INCH-POUND
MIL-STD-202-209A
6 September 2019
SUPERSEDING
MIL-STD-202-209
18 April 2015

DEPARTMENT OF DEFENSE

TEST METHOD STANDARD

METHOD 209, RADIOGRAPHIC INSPECTION

AMSC N/A

FSC 59GP

FOREWORD

1. This standard is approved for use by all Departments and Agencies of the Department of Defense.

2. This entire standard has been revised. This revision has added requirements for real time radiographic inspection.

3. Comments, suggestions, or questions on this document should be emailed to std202@dla.mil or addressed to: Commander, Defense Logistics Agency, DLA Land and Maritime, ATTN: VAT, P.O. Box 3990, Columbus, OH 43218–3990. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at https://assist.dla.mil.

CONTENTS

METHOD 209
RADIOGRAPHIC INSPECTION

1. SCOPE

1.1 Purpose. Radiographic inspection is generally a nondestructive (see 1.2) method for detecting internal physical defects in small component parts which are not otherwise visible. Radiographic techniques are intended to reveal such flaws as improper positioning of elements, voids in encapsulating or potting compounds, inhomogeneities in materials, presence of foreign materials, broken elements, etc.

NOTE: For certain device types, opacity of the construction materials (packages or internal attachment) may effectively prevent radiographic identification of certain types of defects from some or all possible viewing angles. This factor should be considered in relation to the design of each device when application of this test method is specified.

1.2 Precautions. Radiographic inspection may be performed on most parts; however, radiation may cause changes in electrical behavior of some materials.

2. APPLICABLE DOCUMENTS

Not applicable

3. DEFINITIONS

3.1 Device Under Test (DUT). The microelectronic device that is the subject of the radiographic examination.

3.2 Digital radiography. For purposes of this test method, digital radiography is defined as a radiographic examination using x-ray as the source whereby the image is translated into digital data that is passed through an information processing algorithm to be transferred to a viewing media such as a display or monitor. It differs from film radiography, which is a direct transfer of the image onto film.

3.3 DUT lot. Multiple devices, all of the same type, that have been manufactured in a single production run and sequentially being tested as a group.

3.4 Dynamic Radiography. See 3.7, Real Time Radiography. In this test method the terms are interchangeable.

3.5 Image Quality Indicator (IQI). A device manufactured with known conditions to be used to judge image quality. An IQI is a standard used for the purpose of qualifying/calibrating the apparatus. An IQI has built-in physical properties that can be used to adjust system parameters for best imagingresults.

3.6 Qualified Test Personnel. An individual trained on the apparatus being used for radiography, and who is qualified to image or inspect. Personnel involved in acquisition or interpretation of radiographic images should have training in radiographic imaging procedures and techniques so that defects revealed by this method can be validly interpreted and compared with applicable standards. Training should be specific to the radiographic system (film or digital) as well as DUT design and failure criteria. The company employing the test personnel should have a documented training program and will qualify test personnel internally.

3.7 Real Time Radiography. For purposes of this test method, digital radiography is defined as a radiographic examination using x-ray as the source whereby the image is translated into digital data that is passed through an information processing algorithm to be transferred to a viewing media such as a display or monitor. It differs from film radiography, which is a direct transfer of the image onto film.

3.8 Representative Quality Indicator (RQI). Similar to an IQI, an RQI is a device manufactured with known conditions to be used as a representative object for the DUT. An RQI is a device manufactured for the purpose of qualifying/calibrating the apparatus. An RQI has built-in physical properties that can be used to adjust system parameters for best imaging results.

3.9 Static Radiography. The acquisition of images where the DUT is at rest, or fixed in location, resulting in a single distinct image about a predetermined area, axis, and depth.

3.10 Computed Radiography (CR). A two-step radiological imaging process; first, a storage phosphor imaging plate is exposed to penetrating radiation; second, the luminescence from the plate's photo stimulate-able luminescent phosphor is detected, digitized, and presented via an image display monitor. CR is a film replacement technology. Computed Radiography is not recommended for this method due to inherent artifacts present in the imaging plates that will appear as extraneous matter in the DUT.

3.11 Lp/mm. Abbreviation for line pairs per millimeter

4. GENERAL REQUIREMENTS

4.1. Film apparatus and materials.

4.1.1 Radiographic equipment. The radiographic equipment used shall be capable of producing the required radiographic quality as specified in the individual specification. When using X-ray equipment, X-ray tubes with small effective focal-spot sizes and low inherent filtration are recommended.

4.1.2 Film holder. A lightproof film holder of low inherent filtration to radiation is recommended when using voltages of 50 kilovolts. A lead backing plate should be used behind the film holder to minimize fogging due to secondary back-scatter.

4.1.3 Image-quality indicator. The image-quality indicators used to indicate radiographic sensitivity shall be as specified in the individual specification. The sensitivity is the combined measure of the definition and contrast of the radiograph and should be such that the maximum allowable defect shall be shown. The image-quality indicator may be made from a sample part of the same type as the part being radiographed and should contain either an actual or simulated defect which is at least 10 percent smaller than the smallest defect to be detected.

4.1.4 Film. The film shall be compatible with the sensitivity required in 4.1.1. In general, finer detail is achieved by the use of finer grain films with lower exposure indexes. If extreme magnification techniques are required, the use of single emulsion films is recommended.

4.2 Digital apparatus and materials.

4.2.1 Radiographic equipment. The equipment used in this examination will have sufficient voltage, focal spot, and resolution to provide an image of the DUT in accordance with paragraph 4.4.4.1.

NOTE: Computed radiography is not an acceptable radiographic method for electronic components.

4.2.2 Radiographic parameters. Radiographic parameters of the digital x–ray apparatus shall provide appropriate image quality such that all defects specified in individual specification are readily apparent.

4.2.3 Holding fixtures. Holding fixtures may be used if they are capable of holding devices in the required positions without interfering with the accuracy or ease of image interpretation.

4.2.4 Electrostatic Discharge (ESD). The system and any holding fixtures used shall be ESD safe and used in compliance with applicable ESD protocol if devices are ESD sensitive.

4.2.5 Quality Indicators. The image-quality indicators used to indicate radiographic sensitivity shall be as specified in the individual specification. The sensitivity is the combined measure of the definition and contrast of the radiograph and should be such that the maximum allowable defect shall be shown. The image-quality indicator may be made from a sample part of the same type as the part being radiographed and should contain either an actual or simulated defect which is at least 10 percent smaller than the smallest defect to be detected.

4.2.6 Line Pair Gauge. A Line Pair Gauge with a minimum line pair spacing of 20 line pairs per mm shall be used to judge the quality of the system output.

4.2.7 Filters. Filters may be used to harden the x-ray beam to reduce radiation dose. See 6.1 for guidance.

4.3. Film procedure.

4.3.1 Positioning of specimen. The leaded film holder is backed up by the lead plate (see 4.1.2), and the specimen to be radiographed shall be placed in the position or positions specified in the individual specification.

4.3.2 Exposure parameters. The following exposure parameters may be varied to obtain the radiographic quality specified in 4.1.1:

a. Source - film distance.

b. Kilovoltage or type of isotope.

c. Milliamperage or source strength of isotope.

d. Exposure time.

e. Film speed.

f. Intensifying screen.

The detail sensitivity is affected by the following:

a. Focal spot size.

b. Film grain size.

c. Nature of the specimen.

d. Placement of the specimen.

The above factors should be taken into consideration when determining the exposure parameters.

4.3.3 Intensifying screens. In general, metallic intensifying screens should be used at X-ray tube voltages above 125 kilovolts to minimize fogging and for intensifying effects.

4.3.4 Identification of radiographs. Suitable means shall be employed to identify individual specimens on the radiographic record.

4.3.5 Marking of radiographed specimens. If required, suitable marking shall be specified in the individual specification indicating that specimens have been inspected radiographically.

4.4 Digital procedure. The X-ray exposure factors; voltage, current, exposure time and magnification settings shall be selected or adjusted as necessary to obtain satisfactory exposures and achieve maximum image details within the sensitivity requirements for the device or defect features the radiographic test is directed toward.

NOTE: For certain device types, opacity of the construction materials (packages or internal attachment) may effectively prevent radiographic identification of certain types of defects from some or all possible viewing angles. If the best attempt to obtain a clear image results in the inability of the radiographer to clearly see some or all of the rejectable criteria, this shall be noted as an exception on the inspection report and certificate of compliance.

4.4.1 Mounting and views. The devices shall be mounted 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 may be employed to isolate multiple specimens provided the fixtures or masking material do not block the view from X-ray source to the film or detector of any portion of the body of the device.

4.4.1.1 Views. When the required view(s) show internal feature(s) that require a different viewing axis for verification and disposition of a failure mode specified in this test method, then additional views (either Z or X direction) shall be taken as record of the disposition.

4.4.1.1.1 Flat packages, dual-in-line packages, hybrid packages, and single ended cylindrical devices. Flat packages, dual-in-line packages, hybrid packages, and single ended cylindrical devices, unless otherwise specified, shall have one view taken with the X-rays penetrating in the Y direction. The DUT shall be positioned in such a manner relative to the film or detector to avoid image distortion.

4.4.1.1.2 Stud-mounted and cylindrical axial lead devices. Stud-mounted and cylindrical axial lead devices, unless otherwise specified, shall have one view taken with the X-rays penetrating in the X direction. The DUT interface shall be positioned in such a manner relative to the film or detector to avoid image distortion.

4.4.1.1.3 Additional views. When required, additional views may be used to resolve internal features.

4.4.2 Digital image quality indicators. Prior to performing imaging on a DUT Lot, the radiographic examination system shall be sampled using the IQIs or RQIs prescribed in the DUT Specific Technique (4.4.4.1). These images collected prior to the DUT Lot imaging shall be saved for comparison with images of the same IQIs or RQIs taken following the DUT Lot imaging. Grayscale values of the IQI/RQI images collected post-DUT Lot imaging shall be within ±15% of the grayscale values of the reference image collected prior to DUT Lot imaging and all features of interest in the IQI or RQI shall be visible in the images collected before and after DUT Lot imaging. If the IQI/RQI images collected before and after DUT Lot imaging do not meet these requirements, it shall be presumed that the radiographic examination system conditions have been altered from the pre-DUT Lot imaging set up and the DUT Lot imaging shall be performed again after proper adjustments are made.

4.4.2.1 DPA/FA IQI/RQI Samples. Post inspection images of IQI or RQI is not required, however, when the imaging equipment is shut down for any reason (e.g., end of shift), additional IQI or RQI images shall be captured prior to continuing inspections.

4.4.3 Radiographs and marking.

4.4.3.1 Digital Radiographs/Radiographic Images. Procedures and techniques developed from the DUT specific technique (see 4.4.4.1) shall be used for radiographic exposure/imaging. Images shall be acquired using static radiography, unless dynamic (real-time) radiography is specified in the contract. Images shall be maintained and stored for archive in an electronic data file format that does not reduce the resolution or bit depth of the original image (loss-less file type). The following information shall be permanently associated with the archived image file. This may be achieved by annotating the image with the information, by including all information in the file name, or by including a reference text file with image file correlation.

a. Device manufacturer's name or code identification number, if X-ray laboratory is other than device manufacturer.

b. Device type or Part or Identifying Number.

c. Production lot number or date code or inspection lot number.

d. Radiographic view (axis).

e. Date.

f. Device serial or cross reference numbers, when applicable.

g. X-ray laboratory identification, if other than device manufacturer.

4.4.3.2 Serialized devices. When device serialization is required, each device shall be readily identified by a serial number. When multiple devices are radiographed in a single image, they shall be arranged in consecutive, increasing serial order. When a device is missing, the blank space shall contain either the serial number or other X-ray opaque object to readily identify and correlate X-ray data. When large skips occur within serialized devices, the serial number of the last device before the skip and the first device after the skip may be used in place of the multiple opaque objects. For those parts whose size or configuration does not allow for placement of a serial number, the position in the holding fixture will suffice for serialization.

4.4.4 Test Plans. A technique for each DUT lot will be generated to ensure repeatability of the examination.

4.4.4.1 DUT Specific Technique. The DUT specific technique shall be generated to address the unique qualities for that device type, and how that device type is subjected to the radiographic examination, including all information needed to perform a repeatable examination. The DUT Specific Technique shall reference internal operating procedures, if applicable, and acceptance criteria used in the inspection. The plan shall include:

a. The specific device or devices to be examined by manufacturer and part number,

b. Radiographic system (apparatus) used and support equipment, such as the IQIs/RQIs used to bracket the DUT.

c. DUT views (axes). When necessary a drawing, sketch or photograph of the DUT showing the radiation beam axis position(s) of the detector for each and all variations of the DUT orientation and x-ray beam angle.

4.4.4.1.1 Digital Test Parameters. For each view, the following parameters shall be defined: kV, Current/Power, the IQI(s) selected representing the grayscale value of the area(s) interest of the DUT or the RQI associated with the DUT. For digital radiography, parameters can vary with the selected test equipment. The tester shall define those parameters for the particular test set being used. Examples of required parameters include focal spot size, frame averaging, set up geometry and geometric magnification, detector settings (e.g., frames per second, gain, binning, etc.) and image evaluation settings (e.g., digital zoom, window width/window level, image enhancement, etc.), as applicable to the selected apparatus. Radiographs/radiographic images shall be made for each view required (see 3.1). The X-ray exposure factors and image file resolution shall be selected to resolve a wire 0.0254 mm (0.001 inch) in diameter, a bead 0.0508 mm (0.002 inch) in diameter, a separation of 0.0508 mm (0.002 inch) between two solid objects and shall result in an image with a minimum pixel value of 15% of the bit depth range and maximum pixel value of 90% of the saturation limit of the detector. The flow chart presented in Figure 1 provides a suggested method of determining appropriate test parameter selection. One image shall be taken of the overall component. If that image meets the resolution requirements, no further images are required. If that image does not meet the resolution requirements, additional images of higher geometric magnification shall be collected, providing full coverage of the device area (i.e., overlapping views), at the lowest geometric magnification which meets the resolution requirements, unless otherwise specified.

NOTE: Multiple exposure factors and test parameter settings may be required to be able to fully inspect the DUT.

4.4.4.1.2 Further required details. When applicable, the following items are part of the DUT Specific Test Plan. Classification of the DUT into zones for radiographic examination, detector field of view; all system and software settings that can be changed by the operator to affect the outcome of the radiographic examination such as display settings and image processor variables; and the recording media and image file format.

4.4.5 Image processing/enhancement.

4.4.5.1 Digital image evaluation. Image evaluation adjustments for image zoom, window width and level settings (contrast and brightness) and any image processing/enhancement shall be performed in a manner consistent with the DUT Specific Technique and shall not reduce the ability to identify required features in the image of the DUT and IQIs/RQIs.

a. Window Width (Contrast) and Level (Brightness). The initial image evaluation window width and level settings shall be documented in the DUT specific technique, either with quantitative values or by defined viewing presets. This includes any multiple window width and level values or viewing presets required due to changes in the DUT thickness or material.

b. Image processing (i.e., enhancement filters). Image processing used for final product acceptance shall be verified by adequately displaying the pertinent features of the DUT and IQI/RQI and shall be documented on the approved DUT specific radiographic examination technique.

   Since some image processing filters can increase image noise and/or generate artifacts, the image interpreter may remove the filter for the purpose of evaluating whether an indication is false, relevant or non-relevant, however, initial image review shall be performed with the filter applied when required by the DUT specific technique.

c. Digital Magnification (Image Zoom). Digital magnification shall be based on the minimum size of the feature of interest, and the size and resolution of the image display monitor. Images shall not be inspected at less than 100% display size, as reduction of image size below 100% results in loss of displayed data due to pixilation. For the purpose of making measurements or a correct disposition, the image may be digitally magnified beyond that specified in the DUT specific technique.

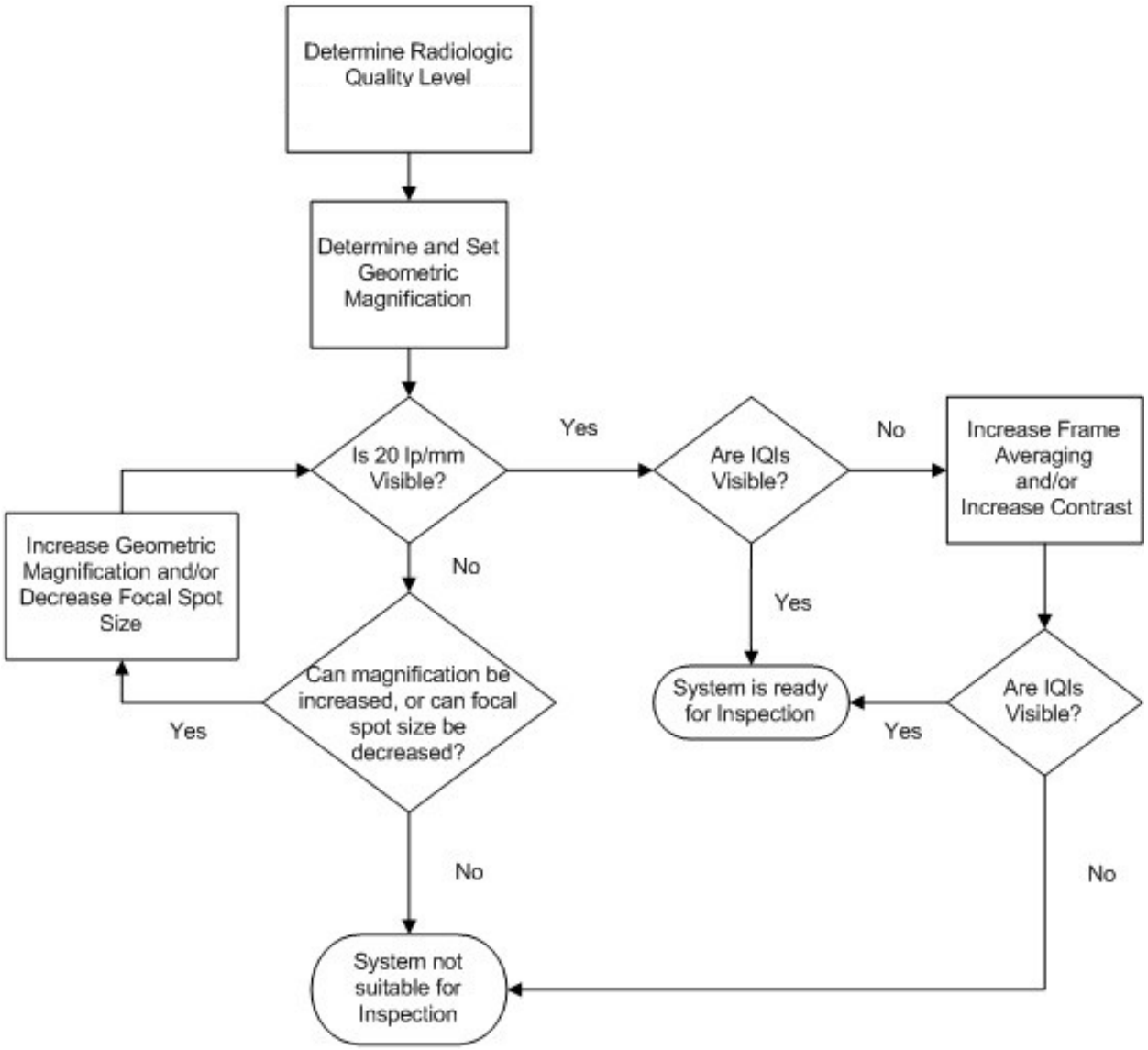

FIGURE 1. Appropriate test parameter selection.

5. DETAILED REQUIREMENTS

5.1 Evaluations.

5.1.1 Film. The final image shall be examined with suitable viewing equipment, which may include magnification, to determine such defects as improper positioning of elements, voids in encapsulating or potting compounds; inhomogeneities in materials; presence of foreign materials; broken elements; and other defects as specified in the individual specification.

5.1.2 Digital. Geometric magnification for image collection shall be determined as specified in 4.4.1. Magnification at the time of inspection is dependent on the spatial resolution of the detector. Inspection magnification may be achieved through a combination of geometric magnification and increasing image display size, until image pixilation occurs or IQI/line pair resolution is lost. Images shall not be inspected at less than 100% display size, as reduction of image size below 100% results in loss of displayed data due to pixilation. All images shall contain a feature of known dimension, from which displayed magnification can be calculated; examples include gold bond wires, the overall package (if dimensions are recorded) or marker bars inserted using calibrated imaging software.

5.2 Summary. The following details are to be specified in the individual specification:

5.2.1 Film.

a. Required radiographic quality (see 4.1.1 and 5.1).

b. Image-quality indicator to be used (see 4.1.3).

c. Position or positions of specimen (see 4.3.1).

d. Marking indicating that specimens have been radiographed, if required (see 4.3.5).

e. Evaluation of images (see 5.1).

(1) Specific kind of viewing equipment, if required.

(2) Magnification, if required.

(3) Defects to be sought in the specimen.

5.2.2 Digital.

a. Number of views. Any requirements that cause a need for differing angle of axis, depth of view, or area of vision from those required by Film Radiography.

b. Radiograph submission, if applicable (see 4.4.3.1).

c. Marking, if other than indicated in 4.4.3 and marking of samples to indicate they have been radiographed, if required (see 4.4.3.2).

d. Defects to be sought in the samples and criteria for acceptance or rejection.

e. Radiograph and report retention.

f. Test reports when required for class level B.

g. If Dynamic (Real Time) Radiography will be used.

h. Archiving requirements including software, recording media, image handling, and records retention period not in accordance to those specified herein.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Filters. ASTM E 1161 may be consulted for further guidance on filter selection.

6.2 Changes from previous issue. The margins of this standard are marked with vertical lines to indicate where changes from the previous issue were made. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the previous issue.

Custodians:
Army - CR
Navy - EC
Air Force - 85
DLA - CC

Review activities:
Army - AR, AT, AV, CR4, MI, SM, TE
Navy - AS, OS, SH
Air Force - 19
NSA - NS

Preparing activity:
DLA – CC

(Project 59GP-2018-008)

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at https://assist.dla.mil/.