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MILITARY STANDARD

INSPECTION, RADIOGRAPHIC

NO DELIVERABLE DATA
REQUIRED BY THIS DOCUMENT

AREA NDTI

DEPARTMENT OF DEFENSE
Washington, DC 20301

Inspection, Radiographic

MIL-STD-453C

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

2. Beneficial comments (recommendations, additions, and deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commanding Officer, Naval Air Engineering Center, Systems Engineering and Standardization Department (SESD), Code 93, Lakehurst, NJ 08733, by using the self addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FOREWORD

This document supersedes MIL-STD-004538(USAF), Inspection, Radiographic and MIL-STD-453, Inspection, Radiographic.

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1. SCOPE

1.1 Purpose. The purpose of this military standard is to prescribe the radiographic inspection requirements for metallic and nonmetallic materials.

1.2 Application. The criteria for the radiographic inspection in this standard are applicable to all types of metallic and nonmetallic materials. The requirements expressed in this standard are intended to control the quality of the radiographic images, and are not intended for controlling the acceptability or quality of materials.

2. REFERENCED DOCUMENTS

2.1 Issues of documents. The following documents of the issue in effect on date of invitation for bids or request for proposal, form a part of this standard to the extent specified herein.

STANDARDS

MILITARY

MIL-STD-410	-	Nondestructive Testing Personnel Qualification and Certification (Eddy Current, Liquid Penetrant, Magnetic Particle, Radiographic and Ultrasonic)

(Copies of specifications, standards, drawings and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this standard to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

GOVERNMENTAL

NATIONAL BUREAU OF STANDARDS

NCRP 39	-	Basic Radiation Protection Criteria
Handbook 55	-	Protection Against Betatron-Synchrotron Radiation up to 100 MeV
Handbook 59	-	Permissible Dose from External Sources of Ionizing Radiation (1954)
Handbook 73	-	Protection Against Radiations from Sealed Gamma Sources (1960)
Handbook 114	-	General Safety Standard for Installations Using Non-Medical X-Ray and Sealed Gamma Ray Sources, Energies Up to 10 MeV (1974)

(Applications for copies should be addressed to the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.)

NON-GOVERNMENTAL

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM E 155	-	Reference Radiographs for Inspection of Aluminum and Magnesium Castings (Vol. I and Vol. II)
ASTM E 186	-	Reference Radiographs for Heavy-Walled (2 to 4.5 in. (51 to 114 mm)) Steel Castings
ASTM E 192	-	Reference Radiographs of Investment Steel Castings for Aerospace Applications
ASTM E 242	-	Reference Radiographs for Appearances of Radiographic Images as Certain Parameters are Changed
ASTM E 272	-	Reference Radiographs for High-Strength Copper-Base and Nickel-Copper Alloy Castings
ASTM E 280	-	Reference Radiographs for Heavy-Walled (4.5 to 12 in. (114 to 305 mm)) Steel Castings
ASTM E 310	-	Reference Radiographs for Tin Bronze Castings
ASTM E 390	-	Reference Radiographs for Steel Fusion Welds
ASTM E 446	-	Reference Radiographs for Steel Castings Up to 2 in. (51 mm) in Thickness
ASTM E 586	-	Reference Radiographs for Inspection of Aluminum and Magnesium Die Castings
ASTM E 746	-	Determining Relative Image Quality Response of Industrial Radiographic Film

(Application for copies should be addressed to American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

AMERICAN WELDING SOCIETY (AWS)

ANSI/AWS A2.4 - Symbols for Welding and Nondestructive Testing

(Copies of the above publication may be obtained from the Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120. Non-Government requests shall be addressed to the American Welding Society, 550 NW LeJeune Road, Miami, FL 33126.)

(Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

3. DEFINITIONS

3.1 Component. The part (parts), or element of a weapon system described, assembled or processed to the extent specified by the drawing.

3.2 Contracting agency. A prime contractor, subcontractor or Government agency procuring radiographic services.

3.3 Definition. The sharpness or clarity of an image.

3.4 Densitometer. A device for measuring radiographic film density.

3.5 Energy. A property of radiation which determines its penetrating ability. In X-ray radiography, energy is usually determined by the accelerating voltage applied to the anode and is expressed as peak kilovolts (kVP), kilovolts constant potential (kVCP) or million electron volts (MeV). In gamma ray radiography, energy is a characteristic of the source and is measured in either eV, KeV, or MeV.

3.6 Film holders or cassettes. Lightproof containers for holding radiographic film with or without accessories such as filters or intensifying screens. These film holders or cassettes may be rigid or flexible.

3.7 Filters. Sheets of lead or other materials placed in the radiation beam, eitner at the X-ray tube, between the specimen and the film or behind the film to improve the quality by selectively removing low energy radiation from the radiation beam and absorbing scattered radiation.

3.8 Government Procurement Agency. Government Procurement Agency shall mean the Government agency for which the weapon system is being built.

3.9 Intensifying screen. Material which converts a part of the radiation from the X-ray machine or isotope into light or electrons. Two kinds of screens in common use are:

Metallic - Dense metal (usually lead foil) or a dense metal compound (such as lead oxide) which emits electrons when exposed to X-rays or gamma rays.

Fluorescent - A crystalline compound which fluoresces when exposed to X-rays or gamma rays

3.10 NDT facility. NDT facility shall mean that organization responsible to the prime contractor and the subcontractor for nondestructive inspection services.

3.11 Masking. Lead or other high density material on or around the test object during the exposure for the purpose of minimizing the effect of secondary or scattered radiation.

3.12 Material thickness. The thickness of material (TM) upon which the penetrameter is based. For castings the material thickness shall be the nominal thickness or actual thickness if measured at the area being radiograpned. For welds the material thickness shall be the nominal thickness or actual thickness, if measured, of the basic materials and shall not include reinforcements, backing rings or strips.

3.13 Maximum effective radiation source dimension. The maximum source or focal spot dimension projected on the center of the radiographic film. For example: A cylindrical isotope source whose length is greater than its diameter will have a greater effective radiation source dimension when oriented coaxially in the center of a pipe for a panoramic exposure than when the axis of the source is positioned at right angles to the pipe.

3.14 Multiple film technique. A procedure in which two or more films of the same or different speed are used in the same film holder.

3.15 Penetrameter/Image Quality Indicator (IQI). A strip of metal the same composition as that of the metal being tested, representing a percentage of object thickness and provided with a combination of steps, holes, and/or slots. Its image on a radiograph is used to determine the radiographic quality level. It is not intended for use in judging the size nor for establishing acceptance limits of discontinuities.

3.16 Penetrameter sensitivity. An indication of the ability of the radiographic process to show (a) the difference in material thickness by a measurement of film contrast and (b) detail definition by the resolution of holes of a specified size.

3.17 Prime contractor. A contractor having responsibility for design, control, and delivery of a system/equipment such as aircraft, engines, ships, tanks, vehicles, guns and missiles, ground communications and electronic systems, ground support, and test equipment.

3.18 Radiograph. A visible image on an X-ray sensitive recording medium produced by the penetration of radiation through the material being tested. When two or more superimposed films are exposed simultaneously in the same film holder, to be viewed later as a superimposed pair, the superimposed pair of exposed film constitutes the radiograph.

3.19 Radiographic inspection. The use of X-rays or gamma rays, to detect discontinuities in material by presenting their images on a recording medium suitable for interpretation by qualified personnel.

3.20 Radiographic contrast. The difference in photographic densities from one area to another of the radiograph. Radiographic contrast, includes both subject contrast and film contrast.

3.21 Radiographic quality level. The ability of a radiographic procedure to demonstrate a certain penetrameter sensitivity.

3.22 Radiographic film density. The quantitative measure of blackening of a photographic emulsion is called film density and is defined by the equation:

$$D = \log \frac{I_o}{I}$$

where: D = film density
I_o = the intensity of light incident on the film
I = the intensity of light transmitted through the film

3.23 Recording medium. Film, paper, or a detector which converts radiation into a visible image or into a signal which can be transformed into a visible image at a later date.

3.24 Source. A machine or radioactive material which emits penetrating radiation.

3.25 Source-to-film distance. The distance between the radiation producing area of the source and the film.

3.26 Subcontractor. Subcontractor (supplier) shall mean that organization responsible to the prime contractor for a portion of the weapons system.

3.27 Unsharpness. The absence of good film definition is considered unsharpness. Unsharpness may have several causes: source-to-film distance, focal spot size, grain size of film emulsion, energy of radiation, film development, and scattered radiation.

4. GENERAL REQUIREMENTS

4.1 Inspection.

4.1.1 Responsibility for inspection. The contractor is responsible for furnishing all supplies in conformance to contract or purchase order requirements and, unless otherwise specified in the contract or purchase order, the performance of all inspection requirements contained herein. The inspection provisions contained herein shall become a part of the contractor's overall inspection system or quality program. The absence of inspection requirements does not relieve the contractor of his responsibility for assuring that all supplies submitted to the Government for acceptance conform to all requirements of the contract. The Government reserves the right to perform any of the inspections set forth herein, or otherwise specified in the contract or purchase order, when such inspections are deemed necessary to assure that supplies conform to prescribed requirements.

4.2 Personnel.

4.2.1 Personnel qualification. Personnel making accept/reject decisions based on the results of radiographic inspections performed in accordance with this standard shall be qualified and certified in accordance with MIL-STD-410.

4.3 Laboratory installations.

4.3.1 Safety. The premises and equipment shall present no hazards to the safety of personnel or property as specified in NBS Handbook 55, 59, 73, 114 and NCRP 39. All radiographic procedures shall be performed so that personnel shall not receive a radiation dosage exceeding the maximum permitted by city, state or national codes.

4.3.2 Radiographic exposure areas. Radiographic exposure areas shall be clean and equipped so that reproducible radiographs may be produced in accordance with the requirements of this standard.

4.3.3 Darkroom. Darkroom facilities, including equipment and materials shall be capable of producing uniform, blemish-free radiographs.

4.3.4 Film viewing room. Film viewing facilities shall be free of objectionable background light that may cause reflection on the radiographic film. 2.5 foot-candles of ambient light measured at the viewer is optimum for viewing.

4.4 Materials.

4.4.1 Film. Production radiographs shall be made on safety film. Unexposed films shall be stored in such a manner to protect them from light, excess heat, humidity, pressure, and penetrating radiation. Table I lists the ASTM film type, relative speeds, description of emulsion and suggested application. Selection of films shall be based on radiographic quality level and the minimum permissible exposure time. The films selected shall be

capable of demonstrating the required penetrameter sensitivity. The requirements of this standard are based on radiographic film. Production radiographs on photographic paper or nonfilm methods shall be correlated with film produced in accordance with this standard. ASTM E 746 provides a standard method for determining the relative image quality response of industrial radiographic film and may be used as the basis for film selection.

4.4.2 Film processing solutions. Production radiographs shall be processed in solutions capable of consistently producing radiographs which meet this standard. The time and temperature at which radiographs are processed shall be within the manufacturer's recommended range. Solutions which have become exhausted and are not capable of producing the sensitivity required shall not be used. In semi-automatic and hand processing installations a log shall be maintained to show the number and size of film processed and replenishing dates. A radiograph of a thickness standard (step wedge) shall be produced once each week by a standard technique and standard processing. The density shall correspond within ±15 percent of an original standard radiograph.

4.5 Equipment.

4.5.1 Radiation sources.

4.5.1.1 X-radiation sources. Selection of appropriate X-ray voltage and current levels is dependent upon variables regarding the specimen being examined (material type and thickness) and exposure time. The suitability of these X-ray parameters shall be demonstrated by attainment of required penetrameter sensitivity and compliance with all other requirements stipulated herein.

4.5.1.2 Gamma radiation sources. Isotope sources which are used shall be capable of demonstrating the required radiographic sensitivity.

4.5.2 Film holders and cassettes. Film holders and cassettes shall be light tight and shall be handled properly to reduce the likelihood that they may be damaged. In the event that light leaks into the film holder and produces images on the radiograph, the radiograph need not be rejected unless the images obscure the area of interest. If film holder exhibits light leaks it shall be repaired before use or discarded. Film holders and cassettes should be routinely examined to minimize the likelihood of light leaks.

4.5.3 Intensifying screens.

4.5.3.1 Lead foil screens. Unless otherwise specified, intensifying screens of the lead foil or lead oxide type shall be used for all production radiography. Screens shall be of the same dimensions as the film being used and shall be in intimate contact with the film during exposure. Recommended screen thicknesses are listed in Table III for the applicable voltage range being used. Lead oxide screens are equivalent to 0.0005 inch of lead. Screens shall be free from any cracks, creasings, scratches, dust, dirt, oxides, sulphides, or any other foreign material that could render undesireable nonrelevant images on the film.

4.5.3.2 Fluorescent or fluorometallic screens. Fluorescent or fluorometallic screens may be used when agreed upon between the acquiring activity and the contractor.

4.5.4 Masking. Shot, masking solutions, sheet lead and foils may be used for masking. The shot shall be a mixture of many diameters to provide a uniform density. Lead salt solutions used for masking may be toxic and the proper health safety precautions and markings shall be used.

4.5.5 Filters. Filters shall be used whenever the contrast reductions caused by low energy scattered radiation occuring on production radiographs is of significant magnitude to cause difficulty in meeting the quality level or radiographic coverage requirements as specified in contract, order or drawing.

4.5.6 Film viewing equipment. Equipment used for radiographic interpretation shall provide the following minimum requirements.

a. A light source of sufficient intensity to transmit at least two foot-candles of light through the film at the viewing surface of the film viewer and including a variable control to allow the selection of optimum intensities to resolve the penetrameter on film having densities from 2.0 to the maximum density usable with the light source shown in Figure 1. The light enclosure shall be so designed as to provide a uniform level of illumination over the entire viewing surface.

b. A suitable fan, blower or other cooling device to provide stable temperature at the viewing port such that film emulsions shall not be damaged during ten minutes of continued contact with the viewing surface.

c. A translucent material front in each viewing port, except for high intensity viewers used for high density film.

d. A set of opaque masks to suit the size of radiographs to be viewed.

e. The densitometer shall be capable of measuring the light transmitted through a radiograph with a film density up to 4.0 with a density unit resolution of 0.02. When film densities greater than 4.0 are permitted, a densitometer applicable to film densities up to maximum density permitted is required. A calibrated reference density strip, traceable to NBS, shall be maintained. Calibrated density film strips are available from film companies for standardization of densitometers.

f. Magnifying glasses 3X to 10X magnification.

4.5.7 Penetrameters. Penetrameters shall be fabricated from material of the same composition or radiographically similar material as the object to be radiographed. Penetrameters of less dense materials may be used in lieu of high density penetrameters (i.e., SS in place of Ni). When specified, undersized penetrameters may be used in lieu of proper thickness size.

4.5.7.1 Dimensions. For all materials the penetrameter thickness and hole diameter size will be in accordance with Figure 2. When specified, use of other types of penetrameters or modification of penetrameters is permitted provided the thickness, hole size requirements, the material designation and thickness identification requirements of Figure 2 are met. In cases where penetrameters other than those conforming to all the requirements of Figure 2 are used, the type of penetrameter used will be noted on all Reports of Inspection.

4.5.7.2 Identification of penetrameters.

4.5.7.2.1 Thickness. The penetrameter shall be identified with an identification number, made of lead alloy and attached to the penetrameter. This number expresses the material thickness, in inches. Fractions of an inch in the identification numbers shall be expressed as decimals.

4.5.7.2.2 Material identification. Penetrameters also shall be identified as to the predominant constituent using lead alloy letters. In cases where other types of penetrameters conforming to 4.5.7 are used, the lead alloy letters identifying the predominant constituent of the penetrameter shall be placed adjacent to the penetrameter. The chemical symbol shall be used for any material not listed in Figure 2. When the material is a metal composite or does not have a predominant single element, a controlled system for penetrameter identification shall be established and maintained.

4.5.7.2.3 Circular penetrameter identification. Lead numbers and letters shall be placed adjacent to the circular penetrameters to provide identification of the penetrameter on the film.

4.5.8 Classification of components to be radiographed.

4.5.8.1 General. The classification of all components shall be determined by the drawing of the part or the material specification. Complex components may be divided into zones and a separate classification and quality grade assigned to each zone in accordance with its reliability requirements. Such division of components shall be shown on the drawing of the component. References to ASTM reference radiographic standards listed (see 2.2) shall include the grade for each zone of the component. The drawing shall specify the radiographic quality level for each part or part zone and the acceptance criteria for each zone.

5. DETAIL REQUIREMENTS

5.1 Radiographic test technique. It shall be the responsibility of the test facility to develop a workable test technique which is capable of consistently producing the desired results and quality level. Included in this test technique shall be the following:

a. A drawing, sketch or photograph of the component showing the location of the film and penetrameter with respect to the radiation source for each exposure. Included shall be the angle of the radiation beam in relation to the component and the source-to-film distance. The illustration of a fabricated part shall include all components of the part pertinent to the radiograph.

b. The exposure time and (for X-ray machines) the kelovoltage, milliamperage, and the focal spot size or (for radiosotope sources) the isotope type, intensity (curies), and source size.

c. Type of film, intensifying screens, or filters used and film density range.

d. Thickness and type of material.

e. Penetrameter size and radiographic quality level.

f. Classification of the component or its sections.

g. The acceptance criteria for each section of the component (specify radiographic standard and grade).

h. Areas to be inspected shall be located on the drawing with NDT symbols in accordance with in ANSI/AWS A2.4, unless otherwise specified.

The above information may be recorded on a form having a format similar to Figure 3. When specified, the test technique shall be approved by the contracting agency prior to the performance of the test. The drawing shall specify the acceptance criteria on all class components.

5.1.1 Inspection and coverage. The number of parts inspected, and the coverage of each part shall be as specified by drawings, radiographic technique charts, radiographic manuals, handbooks for aircraft technical orders, or other specifications, as applicable. If the amount of inspection is not specified, all parts and material requiring radiographic inspection shall receive 100 percent radiographic coverage. Unless othewise specified, welded parts requiring radiography shall be radiographed for 100 percent of the length of the weld zone, including the weld heat affected zone. The orientation of the radiation beam and the number of exposures for any part of materials shall be governed by the test object geometry, the probable size and location of the various types of discontinuities to be detected, and the requirements of the applicable specifications and drawings.

5.2 Examination before and after machining. Radiographic inspection shall be performed at a stage in the process of manufacturing or assembly at which harmful internal discontinuities in the part or assembly can be detected. Areas, from which half or more of the thickness is removed by machining or other means after initial radiography, shall be re-examined by radiography after machining or processing, if specified and the quality requirements shall be as specified in drawings or other acquisition documents.

5.3 Nonfilm radiographic techniques. The use of nonfilm radiographic techniques is permitted, provided the method used is sufficiently sensitive to resolve the required quality level. However, prior approval must be obtained from the contracting agency on the detailed inspection and evaluation procedure.

5.4 Multi-film techniques. Film techniques with two or more films of the same or different speeds in the same film holder, shall be permitted provided that the applicable radiographic quality level for a specific area is achieved.

5.5 Radiographic quality levels. Three minimum quality levels listed in Table II may be assigned on the basis of penetrameter thickness and the perceptibility of one, two, or three holes in the penetrameter image on the radiograph.

5.6 Film density. Unless otherwise specified, radiographic exposure shall produce a film density of 2.0 to 4.0 in the area being examined and in the image of the penetrameter. Film densities above 4.0 are permitted only when it is demonstrated that film density does not exceed the film density that is usable with the film viewer as specified in 4.5.6. Film densities less than 2.0 are permitted only when items not requiring a penetrameter (see 5.9.1) are inspected.

5.7 Processing radiographs. Radiographs shall be free from blemishes which will mask or interfere with film interpretation.

5.8 Placement of penetrameters. A penetrameter shall be placed on each part radiographed, for the duration of exposure, unless a number of identical parts are simultaneously exposed. In such case, a single penetrameter placed upon the source side of that part at the outer edge of the cone of radiation will suffice. Where it is impractical to place the penetrameter upon the part radiographed, the penetrameter may be placed on the source side of a block of material having the same radiograph absorbtivity and approximately the same thickness as the part (or parts) radiographed, and located on the film at an area at the outer edge of the cone of radiation. In the inspection of irregular objects the penetrameter shall be placed on the area of the part farthest from the film. The penetrameter shall be normal to the radiation beam wherever possible.

5.8.1 Multiple film exposure. Where more than one film is used for an exposure, a penetrameter image shall appear on the radiograph at the edge of the film most distant from the center line. When the source is placed on the axis of the object and the complete circumference is radiographed with a single exposure, at least three equally spaced penetrameters are to be used if possible.

5.8.2 Longitudinal circumferential weld junctures. Where portions of longitudinal welds adjoining a circumferential weld are being inspected simultaneously with the circumferential weld, additional penetrameters shall be placed on the longitudinal weld at the end of the sections of those welds being radiographed.

5.8.3 Circumferential welds. When conventional (O.D. source/I.D. film) single wall techniques are used for girth weld radiography, place one penetrameter at the extreme edge of the area to be interpreted and in such a manner that it indicates the same degree of distortion due to curvature as does the part.

5.8.4 Longitudinal welds. For longitudinal welds, place a penetrameter at the extreme end of the area to be interpreted. The long axis of the penetrameter shall be parallel with and at least 1/8 inch, but not more than 1-1/4 inches from the weld edge.

5.8.5 Double wall exposures. For double wall radiography where both walls are to be inspected, a penetrameter shall be placed corresponding to the double wall thickness on the source side of the upper wall in such a manner that it is subject to the same maximum distortion and magnification as any area of the part to be inspected. The minimum source to film distance shall be based on the outside diameter of the tube or pipe. When impractical to do the above, a double wall thickness penetrameter may be placed on the source side of a block equivalent to the combined thickness of both walls. Both penetrameter and block shall be placed on a block of low density material (such as styrofoam) equivalent to the maximum distance from upper wall to the film, in such a manner that the penetrameter is subject to the same maximum distortion and magnification as any area of the part to be inspected. Unless otherwise specified, welds in pipe and tubes 3-1/2 inches and less in nominal size (diameter) may be radiographed using the double wall method. For welds in pipe greater than 3-1/2 inches in size, only the weld closest to the film shall be viewed for acceptance.

5.8.6 Single wall welds. When only the lower wall (film side) is to be inspected, a penetrameter equivalent to the lower wall thickness shall be placed on the source side of the lower wall if accessible, but if inaccessible, it shall be placed on the source side of a block equivalent to the lower thickness with a block equivalent to the upper wall placed on the source side of the penetrameter.

5.9 Applicable area. One penetrameter shall represent an area within which radiographic densities do not vary more than +30 percent or -15 percent from the density at the penetrameter location. A sufficient number of penetrameters shall be shown on the radiograph to indicate the sensitivity level of the complete material thickness range for the area or the part being radiographed. A shim or separate block shall be placed under the penetrameter on the parent metal next to a weld to compensate for the thickness of the weld bead, and/or backing strip.

5.9.1 Non-requirement of penetrameters. Penetrameters are not required when:

a. Examining assemblies for debris.

b. Conducting radiography for defect removal or grind out. The final acceptance inspection radiograph shall include a penetrameter.

c. Testing to show material details or contrast between two or more dissimilar materials in component parts or assemblies including honeycomb areas for the detection of fabrication irregularities or the presence or absence of material.

d. Electronic components for contamination, loose or missing elements or solder, broken or misplaced wires or connectors and potted assemblies for broken or missing potting compounds.

e. When surfaces are inaccessible an alternate method will be used subject to the approval of the contracting agency.

5.10 Contrast. The contrast of the radiograph shall be determined by measuring the difference in density of the film on the penetrameter and the base metal adjacent to the penetrameter. The minimum density difference shown in Figure 4 shall be measured between the penetrameter and the base metals for radiographic quality levels 1 and 2.

5.11 Location of film. The film during exposure shall be as close to the surface of the component being radiographed as practicable.

5.12 Back scatter radiation. During each exposure the film shall be protected against back scatter. Each film holder shall have a lead letter "B" a minimum of 1/2 inch high and a minimum of 1/16 inch thick positioned behind the film and within the general area of the film to be viewed. Should the image of the lead letter "B" attached to the back of the film holder or cassette, appear on the film as a light area, the film should be considered unacceptable and the component re-radiographed.

5.13 Source-to-film distance. Recommended minimum source-to-film distances for radiographic quality levels 1 and 2 are shown on Figures 5 and 6. For any type of radiographic exposure, the ratio of the distance of the source of radiation from the source side of the component to the distance of the radiographic film from the same surface, shall be such that a sharply defined image of the penetrameter holes is attained.

5.14 Identification. Marking of the film and the parts must be provided so that traceability through identification of the parts and the radiograph is provided and maintained.

5.15 Locating test area. Whenever more than one radiograph is required for a weldment or other repairable part, location markers whose images will appear on the film shall be placed on the surface of the part or material in order that the orientation of the film may be established and any defects appearing on the film precisely located.

5.16 Crack detection. When parts are radiographed to detect cracks such as those initiated by fatigue, only the area of the film which falls within a cone of radiation (10° solid angle, apex at the radiation source, central axis of cone equal to central axis of radiation beam) shall be considered valid for interpretation.

5.17 Surface preparation. Metal components may be inspected without surface preparation or conditioning except as required to remove surface conditions which may interfere with proper interpretation of radiographs. Accessible surfaces of welds to be radiographed shall be prepared as necessary in accordance with the applicable welding process specification so that the valleys between beads, weld ripples or other surface irregularities are blended to a degree such that the resulting radiographic contrast due to surface condition cannot mask or be confused with that of any defect.

5.18 Quality assurance provisions.

5.18.1 Detailed data. The NDT facility shall keep a complete record of the details of inspection technique as described in 5.1 of this standard. NDT facilities within a prime contractor's plant may retain the records within the facility. When an identical technique is used for a number of parts, a single record tabulating all identical features of the technique will suffice for all parts. Copies shall be supplied to the contracting agency at their request. For any rejectable item, the test results also shall be recorded and kept in file for five years for future reference.

5.18.2 Radiographs. Each radiograph shall carry the radiographic inspection serial number or code letters of the inspection report of the part (or parts) to which it pertains. In addition each radiograph shall carry the identification of the NDT facility inspecting the parts and the date of the inspection. Radiographs of a repair area shall be identified with R1, R2, R3, etc. indicating number of times repairs were attempted.

5.18.3 Retention of radiographs. Unless otherwise specified by the contracting agency, radiographs shall be kept on file at the prime contractor's plant for reference purposes for five years from the date the radiographs are made.

5.18.4 Rejection. Parts containing discontinuities or defects exceeding the permissible limits of the applicable specification drawing standard or directive shall be separated from acceptable material, appropriately identified as discrepant, and submitted for material review when provided in the contract.

5.18.5 Re-radiography. Whenever there is a reasonable doubt as to the interpretation or clarity of the radiograph because of film artifacts or improper technique, re-radiography is required.

5.19 Marking.

5.19.1 Acceptable parts. Parts which conform satisfactorily to applicable radiographic inspection requirements shall be marked, in a manner and location harmless to the part and which will preclude removal, smearing, or obliteration by subsequent handling. When subsequent processing which would remove identification is planned, the applicable symbol shall be affixed to the records accompanying the parts.

5.19.2 Impression stamping. Impression stamping shall be used where permitted by the applicable specifications or drawings. Marking shall be located in areas adjacent to the part number.

5.19.3 Etching. When applicable, parts shall be marked by etching. Suitable etchants and application methods shall be employed. Etching methods other than fluid etching may be used.

5.19.4 Dyeing. Where etching or impression stamping is not appropriate, identification may be accomplished by dyeing.

5.19.5 Other identification. Other means of identification, such as tagging, may be applied to completely ground and polished parts for which construction, finish or functional requirement preclude the use of etching, stamping or dyeing.

5.19.6 Symbols. Each part which has successfully passed radiographic inspection shall be marked as follows:

a. When etching or stamping is applicable, symbols shall be used. The symbol shall contain an identification symbol to the facility.

1. Except for specialized applications, use the symbol "X" enclosed in a circle to denote 100 percent radiographic inspection.

2. Each item accepted on a sampling basis shall be marked using the symbol "X" enclosed in an ellipse.

b. When dyeing is applicable, blue dye shall be used to indicate 100 percent radiographic inspection and orange dye shall be used to indicate parts accepted on a sampling basis.

6. NOTES

6.1 Density calibration. Calibrated density film strips are available from film companies for standardization of densitometers.

6.2 Dark adaption. The radiographer should wait at least 3 minutes before attempting film interpretation when coming into the viewing room from ordinary artificial room light. When coming from full sunlight, the observer should allow at least 5 minutes for dark adaption before viewing. If the eyes are subject to the full brightness of the illuminator during changes of the radiographs, at least 30 seconds readaption is necessary.

Custodians:
Army - MR
Navy - AS
Air Force - 20

Review activities:
Army - MI
Navy - SH, OS
Air Force - 70, 71, 82, 89

User activities:
Army - AR, GL, MD
DLA - DH, ES

Preparing activity:
Navy - AS
(Project No. NDTI-0082)

Table I. Film applications.

FILM TYPE	RELATIVE SPEED AT (200 kV)	DESCRIPTION	SUGGESTED APPLICATIONS
Special	9	Very slow speed, very high contrast, finest grain size	Electronic components, finest detail at low kV's (up to 130 kV) on thin light metals, plastic, tubing, and other low absorbers
1	30	Slow speed, very high contrast, very fine grain size	Radiography of thin to medium thick light metals, at low to medium kV's (up to 200 kV), thicker light metals and thin sections of heavy metals
	50	Intermediate speed, very high contrast, extra fine grain	At higher kV's - castings, welds, and other assemblies
2	100	Medium speed, high contrast, fine grain size	Radiography of medium thick to thick light metals, medium thick sections of heavy metals. Most suitable for isotope, super-voltage, and betatron radiography
3	170	Fast speed, medium contrast, course grain size	Radiography of thick sections of heavy metals or other materials at isotope, super-voltage or betatron energies - large castings and weldment

Table II. Quality levels of inspection.

Radiographic Quality Level	Penetrameter Designation	Max. Penetrameter Thickness 1/	Min. Penetrameter Hole Diameter 2/	Equiv. Penetrameter Sensitivity 3/
00	1 - 1T	1%	1T	0.7%
0	1 - 2T	1%	2T	1.0%
1	2 - 1T	2%	1T	1.4%
2	2 - 2T	2%	2T	2.0%
3	2 - 4T	2%	4T	2.8%

1/ Expressed as percentage of material thickness.

2/ Expressed as multiple of thickness of penetrameter.

3/ Equivalent penetrameter sensitivity is that thickness of the penetrameter expressed as a percentage of the specimen thickness in which a 2T hole would be clearly visible under the same radiographic conditions.

Table III. Lead screen thickness. 1/

kV RANGE	LEAD THICKNESS	
	Front Screen Maximum (inch)	Back Screen Minimum (inch)
0-150	0.000	0.005
150-200kV-Ir192	0.005	0.005
200-300kV	0.010	0.010
300-kV-1MeV Co 60	0.020	0.010
1-2 MeV Radium	0.030	0.010
10-25 MeV	0.030 to 0.125	0.010

1/ Recommended lead screen thickness for applicable voltage range being used.

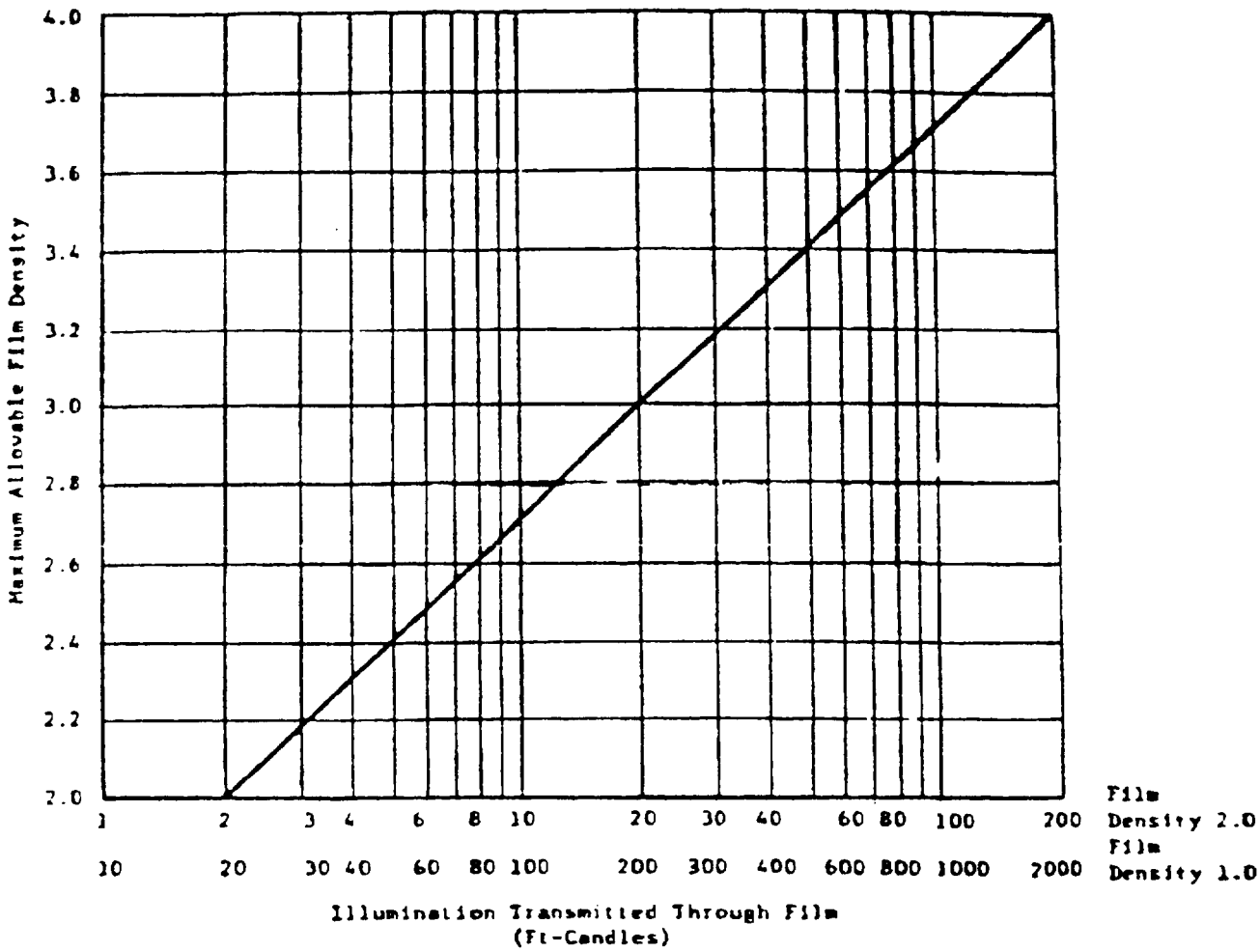
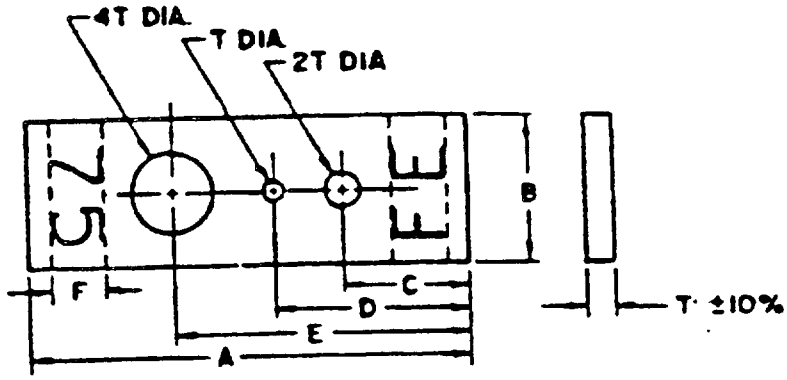


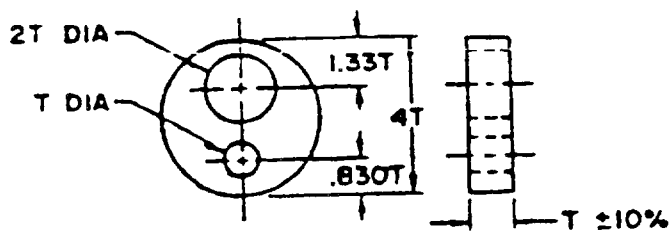
Figure 1. Maximum allowable film density usable with film viewer.



T	INCRE-MENTS	A	B	C	D	E	F
.005-.020INCL	.0025	2.000	.500	.520	.800	1.150	.250
.025-.050INCL	.005	2.000	.500	.520	.800	1.150	.250
.060-.160INCL	.010	2.850	1.000	.800	1.250	1.900	.375

MIN PENETRAMETER THICKNESS .005 ±10 PERCENT
MIN DIAMETER FOR 1T HOLE .010 ∓10 PERCENT
MIN DIAMETER FOR 2T HOLE .020 ∓10 PERCENT
MIN DIAMETER FOR 4T HOLE .040 ∓10 PERCENT

DESIGN FOR PENETRAMETER THICKNESSES UP TO AND INCLUDING 0.160



DESIGN FOR PENETRAMETER THICKNESSES OF 0.180 AND OVER MADE IN .020 INCREMENTS

SYMBOL	MATERIAL
SS	STAINLESS STEEL
AL	ALUMINUM
FE	STEEL
MG	MAGNESIUM
CU	COPPER
TI	TITANIUM

ALL DIMENSIONS IN INCHES
HOLES SHALL BE TRUE AND NORMAL TO THE SURFACE OF THE PENETRAMETER. DO NOT CHAMFER. TOLERANCES ON PENETRAMETER THICKNESSES AND HOLE DIAMETERS SHALL BE +10 PERCENT OR 1/2 OF THE THICKNESS INCREMENT BETWEEN PENETRAMETER SIZES, WHICHEVER IS SMALLER.

Figure 2. Penetrameters.

RADIOGRAPHIC TECHNIQUE DATA SHEET SHEET OF

PATTERN NO. MATERIAL PART NAME

TECHNIQUE SET-UP _____ DATE _____ SET-UP MADE BY _____

HEAT NO. _____ S.O. _____ PLAN NO. _____ DATE ____

FILM EXPOSED BY _____ FILM REVIEWED BY _____

APPROVED _____ _____

_____ _____

Views

Source No.

Source Curies or KV

MA

Distance Source to Film

Time

Thickness of Material

Penetrameter

Pen. Block

Film Size

Film Type

Screen Pb Back

Sensitivity

Inspection Category (Appendix 1)

Density

Sketch of Exposure Set-Up

Screen Pb Front

SHEET OF

PATTERN NO.

Figure 3. Radiographic test technique data sheet.

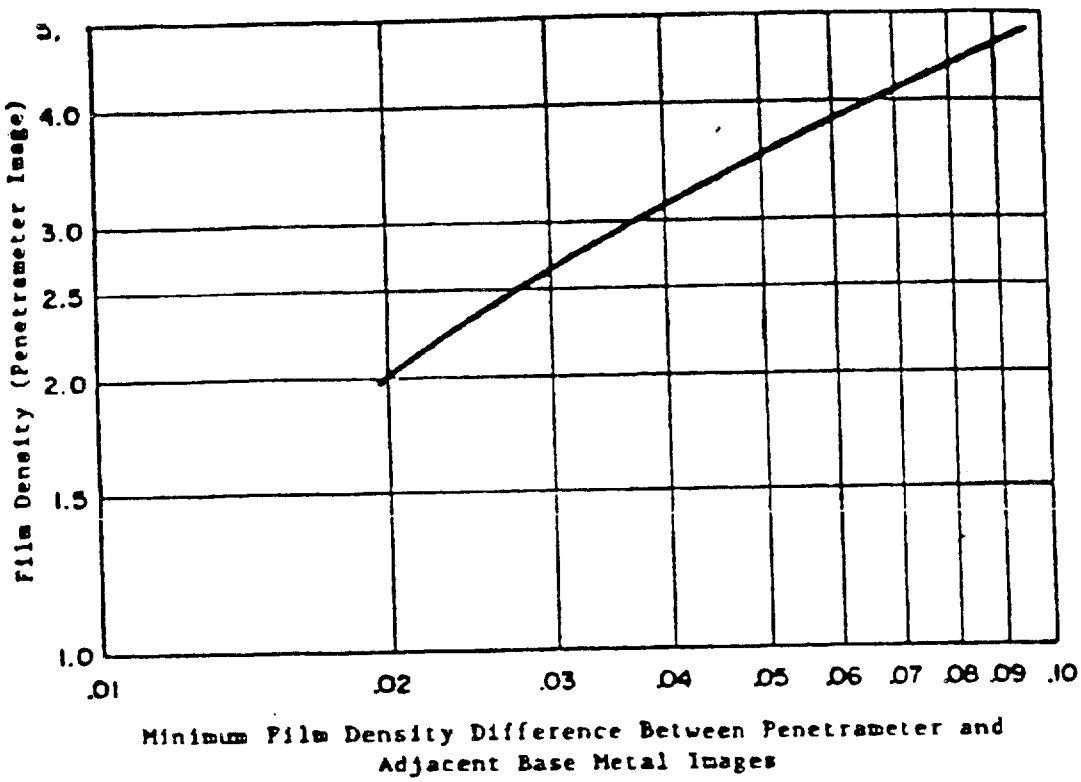
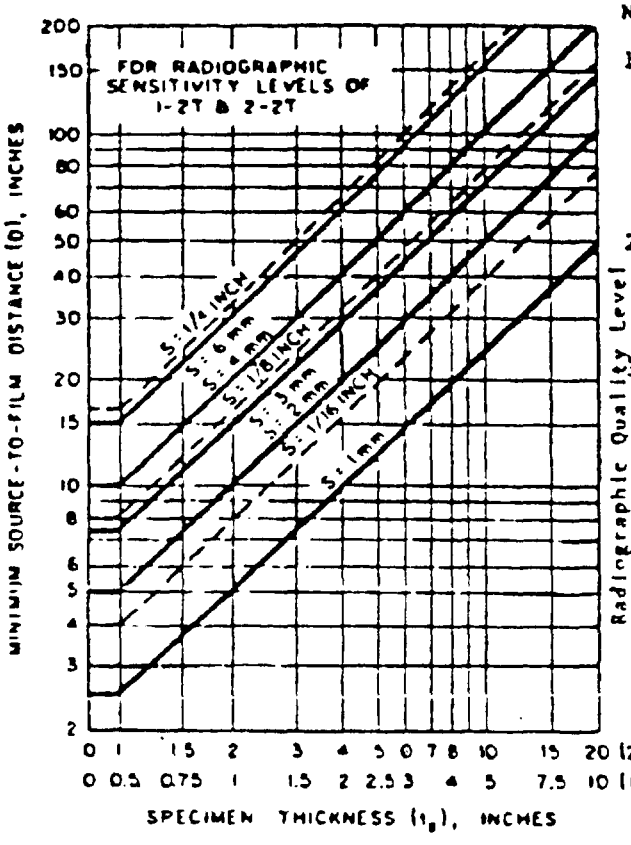


Figure 4. Minimum contrast of radiographs at various film densities.



NOTES:

1. When using radioisotope sources whose lengths are greater than 1/8", source-to-film distances must be increased according to figure 6 to compensate for increased dispersion caused by side effects.
2. For a radiographic quality level of 2, D=2.5 St_s where S=the maximum source size in millimeters (1mm=0.039 inch).
3. For radiographic sensitivity levels or source sizes covered in the graph, the minimum source-to-film distance shall be calculated by the following formula:

$$D = KST_s$$

Where

D= The minimum source-to-film distance, in inches
K= Constant (see listing below for applicable values of K for various Radiographic quality levels)
S= Maximum effective radioisotope source or focal spot dimension in millimeters
T_s= Source side penetrameter to film distance in inches.

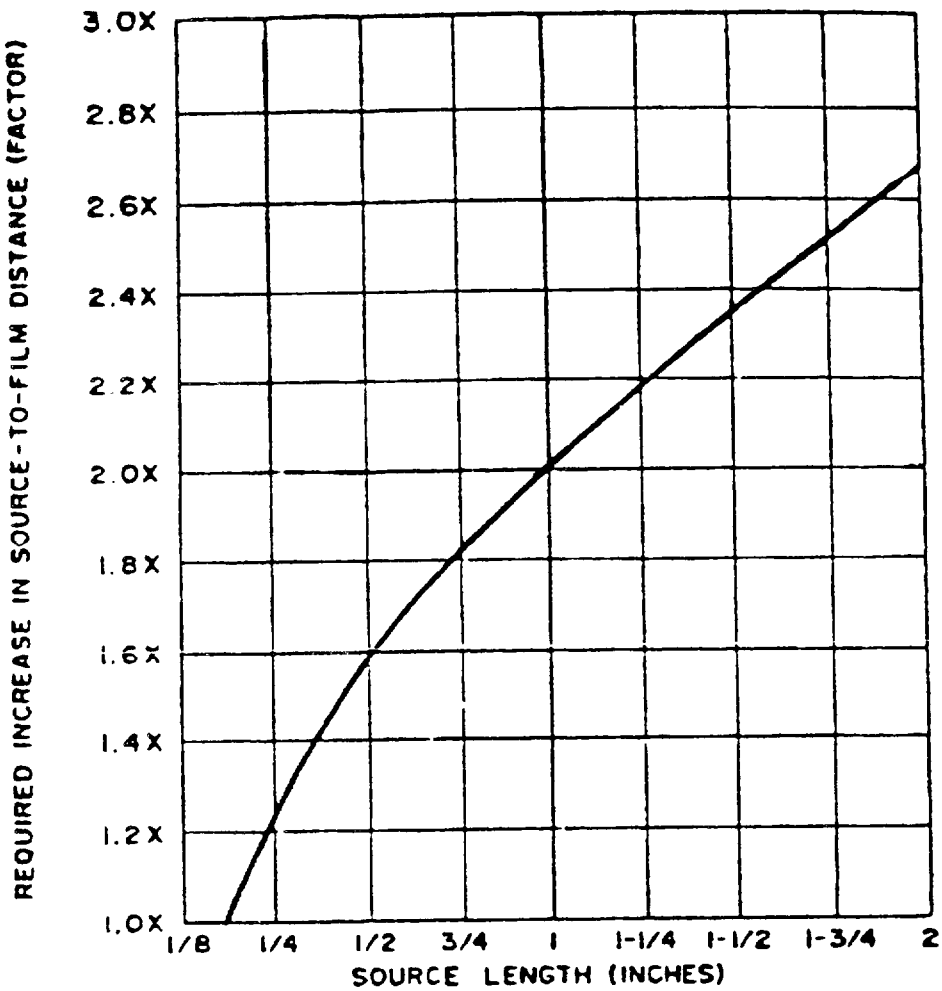
Source-to-film distance calculation constants

Radiographic Quality Level	"K" Values for "S" in mm	"K" Values for "S" in units of 1/16 inch
1	3.6	5.7
2	2.5	4.0
3	2.0	3.2

4. The film shall be as close to the specimen as possible. Where a gap between the specimen and the film holder is unavoidable, the minimum source-to-film distance shall be increased in the ratio of:

$$\frac{\text{Specimen Thickness + Gap}}{\text{Specimen Thickness}}$$

Figure 5. Recommended minimum source-to-film distance for various focal spot or radioisotope source sizes to obtain equivalent geometrical sharpness of image for radiographic quality levels 1 and 2.



NOTE: To find the source-to-film distance to use with a given source, find the minimum source-to-film distance from Figure 5, and multiply this value by the length-factor from the above curve.

Figure 6. Recommended increase in source-to-film distance for various radioisotope sources whose lengths are greater than 1/8 inch.

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