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Section 13 49 00 (13090)
RADIATION SHIELDING

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. The BIDDING REQUIREMENTS, CONTRACT FORMS, and CONTRACT CONDITIONS as listed in the Table of Contents, and applicable parts of Division 1 - GENERAL REQUIREMENTS, shall be included in and made a part of this Section.

B. Examine all Drawings and all other Sections of the Specifications for requirements therein affecting the work of this Section.

1.2 SUMMARY

A. The work of this Section consists of the following shielding materials where shown on the Drawings, as specified herein, and as required for a complete and proper installation. Work includes, but is not limited to the following:

1. Furnish and install the following:
    a. Lead-lined gypsum board.
        1) Lead batten strips, ribbons, disks, and tabs as required for a complete installation.
    b. Lead-lined plywood
    c. Lead glass
    d. Lead acrylic glazing
    e. Lead-lined hollow metal frames
    f. Lead-lined wood doors
    g. Hollow metal door frames
    h. Lead sheet and plate lead
    i. Lead bricks
    j. Borated Polyethylene
    k. High density concrete shielding
    l. Modular concrete shielding system
2. Daily and final cleaning of Work of this Section.

1.3 RELATED SECTIONS

A. Section 01 73 00 - EXECUTION: Administrative and procedure requirements for final cleaning and waste management.

B. Section 09 22 16 - NON-STRUCTURAL METAL FRAMING

C. Section 09 29 00 - GYPSUM BOARD:

1. Application of joint treatment, edging, casings, and trim pieces.
2. Taping and finishing of joints in lead-lined and standard gypsum wallboard partitions.
3. Application of acoustical sealant.

D. Section 09 91 00 - PAINTING: Field-applied prime and finish coatings.

E. Division 23 - HEATING, VENTILATING AND AIR CONDITIONING: Supply and return air registers.

F. Division 26 - ELECTRICAL: Electrical boxes and receptacles.

G. Section 08 80 00 - GLAZING: Conventional glazing.

H. Section 08 71 00 - DOOR HARDWARE: Furnishing finish hardware, and installation templates for hardware cutouts.

I. Section 03 30 00 – CAST-IN-PLACE CONCRETE: Installation of anchors into concrete, placing concrete slabs and walls.

J. Section 08 34 51 (08346) – NEUTRON / RADIATION SHIELDING SWINGING DOORS

K. Section 08 34 50 (08346) – NEUTRON / RADIATION SHIELDING SLIDING DOORS

L. Section 08 34 49 - RADIATION SHIELDING DOORS AND FRAMES.

M. Section 08 34 49.10 - RADIATION SHIELDING GLAZING AND FRAMES.

N. Section 13 49 33 – LINEAR ACCELERATOR SHIELDING SYSTEMS.

1.4 REFERENCES

A. Comply with applicable requirements of the following standards and those others referenced in this Section.

1. American Conference of Government Industrial Hygienists – Industrial Ventilation Manual.
2. American Society for Testing and Materials (ASTM):
   a. ASTM B 29 – Standard Specification for Refined Lead.
   b. ASTM C 1002 – Steel Self-Piercing Tapping Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Wood Studs or Steel Studs.
   c. ASTM C 1396 – Standard Specification for Gypsum Board.
   d. ASTM E 90 – Method of Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions.
   e. ASTM E 119 – Fire Tests of Building Construction and Materials.
   f. ASTM A 109 - Standard Specification for Steel, Strip, Carbon (0.25 Maximum Percent), Cold-Rolled.
   g. ASTM A 415 - Standard Specification for Hot-Rolled Carbon Steel Sheets, Commercial.
   h. ASTM A 568 - Standard Specification for Steel, Carbon and High Strength Low Alloy Hot Rolled Strip, and Cold Rolled Sheet.
   i. ASTM A 653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   j. ASTM A 924 - Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process.
   k. ASTM A 1008 - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.
3. Gypsum Association (GA):
   a. GA 201 – Gypsum Board for Walls and Ceilings.

b. GA 216 – Recommended Specifications for the Application and Finishing of Gypsum Board.

4. American National Standards Institute (ANSI):
   a. ANSI/SDI A250.4 - Test Procedure and Acceptance Criteria for Physical Endurance for Steel Doors, Frames, Frame Anchors and Hardware Reinforcing.
   b. ANSI A250.8 (formerly SDI 100) - Recommended Specifications for Standard Steel Doors and Frames.
5. Glass Association of North America.
   a. Glazing Manual (2004 edition).
6. Door and Hardware Institute (DHI): Publication DHI A115.1G - Installation Guide for Doors and Hardware.
7. International Organization for Standardization (ISO): ISO 9001:2008.
8. National Council on Radiation Protection and Measurements (NCRP):
   a. NCRP Report No. 147 – Structural Shielding for Medical X-Ray Imaging Facilities.
9. U.S. Department of Labor Occupational Safety and Health Administration (OSHA):
   a. OSHA standard 29 CFR 1910.1025 – Lead.
   b. OSHA standard 29 CFR 1926 – Safety and Health Regulations for Construction.
   c. OSHA standard 29 CFR 1926.62 – Lead.
   d. CAL-OSHA Title 8 Sec 1532.1, Sec 5198, and Sec 5216
10. All applicable federal, state, and municipal codes, laws, and regulations.

1.5 SUBMITTALS

A. Submit the following under provisions of Section 01 33 00 - SUBMITTAL PROCEDURES:
   1. Literature: Product data on all radiation shielding materials, performance data, physical properties, and installation instructions for each item furnished hereunder.
      a. Include material characteristics, size limitations, and special application requirements.
   2. Certifications:
      a. Manufacturer's written certification stating that the radiation shielding materials and all related items to be furnished hereunder, meet or exceed the requirements specified under this Section and are in compliance with Physicist of Record report(s), and that the applicator is qualified and approved to install the materials in accordance with manufacturer's product data.
      b. Installer certifications for OSHA 29 CFR 1926.
   3. Shop drawings: Manufacturer’s standard design details of critical intersections within assemblies and complete installation details where the shielding materials will interface with work of other sections.

B. Submit the following under provisions of Section 01 78 00 - CLOSEOUT SUBMITTALS.
   1. Manufacturer’s ISO 9001:2008 field quality control reports of field inspections, including manufacturer’s final punch list.
   2. Manufacturer’s warranties: Include coverage of installation for compliance with shielding requirements based on Physicist of Record report(s).

1.6 QUALITY ASSURANCE

A. Notify the Architect where conflicts apply between referenced standards and existing materials, and existing methods of construction.

B. Installers:

1. Installers, foreman, and job supervisors for the Work of this Section shall be trained by, and approved by, product manufacturer. Foreman and job supervisors shall be certified by manufacturer to have not less than 5 years experience in the installation of neutron / radiation shielding.
2. All construction workers, foreman, and job supervisors for the work of this section shall have a minimum certification of 10 hours of OSHA training in occupational safety and health.

1.7 DELIVER, STORAGE AND HANDLING

A. Do not deliver items to the site, until all specified submittals have been submitted to, and approved by, the Architect. Do not deliver items to the site, until facility is enclosed, weather-tight, and an ambient temperature above 50 degrees Fahrenheit can be maintained by General Contractor.

B. Deliver materials in original packages, containers, or bundles bearing brand name identification of manufacturer or supplier.

C. General Contractor is responsible to store materials inside, under cover and in manner to keep them dry, protected from weather, direct sunlight, surface contamination, corrosion, and damage from construction traffic and other causes.

D. Handle shielding materials so to prevent damage to edges, ends, and surfaces.

E. Provide protection against contamination during handling, storage, and installation procedures.

1.8 ENVIRONMENTAL REQUIREMENTS

A. General Contractor is fully responsible, maintain ambient temperature above 50 degrees Fahrenheit for 24 hours before, during, and 48 hours after installation of lead-lined gypsum board assemblies.

1.9 SEQUENCING AND SCHEDULING

A. Coordinate the work of this Section with the respective trades responsible for installing interfacing work, and ensure that the work performed hereunder is acceptable to such trades for the installation of their work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Specified Manufacturer: To establish a standard of quality, design, and function, desired drawings and specifications have been based on “Lead-Lined Gypsum” as manufactured by NELCO, 2 Burlington Woods Dr, Suite 300, Woburn, MA 01803, www.nelcoworldwide.com (telephone 800-635-2613).

1. Manufacturing Facilities:
   a. NELCO Boston: 3 Gill St - Unit D, Woburn, MA 01801
   b. NELCO Houston: 4600 Homestead Road, Houston, TX 77028
   c. NELCO San Francisco: 1840 Williams Street, San Leandro, CA 94577

B. Alternative products (substitutions): Contractor must furnish appropriate and complete product data, proof of ISO 9001:2008 certification, worker OSHA certifications, environmental characteristics, and sample warranty with bid for the Architect to consider the substitutions as "equal" to the manufacturer, product specified and quality assurance requirements. Further additional information may be requested by the Architect for determination that the proposed product substitution is fully equal to the specified products. There is no guarantee that proposed substitutions will be approved, and the Contractor is hereby directed not to order any materials until said approval(s) are received in writing.

1. Requesting substitutions is at the Contractor's own risk, with regard to uncompensated delays of the Project. Time is required for sufficient review and for additional requests of information. Delays of work which result from substitution reviews and resubmissions are not grounds for additional time or cost change orders, and will not be considered by the Owner.

2.2 MATERIALS

A. Lead-lined gypsum board

Note to Specifier: SELECT GYPSUM BOARD TYPE(S)

1. Gypsum board: UL fire resistance rated, ASTM C 36 'Type X' board, 5/8 inch [15.9mm] thick, except where 1/2 inch thickness is indicated on Drawings, of lengths to minimize end joints, with tapered edges, and enhanced core.
2. Sag-resistant gypsum board ceiling panels: non-rated 1/2 inch [12.7mm] thick, 48 inch width, of lengths to minimize end joints, with tapered edges, conforming to ASTM C 36, ASTM C 1395 and ASTM C 1396.
3. Moisture resistant (MR) gypsum board (green board), fire resistant: Conforming to ASTM C630 and C1396, with Type "X" core 5/8 inch [15.9mm] thick, 48 inch width, of lengths to minimize end joints, with tapered edges.
4. "Paperless" moisture resistant board: 5/8 inch [15.9mm] thick Glass mat, water-resistant, mold-resistant interior wall panel: Coated inorganic glass mat-faced, with Type "X" water-resistant, treated core gypsum wallboard. Physical properties conforming to the applicable sections of ASTM C 1177, and ASTM C 630.
5. Plaster base (blue board): UL fire resistance rated, Type X board 5/8 inch [15.9mm] thick, except as otherwise indicated on the Drawings, of lengths to minimize end joints.
6. Lead sheet: Conforming to ASTM B 29 in uniform thickness(es) as required by Physicist of Record report(s).

Note to Specifier: SELECT LEAD LINING THICKNESS(ES) REQUIRED

7. Thickness: 1/32 inch [0.79mm] (nominal 2 lbs. per square foot) lead sheet to 1/8 inch [3.17mm] (nominal 8 lbs. per square foot) lead sheet.

B. Lead-lined plywood

1. Plywood Panels: EWA graded CDX INT, Group 2 species, touch-sanded, fire-retardant treated having Underwriters Laboratories stamp signifying a FR-S rating certifying a 25 or less flame spread and smoke developed value, when tested in accordance to ASTM E-84. Board thickness shall be as indicated on the Drawings.
   a. Fire-retardant-treated wood products shall be free of halogens, sulfates, ammonium phosphate and have no added formaldehyde.
   b. Size limitations for CDX Plywood is 48" x 96" x ¾" thickness. Other thicknesses available upon request.
2. Lead sheet: Conforming to ASTM B 29 in uniform thickness(es) as required by Physicist of Record report(s).
   a. Plywood panel size up to 48" x 96":
      1) Thickness: 1/64 inch [0.40mm] to 3/4 inch [19.05 mm] lead sheet.

Note to Specifier: NELCO's 1" lead brick may be substituted for plywood lined with lead over 3/4"due to excessive weight; substitution subject to approval by Physicist of Record report(s) and site conditions.

C. Lead Glass
   1. Provide clear x-ray lead glass with a thickness approximately 5/16 to 3/8 inch and installed in single or multiple layers to provide a lead equivalent as required by Physicist of Record report(s).

D. Lead acrylic glazing
   1. Provide shatter-resistant, distortion-free optical clarity lead acrylic grazing.
   2. Fabricate lead acrylic glazing from acrylic copolymer resin into which lead is chemically introduced as an organolead salt compound. Provide polished lead acrylic glazing containing 30 percent minimum lead by weight.
   3. Install in single or multiple thicknesses to provide a lead equivalent as required by Physicist of Record report(s).

E. Lead-lined hollow metal window frames
   1. General: Refer to the Drawings for various types of frames, sizes, and profiles, UL fire-resistive label frames, and other characteristics of frames and related items.
      a. Frame type: Telescopic frames with mitered joints arc-welded, reinforced and ground smooth.
      b. Frame type: Shop welded frames with mitered joints arc-welded, reinforced and ground smooth.
   2. Materials for frames, reinforcement, anchors, anchor clips, and related items: commercial grade cold-rolled steel conforming to ASTM A109 or commercial grade hot-rolled and pickled steel conforming to ASTM A415.
      a. Frame gage: 16-gage, 0.053 inch thick.
      b. Hinge, lock, and strike reinforcement: 7 gage thick.
      c. Door closer reinforcement: 12 gage, minimum 0.093 inch thick.
      d. Glazing stops: 16 gage, minimum 0.053 inch thick.
      e. Shop-fabricate frames as whole single units per opening, except when frame size is too large to ship as a single unit. Oversized frames may be shipped in large sections as practicable for field assembly with concealed splice plates or channels.

f. Reinforcements, stiffeners, and base angle clips: Welded to interior surfaces of frames to provide a stable base and so as to not interfere with installation of hardware.

g. Appearance of finished frames: Strong, rigid, completely free from warp and buckle, with miters well formed and in true alignment, and with surfaces smooth and free from defects of any kind.

h. Glazing beads: Carefully place to properly accommodate the various thicknesses of glass and glazing materials, and loosely-attach to frames with flathead galvanized steel screws through pre-drilled holes having countersunk depressions.

i. Line frames with sheet lead of same thickness as scheduled for partitions in which they occur.
   1) Install sheet lead free of waves, lumps, and wrinkles with as few joints as possible.
   2) Form and permanently adhere lead around and concealed behind the frame.

j. Anchorage:

Note to Specifier: SELECT ANCHOR TYPE(S) BASED ON CONSTRUCTION

k. Anchor clips for frames in metal stud partitions: 16-gage steel z-shaped clips, 1-1/2 inch upturned and downturned legs, or equivalent type standard with the manufacturer, contained within the frames, for screw attachment to metal studs under Section 09 22 16 - NON-STRUCTURAL METAL FRAMING.

l. Anchor clips for frames in wood stud partitions: 18-gage steel with 3/4-inch high bendable straps, or equivalent type standard with the manufacturer, contained, for screw attachment to wood studs.

m. Anchors for frames in masonry walls (new construction): Adjustable, T-shaped, positively engaging the retainers on both flanges of each jamb member, when placed. The stem of the anchors shall be 2 inches wide by 12 gage, minimum, corrugated or perforated for mortar bond, and extend 10 inches into the masonry, unless otherwise indicated.

n. Anchors for frames in existing masonry walls: Counter-sunk bolts of minimum 3/8 inch diameter, set into masonry expansion shields.

o. Provide not less than 3 anchors, clips, or bolts, per jamb, as applicable.

F. Lead-lined wood doors

1. General requirements: Conform to the requirements set forth in the designated Sections of the (WDMA) Industry Standard IS 1A-04, and the applicable requirements of U.S. Commercial Standard CS 171, as amended. Refer to the Drawings for sizes, locations of each type door, glazing cutouts in doors, and other characteristics of doors to be furnished hereunder.

   a. Door Grade: Custom.

   b. Door Facing:

Note to Specifier: SELECT DOOR FACING
WOOD VENEER /or/ MDO (for painted finish) /or/ PLASTIC LAMINATE

   1) Face veneer: WDMA Industry Standard, “A’ Grade veneer minimum 1/50 inch (0.6 mm) thick, mechanically sliced.
      a) Wood Species: _____, [Rift] [Quartered] [Plain] [Flat] [Rotary] Sawn.

b) Matching of adjacent pieces of veneer: [Book matched] [Slip matched].
c) Panel face assembly: [Balanced] [Running].
d) Direction of Grain: [Vertical] [Horizontal].

2) Face veneer: MDO (Medium Density Overlay) face veneer for paint finish.
3) Face veneer: Decorative Laminate Facing, NEMA LD-3 General Purpose type laminate, 0.050 inch (1.3 mm) thick in color selected by Architect from full range available.
4) Crossbanding: Hardwood veneer or composite product at least 1/16 inch thick.

2. Lead-lined Fire-resistance rated 20 minute label doors
1) General Construction: WDMA Industry Standard I.S. 1A-04, S-21 Veneer, Fire Rated Mineral Core, Premium Grade Door.
a) Door thickness: 1-3/4 inches, unless indicated otherwise.
b) WDMA Specification Description: “FD-20 MIN”.
2) Door facing: As specified herein above under Article – “Flush Faced Doors”.
3) Core construction:
a) Core: Particleboard complying with ANSI A208.1 Type 1, Grade 1-LD-2 with Formaldehyde emissions limited to 0.30 ppm.
b) Provide divided core secured by lead covered bolts.
c) Lead sheets: located in door center, extended to outer edges of door.
d) Stiles: Laminated strand lumber or hardwood mill option for inner ply of styles, with outer ply matching face veneer, or visually compatible hardwood species.
e) Provide divided stiles secured by lead covered bolts.
f) Top and bottom rails: Provide divided rails secured by lead covered bolts.
g) Top and bottom rails with wood veneered faced doors: Maple or Birch, as standard with manufacturer.
h) Top and bottom rails with painted or plastic laminate faced doors: Oak, Maple, Birch, Poplar, Structural Composite Lumber (SCL), or UL approved composite material to meet label requirements.
4) Adhesives:
a) Face assembly: Type 1 (waterproof).
b) Core assembly: Type II (water-resistant).
5) Accessories: For all fire-rated doors installed in pairs with both leaves active, provide 20-gage formed steel edges, without astragal, wrapped with veneer matching faces of doors.

3. Lead-lined non-rated solid-core doors
1) General Construction: WDMA Industry Standard I.S. 1A-04, S-9 Veneer, Particleboard Core Bonded, Premium Grade Door.
a) WDMA Specification Description: “PC-5”.
b) Door thickness: 1-3/4 inches, unless indicated otherwise.
2) Door facing: As specified herein above under Article – “Flush Faced Doors”.
3) Core construction:
a) Core: Particleboard complying with ANSI A208.1 Type 1, Grade 1-LD-2 with Formaldehyde emissions limited to 0.30 ppm.
b) Provide divided core secured by lead covered bolts.
c) Lead sheets: located in door center, extended to outer edges of door.

d) Stiles: Laminated strand lumber or hardwood mill option for inner ply of styles, with outer ply matching face veneer, or visually compatible hardwood species.
e) Provide divided stiles secured by lead covered bolts.
f) Top and bottom rails: Provide divided rails secured by lead covered bolts.
g) Top and bottom rails with wood veneered faced doors: Maple or Birch, as standard with manufacturer.
h) Top and bottom rails with painted or plastic laminate faced doors: Oak, Maple, Birch, Poplar, or Structural Composite Lumber (SCL).

4) Adhesives: Type 1 (waterproof) for both face and core assembly.

G. Lead-lined hollow metal door frames

1. General: refer to the drawings for various types of frames, sizes, and profiles, UL fire-resistive label frames, and other characteristics of frames and related items.
   a. Frame type:
      1) Shop welded frames with mitered joints arc-welded, reinforced and ground smooth.
      2) Knock-Down
2. Materials for frames, reinforcement, anchors, anchor clips and related items: commercial grade cold-rolled steel conforming to ASTM A109 or commercial grade hot-rolled and pickled steel conforming to ASTM A415.
   a. Frame gage:
      1) 16-gage, 0.053 inch thick , except as otherwise required for specific U.L. Label.
   b. Hinge, lock, and strike reinforcement: 7 gage thick.
   c. Door closer reinforcement: 12 gage, minimum 0.093 inch thick.
   d. Floor clips: 16 gage thick.
   e. Glazing stops: 16 gage, minimum 0.053 inch (1.3 mm) thick, except as otherwise required for specific U.L. Label.
3. Frame construction:
   a. Fire-rated frame assemblies: Modify specified construction to meet all construction requirements required for fire-resistive rating.
      1) Affix appropriate UL, FM, or Warnock Hersey and other applicable labels to each rated frame assembly, indicating applicable rating.
   b. Shop-fabricate frames as whole single units per door opening, except when frame size is too large to ship as a single unit. Oversized frames may be shipped in large sections as practicable for field assembly with concealed splice plates or channels.
   c. Frame corner construction: As specified in paragraph A, above.
   d. Reinforcements, stiffeners, and base angle clips: Welded to interior surfaces of frames to provide a stable base and so as to not interfere with installation of hardware.
   e. Appearance of finished frames: Strong, rigid, completely free from warp and buckle, with miters well formed and in true alignment, and with surfaces smooth and free from defects of any kind.
   f. Plaster and mortar guards, if required, shall be provided by others.
   g. Silencer holes: Punch three holes in stop of strike jamb of doorframes for application of silencers.

h. Glazing beads: Carefully place to properly accommodate the various thicknesses of glass and glazing materials, and loosely-attach to frames with flathead galvanized steel screws through pre-drilled holes having countersunk depressions.

i. Line frames with sheet lead of same thickness as scheduled for partitions in which they occur.

1) Install sheet lead free of waves, lumps, and wrinkles with as few joints as possible.

2) Form and permanently adhere lead around and concealed behind the frame.

4. Anchorage:

Note to Specifier: SELECT ANCHOR TYPE(S) BASED ON CONSTRUCTION

a. Anchor clips for frames in metal stud partitions: 16-gage steel z-shaped clips, 1-1/2 inch upturned and downturned legs, or equivalent type standard with the manufacturer, contained within the frames, for screw attachment to metal studs under Section 09 22 16 – NON-STRUCTURAL METAL FRAMING.

b. Anchor clips for frames in wood stud partitions: 18-gage steel with 3/4-inch high bendable straps, or equivalent type standard with the manufacturer, contained, for screw attachment to wood studs.

c. Anchors for frames in masonry walls (new construction): Adjustable, T-shaped, positively engaging the retainers on both flanges of each jamb member, when placed. The stem of the anchors shall be 2 inches wide by 12 gage, minimum, corrugated or perforated for mortar bond, and extend 10 inches into the masonry, unless otherwise indicated.

d. Anchors for frames in existing masonry walls: Counter-sunk bolts of minimum 3/8 inch diameter, set into masonry expansion shields.

e. Anchors for fire-resistive rated frames: Conform to all UL requirements for the specific fire-resistive ratings.

f. Provide not less than 3 anchors, clips, or bolts, per jamb, as applicable.

5. Hinges/Pivots/Hardware

a. Due to the size, weight and construction contact specified manufacturer for proper hardware.

H. Lead sheet and lead plate

1. Lead sheet: Conforming to ASTM B 29 in uniform thickness(es) as required by Physicist of Record report(s).

I. Lead brick

1. Conforming to ASTM B-29, NELCO product “N-Series Interlocking Lead Brick”, Solid cast lead bricks with tongue and groove edges composed of 99.5 percent pure lead and 0.5 percent antimony, 4 inches [101.6mm] tall by 12 inches [304.8mm] wide by thickness required for shielding based on Physicist of Record report(s).

J. Borated polyethylene

1. High-density polyethylene consisting of polyethylene and 5 percent boric oxide in green color as specified by Physicist of Record report(s).

K. High density concrete shielding

1. Provide high density “N-Loc” interlocking concrete masonry units equal to NELCO “High Density Concrete Block” comprised of portland cement, sand, water, and manufacturer’s proprietary aggregate.
   a. Compressive strength: 2,800 pounds per square inch minimum.
   b. Size: 6 inches high by 6 inches wide by 12 inches deep.
   c. Provide in density as required by Physicist of Record report(s):
      1) 145 pounds per cubic foot.
      2) 240 pounds per cubic foot.
      3) 288 pounds per cubic foot.
2. Mortar
   1) Mortar: Site-mixed portland cement mortar complying with ASTM C 270 as specified herein.
   2) Mortar materials:
      a) Portland cement for masonry conforming to ASTM C 150, Type I, non-staining, without air entrainment.
      b) Aggregates for mortar: Clean sand, washed uniformly well graded, conforming to ASTM C 144, except use aggregate with 100 percent passing a No. 16 sieve.
      c) Microsilica: Dry densified amorphous silica powder complying with ASTM C 1240.
      d) Provide as 5 percent of cementitious materials.
      e) Lime: Approved brand of plastic hydrated lime, conforming to ASTM C 207, Type “S”.
      f) Water: Clean and fresh without contaminants.
3. Mixing mortars
   1) General: Mix mortar and grout in accordance with the requirements of ASTM C270.
      a) Control batching procedure to ensure proper proportions by measuring materials by volume. Amount of mixing water and mortar consistency shall be controlled by mason.
      b) Control batch sizes to allow for use within manufacturer’s recommended pot life.
      c) Retempering will be permitted only within the first two hours of initial mix or shorter times as directed by manufacturers.
      d) Discard all mortar and grout which exceeds the time limits allowed by the manufacturer Discard mortar that has partially set.
   2) Maintain sand uniformly damp immediately before mixing process.

L. Modular concrete shielding system
1. Provide high density interlocking concrete block modular shielding system equal to NELCO “MegaShield™ Modular Concrete Block System” comprised of portland cement, sand, water, and manufacturer’s proprietary aggregate.
   a. Compressive strength: 4,000 pounds per square inch minimum.
   b. Size:
      1) 2 feet high by 6 feet wide by 2 feet deep.
      2) 2 feet high by 5 feet wide by 2 feet deep.
      3) 2 feet high by 4 feet wide by 2 feet deep.

4) 2 feet high by 3 feet wide by 2 feet deep.
5) 2 feet high by 2 feet wide by 2 feet deep.
6) Other sizes available upon request

c. Provide in density as required by Physicist of Record report(s):
1) 145 pounds per cubic foot.
2) Other densities available upon request.

2.3 ACCESSORIES

A. Lead-lined gypsum

1. Lead Batten Strips (Ribbon Lead): lead strips, free from any imperfections, conforming to ASTM B 29, having same thickness as lead lining on gypsum board. Provide 2 inch [50mm] wide lead strips for straight runs and 3 inch [76mm] wide lead strips at corners as required.
2. Fastener Protection: The following two options are acceptable.
   a. Lead Disc to meet shielding requirements, conforming to ASTM B 29, for installation over gypsum board fastener heads.
   b. Lead Tabs to meet shielding requirements, conforming to ASTM B 29, for installation over gypsum board fastener heads.
3. Lead Lining at Electrical Boxes, Medical Gas Penetrations, and Similar Conditions shall be shielded with the same thickness as the lead walls.

Note to Specifier: SELECT APPROPRIATE FASTENER TYPE

4. Fasteners: Type S, bugle head screws complying with ASTM C 1002, not less than 1 inch [25mm] length for applying lead-lined gypsum board to non-structural metal framing.
5. Fasteners: Type S-6 or greater fine thread rust resistant self-drilling screws complying with ASTM C 1002, not less than 1-1/4 inch [31mm] length, for applying lead-lined gypsum board to light gage metal framing having thickness of 0.033 to 0.112 inch [0.84 to 2.84 mm] thick.
6. Fasteners: Type W, bugle head screws complying with ASTM C 1002, not less than 1-1/4 inch [31mm] length for applying lead-lined gypsum board to wood framing and furring.

B. Lead-lined plywood

1. Lead Batten Strips (Ribbon Lead): lead strips, free from any imperfections, conforming to ASTM B29, having same thickness as lead lining on plywood. Provide 2 inch [50mm] wide lead strips for straight runs and 3 inch [76mm] wide lead strips at corners as required.
2. Lead Lining at Electrical Boxes, Medical Gas Penetrations, and Similar Conditions: Shall be shielded with the same thickness as lead in walls.

Note to Specifier: SELECT APPROPRIATE FASTENER TYPE

3. Fasteners: Type S, bugle head screws complying with ASTM C 1002, not less than 1 inch [25mm] length for applying lead-lined plywood to non-structural metal framing.
4. Fasteners: Type S-6 or greater fine thread rust resistant self-drilling screws complying with ASTM C 1002, not less than 1-1/4 inch [31mm] length, for applying lead-lined plywood to light gage metal framing having thickness of 0.033 to 0.112 inch [0.84 to 2.84 mm] thick.

5. Fasteners: Type W, bugle head screws complying with ASTM C 1002, not less than 1-1/4 inch [31mm] length for applying lead-lined plywood to wood framing and furring.

C. Lead glass and acrylic glazing

1. Glazing tape: Preformed butyl-polyisobutylene rubber with 100 percent solids contained in extruded tape roll form and complying with AAMA 804.1; coiled on release paper; of sizes required for proper glazing, equal to one of the following or an approved equal:
   a. CRL 74418X38BL
   b. Pemko FG3000S45
   c. Pemko FG3000S90
   d. CRL 98418x38BL
2. Setting blocks/Spacers: As required

2.4 SOURCE QUALITY CONTROL

A. Obtain radiation shielding materials and accessories from a single ISO 9001: 2008 certified manufacturer.

3.2 FABRICATION TOLERANCES

A. Lead lined hollow metal frames

1. Maximum variation for lead lined frames: Maximum diagonal distortion 1/16 inch measured with straight edge, corner to corner

B. Hollow metal door frame

1. Maximum variation for lead lined doors and frames: Maximum diagonal distortion 1/16 inch measured with straight edge, corner to corner.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that all items which are to be enclosed by Work of this Section have been permanently installed, inspected, and approved.

B. Inspect framing, ceiling framing, foundations, and other substrates; verify that they are in proper condition to receive the work of this Section.

C. Verify that opening sizes and tolerances are acceptable and in compliance with these specifications and applicable codes.

D. Inspect glazing receiving surfaces and ensure that they are dry and free from dust, or other foreign materials before glazing.

E. Check all openings, prior to glazing, to make certain that the opening is square, plumb and secure in order that uniform face and edge clearances are maintained.

F. Beginning of installation means acceptance of existing conditions.

3.2 PREPARATION

A. During the operation of work of this Section, protect existing work against damage by the exercise of reasonable care and precautions. Repair all existing materials which are damaged by Work of this Section, to match original profiles and finishes. Existing materials repaired shall be removed and replaced with new work to match existing.

B. Foundations:

1. Do not commence installation until foundations are clean, rough, and level.
2. Sandblast the foundation tops, if necessary, and remove all laitance and foreign material.

C. Installer specializing in applying the work of this Section with a minimum of 5 consecutive years documented experience demonstrating previous successful work of the type specified herein.

3.3 INSTALLATION - GENERAL

A. Gypsum: Perform erection procedures for the various gypsum board system conditions, except as otherwise specified, as set forth in GA 201, GA 216, the written instructions of manufacturer, together with the additional requirements specified herein and as indicated on the Drawings.

B. Plywood: Perform erection procedures for the various plywood system conditions, except as otherwise specified, as set forth in GA 201, GA 216, the written instructions of manufacturer, together with the additional requirements specified herein and as indicated on the Drawings.

C. Where fire-resistive rated assemblies are indicated, erect gypsum board systems in strict accordance with the manufacturers' UL V439 listed test constructions for the required fire rating on each specific assembly. All assemblies must be labeled with the UL V439 labels.

D. Install all shielding material as dictated by approved shop drawings. Where built-in items penetrate shielding provide additional shielding as required to maintain full continuity of barrier.

3.4 INSTALLATION OF RADIATION SHIELDING MATERIALS

A. Lead-lined gypsum board

1. Prior to installation of lead-lined gypsum board:
   a. Install 2 inch [50mm] wide lead battens at all vertical stud framing (and ceiling joists). At corner intersections of walls (and ceilings) provide 3 inch [75mm] wide battens or, if framing allows, corner lapping of lead-lined gypsum board.
   b. Install lead lining at all electrical outlet boxes, medical gas boxes, and similar penetrations occurring in gypsum board.
   c. Make provisions for connection with lead-lined doorframes and cutouts for vision panels.
   d. Install screw tabs on studs where required.
2. Screw-fasten boards to framing and furring, with ends and edges occurring over firm bearing. Screw fasten lead-lined gypsum panels 8 inches [200mm] on center at panel edges and 12 inches [300mm] on center to intermediate framing members.
   a. Erect all lead-lined gypsum board vertically on wall surfaces. Install boards horizontally where required by code.

b. Erect ceiling gypsum boards to meet UL requirements, where applicable, stagger end joints over supports. Secure gypsum board with fasteners inserted through ceiling buttons; anchor fasteners directly to framing or suspended support system.

c. Recess gypsum board screws slightly into board surface and cap as required.

3. Wherever items penetrate the gypsum board surfaces, use extra care in cutting the gypsum board to ensure a uniformly dimensioned joint between the penetrating item and the gypsum board. Verify the expected deflection factor of the penetrating members, and cut the gypsum accordingly, to prevent damage thereto from the deflecting members.

B. Lead-lined plywood

1. Prior to installation of lead-lined plywood:

a. Plywood will be predrilled on site as required.

b. Install lead lining at all electrical outlet boxes, medical gas boxes, and similar penetrations occurring in plywood.

c. Make provisions for connection with lead-lined doorframes and for cutouts for vision panels.

2. Installation of lead battens: (Lead battens may be substituted with corner lapping as shown on approved shop drawings)

a. For lead thickness less than or equal to 1/8 inch [3.17mm], install lead battens at all vertical stud framing, ceiling joists, and corner intersections of walls and ceilings as required.

b. For lead thickness greater than 1/8 inch [3.17mm], lead battens are applied after the lead-lined plywood is attached. Corners and perimeter lead may be installed in multiple layers of 1/8 inch [3.17mm] material.

3. Screw-fasten boards to framing and furring, with ends and edges occurring over firm bearing. Screw fasten lead-lined plywood panels 8 inches [200mm] on center at panel edges and 12 inches [300mm] on center to intermediate framing members.

a. Erect all lead-lined plywood vertically on wall surfaces. Install boards horizontally where required by code.

b. For lead thickness greater than 1/8 inch [3.17mm], dado/rabbit plywood at vertical edges to equivalent depth of the lead lining. One horizontal edge dado/rabbit may be required depending on shielding height requirements.

c. Erect ceiling plywood by staggering end joints over supports. Secure plywood with fasteners inserted through ceiling buttons; anchor fasteners directly to framing or suspended support system.

d. Recess screws slightly into board surface.

4. Wherever items penetrate the plywood surfaces, use extra care in cutting the plywood to ensure a uniformly-dimensioned joint between the penetrating item and the plywood. Verify the expected deflection factor of the penetrating members, and cut the plywood accordingly, to prevent damage thereto from the deflecting members.

C. Installation of lead glass and acrylic glazing

1. Glazing

a. Utilize dry glazing methods for field installation of glass in interior doors and frames.

b. Cut glazing tape to length and set against permanent stops, projecting 1/16 inch (2 mm) above sight line.

c. Rest glazing on setting blocks and push against tape for full contact at perimeter of pane.

d. Place glazing tape on free perimeter of glazing in manner as described above.

e. Install removable stop without displacement of tape. Exert pressure on tape for full continuous contact.

f. Trim protruding tape neatly.

D. Hollow metal frames

1. Pre-coordination for rough openings in framing.
2. General: Install frames in accordance with the manufacturer's recommendations, and applicable parts of ANSI A250.8. Install with a maximum diagonal distortion of 1/16 inch measured with a straight edge, corner to corner.
3. Place in position all steel frames, in accordance with the approved shop drawings and frame schedule.
   a. Coordinate installation of frames with the various trades installing abutting wall construction for anchor placement and continuity of lead lining.
   b. Provide rigid temporary bracing for frames as required to ensure maintenance of positioning, and remove only after frames have been permanently anchored.
   c. Secure frames, occurring in existing masonry, with expansion bolts and sleeves.
   d. Where exposed fastener heads occur in frames, fill with automotive body filler and sand smooth.

E. Lead-lined wood doors

1. Doors, operators, and frame mounted equipment interlocks shall be installed by the manufacturer and as indicated on the approved shop drawings. Touch up shop applied prime coat as required and ready for finish paint.
   a. Door speeds: Set by the manufacturer to comply with ANSI 156.10-2005
   b. Electrical connections: Frame mounted equipment interlocks shall be connected to the electrical distribution system under Division 26 – Electrical.

F. High density concrete shielding

1. General: Interlocking high density concrete masonry vault system shall be installed by the manufacturer’s trained installers as indicated on the approved shop drawings.

G. Modular concrete shielding system

1. Interlocking high density modular vault system shall be installed by the manufacturer’s trained installers according to the approved shop drawings.

3.5 TOLERANCES

A. Lead-lined gypsum

1. Maximum variation for gypsum board partitions and ceilings from true flatness: 1/8 inch [3mm] per 10 feet [3 m], noncumulative.

B. Lead-lined plywood

1. Maximum variation for plywood partitions and ceilings from true flatness: 1/8 inch [3mm] per 8 feet [3 m], noncumulative

C. Lead-lined hollow metal frames
   1. Maximum variation from plumb or level: 1/8 inch.
   2. Maximum offset from true dimensional alignment: 1/8 inch.

D. Hollow metal door frames
   1. Maximum variation from plumb or level: 1/8 inch.
   2. Maximum offset from true dimensional alignment: 1/8 inch.

3.6 FIELD QUALITY CONTROL

A. Field inspection and physicist testing to be performed under separate contract with Owner.

3.7 CLEANING

A. General: Clean work under provisions of Section 01 73 00 - EXECUTION.
   1. Upon completion of the work of this Section in any given area, remove tools, equipment and all rubbish and debris from the work area.

B. Clean glass surfaces promptly after installation, exercising care to avoid damage to the same. Remove excess glazing tape, labels, dirt, and other contaminants.

C. Daily clean work areas by disposing of debris, scraps, and lead. Vacuum floor surfaces with HEPA (High Efficiency Particulate Air filter) vacuum in compliance with OSHA Standard 1926.62.

D. After completion of the work of this Section, remove rubbish, tools and equipment, and clean all wall, partition, and floor areas free from deposits of lead, and other materials installed under this Section. Vacuum surfaces with HEPA vacuum in compliance with OSHA Standard 1926.62.

3.8 PROTECTION

A. General Contractor is responsible to protect finished work under provisions of Section 01 50 00 - TEMPORARY FACILITIES AND CONTROLS.

End of Section