inspecting a large assembly with many installed devices, such as a printed circuit board, areas that are not under examination shall be masked with lead shielding. Prop lead shielding up on blocks or other means so the weight of the lead shielding does not damage the assembly.

8.2.3 *Exposure Time and Distance :*

8.2.3.1 Minimize the exposure time where practical:

(1) When developing the examination technique, use only one device for technique experimentation when there is more than one device in the lot to be examined.

(2) Limit re-radiography, that is, do not re-expose the entire lot when only one device needs re-radiography.

(3) Do not leave any devices in the exposure area that are not currently being examined.

(4) When performing non-film radiology, and when practical, minimize the dose by capturing a static image of the device rather than performing image interpretation with the radiation source continuously irradiating the device.

8.2.3.2 For non-film applications where geometric enlargement is necessary, limit the geometric magnification to the minimum required to achieve an acceptable examination (see 10.11.1). By keeping the distance of the device as far as possible from the focal spot, total radiation dose can be reduced.

8.2.4 *Calculating Radiation Dose*—When specified in the controlling documentation, radiation dose shall be monitored by using TLD in accordance with Practice E 666, or when allowed, the dose may be estimated when using non-film systems that have had their radiation output characterized and documented as required in 6.2.3.

8.2.5 X-ray voltage shall not exceed 160 kV. Although higher voltages may be necessary to penetrate certain packages, these levels may be damaging to some device technologies. Higher voltages shall only be used when approved by the manufacturer or CEO.

8.3 *Handling*:

8.3.1 *Pre-Cap Examination*—When performing examination at the pre-cap level, special precautions shall be taken to prevent damage of internal components. Care shall be taken to not touch the inside area of the device. When practical, leave the device in its protective carrier unless it will interfere with complete coverage or reduce the radiological quality level (Pre-cap protective carriers often have a plastic lid in place to protect the interior of the device).

8.3.2 *Final examination*—When practical, leave the device in its protective carrier unless it will interfere with complete coverage or reduce the radiological quality level (Sealed devices may be installed in protective carriers to prevent damage to external leads).

8.4 *Exposure Areas*—Exposure areas shall be kept clean and free of debris that can interfere with the examination process. Exposure areas shall not be located where particulate contamination can be introduced into the interior of the device (when performing pre-cap examinations) or on the exterior of the device where it would show up as extraneous matter on the resulting radiological image.

8.5 Whenever practical, prior to radiological examination, examine the exterior of the device with magnification between 6× and 25× to verify no debris is present on the exterior of the case.

9. Procedure

~~9.1Select or adjust the X-ray exposure factors, voltage, milliampere setting, and time settings as necessary to obtain satisfactory exposures and image detail within the sensitivity requirements for the device or defect features toward which the radiographic examination is directed. The X-ray voltage shall be the lowest consistent with these requirements and shall not exceed 150kV.~~

~~9.2*Mounting and Views*—Mount the devices in the holding fixture so that the devices are not damaged or contaminated and are in the proper plane as specified. The devices may be mounted in any type of fixture and masking with lead diaphragms or barium clay may be employed to isolate multiple devices. The fixtures or masking materials must not block the view from the X-ray source to the film of any portion of the body of the device that requires examination.~~