

**SECTION 13 49 00  
RADIATION PROTECTION**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

- A. This section specifies lead radiation shielding.
- B. Construction of products and assemblies used for radiation shielding complying with applicable requirements of NCRP Reports 147 and 102.
- C. This section includes the following items:
  - 1. Lead Lined Wood Doors
  - 2. Lead Lined Shields
  - 3. Lead Glass
  - 4. Lead Lined Frames
  - 5. Thresholds
  - 6. Lead Sheet
  - 7. Lead Lined Gypsum Wallboard

**1.2 RELATED WORK**

- A. Wood Veneer finish for doors: Section 08 14 00, WOOD DOORS, and Section 09 06 00, SCHEDULE FOR FINISHES.
- B. Steel door frames: Section 08 11 13, HOLLOW METAL DOORS AND FRAMES.
- C. Hardware for doors: Section 08 71 00, DOOR HARDWARE.
- D. Installation of Doors and Hardware: Section 08 11 13, HOLLOW METAL DOORS AND FRAMES Section 08 14 00, WOOD DOORS Section 08 71 00, DOOR HARDWARE.

**1.3 MANUFACTURERS QUALIFICATIONS**

- A. Approval by Contracting Officer is required of product or service of proposed manufacturer and suppliers, and will be based upon submission by Contractor of certification that:
  - 1. Manufacturer regularly and presently manufactures lead radiation shielding as specified as one of its principal products.
  - 2. Manufacturer's product submitted has been in satisfactory and efficient operation or three installations similar and equivalent to this project for three years.
  - 3. Manufacturer submits list of installations.

**1.4 TESTS**

- A. Lead radiation shielding will be tested at the expense of the Government after X-ray equipment is installed.
- B. Any additional testing required due to correction and replacement of defective work will be done by the Government at Contractor's expense.

**NOTE:** Lead glass, lead lined concrete masonry units, lead lined gypsum lath, lead lined gypsum wallboard and lead lined plywood will not be tested prior to installation.

#### 1.5 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Shop Drawings: Each lead radiation shielding item specified showing thickness of lead, details of construction and installation.
- C. Samples:
  - 1. Lead lined concrete masonry units, gypsum lath and gypsum wallboard.
  - 2. Bottom corner section of lead lined door, 300 mm (12 inches) square showing bottom and side edge strips.
- D. Manufacturers' Literature and Data: Each lead radiation shielding item specified.

#### 1.6 WARRANTY

- A. Warranty lead lined doors against defects in workmanship and materials subject to terms of "Warranty of Construction" Article in GENERAL CONDITIONS, except that warranty period shall be two years.
- B. Warp or twist of lead lined flush veneered doors may not exceed 6 mm (1/4 inch) in any face dimension of door (including full diagonal), measured not less than six months after doors have been hung and finished.

#### 1.7 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Federal Specifications (Fed. Spec.):  
QQ-L-201F(2).....Lead Sheet
- C. American Society for Testing and Materials (ASTM):  
A167-99(2009).....Stainless and Heat Resisting Chromium-Nickel  
Steel Plate, Sheet and Strip  
C1396/C1396M-04.....Gypsum Wallboard/Gypsum Lath  
C90-11.....Load-Bearing Concrete Masonry Units  
C1002-07.....Steel Drill Screws for the Application of Gypsum  
Board or Metal Plaster Bases  
D1187-97(R2002).....Asphalt-Base Emulsions for Use as Protective  
Coatings for Metal
- D. United States Department of Commerce Product Standard (PS):  
FED PSI 83-84.....Construction and Industrial Plywood

E. Military Specifications (Mil. Spec.):

MIL-C-36373.....Cabinet, Cassette Transfer, Wall Mounted

F. National Council on Radiation Protection and Measurements (NCRP):

Report 147.....Structural Shielding Design for Medical X-Ray

Imaging Facilities (2004)

Report 102.....Medical X-Ray, Electron Beam and Gamma-Ray

Protection for Energies up to 50 MeV (Equipment  
Design, Performance and Use), (1989)

**PART 2 - PRODUCTS**

**2.1 MATERIALS**

- A. Lead Sheet: Fed. Spec. QQ-L-201, Grade C, of thickness shown on drawings.
- B. Lead Lined Concrete Masonry Units: Not Used.
- C. Lead Lined Gypsum Lath: Not Used.
- D. Lead Lined Gypsum Wallboard:
  - 1. ASTM C1396, Type X, 16 mm (5/8 inch) thick.
  - 2. Factory bond sheet lead to one side of wallboard.
  - 3. Apply sheet lead in thicknesses shown, unpierced and in one piece.
- E. Lead Lined Plywood Panels: Not Used.
- F. Stainless Steel: ASTM A167.
- G. Lead Glass: Clear, X-ray proof, of sufficient thickness to provide X-ray protection equivalent to that provided by partition or door in which glass occurs.
- H. Lead Control Windows: Cast lead, rigid, single unit type without joints, with or without voice passage as shown and with lead stop beads and lead glass.
- I. Cassette Transfer Cabinets, MIL-C-36373: Not Used.
- J. Thresholds:
  - 1. Lead lined stainlesssteel as detailed.
  - 2. Stainless steel thresholds over lead lining as detailed.
- K. Fasteners:
  - 1. Cadmium or chromium plated steel screws for securing lead louvers.
  - 2. Standard steel drill screws, ASTM C1002, with lead washers for application of lead lined sheet materials to metal studs and attach washers in accordance with shielding manufacturer's instructions.
- 3. Nails:
  - a. Use barbed lead head nails for application of lead lined materials to wood furring strips.
  - b. Long enough to penetrate furring strips not less than 25 mm (one inch).

- c. Cast-lead head sufficiently thick to equal lead shielding of room provided.
- L. Lead Discs: Same thickness as lead lining, diameter 25 mm (1 inch) larger than fastener.

## **2.2 FABRICATION**

- A. General: Lead lining of frames, doors and other items occurring in partitions shall provide an X-ray absorption equivalent to that of partitions in which they occur.
- B. Clearance between Doors and Frames and Floors:
  - 1. Jambs and Heads: A maximum 3 mm (1/8 inch) clearance.
  - 2. Bottom of door to finish floor: Maximum 19 mm (3/4 inch) clearance.
- C. Lead Lined Wood Doors:
  - 1. Flush veneered construction.
  - 2. Construct doors of two separate solid wood cores with a single sheet of lead lining through center.
  - 3. Doors shall have filler strips, crossbanding, face veneers and hardwood edge strips, all glued together with unextended urea resin glue applied under heavy pressure.
  - 4. Extend sheet lead lining to all door edges, providing X-ray absorption equal to partition in which door occurs.
  - 5. Fasten wood cores together with either countersunk steel bolts through lead with bolt heads and nuts covered with poured lead, or with poured lead dowels.
  - 6. Bolts or dowels shall be located 38 mm (1-1/2 inches) from door edges, and at not more than 200 mm (eight inches) on center in each direction over door area.
  - 7. Finish face of dowels and lead covering of bolt heads and nuts flush with wood cores.
  - 8. Edge strips:
    - a. Same species of wood as face veneer.
    - b. Minimum thickness of edge strips shall be 38 mm (1-1/2 inches) at top edge and 63 mm (2-1/2 inches) at bottom edge.
    - c. Glue strips to cores before face veneer is applied.
    - d. Extend vertical edge strips full height of door and bevel 3 mm (1/8 inch) for each 50 mm (two inches) of door thickness.
    - e. Give top and bottom edges of doors to receive transparent finish two coats of water resistant sealer before shipment to site.
  - 9. Crossbanding of hardwood:
    - a. Not less than 2 mm (1/12 inch) thick and face veneer not less than 1 mm (1/28 inch) thick, after sanding.

- b. When straight grain stock such as Basswood, Aspen or Poplar is used for crossbanding, its thickness may be 1.6 mm (1/16 inch) in lieu of 2 mm (1/12 inch).
  - 10. Face veneer for doors specified in Section 09 06 00, SCHEDULE FOR FINISHES to have transparent finish, shall be rotary cut premium grade, uniform light, Birch.
  - 11. Face veneer for painted doors shall be rotary cut, good grade, mill choice close grained hardwood, except lauan is not acceptable. Use only one species of wood for face veneer. Match door veneer specified in Interior Wood Door Section 08 14 00.
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- a. Use identical face veneer on both sides of door. Apply face veneer with grain vertical.
  - b. Give doors to be painted a shop prime coat of exterior oil paint on all surfaces before shipment to site.
12. Secure glass panels with hardwood stops of same species as face veneer. Glue stops to doors on corridor side and fasten with countersunk ovalhead screws on room side. Finish edge of stop flush with face veneer.
- D. Hardware:
- 1. Hardware for doors is specified in Section 08 71 00, DOOR HARDWARE.
  - 2. Stagger bolts to door pulls on plates which penetrate lead lining relative to opposite plate and recess on side of door opposite pull.
  - 3. Provide lead plugs or discs over recessed nut ends of such bolts, unless otherwise shown.
  - 4. Nut ends of bolts for surface applied hinges, door closures and automatic door operators shall be countersunk and covered with lead lined 16 gage stainless steel pans.
  - 5. Provide round head screws with dull chromium plated finish to secure stainless steel pans.
  - 6. Provide mortises for flushbolts, floor hinge arms, and top pivots with sheet lead on each side. Enclose floor boxes of floor hinges with sheet lead at sides and bottom.
  - 7. Make recesses for lock and latch cases at mill and line with lead butted tightly to lead in door.
  - 8. Make total thickness of sheet lead used for lining hardware, equivalent to thickness of sheet lead core of door.
  - 9. Protection and installation of doors and hardware is specified in Section, 08 11 13 / 08 14 00 / 08 71 00, HOLLOW METAL DOORS AND FRAMES / WOOD DOORS / DOOR HARDWARE.

E. Lead Lining of Frames:

1. Line or cover steel frames, stops for doors, and corner type control windows with sheet lead.
2. Install sheet lead free of waves, lumps and wrinkles with as few joints as possible.
3. Make joints in sheet lead to obtain X-ray absorption equivalent to adjacent sheet lead. Finish joints smooth and neat.
4. Structural steel frames and metal door frames for lead lined doors are specified in Section 05 50 00, METAL FABRICATIONS and Section 08 11 13, HOLLOW METAL DOORS AND FRAMES respectively.

F. Thresholds:

1. Neatly fit thresholds around cover plates of floor hinges. Lead lining shall enclose box of floor hinge.
2. Provide stainless steel expansion bolt fasteners as detailed.

G. Lead Rayproof Louvers:

1. Fabricate louvers entirely of lead of thickness required to provide protection equivalent to that required in adjoining construction, and fastened with exposed screws.
2. Fastenings for louvers in doors must not penetrate lead lining of door.

**PART 3 - EXECUTION**

**3.1 LEAD LINED MASONRY UNIT PARTITIONS**

- A. Lay lead lined concrete masonry units in courses with staggered vertical joints and lay to provide log cabin bond of at least 100 mm (four inches) at corners and angles.
1. Concrete masonry units designed to have lead laps at joints: Erect in a manner to provide minimum 25 mm (one inch), tight lead laps without soldering or burning.
  2. Concrete masonry units designed to have lead bars in joints: Erect in a manner to permit lead bars (horizontal and vertical), of thickness not less than that in concrete masonry units, to be inserted in each joint.
  3. Masonry units containing 6.0 mm (1/4-inch) lead or less in thickness: Constructed to provide a 38 mm (1-1/2 inch) lead lap between units by overlapping of lead in adjoining masonry units when erected.
  4. Masonry units containing more than 6.0 mm (1/4-inch) lead thickness:
    - a. Construct to receive lead bars in all joints when erected.
    - b. Bars shall lap lead in adjoining masonry units not less than 19 mm (3/4 inch).

5. Provide special shapes to maintain proper bond. Cut units in the field in a manner not to effect the bond, lapping margin, or the shielding qualities of the lead.

B. Mortar joints:

1. 13 mm (1/2 inch) thick and filled solid with mortar as specified under Section 04 20 00, UNIT MASONRY.
2. Mortar between lead laps will not be permitted.

C. Extend partitions into frame openings, with lead projecting into rabbets of frames to effectively lap with lead frames or frame lining. Fill voids around frames with mortar.

D. Where pipe and conduit chases occur within the partitions, concrete may be removed from one side of the partition as required to permit pipe installation.

1. Where it is necessary to remove lead lining for pipe or conduit installations, install continuous sheet lead and fasten in a manner to overlap the adjoining construction.
2. Fill voids around pipe and conduit chases within the partitions with mortar and finish flush with the face of the partition. Pipe and conduit chases shall not be installed directly opposite each other within the same partitions.

### 3.2 FLOOR LEAD

A. Concrete floor slabs:

1. Thoroughly cleaned and smooth, and free of defects that might cause damage to lead.
2. Floor slab shall be cured a minimum of 90 days.
3. Before installation of lead, coat concrete surfaces with two coats of asphalt-base emulsion (ASTM D1187).
4. Lap sheets of floor lead not less than 38 mm (1-1/2 inches).

B. After installation of sheet lead, apply two coats of Asphalt base emulsion material over the lead and protect from damage until concrete fill and floor topping is installed.

C. Lead lined concrete masonry partitions:

1. Place a continuous lead strip under new partitions with a 50 mm (two inch) projection on X-ray room side.
2. Overlap sheet lead on floors on lead strips at least 38 mm (1-1/2 inches).

D. Lead lined lath or panels: Sheet lead on floors shall lap lead lining in wall a minimum of 38 mm (1-1/2 inches).

E. Where lead lined thresholds are not required, continue lead strips under partitions across door opening and extend strip 300 mm (12 inches)

outside of partition and 300 mm (12 inches) beyond each jamb of door openings.

F. For existing floors:

1. Lay lead sheets with butt joints.
2. Lay lead strip 38 mm (1-1/2 inches) wide and of same thickness as floor lead centered under full length of each butt joint.
3. Lay strips in concrete fill as shown, to same clearances provided in existing floor so that top of strip will be level with existing floor.

**3.3 LEAD LINED PLYWOOD PANELS - NOT USED**

**3.4 LEAD LINED GYPSUM LATH - NOT USED**

**3.5 LEAD LINED GYPSUM WALLBOARD PANELS**

- A. Apply lead lined gypsum wallboard to metal studs as shown.
- B. Predrill or drill pilot holes for nails or screws as necessary to prevent deformation of the fastener and leadshielding and to prevent distortion of the wallboard.
- C. Apply wallboard vertically with lead linings placed next to supports.
- D. Install sheet lead strips behind joints not less than the thickness used for the wallboard.
  1. The lead strips: 45 mm (1-3/4 inches) wide, except at corner joints, 45 mm by 45 mm (1-3/4 by 1-3/4 inch) lead angles shall be used.
  2. Secure the lead strips to supports at outer edges of strips.
- E. Wallboard:
  1. Nail to supports with fasteners to supports with screws and lead washers or discs at approximately 250 mm (ten inches) on centers.
  2. Make provisions for connection with lead lined door frames and for cutouts for vision panels.
  3. Joint treatment of lead lined gypsum board panels and fastening depressions shall be as specified for wallboard in Section 09 29 00, GYPSUM BOARD.

**3.6 SUPPLEMENTAL LEAD SHIELDING**

- A. Line or cover penetrations of wall lead, pipe chases, columns fasteners and elsewhere where shown with sheet lead. Install sheet lead free of waves, lumps and wrinkles and with as few joints as possible. Joints in sheet lead shall provide X-ray absorption equivalent to adjacent sheet lead finished smooth and neat.
- B. Where plaster finish is required over columns or other vertical surfaces covered with sheet lead, drive bolts or other fasteners securing the sheet lead to backing surface half way, and wrap an 18 gage stainless



steel tie wire around fasteners. Both ends of each tie wire shall be of sufficient length so that when fastener is fully driven, fastening of metal lath may be accomplished. Locate fasteners not over 400 mm (16 inches) on centers both ways and cover heads with lead strips or discs if washers are not used.

- C. Provide sufficient lead shielding for spaces around outlet boxes, junction boxes, film illuminators, and pipes, to obtain a net radiation protection at these spaces equaling net radiation protection specified for wall or partition in which they occur.

### 3.7 SIGNS: FURNISH SIGNS AS FOLLOWS:

- A. One for each X-Ray, lettered as follows:

THE PARTITIONS, THE DOORS AND THE SHIELD OF THIS ROOM HAVE BEEN INSULATED WITH SHEET LEAD OF 1/16" THICKNESS PROVIDING A TOTAL LEAD EQUIVALENT PROTECTION OF 1/16".

- B. One for each Angio Room Insulated with sheet lead and lettered as follows:

SURFACES OF THIS ROOM HAVE BEEN INSULATED WITH SHEET LEAD OF THE FOLLOWING THICKNESS TO A HEIGHT OF 2100 mm (7 FEET) ABOVE FLOOR SLAB:

	TOTAL LEAD	
	LEAD	EQUIVALENT
	THICKNESS	PROTECTION
DOORS AND FRAMES - -	1/16"	1/16"
PARTITIONS - - - - -	1/16"	1/16"
FLOORS - - - - -	1/16"	1/16"

- C. One for each lead insulated partition in room in which not all partitions are insulated (or in which partitions on dark room side have been insulated differently from other partitions of room), located on partition and lettered as follows:

THIS PARTITION HAS BEEN INSULATED TO HEIGHT OF 7'-0" FEET WITH SHEET LEAD OF 1/16" THICKNESS, PROVIDING A TOTAL LEAD EQUIVALENT PROTECTION OF 1/16".

- D. One for door to which only the door is insulated, lettered as follows:

THIS DOOR HAS BEEN INSULATED WITH SHEET LEAD OF 1/16" THICKNESS, PROVIDING A TOTAL LEAD EQUIVALENT PROTECTION OF 1/16".

- E. Signs:

1. Heavy white paper or cardboard.
2. Height of lettering and number not less than 3 mm (1/8 inch).
3. Fill in blank spaces on signs with mm thickness of lead as installed and total mm thickness of lead equivalent (determined by VA Physicist) and height of such insulation where required.

4. Mount in stainless steel or extruded aluminum frames (with acrylic plastic, 3 mm (1/8 inch) thick over sign) and fasten with suitable screws, one to each corner of each frame.
5. Provide manufacturer's standard stainless steel frame, to hold card size 100 mm by 150 mm (four by six inches).

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