3. Accessories

   Ensure that the accessories for fabricating the signs meet the following:

   a. Bolts: Use bolts for connecting the panels that are 3/8 in (M10x1.5), tolerance grade 16 UNC 2A thread (6G threads), and 3/4 in (19 mm) long. Use bolts that meet the requirements of ASTM F 468 (F 468M), Alloy 2024-T4.

   b. Hex Nuts: Use hex nuts with tolerance grade 4 threads that meet the requirements of ASTM F 467 (F 467M), Alloy 6061-T6.

   c. Washers: Use washers that meet the requirements of ASTM B 209 (B 209M), Alloy 2024-T4.

   d. Posts Clips: Use clips as shown on the Plans and that meet the requirements of ASTM B 108, Alloy 356-T6.

   e. Post Clip Bolts: Use bolts that are 3/8 in (M10x1.5), tolerance grade 16 UNC 2A thread (6G threads), and 1-3/4 in (44 mm) long, and meet the requirements of ASTM F 468 (F 468M), Alloy 2024-T4.

   f. Post Clip Nuts: Use hex locknuts that meet the requirements of ASTM B 211(B 211M), Alloy 2017-T4.

   g. Post Clip Washers: Use washers that meet the requirements of ASTM B 209 (B 209M), Alloy 2024-T4.

4. Tolerances

   Ensure that the sections are within the established commercial tolerances of the aluminum industry.

   a. Ensure that all panels 6 in (150 mm) wide have a nominal weight of 1.115 lb/ft (1.7 kg/m). Use these sections only at the top of signs that do not conform to 1 ft (300 mm) modules.

   b. Ensure that all panels 1 ft (300 mm) wide have a nominal weight of 2.707 lb/ft (4.0 kg/m). Use these sections as the normal sign panel.

   c. Before supplying an alternate extruded panel section of equal or greater section moduli with dimensions suitable to use hardware, as shown on the Plans, obtain written approval from the Engineer.

5. Submit to the Engineer at least 1 ft² (0.1 m²) of the sign material for each lot or shipment of each type.

B. Fabrication

1. Make the extruded panel signs as shown on the Plans.
2. Finish the extruded panels as specified in Subsection 912.2.01.B.4.

C. Acceptance

The Department will accept these sign panels based on results of chemical and physical tests of materials, approval of methods and procedures for metal treatment, and the quality of workmanship on the finished panel.

D. Materials Warranty

General Provisions 101 through 150.

Section 913—Reflectorizing Materials

913.1 General Description

This section includes the requirements for reflective sheeting.

913.1.01 Related References

A. Standard Specifications

General Provisions 101 through 150.

B. Referenced Documents

AASHTO M 268

ASTM G 7

ASTM D 523

ASTM E 810

ASTM D 4956

QPL 29

913.2 Materials

913.2.01 Type I, II, III, and IV Reflective Sheeting

A. Requirements

1. Use reflective sheeting that meets the requirements of AASHTO M 268.
2. Use reflective sheeting as listed in QPL 29.
3. Use reflective sheeting that has been evaluated (3 year field exposure) by the National Transportation Product Evaluation Panel (NTPEP) test facility or other approved test facility.
4. Use Silver-White, Type III or Type IV reflective applied copy for Type I reflective sheeting signs including letters, numerals, symbols, borders, and specified route markers.
5. Submit the following to the Department:
   a. A certificate with each lot or shipment stating the following:
      - The material supplied will meet all the test requirements listed herein.
      - You have performed the specified tests to ensure compliance.
      - You will submit test results upon request.
6. Definitions
   a. Reflective Sheeting Types:
      Type I: Medium-intensity retroreflective sheeting (engineering grade) that is typically an enclosed lens glass-bead retroreflective material.
      Type II: Medium-high-intensity retroreflective sheeting (super engineering grade), that is typically enclosed lens glass-bead retroreflective material.
      Type III: High-intensity retroreflective sheeting that is typically an encapsulated glass-bead retroreflective material.
      Type IV: High-intensity retroreflective sheeting that is typically an unmetallized microprismatic retroreflective element material.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

1. The Engineer will reject reflective sheeting in the following situations:
   a. The material fails to meet any one of the designated requirements.
   b. The material meets the requirements but later fails during sign fabrication or in actual field use. Cracks, wrinkles, delamination, color change, or abnormal loss of reflectivity constitute failure.
   c. Natural causes deteriorate the material to the extent that:
      1) The sign is ineffective for its intended purpose as defined in Subsection 913.2.01.C.1.b above.
      2) The average nighttime reflective brightness does not meet the outdoor weathering requirements of AASTHO M 268.

D. Materials Warranty

Transfer to the Department a performance warranty for Type I, II, III, or IV reflective sheeting issued by the manufacturer.

Ensure that the warranties cover the full replacement cost, including material and labor.

Include in these warranties a provision that the warranty is subject to a transfer to the Department.

Submit a warranty from the manufacturer that states that the reflective sheeting—processed, applied to sign blank materials, and cleaned—meets the outdoor weathering photometric requirements of AASHTO M 268.

913.2.02 Type V and VI Reflective Sheeting

A. Requirements

Use wide-angle prismatic reflective sheeting—Type V or Type VI that has a smooth surface and a distinctive interlocking diamond seal pattern and orientation marks visible from the face. Ensure that the sheeting is precoated with a pressure-sensitive adhesive backing protected by a removable liner.

1. Reflective Intensity

The wide-angle reflective sheeting shall have minimum reflective intensity values as shown in Table 1, Type V or Table 2, Type VI expressed as candlepower/foot per candle/square foot (candela/lux/m^2) of material. Determine the reflective intensity according to ASTM E 810.

TABLE 1

MINIMUM REFLECTIVE INTENSITY VALUES - TYPE V

Observation Angle°	Entrance Angle°	White	Yellow	Red	Blue	Green	Fluorescent Orange
0.1	-4	850	680	235	45	90	--
0.1	+30	625	500	155	32	65	--
0.1	+45	300	250	75	15	30	--
0.2	-4	800	660	215	43	80	200
0.2	+30	425	370	105	20	35	120
0.2	+45	165	130	40	9	15	--
0.2	+50	--	--	--	--	--	50
0.5	-4	235	190	58	10	21	80
0.5	+30	110	92	28	5.2	10	50
0.5	+45	75	65	18	3	7	--
0.5	+50	--	--	--	--	--	20
1.0	-4	12	10	3.0	0.5	1.0	--
1.0	+30	10	8	2.4	0.4	0.8	--
1.0	+45	10	8	2.4	0.4	0.8	--

TABLE 2

MINIMUM REFLECTIVE INTENSITY VALUES – TYPE VI

Observation Angle°	Entrance Angle°	White	Yellow	Red	Green	Blue	Yellow-Green
0.1	-4	625	565	165	80	42	--
0.1	+30	430	315	110	45	22	--
0.1	+45	120	90	24	12.5	6	--
0.2	-4	370	300	98	45	22	275
0.2	+30	225	180	65	28	14	180
0.2	+45	90	70	26	9.8	4.5	125*
0.5	-4	275	220	70	32	17	250
0.5	+30	125	100	32	16	8	70
0.5	+45	35	27	10	3.5	1.5	40*
1.0	-4	75	58	20	9	4.5	50
1.0	+30	42	35	11	6	3	25
1.0	+45	10	8.8	3	1.6	0.8	12*

For colored, transparent overlay films and for screen printed transparent color areas on white sheeting, the ratios of the intensity for the white to the intensity for the color, when measured at 0.2º observation, -4º entrance, and 0º rotation, shall be 5:1 to 15:1 for red, and not less than 5:1 for blue or for green when processed in accordance with sheeting manufacturer's recommendations.

2. Color

The colors specified shall be matched visually and be within the color tolerance limits shown on the appropriate Highway Color Tolerance Charts issued by the Federal Highway Administration utilizing the instructions thereon. The purchaser may accept certification by the manufacturer as to conform with this requirement. Or through instrumental color testing the diffuse day color of the sheeting material shall conform to the requirements of Table 3. The test instrument shall be one of the following or approved equal:

- **Gardner** Multipurpose Reflectometer
- **Gardner** Model AC-2a Color Difference Meter
- **MEECO** Model V Colormaster
- **Hunterlab** D 25 Color Difference Meter

If the results of instrumental testing are disputed, the visual test is the referee method and shall prevail.

TABLE 3

COLOR SPECIFICATION LIMITS* (DAYTIME)

									Reflectance Limit	
Color	**1**		**2**		**3**		**4**		**Y (%)**	
	x	**y**	**x**	**y**	**x**	**y**	**x**	**y**	**min.**	**max.**
White	0.305	0.305	0.355	0.355	0.335	0.375	0.285	0.325	40	---
Yellow	0.487	0.423	0.545	0.454	0.465	0.534	0.427	0.483	24	45
Red	0.690	0.310	0.595	0.315	0.569	0.341	0.655	0.345	3	15
Blue	0.078	0.171	0.150	0.220	0.210	0.160	0.137	0.038	1	10
Green	0.030	0.398	0.166	0.364	0.286	0.446	0.201	0.794	3	9
Yellow-Green	0.387	0.610	0.460	0.540	0.421	0.486	0.368	0.539	60	---
Fluorescent Orange	0.583	0.416	0.523	0.397	0.560	0.360	0.631	0.369	30	---

* The four pairs of chromacity coordinates determine the acceptable color in terms of the CIE 1931 standard colorimetric system measured with standard illuminant D_{65}.

3. Specular Gloss

The retroreflective sheeting shall have an 85º specular gloss of not less than 40 when tested in accordance with ASTM D 523.

4. Color Processing

Use retroreflective sheeting designed to work in concert with recommended imaging systems. The retroreflective sheeting shall permit cutting and color processing with compatible transparent and opaque process colors according to the sheeting manufacturer's recommendations at temperatures of 60 ºF to 100 ºF (16 ºC to 38 ºC) and relative humidity of 20% to 80%. Ensure that the sheeting is heat resistant and will permit force curing without staining of applied or unapplied sheeting at temperatures recommended by the sheeting manufacturer.

5. Shrinkage

Ensure the retroreflective sheeting complies with the shrinkage requirements contained in ASTM D 4956 section 7.6.

6. Flexibility

The reflective sheeting with the liner removed and conditioned as in ASTM D 4956 section 8.1 & 8.2 shall be sufficiently flexible to show no cracking when slowly bent, in one second's time around a 1/8 inch (3.175 mm) mandrel with adhesive contacting the mandrel. Spread Talcum powder on the adhesive to prevent sticking to the mandrel.

7. Adhesive

   Ensure the reflective sheeting complies with the liner removal and adhesion requirements contained in ASTM D 4956 sections 7.8 and 7.9.

8. Impact Resistance

   The reflective sheeting, when applied according to the manufacturer's recommendations to a cleaned, etched aluminum panel of alloy 6061-T6, 0.040 inch x 3 inches x 5 inches (1.02 mm x 76 mm x 127 mm) and conditioned as in ASTM D 4956 sections 8.1 & 8.2, shall show no cracking when the face of the panel is subjected to an impact of a 2.0 inch (51 mm) diameter steel ball, 1.19 lbs. (0.54 kg), dropped from a height of 8.5 inches (216 mm) through a 2.125 inch (54 mm) tube.

9. Resistance to Accelerated Weathering

   The retroreflective surface of the sheeting shall be weather resistant and show no appreciable cracking, blistering, crazing or dimensional change after three years unprotected outdoor exposure conducted according to ASTM G 7 and inclined at 45^{o} from the horizontal facing the equator. After cleaning, the coefficient of retroreflection shall not be less than 70% of the values in Table 1 and II and shall show no appreciable evidence of cracking, scaling, pitting, blistering, edge lifting or curling or more than 1/32 inch (0.79 mm) shrinkage or expansion. Where more than one panel of a color is measured, the coefficient of retroreflection shall be the average of all the determinations. The reflective sheeting shall not be removable from the aluminum panels without damage.

10. Resistance to Heat, Cold and Humidity

    Expose three samples of retroreflective sheeting, 3 inch x 6 inch (76 mm x 152 mm), applied to test panels according to ASTM 4956 section 8.1 & 8.2 as follows:

    - Heat: Place one specimen in an oven at 160 ºF ± 5 ºF (71 ºC ± 3 ºC) for 24 hours, then condition for 2 hours
    - Cold: Expose one specimen to an air temperature of –70 ºF ± 5 ºF (-57 ºC ± 3 ºC) for 72 hours, then condition for 2 hours.
    - Humidity: Subject one specimen to 100% relative humidity at a temperature of 75 ºF – 78 ºF (24 ºC – 26 ºC) according to Federal Test Method Standard 141, method 6201, for 24 hours, then condition for 24 hours.

    Ensure through examination of each of the samples following exposures that there is no evidence of cracking, peeling, chipping or delaminating from the test panel. After heat exposure, ensure the sheeting retains a minimum of 85% and a maximum of 115% of the original coefficient of retroreflection when measured at room temperature at all specified angles.

11. Fungus Resistance

    Ensure the retroreflective sheeting complies with the supplementary requirements contained in section S1 of ASTM D 4956.

12. Intended Use

    The reflective sheeting specified herein is intended for use on surfaces of highway signs to assure their optimum visibility by day and at night when exposed to a light source and whether day or totally wet by rain.

13. Lettering Paint

    Use the sheeting manufacturer's recommendations for all paint or ink used on the sheeting for symbols, message, numerals, and borders.

14. Use reflective sheeting that has been evaluated (3 year field exposure) by the National Transportation Product Evaluation Panel (NTPEP) test facility or other approved test facility.

15. Use reflective sheeting as listed in QPL 29.

B. Fabrication

General Provisions 101 through 150.

C. Acceptance

1. The Engineer will reject reflective sheeting in the following situations:

   a. The material fails to meet any on of the designated requirements.

   b. The material meets the requirements but later fails during sign fabrication or in actual field use. Cracks, wrinkles, delamination, color change, or abnormal loss of reflectivity constitute failure.

c. Natural causes deteriorate the material to the extent that:

1) The sign is ineffective for its intended purpose as defined in Subsection 913.2.01.C.1.b above.

2) The average nighttime reflective brightness is less than 70% of the values specified in Table 1 or Table 2.

D. Materials Warranty

Transfer to the Department a performance warranty for Type V or Type VI reflective sheeting issued by the manufacturer.

Ensure that the warranties cover the full replacement cost, including material and labor.

Include in these warranties a provision that the warranty is subject to a transfer to the Department.

Submit a warranty from the manufacturer that states that the reflective sheeting—processed, applied to sign blank materials, and cleaned—shall maintain 70% of the values listed in Table 1 or Table 2 for 10 years.

Section 914—Sign Paint

914.1 General Description

This section includes the requirements for opaque silk screen lettering paint and transparent process colors intended for fabricating high quality, durable reflective signs and emblems by screen processing, spraying, roll coating, or hand brushing.

914.1.01 Related References

A. Standard Specifications

General Provisions 101 through 150.

B. Referenced Documents

ASTM G 23, Type D

ASTM D 822

914.2 Materials

914.2.01 Silk Screen Lettering Paint

A. Requirements

1. Process Colors

   Use process colors and toner that are weather resistant and designed for use on reflective sheeting.

   a. You may tone or blend process colors to make the desired color, but supply each color ready-mixed to a smooth, uniform texture.

   b. If painting on reflective sheeting, use only paint recommended by the sheeting manufacturer.

2. Submittals

   a. Submit a 1/2-pint (0.25L) sample of each color paint from each lot to be used.

   b. Submit to the Engineer a certificate from the fabricator stating that the paint used on the Project signs is recommended by the sheeting manufacturer and is of the same lot as the test sample.

3. Color and Transparency

   Ensure that the transparent colors have the following characteristics when processed, according to the manufacturer's instructions, through a 10XX screen onto silver-white reflective sheeting background:

   a. Produce a true color under both diffuse and reflected light.

   b. Match the color samples submitted by the Engineer.

   c. Allow good reflective brilliance of the processed sheeting.

4. Process Color and Toner

   Use process colors that flow out and dry to a tough, smooth, glossy surface free of defects, pattern, non-wet spots, and have a sharp edge (screen processed).