SECTION 710 - FENCE AND GUARDRAIL

710.01 Barbed Wire. Barbed wire shall conform to ASTM A 121. The size, construction and class of coating weight shall be according to the contract. *|

Tie wires shall be zinc-coated No. 13 gage. The Contractor shall zinc coat the staples. *|

710.02 Woven Wire. Woven wire shall conform to ASTM A 116. The size, staple and class of coating weight shall be according to the contract. |

Tie wires shall be zinc-coated No. 13 gage. The Contractor shall zinc-coat the staples. *|

710.03 Chain Link Fence. Chain link fabric and required fittings and hardware shall conform to AASHTO M 181 and as below. |

The Contractor shall furnish either a zinc-coated steel or an aluminum alloy product according to the contract. |

The Contractor shall weave chain link fence fabric into about two (2) inch mesh. The Contractor shall weave chain link fabric for tennis courts about one and three-quarters (1-3/4) inch mesh. *|

(A) Zinc-Coated Steel.

(1) Fabric. The wire used for the fabric shall be: *|

(a) No. 11 gage for fences forty-eight (48) inches or less in height and *|

(b) No. 9 gage for fences over forty-eight (48) inches in height. *|

Zinc-coating shall be by hot-dip process after fabrication or weaving. Zinc-coating shall conform to Type I Class D coating stated in Table 3, AASHTO M 181. *|

(2) Post, Fittings and Hardware. Steel pipe used for posts, braces, top railing, and gate frames shall conform to: |

(a) ASTM A 53 or |

(b) a high strength tubing made by cold rolling and radio frequency welding from steel conforming to ASTM A 446, Grade D. The Contractor shall give the exterior surface a hot-dipped zinc coating of one (1) ounce per square foot followed by a chromate conversion coating and 0.5 $\pm$ 0.2 mils of clear acrylic. The interior surface shall have a hot-dipped zinc *|

coating of one (1) ounce per square foot followed by a chromatic conversion coating. The product of the yield strength and the section modulus shall more than that of pipe conforming to ASTM A 53. Posts shall be of the dimensions and weights shown in Table 710-I.

TABLE 710-I - POST DIMENSION AND WEIGHT

Nominal Size inches	OD inches	Wall inches	Wt./Ft. #/Ft.
1-3/8	1.315	0.095	1.24
1-5/8	1.660	0.110	1.82
1-7/8	1.900	0.120	2.28
2-3/8	2.375	0.130	3.12
2-7/8	2.875	0.160	4.64
4	4.000	0.160	6.56

Rolled Formed "C" Sections

Dimensions inches	Wall inches	Wt./Ft. #/Ft.
2.250 x 1.625	0.120	2.64
1.875 x 1.625	0.120	2.15
1.875 x 1.625	0.080	1.51
1.625 x 1.250	0.080	1.35

(c) Rolled Formed "C" Sections. The Contractor shall make roll formed "C" sections from steel having a minimum yield strength of forty-five (45) kips per square inch. The Contractor shall zinc-coat the roll formed shapes according to ASTM A 123. Weight of zinc coating shall be two (2) ounces per square foot of surface. The Contractor shall protect the surface further by a chromate conversion coating and 0.5 $\pm$ 0.2 mil of clear acrylic.

The Contractor shall use rolled formed "C" sections only as line posts, braces and top rails. Rolled formed "C" sections shall be of the dimensions and weights shown in Table 710-I.

The bottom and top tension wires shall be at least no. 7 gage zinc-coated coil steel wire with 1.2 ounces of zinc coating per square foot of surface.

Tie wire shall be No. 13 gage zinc-coated steel or aluminum wire. The Engineer will permit the use of accepted zinc-coated steel or non-corrosive metal bands instead of the wires for fastening chain link fabric to posts and gate frames.

Posts shall be of the total length of more than the depth of the concrete footings plus the length required above ground.

The Contractor shall fit the posts with accepted tops designed to fit securely over the posts. The top rail or top tension wire shall pass through the base of these tops.

(B) Aluminum Alloy.

(1) Fabric. The wire used in the manufacture of the fabric shall be 0.148-inch nominal diameter.

(2) Post, Fittings and Hardware. Aluminum pipes used for posts, braces, top railings and gate frames shall conform to ASTM B 241. Such pipes shall conform to the size of ANSI Schedule 40.

The Contractor shall coat the portion of aluminum fence posts that the Contractor will embed in portland cement concrete a minimum of ten (10) mils dry film thickness with a properly pigmented amine or polyamide curing epoxy type paint. The epoxy paint after incorporating the amine or polamide curing agent shall produce a film that shall completely cure at a minimum temperature of seventy (70) degrees Fahrenheit. The cured paint film shall have alkali resistance, adhesion to aluminum, flexibility, water resistance and hardness.

The bottom and top tension wire shall be nominal 0.192-inch diameter.

Tie wire shall be 0.148-inch diameter. The Contractor may use flat band ties instead of wire. The flat bands shall be one-eighth (1/8) inch thick by seven-eighths (7/8) inch wide. Hog rings for attaching tension wire to fabric shall be more than a nominal 0.110-inch diameter.

Expansion sleeves shall be six (6) inches long of the outside type. The Contractor shall indent the expansion sleeves around the circumference at the center to prevent creeping.

710.04 Metal Beam Rail.

(A) Steel Rail. The corrugated sheet steel beams shall conform to AASHTO M 180 and according to the contract. The Contractor shall furnish Class A, Type 2.

The Contractor shall zinc-coat the rail elements according to Subsection 501.03(G) - Zinc-coating.

(B) Certificate of Compliance. The Contractor shall submit certified inspection reports with test results certifying compliance of the metal beam rails according to the contract. The Contractor shall furnish certification before installation of the railings.

710.05 (Unassigned)

710.06 Fence Posts. Fence posts shall be according to the contract.

Posts for chain link fencing shall be according to Subsection 710.03 - Chain Link Fencing.

(A) Wood Posts. Wood posts shall be according to the contract. The wood posts shall be of sound, seasoned wood, peeled and with ends cut square or shown in the contract. The posts shall be straight and knots trimmed flush with the surface. If the contract calls for treated posts, the kind and type of treatment shall be according to the contract. If the Contractor furnishes red cedar posts or bracing, the Contractor may omit requirements for peeling.

Timber and lumber required for fences or gates shall be sound, straight and free from knots, splits and shakes. Timber and lumber shall be of the species and grade shown in the plans. The Contractor shall dress and finish on 4 sides (S4S).

(B) Concrete Posts. Precast reinforced concrete posts shall be of the section and length specified in the contract. Concrete and reinforcing steel shall conform to Section 601 - Structural Concrete and Section 602 - Reinforcing Steel.

The Contractor shall make precast reinforced concrete posts according to Section 503 - Concrete Structures. The Contractor shall not remove the forms earlier than twenty-four (24) hours after casting. The Contractor shall cure the posts for three (3) days after casting. Ordinary surface finishing is satisfactory.

The Contractor shall not handle or place concrete posts roughly in position before seven (7) days after casting.

710.07 Guardrail Posts. Railing posts shall be according to the contract. |

Steel posts shall be of the section and length according to the contract. Steel shall conform to ASTM A 36. The Contractor shall zinc-coat steel posts after fabrication. |*|

710.08 Guardrail Hardware. The Contractor shall zinc-coat metal fittings, bolts, washers and accessories according to AASHTO M 111 or ASTM A 153. The Contractor shall zinc-coat after fabrication. |*|

(A) Offset Brackets. Offset brackets (or spacer blocks) of the resilient and non-resilient types shall be according to the contract. |

(1) Wooden Offset Brackets. Wooden offset brackets (or spacer blocks) used with precast reinforced concrete posts shall be of laminated Douglas Fir or a solid piece of dense structural grade redwood. The Contractor shall surface the laminated Douglas Fir or solid redwood offset brackets on four (4) sides (S4S), the nominal dimensions according to the contract. The Contractor shall pressure treat the wood according to Section 502 - Timber Structures. Preservative shall be pentachlorophenol petroleum solution or creosote petroleum solution. |*|

Laminated wood spacer blocks shall be Douglas Fir Common Structural J & P, 1250 "c". The laminated wood spacer blocks shall be of a width and thickness to produce upon lamination a block of the size shown in the contract. The Contractor shall use less than four (4) and more than three (3) pieces of equal thicknesses to produce the laminated wood blockouts. Glue for laminating shall be waterproof, suitable for outdoor use. |*|

Redwood spacer blocks shall be Dense Structural, 140 "c" and shall conform to the requirements for wooden spacer blocks.

(2) Metal Offset Brackets. Metal offset brackets shall be of the same material required for steel post according to Subsection 710.07 - Guardrail Posts. |

(B) Splices and End Connections. Splices and end connections shall be according to the contract and shall be of such strength as to develop the full design strength of the rail elements. |

End section shall conform to AASHTO M 180, Class A, Type 2. |

W beam terminal connectors shall conform to AASHTO M 180, Class B, Type 2. |

(C) End Spring Assemblies. When specified, end spring assemblies shall be positive and of a type and design coinciding with the intent, design and strength of the railing structure according to the contract. | |

(D) End Anchor Rods and Accessories. End anchor rods and accessories shall be according to the contract and shall be of such size and strength to develop the full design strength of the rail elements.

(E) Bolts and nuts. Bolts and nuts shall conform to ASTM A 307 and ASTM A 563, Grade A or better, respectively.

High strength bolts shall conform to ASTM A 325 or ASTM A 449.

710.09 Aluminum Bridge Railing. Aluminum bridge railing shall be according to the contract.

(A) Cast Posts. Cast posts shall be permanent mold castings of Alloy A 444-T4 (ASTM B 108) and shall conform to the following provisions:

(1) Material. The chemical composition shall conform to the limits listed in Table 710-II.

TABLE 710-II - COMPOSITION LIMITS

Cu	Fe	Si	Mn	Mg	Zn	Ti	Other (each)	Other (total)
0.10	0.20	6.5-7.5	0.10	0.05	0.10	0.20	0.05	0.15

NOTE: The values are maximum unless shown as a range

(2) Mechanical Properties. Minimum mechanical properties of test bars machined either vertically or horizontally from the high stressed area of the post tension flange (lower 14 inches), but not at the junction of the rib and tension flange, shall be according to Table 710-III. *

TABLE 710-III - MECHANICAL PROPERTIES CASTING TENSION FLANGE

Ultimate Tensile Strength (psi)	20,000
Elongation (% in 2 inches or 4D)	20

(3) Lot. A lot of castings includes less than one thousand (1,000) pounds of trimmed castings when produced from batch type furnaces or two thousand (2,000) pounds of trimmed castings when produced from a continuous furnace not exceeding eight (8) consecutive hours.

(4) Chemical Analysis. The Contractor shall analyze a minimum of one (1) sample, representative of each lot of castings, to determine conformance with Table 710-II. *

(5) Mechanical Property Tests. The Contractor shall machine one (1) tensile specimen from the designated area of the tension flange (see Subsection 710.09(A)(2) - Mechanical Properties) of one (1) casting from each lot or castings. The Contractor shall test the specimen to ascertain conformance with Table 710-III. *|

Specimens machined from the castings shall be Type R1, R2, R3, or F2 (or other sheet type specimen acceptable to the Engineer) shown in FED-STD-151a, Method 211.1. The Contractor shall use the largest possible round specimen. The Contractor shall use flat (sheet type) specimens only when the casting thickness shall not permit the extraction of at least an R3 specimen. *|

The Contractor shall test according to FED-STD-151a, Method 211.1. An accepted laboratory shall certify the test or accepted by the Engineer. *|

(6) Retests. If the test specimen does not conform to Table 710-III, after taking advantage of Paragraph 3.6 of FED-STD-151a, the Contractor shall select two (2) additional specimens to replace each specimen that failed. The two (2) replacement specimens shall conform to Table 710-III or the Engineer will reject the lot of castings that the specimen represents. *|

(7) Heat Treatment. The Contractor shall heat-treat the castings to produce material with the utmost uniformity that shall conform to the properties specified. The Contractor shall heat-treat the whole casting and never heat-treat a portion only. *|

(8) Quality Requirements. Castings shall be of uniform quality and conditions, free of cracks, shrinks, porosity, blowholes or other defects that shall detrimentally affect the suitability of the castings for their intended use. Castings shall be smooth and well cleaned before inspection. *|

The Contractor shall produce the castings under radiographic control as follows: *|

(a) Castings shall be X-ray inspected one hundred (100) percent until the Contractor has established a foundry technique for each mold that shall assure production of castings and are commercially free from harmful defects. *|

(b) When the Contractor has established an acceptable foundry technique, each production lot of castings shall be X-ray inspected according to Special Level S-2, AQL 6.5 percent of MIL-STD-105D. *|

(c) The Contractor shall inspect the bottom fourteen (14) inches of tension and compression flanges and the casting base areas. *|

(d) The Contractor shall consider one (1) X-ray exposure that covers these three (3) areas sufficient. *|

The Contractor shall base radiographic acceptance levels for critical areas on ASTM E 155 Reference Radiographs for Inspection of Aluminum and Magnesium Castings (Series II) shown in Table 710-III. Non-critical areas do not require production X-ray inspection.

TABLE 710-IV - RADIOGRAPHIC ACCEPTANCE STANDARDS

Type of Defect	Reference Radiograph	Thickness 1/4"	Thickness 3/4"
Gas Holes	1.1	2	3
Gas Porosity (round)	1.21	3	2
Gas Porosity (elongated)	1.22	-	-
Shrinkage Cavity	2.1	2	-
Shrinkage-Sponge	2.2	2	2
Foreign Material (less Dense)	3.11	3	3
Foreign Material (more Dense)	3.12	2	1

Presence of one (1) or more defects greater than shown by the above acceptance standards shall be cause for rejection of the casting.

Presence of defects equal to but not greater than shown in the acceptance standards shall be limited to a total of two (2) each of all types, or three (3) of one type.

(9) Post Finish. Front, top and rear faces of posts shall receive a standard scratch brush finish that the Engineer will accept.

(10) Inspection. The Contractor may make inspection where the Contractor receives the material. *|

The Contractor shall check the general requirements specified under Subsection 710.09(A)(8) - Quality Requirements by visual inspection of the castings or by comparison with observational standards where the Contractor has established such standards. *|

(11) Reports. The Contractor shall submit to the Engineer inspection reports certifying compliance according to the contract. *|

(B) Five-sixteenth (5/16) Inch Toggle Bolt Assembly. Toggle bolt assembly shall conform to the following requirements:

(1) Toggle Bolt Material. Five-sixteenth (5/16) inch - 18 NC, SAE 1020 C.R. Steel - Unannealed after forming.

(2) Toggle Material. H.R. Steel - Pickled and oiled.

(3) Washer. 1020 C.R. Steel.

(4) Nut. Five-sixteenth (5/16) inch - 18 NC American Standard cold punched 1020 steel.

Steel parts shall have cadmium plating - Type NS 0.0005-inch thick conforming to ASTM A 165.

(C) One-Half (1/2) Inch Toggle Bolt Assembly. Toggle bolt assembly shall conform to the following requirements:

(1) Toggle Bolt Material. One-half (1/2) Inch - 13 NC, 1335 C.R. Steel heat treated RC 32038, conforming to ASTM A 354.

(2) Toggle Material. 1015 H.R. Steel pickled and oiled with rounded edge conforming to ASTM A 570.

(3) Washer. SAE 1020 H.R. Steel plate break sharp edges - conforming to ASTM A 283.

(4) Nut. One-half (1/2) inch - 13 American standard hexagon nut heavy. 1035 C.R. Steel, heat treated conforming to ASTM A 325.

Steel parts shall have cadmium plating - Type NS 0.005-inch thick, conforming to ASTM A 165.

(D) Steel Anchor Bolt Assemblies. Steel anchor bolt assemblies shall conform to the following requirements:

(1) Steel Anchor Bolt, Washer and Nut. Steel anchor bolt, washer and nut shall conform to ASTM A 325, except that the Rockwell C hardness of the bolts shall not exceed thirty-two (32) after heat treating and before zinc-coating. |

(2) Anchor Plate. The Contractor shall make anchor plate from steel plate conforming to ASTM A 36. *|

The Contractor shall zinc-coat the steel parts of the anchor bolt assemblies after threading, cutting, and drilling or punching according to ASTM A 153. *|

(E) Extruded Aluminum Tube. Extruded aluminum tube shall conform to ASTM B 221, Alloy 6061-T6. |

(F) Insulating Materials for Aluminum Members. Pads for insulating aluminum members from concrete or dissimilar metals shall be of materials, shapes and sizes shown in the contract or as required to suit the particular conditions.

(G) Compliance Reports. The Contractor shall submit to the Engineer, certified inspection reports with test results certifying compliance of the cast posts, anchor bolts, extruded aluminum tubes and appurtenances according to the contract. The certification for the anchor bolts shall be the inspection test report specified in paragraph 9.3.7 or 9.4.6 of ASTM A 325. The Contractor shall submit the certificates before the installation of the railings.

710.10 Steel Bridge Railing. Steel bridge railings include Type 1 or other types designated on the plans. Steel bridge railings include metal rails supported by metal posts, anchor bolts, hardware, and fittings shown in the contract. The Contractor shall zinc-coat the assembly according to ASTM A 123 and ASTM A 153 after fabrication.

Steel rails shall be shop bent to fit the horizontal curve when noted in the contract.

If the horizontal radius of the railing is thirty (30) feet or less, the Contractor may shop bend or build up portion of the railing from structural steel posts quarter (1/4) inch thick conforming to ASTM A 36 at the option of the Contractor. Built up railing shall match the seamless tubing in appearance.

The difference between out-to-out rail sleeve dimensions and the clear inside dimensions of the steel rails shall not exceed one-sixteenth (1/16) inch after zinc-coating.

The Contractor shall clean the bearing surfaces and surfaces to be in permanent contact before the Contractor assembles the railing parts. The bases of posts shall be true and flat to provide uniform bearing on the concrete portions of the railing.

Materials for rails, posts, rods, bolts, and nuts shall conform to the following requirements:

Material	ASTM Designation
Steel Rails	A 500 Grade B
Steel Posts	A 36
Steel Sleeves For Rails	A 36
Steel Bolts	A 108 Grades 1015 to 1020
Anchor Bolts, Bolts, Nuts And Washers	A 325 except that the Rockwell C hardness of the bolts shall not exceed 32 after heat treating and before zinc-coating.

Metal railing shall conform closely to the horizontal and vertical lines shown on the plans or ordered by the Engineer. The railing shall present a smooth uniform appearance in its final position.

The Contractor shall install shims at posts and railings where necessary *| to provide uniform bearing and conformance with horizontal lines and vertical grade lines. Shims at steel posts shall be commercial quality zinc-coated sheet steel.

The Contractor shall submit to the Engineer, certified inspection reports with test results certifying compliance of the rails, posts, sleeves, anchor bolts, bolts, nuts and washers according to the contract. The | certification for the anchor bolts shall be the inspection test report | specified in paragraph 9.3.7 or 9.4.6 of ASTM A 325. The Contractor shall *| certificates before the installation of the materials. *|

710.11 Steel Pipe for Railings. Steel pipe shall conform to ASTM A 120, | Black and Hot-Dipped Zinc-Coated Welded and Seamless Steel Pipe for | Ordinary Uses. The Contractor shall zinc-coat the steel pipes one and a half *| (1-1/2) inches inside diameter, standard weight for rails, and extra strong for posts and sleeves. Materials such as flanges and bolts shall be hot-dip | zinc-coated. |