SECTION 13 49 00
RADIATION PROTECTION

SPEC WRITER NOTE: Delete between // -- // if not applicable to project. Also delete any other item or paragraph not applicable in the section and renumber the paragraphs.

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. Cassette Transfer Cabinets
   7. Lead Louvers
   8. Lead Lined Concrete Masonry Units
   9. Lead Sheet
   10. Lead Lined Plywood
   11. Lead Lined Gypsum Lath
   12. Lead Lined Gypsum Wallboard

1.2 RELATED WORK

A. Masonry mortar: Section 04 20 00, UNIT MASONRY.
B. Structural steel: Section 05 50 00, METAL FABRICATIONS.
C. Wood Veneer finish for doors: Section 08 14 00, WOOD DOORS, and Section 09 06 00, SCHEDULE FOR FINISHES.
D. Steel door frames: Section 08 11 13, HOLLOW METAL DOORS AND FRAMES.
E. Hardware for doors: Section 08 71 00, DOOR HARDWARE.
F. 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
   Report 102 ............. Medical X-Ray, Electron Beam and Gamma-Ray
                         Protection for Energies up to 50 MeV (Equipment

PART 2 - PRODUCTS

SPEC WRITER NOTE: Make material requirements agree with application requirements specified in the referenced Applicable Publications. Update and specify only that which applies to the project.

2.1 MATERIALS


B. Lead Lined Concrete Masonry Units:
   1. ASTM C90.
   2. Units shall have unpierced sheet lead through vertical centers arranged to provide effective lead insulation through all joints.
   3. Secure sheet lead to masonry units either by latex bonding (vulcanizing) method, or by galvanized iron anchors soldered or cemented to lead.

C. Lead Lined Gypsum Lath:
   1. ASTM C1396, 9 mm (3/8 inch) thick.
   2. Bond sheet lead to one side of lath using plastic adhesive which will not dry out, nor set up hard, nor allow sheet lead to pull loose.
   3. Apply sheet lead in uniform thickness shown, unpierced and in one piece.
   4. Extend lead one inch beyond edge of each piece of lath at top and at one end.

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:
1. Prod. Std. PS1, Grade A-A interior type, 9 mm (3/8 inch) thick.
2. Factory bond sheet lead to one side of plywood.
3. Apply sheet lead in thicknesses shown, unpierced and in one piece.
4. Make each panel in one piece and of width to fully sustain its own weight without requiring intermediate nailing between joints.

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: Sheet lead lining of cabinets shall provide X-ray protection equal to that provided by partition in which cabinets occur.

J. Thresholds:
//1. Lead lined stainless steel 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.
   //f. For door to Deep Therapy, provide lead strip on all four edges of door. //
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).

SPEC WRITER NOTE: Specify the veneer type and species for transparent finish doors.

10. Face veneer for doors specified in Section 09 06 00, SCHEDULE FOR FINISHERS 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.

   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.
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. 

SPEC WRITER NOTE: All doors with lead 3 mm (1/8 inch) thick or greater will have stainless steel thresholds over lead, or lead lined stainless steel thresholds.

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.
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 in installed.
   SPEC WRITER NOTE: Use Subparagraph 1 for NEW CONSTRUCTION. Use Subparagraph 2 for EXISTING CONSTRUCTION.
C. Lead lined concrete masonry partitions:
1. Place a continuous lead strip under 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
A. Vertically apply panels over wood strips / metal studs // as shown. Predrill or drill pilot holes for nails // screws // as necessary to prevent deformation of the nail // lead shielding // and to prevent distortion of the panel.
B. Lead lined panels: Butt jointed with all joints placed over supports and with lead linings placed next to supports.
C. Lead laps at corners and around frames of openings: Made with panels having lead extensions or with sheet lead strips not less than the thickness of the lead in the panel.
D. Nails:
   1. Set 2 mm (1/16 inch) below face of the panel or joint strip in which they occur and finished with filler or plugs.
   2. Nailings at intermediate supports will not be permitted.
E. Nailing at joints shall conform to one of the following methods:
   1. Joints with lead lined joint strips:
      a. Nail sides and ends of panels at approximately 200 mm (eight inches) on centers with wire nails of sufficient length //to penetrate 38 mm (1-1/2 inches) into supports // and to penetrate furring members/.
      b. Cover joints with a 50 mm (two inch) wide lead lined joint strip of the same material as the panels and secured to supports with lead headed nails.
      c. Nail joint strips at approximately 200 mm (eight inches) on centers with the nails located in center of joint strips.
   //d. Quarter round strips: Install adjacent to joint strips and secured by nailing with wire nails to joint strips without penetrating the lead/.
   2. Joints backed with lead strips:
      a. Sheet lead strips not less than the thickness used for the panels and not less than 38 mm (1-1/2 inches) wide shall be installed on supports where panel joints occur.
      b. Secure the lead strips to supports by nailing with wire nails at outer edges of strips.
c. Nail sides and ends of panels at approximately 200 mm (eight inches) on centers with lead headed nails.

d. Install molding strips to cover joints and secure with nails at approximately 200 mm (eight inches) on centers.

3.4 LEAD LINED GYPSUM LATH

A. Apply lath to // wood furring strips // metal studs // as shown.

B. Predrill or drill pilot holes for // nails // screws // as necessary to prevent deformation of the // nail // lead shielding // and to prevent distortion of the lath.

C. Apply lead lined lath with long edges at right angles to supports and with lead linings placed next to supports.

1. Place end joints over supports, and stagger in alternate courses.

2. Wall joints shall not coincide with ceiling joints.

3. Each sheet shall overlap the lead extension on the adjacent sheet, providing an effective lead lap.

4. Lath shall be close fitted and uniformly secured to supports.

D. Extend lath into frames of openings effectively lapping with lead frames or frame linings. Unless otherwise approved, arrange lath around openings so that neither horizontal nor vertical joints occur at corners of openings.

E. Reinforce external corners with corner beads. Internal corners // except at unrestrained suspended ceilings // shall be reinforced as required by manufacturer and installed with // nails or tie wire and lead clips or screws and washers.

F. Uniformly nail lath to wood supports with heads flush with lath surface or secure to studs with screws and lead washers at approximately 175 mm (seven inches) on centers.

//G. At unrestrained ceilings, install square-nosed casing beads at junction of wall and suspended ceilings.//

H. When ceramic tile wall finish on metal lath and mortar setting bed is to be installed over lead lined gypsum lath, wrap an 18 gage stainless steel tie wire about center of every second nail or screw when half-driven. Both ends of each tie wire shall be of sufficient length so that when nail or screw is fully driven, fastening of metal lath may be accomplished.

3.5 LEAD LINED GYPSUM WALLBOARD PANELS

A. Apply lead lined gypsum wallboard to wood furring strips // metal studs // as shown.

B. Predrill or drill pilot holes for nails or screws as necessary to prevent deformation of the fastener and lead shielding 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 nails //fastened 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.
   SPEC WRITER NOTE: Drawings shall show thickness of lead and height in partitions.

3.7 SIGNS: FURNISH SIGNS AS FOLLOWS:
A. One for each //Dental X-Ray Room // X-Ray // and // Examination Rooms//, lettered as follows:
THE PARTITIONS, THE DOORS // AND THE SHIELD // OF THIS ROOM HAVE BEEN INSULATED WITH SHEET LEAD OF _____ mm THICKNESS PROVIDING A TOTAL LEAD EQUIVALENT PROTECTION OF ___ mm.

B. One for each // Radiographic Room // Radiographic and Fluoroscopic Room // Special Procedures Room // and for each // Fluoroscopic Room // Cystoscopic 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//:

<table>
<thead>
<tr>
<th>TOTAL LEAD</th>
<th>LEAD</th>
<th>EQUIVALENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>THICKNESS</td>
<td>PROTECTION</td>
<td>mm</td>
</tr>
<tr>
<td>DOORS //AND FRAMES//</td>
<td>- -</td>
<td>_____ mm</td>
</tr>
<tr>
<td>PARTITIONS</td>
<td>- - - - - -</td>
<td>_____ mm</td>
</tr>
<tr>
<td>FLOORS</td>
<td>- - - - - - -</td>
<td>_____ mm</td>
</tr>
</tbody>
</table>

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 // FULL HEIGHT // TO HEIGHT OF _____ FEET // WITH SHEET LEAD OF _____ mm THICKNESS, PROVIDING A TOTAL LEAD EQUIVALENT PROTECTION OF _____ mm.

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

THIS DOOR HAS BEEN INSULATED WITH SHEET LEAD OF _____ mm THICKNESS, PROVIDING A TOTAL LEAD EQUIVALENT PROTECTION OF _____ mm.

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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