Designation: E 1734 – 04

Standard Practice for Radioscopic Examination of Castings[1]

This standard is issued under the fixed designation E 1734; 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 covers a uniform procedure for radioscopic examination of castings.

1.2 This practice applies only to radioscopic examination in which an image is finally presented on a display screen (monitor) for evaluation. Test part acceptance may be based on a static or dynamic image. The examination results may be recorded for later review. This practice does not apply to fully automated systems in which evaluation is performed automatically by a computer.

1.3 Due to the many complex geometries and part configurations inherent with castings, it is necessary to recognize the potential limitations associated with obtaining complete radioscopic coverage. Consideration shall be given to areas where geometry or part configuration does not allow for complete radioscopic coverage.

1.4 The values stated in inch-pound units are to be regarded as the standard. The values given in brackets are for information only.

1.5 *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 543 Practice for Agencies Performing Nondestructive Testing

E 747 Practice for Design, Manufacture and Material Grouping Classification of Wire Image Quality Indicators (IQI) Used for Radiology

E 1000 Guide for Radioscopy

E 1025 Practice for Design, Manufacture, and Material Grouping Classification of Hole-Type Image Quality Indicators (IQI) Used for Radiology

E 1255 Practice for Radioscopy

E 1316 Terminology for Nondestructive Examinations

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 Test Data

2.2 *ASNT Standards:*[3]

ASNT SNT-TC-1A Personnel Qualification and Certification in Nondestructive Testing

ANSI/ASNT CP-189 Personnel Qualification and Certification in Nondestructive Testing

2.3 *Military Standard:*

NAS-410 NAS Certification and Qualification of Nondestructive Personnel (Quality Assurance Committee)[4]

3. Terminology

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

4. Significance and Use

4.1 The requirements in this practice are intended to control the quality of the radioscopic images to produce satisfactory and consistent results. This practice is not intended for controlling the acceptability of the casting. The radioscopic method may be used for detecting volumetric discontinuities and density variations that are within the sensitivity range of this practice. The dynamic aspects of radioscopy are useful for maximizing defect response.

5. Basis of Application

5.1 The following items shall be agreed upon between the purchaser and the supplier:

5.1.1 *Nondestructive Testing Agency Evaluation*—If specified in the contractual agreement, nondestructive testing (NDT) agencies shall be qualified and evaluated as described in Practice E 543. The applicable edition of Practice E 543 shall be specified in the contractual agreement.

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[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.

Current edition approved February 1, 2004. Published March 2004. Originally approved in 1995. Last previous edition approved in 1998 as E 1734 - 98.

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

[3] Available from The American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518.

[4] Available from Aerospace Industries Association of America, Inc. 1250 Eye Street N.W., Washington, DC 20005.

5.1.2 *Personnel Qualification*—If specified in the contractual agreement, personnel performing examinations to this standard shall be qualified in accordance with a nationally or internationally recognized NDT personnel qualification practice or standard such as ANSI/ANST-CP-189, SNT-TC-1A, 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.

5.1.3 *Recording Media*—If required, the recording media to be used shall be specified in accordance with the requirements of Section 6.

5.1.4 *Performance Measurements*—Performance measurement shall be specified in accordance with the requirements of Section 6.

5.1.5 *Procedure*—Procedural requirements shall be specified in the contractual agreement.

5.1.6 *Records*—Records shall be specified in the contractual agreement.

6. Apparatus

6.1 Success of the radioscopic process depends on the overall system configuration and the selection of appropriate subsystem components. Guidance on the selection of subsystem components and the overall system configuration is provided in Guide E 1000 and Practice E 1255. Guidance on the initial qualification and periodic re-qualification of the radioscopic system is provided in Practice E 1411. The suitability of the radioscopic system shall be demonstrated by attainment of the required image quality and compliance with all other requirements stipulated herein.

6.2 *Equipment*:

6.2.1 *Radiation Source (X-Ray or Gamma-Ray)*—Selection of the appropriate source is dependent on variables regarding the casting being examined, such as material composition and thickness. Guidance on selection of the radiation source may be found in Practice E 1255.

6.2.2 *Manipulation Subsystem*—Selection of the appropriate manipulation system (where applicable) is dependent on variables such as the size and orientation of the object being examined and the range of motions, speed of travel, and smoothness of motion. Guidance on selection of the manipulation subsystem may be found in Practice E 1255.

6.2.3 *Detector Subsystem*—Selection of the appropriate detection system is dependent on variables such as the material and size of the object being examined and the energy and intensity of the radiation used for the examination. Guidance on selection of the detector subsystem may be found in Practice E 1255.

6.2.4 *Image Processing Subsystem*—Where agreed upon between the purchaser and the supplier, image processing systems may be used for noise reduction through image integration or averaging, contrast enhancement, and other image processing operations. Users of digital image processing are cautioned to test image processing parameters thoroughly before use. For example, some spatial filter functions produce directional results and may suppress desired image information. Other spatial filters can introduce artifacts into the image.

6.2.5 *Image Display Subsystem*—Selection of the appropriate image display is critical to the transfer of image information from the radioscopic system to the person making the accept-reject decision. The image display should be suitably sized and placed in a controlled environment with subdued lighting to maximize the transfer of image information to the radioscopic system operator.

6.2.6 *Collimation*—Selection of appropriate collimation is dependent on the geometry of the object being examined. It is generally useful to select collimation to limit the primary radiation beam to the detector area or region of interest, whichever is smaller, thereby limiting scatter radiation in order to improve radioscopic image quality.

6.2.7 *Filters and Masking*—Filters and masking may be used to improve image quality by alleviating contrast reductions caused by low-energy scattered radiation. Guidance on the use of filters and masking is provided in Guide E 94.

6.3 *Performance Measurement*—Radioscopic examination system performance parameters must be determined initially and monitored regularly to ensure consistent results. The best measure of total radioscopic examination system performance can be made with the system in operation, using a test object similar to the test part under actual operating conditions. This indicates the use of an actual or simulated test object or calibration block containing actual or simulated features that must be detected reliably. Such a calibration block will provide a reliable indication of the radioscopic examination system's capabilities. Conventional wire or plaque-type image quality indicators (IQIs) may be used in place of, or in addition to, the simulated test object or calibration block. Performance measurement methods are subject to agreement between the purchaser and the supplier of radioscopic examination services.

6.3.1 *Performance Measurement Intervals*—System performance measurement techniques should be standardized so that performance measurement tests may be duplicated readily at specified intervals. Radioscopic examination performance should be evaluated at sufficiently frequent intervals, as may be agreed upon between the purchaser and the supplier of radioscopic examination services, in order to minimize the possibility of time-dependent performance variations.

6.3.2 *Measurement with IQIs*—System performance measurements using IQIs shall be in accordance with accepted industry standards describing the use of IQIs. The IQIs should be placed on the radiation source side of the test object, as close as possible to the region of interest. The use of wire IQIs should also take into account the fact that the radioscopic examination may exhibit asymmetrical sensitivity, in which case the wire diameter axis shall be oriented along the system's axis of least sensitivity. Selection of IQI thickness should be consistent with the test part radiation path length.

6.3.3 *Measurement With a Calibration Block*—The calibration block may be an actual test part with known features that are representative of the range of features to be detected, or it may be fabricated to simulate the test object with a suitable range of representative features. Alternatively, the calibration block may be a one-of-a-kind or few-of-a-kind reference test object containing known imperfections that have been verified independently. Calibration blocks containing known, natural

defects are useful on a single-task basis, but they are not universally applicable. A duplicate manufactured calibration block should be used where standardization among two or more radioscopic examination systems is required. The calibration blocks should approximate the test object as closely as is practical, being made of the same material with similar dimensions and features in the radioscopic examination region of interest. Manufactured calibration blocks shall include features at least as small as those that must be detected reliably in the actual test object in locations where they are expected to occur. It is permissible to produce the calibration block in sections where features are internal to the test object. Calibration block details are a matter of agreement between the purchaser and the supplier of radioscopic examination services.

6.3.3.1 *Use of a Calibration Block*—The calibration block shall be placed in the radioscopic examination system in the same position as the actual test object. The calibration block may be manipulated through the same range of motions as are available for the actual test object so as to maximize the radioscopic examination system's response to the simulated imperfections.

6.3.3.2 *Radioscopic Examination Techniques*—Techniques used for the calibration block shall be identical to those used for actual examination of the test part. Technique parameters shall be listed and include, as a minimum, radiation beam energy, intensity, focal spot size, enlargement, digital image processing parameters, manipulation scan plan, and scanning speed.

6.3.4 *Use of Calibrated Line Pair Test Pattern and Step Wedge*—A calibrated line pair test pattern and step wedge may be used, if desired, to determine and track the radioscopic system performance in terms of spatial resolution and contrast sensitivity. The line pair test pattern is used without an additional absorber to evaluate system spatial resolution. The step wedge is used to evaluate system contrast sensitivity.

6.3.4.1 The step wedge must be made of the same material as the test part, with steps representing 100, 99, 98, 97, and 96 % of both the thickest and thinnest material sections to be examined. The thinner steps shall be adjacent to the 100 % thickness in order to facilitate discerning the minimum visible thickness step. Other thickness steps are permissible upon agreement between the purchaser and the supplier of radioscopic examination services.

6.3.4.2 The line pair test pattern and step wedge tests shall be conducted in a manner similar to the performance measurements for the IQI or calibration block. It is permissible to adjust the X-ray energy and intensity to obtain a usable line pair test pattern image brightness. In the case of a radioisotope or X-ray generating system in which the energy or intensity cannot be adjusted, additional filtration may be added to reduce the brightness to a useful level. Contrast sensitivity shall be evaluated at the same energy and intensity levels as are used for the radioscopic technique.

6.3.4.3 A system that exhibits a thin section contrast sensitivity of 3 %, a thick section contrast sensitivity of 2 %, and a spatial resolution of 3 line pairs/mm may be said to have a quality level of 3 % − 2 % − 3 lp/mm.

6.3.4.4 The line pair test pattern and step wedge may be used to make more frequent periodic system performance checks than are required in 6.3.1. Resolution and contrast sensitivity checks must be correlated with IQI or calibration block performance measurements. This may be accomplished by first evaluating the system performance in accordance with 6.3.2 or 6.3.3 and immediately thereafter determining the equivalent spatial resolution and contrast sensitivity values.

6.4 *Location and Identification Markers*—Lead numbers and letters may be used to designate the part number and location number, as needed, provided they do not mask regions of interest on the casting. On-part identification is not required where the manipulator is programmable or manipulator coordinates are provided as a means of ensuring that all regions of interest are covered. A video typewriter or similar device may be used to display location and identification information electronically. When identification is not provided on the part, the method of identification shall be documented in the records in accordance with Section 9.

6.5 *Recording Media*—Recording media for storage of analog or digital images shall be agreed upon between the purchaser and the supplier.

7. Safety

7.1 Radioscopic procedures shall comply with applicable local, state, and federal safety regulations.

8. Procedure Considerations

8.1 *Time of Examination*—Radioscopy may be performed in the as-cast, intermediate, or final machined condition, as may be specified by the applicable job order or contract.

8.2 Material and thickness range to be examined.

8.3 *Surface Preparation*—While no surface preparation is required for radioscopy, the removal of flash, surface blemishes, and debris that could confuse the radioscopic image is recommended.

8.4 *Examination Speed*—For dynamic examination, the speed of the test object relative to the radiation source and detector shall be subject to agreement between the purchaser and the supplier. Base this determination on the achievement of the required radioscopic quality level at that examination speed.

8.5 *Direction of Radiation*—The direction of radiation shall be governed by the geometry of the casting, coverage, and quality requirements stipulated by the applicable job order or contract. Practically, place the central beam of the radiation perpendicular to and centered on the surface of the detector.

8.6 *Scattered Radiation*—Scattered radiation (radiation scattered from the test object and surrounding structures) reduces radioscopic contrast and may reduce radioscopic quality. Precautions such as collimation of the source, collimation of the detector, and additional shielding should be used, as appropriate.

8.7 *IQI Selection*—Where specified, IQI selection shall be based on the following: if the thickness to be inspected exceeds the design thickness of the finished piece, the IQI size shall be based on the thickness that does not exceed the design thickness of the finished piece by more than 20 % or ¼ in. [6.35 mm], whichever is greater. The IQIs should be of the

same or similar material to that being examined. In no case shall the IQI size be based on a thickness greater than the thickness to be examined.

8.8 *Number of Image Quality Indicators*:

8.8.1 Where an IQI is required, at least one IQI (Practice E 747 or Practice E 1025) shall be placed in the area of interest in which the brightness is relatively uniform.

8.8.2 When a series of radioscopic images is made under similar conditions of unsharpness, it is permissible for the IQIs to be used only on the first and last images in an inspection series subject to agreement between the purchaser and the supplier. Where the irregular shape or size of a casting makes meaningful IQI placement difficult, the qualifying images may be of the IQIs on mounting blocks, simulating the thinnest and thickest sections of the casting that must be imaged.

8.8.3 Qualifying images shall be retained as part of the radioscopic examination record in order to validate the required IQI sensitivity and placement.

8.9 *IQI Placement*:

8.9.1 Wherever possible, placement of the IQI shall be on the source side of the casting or mounting block.

8.9.2 *Detector Side IQIs*—In those cases in which the physical placement of the image quality indicators on the source side is not possible, the IQIs may be placed on the detector side of the casting, along with a lead letter "D." The applicable job order or contract shall specify the applicable detector-side quality level. The accompanying documents shall indicate clearly that the IQIs were located on the detector side.

8.9.3 When Practice E 1025 IQIs are used on mounting blocks, the mounting block length and width dimensions shall exceed the IQI length and width dimensions by at least 0.12 in. [3 mm] on at least three sides. At least three edges of the IQI shall be visible in the radioscopic image.

8.9.4 *Image Identification*—A system of positive identification of the radioscopic image shall be provided. As a minimum, the following shall appear along with the radioscopic image: the name or symbol of the company performing radioscopy, date, and casting identification number traceable to part and contract. Reshots and different views of the same test part area shall be identified uniquely. Subsequent images made of a repaired area shall be identified using "R-1," "R-2," and so forth.

8.10 *Radioscopic Techniques*:

8.10.1 *Single-Wall Technique*—A technique in which the radiation passes through only one casting wall to form the radioscopic image.

8.10.2 *Double-Wall Technique*—A technique in which the radiation passes through both casting walls to form the radioscopic image.

8.11 *Radioscopic Coverage*—Areas that require examination should be marked on the Radiographic Shooting Sketch (RSS) that accompanies the scan plan. The RSS shall be prepared similarly to the example given in Appendix Appendix X1 and shall be available for review during interpretation.

8.12 *Examination Speed*—For dynamic examination, the speed of test object motion relative to the radiation source and detector shall be controlled to ensure that the required radioscopic quality level is achieved and maintained.

8.13 *Radioscopic Image Quality*—All images shall be free of artifacts that could mask or be confused with the image of any discontinuity in the area of interest. It may be possible to prevent artifacts from masking discontinuities or being confused with discontinuities by moving the object being examined relative to the direction of radiation. If any doubt exists concerning the true nature of an indication exhibited in the image, the image shall be rejected and a new image of the area shall be made.

8.14 *Image Viewing Facilities*—Viewing facilities shall provide subdued background lighting with an intensity that will not cause troublesome reflection, shadows, or glare on the image. The image-viewing environment should be conducive to operator concentration, thereby improving the quality of the accept-reject decision.

8.15 *Storage of Images*—When storage is required by the applicable job order or contract, the images should be stored in a format stipulated by the applicable contract, job order, drawing, or other purchaser and supplier agreement. Guide E 1453 should be consulted for radioscopic data media storage precautions. Guide E 1475 should be consulted if stored radioscopic data is to be shared with dissimilar radioscopic storage, retrieval, display, and hard copy systems. Image-storage duration and location shall be subject to agreement between the purchaser and the supplier.

9. Records

9.1 Records shall be maintained for a specified period of time. As a minimum, the following records shall be maintained as subject to agreement between the purchaser and the supplier:

9.1.1 Radioscopic shooting sketch (RSS), including examination geometry, source-to-object distance, object-to-detector distance, and orientation;

9.1.2 Material and thickness range examined;

9.1.3 Radioscopic system qualification details, as specified in Practice E 1411;

9.1.4 Qualifying images;

9.1.5 Test-object scan plan;

9.1.6 Image processing parameters;

9.1.7 Image-storage data;

9.1.8 Casting repair documentation; and

9.1.9 Image-interpretation record, containing the following information as a minimum:

9.1.9.1 Disposition of each casting (acceptable or rejectable);

9.1.9.2 If rejectable, part identification number, view number, and cause for rejection (shrink, crack, porosity, and so forth.);

9.1.9.3 Surface indications that have been verified by visual examination; and

9.1.9.4 Signature of the interpreter, including level of certification.

9.2 Guide E 1453 should be consulted for radioscopic data media storage precautions.

9.3 Guide E 1475 should be consulted if stored radioscopic data is to be shared with dissimilar radioscopic storage, retrieval, display, and hard-copy systems.

10. Precision and Bias

10.1 No statement is made about either the precision or bias of this practice for radioscopic examination of castings. The result states merely whether there is conformance to the criteria for success specified in the procedure.

11. Keywords

11.1 castings; digital image processing; gamma ray; in-motion; nondestructive testing; radiation; radioisotope; radioscopic examination; radioscopy; X-ray

APPENDIX

(Nonmandatory Information)

X1. RADIOSCOPIC SHOOTING SKETCH (RSS)

X1.1 The RSS provides the operator and radioscopic interpreter with pertinent information regarding the examination of a casting. The RSS is designed to standardize radioscopic methodologies associated with casting examination; it may also provide a means for purchaser and supplier agreement, prior to initiation of the examination on a production basis. The use of a RSS is advantageous due to the many configurations associated with castings and the corresponding variations in techniques for inspection of any particular casting. The RSS provides a map of location marker placement, directions for source and detector arrangement, and instructions for all other parameters associated with radioscopy of a casting. This information serves to provide the most efficient method of controlling the quality and consistency of the resultant radioscopic representations. The RSS usually consists of an instruction sheet and one or more sketches of the casting: the instruction sheet specifies the radioscopic equipment, materials, techniques, and acceptance parameters for each location; the sketches illustrate the location, orientation, and source and conversion device arrangement for each radioscopic location. The RSS should provide the following information, unless marked not applicable (NA).

X1.1.1 The instruction sheet should provide the following:

X1.1.1.1 Purchaser of radioscopic services;

X1.1.1.2 Supplier of radioscopic services;

X1.1.1.3 Company and individual preparing the RSS and date;

X1.1.1.4 Entity performing radioscopy;

X1.1.1.5 Casting information, including the following:

(1) Drawing number,

(2) Casting identification number,

(3) Descriptive name (for example, pump casting, valve body, and so forth),

(4) Material type and material specification,

(5) Heat number, and

(6) Pattern number;

X1.1.1.6 Casting condition at time of radioscopy (as-cast, rough-machined, or finished-machined);

X1.1.1.7 Method for determining image quality;

X1.1.1.8 Performance monitoring intervals;

X1.1.1.9 The following radioscopy technique parameters for each radioscopic location:

(1) Single-wall thickness for radioscopy,

(2) Single-wall finished thickness,

(3) Double-wall thickness for radioscopy,

(4) Double-wall finished thickness,

(5) Radioscopic sensitivity measuring device—IQI, calibration block, or actual test part,

(6) Required sensitivity,

(7) X-ray kilovolt range or radioisotope source type,

(8) X-ray milliampere range or radioisotope source strength,

(9) Focal spot size,

(10) Magnification mode,

(11) Source-detector-distance (SDD),

(12) Object-detector-distance (ODD),

(13) Radioscopy accept/reject standard, and

(14) Applicable radioscopic acceptance criteria; and

X1.1.1.10 Spaces for approval, as applicable.

X1.1.2 The RSS's should provide the following information:

X1.1.2.1 Location marker placement;

X1.1.2.2 Location of foundry's identification pad or symbol on the casting;

X1.1.2.3 Designation of areas that require inspection, as applicable;

X1.1.2.4 Designation of areas that are considered impractical or very difficult to view (see 1.3 and 6.4); and

X1.1.2.5 Radiation source, masks, collimators, and filters used and radiation beam direction for each location.

NOTE X1.1—The RSS should designate the involved locations and stipulate that the technique for those locations is typical for sections of the casting on which a continuing series of locations are to be imaged with the same basic source and detector arrangement for each location. This appendix provides a sample RSS that includes an instruction sheet (Fig. X1.1) and shooting sketch (Fig. X1.2) that have been developed for a typical casting application.

CASTING RADIOSCOPIC EXAMINATION INSTRUCTION SHEET

Date _____ Revision Level _____

Purchaser of Radioscopic Services _____

Supplier of Radioscopic Services _____

Radioscopic Shooting Sketch Provided By _____

Date of Shooting Sketch Preparation _____

Entity Performing Radioscopy _____

Casting Information

Drawing Number _____

Identification Number _____

Descriptive Name _____

Material Type and Specification _____

Heat Number _____

Pattern Number _____

Casting Condition when Radioscopy is Performed _____
_____

Method for Determining Image Quality _____
_____
_____

Performance Monitoring Intervals _____
_____

Radioscopic Location	1	2	3	4
Single-Wall Thickness	_____	_____	_____	_____
Finished Thickness	_____	_____	_____	_____
Double-Wall Thickness	_____	_____	_____	_____
Finished Thickness	_____	_____	_____	_____

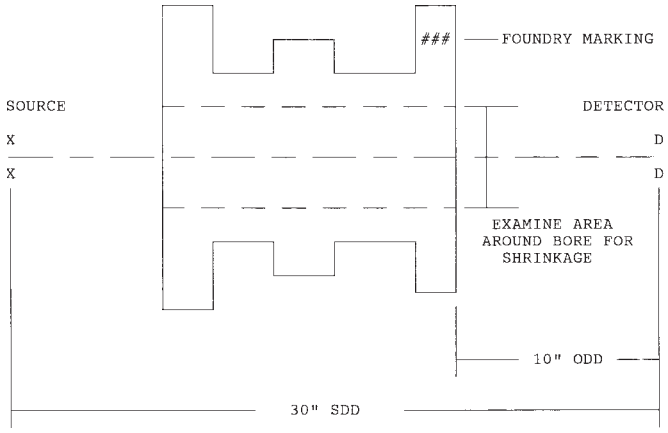
FIG. X1.1 Casting Radioscopic Examination Instruction Sheet

IQI				
Required Sensitivity				
Calibration Block				
Required Feature				
Actual Test Part				
Required Feature				
X-Ray kV Range or Radioisotope Energy				
X-Ray mA Range or Radioisotope Intensity				
Focal Spot Size				
Magnification Mode				
Source-Detector Dist.				
Object-Detector Dist.				
Accept/Reject Std.				
Severity Level				

Approved for Use _____

Date _____

FIG. X1.1 Casting Radioscopic Examination Instruction Sheet *(continued)*



NOTE 1—Indicate scan plan details, including each required view, location of required IQIs and markers, sequence of required views, and direction and maximum speed of manipulation. Where it is impractical to place the IQI on the casting, indicate the selection and location of the appropriate mounting block and IQI.

NOTE 2—The radioscopic technique for this view is typical of other sections of the casting on which a continuing series of locations is to be imaged with the same basic source and detector arrangement.

FIG. X1.2 Radioscopic Shooting Sketch