
USACE / NAVFAC / AFCEA / NASA UFGS-13 49 19 (February 2009)

Preparing Activity: USACE Superseding
UFGS-13 49 19 (April 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2013

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SECTION 13 49 19

X-RAY SHIELDING 02/09

NOTE: This guide specification covers the requirements for x-ray shielding for medical and dental radiological facilities.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

PART 1 GENERAL

NOTE: This specification essentially implements the requirements of NCRP Reports 49, 102 and 145; however, designers are cautioned to ensure that the requirements of TB MED 521 be met in addition to the requirements of applicable NCRP publications. In case of conflict between NCRP publications and TB MED 521, the more stringent requirements will be applied.

The installation systems given in this guide specification are the systems more commonly used. Where details of construction require systems not included in this guide specification, the guide specification requirements will be revised to specify the required system. Criteria for users on

radiation protection surveys is contained in TB MED 521.

Design or modification of diagnostic x-ray, therapeutic x-ray, or gamma-beam therapy facilities must only be undertaken by experts certified in radiological physics or therapeutic radio-logical physics by the American Board of Radiology or the American Board of Health Physics.

Where the increase in cost can be justified by substantial increases in flexibility of the facility, allow for future rearrangement of x-ray equipment and facilities by providing the maximum thickness of shielding which provides the minimum protection in all areas that could be covered by the primary beam. In any case, lead thickness must be uniform for the entire wall, ceiling, floor or partition to which it is applied.

Department of the Army Technical manual 5-805-12, "X-Ray Shielding," has standard details. It is included in the CCB.

Include on the drawings:

1. Extent of the shielding; length, width, and height of the lead sheeting.
2. Joint, opening, and corner details showing the method of continuation of protection.
3. Door and window details, including louvers and screens.
4. Pipe and conduit chases and penetration sleeves.
5. Location of all door and wall plaques.
6. Stud spacing for lead lined gypsum board or lath.

1.1 REFERENCES

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically
be deleted from this section of the project
specification when you choose to reconcile
references in the publish print process.

The publications listed below form a part of this specification to the
extent referenced. The publications are referred to within the text by the
basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM B749	(2003; R 2009) Standard Specification for Lead and Lead Alloy Strip, Sheet and Plate Products
ASTM C129	(2011) Standard Specification for Nonloadbearing Concrete Masonry Units
ASTM C1396/C1396M	(2013) Standard Specification for Gypsum Board

HARDWOOD PLYWOOD AND VENEER ASSOCIATION (HPVA)

HPVA HP-1	(2009) American National Standard for Hardwood and Decorative Plywood
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NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS (NCRP)

NCRP 102	(1989) Medical X-Ray, Electron Beam and Gamma-Ray Protection for Energies up to 50 MeV (Equipment Design, Performance and Use)
NCRP 144	(2003) Radiation Protection for Particle Accelerator Facilities
NCRP 145	(2003) Radiation Protection in Dentistry
NCRP 49	(1976) Structural Shielding Design and Evaluation for Medical Use of X-Rays and Gamma Rays of Energies up to 10 MeV

STEEL DOOR INSTITUTE (SDI/DOOR)

SDI/DOOR A250.8	(2003; R2008) Recommended Specifications for Standard Steel Doors and Frames
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U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.1025	Lead
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WINDOW AND DOOR MANUFACTURERS ASSOCIATION (WDMA)

WDMA I.S.1A	(2011) Architectural Wood Flush Doors
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1.2 SUBMITTALS

NOTE: Review submittal description (SD) definitions

in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

X-Ray Shielding[; G][; G, [____]]
Operators Protective Screen[; G][; G, [____]]

SD-03 Product Data

Leaded Glass
Lead-Lined Wood Doors
Lead window Frames
Lead Lightproof Louvers
Lead-Lined Steel Doors and Frames
Film Cassette Transfer Cabinets

SD-04 Samples

Lead-Lined Wood Panels

SD-06 Test Reports

Testing and Certification

Submit four copies of surveyor's report.

SD-07 Certificates

X-Ray Shielding

1.3 QUALIFICATIONS

Work shall be performed by a company which specializes in the type of shielding work required by the Contract documents. Company shall have a minimum of [5] [_____] years of documented successful experience.

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver materials in the original containers bearing the name of the manufacturer and brand name. Store shielding materials off the ground under watertight cover. Handle materials preventing damage to edges, ends or surfaces in conformance with 29 CFR 1910.1025. Remove damaged materials from the premises. [Leave protective paper on acrylic panels until installation is complete.]

1.5 WARRANTY

Lead sheet shielding materials shall be warranted against sagging and curling for [10] [_____] years.

PART 2 PRODUCTS

2.1 SHIELDING SYSTEM

NOTE: For Navy projects, submit x-ray shielding designs and calculations to Chief, Bureau Medicine and Surgery, 2300 E Street NW, Washington, D.C. 20372-5000, for review and approval prior to design release.

Coordinate work of this section with Sections 11 27 13 RADIOGRAPHIC DARKROOM EQUIPMENT and 11 70 00 GENERAL REQUIREMENTS FOR MEDICAL AND DENTAL EQUIPMENT.

Construct X-ray shielding unimpaired by joints, openings for ducts, pipes, or other openings through shielding, or conduits, service boxes, and other items embedded in the shielding. The shielding shall appear to be continuous. Install lead patches, lead sleeves, and/or mazes as required to provide continuity of the shielding. Minimum lead lap shall be 25 mm 1 inch. Sleeves shall be not less than 25 mm 1 inch in length. Thicknesses indicated for shielding are minimum acceptable thickness.

- a. Submit shop drawings that indicate thickness of lead at all locations; construction at floor, walls, ceiling, and columns; details of lead laps and lap securing methods; fastenings, profiles, details of items and accessories penetrating the shielding materials; and any special method of construction.
- b. Certify the shielding materials supplied comply with specified quality

and thicknesses

2.2 LEAD SHEET

Lead sheet shall conform to **ASTM B749**, Grade C, thickness as indicated.

2.3 LEAD-LINED CONCRETE MASONRY UNITS

NOTE: Coordinate the requirements of this Section with Section **04 20 00 MASONRY**. Lead-lined masonry units have a broad range of lead thicknesses. Lead-lined masonry units offer the advantages that they are relatively simple to construct, provide considerable structural strength, and may be surfaced easily with plaster. However, the cost is considerably higher (up to a specific kV) than using lead-lined wallboard, lath, panels, concrete, or earth.

Provide lead-lined concrete masonry units conforming to **ASTM C129**, Type 1. Each unit shall have a single thickness of unpierced lead sheet bonded or anchored permanently in the center of the unit/block. Construct blocks to provide an effective lead lap between adjoining blocks either by the overlapping of lead in adjoining blocks or by lead bars at block joints when erected. Nominal dimensions for full-size units shall be **300 by 300 by [100] [150] mm 12 by 12 by [4] [6] inch**. Nominal dimensions for half-size units shall be **150 by 300 by [100] [150] mm 6 by 12 by [4] [6] inch**. Units **100 mm 4 inch** thick shall be used for shielding requirements up to **6 mm 1/4 inch** of lead, and **150 mm 6 inch** thick units shall be used for shielding requirements above **6 mm 1/4 inch** of lead.

2.4 LEAD-LINED WOOD PANELS

NOTE: When a matching finish is not required, specify prefinished panels.

Lead-lined panels shall be unpierced sheet lead laminated to hardwood veneer plywood conforming to **HPVA HP-1**, not less than **9 mm 3/8 inch** thick. The lead sheet shall extend the full height and width of the panels except for applications at corners, frames, and other similar locations. The lead sheet may extend beyond the edge of the panels to form effective lead laps. Face veneer shall be [birch] [mahogany] [red gum] [red oak] [white oak]. Face veneer shall [have an approved natural finish] [be polished sanded] [have a primary coat of varnish, lacquer, or synthetic coating]. Submit **200 by 250 mm 8 by 10 inch** sample of each specified panel.

2.5 LEAD-LINED LATH

Lead-lined lath shall have a single thickness unpierced sheet of lead laminated to gypsum lath, conforming to **ASTM C1396/C1396M**, Type 1, Grade R, Class 1, Form a, Style 1, **9 mm 3/8 inch** thick, so that the lead extends **25 mm 1 inch** beyond lath on one long side and one short side.

2.6 LEAD-LINED GYPSUM WALLBOARD

Lead-lined gypsum wallboard shall be a single thickness of unpierced lead laminated to [13] [16] mm [1/2] [5/8] inch thick gypsum board conforming to ASTM C1396/C1396M, Type III, Grade R, Class 1, Form a, [Style 1] [Style 3].

2.7 LEADED GLASS

Leaded glass shall be clear X-ray protective quality glass in single or multiple thicknesses. Leaded glass shall have lead equivalence required for the shield wall, door, or partition in which the leaded glass is installed.

2.8 LEAD-HEADED NAILS

**NOTE: Lead-headed nails are seldom required; use if
radiological calculations show a need for them.**

Lead-headed nails may be used to accomplish shielding not less than that provided by the barrier. The size, type and design shall be recommended by the manufacturer of material to be installed.

2.9 LEAD TABS OR CLIPS

Lead tabs or clips shall be unpierced sheet lead not less than the thickness of lead in the barrier. Prior to folding, the tabs shall be rectangular in shape and shall be the required size to provide an effective lead lap over an unleaded nail, screw, or tie wire penetration when folded.

2.10 LEAD-LINED WOOD DOORS

Lead-lined wood doors shall be [premium grade, book matched] [good grade], hardwood veneer, solid core, in accordance with WDMA I.S.1A. Lead sheet shall extend to door edges and provide x-ray absorption equal to the partition in which the door is installed. Face veneer for lead-lined doors shall be [birch] [mahogany] [red gum] [red oak] [white oak] [_____] finished with [an approved natural finish] [_____]. Doors shall have filler strips, crossbanding face veneers and hardwood edge strips glued under heavy pressure with contact adhesive.

2.10.1 Shielding

Secure cores together with [poured lead fasteners] [or] [steel bolts], using washers under heads and nuts. Bolts shall be spaced not more than 38 mm 1-1/2 inch from edges around door perimeter and not more than 200 mm 8 inch on centers in both directions. Bolts shall be countersunk and have poured lead or lead dowels covering heads and nuts flush with face of core. Door thickness shall be manufacturer's standard for lead thickness used, unless shown otherwise.

2.10.2 Painting and Sealing Doors

Top and bottom edges of doors to be painted shall receive two factory coats of spar varnish before shipment to jobsite. Doors to be stained or have a natural finish shall receive two shop coats of water-resistant sealer before shipment to jobsite.

2.10.3 Door Hardware

Door hardware shall be as specified in Section 08 71 00 DOOR HARDWARE. Mortises for floor hinge arms and top pivots with sheet lead and necessary lead plugs, sheet lead, stainless steel pans, bolts and screws shall be provided.

2.10.4 Thresholds

NOTE: Threshold construction is determined by radiographic equipment required, work load, and location of radiation source from the door (i.e., threshold may not be required for installation operating below 125 kVp if the primary beam does not strike the door area).

Thresholds are specified in Section 08 71 00 DOOR HARDWARE. Line thresholds with a single sheet of lead to provide required shielding.

2.11 LEAD WINDOW FRAMES

Construct lead window frames for viewing windows mounted in lead-lined doors from [lead extrusion welded in one piece] [extruded aluminum alloy with concealed lead lining], splayed on four sides for wide-angle viewing. Frames shall form a minimum overlap of 9 mm 3/8 inch at the perimeter of the lead glass or twice the thickness of the shielding, whichever is greater. Thickness of lead shall be the same as the lead in the barrier in which they occur. Frames can be either solid or telescoping type. Lead stops shall be provided for glass or acrylic installation. Clear acrylic panel shall be provided with lead equivalence [_____] [as required by unit in which panel is installed.] [Provide a baffled slot for voice passage in the frame.]

2.12 LEAD LIGHTPROOF LOUVERS

Lead lightproof louvers for doors shall be fabricated entirely of lead of not less than the thickness of lead in barrier in which they are installed. Louvers shall be one-unit construction designed with a maze-type blade to exclude the passage of light. Louvers shall allow 30 percent free area for air circulation. Louvers shall be factory-fitted, boxed separately, and shipped with door or assembled before shipment.

2.13 LEAD-LINED STEEL DOORS AND FRAMES

2.13.1 Doors

NOTE: Threshold construction is determined by radiographic equipment required, work load, and location of radiation source from the door (i.e., threshold may not be required for installation operating below 125 kVp if the primary beam does not strike the door area).

Doors shall conform to Section 08 11 13 STEEL DOORS AND FRAMES, in accordance with SDI/DOOR A250.8, Grade II, heavy duty, Model 1, minimum 18

gage faces with steel stiffeners throughout. Apply unpierced lead sheet, of thickness equal to that used in the adjoining wall, in the center of the door between the two faces, continuously from top to bottom and edge to edge. Shield cutouts for locksets with sheet lead of the same thickness as used in the door; lap lead lining of locksets and the door lining. Prepare doors to receive viewing windows and louvers as indicated. Provide removable stops for glazed openings. Use Section 08 71 00 DOOR HARDWARE for protective hardware requirements. Line thresholds with a single sheet of lead to provide required shielding.

2.13.2 Frames

Provide steel frames as specified in Section 08 11 13 STEEL DOORS AND FRAMES. The inside of frames shall be lined with a single thickness of sheet lead. The thickness of the lead lining shall be the same as the lead lining of the system in which the frames are used. Linings shall be installed at the factory, and shall be continuous. Lining shall be formed to contour of frame. Lead shields shall be formed around areas prepared to receive hardware. Each lining shall be wide enough to provide and maintain an effective lead lap with the lead of the adjoining shielding units.

2.14 FILM CASSETTE TRANSFER CABINETS

Cassette transfer cabinet shall be double-wall steel cabinet divided into two compartments with doors of one cabinet plainly marked for exposed cassettes and doors of the other cabinet plainly marked for unexposed cassettes. Interlocking device shall prevent the doors on opposite ends of the cabinets from being opened at the same time. Sheet lead lining of cassette cabinet shall provide x-ray absorption equal to the X-ray absorption provided by partition in which the cabinet is installed. Cabinets shall have identification marking. Cabinet floor shall be corrugated rubber with chrome-plated door knobs.

2.15 OPERATORS PROTECTIVE SCREEN

Operators protective screen shall be constructed [of studs, surfaced with lead-lined [gypsum lath conform to ASTM C1396/C1396M] [gypsum wallboard conforming to ASTM C1396/C1396M] secured to studs with appropriate fasteners, with lead washer or tabs.] [of sheet lead laminated between plywood panels, 19 mm 3/4 inch thick conforming to HPVA HP-1.]

2.16 DESIGNATING PLAQUES

2.16.1 Required Information

Furnish and install designating plaques as specified below in rooms and as indicated on the drawings. Locations where shielding thickness changes, or is not continuous, shall be indicated on the plaque. Plaque shall be of aluminum, plastic, bakelite, or other approved materials and shall be [_____] mm inches high by [_____] mm inches long to contain the required information as specified below.

2.16.2 X-Ray and Examination Rooms

One sign shall be provided for [dental x-ray room] [x-ray] [and] [examination rooms] lettered as follows:

: "THE PARTITIONS, THE DOORS, AND THE LEAD-LINED SHIELD OF THIS ROOM HAVE BEEN INSULATED WITH SHEET LEAD [_____] mm INCH THICK PROVIDING A TOTAL LEAD

EQUIVALENT PROTECTION OF [_____] mm INCH."

2.16.3 Radiographic, Fluoroscopic, and Cystoscopic Rooms

One sign shall be provided for each room insulated with sheet lead lettered as follows:

: "SURFACES OF THIS ROOM HAVE BEEN INSULATED WITH SHEET LEAD OF FOLLOWING THICKNESS TO A HEIGHT OF 2.1 m 7 FEET ABOVE FLOOR SLAB:

	LEAD THICKNESS	TOTAL LEAD EQUIVALENT PROTECTION
DOORS	[_____] mm inches	[_____] mm inches
PARTITIONS	[_____] mm inches	[_____] mm inches
FLOORS	[_____] mm inches	[_____] mm inches

2.16.4 Deep Therapy Room

One sign shall be provided for each deep therapy room lettered as follows:

"ALL SURFACES OF THIS ROOM HAVE BEEN SHIELDED WITH AN EQUIVALENT SHEET LEAD OF THE FOLLOWING THICKNESS:

	TOTAL LEAD EQUIVALENT PROTECTION
DOORS	[_____] mm inches
PARTITIONS	[_____] mm inches
FLOOR	[_____] mm inches
CEILING	[_____] mm inches

2.16.5 Rooms With Nonshielded Partitions

Provide one sign for each lead-shielded partition in a room for which all partitions are not shielded. A sign shall be located on lead-insulated partition and lettered as follows:

: "THIS PARTITION HAS BEEN SHIELDED THE [FULL HEIGHT] [HEIGHT OF [_____] m FEET] WITH SHEET LEAD [_____] mm INCH THICK, PROVIDING A TOTAL LEAD EQUIVALENT PROTECTION OF [_____] mm."

2.16.6 Cardiac Fluoroscopy Room

One sign shall be provided for the door to cardiac fluoroscopy or other room to which only the door is shielded, lettered as follows:

: "THIS DOOR HAS BEEN SHIELDED WITH SHEET LEAD OF [_____] mm INCH."

2.17 CONCRETE

[Concrete shielding material shall be uniform density of 2355 kg/cubic meter 147 pcf] [High-density concrete shielding material shall be of uniform density in the range of 3045 to 3445 kg/cubic meter 190 to 340 pcf].

PART 3 EXECUTION

3.1 INSTALLATION

NOTE: NCRP Reports 49, and 144 or 102 will be included for medical facilities. NCRP Report 145 will be included for dental clinics. For facilities with both medical and dental x-ray construction, NCRP Reports 145, 49 and 144 or 102 will be included. This Section is applicable only to the design of medical and dental facilities; other type facilities are required to meet different radiation protection standards, and must be coordinated with NAVSEASYS COM Detachment, Radiological Affairs Support Office, Yorktown, VA 23691-5098 for Navy projects.

Perform installation of materials and assemblies in accordance with drawings and approved manufacturer's recommendations and [NCRP 145] [NCRP 49] [NCRP 102] [or] [NCRP 144].

3.1.1 Workmanship

Install sheet lead free of waves, lumps, and wrinkles and with a minimum of joints. Joints in sheet lead shall provide protection equivalent to the protection provided by the adjacent sheet lead. Joints shall be finished smooth and neat.

3.1.2 Protection

Use lead shields to maintain continuity of protection where unshielded built-in items penetrate lead linings. Where outlet boxes, junction boxes, ducts, conduits, and similar items prevent the use of shields, lead sleeves or lead lining shall be used. Fasteners shall not disrupt the continuity of shielding.

3.2 LEAD-LINING FOR CONCRETE FLOORS

NOTE: In rooms scheduled for sheet lead ceiling, the sheet lead lining shall be placed on top of the floor slab above the room protected, unless a suspended lead ceiling is required. Vertical wall shieldings shall be erected on lead strips prior to the installation of floor linings in the shielded room. Lead strips shall project approximately 75 mm (3 inches) into the shielded room area. Lead lining at the door sill opening shall be not less than 600

mm (2 feet) wider than the opening and shall extend not less than 300 mm (1 foot) beyond the door jamb openings.

Surfaces of concrete floors receiving lead linings shall be clean, dry, and free of sharp projections that will damage or penetrate the sheet lead. When necessary, a smooth screed coat of concrete shall be applied over rough concrete surfaces. A coat of asphalt or latex paint shall be applied to the concrete surfaces prior to installation of the sheet lead.

3.2.1 Shielding

Sheet lead less than 3 mm 1/8 inch thick shall be applied in a single layer with a 38 mm 1-1/2 inch minimum lap at joints. Sheet lead more than 3 mm 1/8 inch thick shall be applied in two or more layers 3 mm 1/8 inch or less in thickness with 38 mm 1-1/2 inch minimum lap at joints or shall be applied in a single layer with joints butted and covered with lead strips not less than the thickness required for floor lining and as detailed.

3.2.2 Protection from Damage

Apply a coat of asphalt paint to the top surface of the sheet lead prior to application of concrete surfacing. Traffic or other work will not be permitted in the area until concrete is applied over lining.

3.3 LEAD-LINED BLOCKS

Lead-lined blocks shall be laid in running bond courses with staggered vertical joints. Blocks designed for lead laps at joints shall be erected to provide minimum 25 mm 1 inch tight lead laps without soldering or burning or provide lead bars in vertical and horizontal joints. Blocks designed to have lead bars in joints shall be erected to permit lead bars with a thickness not less than the lead sheet thickness in block to be inserted in horizontal and vertical joints.

3.3.1 Joints

Mortar joints shall be 9 mm 3/8 inch thick and shall be filled solid with Type N mortar as specified under Section 04 20 00 MASONRY. Mortar between lead laps will not be permitted.

3.3.2 Blocks

Extend blocks into frame openings, with lead projecting into rabbets of frames to effectively lap with lead frames of frame linings. Voids around frames shall be filled with mortar.

3.3.3 Pipe and Conduit Chases

Where pipe and conduit chases occur within the blocks, concrete may be removed from one side of the partition as required to permit pipe installation. Where necessary to remove lead lining for pipe or conduit installations, continuous sheet lead shall be installed and overlapped on the adjoining construction. Voids around pipe and conduit chases within the blocks shall be filled with mortar. Voids shall be finished flush with the face of partition. Pipe and conduit chases shall not be installed directly opposite each other within the same partition.

3.4 LEAD-LINED PANELS

NOTE: When the finish of the panels must match the finish of other woodwork, the polish sanding for finish on the job will be specified. Length and width of panels and joint pattern will be indicated on the drawings and will be selected to keep weights of panels to reasonable minimums.

Lead-lined panels shall be applied over supports specified in Section 06 10 00 ROUGH CARPENTRY. The method of predrilling or drilling pilot holes for fasteners shall prevent deformation of the fastener and shall prevent distortion of the panel. Lead-lined panels shall be butt-jointed and shall be placed over supports with lead linings placed next to supports. Effective lead laps at corners and around frames of openings shall be made with panels having lead extensions or with sheet-lead strips not less than the thickness of the lead in the panel. Fasteners shall be set 2 mm 1/16 inch below the face of panel or joint strip. Fasteners shall be finished with filler or plugs to match the panel. Sides and ends of panels shall be secured at approximately 200 mm 8 inch on centers with fasteners to penetrate 40 mm 1-1/2 inch into supports. At intermediate supports, panels shall be fastened in a uniform pattern at approximately 400 mm 16 inch on centers. Fastening at joints shall conform to one of the following methods:

3.4.1 Joints With Lead-Lined Joint Strips

Cover joints with sheet-lead strips not less than the panel thickness and not less than 50 mm 2 inch wide. Secure joint strips to supports with fasteners located in the center of joint strip at approximately 200 mm 8 inch on center.

3.4.2 Joints Backed with Lead Strips

Sheet-lead strips not less than the panel thickness and not less than 40 mm 1-1/2 inch wide shall be installed on supports at panel joints. Lead strips shall be secured at outer edges of strips. Finish molding strips shall match the panel finish. Finish molding strips shall be installed to cover joints and shall be secured with fasteners at approximately 200 mm 8 inch on centers.

3.5 LEAD-LINED LATH

NOTE: Lead-lined lath with lead 8 mm (5/16 inch) thick or less will be 400 x 1220 mm (16 x 48 inches) with lead extensions on two sides for lapping and installed with the long dimension at right angles to supports. Lead-lined lath with lead over 8 mm (5/16 inch) thick will be 300 mm (12 inches) wide by manufacturer's standard length with lead cut the same size as the lath installed with the long dimension parallel to supports. Drawings will indicate support spacing at 300 mm (12 inches) on centers where the 300 mm (12 inch) wide lath is used.

Lead-lined lath shall be applied over supports specified in Section 06 10 00 ROUGH CARPENTRY and Section 09 22 00 METAL SUPPORT ASSEMBLIES. The method of predrilling or drilling the pilot holes shall prevent deformation of the fastener and shall prevent distortion of the lath. Lead-lined lath shall be applied with long edges at right angles to supports and with lead linings placed next to supports.

3.5.1 Joints

[Place end joints over supports staggered in alternate courses.][Wall joints shall not coincide with the ceiling joints.][Each sheet shall overlap the lead extension on the adjacent sheet, providing an effective lead lap.][Lead-lined lath shall be applied with long edges parallel to supports and with lead linings placed next to supports. Blocking shall be provided at end joints. Sheet-lead strips, not less than the lath thickness and not less than 40 mm 1-1/2 inch wide, shall be applied on blocking and on supports at joints. Lead strips shall be secured to blocking and supports at outer edges of strips.] Lath shall be close fitted and uniformly secured to supports. Approximately 6 mm 1/4 inch shall be allowed between horizontal joint to form key for plaster.

3.5.2 Frames and Corners

Lath shall extend into frames of openings effectively lapping with lead frames or frame linings. Unless otherwise approved, lath shall be arranged around openings such that neither horizontal nor vertical joints occur at corners of openings. External corners shall be reinforced with corner bead. Internal corners, except at unrestrained suspended ceilings, shall be reinforced as required and shall be installed with lead-headed nails or tie wires and lead tabs. At unrestrained ceilings, square-nosed casing beads shall be installed at the junction of walls and suspended ceilings.

3.5.3 Wood Supports

Lath shall be uniformly nailed to wood supports at approximately 175 mm 7 inch on centers with lead-headed nails. Nail heads shall be flush with lath surface.

3.5.4 Metal Supports

Lath shall be uniformly secured to [wood furring strips which are secured at right angles to the metal supports with bolts or screws. Lath shall be secured with lead-headed nails with the nail heads flush with lath surface] [metal supports with 25 mm 1 inch screws or tie wire and lead tabs folded over the fasteners].

3.6 LEAD-LINED GYPSUM WALLBOARD

NOTE: A nonlead-lined finish ply of gypsum wallboard may be installed where required by design requirements. Style 1, butt-joints, will be used for the base ply of two-ply construction. The finish ply shall be bonded to the first ply with laminating adhesive applied as recommended by the manufacturer of the wallboard. A shoring system shall be used to hold the finish ply in place during the adhesive drying period. Shoring shall be left in place at least 24 hours. Nailing of the finish

ply will not be permitted. Joint and corner treatment shall be as specified in Section 09 29 00 GYPSUM BOARD.

Lead-lined gypsum wallboard shall be applied over supports specified in Section 06 10 00 ROUGH CARPENTRY and Section 09 22 00 METAL SUPPORT ASSEMBLIES. Method of predrilling or drilling pilot holes shall not cause deformation of the fastener and shall not cause distortion of wallboard. Wallboard shall be applied vertically, with long edges parallel to supports, and with lead linings placed next to supports. Blocking shall be provided at end joints.

3.6.1 Joints

Sheet-lead strips not less than the lead thickness used for wallboard and not less than 38 mm 1-1/2 inches wide shall be installed on blocking and supports at all joints.

3.6.2 Corner Joints

Corner joints shall consist of 45 by 45 mm 1-3/4 by 1-3/4 inch lead angle.

3.6.3 Wood Supports

The sheet-lead strips shall be secured to blocking and supports at outer edges with wire nails. Edges of wallboard shall then be butt-jointed and fastened to supports with lead-headed nails at approximately 200 mm 8 inch on centers at joints and 300 mm 12 inch on center at intermediate supports with nail heads driven slightly below the surface of wallboard.

3.6.4 Metal Supports

Edges of gypsum wallboard at metal studs shall be fastened with 25 mm 1 inch long lead-headed screws. Heads shall be covered with 13 mm 1/2 inch diameter lead disc cemented to wallboard and installed flush with surface of wallboard.

3.6.5 Finish Ply

Gypsum wallboard not scheduled to be plastered shall receive a finish ply of gypsum wallboard bonded to the first ply with laminating adhesive as recommended by the wallboard manufacturer. Nailing the finish ply will not be permitted. A shoring system shall be used to hold finish ply in place during adhesive drying period. Shoring shall be left in place at least 24 hours. Joint and corner treatment shall be as specified in Section 09 29 00 GYPSUM BOARD.

3.7 SUSPENDED LEAD-LINED CEILINGS

Provide suspended lead-lined ceilings consisting of lead-lined lath, ceiling bars, and hangers. Continuous bars shall be spaced approximately [315] [415] mm [12-1/2] [16-1/2] inch on center and supported by steel hangers from overhead structure. Lead in the ceiling shall lap lead in the wall by not less than 38 mm 1-1/2 inch.

3.8 LEAD DOOR THRESHOLDS

NOTE: Drawings should indicate type of threshold for each specified radiographic or therapy room. Thresholds will be included in installations where floor lining is not installed and if required by design conditions.

Thresholds shall be installed in accordance with approved detail drawings. Prior to installation, lead threshold surfaces in contact with concrete shall be painted with a coat of asphalt paint or latex material.

3.9 LEAD-LINED WOOD DOORS

Doors shall be fit, hung, and trimmed as required. Doors shall be installed with a clearance of 2 mm 1/16 inch at sides and top and minimum adequate clearance at bottom. Lock edge shall be beveled 3 mm 1/8 inch, and hardware shall be adjusted as required. Warp or twist of lead-lined doors after doors have been hung and finished shall not exceed 6 mm 1/4 inch in any face dimension of door including full diagonal. Cuts required for installation shall be sealed with a clear varnish or sealer.

3.9.1 Door Hardware

Bolts and screws which penetrate lead lining shall be recessed on the side of the door opposite hardware and shall be plugged with lead plugs to match face of door. Nuts for securing surface-applied hardware such as hinges, door closers and automatic door operators shall be countersunk and covered with lead-lined 1.59 mm 16 gauge thick stainless steel pans. Stainless steel pans shall be secured with round-head screws with dull chromium-plated finish. Cutouts for lock sets and latch cases shall be patched with sheet lead. Lead lining of the lock set and lead lining of the door shall be lapped to provide x-ray absorption equal to the door.

3.9.2 View Windows

View windows shall be installed in doors with hardwood stops to match face veneer. Stops shall be glued to door on corridor side and shall be fastened with countersunk oval head screws or finishing nails.

3.9.3 Lead Louvers

Lead louvers shall be installed in doors with cadmium-plated or chromium-plated screws. Fastenings shall not penetrate lead lining of the door.

3.10 OPERATOR'S PROTECTIVE SCREEN

Finish plywood-hinged screens and fixed screens after installation in the same manner as that specified for doors. Edge strips are not required for fixed screens. At corners or where screen abuts a wall or floor, provide a lap of lead. [Build-in viewing window of lead glass or acrylic with lead equivalence [indicated.] [matching adjacent panel].]

3.11 TESTING AND CERTIFICATION

NOTE: NCRP Reports 49, 144, and 102 will be included for surveying medical facilities. NCRP Report 145 will be included for surveying dental

clinics. For facilities incorporating medical and dental x-ray installations, NCRP Reports 145, 49 and 144 or 102 will be included.

Before and after x-ray equipment has been installed and placed in operating condition, the x-ray installation shall be surveyed by a qualified expert as defined in [NCRP 145] [NCRP 49] [NCRP 102] [or] [NCRP 144]. Survey shall be performed in accordance with [NCRP 145] [NCRP 49] [NCRP 102] [or] [NCRP 144]. Any part of x-ray shielding work found to be defective shall be corrected or replaced, including all other work affected thereby.

-- End of Section --