



800 West Cummings Park, Suite 3950
Woburn, Massachusetts 01801

800-NELCO-13 (800-635-2613)
www.nelcoworldwide.com

Section 13 49 33 (13090)

LINEAR ACCELERATOR SHIELDING SYSTEMS

(Accuray CyberKnife®, Gamma Knife®, TomoTherapy®, Varian, Siemens, BrainLAB, Elekta, HDR, Proton Therapy, IMRT, IGRT)

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 linear accelerator shielding systems including floor, wall, overhead (ceiling), and duct shielding, 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. Steel framing.
 - b. Lead bricks, plates, and sheets.
 - c. Borated polyethylene.
 - d. Rigid polyethylene sheet (HDPE).
 - e. Concrete including high density concrete masonry (Section 13 49 17: High Density Concrete Masonry Shielding) and modular shielding partitions (Section 13 49 23: Modular Shielding Partitions (MegaShield™)).
 - f. Fasteners.
 - 2. Furnish anchors, bolts, inserts, and sleeves, required to attach steel framing for embedment into concrete under Section 03 30 00: Cast-in-Place Concrete.
 - 3. Perform all shop priming for all surfaces of exposed to view metals, and post-erection touchup of shop prime coat, using the same material as shop-prime coating.
 - 4. Daily cleaning and final cleaning of Work of this Section.

1.3 RELATED SECTIONS

- A. Section 01 73 00 – EXECUTION: Waste management and recycling during Final Cleaning.
- B. Section 03 30 00 – CAST-IN-PLACE CONCRETE: Installation of anchors into concrete, placing concrete slabs and walls.
- C. Division 23 – HEATING, VENTILATION, AND AIR CONDITIONING: Furnishing and installing ductwork.
- D. Section 08 34 51 (08346) – NEUTRON / RADIATION SHIELDING SWINGING DOORS
- E. Section 08 34 50 (08346) – NEUTRON / RADIATION SHIELDING SLIDING DOORS



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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 Institute of Steel Construction (AISC):
 - a. AISC - Code of Standard Practice for Steel Buildings and Bridges.
 - b. AISC - Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings.
 - c. AISI referenced standards.
 3. American Society for Testing and Materials (ASTM):
 - a. ASTM A 108 - Standard Specification for Steel Bar, Carbon and Alloy, Cold Finished.
 - b. ASTM A 283 - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
 - c. ASTM A 307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
 - d. ASTM A 36 - Standard Specification for Carbon Structural Steel.
 - e. ASTM A 568 – Standard Specification for Steel, Carbon, Structural, and High Strength, Low Alloy, Hot-Rolled and Cold-Rolled, General Requirements for.
 - f. ASTM B 29 - Standard Specification for Refined Lead.
 4. American Welding Society (AWS): Standard Code for Arc and Gas Welding in Building Construction.
 5. International Organization for Standardization (ISO): ISO 9001:2008.
 6. National Council on Radiation Protection and Measurements (NCRP):
 - a. NCRP Report No. 038 – Protection Against Neutron Radiation.
 - b. NCRP Report No. 144 – Radiation Protection for Particle Accelerator Facilities.
 - c. NCRP Report No. 147 – Structural Shielding for Medical X-Ray Imaging Facilities.
 - d. NCRP Report No. 148 – Radiation Protection in Veterinary Medicine.
 - e. NCRP Report No. 151 – Structural Shielding Design and Evaluation for Megavoltage X- and Gamma Ray Radiotherapy Facilities.
 7. 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
 8. 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:

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1. Literature: Manufacturer's product data sheets, specifications, performance data, and physical properties.
 - a. Recycled material content: Indicate recycled content and provide manufacturer's written certification of recycled steel and lead products (LEED™ NC Version 2.2, MR Credits 4.1 and 4.2).
 - 1) Indicate percentage both post-consumer and pre-consumer recycled content per unit of product.
 - b. Local / regional materials (LEED™ NC Version 2.2, MR Credit 5.1):
 - 1) Indicate location of extraction, harvesting, and recovery; indicate the distance between extraction, harvesting, and recovery and the project site.
 - 2) Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
 - c. Include certification of data indicating Volatile Organic Compound (VOC) content of all adhesives used in field. Submit MSDS highlighting VOC limits. (LEED™ NC Version 2.2, EQ Credit 4.1).
 2. Certification: Manufacturer's written certification stating that linear accelerator shielding systems and all related items to be furnished hereunder, meet or exceed the requirements specified under this Section, and that the applicator is qualified and approved to install the materials in accordance with manufacturer's product data.
 3. Manufacturer's instructions: Manufacturer's installation instructions indicating special procedures, and perimeter conditions requiring special attention.
 4. Warranty: Provide sample copies of manufacturers' actual warranties for all materials to be furnished under this Section, clearly defining all terms, conditions, and time periods for the coverage thereof.
 5. Shop drawings:
 - a. Large-scale drawings and details of linear accelerator shielding system including floor, wall, overhead (ceiling), and duct shielding.
 - 1) Indicate layout, dimensions, description of materials and finishes, and general construction. All details bearing dimensions of actual measurements taken at the project.
 - 2) Indicate lead and/or lead equivalency thickness of components.
 6. Welders' certificates as specified under Article entitled "QUALITY ASSURANCE".
- B. Submit the following under provisions of Section 01 78 00 - CLOSEOUT SUBMITTALS.
1. Manufacturer's warranties: Include coverage of materials and installation and resultant damage from failure of installation to resist penetration of moisture.

1.6 QUALITY ASSURANCE

- A. Obtain linear accelerator shielding system furnished under this Section from a single ISO 9001:2008 certified manufacturer.
- B. Professionally designed and engineered.
- C. Welders' Certificates: Utilize only qualified welders employed on the Work. Submit verification that welders are AWS D1.1 and D1.4 qualified within the previous 12 months.
- D. Installers:



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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 linear accelerator shielding assemblies.
2. All construction workers, foreman, and jobs 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 PRE-INSTALLATION CONFERENCE

- A. General Contractor shall prior to commencing the Work of this Section, conduct a pre-installation conference. Comply with requirements of Section 01 31 00 - PROJECT MANAGEMENT AND COORDINATION. Coordinate time of meeting to occur prior to installation of work under the related sections named below.
 1. Required attendees: Architect, General Contractor's Project Superintendent, Linear Accelerator Shielding Manufacturer's Representative (as available by telephone conference call, or by webcast), and representatives of other related trades as directed by the Architect or Contractor, and representatives for installers of related work specified under the following Sections:
 - a. Division 23 - HEATING, VENTILATION AND AIR CONDITIONING.
 2. Agenda:
 - a. Scheduling of linear accelerator shielding work.
 - b. Review of staging, material storage locations, and temporary protection during storage.
 - c. Review of installation schedule and access requirements.
 - d. Coordination of work by other trades.
 - e. Installation procedures for door controls and ancillary equipment.
 - f. Protection of completed Work.
 - g. Establish working environmental (exposure, temperature, and humidity) conditions to which Architect and Contractor must agree.
 - h. Discuss process for Owner's and manufacturer's inspection and acceptance of completed Work of this Section.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Do not deliver items to the site, until all specified submittals have been submitted to, and approved by, the Architect.
- B. Deliver materials in original packages, containers, or bundles bearing brand name identification of manufacturer or supplier.
- C. Handle materials following manufacturer's recommended procedures, and in accordance with material safety data sheets.
- D. General Contractor is responsible to store materials 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.



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1.9 ENVIRONMENTAL REQUIREMENTS

- A. General Contractor is responsible to maintain ambient temperature above 50 degrees Fahrenheit for 24 hours before, during, and 48 hours after installation of linear accelerator shielding system.

1.10 FIELD MEASUREMENTS

- A. General Contractor is responsible to take field measurements before preparation of shop drawings and fabrication, where possible, to ensure proper fitting of Work.

1.11 SEQUENCING AND SCHEDULING

- A. General Contractor is responsible to coordinate schedule of linear accelerator shielding installation, size of access and route to place of installation to prevent delay of installation due to physical impediments. Any work involving the demolition and reconstruction of partitions, walls, floors, roofing, windows, or doors to place and install the work of this Section shall be performed at no additional cost to the Owner.
- B. Coordinate the work of this Section with the respective trades responsible for installing inserts and anchorages furnished by this Section; make arrangements for delivery, receipt and installation of inserts and anchorages to prevent delay of the 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 products manufactured by NELCO, 800 West Cummings Park, Suite 3950, Woburn, MA 01801, 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.



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2.2 MATERIALS

- A. Steel shapes, plates and bars: ASTM A 36.
- B. Steel bars and bar-size shapes: ASTM A36.
- C. Cold-finished steel bars: ASTM A108.
- D. Steel plates to be bent or cold-formed: ASTM A283, grade C.
- E. Steel sheet and strip, commercial quality carbon steel: ASTM A568.
- F. Lead bricks: 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).
- G. Lead sheet: conforming to ASTM B-29, defect free. Uniform thickness(es) as specified by Physicist of Record report(s).
- H. Borated polyethylene: High-density polyethylene consisting of polyethylene and 5 percent boric oxide in green color as specified by Physicist of Record report(s).
- I. Rigid Polyethylene Sheet: HDPE (Rigid High-Density Polyethylene) as specified by Physicist of Record report(s).
- J. Concrete including high density concrete masonry and modular shielding partitions as specified by Physicist of Record report(s).
- K. Expansion anchors: 1/2 inch [13mm] diameter by 4 inch [100mm] length expansion anchor (diameter and length to be as determined by engineer).
- L. High Strength Bolts: ASTM A325, Type I, heavy hex structural bolts, heavy hex nuts, and hardened steel washers.
- M. Unfinished Bolts: ASTM A307, Grade A, regular hexagon type, low carbon steel.
- N. Shop and touch-up zinc rich primer.

2.3 FABRICATION – SUPPORT FRAMING

- A. Metal surfaces shall be clean and free from mill scale, flake, rust and rust pitting; well formed and finished to shape and size, true to details with straight, sharp lines, and angles and smooth surfaces. Curved work shall be to true radii. Exposed sheared edges shall be eased.
- B. Shop fabricate items wherever practicable, accurately fitting all parts and making all joints tight. Do not fabricate materials until all specified submittals have been submitted to, and approved by, the Architect.
- C. Do all cutting, punching, drilling, and tapping required for installation of support framing and attachment of anchor bolts.



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1. Drill or punch holes at right angles to the surface of the metal, not more than 1/16 inch [2mm] larger than the connector diameter. Do not make or enlarge holes by burning. Drill holes (do not punch) where steel has a thickness in excess of the connector diameter and material thicker than 7/8 inch [22mm]. Make clean-cut holes without torn or ragged edges. Remove outside burrs resulting from drilling operations.
 2. Cutting: Use only mechanically guided torch for manual oxygen cutting, except unguided torch may be used provided the cut is within 1/8 inch [3mm] of the required line.
- D. Grind all edges of bars and plates completely free from nicks and machine marks, prior to galvanizing and/or shop priming.
- E. Weld all permanent connections, make all welds in a continuous manner; tack-weld only where specifically indicated on the Drawings. Grind all exposed-to-view welds completely smooth and flush to the surface plane of the base metals. Perform welding work prior to galvanizing in all cases, except where field welding is necessary, in which case, completely coat all such welds with specified zinc-rich coating, after performing grinding operations.
- F. Use bolts of sufficient size to ensure against loosening from normal usage of miscellaneous metal items furnished hereunder. Furnish and install per Manufacturer's specifications.
- G. Fit and assemble metal fabrications in largest practical sections for delivery to site, ready for installation.

2.4 FINISHING

- A. Applied shop finish:
1. All support steel shall receive a shop coat of primer paint; Do not apply paint to the following items:
 - a. Contact surfaces of welded connections and areas within 2 inch of field welds.
 - b. Contact surfaces of high-strength friction bolted connections.
 2. Apply specified primer to provide a minimum dry film thickness of 2.0 mils, except for milled surfaces.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Inspect all surfaces and verify that they are in proper condition to receive the work of this Section.

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.



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3.3 INSTALLATION

- A. 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.
- B. Touchup shop applied primer.

3.4 TOLERANCES

- A. As dictated by approved shop drawings.

3.5 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. 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.
- C. 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.

3.6 PROTECTION

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

End of Section