SECTION 1212 – HIGHWAY SIGNS AND POSTS

1212-1 DESCRIPTION

This work item consists of furnishing, fabricating, and installing highway signs, delineators, and supporting structures.

1212-2 MATERIALS

A. General. All materials furnished and used in this work shall be new and shall meet the plans, the NDDOT Standard Drawings, Section 1212 of the Standard Specifications, and the following requirements:

Signs, supporting structures, breakaway bases, anchor units, brackets, stringers, and hardware shall be fabricated to meet the dimensions, metal gauge, and bolt holes set forth in the contract and NDDOT Standard Drawings. All flat sheet sign backings shall be aluminum with reflective sheeting applied as specified.

The traffic control sign details not otherwise specified shall meet the MUTCD published by the Federal Highway Administration.

All sign faces shall be according to the detail drawings and the alphabets shown in the MUTCD, Standard Highway Signs, and Standard Alphabets, published by FHWA. Sign faces not detailed in these publications shall meet the detailed drawings shown in the supplementary Standard Highway Signs booklet published by the NDDOT.

Regulatory, warning, and guide signs shall be detailed and dimensioned according to detailed drawings of the Standard Highway Signs booklet. These detail drawings are available to the sign fabricator upon request from the NDDOT. Signs not illustrated in these booklets shall be as shown on the NDDOT Standard Drawings. The last number in the sign numbers shown is the width of the sign required.

Variable message sign dimensions have been computed by the North Dakota Department of Transportation in order to draft these signs by mechanical means. These message computations have been tabulated and shall be used to lay out these sign faces in the fabricator's shop. These tabulated sheets will be furnished to the CONTRACTOR upon request after the Contract has been awarded.

B. Concrete. Concrete used in this item of work shall be Class AE portland cement concrete mixed and proportioned as specified in Section 500.

C. Reinforcing Steel. The reinforcing steel shall meet Subsection 501-2.9.

D. Delineators. Delineators shall meet Subsection 1212-6.

E. Hardware and Fittings. Signs, supporting structures, breakaway bases, anchor units, brackets, stringers, and all hardware and fittings shall meet Subsection 1212-5 A.

F. Posts. Posts shall meet Subsection 1212-5 B.

1212-3 CONSTRUCTION REQUIREMENTS

A. Locating and Positioning Signs and Sign Structures. Each sign and structure shall be located according to the Plans or, where necessary, for maximum effect of the sign. Installed signs and structures will be inspected at night for maximum effect and minimum specular reflection. If any sign exhibits specular reflection or is ineffective at night, the sign shall be adjusted at the CONTRACTOR's expense.

Signs and delineators located less than 30 feet from the pavement edge shall be erected with the sign face truly vertical and turned 93 degrees away from the center and direction of travel of the lane which the facility serves. Signs located 30 feet or more from the edge of the pavement edge shall be erected with the sign face truly vertical and aligned 90 degrees from the center and direction of travel of the lane which the offset sign serves. Special attention shall be given to the location and positioning of signs and delineators at the point where lanes divide, or on curves, to avoid specular reflection and to obtain maximum effectiveness of the facility.

B. Sign Fabrication.

1. General. All sign backing for flat sheet signs shall be aluminum unless noted otherwise, with reflective sheeting applied as specified herein. On large variable message signs the messages, symbols, and borders shall consist of directly applied reflective sheeting cut to desired shapes. The message, symbols, and border shall be applied as specified by the sheeting manufacturer.

2. Fabrication of Sign Backing. Sign backings shall be cut to size and shape and shall be free of buckles, warps, dents, cockles, burrs, and all defects resulting from fabrication. The surface of all signs shall be plane surfaces. All cutting, shearing, and drilling or punching of holes (except mounting holes for demountable letters, numerals, symbols, and borders) shall be completed before metal degreasing and application of reflective sheeting.

3. Cleaning and Processing. Cleaning and processing of sign backing shall take place before applying the reflective sheeting. Cleaning and processing shall be performed using the sheeting manufacturer's instructions and recommendations as well as the requirements of Section 1212.

All metal sign backing material shall be handled only by handling devices or clean canvas gloves between cleaning and applying reflective sheeting. Metal shall not come in contact with greases, oils, or other contaminants before application of reflective sheeting. When backing materials are chromate-

conversion coated beforehand and are allowed to set for several days before applying reflective sheeting, the application surface shall be given a solvent wipe before reflective sheeting application.

4. **Fabrication of Flat Sheet Signs.** The background of the flat sheet signs shall be screened on reflective sheeting as specified by the manufacturer of the reflective material and as specified herein. Messages, symbols, and borders may be screened on or directly applied reflective sheeting. Directly applied reflective sheeting shall be applied as specified by the sheeting manufacturer. Colors shall meet the requirements of the contract and as shown in the MUTCD. Care shall be taken so screening inks are compatible with reflective sheeting backgrounds.

   Reflective material shall meet Subsection 1212-2.

   The reflective sheeting used on flat sheet sign backings larger than the manufacturer's material shall require splicing. All sheeting on each individual sign shall be from the same manufacturer's lot, and shall be spliced in one direction only. No more than one splice will be permitted per sign. Vertical splices shall be in the center of the sign. Horizontal splices, if used in lieu of the vertical splice, shall be in the center of the sign with the top portion overlapping the bottom portion of the sheeting when it is in the upright position.

   Heat-activated, adhesive-coated, reflective sheeting may be overlapped not less than 3/16 inch or by a butted gap not to exceed 1/32 inch. Splices will be permitted only on sign screens processed with transparent colors. Pressure-sensitive, adhesive-coated, reflective sheetings shall be overlapped not less than 3/16 inch.

   The overlapped splice shall be made without screening paints between the reflective sheeting.

   The sign face shall be processed and finished with material as specified by the sheeting manufacturer. Processing of Type III A or III B Reflective Sheeting with screened-on messages shall be accomplished before applying to the sign backing. Processing of Type II Reflective Sheeting may be accomplished before or after applying to the sign backing.

   The finished signs shall have a smooth, uniform surface. All letters and numbers shall be clear cut and sharp.

5. **Fabrication of Panel Signs.** The background shall be applied to the panels as specified by the reflective sheeting manufacturer.

   Reflective sheeting shall be overlap spliced. The splice shall be overlapped not less than 3/16 inch, and sheeting applied to panels shall extend over the edges and down the side legs a minimum of 1/16 inch. Splices shall be at a 90-degree

angle to the length of the panel. The splices shall be uniformly and neatly made throughout their entire length. No individual panel shall have more than two splices, and the minimum distance between adjacent splices shall be 8 feet.

When guide sign symbols (e.g., handicap, hospital, and airport symbol signs) are required on larger guide signs as part of the message, the symbol signs shall be riveted to the larger signs and be installed at the locations shown on the plans. The cost of the symbol signs and the labor, equipment, and material needed to attach them will not be bid separately, but will be included in the price bid for the panel or overlay of the sign.

6. **Date of Fabrication.** All signs receiving new sign facings shall be dated with the month and year fabricated. The date shall be placed on the back of the metal backing on the lower corner of sign near the edge closest to traffic so that it can be read from the ground. The dating layout shall consist of 1/4 inch high numbers on a 2¼ inches long by 1¾ inches high pressure-sensitive label. The numbers imprinted on the upper part of the label shall be 1 through 12, with the last two digits of four consecutive years printed across the bottom (as 92, 93, 94, 95). The month and year of fabrication shall be punched out. The label shall meet Section 1212-4. The cost of furnishing, fabricating, and installing labels shall be included in the price bid for "Flat Sheet for Signs Type II and III A," "Panel for Signs Type II and III A," "Refacing Signs Type II and III A," or "Overlay Panel Type II and III A."

C. Packaging, Labeling, Handling, and Shipping.

Completed signs shall be dry before packaging or storing. Packaged signs that become wet before use shall not be used. A warning label with instructions designed to prevent damage to the signs shall be on the outside of the package, and an additional warning label shall be placed in the packages between the first and second sign, before the last sign, and after each five signs in a package. Packaged signs shall not be banded and shall be stored and shipped on edge.

Packaging shall be done so that the signs are protected during storage, shipping, and handling. Packaged signs shall be slipsheeted using the material and methods recommended by the sheeting manufacturer.

Unmounted reflective sheeting may be stacked flat to a maximum height of 5 inches for temporary storage. Otherwise, they shall be stored on edge. The sheeting on signs shall not be exposed to temperatures above 150°F. The slipsheeting shall be left on the sign face until mounted.

Panel signs may be assembled or separated into sections for ease in handling, storing, and shipping. In lieu of packaging, the sign faces may be turned toward each other and fastened together firmly with sufficient spacers to prevent the sign faces from touching. Sign faces that cannot be protected by packaging or fastening face to face shall have protective covers placed over them.

D. Label (Handling, Storage, and Installation Instructions). The label referred to in Subsection 1212-3 C shall contain the following instructions:

1. Loading on Vehicles. Signs shall be secured vertically in racks to prevent them from rubbing, scratching, or marring front surfaces. Signs that have protective wrappings or slipsheeting shall be kept dry.

Signs shall be carefully unloaded, stacked on edge off the ground in an upright position.

2. Storage at Job Site. Signs shall be stored indoors and upright on edge to prevent damage to the reflective sheeting.

Signs shall be kept dry. Packaged signs that get wet will be rejected.

3. Installation.

a. Signs shall be handled carefully and not scuffed or walked on.

b. Nylon washers shall be used between flat washers and sign face for all Type III and IV reflective sheeted signs.

c. When washing signs is necessary, a soft bristle brush or sponge and water shall be used.

E. Erection of Sign Supports and Delineators.

1. General. The ENGINEER will verify the support lengths on all new sign supports prior to the materials being ordered by the CONTRACTOR. All sign supports shall be firmly set and plumb after erection. All concrete foundations shall be constructed as specified, with the top sloped enough to drain away from the sign support. All exposed concrete above ground surface shall be given a rubbed finish. Excess excavation material removed to set sign supports shall be disposed of at the CONTRACTOR's expense. A driving cap shall be used when driving a sign support.

2. Delineator Posts. Delineator posts shall be driven without being damaged. If the drilled or punched hole method is used, the hole shall be large enough so the post can be set without damage. Any damage to utilities or structures as a result of construction operations shall be repaired at the CONTRACTOR's expense.

3. Anchor for Telescoping Perforated Tubes and Flange Channel Supports. Anchors for telescoping perforated tubes and flange channel supports shall be driven. The perforated tube anchor shall be driven to a maximum of 4 inches

above the ground or sidewalk and 4 inches maximum installed height above ground or sidewalk for flange channel anchor.

Anchors shall be installed at Plan length, unless the ENGINEER determines a shorter length is sufficient due to good soil bearing developed when driving the anchor. Anchor lengths may be reduced to a minimum of 3 feet. When set in sidewalk, the anchor plate may be omitted.

The sidewalk shall be cored to install the anchor unit and the cored area shall be filled with new concrete to restore the sidewalk surface.

4. **Tubular Sign Supports.** Tubular Sign Supports shall be set in a Class AE portland cement concrete base, constructed as shown on the plans. Breakaway base plates shall be assembled with the bolts torqued to plan requirements. The plates shall be carefully placed so the tapered bolt slot tapers toward approaching traffic. Either the stub post or the anchor bolt design may be used as detailed. If the anchor bolt design is used, a portland cement grout shall be used to raise the top of the foundation to a snug fit under the base plate. When standard round pipe posts are shown on the plans for signs that have two or more posts, the CONTRACTOR may elect to use either round sign supports or W-shape posts. Signs with one post shall use the round sign supports as shown on the plans.

5. **Splicing.** Splicing is permitted on telescoping and flange channel posts only to obtain the required post length. A splice shall be more than 5 feet above ground, and only one splice is permitted per post. Splicing costs shall be at the CONTRACTOR's expense. The weight of the splice will not be added to the post pay weight.

6. **W-Shaped Sign Supports.**

   a. The CONTRACTOR shall install H-Pile footings for W-Shaped Sign Supports constructed as shown on the plans. Breakaway base plates shall be assembled with the bolt torqued to plan requirements. The plates shall be carefully placed so the tapered bolt slot tapers toward approaching traffic. W-Shaped Supports shall use the stub post design.

   b. Flame Cutting of W-Shape Posts. The gas cutting torch may be used for cutting metals or preparing joints. Carbon steel above 0.30 percent carbon, high alloy steels, heat treated steel, and plated metals shall not be flame cut unless subsequent corrective treatment is provided as approved by the Materials and Research Engineer.

   All flame cutting work shall be done by the oxyacetylene gas method or other method approved by the ENGINEER. The maximum permissible deviation from true lines shall be 1/16 inch. Repairs of edge defects shall be done according to Section 3.2 of AWS Structural Welding Code, as amended by

AASHTO Specifications for Welding of Structural Steel Highway Bridges. In general, the roughness of flame cut surfaces shall be no greater than an ANSI roughness value of 1,000 microinches. All slag from flame cutting shall be completely removed.

When flange plates or other members are cut to a curve, the curve shall be uniform to the radius required. A series of straight cuts tangent to the curve shall not be acceptable.

When ends of members which are to take bearing are cut with a torch, a suitable allowance in their length shall be made to permit proper milling or planing.

Joints for welding may be prepared by "flame cutting" or "flame gouging" provided all slag and oxidized metals are removed.

c. Edge Finishing. Members formed to specific size by shearing of structural steel plates having a thickness of 1/2 inch or more, shall be machined or planed to correct size by removing not less than 1/4 inch of metal. All field splice plates and stiffeners less than 1/2 inch in thickness shall have a minimum of 1/8 inch of metal removed by machining or planing after shearing.

F. Mounting Flat Sheet Signs Type III A and III B Sheeting. Flat sheet signs shall be bolted to the supports and shall have a nylon washer between the flat washer and the sign face. Rubber incased washers may be substituted for nylon washers on work zone traffic control signs specified under Section 1211.

G. Removing and Resetting Signs and Supports. Existing signs and supports shall be removed and reset as specified. All signs and supports not to be reset shall be stockpiled on the project right-of-way at designated locations. The stockpiled signs and supports shall remain the Engineering Department's property.

Removed or reset signs and supports that become damaged during removing, resetting, or stockpiling shall be replaced at the CONTRACTOR's expense.

Existing signs and supports shall be removed as construction progresses, and shall be immediately reset or installed. The CONTRACTOR shall install new signs or reset signs as shown on the plans. All signs and supports shall be on the project site at the time construction begins. The CONTRACTOR may choose to temporarily reset existing signs, or temporarily install new signs. The cost of installing and resetting signs temporarily shall be included in the price bid for other items. Any damaged signs or supports shall be replaced at the CONTRACTOR's expense.

H. Remove Sign Foundations. This item consists of removing signs, steel pipe supports, and concrete foundations or piling and restoring the surface to match the surrounding area. Concrete foundations shall be removed to a depth of 2 feet below

the ground line unless otherwise specified in the plans. The signs, steel pipe supports, piling, and concrete foundations removed shall become the property of the CONTRACTOR and be disposed of outside the highway right-of-way.

I. Revise Fuse Joints. This item consists of removing the existing front fuse plate and back hinge plate and installing a new front perforated fuse plate and a new back hinge plate as shown on the detail sheets in the plans. All nuts will be tightened securely, torquing is not required.

J. Overlay Panel Sign Refacing. This item consists of removing the legend, border, and symbol on those signs that have demountable copy and place overlay panels on the signs. Those signs that have direct applied reflective sheeting legends, borders, and symbols need not have these removed. The new changed legends, borders, and symbols shall be direct applied to the thin metal overlay panels and installed on the existing signs. The legends, borders, and symbols are deemed not salvageable and shall be disposed of by the CONTRACTOR outside the highway right-of-way.

The overlay panels shall be fabricated from 0.063-inch aluminum alloy conforming to ASTM B209 Alloy 6061-T6 or 5052-H38 with mill finish. The overlay panels shall be fabricated according to Subsection 1212-1 and degreased, etched, and coated according to Subsection 1212-1 of these specifications. The reflective sheeting applied to the overlay panels shall meet the requirements of Subsection 1212-2 of these specifications.

The letters, numerals, symbols, and borders shall be directly applied according to Subsection 1212.04. The Reflective sheeting shall meet the requirements of Subsection 1212-2. Type IIIA reflective sheeting letters, numerals, symbols, and borders shall be used on Type II background. Type IIIA reflective sheeting letters, numerals, symbols, and borders shall be used on Type IIIA background. The overlay panels, after fabrication, shall be installed on the existing signs with aluminum blind fasteners 5/32 inch diameter with 1/8 inch out the back of the existing sign backing or other non-corrosive fasteners approved by the ENGINEER. The panels are to be butted together with no overlap. Where legends, numerals, symbols, and borders cross the butt joints, they will need to be cut.

Signs that are to be overlaid that are larger than manufactured overlay panels shall be fabricated as follows: Overlay panels shall be a minimum of 18 inches wide and a maximum of 4 feet wide. Panels will have a minimum length of 8 feet. If the overlay panels do not cover the full height of the sign, the overlay panels shall be placed on the lower portion of the sign first so the longer side of the panel is vertical. The remaining panels shall be placed above these panels with their long side placed horizontally. The overlay panels shall be riveted around the panel with the rivets 1 inch from the edge of the panel. The rivets shall be evenly spaced with no more than 12 inches between rivets, horizontally and vertically. Panels more than 24 inches wide shall be riveted down the middle of the panel at 12-inch centers.

K. Auxiliary Signs. The auxiliary signs used with route markers shall be the same background color as the route markers they are used with. (Interstate - Blue, State - White, Interstate Business Loop - Green, and County - Blue.)

L. Road Closed, Type III Barricade, Snow Fence Combination. This item consists of a diamond grade Road Closed Sign R-11-2-48, 3 post mounted to a Type III Barricade per NDDOT detail D-754-32 Assembly No. 37. The barricade shall be anchored 4 feet deep with minimum 2-inch by 2-inch perforated tubes per NDDOT detail D-754-18. Orange plastic safety fence shall be installed with steel fence posts spaced 8 feet apart and behind the road closed sign. The barricade shall be installed across the entire width of the proposed street, curb to curb. This combination shall be set no more than 10 feet beyond the end of the pavement. This combination shall also be in accord with Standard Detail 1212-1.

M. Relocate Road Closed, Barricade, Fence Combination. This item consists of removing and resetting combination as specified in subsection 1212-3(L), including replacing any damaged items.

1212- 4 METHOD OF MEASUREMENT AND BASIS OF PAYMENT

METHOD OF MEASUREMENT

A. Flat Sheets, Panels, and Extruded Aluminum Panels. Flat sheets, panels, and extruded aluminum panels for signs will be measured to the closest 1/10 square foot, complete, in place, and accepted by the ENGINEER. All hardware, stringers, and brackets required to attach signs to the posts shall be included in the pay item.

B. Galvanized Steel Posts.

1. Galvanized Steel Posts - Telescoping Tube and Flange Channel. Telescoping Tube and Flange Channel posts will be measured by the linear foot, complete, in place, and accepted by the ENGINEER. All sizes will be measured and paid for as “Galvanized Steel Posts - Telescoping Perforated Tube or Flange Channel.”

The post length shall be measured from the top of the post to the bottom of the anchor unit, as shown on the plans. The sleeves and breakaway base, if included, will not be measured for payment, but will be considered incidental to the cost of the post.

2. Galvanized Steel Posts - Standard Pipe (single). Single post signs will be measured by the linear foot of each size installed and accepted by the ENGINEER. The post length shall be measured from the top of the breakaway base to the top of the post, as shown on the plans. The concrete base will be paid for separately.

3. **Galvanized Steel Posts - W-shaped Posts (two or more).** W-shaped posts will be measured by the linear foot of each size installed and accepted by the ENGINEER. The post length, the 12-foot driven pile length, and the 2-foot stub post, as shown on the plans, will be included in the length of post to be measured and paid for.

C. Breakaway Bases. Breakaway bases for standard pipe, W-shape, and telescoping tubes will not be measured, and all hardware, stub posts, slip bases, and assembly will not be measured but will be incidental to the contract unit price bid for posts.

D. Delineators. The quantity will be measured by the number of delineators of each type installed, complete with reflectors.

E. Concrete Foundation. When concrete foundations are used on single post signs, the concrete will be measured by the cubic yard based on the quantity shown for each foundation complete, in place, and accepted by the ENGINEER. Reinforcing steel will not be measured but shall be included in the price bid for concrete.

The splices, post caps, plates, bolts, cutting fuse joints, and assembly will not be measured but will be incidental to the post.

F. Reset Sign Panels. The quantity to be paid for will be measured by the number of locations at which a sign, or a sign assembly, has been reset. Signs and assemblies will be measured in place and accepted by the ENGINEER.

G. Reset Sign Supports. The quantity to be paid for will be measured by the number of supports installed, complete, and accepted by the ENGINEER.

H. Removed Signs and Supports. Removed signs and supports will not be measured for payment, but will be incidental to other bid items. Cost of removal shall be included in the price bid for other items.

I. Remove Sign Foundations. The item “Remove Sign Foundations” will be measured by the number of foundations removed. The quantities measured will be paid for at the contract unit price, and will be full compensation for all labor, equipment, and material necessary to complete the removal and disposal.

J. Revise Fuse Joint. The item “Revise Fuse Joint” will be measured by the number of fuse joints revised. The quantities measured will be paid for at the contract unit price and will be full compensation for all labor, equipment, and material necessary to complete the work.

K. Overlay Panel. The item “Overlay Panel” will be measured by the square foot of panel in place and accepted by the ENGINEER. The quantities measured will be paid for at the contract unit price and shall include all labor, equipment, and material needed to complete the work.

L. Road Closed, Barricade, Fence. This item, "Road Closed, Barricade, Fence," will be measured and paid per each combination complete in place and accepted by the ENGINEER.

M. Relocate Road Closed, Barricade, Fence. This item shall be measured and paid per each relocation complete in place and accepted by the ENGINEER.

BASIS OF PAYMENT

Payment will be made at contract unit prices for the following:

Pay Item	**Pay Unit**
Flat Sheet for Signs, Type II, III A, or III B Reflective Sheeting	Square Foot
Panel for Signs -Type II, III A, or III B Reflective Sheeting	Square Foot
Extruded Aluminum Sign Panels Type III A, and III B Reflective Sheeting	Square Foot
Delineators, Type A, B, C, D, or E	Each
Class AE Concrete – Sign Foundations	Cubic Yard
Reset Signs	Each
Reset Sign Supports	Each
Galvanized Steel Posts – Telescoping Perforated Tube or Flange Channel	Linear Foot
____" Galvanized Steel Post – Standard Pipe (Single Post)	Linear Foot
____" Galvanized Steel Posts (two or more)	Linear Foot
Remove Sign Foundations	Each
Revise Fuse Joint	Each
Overlay Panel	Square Foot

This payment will be full compensation for all labor, equipment, and materials necessary to complete the work.

1212-5 SIGN BACKING MATERIAL

A. Materials.

1. Flat Sheet Aluminum. Flat sheet aluminum shall be an alloy meeting ASTM B209 alloy 6061-T6, or 5052-H38 with mill finish.

2. Extruded Aluminum Panels. Extruded Aluminum Panels shall meet ASTM B221 Alloy 6063-T6. The panels shall be furnished in 12-inch and 6-inch sections as shown on the plans. All panels shall be flat and straight within commercial tolerances established by the aluminum industry.

B. Shop Surface Preparation and Processing. All sign backing shall be clean and free of rust, white rust, oil, and dirt. The holes shall be shop drilled to the sizes and at locations shown in the contract. Holes required in the sign backing shall not be field drilled.

1. Degreasing. The extruded aluminum panels shall be rubbed with a clean white cloth after degreasing and if any sticky material shows up on the cloth, the panels shall be degreased again. All aluminum sign backing shall be degreased by one of the following methods:

a. Vapor Degreasing. Aluminum materials shall be immersed in a saturated vapor of trichloroethylene. Trademark printing shall be removed with a lacquer thinner or a controlled alkaline cleaning system.

b. Alkaline Degreasing. The aluminum shall be immersed in an alkaline solution controlled and titrated according to the solution manufacturer 's recommendations. The immersion time shall be dependent upon the gauge of the metal and the amount of soil to be removed.

2. Etching. All sheet aluminum shall be etched after degreasing. Extruded aluminum panels which have a roughened surface texture suitable for paint or sheeting shall not be etched after degreasing unless the ENGINEER determines the panels are unsuitable. Etching shall be performed by one of the following methods:

a. Acid Etch. The aluminum shall be etched in a 6 percent to 8 percent solution of phosphoric acid at 100°F, or a proprietary acid etching solution. It shall be rinsed after etching with cold running water followed by a hot water rinse.

b. Alkaline Etch. The aluminum shall be etched in an alkaline solution controlled by titration. The length of time the aluminum is etched and the temperature and concentration of the solution shall comply with the solution manufacturer's instructions. The aluminum shall be well rinsed after etching. Smut on the aluminum shall be removed with an acidic chromium solution recommended by the solution manufacturer and then well rinsed.

3. Coating. Aluminum panels that have not had reflective sheeting applied for several days or longer, after being etched, shall be treated with a light, tightly adherent chromate conversion coating before applying the reflective sheeting. The chromate conversion coating shall be free of powdery residue and shall range in color from a silvery iridescence to a pale yellow. The coating shall meet ASTM B449, Class 2, 10-35 milligrams/square foot with a median of 25 milligrams per square foot as an optimum coating weight.

4. Drying. All sign backing material shall be dried with forced hot air after preparation and processing.

1212-6 RETRO-REFLECTIVE SHEETING MATERIALS

A. General. The retroreflective sheeting stored under normal conditions shall be used within one year from the manufactured date. The packaging cartons or roll goods shall be marked with the manufacturer's lot numbers and manufacture date.

The surface of the barricade rails, drums, or cones shall be treated as recommended by the sheeting manufacturer before applying the reflective sheeting.

Type III C reflective sheeting shall have an identification symbol on the surface to differentiate it from other types of sheeting. The identification symbol shall not interfere with the function of the sheeting, but shall be visible to inspectors day or night without the use of special devices. The symbol shall be in a repeat pattern such that any 4-inch by 8-inch or 5-inch by 5-inch piece of the sheeting contains at least one full symbol.

The durability of the retroreflective sheeting shall be substantiated by the following accelerated weathering tests:

1. **Accelerated Outdoor Test.** When the retroreflective sheeting is processed and applied according to recommended procedures, the sheeting shall be weather-resistant, resistant to dirt and fungus accumulation, and following cleaning, shall show no discoloration, cracking, crazing, blistering, or dimensional change, and have not less than 50 percent for Type II and IV sheeting and not less than 80 percent for Type III A sheeting of the specified minimum brightness values shown in ASHTO M268 measured at an observation angle of 0.2 degrees and an entrance angle of -4 degrees when exposed to accelerated weathering for 30 months, south-facing, unprotected at 45°F.

2. **Accelerated Machine Test.** The retroreflective sheeting shall meet the artificial weathering requirements of AASHTO M268 measured at an observation angle of 0.2 degrees and an entrance angle of -4 degrees.

The CONTRACTOR shall furnish written evidence showing conformance with one of the following:

a. The accelerated outdoor test, done in North Dakota or in a state located at lower latitudes, or

b. The accelerated machine test and 3 years of performance in the field with no problems.

The CONTRACTOR shall secure from the manufacturer all warranties and guarantees with respect to materials, parts, workmanship, or performance which the products covered by the proposal bear, and include these warranties and guarantees with the certification.

B. Type II and III A Retroreflective Sheeting Material. Type II and III A retroreflective sheeting shall meet AASHTO M268 and the following:

Processed retroreflective sheeting shall be applied to approved sign base material and cleaned according to manufacturer's recommendations for use on traffic control signs. The CONTRACTOR shall furnish a written assurance that the sheeting will meet the requirements of the following tables throughout the satisfactory performance life and be effective for its intended purpose when viewed from a vehicle.

TYPE II RETROREFLECTIVE SHEETING

Sheeting Type And Color	Average Minimum Candelas per foot Candle per sq. ft. at 0.2° divergence and -4° incidence*	Satisfactory Performance Life
Silver-White #1	30.0	5 years
Silver-White #2	36.0	5 years
Yellow	20.0	5 years
Red	5.0	5 years
Blue	2.0	5 years
Green	3.0	5 years
Orange	10.0	5 years
Brown	0.4	5 years

TYPE III A RETROREFLECTIVE SHEETING

Sheeting Type And Color	Average Minimum Candelas per fort Candle per sq. ft. at 0.2° divergence and -4° incidence*	Satisfactory Performance Life
Silver-White	200.0	10 years
Green	36.0	10 years
Yellow	136.0	10 years
Red	36.0	10 years
Orange	80.0	3 years
Blue	16.0	10 years

*Candlepower measurement shall be made, following sign cleaning, in accordance with procedure recommended by the sheeting manufacturer.

C. Type III B Retroreflective Sheeting. Type III B retroreflective sheeting shall consist of optical lens elements adhered to a synthetic resin and encapsulated by a

flexible transparent plastic that has a smooth outer surface. The sheeting shall have a pre-coated adhesive protected by an easily removable liner. This sheeting is intended for use on rigid substrate signs and barricades used in the construction work zone. Type III B retroreflective sheeting shall meet AASHTO M268 and the following:

The CONTRACTOR shall furnish a written assurance that the sheeting will meet the requirements of the following table throughout the satisfactory performance life and be effective for its intended purpose when viewed from a vehicle:

TYPE III B RETROREFLECTIVE SHEETING

Sheeting Type And Color	Average Minimum Candelas per foot Candle per sq. ft. at 0.2° divergence and -4° incidence*	Satisfactory Performance Life
White	200	3 years
Yellow	136	3 years
Orange	80	3 years
Prestriped Barricade	200/80	3 years

*Candlepower measurement shall be made, following sign cleaning, in accordance with procedure recommended by the sheeting manufacturer.

The impact resistance shall be tested on reflective sheeting, applied according to the manufacturer's recommendations to a cleaned, etched aluminum panel of Alloy 6061 T 6,0.063 inches by 3 inches by 5 inches and conditioned for 24 hours at 0°C.

The sheeting to be tested for flexibility shall be conditioned for 24 hours at 0°C.

D. Type III C Retroreflective Sheeting. Type III C retroreflective sheeting shall consist of optical lens elements adhered to a synthetic resin and encapsulated by a flexible transparent plastic that has a smooth outer surface. The sheeting shall have a pre-coated adhesive protected by an easily removable liner. This sheeting is intended for use on plastic reboundable devices such as drums and flexible delineation posts. Type III C retroreflective sheeting shall meet the weathering requirements of AASHTO M268, Type IV and the following:

The CONTRACTOR shall furnish a written assurance that the sheeting will meet the requirement of the following table and be effective for its intended purpose when viewed from a vehicle.

TYPE III C RETROREFLECTIVE SHEETING
Average minimum Candelas per foot candle per square foot

Observation Angle	Entrance Angle	White	Yellow	Orange
0.2°	-4°	250	170	100
0.2°	+30°	150	100	60
0.5°	-4°	95	62	30
0.5°	+30°	65	45	25

The impact-resistant aluminum panel shall be the same as Type III B reflective sheeting.

The impact resistance shall be tested on a Gardner Variable Impact Tester, I6-1120 using a 4-pound weight with a 5/8-inch rounded tip dropped from a 100 inch-pound setting.

Type III C reflective sheeting performance on reboundable plastic substrates shall be measured using the following test:

The device shall be impacted 3 times by a 4,000 pound vehicle, with a 20-inch bumper, at 40 mph. Each impact shall be a direct hit (glancing blows will not be allowed). After the impacts, the reflective sheeting shall be considered performing satisfactorily when no loss of sheeting results and there is no visible change in day and night performance (when viewed from 500 feet).

The sheeting to be tested for flexibility shall be conditioned for 24 hours at 0°C.

E. Type IV Reflective Sheeting. The Type IV reflective sheeting shall consist of high-gloss transparent ultra-violet light-stabilized polyester film bonded to a layer of polyester cube corner prisms with not less than 40,000 prisms per square inch meeting AASHTO M268 and the following:

1. Type IV, Class 1 Reflective Sheeting. The backing for the polyester sheeting used on barricade rails, drums, and traffic cones shall be an opaque-white plasticized polyester film not less than 0.004 inch thick with an adhesive backing meeting AASHTO M268, Class 1.

2. Flexible Rollup Sign, Non-Adhesive Backing Fabric. The polyester sheeting on the flexible rollup portable signs shall be coated on both sides with orange pigment polyester and shall meet the following specifications:

Base Fabric	
Fiber	1,000 denier polyester
Weight	3 ounces/square yard
Fabric Count	10 warp, 10 fill

Coated Fabric	
Total Weight	14 ± 1/2 ounces/square yard
Type of Coating	PVC
Color	Orange
Distribution	60 face, 40 back

Mechanical Properties		**Federal Standard 191 Method**
Tensile Strength	Warp 250, Fill 200	5100
Tear Strength	Warp 85, Fill 95	5134.1
Low Temperature	-65°F	
High Temperature Continuous	+180°F	
Abrasion Resistance (Taber)	1700 Cycles	5306
Flame Resistance	California Fire Marshall Approved Reg. No. F 102.4	

F. Wide Angle Prismatic Reflective Sheeting. The sheeting shall consist of prismatic lenses formed in a transparent synthetic resin, sealed, and backed with an aggressive pressure sensitive adhesive protected by a removable liner. The sheeting shall have a smooth surface with a distinctive interlocking diamond seal pattern and orientation marks visible on the face.

MINIMUM COEFFICIENT OF RETROREFLECTION
(Candelas per foot-candle per square foot)
90° Rotation Angle

Observation Angle (Deg.)	**Entrance Angle (Deg.)**	**White**	**Orange**
0.2	-4	800	300
0.2	+30	400	150
0.2	+50	120	50
0.5	-4	200	100
0.5	+30	100	50
0.5	+50	40	20

Daytime color shall conform to the table shown below. Color of sheeting mounted on aluminum test panels shall be determined instrumentally in accordance with ASTM E1164. Values shall be determined on a Hunter Lab Labscan 6000 0/45 Spectrocolorimeter with option CMR 559. Computations shall be done in accordance with ASTM E308 for the 2° observer.

COLOR SPECIFICATION LIMITS* (DAYTIME)

Color	1		2		3		4		Reflectance Limit Y (%)	
	X	Y	X	Y	X	Y	X	Y	Min	max.
White	.305	.305	.355	.355	.335	.375	.285	.325	40	–
Orange	.583	.416	.523	.397	.560	.360	.631	.369	12	30

*The 4 pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 standard colorimetric system measured with standard illuminant D65.

The sheeting shall show no cracking outside the impact area when the face of the panel is subjected to an impact of 100 inch-pounds, using a weight with a 5/8 inch diameter rounded tip dropped from a height necessary to generate an impact of 100 inch-pounds, at temperatures of both 32°F and 72°F.

The impact-resistant aluminum panel shall be the same as required for Type III B reflective sheeting.

The Retroreflective Sheeting shall be processed and applied to aluminum sign blank materials in accordance with the sheeting manufacturer's instructions. The sheeting shall perform effectively for three (3) years. If, within three (3) years from the date of acceptance, the sheeting has deteriorated due to natural causes to the extent that (1) the sign is ineffective for its intended purpose when viewed from a moving vehicle under normal day or night driving conditions by a driver with normal vision; or (2) the coefficient of retroreflection, after cleaning, is less than 400 for white and 150 for orange when measured at 0.2 degree observation and -4 degree entrance at 90 degree rotation; new sheeting will be furnished and installed by the CONTRACTOR.

G. Fluorescent Orange Wide Angle Prismatic Retroreflective Sheeting. The sheeting shall consist of prismatic lenses formed in a transparent fluorescent orange synthetic resin, sealed, and backed with an aggressive pressure sensitive adhesive protected by a removable liner. The sheeting shall have a smooth surface with distinctive interlocking diamond seal pattern and orientation marks visible from the face.

MINIMUM COEFFICIENT OF RETROREFLECTION
(Candelas per foot-candle per square foot)
90º Rotation Angle

Observation Angle (Deg.)	Entrance Angle (Deg.)	Orange
0.2	-4	200
0.2	+30	120
0.2	+50	50
0.5	-4	80
0.5	+30	50
0.5	+50	20

Daytime color and maximum spectral radiance factor (peak reflectance) shall be determined in accordance with ASTM E991 using a Hunter Lab Labscan 6000 0/45.

COLOR SPECIFICATION LIMITS (DAYTIME)

									Reflectance Limit Y (%)	
Color	1		2		3		4			
	X	Y	X	Y	X	Y	X	Y	min	max.
Orange (new)	.583	.416	.523	.396	.560	.360	.631	.369	30	–
Orange (weathered)	.583	.416	.523	.396	.560	.360	.631	.369	20	–

Nighttime color shall be determined in accordance with ASTM E811 and calculated in the u,' v ' coordinate system in accordance with ASTM E308. Sheeting shall be measured at 0.33D observation and -4° entrance at 90° rotation.

COLOR SPECIFICATION LIMITS (NIGHTTIME)

Color	1		2		3		4	
	U'	V'	U'	V'	U'	V'	U'	V'
Orange (new) (weathered)	.583	.416	.523	.396	.560	.360	.631	.369

The sheeting impact resistance requirements shall be the same as in Subsection 1212-2 F.

The impact-resistant aluminum panel shall be the same as that required in Subsection 1212-2 F.

The field performance requirements shall be the same as specified in Subsection 1212-2 F., except that coefficient of refraction for the fluorescent sheeting can be no lower than 100.

1212-7 PIGMENTED PLASTIC FILM, PRESSURE-SENSITIVE ADHESIVE

A. Description. This material shall be flexible, pigmented plastic film completely precoated with a pressure-sensitive adhesive. The adhesive shall be protected by a treated paper liner which shall be removable without soaking in water or other solvents. The material shall be available in colors listed in Subsection 1212-3 B.7.

B. Material Requirements. Material requirements shall be as follows:

1. Thickness. The thickness of the plastic film with adhesives shall be a minimum of 0.003 inch and a maximum of 0.0045 inch.

2. Film. The unapplied and applied film shall be readily processed and shall ensure adequate adhesion with process or printed inks recommended by the manufacturer.

3. Flexibility. The material shall be sufficiently flexible to permit application over and conformance to moderately-contoured surfaces.

4. Gloss. The film shall have a minimum initial 60-degree gloss value of 35 when tested according to ASTM D523, measuring at least 3 portions of the film to obtain uniformity.

5. Adhesive. The precoated adhesive shall form a durable bond to smooth, clean, corrosion-resistant, and weather-resistant surface; shall be of uniform thickness; shall be non-corrosive to applied surfaces; and shall have no staining effect on the film. The adhesive shall adhere securely at temperatures of -30°F to +200°F; shall not crack, chip, or peel voluntarily; nor shall it be removed from the panel in one piece without the aid of a tool.

6. Sunlight Resistance. There shall be no effect on the adhesive tack or performance following exposure of the adhesive face under a new General Electric RS Sunlamp for a period of 6 hours at a distance of 8 inches.

7. Exterior Exposure. The unprocessed material shall withstand the years of exposure, listed below by color, in a vertical, south facing exterior exposure in Texas. During the exposure, the unprocessed material shall show no appreciable discoloration, cracking, crazing, blistering, delamination, or loss of adhesion. A slight amount of chalking is permissible. The CONTRACTOR shall furnish a written assurance from the manufacturer that the sheeting will meet the requirements of the following table and be effective for its intended purpose when viewed from a vehicle, throughout the satisfactory performance life:

Color	Satisfactory Performance Life
White	7 years
Black	7 years
Yellow	5 years
Aluminum	5 years
Insignia Blue	5 years
Transparent	5 years
Red	3 years
Gold	3 years

The CONTRACTOR shall secure from the manufacturer all warranties and guarantees with respect to materials, parts, workmanship, or performance which the products covered by the proposal bear, and include these warranties and guarantees with the certification.

8. **Fungus Growth.** The film shall not support fungus growth.

9. **Plastic Lettering.** Plastic lettering film as furnished in rolls, sheets, or letters shall be free from ragged edges, cracks, blisters, streaks, foreign matter, or other surface imperfections which would make it unsuitable for usage. The plastic lettering film shall be capable of being readily cut with scissors, knives, blades, or shears without cracking, crazing, checking, or flaking.

1212-8 LETTERS, NUMERALS, SYMBOLS, AND BORDERS FOR PANEL SIGNS

A. General. All letters, numerals, symbols, and borders shall meet the requirements shown in the contract and the MUTCD.

All letters, numerals, symbols, and borders shall have a regular outline and be clean-cut and sharp. All letters, numerals, and symbols shall have a continuous stroke and border. In special cases, symbols may have a broken stroke and border, provided they do not exceed more than 2 increments and that they are necessary for manufacturer's fabrication.

Blind rivets used for mounting shall conform to the Plans and shall extend past the back of the sign backing for a minimum distance of 1/8 inch. They shall be made of non-rust material.

B. Demountable Reflectorized Cutout Letters, Numerals, Symbols, and Borders. Demountable reflectorized cutout type letters, numerals, symbols, and borders shall consist of adhesive-coated reflective sheeting permanently adhered to a flat sheet aluminum backing. Type III and IV reflective sheeting meeting Subsection 1212-2 shall be used.

The reflective sheeting shall be applied to the properly prepared aluminum with the equipment and in the manner prescribed by the sheeting manufacturer.

Letters, numerals, symbols, and border backing shall be aluminum alloy meeting ASTM B209, Alloy 6061-T6 or 5052-H38 with mill finish and of the thickness shown on the Plans. Aluminum backing shall be properly degreased and etched as specified in Subsection 1212-1 B.

Mounting holes shall be uniformly spaced around the letters or characters and shall have the edge clearance shown in the contract. The spacing shall be determined by the character size and shape. Mounting holes shall be spaced no more than 8 inches on centers, except for characters of 8 inches high or less. For characters 8 inches high or less, the maximum spacing of mounting holes shall be 4 inches. Mounting holes shall be drilled by the manufacturer.

Each letter, numeral, symbol, and border shall be offset, unless otherwise specified, as shown on the Plans with aluminum shim spacers meeting ASTM B221, Alloy 2024. Finish of the letters, numerals, symbols, and borders shall be done with material and in the manner specified by the manufacturer of the reflective sheeting.

C. Demountable Cutout Letters, Symbols, Numerals, and Borders Using Acrylic Plastic Reflectors. Demountable cutout letters, symbols, numerals, and borders shall consist of acrylic plastic prismatic reflectors supported by embossed aluminum frames.

1. Acrylic Plastic Reflectors. The reflectors shall meet the following:

a. Material. The material shall be an acrylic plastic made from methyl methacrylate. The reflector shall have a clean, transparent face (lens). The back shall be opaque and shall be made of identical material to the lens. It shall be fused to the lens around the entire perimeter to form a permanent seal against dust, water, and water vapor.

The lens shall have a smooth front surface free of indentation or projection other than identification. The rear surface of the lens shall have a prismatic configuration to effect a total internal reflection of light. The lens shall be colorless.

b. Optical Requirements. The optical requirements shall be tested as specified in Subsection 1212-6 B.2.c. with the following minimum values:

Observation Angle Degrees	Entrance Angle Degrees	Specific Brightness Candelas/Ft. Candle/Sq. Ft.
0.2°	0°	3.0
0.2°	20°	1.2

c. Durability. The reflectors shall conform to Subsection 1212-6 B.2.d.

d. Corrosion. The assembled cutout letter, symbol, or accessory shall withstand the combined corrosion test of ASTM B117.

2. Embossed Aluminum Frames. All letters, numerals, and symbols shall be fabricated from aluminum alloy meeting ASTM B209, Alloy 3003 sheet aluminum. Border strips shall be fabricated from aluminum alloy meeting ASTM B211, Alloy 6061-T6 sheet aluminum of the thickness shown on the Plans. Fabrication requirements are as follows:

Mounting holes shall be provided within frames to permit the use of non-rust screw, rivets, or other common non-rust fasteners.

The size and spacing of reflector holes shall afford maximum night legibility and visibility to the finished cutout figures.

After metal fabrication has been completed, the finish process shall be as follows:

Aluminum frames shall be degreased, etched, and given an alkaline chrome surface treatment and then rinsed and dried before prefiring.

The pre-prepared frames shall be sprayed with enamel slip consisting of a finely ground water-suspended glass frit, pigment, suspension agent, and opacifiers. Firing temperatures range from 930°F to 1,010°F depending on frit formulation, alloy, etc. Oven temperature shall be controlled ±1°F. Temperatures for baking on enamel shall be as specified by the manufacturer of the enamel slip.

D. Direct Applied Type III A and III B Reflective Sheeting Letters, Numerals, Symbols, and Borders.

1. General. The letters, numerals, symbols, and border shall consist of adhesive-coated, pressure-sensitive reflective sheeting meeting Subsection 1212-2. The material used for fabrication of letters, numerals, symbols, borders, and route markers shall be sampled and tested as specified for other reflective materials.

2. Fabrication. Letters, numerals, symbols, and borders shall be cut from reflective sheeting and shall have smooth regular outline, free from ragged or torn edges. Letters, numerals, and symbols having interior or exterior corners shall have these corners cut with a smooth 3/16 inch ±1/16 inch radius. Border corners and strips shall have no corner radius. Route markers used in conjunction with direct-applied letter shall be applied to 0.040 aluminum backing and shall be attached with blind rivets or other common non-rust fasteners. Fasteners shall be placed a maximum of 6 inches on center around the perimeter of the shield. The reflective sheeting shall be of the same type

specified for the letters. All sheeting, numerals, symbols, and borders shall show careful workmanship and shall be of regular outline.

1212-9 POSTS AND HARDWARE FOR SIGNS

A. Hardware for Signs.

1. **General.** All aluminum bolts, nuts, U-bolts, lock washers, and washers shall be given at least a 0.002-inch anodic coating and chromate seal. All steel bolts, nuts, U-bolts, lock washers, and washers shall be galvanized steel meeting ASTM A153.

   Use of substitute alloys in lieu of the alloy specified for various items of "Hardware for Signs" may be approved by the ENGINEER upon submission of documented evidence that the proposed substitute alloy has applicable qualities equal to or superior to the designated alloy.

2. **Bolts.** Aluminum panel bolts, etc., shall be fabricated of aluminum alloy meeting ASTM B211, Alloy 2024-T4 or 6061-T6.

   Steel panel bolts, machine bolts, etc., shall meet ASTM A307.

3. **Nuts.** Aluminum nuts, hex nuts, vandal-resistant nuts shall be fabricated of aluminum alloy meeting ASTM B211, Alloy 6061-T6.

   Steel hex nuts shall meet ASTM A307.

   In lieu of using torque wrenches to obtain the required torques for fuse joints and slip base used in the breakaway system, the Torque Control Nut System may be used. This system shall provide automatic torque control, consistently-controlled preload, vibration resistance, high strength, easy installation, simple inspection, and resistance to weather effects.

   The torque control nut shall be designed to mate with standard high-strength bolts meeting ASTM A325. The minimum stripping strength of the threads shall be equal to or shall exceed the strength level of the mating bolts.

   The self-locking quality of resistance to loosening shall meet the tests in Federal Specification MIL-N-25027 and shall be installed according to the manufacturer's recommendations.

4. **Washers.** Aluminum lock washers shall be fabricated of aluminum alloy meeting ASTM B209, Alloy 7075-T6.

   Aluminum flat washers shall be fabricated of aluminum alloy meeting ASTM B209, Alloy 2024-T4.

Steel lock washers shall be fabricated of steel meeting ANSI B27.1.

Steel flat washers shall be fabricated of steel meeting ASTM A307.

Plastic washers shall be fabricated to the sheeting manufacturer's specifications.

5. **Stringers.** Aluminum stringers shall be fabricated to Plan dimensions and made of aluminum alloy meeting ASTM B221, Alloy 6061-T6 or ASTM B308, Alloy 6061-T6.

   Steel stringers shall be fabricated to Plan dimensions and made of steel meeting ASTM A36.

6. **Aluminum Alloy Castings.** Brackets, post caps, and fuse plates may be either permanent mold castings or sand castings.

   Aluminum alloy permanent mold castings shall meet ASTM B108, Alloy SG70A-F or SG80A-T6.

   Aluminum alloy sand castings shall meet ASTM B26, Alloy SG70A-F or SG70A-T6.

7. **Steel Castings.** Brackets, post caps, and fuse plates shall meet AASHTO M103, Grade 65-35.

8. **U-Bolts.** Aluminum U-bolts shall be fabricated of aluminum alloy meeting ASTM B211, Alloy 2017-T4.

   Steel U-bolts shall be fabricated of steel meeting ASTM A307.

9. **Anchor Bolts.** Anchor bolts, anchor studs, nuts, and washers shall be fabricated of steel meeting ASTM A307.

   All nuts, washers, and anchor studs shall be galvanized steel meeting ASTM A153.

   The hex bar shall be tapped with U.S. Steel. Standard right thread, both ends, and made of steel meeting ASTM A307.

10. **Attachment Clip and Plate.** Attachment clip and plate for attachment of steel panels shall be fabricated as shown in the Contract, and made of steel meeting ASTM A283 and galvanized in conformance to ASTM A153.

11. **Fuse Joint Bolts.** Aluminum fuse plate bolts and washers shall be fabricated from aluminum meeting ASTM B211, Alloy 2024-T4.

Steel fuse plate bolts and washers shall be fabricated from steel meeting ASTM A325, and nuts shall be of the capacity to develop the bolt strength. Bolts, nuts, and washers shall be galvanized according to ASTM A153.

12. **Breakaway Base Bolts.** All breakaway base bolts shall have bolts and washers fabricated from steel meeting ASTM A325, and nuts shall be of the capacity to develop the bolt strength. Bolts, nuts, and washers shall be galvanized according to ASTM A153.

B. Posts.

1. **General.** Tubular post size, length, and weight shall be as shown in the Contract for each type of sign.

   Welding on aluminum shall be done according to Section 5 and welding on galvanized steel shall be done according to Section 4 of the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

   All markings on posts, signs, casting, etc., shall be removed after erection.

2. **Aluminum Tubular Posts and Accessories.**

Material	**Specification**
Drawn Seamless Tubes and Extruded Round or Square Tubes	ASTM B210, Alloy 6061-T6 or ASTM B241, Alloy 6061-T6
Extruded Structural Shapes	ASTM B221, alloy 6061-T6
Breakaway Bases	ASTM B209, Alloy 6061-T6
Fuse Plates	ASTM B209. Alloy 6061-T6
Fuse Plate Bolts and Washers	ASTM B211, Alloy 2024-T6

3. **Steel (Galvanized) Posts and Accessories.**

Material	**Specification**
Standard Steel Pipe	AASHTO M111, M183, and M232
Breakaway Bases	AASHTO M183 and M232
Fuse Plates	AASHTO M183 and M232

4. Square Steel Telescoping Tubular Posts. Tubing shall be of the size and shape shown in the Contract and shall meet the following requirements:

a. Material. Steel posts shall conform to the standard specifications for a Grade 55 hot rolled carbon sheet steel, structural quality, ASTM designation A570.

b. Shape. The cross section of the post shall be square tube formed of 12-gauge (.105 U.S. Steel. gauge) and 10-gauge (.135 U.S.S. gauge) steel, carefully rolled to size and shall be welded directly in the corner by high frequency resistance welding and externally scarfed to agree with corner radii.

c. Finish. Signposts shall be manufactured from hot-dipped galvanized steel conforming to ASTM specification A653, designation G90. The corner weld shall be zinc coated after scarfing operation. The steel shall be coated with a chromate conversion coating and a clear organic polymer topcoat. Both the interior and the exterior of the post shall be galvanized.

d. Cross Section. Perforated sign posts shall be one or more of the following sizes:

Size	U.S.S. Gauge	Weight (lbs./foot)
1½" x 1 1/2"	12	1.70
2" x 2"	12	2.42
2¼" x 2¼"	12	2.77
2½" x 2½"	12	3.14
2 3/16" x 2 3/16"	10	3.43
2½“ x 2½"	10	4.01

e. Holes. Holes shall be 7/16 ±1/64 inches in diameter on 1-inch centers on all four sides down the entire length of the post. The holes shall be on centerline of each side in true alignment and opposite each other directly and diagonally.

f. Length. The length of each post shall have a permissible length tolerance of ±1/4 inch.

g. Telescoping Properties. The finished posts shall be straight and have a smooth, uniform finish. It shall be possible to telescope all consecutive sizes of square tubes freely and for not less than ten feet of their length without the necessity of matching any particular face to any other face. All holes and ends shall be free from burrs and ends shall be cut square.

h. Tolerances.

(1) Tolerances on outside sizes:

Nominal Outside Dimensions	Outside Tolerances at All Sides at Corners
1½" x 1½"	±.006"
2" x 2"	±.008"
2¼" x 2¼"	±.010"
2½" x 2½"	±.010"
2 3/16" x 2 3/16"	±.010"

Note: Measurements from outside dimensions shall be made at least 2 inches from the end of the tube.

(2) Wall Thickness Tolerances. Permissible variation in wall thickness is +.011 ” - .008.”

(3) Convexity and Concavity. Measured in the center of the flat sides, tolerance in ±.010,” determined at the corner.

(4) Squareness of Sides and Twist.

Nominal Outside Dimensions	Squareness Tolerance	Twist Permissible in 3' Length
1½" x 1½"	±.009"	.050"
2" x 2"	±.012"	.062"
2¼" x 2¼"	±.014"	.062"
2½" x 2½"	±.015"	.075"
2 3/16" x 2 3/16"	±.014"	.062"

Note: A sample shall be considered to fail if its sides are not 90° to each other within the squareness tolerance listed above.

(5) Straight Tolerance. Permissible variation in straightness is 1/6 of an inch in 3 feet.

(6) Corner Radii. Standard outside corner radius shall be 5/32 of an inch ±1/64 inch.

i. Installation. The square end of the post shall not be modified or pointed, but shall be capable of being driven into the ground with the use of an approved driving cap.

j. Slip Base Assembly. The design and the construction of the slip base assembly shall be as shown on the Plans. The assembly shall be as manufactured by Unistrut Corporation or equal. The manufacturer shall certify that the chemistry, geometry, and mechanical properties are the

same as those used in the tests and that the assembly will meet FHWA change-in-volocity requirements.

5. **Flange Channel and Accessories.** Flange channel shall be of the size and shape specified and shall meet the following requirements:

   a. **Anchor Plates.** The flange channel and anchor plates shall be rolled from High Strength, Hot-Rolled Steel conforming to ASTM A499, Grade 60, 60,000 psi minimum yield strength and 90,000 psi minimum ultimate strength.

   b. **Safety Retainer-Spacer Strap.** The straps shall be of the size and shape specified and shall be fabricated from steel meeting AISI 1020.

   c. **Nuts and Bolts.** The bolts shall be the size specified and shall be fabricated from steel meeting ASTM A354, Grade BD, case hardened. The nuts shall meet AASHTO M291, Grade DH, and lockwashers shall be heavy-duty external type. Nuts and bolts shall be cadmium plated ASTM A165, Type 05, except when using clear chromate.

   d. **Fabrication.** The finished post shall be machine straightened and have a uniform finish, free from defects affecting its strength, durability, or appearance. All holes and sheared ends shall be commercially free from burrs.

   Sign posts and stringers shall be punched on the center line with 7/16-inch diameter holes on 1-inch centers for the entire length.

   Base posts shall be punched on centerline with a minimum of twelve 7/16-inch diameter holes on 1-inch centers. The first hole shall be 1 inch from the top. The bottom of the post shall be pointed for easy installation.

   The sign post, base posts, retainer-spacer, and anchor plates shall be galvanized according to AASHTO M232.

6. **Structural Steel Posts.** Structural steel posts shall be fabricated from material conforming to Section 834.01A and shall be galvanized according to Section 854 after fabrication.

1212-10 DELINEATORS

A. Posts. Steel posts shall meet ASTM A702.

Steel posts shall be galvanized according to AASHTO M111 or be aluminum posts fabricated from aluminum alloy meeting ASTM B308, Alloy 6061-T6. Posts shall have holes at 1-inch spacing the entire length of the post.

B. Reflectors.

1. Reflective Sheeting. Type III reflective sheeting for delineators shall be white or yellow adhesive coated, permanently adhered to aluminum or galvanized steel.

The reflective sheeting shall meet Subsection 1212-2. Backing material shall meet Subsection 1212-1.

The finished reflector shall show careful workmanship; be free of burrs, scratches, or damaged reflective sheeting; and have essentially a flat surface.

2. Acrylic Plastic.

a. Metal Parts. The housing shall be .020-inch ASTM B209 3003-H14 or 5052-0 sheet aluminum formed to approximately 3 1/4 inches in diameter and .235 inch in depth to retain the acrylic reflector. The housing shall be provided with 4 embossed circular reinforcement ribs and marked with the manufacturer's name and part number.

An aluminum grommet with a 3/16-inch inside diameter shall be expanded within the reflector mounting hole.

b. Acrylic Plastic. The reflector shall be an acrylic plastic manufactured from methyl methacrylate. The reflector shall consist of a clear and transparent plastic face, with a minimum of 7 square inches of reflective area, referred to as the lens. It shall have a heat sealable plastic coated metallic foil back fused to the lens under heat and pressure around the entire perimeter of the lens and the central mounting hole to form a unit permanently sealed against dust, water, and water vapor. The reflector shall be colorless, yellow, or red.

The lens shall consist of a smooth front surface free from projection or indentation other than the central mounting hole and identification with a rear surface bearing a prismatic configuration such that it will provide total internal reflection of light.

c. Optical Requirements. The optical requirements shall be as follows:

Color	**Candelas per Foot-Candle per Square Foot Divergence Angle, -01 Degrees Entrance Angle, Deg.**	
	0	20
Crystal or Silver	119	47
Yellow	71	28
Red	29	11

The reflex reflector to be tested shall be located 100 feet from a single light source having an effective diameter of 2 inches; the light source shall be operated at approximately normal efficiency. The return light from the reflector shall be measured by a photoelectric photometer having a minimum sensitivity of 1×10^{-7} foot candles per mm scale division. The photometer shall have a receiver aperture of 0.5 inch diameter, shielded to eliminate stray light. The distance from light source center to aperture center shall be 2.1 inches for 0.1 degree observation angle. During testing, the reflector shall be spun to average the orientation effect. If a test distance other than 100 feet is used, the source and aperture dimensions and the distance between source and aperture shall be modified in the same proportion as the test distance.

Failure to meet the specific intensity minimum shall constitute failure of the reflector being tested; failure of more than 2 reflectors out of 50 subjected to test shall constitute failure of the lot.

d. Durability. The durability tests shall be as follows:

(1) Seal Test. The following test shall be used to determine if a reflector is adequately sealed against dust and water.

Submerge 50 samples in a water bath at room temperature. Subject the submerged samples to a vacuum of 5 inches for 5 minutes, then examine them for water intake. Failure of more than 2 percent of the number tested shall be cause for rejection.

(2) Heat Resistance Test. Three reflectors shall be tested for 4 hours in a circulating air oven at 175° ± 5°F. The test specimens shall be placed in a horizontal position on a grid or perforated shelf permitting free air circulation. At the conclusion of the test, the samples shall be removed from the oven and permitted to cool in air to room temperature. The samples, after exposure to heat, shall show no significant change in shape and general appearance when compared with unexposed control standards. No failures will be permitted.

C. Fasteners. Aluminum tension pin fasteners shall be an aluminum alloy meeting ASTM B211 Alloy 2024-T4 or 6061-T6. The collar shall be aluminum alloy 509.1212-6 C meeting ASTM B211 Alloy 6061-T67 or 6061-T6. The fasteners shall conform to the Contract.

Steel tension pin fasteners shall be a medium carbon steel with a minimum shear strength of 70,000 psi and a minimum tensile strength of 67,500 psi. They shall be galvanized according to AASHTO M232 conforming to the Contract.

1212-11 SAMPLING AND TESTING

A. Base Metal. The CONTRACTOR shall furnish to the inspector a certification as specified in Subsection 801-1.

B. Solutions for Cleaning and Etching. The solutions used for cleaning and etching shall not vary more than 10percent from the manufacturer's recommendation. In addition, all treatment tanks shall be charged with fresh chemicals at least once a year. Titration equipment shall be available for the inspector 's use to check the solution strengths.

C. Inspection. All material and finished signs are subject to inspection at the place of manufacture and shall be subject to final inspection at the time of erection. Test panels, 12 inches by 12 inches representative of any stage of production, shall be furnished upon the inspector's request. These panels shall be processed with the regular production run and witnessed by the inspector. All surfaces exposed to weathering shall be free of any defects that may impair the serviceability or detract from the general appearance or color matching of the sign. Signs with any defects or damage that would affect their appearance or serviceability will not be accepted. No repairs shall be made to the face sheet without the approval of the inspector. Signs not conforming in all respects to the requirements will be rejected.

D. Reflective Sheeting. The reflective sheeting shall be certified by the manufacturer that the minimum brightness values previously listed for each color, have been met. The color of each type shall be checked by the inspector using the standard color charts as specified.

1. **Reflective Sheeting Flexibility.** The CONTRACTOR shall furnish test specimens for each color of reflective sheeting according to AASHTO M268. Type III and Type IV reflective sheeting shall be applied to a plate as specified in AASHTO M268 and shall be furnished for each color. These test specimens shall be processed with the regular production run and witnessed by the inspector.

2. **Inspection.** The reflective sheeting packages shall be inspected before installation on sign backings. The CONTRACTOR shall provide access by the inspector and shall indicate the roll packages or flat packages to be used on a particular Project. The inspector will mark the roll of flat material and note the manufacturer's date. All material used on that Project shall be used within one year of this date. If this date is past on the date of inspection, the roll shall be rejected.

E. Torque Control Nuts. The CONTRACTOR shall furnish to the inspector a certification if torque control nuts are chosen for use.