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live load design shall be provided for other locations.

SECTION 715 MISCELLANEOUS MATERIALS

715.1-CALCIUM CHLORIDE:

The material shall conform to the requirements of ASTM D 98.

715.2-SODIUM CHLORIDE:

The material shall conform to the requirements of ASTM D 632.

715.3 AND 715.4-BLANK

715.5-PACKAGED DRY, HYDRAULIC-CEMENT GROUT (NON-SHRINK):

The material shall conform to the requirements of ASTM C1107.

715.6-HYDRATED LIME:

The material shall conform to the requirements of ASTM C 6.

715.7-WATER FOR USE WITH HYDRAULIC CEMENT:

Water from sources other than treated public water systems shall conform to the requirements of MP 715.07.20.

715.8-WATERPROOFING FABRIC:

The material shall conform to the requirements of AASHTO M 117.

715.9-WARNING DEVICES:

715.9.1-General: Warning devices shall include, but not be limited to, signs, barricades, auxiliary barriers, channelizing devices, hazard warning lights, flares, and reflectors. Unless otherwise indicated such devices shall conform to the Standard, "Traffic Control for Street and Highway Construction and Maintenance Operations", published by the Division.

The Contractor shall exhibit evidence that the warning devices furnished meet the requirements detailed.

715.9.2-Signs: Sign blank material shall be either 0.50 in. (12 mm) thick interior grade plywood, 0.10 in. (2.5 mm) thick aluminum, or 16 gage (1.6 mm) galvanized steel (thickness or gages shown here are nominal).

Reflectorization shall be required and shall compare favorably with reflective type sheeting meeting the requirements prescribed.

All warning signs shall have an orange background with black legend.

715.9.2.1-Reflective Sheeting, Type I: The reflective sheeting shall

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consist of optical lens elements incorporated within a transparent weatherproof film having a smooth, flat outer surface.

715.9.2.1.1-Reflective Intensity: The reflective sheeting shall have a minimum reflective intensity values of 0.2° and 0.5°, divergence, as shown in Table 715.9.2.1.1-I, expressed as candlepower per foot candle per square foot (candles per lux per square meter) of material.

**TABLE 715.9.2.1.1-I
MINIMUM REFLECTIVE INTENSITY FOR
TYPE I SHEETING**

Divergence Angle (E)	Incidence Angle (E)	Silver White No. 1	Yellow	Red	Orange	Green	Blue	Brown	Silver White No. 2
0.2	-4	70	50	14.5	25	9	4.0	1	80
0.2	+30	30	22	6	7	3.5	1.7	0.3	35
0.5	-4	30	25	7.5	13.5	4.5	2	0.5	41
0.5	+30	15	13	3	4	2.2	0.8	0.20	21

Wet Performance-After accelerated weathering as specified under 715.9.2.1.3 Durability, the reflective intensity values of the sheeting material, when subjected to the rainfall test, shall not be reduced by more than 10 percent of the dry measured reflective intensity values of the weathered sample.

Copy-Reflective sheeting for all sign copy including letters, numerals, symbols, borders, and route markers shall be Silver White No. 2 which has been carefully selected by the manufacturer for day and night appearance.

Color-Through instrumental color testing the diffuse day color of the reflective material shall conform to the requirements of Table 715.9.2.1.1-II and shall be determined in accordance with ASTM E 97. Geometric characteristics shall be confined to illumination incident within 10deg. of, and centered about, a direction of 45 deg from the perpendicular to the test surface. Viewing shall be within 15 deg. of, and centered about, the perpendicular to the test surface. Conditions of illumination and observation shall not be interchanged. The standards to be used for reference shall be theMUNSELL PAPERS designated in Table 715.9.2.1.1-II. The papers shall be recently calibrated on a spectrophotometer.

**TABLE 715.9.2.1.1-II
COLOR SPECIFICATIONS LIMITS AND REFERENCE
STANDARDS FOR TYPE I SHEETING**

Chromaticity Coordinates *								Reflectance Limit			
1		2		3		4		y			
	x	y	x	y	x	y	X	y	Min	Max	Ref. Std. MUSELL PAPERS
Silver	.305	.295	.360	.360	.338	.377	.280	.310	34	--	6.3GY6.7 7/0.8
White											
Red	.602	.317	.664	.336	.644	.356	.575	.356	8	12	8.2R3.78 /14.0
Orange	.535	.375	.607	.393	.582	.417	.535	.399	18	30	2.5YR 5.5/14.0
Brown	.445	.353	.604	.396	.556	.443	.445	.386	4	9	5.0YR 3 /6
Yellow	.482	.450	.532	.465	.505	.494	.475	.485	29	45	1.25Y 6/12
Green	.130	.369	.180	.391	.155	.460	.107	.439	3.5	9	0.65BG 2.84/8.45
Blue	.147	.075	.176	.091	.176	.151	.106	.113	1.0	4	5.8PB 1/32/6.8

715.9.2.1.2-Adhesive: The reflective sheeting shall include a precoated pressure sensitive adhesive backing (Class 1) or a tack-free heat activated adhesive backing (Class 2) either of which may be applied without necessity of additional adhesive coats on either the reflective sheeting or application surface.

The protective liner attached to the adhesive shall be removed by peeling, without soaking in water or other solvents, without breaking, tearing or removing any adhesive from the backing. The protective liner shall be easily removed following accelerated storage for four hours at 160° F (71°C) under a weight of 2.5 psi (17 kPa).

The adhesive backing of the reflective sheeting shall produce a bond to support a 1: lb. (0.79 kg.) weight for five minutes, without the bond peeling for a distance of more than 2.0 in (50.8 mm.) when applied to a smooth aluminum surface.

715.9.2.1.3-Film:

General-The reflective sheeting shall have sufficient strength and flexibility so that it can be handled, processed, and applied according to the recommendations of the sheeting manufacturer without appreciable stretching,

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tearing, or other damage. The sheeting shall permit cutting and color processing with compatible transparent and opaque process inks at temperatures of 60° F to 100° F (15 to 38°C) and relative humidity at 20 to 80 percent. The sheeting shall be heat resistant and permit force curing without staining of applied or unapplied sheeting at temperatures as recommended by the manufacturer.

Shrinkage-Following liner removal, the reflective sheeting shall not shrink more than 1/32 in. (0.79 mm.) in 10 minutes nor more than 1/8 (3.18 mm.) in 24 hours in any dimension per nine inch (22.9 cm.) square at 72° F (22°C) and 50 percent relative humidity.

Flexibility-The sheeting, applied according to the manufacturer's recommendations to a clean and etched .020 in. by 2 in. by 8 in. (0.51 mm. by 50.8 mm. by 203 mm.) aluminum panel, conditioned a minimum of 48 hours and tested at 72° F (23°C) and 50 percent relative humidity, shall be sufficiently flexible to show no cracking when bent around a 3/4 in. (19.1 mm.) mandrel.

Specular Gloss-The reflective sheeting shall have an 85 deg specular gloss of not less than 40 when tested in accordance with ASTM D 523.

Impact Resistance-The reflective sheeting material, applied according to the manufacturer's recommendations to a cleaned, etched aluminum panel 3.0 in. by 5 in. (76.2mm by 127mm) and conditioned for 24 hours at 72° F (23° C) and 50 percent RH shall show no cracking when the face of the panel is subjected to an impact of a 2.0 lb. (0.9 kg.) weight with a 5/8 in. (15.9mm) rounded tip dropped from a 10 in.-lb. (1.13newton meter) setting on a variable impact tester.

Durability-Processed and applied in accordance with recommended procedures, the reflective material shall be weather resistant and following cleaning, shall show no appreciable discoloration, cracking, blistering or dimensional change and shall not have less than 50 percent of the specified minimum reflective intensity values listed in Table 715.9.2.1.1-I when subjected too accelerated weathering for 1,500 hours in accordance with ASTM G 23, Type E or EH Weatherometer and when subjected to outdoor weather conditions for a period of seven (7) years.

715.9.2.1.4-General Characteristics and Packaging: The reflective sheeting as supplied shall be of good appearance, free from ragged edges, cracks, and extraneous materials, and shall be furnished in both rolls and sheets. When reflective sheeting is furnished in continuous rolls, the average number of splices shall not be more than three per 50 yd of material with a maximum of four splices per 50 yd length and splices shall be suitable for continuous application as supplied.

Rolls shall be packed snugly in corrugated fiberboard boxes in such a manner that no damage or defacement may occur to the reflective sheeting during shipment or storage.

Cut sheets shall be packaged flat between pressed composition board or corrugated pads of the same dimension to prevent damage or defacement

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during shipment or storage.

Stored under normal conditions, the reflective sheeting shall be suitable for use for a period of at least one year.

715.9.2.2-Nonreflective Sheeting: The material shall consist of a flexible, pigmented plastic film, completely precoated with a pressure sensitive (Type I) or tack-free heat activated (Type II) adhesive. The adhesive shall be protected by a treated paper liner which shall be removable without soaking in water or other solvents.

715.9.2.2.1-Film: The material shall be sufficiently flexible to permit application over, and conform to, moderately contoured surfaces.

The unapplied or applied film, or both, shall be readily processed and shall insure adequate adhesion with process inks recommended by the manufacturer.

The film shall have an initial 60° gloss value of 35 (minimum) when tested in accordance with ASTM D 523, measuring at least three portions of the film to obtain uniformity.

The thickness of the plastic film with adhesive shall be a minimum of 0.003 in. (76 μm) and a maximum of 0.0045 inches (114 μm).

The material shall show not more than 1/64 in. (400 μm) shrinkage in any direction from the edge of the panel after being subjected to a temperature of 150° F (65° C) for 48 hours.

The material shall be heat resistant enough to retain adhesion after one week at 150° F (65° C).

715.9.2.2.2-Adhesive: When applied in accordance with the recommendations of the film manufacturer, the precoated adhesive shall form a durable bond to smooth, clean, corrosion-resistant and weather resistant surfaces, shall be of uniform thickness, shall be noncorrosive to applied surfaces and shall have no staining effect on the film.

The adhesive shall have proper bond, not to allow removal from the panel in one piece without the aid of a mechanical tool.

715.9.2.2.3-General Characteristics and Packaging: The material shall withstand one year's shelf life when stored in a clean area free from exposure to excessive heat, moisture, and direct sunlight.

The plastic film shall be furnished in rolls, cut sheets, or characters as may be specified. The film, as supplied, shall be free from ragged edges, streaks, blisters, foreign matter or other surface imperfections which would make it unsuitable for the intended usage, and shall be readily cut with scissors, knife, blade, shears or other production methods.

Rolls, sheets, or letters shall be individually packaged in suitable containers and in such a manner that no damage or defacement may occur to the plastic film during transport to destination.

715.9.2.2.4-Colors: Nonreflective sheeting shall be supplied in colors; red,

white, black, and yellow. The red and yellow colors shall be within the tolerance established by the Federal Highway Administration for highway signs.

715.9.2.3-Reflective Sheeting, Type II: The reflective sheeting shall consist of optical lens elements incorporated within a transparent, weatherproof film having a smooth outer surface. The sheeting shall have a precoated adhesive backing protected by a removable liner.

Test procedures will be in accordance with AASHTO T 257.

715.9.2.3.1-Reflective Intensity: The reflective sheeting shall have minimum reflective intensity values at 0.2° and 0.5°, divergence, as shown in Table 715.9.2.3.1-I, expressed as candlepower per square foot (candelas per lux per square meter) of material.

TABLE 715.9.2.3.1-I

**MINIMUM REFLECTIVE INTENSITY VALUES FOR TYPE II
AND IV SHEETING**

Diver- gence Angle(E)	Inci- dence Angle(E)	Silver-White	Yellow	Red			Orange
0.2	-4	250	170	45	100	45	20
0.2	+30	150	100	25	60	25	11
0.5	-4	95	62	15	30	15	7.5
0.5	+30	65	45	10	25	10	5

Wet Performance-After accelerated weathering as specified under 715.9.2.3.3 Durability, the reflective intensity values of the sheeting material, when subjected to the rainfall test, shall not be reduced by more than 10 percent of the dry measured reflective intensity values of the weathered sample.

Color-Through instrumental color testing the diffuse day color of the reflective material shall conform to the requirements of Table 715.9.2.3.1-II and shall be determined in accordance with ASTM E 97. Geometric characteristics shall be confined to illumination incident within 10deg of, and centered about, a direction of 45 deg from the perpendicular to the test surface. Viewing shall be within 15 deg of, and centered about, the perpendicular to the test surface. Conditions of illumination and observation shall not be interchanged. The standards to be used for reference shall be the MUNSSELL PAPERS designated in Table 715.9.2.3.1-II. The papers shall be recently calibrated on a spectrophotometer.

715.9.2.3.2-Adhesive: The reflective sheeting shall include a precoated pressure sensitive adhesive backing (Class 1) or a tack-free heat activated adhesive backing (Class 2) either of which may be applied without necessity

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of additional adhesive coats on either the reflective sheeting or application surface.

The protective liner attached to the adhesive shall be removed by peeling, without soaking in water or other solvents, without breaking, tearing or removing any adhesive from the backing. The protective liner shall be easily removed following accelerated storage for four hours at 160° F (71°C) under a weight of 2.5 psi (17kPa).

The adhesive backing of the reflective sheeting shall produce a bond to support a 1 ¾ lb. (0.79 kg.) weight for five minutes, without the bond peeling for a distance of more than 2.0 in. (50.8 mm.) when applied to a smooth aluminum surface.

TABLE 715.9.2.3.1-II

**COLOR SPECIFICATIONS LIMITS AND REFERENCE
STANDARDS FOR TYPE II & IV SHEETING**

	Chromaticity Coordinates (Corner Points)								Reflectance Limit		Ref. Std. MUNSELL PAPERS	
	1		2		3		4		y	Min.		Max.
	x	y	x	y	x	y	x	y				
Silver-White	.303	.287	.368	.353	.340	.380	.274	.316	27	---	5.OPB 7/1	
Red	.613	.297	.708	.292	.636	.364	.558	.352	2.5	11	7.5R 3/12	
Orange	.550	.360	.630	.370	.581	.418	.516	.394	14	30	2.5YR 5.5/14	
Yellow	.498	.412	.557	.442	.479	.520	.438	.472	15	40	1.25Y 6/12	
Green	.030	.380	.166	.346	.286	.428	.201	.776	3	8	10G 3/8	
Blue	.144	.030	.244	.202	.190	.247	.066	.208	1	10	5.8PB 1.32/6.8	

715.9.2.3.3-Film:

General-The reflective sheeting shall have sufficient strength and flexibility so that it can be handled, processed, and applied according to the recommendations of the sheeting manufacturer without appreciable stretching, tearing, or other damage. The sheeting shall permit cutting and color processing with compatible transparent and opaque process inks at temperatures of 60° F to 100° F (15 to 38°C) and relative humidity at 20 to 80 percent. The sheeting shall be heat resistant and permit force curing without staining of applied or unapplied sheeting at temperatures as recommended by the manufacturer. Color processing for Type II material shall be restricted to sheeting with heat activated adhesive backing unless otherwise recommended by the manufacturer.

Shrinkage-Following liner removal, the reflective sheeting shall not shrink more than 2/32 in. (0.79 mm.) in 10 minutes nor more than 1/8 in. (3.18 mm.) in 24 hr. in any dimensions per nine inch (22.9 cm.) square at 72° F (22°C) and 50 percent relative humidity.

Flexibility-The sheeting, with the liner removed and conditioned for 24 hours at 72° F (22°C) and 50 percent RH, shall be sufficiently flexible to show no cracking when slowly bent, in one second's time, around a 1/8 in. (3.2 mm.) mandrel with adhesive contacting the mandrel. For ease of testing, talcum

powder may be spread on adhesive to prevent sticking to the mandrel.

Specular Gloss-The reflective sheeting shall have an 85 deg specular gloss of not less than 50 when tested in accordance with ASTM D 523.

Impact Resistance-The reflective sheeting material, applied according to the manufacturer's recommendations to a cleaned, etched aluminum panel 3.0 in. by 5 in. (76.2 mm. by 127 mm.) and conditioned for 24 hours at 72° F (23°C) and 50 percent RH, shall show no cracking when the face of the panel is subjected to an impact of 2.0 lb. (0.9 kg.) weight with a 5/8 in. (15.9 mm.) rounded tip dropped from a 10 in.-lb. (1.13 newton meter) setting on a variable impact tester.

Durability-Processed and applied in accordance with recommended procedures, the reflective material shall be weather resistant and following cleaning, shall show no appreciable discoloration, cracking, blistering, or dimensional change and shall not have less than 70 percent of the specified minimum reflective intensity values listed in Table 715.9.2.3.1-I when subjected to accelerated weathering for 2,200 hours in accordance with ASTM G23, Type E or EH Weatherometer and when subject to outdoor weather conditions for a period of seven (7) years.

715.9.2.3.4-General Characteristics and Packaging: The reflective sheeting as supplied shall be free from ragged edges, cracks, and extraneous materials and shall be furnished in both rolls and sheets. There shall be no more than four splices per 50 yd (45 m) length and splices shall be suitable for continuous application as supplied.

Rolls shall be packed in corrugated fiberboard boxes in such a manner that no damage or defacement may occur to the reflective sheeting during shipment or storage.

Cut sheets shall be packaged flat between pressed composition boards or corrugated pads of the same dimensions as the sheets and shall be so packed as to prevent damage or defacement during shipment or storage.

The reflective sheeting as supplied, stored under normal conditions shall be suitable for use for at least one year after purchase.

715.9.2.4-Reflex Reflectors: The reflectors shall consist of a clear and transparent plastic face, referred to as the lens, and an opaque plastic back fused to the lens under heat and pressure around the entire perimeter to form a unit permanently sealed against dust, weather, and water vapor. The lens shall consist of a smooth front surface free from projections or indentations other than those for identification or orientation of the reflectors. The rear surface shall have a prismatic configuration such that it will effect total internal reflection of light. The manufacturer's trademark shall be molded legibly into the face of the lens.

The specific brightness of each reflex reflector intended for use in cutout letters, symbols, and accessories shall be equal to or exceed the following minimum values with measurements made with reflectors spinning. Failure to meet the specific brightness minimum shall constitute failure of the reflector

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being tested. Upon failure of more than two reflectors out of 50 tested, a resample of 100 reflectors shall be tested; failure of more than four of these shall be cause for the rejection of the lot.

Observation Angle Degrees	Entrance Angle Degrees	Specific Brightness Candlepower/Square Inch/Footcandle (Crystal)
1/10	0	14.0
1/10	20	5.6

For yellow reflectors the specific brightness minimum shall be 60 percent of the value shown for crystal.

For red reflectors the specific brightness minimum shall be 25 percent of the value shown for crystal.

For green reflectors the specific brightness minimum shall be 25 percent of the value shown for crystal.

Test procedure shall be in accordance with MP 107.07.21.

715.9.2.5-Enclosed Lens Reflective Sheeting, Type III: The reflective sheeting shall consist of optical lens elements incorporated within a transparent, weatherproof, flat outer surface which will provide an optical retroreflective system that will meet the requirements of this specification. The sheeting shall have a precoated adhesive backing protected by a removable liner. The reflective sheeting shall have a watermark between the top film layer and the lens elements which shall be visible to the naked eye when viewed from a distance of 5 feet (1.5 m) under normal indoor lighting conditions. The watermark shall be spaced no more than 6 inches (150 mm) apart throughout the sheeting surface. Test procedures will be in accordance with AASHTO T 257.

715.9.2.5.1-Reflective Intensity: The reflective sheeting shall have minimum reflective intensity values at 0.2° and 0.5° observation angles as shown in Table 715.9.2.5.1-I expressed as average candlepower per foot candle per square foot (candelas per lux per square meter) of material.

TABLE 715.9.2.5.1-I
MINIMUM REFLECTIVE INTENSITY FOR
TYPE III ENCLOSED LENS SHEETING

Observation Entrance

Diver- gence Angle(E)	Inci- dence Angle(E)	White	Yellow	Green
0.2	-4	140	70	30
0.2	+30	65	33	8
0.5	-4	48	30	7
0.5	+30	28	18	3.5

Wet Performance-The reflective intensity values, when subjected to the rainfall test shall not less than 90 percent of the dry values listed in the above table.

Color-Through instrumental color testing, the diffuse day color of the reflective material shall conform to the requirements of table 715.9.2.5.1-II and shall be determined in accordance with subsection ASTM E-97.

Table 715.9.2.5.1-II

**COLOR SPECIFICATIONS LIMITS AND REFERENCE
STANDARDS FOR TYPE III ENCLOSED LENS SHEETING**

Color	Chromaticity Coordinates								Reflectance		Reference Standard <u>MUNSELL PAPERS</u>	
	1		2		3		4		Limit y	Max.		
x	y	x	y	x	y	x	y	Min.	Max.			
White	.305	.290	.330	.318	.302	.338	.274	.316	35	---	6.3GY	6.77/0.80
Yellow	.490	.442	.532	.465	.493	.506	.462	.470	29	45	1.25Y	6/12
Green	.135	.352	.185	.375	.155	.460	.107	.439	3.5	9	.65BG	2.84/8.45

715.9.2.5.2-Adhesive: The reflective sheeting shall have a pressure sensitive backing (Class I) or a tack-free heat activated adhesive backing (Class II) that shall be applied to approved sign surfaces without the necessity of additional adhesive coats on either the reflective sheeting or the application surface.

The protective liner shall be attached to the adhesive and shall be removable by peeling, without soaking in water or other solvents, without breaking or tearing or removing any adhesive from the backing. The protective liner shall be easily removed following accelerated storage for four hours at 160° F

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(71°C) under a weight of 2.5 psi (17KPa).

The reflective sheeting shall be tightly adhered to approved application surfaces when applied according to manufacturer's instructions and shall show no discoloration, cracking, crazing, blistering, wrinkling or dimensional change. The sheeting, when applied to approved surfaces at 72° F (22° C) and conditioned for 24 hours at this temperature, shall form a durable bond that will remain effective in temperatures of -30° F to 100° F (-35 to 38° C). Sheeting applied to clean, etched aluminum panels 6" x 6" (panels 150 mm x 150 mm) and conditioned at 72° F (22° C) for 48 hours, shall be subjected to 180° pullback at 12" per minute (300 mm per minute). Minimum pull strength shall be 4.4 pounds per inch (78 grams per millimeter).

715.9.2.5.3-Film:

General-The reflective sheeting shall have sufficient strength and flexibility so that it can be handled, processed, and applied according to the recommendations of the sheeting manufacturer without appreciable stretching, tearing, or other damage. The sheeting shall permit cutting and color processing with compatible transparent and opaque process inks at temperatures of 60° F to 100° F (15 to 38°C) and relative humidity at 20 to 80 percent. The sheeting shall be heat resistant and permit force curing without staining of applied or unapplied sheeting at temperatures as recommended by the manufacturer.

Shrinkage-Following liner removal, the reflective sheeting shall not shrink more than 1/32 inch (0.79 mm.) in 10 minutes or more than 1/8 inch (3.18 mm.) in 24 hours in any dimension per nine-inch (22.9 cm.) square at 72° F (22°C) and 50 percent relative humidity.

Flexibility-The sheeting, applied according to the manufacturer's recommendations to a clean and etched .020 inch by 2 inch by 8 inch (0.51 mm. by 50.8 mm. by 203 mm.) aluminum panel, conditioned a minimum of 48 hours and tested at 72° F (22°C) and 50 percent relative humidity, shall be sufficiently flexible to show no cracking when bent around a 3/4 inch (19.1 mm.) mandrel.

Specular Gloss-The reflective sheeting shall have an 85 degree specular gloss not less than 80 when tested in accordance with ASTM D 523.

Impact Resistance-The reflective sheeting material, applied according to the manufacturer's recommendations to a cleaned, etched aluminum panel 3.0 inch by 5 inch (76.2 mm. by 127 mm.) and conditioned for 24 hours at 72° F (22°C) and 50 percent RH shall show no cracking when the face of the panel is subjected to an impact of a 2.0 pound (0.9 kg.) weight with a 5/8 inch (15.9 mm.) rounded tip dropped from a 10 inch/pound (1.13 newton meter) setting

on a variable impact tester.

Durability-Processed and applied in accordance with recommended procedures, the reflective material shall be weather resistant and following cleaning, shall show no appreciable discoloration, cracking, blistering or dimensional change and shall not have less than 50 percent of the specified minimum reflective intensity values listed in Table 715.9.2.3.1-I when subject to accelerated weathering for 2,000 hours in accordance with ASTM G23, Type E or EH Weatherometer and when subjected to outdoor weather conditions for a period of seven (7) years.

715.9.2.5.4-General Characteristics and Packaging: The reflective sheeting as supplied shall be of good appearance, free from ragged edges, cracks and extraneous materials, and shall be furnished in both rolls and sheets. When reflective sheeting is furnished in continuous rolls, the average number of splices shall not be more than three per 50 yards (45 meters) of material with a maximum of four splices per 50 yard (45 meters) length and splices shall be suitable for continuous application as supplied.

Rolls shall be packed snugly in corrugated fiberboard boxes in such a manner that no damage or defacement may occur to the reflective sheeting during shipment or storage.

Cut sheets shall be packaged flat between pressed composition board or corrugated pads of the same dimension to prevent damage or defacement during shipment or storage.

Stored under normal conditions, the reflective sheeting shall be suitable for use for a period of at least one year.

715.9.2.6-Reflective Flexible Sheeting, Type IV: The reflective sheeting shall consist of a retroreflective lens system having a smooth outer surface. The sheeting shall have a precoated adhesive backing protected by a removable liner.

715.9.2.6.1-Reflective Intensity: The reflective sheeting shall have a minimum reflective intensity values at 0.2° and 0.5° , divergence, as shown in Table 715.9.2.3.1-I, expressed as candlepower per square foot (candelas per lux per square meter) of material.

Color-Through instrumental color testing the diffuse day color of the reflective material shall conform to the requirements of Table 715.9.2.3.1-II and shall be determined in accordance with ASTM E 97. Geometric characteristics shall be confined to illumination incident within 10 degrees of, and centered about, a direction of 45 degrees from the perpendicular to the test surface. Viewing shall be within 15 degrees of and centered about, the perpendicular to the test surface. Conditions of illumination and observation shall not be interchanged. The standards to be used for reference shall be the MUNSSELL PAPERS designated in Table 715.9.2.3.1-II. The papers shall be

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recently calibrated on a spectrophotometer.

715.9.2.6.2-Adhesive: The reflective sheeting shall include a precoated pressure sensitive adhesive backing (Class I) which may be applied without necessity of additional adhesive coats on either the reflective sheeting or application surface.

The protective liner attached to the adhesive shall be removed by peeling without soaking in water or other solvents, without breaking, tearing or removing any adhesive from the backing. The protective liner shall be easily removed following accelerated storage for four hours at 160° F(71°C) under a weight of 2.5 psi (17kPa).

The adhesive backing of the reflective sheeting shall produce a bond to support a 1 ¾ lb. (0.79 kg.) weight for five minutes without the bond peeling for a distance of more than 2.0 in. (50.8 mm.) when applied to a smooth aluminum surface.

715.9.2.6.3-Film:

General-The reflective sheeting shall have sufficient strength and flexibility so that it can be handled, processed and applied according to the recommendations of the sheeting manufacturer without appreciable stretching, tearing or other damage.

Shrinkage-Following liner removal, the reflective sheeting shall not shrink more than 1/32 in. (0.79mm) in 10 minutes nor more than 1/8 in. (3.18 mm.) in 24 hours in any dimensions per nine-inch (22.9 cm.) square at 72° F (22°C) and 50 percent relative humidity.

Flexibility-The sheeting, with the liner removed and conditioned for 24 hours at 32° F (0°C) and 50 percent RH, shall be sufficiently flexible to show no cracking when slowly bent, in one second's time, around a 1/8 in. (3.2 mm.) mandrel with adhesive contracting the mandrel. For ease of testing, talcum powder may be spread on adhesive to prevent sticking to the mandrel.

Specular Gloss-The reflective sheeting shall have an 85 deg specular gloss of not less than 50 when tested in accordance with ASTM D 523.

Impact Resistance-The reflective sheeting material, applied according to the manufacturer's recommendations to a cleaned, etched aluminum panel 3.0 in. by 5.0 in (76.2 mm. by 127.0 mm.) and conditioned for 24 hours at 32° F (0°C) and 50 percent RH, shall show no cracking when the face of the panel is subjected to an impact of 2.0 lb. (0.9 kg.) weight with a 5/8 in. (15.9 mm.) rounded tip dropped from a 10 in./lb. (1.13 newton meter) setting on a variable impact tester.

Durability-Processed and applied in accordance with recommended

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procedures, the reflective material shall be weather resistant and following cleaning, shall show no appreciable discoloration, cracking, blistering or dimensional change, and shall not have less than 70 percent of the specified minimum reflective intensity values listed in Table 715.9.2.3.1-I when subjected to accelerated weathering for 2,200 hr. in accordance with ASTM G23, Type E or EH Weatherometer.

715.9.2.6.4-General Characteristics and Packaging: The reflective sheeting as supplied shall be free from ragged edges, cracks and extraneous materials and shall be furnished in both rolls and sheets. There shall be no more than four splices per 50 yd. (45 m) length and splices shall be suitable for continuous application as supplied.

Rolls shall be packed in corrugated fiberboard boxes in such a manner that no damage or defacement may occur to the reflective sheeting during shipment or storage.

Cut sheets shall be packaged flat between pressed composition boards or corrugated pads of the same dimensions as the sheets and shall be so packed as to prevent damage or defacement during shipment or storage.

The reflective sheeting as supplied, stored under normal conditions shall be suitable for use for at least one year after purchase.

715.9.2.7 - Reflective Fluorescent Orange Sheeting, Type V: The fluorescent orange wide angle prismatic retroreflective sheeting is specifically designed for use on rigid substrate work zone signs to provide high visual impact under nighttime and daytime driving conditions, including low visibility periods such as dawn, dusk, and overcast days. The sheeting shall consist of prismatic lenses formed in a transparent fluorescent orange synthetic resin, scaled, and backed with an aggressive pressure sensitive adhesive protected by a removable liner. The sheeting shall have a smooth surface and with a distinctive interlocking diamond seal pattern and orientation marks visible from the face.

715.9.2.7.1 - Reflective Intensity: The reflective sheeting shall have minimum reflective intensity values at 0.2° and 0.5° , divergence, as shown in Table 715.9.2.7.1-I, expressed as candelas per footcandle per square foot (per lux per square meter) of material.

TABLE 715.9.2.7.1-I

Minimum Reflective- Intensity Values for Type V Sheeting

Divergence Angle (Deg.)	Incidence 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

*The datum mark (arrow) imprinted on the face of the sheeting shall be the datum mark for test purposes. For the specified 90° rotation angle, the sheeting shall be positioned on the goniometer so that the direction of the datum mark is perpendicular to the observation plane (this geometry is equivalent to a 90° orientation angle with a presentation angle of 0° in the measurement geometry described in Fed. Test Method Standard 370).

Daytime Color - Color shall conform to the requirements in Table 715.9.2.7.1-11. Daytime color and maximum spectral radiance factor (peak reflectance) of sheeting mounted on aluminum test panels shall be determined instrumentally in accordance with ASTM E 991. The values shall be determined on a HunterLab Labscan 6000 0/45 Spectrocolorimeter with option CMR 559 [or approved equal 0/45 (45/0) instrument with circumferential viewing (illumination)]. Computations shall be done in accordance with ASTM E 308 for the 2° observer.

TABLE 715.9.2.7.1-11

Color Specification Limits ** (Daytime)

Color	1		2		3		4		Reflectance Limit Y (%)	
	x	y	x	y	x	y	x	y	min.	max.
Orange (new)	.583	.416	.523	.397	.560	.360	.631	.369	30	--
Orange (weathered)	.583	.416	.523	.397	.560	.360	.631	.369	20	45

Maximum spectral radiance factor, new: 110%, min.
weathered: 60%, min.

**The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 standard colorimetric system measured with standard illuminant D 65.

Nighttime Color - Nighttime color of the, sheeting applied to aluminum test

panels shall be determined instrumentally in accordance with ASTM E 811 and calculated in the u' , v' coordinate system in accordance with ASTM E 308. Sheeting shall be measured at 0.330 observation and -4° entrance at 90° rotation. Color shall conform to the requirements of Table 715.9.2.7.1-III.

TABLE 715.9.2.7.1-III
Color Specification Limits ** (Nighttime)

Color	1		2		3		4	
	$\frac{u'}{v'}$	$\frac{v'}{u'}$	$\frac{u'}{v'}$	$\frac{v'}{u'}$	$\frac{u'}{v'}$	$\frac{v'}{u'}$	$\frac{u'}{v'}$	$\frac{v'}{u'}$
Orange (new and weathered)	.416	.538	.414	.530	.414	.530	.466	.526

715.9.2.7.2 - 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 one year's unprotected outdoor exposure in south Florida, south-facing and inclined 45 degrees from the vertical or after 1500 hours' exposure in a xenon arc weatherometer in accordance with ASTM G 26, Type B, Method A. Following exposure, panels shall be washed in a 5% HCL solution for 45 seconds, rinsed thoroughly with clean water, blotted with a soft, clean cloth and brought to equilibrium at standard conditions: After cleaning, the coefficient of retroreflections shall be not less than 100 when measured in 2, below, and the color is expected to conform to the requirements of Tables 715.9.2.7.1-11 and III for weathered sheeting. The sample shall:

1. Show no appreciable evidence of cracking, scaling, pitting, blistering, edge lifting or curling, or more than 1/32 inch (0.08cm) shrinkage or expansion.
2. Be measured only at angles of 0.2 degrees observation, -4 degrees entrance and 90 degrees rotation. Where more than one panel of a color is measured, the coefficient of retroreflection shall be the average of all determinations.

715.9.2.7.3 - Impact Resistance: The retroreflective sheeting applied according to the sheeting manufacturer's recommendations to a test panel of alloy 6061-T6, 0.040" (0.10cm) by 3" (7.6cm) by 51, (12.7cm) and conditioned for 24 hrs., shall show no cracking outside the impact area when the face of the panel is subjected to an impact of 100 inch-pound (11.3Nm), using a weight with a 5/8 in. (15.8cm) diameter rounded tip dropped from a height necessary to generate an impact of 100 inch-pounds, at test temperatures of both 32 degrees F (0 deg. C) and 72 degrees F (12 deg. C).

715.9.2.7.4 - Resistance to Heat: The retroreflective sheeting, applied to a test panel as in 715.9.2.7.3, above, and conditioned for 24 hours, shall be measured in accordance with 715.9.2.7.1, at 0.20 observation and -40 entrance angles at 900 rotation and exposed to $170 + 5$ degrees F ($77 + 3$ degrees C) for

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24 hours in an air circulating oven. After heat exposure, the sheeting shall retain a minimum of 70% of the original coefficient of retroreflection.

715.9.2.7.5 - Field Performance: Retroreflective sheeting processed and applied to sign blank materials in accordance with the sheeting manufacturer's recommendations, is expected to perform effectively for a minimum of 3 years. The retroreflective sheeting will be considered unsatisfactory if it 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 and night driving conditions; or (2) the coefficient of retroreflection is less than 100 when measured at 0.2° observation and -4° entrance at 90° rotation. All measurements shall be made after sign cleaning according to the sheeting manufacturer's recommendations.

715.9.2.8 – Retroreflective Sheeting for Traffic Control: The retroreflective sheeting shall conform to the requirements of AASHTO M 268. Either of the following classification types may be used.

1. Type IV
2. Type V

The retroreflective sheeting color and size shall be as specified on the plans.

715.9.2.8.1 – Adhesive:

General – The retroreflective sheeting shall include a Class 1 adhesive backing.

Test Method – The test panels shall be according to AASHTO M 268. Retroreflective sheeting that is to be applied to guardrail surfaces shall require certification of test performed on panels cut from Corrugated Sheet Steels for Highway Guardrail, per AASHTO M 180. The panel size shall be per AASHTO M 268.

715.9.3-Channelizing Devices and Auxiliary Barriers: Traffic cone markers shall be constructed of rubber or other flexible material acceptable to the Engineer, shall have a height of 28 to 36 in. (700 to 900 mm) and a base of approximately 14 in. by 14 in. (350 by 350 mm), and shall be predominantly orange in color. If the cones are required to be in place during periods of darkness, they shall be reflectorized.

Barricades shall be fabricated in accordance with details shown on the plans and shall not be constructed with sufficient strength to stop any vehicle which collides with them, but shall be so constructed as to do a minimum amount of damage to a vehicle colliding with them.

Traffic control drums shall be flexible plastic and appear basically cylindrical viewed from any direction. Drums shall have a minimum profile width of 18 inches (450 mm) regardless of orientation. The drum shall be 36 inches (900 mm) in height and orange in color.

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The markings on the drum shall be horizontal, circumferential, orange and white reflectorized stripes 6 inches (152.4 mm) minimum width fabricated from Type I or Type IV sheeting. There shall be two orange and two white stripes uniformly spaced on each drum.

The drum shall be designed to securely attach a Type A or C warning light to the top of the drum. The drum shall contain a removable base not to exceed 5 inches (127 mm) in height.

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715.9.5-Warning Lights: Warning lights shall meet the requirements prescribed and shall be of three types, as follows:

- i. Type A - Low Intensity Flashing Warning Light
- ii. Type B - High Intensity Flashing Warning Light
- iii. Type C - Steady Burn Warning Light

Each warning light shall be permanently marked as to type, the manufacturer's name, and the model number. Photoelectric controls, if provided on Type A or Type C lights, shall keep the light operating whenever the ambient light falls below 215 Lux.

715.9.5.1-General Requirements: The lens shall be illuminated by means of an electric lamp behind the lens and shall be externally illuminated by retro-reflective elements built into the lens to enable it to be seen by retro-reflection of light from the headlights of oncoming automotive traffic.

715.9.5.1.2 - Battery Powered: When the unit is to be operated by batteries, the batteries must be entirely enclosed in a housing meeting 715.9.5.5 with capability of being secured by a locking device.

715.9.5.1.3 - A. C. Powered: When the unit is to be operated by a 120-volt, 60 Hz power supply, the unit shall be supplied with a separate ground wire and be protected with suitable fuses. At no time shall the effective intensity have a value greater than 500 candelas. The connections and equipment used shall be in accordance with the pertinent current standards of the Institute of Electrical and Electronic Engineers, the American Society of Testing Materials, and the National Board of Fire Underwriters.

715.9.5.2 - Flash Requirements:

715.9.5.2.1 - Flash Rate: The light from Type A and Type B shall have a flash rate of 65, plus or minus 10 pulsations per minute from -20 to 150° F (-29 to 66° C) exclusive of power source.

715.9.5.2.2 - On-Time:

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- i. Definition - On-time is defined as the period of the flash where instantaneous intensity is equal to or greater than the effective intensity as specified in Section 715.9.5.3.1.
- ii. Type A - The light shall have an on-time of not less than 10 percent of the flash cycle.
- iii. Type B - The light shall have an on-time of not less than 8 percent of the flash cycle.
- iv. Maximum allowable on-time for either Type A or Type B lights shall be 50 percent.

715.9.5.3 - Optical Requirements:

715.9.5.3.1 - Effective Intensity:

- i. The light distribution shall have a minimum lateral width of ± 9 degrees and a minimum vertical height of ± 5 degrees from the optical axis of the system. Within these confines, minimum candela requirements, as specified in Sections ii, iii, and iv of this paragraph, shall be met.
- ii. For Type A, the effective intensity shall not drop below 4.0 candelas within the area specified in paragraph i, during the first 336 hours of continuous flashing.
- iii. For Type B, the effective intensity shall not drop below 35 candelas within the area specified in paragraph i, during the first 168 hours of continuous flashing.
- iv. For Type C, the beam luminous intensity shall not drop below 2.0 candelas within the area specified in paragraph i, during the first 168 hours of continuous burning.

715.9.5.3.2 - Retro-Reflective Performance: The specific intensity of the retro-reflector at an observation angle of 0.2 degrees and a light incidence angle of zero (0) degrees shall not be less than 1.67 candelas/lux.

715.9.5.3.3 - Testing Procedure:

- i. Warning lights furnished under this specification shall be tested in accordance with the latest revision of ATSA Test Procedure T-101 (American Traffic Services Association).
- ii. The effective intensity of Type A and Type B lights shall be calculated using the "Guide for Calculating the Effective Intensity of Flashing Signal Lights," as approved by the Illuminating Engineering Society.
- iii. The intensity of the Type C light shall be tested as set forth in S.A.E. Standard J575.
- iv. Reflex-reflection shall be tested in accordance with S.A.E. Standard

J594.

715.9.5.4 - Lens Requirements:

715.9.5.4.1 - Size of Lens: The lens shall not be less than 7 inches (175 mm) in diameter, including a retro-reflector ring of approximately ½ in. (13 mm) width around a minimum of 300° of the periphery.

715.9.5.4.2 - Number of Lens: Type A and Type C shall have either a bidirectional or unidirectional lens. Type B shall have an unidirectional lens.

715.9.5.4.3 - Lens Chromaticity: If the light uses an incandescent lamp, the chromaticity of the lens color shall be defined by the trilinear coordinates of the C.I.E. Standards (Commission International d'Eclairage). When tested with illuminants from 2856K to 2366K, the lens color shall fall within the area of the Chromaticity Diagram according to the 1931 C.I.E. Standard Observer defined by the following coordinates:

X	Y	Z
0.543	0.452	.005
0.548	0.452	.000
0.584	0.411	.005
0.589	0.411	.000

If the light uses other than an incandescent lamp, the light output shall be in the same range as the light obtained with the incandescent lamp and the specific lens.

715.9.5.4.4 - Lens Luminous Transmittance: The minimum relative luminous transmittance of the lens with illuminant at 2856K shall be 0.440.

715.9.5.4.5 - Lens Material: The lens shall be of one-piece construction. The lens material shall be plastic capable of producing a lens that can meet the chromaticity and luminous transmission requirements of this specification. The lens material shall meet the test requirements set forth in the most recent edition of S.A.E. Standard J 576 (Society of Automotive Engineers, Inc., "Lighting Equipment and Photometric Tests") except that the exposure time and conditions (S.A.E. Standard, Paragraph 3.4.3) for the purposes of this specification shall be one year.

715.9.5.5 - Head and Housing:

715.9.5.5.1 - Swivel Head: When swivel capabilities as described in this subsection are not incorporated in the device used to mount a Type A or Type C light to a barricade or a sign, the head shall be mounted on the housing in a manner permitting it to be swiveled through a minimum 90° arc in a horizontal

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plane. When swiveling is to be accomplished by rotation of the head, construction shall be such that the head rotation will not damage the wiring.

715.9.5.5.2 - Housing:

- i. Definition - Housing is defined as the case containing the batteries and circuitry.
- ii. Material - The housing shall be constructed of No. 18 U.S. Standard Gauge (1.3 mm) Steel or any other material which by engineering judgment is considered capable of withstanding considerable abuse.

715.9.5.5.3 - Painting: The housing and the lens frame, if of corrodible metal, shall be properly cleaned, degreased and pretreated to promote adhesion. It shall be given one or more coats of enamel which, when dry, shall completely obscure the metal substrate. The enamel coating shall be of such quality that when the coated case is struck a light blow with a sharp tool, the paint shall not chip or crack and if scratched with a knife shall not powder.

715.9.5.5.4 - Weatherproofing: The case shall be so constructed and closed as to exclude moisture that would affect the specified operation of the light. The case shall have a weep hole to allow the escape of moisture.

715.9.5.6 - Certification: Certified Test data shall be furnished by the manufacturer based on testing by a qualified independent testing laboratory. Whenever any changes are made in the lens, bulb or circuit the warning lights shall be retested for compliance.

715.9.5.7 - Summary Information:

	Type A Low Intensity	Type B High Intensity	Type C Steady Burn
Lens Directional Faces	1 or 2	1	1 or 2
Flash Rate Per Minute	55 to 75	55 to 75	N.A.
Minimum On-Time	10%	8%	N.A.
Minimum Effective Intensity *	4.00 Candelas	35 Candelas	
Minimum Beam Luminous Intensity *			2 Candelas
Hours of Required Operation *	Dusk to Dawn	24 Hrs./Day	Dusk to Dawn

* These values must be maintained within the areas specified in subsection 715.9.5.3.1, paragraph i.

715.10-PREFABRICATED DRAINAGE SYSTEMS:**715.10.1 - Prefabricated Pavement Edge Drain:**

715.10.1.1 - General: Prefabricated pavement edge drain shall be a flexible rectangular hollow mat consisting of a supporting polymeric drainage core encased in an engineering fabric envelope and having sufficient flexibility to withstand installation bending and handling without damage.

715.10.1.2 - Core: The drainage core shall be constructed from a polymeric material, have a minimum thickness of $\frac{3}{4}$ inch (19 mm) and a minimum compressive strength of 3,000 pounds per square foot (145 kPa) with a maximum deflection of 20 percent determined by ASTM D 1621, except the sample size may be increased to a maximum of 12 in. by 12 in. (300 mm by 300 mm) The edge drain shall permit inflow on both sides of the drain and produce a minimum flow rate of 10 gal/minute/ft (123 liters/minute/meter) of width as determined by ASTM D 4716. Flow rates shall be based on a hydraulic gradient of 0.1 and a confining pressure of 10 psi (69 kPa) using a closed-cell foam rubber layer on both sides. The height of the edge drain shall be as shown on the Plans.

715.10.1.3 - Fabric: The fabric shall be suitable for subsurface drainage applications and shall meet the requirements of 715.11 except the minimum tensile strength shall be 90 lbs. (400 N). The fabric shall be bonded to or stretched tightly over the core support contact points.

715.10.1.4 - Fittings: All fittings shall be in accordance with the manufacturer's published specifications.

715.10.1.5-Outlet Pipe: The outlet pipe shall be a smooth inner wall unperforated pipe meeting the requirements of 714.19 (AASHTO M252, Type S only) or [714.22](#)

715.10.1.6 - Acceptance: All components of the edge drain shall be approved before use. The Contractor shall furnish certified test data with the material supplied for each project. Tests for all required properties shall be performed in accordance with the procedures specified. Compliance of this data with the requirements specified will be the basis of acceptance.

715.11-ENGINEERING FABRIC:

715.11.1-General: Engineering fabric shall meet the applicable requirements of AASHTO M 288.

715.11.2-Acceptance: All engineering fabric shall be approved before use. When using a fabric not on the Division's approved list, the Contractor shall

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furnish certified test data with each shipment of fabric. Compliance of this data with the requirements of the specific application will be the basis of acceptance.

The test results submitted shall be derived from testing samples representing the fabric contained in each shipment. Tests for all required properties shall be performed in accordance with the procedures specified. Each roll shipped shall be identified so as to show its relationship to the test data submitted.

715.11.3-Maintenance and Repairs: Any fabric damaged or displaced shall be replaced or repaired at the Contractor's expense. Any fabric, other than that used for silt fence, not covered within 14 days after installation shall be removed and replaced at no expense to the Division. Minor tears or ruptures in the fabric may be repaired by sewing or by placing another piece of fabric over the damaged area so that the overlap is at least 2 feet (600 mm) in each direction or as directed by the Engineer.

715.11.4-ENGINEERING FABRIC FOR SUBSURFACE DRAINAGE

Engineering fabric for subsurface drainage shall meet the applicable requirements of AASHTO M 288, Section 7, Class 2. Additionally, the permeability shall be a minimum of 0.2 sec^{-1} and the apparent opening size shall be no larger than No. 60 (250 μm) sieve.

715.11.5-ENGINEERING FABRIC FOR SEDIMENT CONTROL (SILT FENCE)

Engineering fabric for sediment control shall meet the applicable requirements of AASHTO M 288, Section 8.

715.11.6-ENGINEERING FABRIC FOR EROSION CONTROL:

Engineering fabric for erosion control shall meet the applicable requirements of AASHTO M 288, Section 7.

715.11.7-ENGINEERING FABRIC FOR PAVING:

Engineering fabric for paving shall meet the applicable requirements of AASHTO M 288, Section 9.

715.11.8-ENGINEERING FABRIC FOR SEPARATION:

Engineering fabric for separation shall meet the applicable requirements of AASHTO M 288, Section 7.

715.11.9-ENGINEERING FABRIC FOR STABILIZATION:

Engineering fabric for stabilization shall meet the applicable requirements of AASHTO M 288, Section 7.

715.12-CONCRETE FOR MISCELLANEOUS USES:

Concrete specified in this Section is intended for such uses as cast-in-place footers for right-of-way fence and footers for guardrail breakaway cable

terminals and special trailing end terminals. The concrete may be mixed with or without air entrainment at the option of the Contractor. Batching and mixing may be by hand, by portable mixer, or by a commercial plant. At the time of placement, the concrete shall be of a workable consistency which can be consolidated satisfactorily by spading or vibrating. Indications of initial set in the concrete to such an extent as to adversely affect the workability of the concrete during placement shall be cause for rejection. The concrete shall be in accordance with one of the following:

- i. Concrete produced for other construction items under an approved mix design.
- ii. Concrete produced from premixed ingredients sold commercially in acceptable sacks, such as "Sacrete", or "Quickrete", "Handicrete or approved equal. Premixed commercial preparations shall be mixed in accordance with the manufacturer's instructions.
- iii. Concrete produced from separate components proportioned by volume in the ratio of one part portland cement to two parts sand to three parts coarse aggregate. Sand and coarse aggregate shall be visually inspected for deleterious substances, and such matter shall be removed prior to mixing.

715.13-PREFORMED FABRIC PADS:

Material shall conform to the requirements of the AASHTO Standard Specifications for Highway Bridges, Division II, Section 18.4.10.1.

A certified copy of test reports showing compliance with the above requirements shall be furnished the Division's Shop Inspector, or to other representatives of the Division as may be designated, for each shipment.

715.14-ELASTOMERIC BEARING PADS:

Bearing pads shall meet the requirements of the AASHTO Standard Specifications for Highway Bridges

715.15-ELASTOMERIC BEARING PADS FOR BRIDGE RAILING POSTS:

Elastomeric bearing pads for bridge railing posts shall have a thickness of $\frac{1}{8}$ inch (3 mm) unless modified by the project plans.

The pads shall have a minimum tensile strength of 1,000 psi (7 MPa) when tested in accordance with ASTM D 412. The pads shall have a durometer hardness of 55 to 75 when tested in accordance with D2240.

715.16-CLAY OR SHALE BRICK:

Brick shall conform to the requirements of one of the following Specifications:

Sewer Brick	AASHTO M 91, Grade SM or MM
Sewer Brick	ASTM C 32, Grade SM or MM
Building Brick	AASHTO M 114, Grade SW

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Building BrickASTM C 62, Grade SW

715.17-CONCRETE BRICK:

Concrete brick shall conform to the requirements of ASTM C 55; the grade shall be as specified on the Plans.

715.18-CONCRETE MASONRY UNITS:

Hollow load-bearing concrete masonry units shall conform to the requirements of ASTM C 90. The type and grade shall be as shown on the Plans.

Solid precast segmental concrete masonry units for construction of catch basins and manholes shall conform to the requirements of ASTM C 139.

715.19-PRECAST CONCRETE UNITS FOR MANHOLES AND INLETS:

Precast concrete units for manholes shall conform to the requirements in AASHTO M 199. In addition, air entrainment in the concrete shall be seven percent plus or minus two percent.

Portland cement concrete for precast inlets shall be in accordance with the applicable portions of the "Materials", "Manufacture" and "Physical Requirements" sections of AASHTO M 199, with the additional statement regarding compression tests to be included in the "Physical Requirements" section: "If no design strength is specified for precast concrete inlets, the minimum 28-day compressive strength shall be considered to be the 3,200 psi (20 MPa) minimum cylinder strength."

Also, for precast inlets, air entrainment in the concrete shall be seven percent plus or minus two percent. Surface finish for precast inlets is not required, except, if resultant exposed surfaces have unsightly voids, flaking or other surface defects present, those imperfections shall be repaired in accordance with the requirements of 601.11.1 for Class 1, Ordinary Surface Finish.

715.20-PRECAST CONCRETE TRAFFIC DIVIDERS:

715.20.1-Materials:

715.20.1.1-Cement: The cement used shall conform to the requirements of 701.1 or 701.3. It shall, in addition, be manufactured to conform to the whiteness of Atlas or Medusa brands of white portland cement.

715.20.1.2-Water: Water shall conform to the requirements of 715.7.

715.20.1.3-Aggregates: Fine aggregate shall be white silica sand conforming to the requirements of 702.1.1, 702.1.2, 702.1.4 and 702.1.5. Coarse aggregate shall be marble, $\frac{3}{8}$ in. (9.5 mm) nominal top size. Fine and coarse aggregates shall meet the soundness requirements in 715.20.1.4.

715.20.1.4-Acceptance Tests: When tested in accordance with ASTM C 88 using sodium sulphate, the weighted average loss in five cycles shall not exceed five percent. If materials are blended to produce the aggregate, each component of the blend shall meet the soundness requirements specified above.

A sample of concrete made with the materials proposed for use in the item, combined in the proportions specified in 715.20.2, shall be submitted to the Engineer for inspection and approval of color. The sample size shall not be less than a two-inch (50 mm) cube.

Certified test reports from the manufacturer for all materials used in manufacturing the dividers shall be furnished.

715.20.2-Proportioning: Concrete shall be proportioned to meet the following requirements:

- i. The sand-aggregate ratio shall be in the range of 30 to 45 percent.
- ii. The maximum allowable slump shall be 1 in. (25 mm).
- iii. The maximum water content shall be five gallons per sack (0.44 liters per kg) of cement.
- iv. The minimum cement factor shall be eight sacks per cubic yard (446 kg per cubic meter) of concrete.
- v. The amount of entrained air in the plastic concrete shall be seven plus or minus two percent.

715.20.3-Placing and Curing: Concrete shall be placed in forms designed to conform to the lengths, shapes and other details of the traffic divider shown on the Plans. Curing shall be in accordance with the applicable requirements in 601.

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715.22-PRECAST CONCRETE MEDIAN BARRIERS (PERMANENT):

715.22.1-Description: Precast median barriers shall conform to the shape and dimensions shown on the Plans and shall meet the following requirements:

715.22.2-Materials: Materials shall meet the requirements specified in the following Subsections of Division 700:

MATERIAL	SUBSECTION
Cement	701.1
Fine Aggregate.....	702.1
Coarse Aggregate	703.1, 703.2 or 703.3
Air Entraining Admixture.....	707.1
Expansion Joint Filler Preformed.....	708.1
Joint Sealing Material.....	708.3
Reinforcing Steel	709.1 and 709.4

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Water.....715.7

Sampling and testing of materials shall be in accordance with the minimum frequency stated in Table 2 of MP 711.03.30.

715.22.3-Proportioning: Concrete shall be in proportion to meet the following requirements:

- i. The minimum cement factor shall be seven sacks (6.58 cwt) per cubic yard (390 kg per cubic meter) of concrete.
- ii. The maximum water content shall be five gallons per sack (0.94 cwt) (0.44 liters per kg) of cement.
- iii. The amount of entrained air in the plastic concrete shall be seven plus or minus two percentage points.
- iv. The consistency shall be such as to allow proper placement, consolidation, and finishing.

715.22.4-Placing and Curing: Concrete shall be placed in forms designed to conform to the lengths, shapes and other details of the median barrier shown on the Plans. Curing shall be in accordance with the applicable requirements of 601.

715.22.5-Finishing: The surface of the barrier shall be smooth and free from air bubble pockets, depressions, and honeycombs.

When the barriers are removed from the forms, any surface imperfections present shall be repaired in accordance with the requirements of 601.11.1-Class I, Ordinary Surface Finish.

715.23-GABIONS:

715.23.1-Fabrication: Gabions shall be fabricated in such a manner that the sides, ends, lid and diaphragms can be assembled at the construction site into rectangular baskets of the specified sizes. Gabions shall be of single unit construction. The base, ends, and sides shall either be woven or welded into a single unit or one edge of these members connected to the base section of the gabion in such a manner that strength and flexibility at the point connection is at least equal to that of the mesh.

Where the length of the gabion exceeds its horizontal width, the gabion shall be equally divided by diaphragms, of the same mesh and gage as the body of the gabions, into cells whose lengths do not exceed the horizontal width. The gabion shall be furnished with the necessary diaphragms secured in proper position on the base section in such a manner that no additional tying at this juncture will be necessary.

All perimeter edges shall be securely selvedged, bound, or welded so that the joints formed have approximately the same strength as the body of the mesh.

715.23.2-Dimensions: Gabions shall be supplied, as specified, in various lengths and heights. However, all gabions furnished by a manufacturer shall be of uniform width and shall be shipped flat.

715.23.3-Tolerances: All gabion dimensions are subject to a tolerance limit of ± 3 percent of the manufacturer's stated sizes.

715.23.4-Twisted Wire Mesh Gabions:

715.23.4.1-Mesh Openings: Openings of the mesh shall not exceed $4\frac{1}{2}$ inches (114 mm) in the longest dimension.

715.23.4.2-Wire: All wire used in the fabrication and fastening shall be zinc coated in accordance with Class 3 of ASTM A641 when tested by ASTM A90. The adhesion of the coating to the wire shall be in accordance with ASTM A641.

The minimum wire sizes shall be as follows:

Tie Wire	0.087 \pm 0.004 inches (2 mm \pm 100 μ m)
Body Wire	0.118 \pm 0.004 inches (3 mm \pm 100 μ m)
Selvedge Wire	0.154 \pm 0.004 inches (3.91 mm \pm 100 μ m)

All the wire shall have a minimum tensile strength of 60,000 psi (400 MPa) when tested in accordance with ASTM A370.

The wire netting shall have a minimum of 10 percent elongation and a minimum 6,000 pound (26.7 kN) load bearing resistance. This testing shall be conducted as follows:

A section of mesh 6 feet (1.83 m) long, not less than 3 feet (914 mm) wide and including all selvedge binding shall have the ends securely clamped for 3 feet (914 mm) along the width. When the width of the sample under test exceeds 3 feet (914 mm), the clamps will be placed in the middle portion of the width and the excess width will be allowed to fall free on each side of the clamped section. The sample shall then be subjected to sufficient tension to cause 10% elongation of the sample section between the clamps. After elongation and while clamped, the section will be subjected to a load applied to an area of one square foot (300 sq. mm) located approximately in the center of the sample section between the clamps, and in a direction perpendicular to the direction of the tension force. The sample shall withstand, without rupture of any

715.23.5

wire, or opening of any mesh fastening, a load of 6,000 pounds (26.7 kN). The ram head used in the test shall be circular with its edges beveled or rounded to prevent cutting of the wires.

715.23.5-Welded Wire Mesh Gabions:

715.23.5.1-Mesh Openings: Openings of the mesh shall not exceed 3 inches (75 mm) in the longest direction.

715.23.5.2-Wire: All wire used in the fabrication and fastening shall be zinc coated in accordance to Class 3 of ASTM A641 when tested by ASTM D90. The adhesion of the coating to the wire shall be in accordance with ASTM A641

The minimum wire sizes shall be as follows:

Body Wire	0.118 ± 0.004 in. (3 mm ± 100 μm)
Tie Wire	0.087 ± 0.004 in. (2 mm ± 100 μm)

The welded joints of the wire mesh shall conform to ASTM A185 except that the minimum weld shear strength shall be 600 lbs. (2.67 kN) All the wire shall have a minimum tensile strength of 60,000 psi (400 MPa) when tested in accordance with ASTM A370.

715.23.6-Alternate Fasteners: The use of rings in assembly may be permitted by the Engineer. The rings shall have at least the same tensile strength, zinc coating, and size as the body wire.

715.24-MATTING FOR EROSION CONTROL:

715.24.1-General: Matting for erosion control shall be commercially designed and manufactured especially for the prevention of soil erosion.

The matting used shall be recommended by the technical representative for a manufacturer and approved by the Engineer after an evaluation of the site conditions has been made. The manufacturer shall provide installation instructions and attest that the proposed matting is well suited to the particular site to be protected.

The matting shall be stabilized or manufactured in such a way that the physical integrity of the product is maintained throughout the intended life expectancy. The matting shall not effect the germination of seed nor inhibit plant growth. Temporary matting shall gradually deteriorate with not adverse environmental effects.

715.24.2-Acceptance: Acceptance shall be based on the manufacturer's written certification that the erosion control mat used is well suited to the particular site to be protected and on the Division's visual inspection of the

material.

715.24.3-Permanent Erosion Matting: The matting shall consist of a machine produced mat of ultraviolet stabilized polymeric or other suitable fibers resistant to degradation and having a uniform weave distribution throughout. The mat shall conform to the following:

	<u>ASTM</u>	
(1) Minimum Mat Thickness	D 1777	0.4 in. (11 mm)
(2) Minimum (Wide Width) Tensile Strength*	D 4632	541 lb/ft
(3) Maximum Elongation	D 4632	75%
(4) Minimum Porosity (Calculated)**		90%
(5) Resiliency ***	D 1777	80%
(6) Ultraviolet Stability	D 4355	80%

Type A Matting shall have the ability to prevent vegetation and soil loss at water velocities of 4-8 fps as certified by the manufacturer.

Type B Matting shall have the ability to prevent vegetation and soil loss at water velocities of 8-15 fps as certified by the manufacturer.

- * Weakest principle direction
- ** Porosity calculation based upon unit weight, thickness and specific gravity
- *** Percentage of original thickness retained after three cycles of a 100 psi (.75 Mpa) load for 60 seconds followed by 60 seconds without a load thickness measured 30 minutes after load is removed.

715.25-GROUND AGRICULTURAL LIMESTONE:

Ground agricultural limestone shall consist of high calcitic or dolomitic limestone containing not less than 85 percent of total calcium and magnesium carbonates, ground to such fineness that not less than 35 percent will pass through a No. 100 (150 μ m) sieve and 100 percent through a No. 10 (2 mm) sieve.

715.26-FERTILIZERS:

Commercial fertilizers shall be supplied separately or in mixtures containing the specified percentages of total nitrogen, available phosphoric acid, and water

715.26.1

soluble potash. Fertilizer shall be furnished in standard containers with weight, name of plant nutrients and guaranteed percentages, clearly marked, all in accordance with governing State and Federal laws. Brands must be registered with the West Virginia State Department of Agriculture.

715.26.1-Fertilizer for Seeding: Fertilizer for seeding shall consist of any type with a 1-2-1 ratio providing the minimum nutrient equivalent specified. Urea formaldehyde fertilizer shall contain a minimum of 38 percent slowly available nitrogen.

Commercial fertilizer for seeding may be supplied in any of the following forms, subject to the approval of the Engineer.

- i. A dry, free flowing fertilizer that may be applied by ordinary agricultural spreaders.
- ii. A fertilizer which is water soluble or one which will permit complete suspension of insoluble particles in water, applicable to hydraulic methods of application.

715.26.2-Fertilizer for Landscape Planting: The fertilizer shall be a co-granulated magnesium ammonium phosphate and magnesium potassium phosphate, controlled release, inorganic fertilizer compound (coarse grade). It shall have a guaranteed minimum analysis of:

	Percent
Nitrogen	7
Maximum water soluble ammoniacal nitrogen	2
Minimum water insoluble ammoniacal nitrogen.....	5
Phosphoric acid (available P ₂ O ₅)	40
Potash(K ₂ O).....	6

715.27-MULCH MATERIAL:

715.27.1 - Mulch Material for Seeding:

715.27.1.1 - Straw Mulch: Straw mulch for seeding shall include baled wheat or oats straw, or baled grass hay. Alfalfa, clover and salt grass hay are not acceptable. Straw mulch shall be dry and reasonably free from weeds, sticks, or other foreign material.

Acceptance shall be based on the Division's visual inspection of the material.

715.27.1.2 - Wood Cellulose Mulch: Mulch for use with the hydraulic application of grass seed shall consist of wood cellulose fiber. It shall contain no growth or germination inhibiting factors and shall be dyed green. When the material is agitated in slurry tanks with fertilizers, grass seed, water and other approved additives, the fibers shall become uniformly suspended to form a homogeneous slurry. The hydraulically sprayed slurry shall form a blotterlike ground cover impregnated with grass seed. The ground cover shall permit the absorption of water and allow rainfall or mechanically applied water to

percolate to the underlying soil.

The wood cellulose fiber mulch shall conform to the following requirements:

Length of fibers	10 mm. maximum
Thickness of Fibers	1 mm. maximum
Net Dry Weight Content*	Minimum stated on bag
pH*	4.0 - 8.5
Water Holding Capability*	90% Minimum

* Test Procedure - MP 715.27.20

The mulch shall be delivered in packages not to exceed 100 lbs. (45 kg) The package shall bear the name of the manufacturer, the net weight and a supplemental statement of the net dry weight.

The material must be approved prior to being used. Acceptance will be based on sampling and testing by the Division for conformance to specifications.

715.27.1.3 - Chemical Mulch Binder: A chemical mulch binder shall consist of a polymer synthetic resin, polypectate, or other material which can readily be removed and will give similar adhesive properties as asphalt when sprayed on straw or other fiber mulches.

715.27.2-Mulch Materials for Landscape Plantings: Acceptable materials for mulching shall be shredded bark, buckwheat hulls, wood chips or other organic materials approved by the Engineer.

Certain inorganic materials such as calcined clay, crushed rock or coarse gravel will be acceptable when designated on the Plans.

715.28-SEED:

The varieties of grass and legume seeds to be furnished to the project shall bear a tag on each bag of each species showing the lot number, the seedman's name, the percent of purity, the percent of germination and the weed seed content, in accordance with governing State and Federal laws.

All seeds shall be free from noxious weed seeds as set forth in the West Virginia State seed law and in no event shall the total weed content of any lot of seed or seed mixture exceed one-half percent by weight. The minimum percent purity and germination for the various seeds shall be as shown in Table 715.28.

715.29

		Germination	
Seed	Purity Mininum %	Total Mininum (%)	Mininum Quick Sprouts (%)
Crownvetch	99	*70	35
Kentucky Bluegrass	85	75	
Kentucky 31 Fescue	98	85	
Marion Bluegrass	90	75	
Perennial Ryegrass	95	85	
Red Fescue	98	85	
White Dutch Clover	98	*85	55

Crownvetch seed shall be inoculated according to the supplier's recommendations. However, when seeding with the hydroseeder the inoculant shall be increased to five times the recommended rate.

If test results indicate noncompliance with the above germination or purity requirements, or both, additional seed may be added to give the equivalent germination or purity, or both.

The Division reserves the right to test, reject or approve all seed after delivery on the project.

715.29-INOCULATING BACTERIA:

This material shall be used to treat all leguminous seed and shall be a pure culture of nitrogen fixing bacteria selected for maximum vitality and ability to transform nitrogen from the air into soluble nitrates and deposit them in the soil. It shall not be more than one year old.

715.30 THROUGH 715.32-BLANK

715.33-VINES AND GROUND COVER PLANTS:

This material shall have a healthy, well-formed root system, free from disease. All transported stock is subject to inspection by the State Agriculture Department for insect or plant pests, and subject to rejection if found lacking in any of the above requirements. All plants shall be nursery grown, two years or older, and of the quality and size designated on the Plans, subject to approval both at the nursery and on the planting site. All vines and ground cover plants shall meet the requirements of U.S.A. Standard for Nursery Stock, AAN. The 1969 edition shall govern unless a more recent issue is in effect at the time of advertisement of bids.

For vines and ground cover plants, a listing by standard names in effect on any date is on file with the Division and is available on request.

715.34-SEEDLING PLANTS:

This material shall have a healthy, well formed root system, free from disease. All transported stock is subject to inspection by the State Agriculture Department for insect or plant pests, and subject to rejection if found lacking

in any of the above requirements.

All plants shall be nursery grown, two years or older, and of the quality and size designated on the Plans, subject to approval both at the nursery and on the planning site. All seedling plants shall meet the requirements of U.S.A. Standard for Nursery Stock, AAN. The 1969 edition shall govern unless a more recent issue is in effect at the time of advertisement of bids.

For seedling plants, a listing of standard names in effect on any date is on file with the Division and is available on request.

715.35-TREES AND SHRUBS:

Plants shall be healthy with well developed root systems and top growth for the species and shall be free of injury from disease, insects or other causes. All plants shall be true to type and name in accordance with "Standardized Plant Names" where applicable. Plants shall conform to the requirements of U.S.A. Standard for Nursery Stock, AAN. The 1969 edition shall govern unless a more recent issue is in effect at the time of advertisement of bids.

Collected plants shall be native or naturalized trees or shrubs growing in soils favorable for digging. The soil shall be of such character as to be readily retained on the roots of transplanted trees and shrubs.

The minimum root spread of bare-root collected plants shall be at least one third greater than that for nursery grown bare-root plants. Nursery grown stock, balled and burlapped for shipment, shall have ball sizes conforming to an AAN Standards. In the case of collected plants, ball sizes shall be at least 10 percent greater in diameter than those specified for nursery grown stock and shall be of sufficient depth to include the greater portion of the root system.

For ornamental flowering trees, deciduous and evergreen trees, and deciduous and evergreen shrubs, a listing by standard names in effect on any date is on file with the Division and is available on request.

Wherever balled and burlapped material is mentioned in these Specifications, the Contractor may with the approval of the Engineer, substitute container stock for balled and burlapped stock of small trees and shrubs. The container grown plants shall conform to the AAN Standards.

Plantable type pots can be used in lieu of burlapping balled plants; however, a firm ball must be placed in the pot, and the hole dug with the same care and to the same size as for balled and burlapped plants. Plants with balls which have been manufactured on bare-root dug material or bare-root material that has only recently been potted will be rejected. These improperly potted plants will not be considered equal to balled and burlapped or container grown plants.

715.36-ASPHALTUM BASE PAINT FOR TREE SURGERY:

Paint for tree wounds shall be antiseptic and waterproof, black in color and with an asphaltic base. It shall contain no coal-tar creosote, oils, kerosene, turpentine or other material harmful to the living tissue of trees.

715.37-MISCELLANEOUS ITEMS FOR LANDSCAPE PLANTINGS:

715.37.1-Tree Stakes: Stakes used for guying or supporting newly planted

715.37.2

trees shall be made from rough sawed oak, or other approved material, free from unsound or loose knots that impair its strength. The stakes shall be two inch (50 mm) by two inch (50 mm) square and of a length in proportion to the height of the tree. The following lengths for stakes shall be used as a guide:

Approximate Tree Height Feet (m)	Stake Length Feet (m)
3 to 6 (1 to 2)	5 (1.5)
6 to 9 (2 to 3)	6 (2.0)
9 to 14 (3 to 5)	7 (2.5)

Larger size trees shall be guyed or supported by stakes as shown on the Plans.

715.37.2-Wire: The wire used for guying and staking plants shall be galvanized steel wire, free from bends and kinks. Trees less than 3 inches (75 mm) in diameter shall be guyed with No. 14 gage (1.9 mm) wire, and trees 3 inches (75 mm) and larger shall be guyed with No. 12 gage (2.7 mm) wire.

715.37.3-Hose: The hose used for staking and guying plants shall be new $\frac{3}{8}$ to $\frac{5}{8}$ in. (10 to 16 mm) nominal I.D. rubber garden hose or equal. The walls of the hose shall be of sufficient thickness to prevent wire damage to the plans.

715.37.4-Twine: The material used for tying wrapped tree trunks shall be binder twine not less than two-ply strength.

715.37.5-Tree Wrap: The material shall be four-inch (100 mm) wide waterproof sisal paper manufactured especially for wrapping trunks of trees.

715.37.6-Anti-Desiccant: Anti-desiccant shall be an emulsion which provides a protective film over plant surfaces, permeable enough to permit transpiration. It shall be delivered in the manufacturer's containers and shall be mixed according to the manufacturer's directions.

715.38-REINFORCED PLASTIC OR REINFORCED CORROSION-RESISTANT RUBBER MANHOLE STEPS:

715.38.1-General: Steps shall be composed of a steel reinforcing bar encased in plastic or rubber, pressure-molded to the steel; steps shall have a minimum cross-sectional dimension of 1 in. (25 mm). Reinforcing shall be continuous through the entire length of the legs and tread. Steps shall have a depressed tread or a $\frac{1}{2}$ inch (12 mm) minimum height cleat at tread ends, and a top surface configuration such that it will prevent or minimize slippage during ascent or descent.

715.38.2-Steel Reinforcing: Steel shall be a deformed reinforcing bar; either No. 3, Grade 60, or No. 4, Grade 40 or 60 (Metric No. 10, Grade 300 or

Grade 400); meeting the requirement of AASHTO M 31.

715.38.3-Plastic: Plastic shall be a grade of propylene copolymer which meets the requirements of ASTM D4101.

715.38.4-Corrosion-Resistant Rubber: The rubber compound shall meet the physical requirements of ASTM C443 except the durometer, Shore A, hardness shall be 70 plus or minus five.

715.38.5-Acceptance: Steps which have been evaluated by the Division and appear on the Division's list of approved sources will be accepted. If the Contractor proposes to use a step not previously approved, a complete step and certified test data conforming to the above stated requirements shall be submitted for evaluation.

715.39-ELASTOMERIC GASKET AND SEALING MATERIAL:

These Specifications cover those elastomeric materials intended for use as, but not restricted to, such noncritical applications as gaskets, sealing materials, miscellaneous drainage items, etc. The elastomeric material shall meet the following requirements:

Tensile Strength, minimum psi (MPa), ASTM D 412.....	1,200 (8.3)
Elongation at Break, minimum percent, ASTM D 412.....	350
Shore Durometer Hardness, ASTM D 2440	
Minimum	35
Maximum	65
Compression Set, max percent, ASTM D 395,	
Method B.....	25
Accelerated Aging, ASTM D 573 (96 hr. at 70EC):	
Decreased Tensile Strength, maximum percent.....	15
Decreased Elongation, maximum percent.....	20
Water Absorption by Weight, maximum percent, ASTM D 471.....	10

715.40-PAVEMENT MARKING MATERIAL:

This material includes all pavement marking material exclusive of White or Yellow Fast-Dry Traffic Zone Paint (Types II or IX).

Certification from the manufacturer that the material supplied meets the applicable requirements of these Specifications is required. The certification shall include the name and address of the manufacturer, the trademark or trade name, kind of material, reference to the Division's Standard Specification (Subsection Number), quantities, lot number and date of manufacture.

The supplier shall have equipment and qualified personnel to conduct all of the tests that are required by these specifications.

715.40.1-Blank

715.40.2-Preformed Traffic Markings: The markings described are

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performed, retroreflective pavement markings conforming in color, size and shape to the West Virginia Department of Transportation, Division of Highways' Standard Details Book, Vol. II, and to the metric edition of the Federal Highway Administration's Standard Alphabets for Highway Signs and Pavement Markings. Transverse markings shall adhere to both asphalt and concrete for a minimum of three (3) years when applied according to the manufacturer's recommendations and shall maintain a minimum reflectivity of 150 millicandelas during this period. Longitudinal lines shall adhere to both asphalt and concrete for a minimum of four (4) years when applied according to the manufacturer's recommendations and shall maintain a minimum reflectivity of 150 millicandelas during this period. All reflectivity measurements will be taken with a Mirolux 12 retroreflectometer. If the material fails either the adherence or the reflectivity requirements during the time period specified, the material shall be completely replaced on the roadway surface by the Manufacturer at no additional charge to the Division. Upon completion of the contract, the warranty shall be transferred to the Division of Highways.

The Contractor shall provide the Engineer with certification from the manufacturer that they have been adequately trained through the Division of Highway's approved training seminar to apply this material. This certification shall be good for only one (1) year. The Contractor shall be required to recertify each year. The material must perform successfully in the Division's field evaluation test. A list of approved Contractor's personnel and suppliers and their code numbers may be obtained by contacting:

**West Virginia Division of Highways
Materials Control, Soil and Testing Division
312 Michigan Avenue
Charleston, West Virginia 25305**

715.40.2.2-Individual Requirements: The following are the individual requirements for the Preformed Traffic Markings (Type V):

- i. **Tensile Strength:** The film shall have a minimum tensile strength of 40 psi (276 kPa) of cross section when tested according to ASTM D 638. A sample 6 x 1 x 0.06 in. (150 x 25 x 1.5 mm) shall be tested at a temperature between 70° F and 80° F (21° C and 26° C), using a jaw speed of 10 to 12 in per min.
- ii. **Elongation:** A sample 6 x 1 x 0.06 in. (250 to 300 mm) shall have a minimum elongation of 75 percent when tested according to ASTM D 638 using a jaw speed of 10 to 12 in. (250 to 300 mm) per min.
- iii. **Skid Resistance:** The surface of the retroreflective pliant polymer shall provide a minimum skid resistance value of 35 BPN when tested according to ASTM E 303.
- iv. **Reflective Intensity:** The white and yellow film shall have the following initial minimum reflective values at 0.2 degrees and 0.5 degrees observation angles and 86.0 degrees entrance angle measured in

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accordance with the testing procedures of Federal Test Method Standard 370. The photometric quantity to be measured shall be specific luminance (SL)*, and shall be expressed as millicandelas per square foot per footcandle ($\text{mcd}\cdot\text{ft}^{-2}\cdot\text{fc}^{-1}$). The metric equivalent shall be expressed as millicandelas per square meter per lux. The test distance shall be 50 feet (15 m) and the sample size shall be 2.0 x 2.5 feet rectangle (0.61 x 0.76 m).

The angular aperture of both the photoreceptor and the light projector shall be 6 minutes of arc. The reference center shall be the geometric center of the sample, and the reference axis shall be taken perpendicular to the test sample.

	<i>White</i>		<i>Yellow</i>	
Observation Angle	0.2 degrees	0.5 degrees	0.2 degrees	0.5 degrees
SL ($\text{mcd}\cdot\text{ft}^{-2}\cdot\text{fc}^{-1}$)	550	380	410	250

* "The quantity SL treats the retroreflector as a surface source (rather than a point source) whose projected area is visible as an area at the observation position). The quantity SL relates to the way the effective retroreflective surface is focused on the retina of the human eye and to the visual effect produced. It is recommended for describing the performance of highway signs and striping, or large vehicular markings which are commonly viewed as discernible surface areas."

715.40.3 THROUGH 715.40.5 – Blank

715.40.6-Raised Marker:

715.40.6.1-Raised Markers (Type P-2): Type P-2 markers shall consist of an iron casting to which is attached a replaceable prismaticretroreflector for reflecting light from a single or opposite direction. Both ends of the casting shall be shaped to deflect a snowplow blade upward, thus preventing damage to the reflectors. The bottom of the casting shall incorporate two parallel keels and an accurately shaped web designed to fit into parallel slots cut into the road surface. Fastening to the road surface is to be accomplished by the use of an epoxy adhesive.

Reflectors shall consist of a base molded from a high strength engineering polymer. The base shall contain one or two prismatic reflective lenses to reflect incident light from a single or opposite direction. The lenses shall be hermetically sealed and permanently bonded to the reflector base. The reflector shall be adhesively attached to the casting as recommended by the manufacturer. Thin untempered glass shall be bonded to the front surface of the prismatic retroreflective lens faces to provide an extremely hard and durable abrasion resistant surface. color shall be as specified on the plans.

Using a steel wool abrasion procedure, the specific intensity of each

715.40.6

crystal reflecting surface at 0.2° observation angle shall be less than the following when the incident light is parallel to the base of the reflector.

Horizontal Entrance Angle	Specific Intensity
0°	4.0
20°	1.6

For yellow reflectors, the specific intensity shall be 60% of the value for crystal. For red reflectors, the specific intensity shall be 25% of the value for crystal.

Type P-2 marker shall be a Stimsonite Model No. 101 or approved equal.

715.40.6.2-Raised Markers (Type R-4): Markers shall consist of an acrylic plastic shell filled with a tightly adherent potting compound. The shell shall contain one or two glass covered prismatic reflective faces as required to reflect incident light from a single or opposite direction. The base of the marker shall be substantially free from gloss and substances that may reduce its bond to adhesive. Thin untempered glass shall be bonded to the prismatic reflective faces to provide an extremely hard and durable abrasion resistant surface. The outer surface of the shell shall be smooth except for purposes of identification. Color shall be as specified on the plans.

The adhesive used for installing the markers shall be one that is recommended by the manufacturer. It shall be mixed and used only as recommended by the manufacturer. The adhesive shall be mechanically mixed and placed on any given job requiring 50 or more markers.

715.40.6.3-Raised Markers (Type C-4, C-6 and C-8): Materials in this marker shall have a smooth abrasion resistant surface to produce the properties required in the specification.

The marker dimensions shall be as shown on the plans.

The marker shall have the shape of the outer segment of a spheroid and any change in curvature shall be gradual. The bottom surface shall not be smooth and shall be free from gloss or glaze.

The top surface material thickness shall be not less than 0.004 inches (100 µm) and shall not spall, craze or peel. The water absorption shall not exceed three percent of the original dry weight. The compressive strength of the marker shall not be less than 4,000 psi (27.6 MPa).

The color of the marker shall be uniform over the entire top surface and shall be as specified on the plans. The marker shall be R for reflective or NR for nonreflective as specified on the plans. The marker shall be nonreflective unless otherwise specified. The reflective marker shall be reflective in both directions unless specified as monodirectional in which case it shall face oncoming traffic. The reflectivity shall be accomplished by use of approved reflective lens inserts.

715.40.6.4 - Temporary Raised Markers (Type TCZ): Temporary Raised Markers (Type TCZ) shall consist of a plastic shell to which is hermetically sealed two prismatic reflective lenses to reflect incident light.

The markers shall be in the shape of a shallow round-cornered square with a spherical dome for enhancing the daytime signal. The marker dimensions shall be approximately 4 inches (100 mm) square and 0.75 inch (19 mm) in height when measured at the centroid. Color shall be as specified on the plans. The prismatic reflective lenses shall have a minimum reflective surface of 0.38 square inch (245 sq. mm) with the following minimum optical requirements:

OBSERVATION ANGLE (E)	ENTRANCE ANGLE (E)	SPECIFIC INTENSITY *
0.2	0	1.0
0.2	20	0.4

- * Specific intensity shall be the candlepower (candelas) of the returned light at the specified observation and entrance angles for each foot candle (lux) of illumination at the reflector on a plane perpendicular to the incident light.

The above values are for white reflectors. For yellow reflectors, the specific intensity shall be 60 percent of the value for white.

Markers shall be capable of supporting a load of 10,000 pounds.

Markers shall be installed with the use of primer and butyl pad as recommended by the manufacturer or with the use of a bituminous adhesive as recommended by the manufacturer.

715.40.7-Blank

715.41-TRAFFIC SAFETY DEVICES:

Traffic Safety Devices shall meet the requirements of the AASHTO Roadside Design Criteria and the National Cooperative Highway Research Program Report 350, Recommended Procedures for the Safety Performance Evaluation of Highway Appurtenances.

The Manufacturer of the Safety Device shall provide certified crash test data that indicates the product meets the requirements noted above.

The manufacturer shall submit to Traffic Engineering Division 8 copies of their design (installation) drawings for the specific device. This drawing will be reviewed, if approved, it will be stamped and one copy returned to the manufacturer. Multiple devices of the same design for the same project or purchase order will require one set of drawings, not one set for each device. In addition, one design and one installation manual shall be shipped with each safety device.

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All safety devices shall be manufactured and fabricated using the same components as crash tested. Any changes in design or compound shall be requested in writing by the supplier. The Engineer's concurrence is required prior to any change.

715.41.1-Sand Barrel Impact Attenuating Device (Type V):

715.41.1.1-Description: The unit shall have cylindrical containers capable of holding various amounts of sand. The amount of sand capable of being held shall include at least 2, 4, 7, 14, or 21 cubic feet (0.056, 0.112, 0.196, 0.393 or 0.588 cubic meters).

715.41.1.2-Performance: The unit shall be constructed so as to shatter upon impact to permit dispersion of the sand mass contained within. The center of gravity of each module shall be at a height which will control the attitude of the vehicle. The manufacturer shall certify that the units shall not crack, split, or color fade within five years of installation.

715.41.2-Crash Cushion Terminal Impact Attenuating Device (Type VI):

715.41.2.1-Description: The unit shall consist of a cable anchored system using slotted standard depth guardrail with breakaway wooden posts.

715.41.2.2-Performance: The unit shall be capable of redirecting 1,800 to 4,500 pounds (815 to 1 900 kg) vehicles at speeds up to 60 mph. (100 km/hr) which impacts the side of the unit at angles up to 15 degrees for the 1,800 pound (815 kg) vehicle and 25 degrees for the 4,500 pound (1 900 kg) vehicle.

715.41.3-Truck Mounted Impact Attenuating Device (Type VII):

715.41.3.1-Description: The unit shall consist of a crushable cartridge, a backup and a backup support structure for attaching the backup to the shadow vehicle. The unit shall have a standard trailer lighting system, including brake lights, taillights, turn signals and ICC bar lights. The back of the unit shall have a device attached with alternative diagonal black and reflectorized yellow stripes, 6 inches (150 mm) wide, similar to an XS-15 marker and in accordance with Section 3C-2 of the latest edition of the Manual on Uniform Traffic Control Devices for Streets and Highways.

715.41.3.2-Performance: The unit when attached to a standard truck weighing between 10,000 lb. and 24,000 lb. (4 530 kg and 10 872 kg) GVW, shall be capable of yielding according to the requirements of National Cooperative Highway Research Program Report 350. During the tests the truck shall have the brake set, transmission in gear, and engine off.

715.41.4-Quad Guard Impact Attenuating Device (Type VIII):

715.41.4.1-Description: The unit shall consist of crushable cartridges surrounded by a framework of steel Quad-beam guardrail which can telescope rearward during head-on impacts. The Quad Guard System shall have a center monorail which will resist lateral movement during side angle impacts. The nose shall consist of a formed plastic nose wrap.

715.41.4.2-Performance: The unit shall be capable of redirecting 1,800 to 4,500 pounds (815 to 1 900 kg) vehicles which impact the side of the system at speeds up to 60 mph. (100 km/hr) at angles up to 20 degrees for both right way and wrong way impacts (angles measured from systems longitudinal centerline). The unit shall be constructed so that there is no soliddebris which can create a hazard on the roadway after impact.

715.41.5-Acceptance: Acceptance shall be based upon review and approval of the certified crash test data by the Division. An approved list of Traffic Safety Devices shall be developed by the Contract Administration Division.

715.42-TRAFFIC SIGNAL MATERIALS AND EQUIPMENT:

715.42.1-Pre-timed Fixed Cycle Traffic Signal Controllers:

715.42.1.1-Definition of Terms: Following are definitions of terms used by the Division for pre-timed fixed cycle traffic signal controllers:

Cabinet: A dustproof and weatherproof enclosure for housing the controller and associated equipment.

Circuit Contact Cam Shaft: A device to operate the circuit contacts to provide the desired interval sequence.

Controller: A complete electrical mechanism for controlling the operation of traffic control signals, including the timer and all necessary auxiliary apparatus mounted in a cabinet.

Local Controller: A controller for operating traffic control signals at an intersection which may be isolated or included in an interconnected traffic control signal system.

Master Controller: An automatic device for supervising a system of controllers, maintaining definite time inter-relationship, selecting among alternate available modes of operation or accomplishing other supervisory functions.

Pedestrian Actuated Controller: An automatic controller in which part of the intervals or groups of intervals, particularly pedestrian WALK and clearance intervals, are initiated by actuation of a pedestrian detector.

Pre-timed Controller: A controller for the operation of traffic signals with predetermined:

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- i. Fixed cycle length(s).
- ii. Fixed interval duration(s)
- iii. Interval sequence(s)

Synchronous Controller: An automatic controller operated by a synchronous motor which will keep in step with the frequency of the power supply circuit.

Emergency Feature: A mercury contact bus bar relay installed in a controller, which when energized from a manual switch, remote point, discontinues the normal signal operation and displays special signal indications for the movement of high speed fire apparatus, etc.

Field Terminals: Devices mounted on a panel board for connecting all wires entering the controller cabinet.

Flashing Feature: A mercury contact bus bar relay installed in a controller which, when energized from a manual switch, remote point or by automatic time switch, discontinues normal signal operation and causes the flashing of any predetermined combination of signal lights.

Interval: The part or parts of the signal cycle during which signal indications do not change.

Interval Sequence: The order of appearance of signal indications during successive intervals of a cycle.

Jack Mounted Relay: A relay which may be removed or replaced without the use of tools and without disturbing any wiring.

Manual Operation: The operation of a controller assembly by means of a hand-operated device(s); (i.e., push-button).

Offset: The number of seconds or percent of the cycle length that a defined time-reference point (normally the start of major street green) at a traffic signal occurs after the time-reference point of a master controller or of an adjacent traffic signal.

Offset Control Switch: A device which when operated stops the timing of the cycle length and intervals in order to manually adjust the offset.

Offset Dial: A calibrated dial on an automatic timer equipped with adjusting devices by means of which it is possible to set any desired offset of the beginning of the green traffic control signal indication.

Offset Interrupter: A device which will distribute over two or more cycles the time required for large offset changes.

Panel: A panel board within the controller cabinet upon which are mounted fuse receptacles, circuit breakers, contactors, terminals, relays, and electrically operated switches and other equipment, all suitable insulated.

Pedestrian Phase (Pedestrian Movement): A traffic phase or traffic movement allocated exclusively to pedestrian traffic.

Radio Interference Suppressor: A device inserted in the power line in the controller assembly (cabinet) than minimizes the radio interference transmitted back into the power supply line, which interference may be generated by the controller or other mechanisms in the cabinet.

Relay Jack: A set of clips, plugs or receptacles in a controller or cabinet by means of which a relay may be mounted or connected to the circuit.

Reset: An adjustment mechanism applied to an automatic controller providing for the setting up of the timing arrangement of the start of the green traffic control signal indication.

Automatic Reset: A reset by means of which the offset or beginning of the green is checked automatically and adjusted, if necessary, once each time cycle.

Double Automatic Reset: A reset by means of which it is possible to automatically select any one of two automatic resets.

Triple Automatic Reset: A reset by means of which it is possible to automatically select any one of three automatic resets.

Manual Reset: A reset by means of which it is possible to manually adjust the offset or beginning of the green.

Reset Interrupter: A device which will automatically distribute the time lag resulting from a particular resetting over a period of time varying from one to several cycle lengths.

Shutdown Feature: A mercury contact bus bar relay installed in a controller which, when energized from a manual switch, remote point or by an automatic time switch, discontinues normal traffic control signal operation and turns the signal indications off.

Shutdown Switch: A switch in a controller which may be operated by hand to discontinue the operation of traffic control signals.

Signal Circuit Contact: A device arranged to energize or de-energize signal light circuits during a specified interval.

Signal Indication: The illumination of a traffic signal lens, or equivalent device, or of a combination of several lenses or equivalent devices at the same time.

Split: A division of the cycle length allocated to each of the various phases (normally expressed in percent).

Time Cycle: The number of seconds required for one complete revolution of the timing dial or complete sequence of signal indications.

Time Cycle Indicator: An indicating device applied to an automatic timer for indicating the time cycle in seconds.

Timing Dial: A calibrated dial on an automatic timer equipped with adjusting devices by means of which it is possible to divide the time cycle into the required number of intervals and set up the offset and interlock.

Timer: An automatic timing unit in a controller, including all dials, dial transfer relays, switching and circuit contacts, motors, gears, camshaft, etc.

Time Switch: A device for the automatic selection of modes of operation of traffic signals in a manner prescribed by a predetermined time schedule.

Traffic Phase: Those right-of-way and clearance intervals in a cycle assigned to any independent movement(s) of traffic.

Yellow-Red Flash Terminals: Addition terminals installed in a traffic signal controller so wired that by an interchange of jumpers, flashing operation may be arranged to give either yellow or red on the main or cross streets.

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715.42.1.2-General Design Requirements: The following are minimum design and operating requirements for all pre-timed, fixed cycle traffic signal controllers and associated equipment described in these specifications.

The signal time cycle shall be constant and accurate, regulated by the power line frequency. Neither cycle length variations nor interval timing variations shall occur if voltage of the power line varies between the limits of 10 percent above and 10 percent below 120 volts, 60 Hz AC standard service voltage. Similarly, neither cycle length variations nor interval timing variations shall occur if outside cabinet temperatures change to any value between -30° F (-34° C) and plus 122° F (50° C). Maximum inside cabinet temperature for above operation is plus 165° F (74° C).

It shall be possible to accurately set or adjust the cycle lengths between the limits of 30 and 130 seconds with accurate and definite settings within this range in five-second steps up to 100 seconds, and in ten-second steps above 100 seconds. This adjustment shall be accomplished by a change of marked gears requiring no more than the use of simple tools. Gear and gear shaft shall be designed to prevent slippage. Gear meshing pressure must be adjustable.

The cycle length in operation shall automatically be indicated on a scale visible on the front of the dial unit.

All pre-timed controllers shall contain three timing dials and be capable of being interconnected into a three-dial, three-offset system and shall include all the necessary keys, contacts, rider arms, etc.

The signal color sequence period adjustments and offset adjustments shall be made on the same timing dial without the aid of any tools. The timing dial shall be calibrated for the signal color period in steps of one percent from 1 to 99 percent. The offset calibration shall be in reverse order of the signal color sequence period. Each offset key shall be clearly identifiable as to its function and distinguishable from the color period keys. All keys for a given function shall be identical and each key having a specialized function shall be appropriately colored or otherwise identifiable to provide a visual indication of such function.

Any changes in operation of traffic control signal lights caused by turning the signal lights off, or turning them on flashing operation, shall not interfere with the continued in-time operation of the timer motor presently operating in each controller. A transfer from such special operation back to normal automatic operation shall immediately establish the normal time cycle and subsequently the in-time relation. The dial transfer mechanism shall be so designed that not more than one dial may operate at any one time. Dial No. 1 shall operate in absence of call for dial No. 2 or dial No. 3 or when there is a conflict on dial calls.

Each controller shall be furnished with three service manuals complete with all necessary instructions and diagrams for the installation and maintenance of the equipment supplied. Each controller shall be supplied with three complete sets of wiring diagrams. These wiring diagrams shall identify the color code or wire tagging used in all connections.

715.42.1.2.1-Interval Sequence: The controller shall provide consecutive divisions of the time cycle termed "intervals," during which time the combination of signal indications do not change. Each controller shall be provided with 12 or 16 interval cams. The cams shall be programmed so that a minimum number of dial unit keys are required for the plan specified phasing. If phasing is not specified, the cam lobes are not to be broken out.

715.42.1.2.2-Interval Adjustment: The controller shall provide for the setting of each interval of the cycle by means of a positive setting on each calibrated dial. The setting shall at all times show a visual indication of the amount of time allocated to each interval, in units of percent of the cycle length. When the controller is operating within a specified voltage and temperature limits, the time duration of each interval shall be within plus or minus 500 milliseconds of the time indicated by the setting of that interval, and timing of successive intervals shall be without cumulative errors that would affect the accuracy of the cycle length.

Each dial unit shall be provided with a scale calibrated in steps of one percent of the cycle length or one second, and shall provide for the accurate setting of any interval within the range of adjustment from 2 percent to 90 percent of the cycle length or from one second to 99 seconds.

The minimum time for any interval is not required to be less than one second whenever that is greater than two percent of the cycle length, nor is the minimum time for any interval required to be less than two percent of the cycle length when that is greater than one second.

The timing controls shall be on the front of the controller unit, easily identifiable, and it shall not be necessary to remove or change wires or contacts or to use any tools in making interval adjustments.

The three controller dial units specified shall provide for separate programs of interval timing. The dial units shall be readily identifiable and a change of one dial shall not affect or alter the other two dials. Dial transfer shall be accomplished at the beginning of main-street green.

The cam-shaft dial synchronization key (commonly called the camswitch release key, interlock, drum release or release key) shall terminate the main-street green interval. No more than two cycle lengths shall be required to effect a dial transfer.

715.42.1.2.3-Mechanism: The controller components shall be of unitized design and readily interchangeable.

All mechanisms, motors, operating coils, bearings, contacts, relays, flashers and similar components shall be sufficiently large, rugged and accessible to insure reliability and minimum maintenance. All equipment shall be neatly and systematically arranged and mounted to allow thorough inspection while the controller is operating normally, and to permit easy removal of removable components without interfering with other portions of the controller. Components shall be securely fastened in place to prevent accidental contact with moving parts or electrical power and to permit the cabinet door to be

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opened and closed without interference or damage to the controller and wiring. Component accessibility shall permit easy access for any needed lubrication.

A 30 ampere, mercury contact-type bus bar relay shall be provided for opening the bus bar circuit for signal shutdown, flashing operation or any other type of controller preemption.

All relays associated with the control system shall be of the electromechanical type and designed for heavy, continuous operation. Except for the mercury contactors, all relays shall be mounted on a plug-in base with plug-in mounting. Dial transfer relays shall be jack or plug mounted within the timer unit chassis.

Solid state circuitry shall not be used in the dial transfer, offset or split functions. Point to point wiring must be used on all circuitry. Copper or other track board circuitry is not permitted.

The controller dial motors shall be designed for synchronous self-starting operation on 120 volts, 60 Hz, single-phase alternating current. The motors shall have ample torque for all requirements of controller operation. Motor and reduction gearing shall be a completely enclosed unit containing a lifetime supply of lubricant. This unit shall not be an integral part of the timer but shall be arranged for easy removal. A maximum of one connector of the screw or bolt type shall be used to hold the timing dial firmly in position.

The complete dial unit assembly shall be mounted in a manner which allows it to slide or hinge out of the timer chassis for complete access for inspection and maintenance.

Each dial unit shall be furnished with an assembly of five gears (15 per controller). Gears for cycle lengths of 50, 60, 70, 80 and 90 seconds shall be provided per dial, unless otherwise specified.

Only one contact (movable) shall be provided per controller circuit. Line side power for these circuits shall be by direct mechanical connection.

All make and break contacts shall be of fine silver or a superior alternate material and shall be capable of breaking a current of 15 amperes of tungsten lamp at 120 volts, 60 Hz AC, one half million times without breaking physically or falling to conduct current to the tungsten load when operated 360 times an hour. All signal contacts shall be readily accessible and easily inspected. The movable contacts shall be designed to eliminate the possibility of accidental cross connection between adjacent contacts. The contact assembly shall be designed so that the contacts can be arranged or rearranged to cause any signal light circuit to be energized or de-energized during any one of the intervals. All contacts shall be easily replaceable by the use of simple tools.

The controller signal common and signal circuit bus shall have an ampacity of not less than 30 amperes.

The controller shall provide terminals, wiring, cams and contacts for 18 circuits complete.

Cam sequence switching shall be so designed that it shall not be possible to display a noticeable "dark out" interval at any time following any control function transfer, transfer to flash or any preempt transfer. In addition, the

closing or opening of signal load contacts shall be positive, without objectionable dark intervals, flickering of lights or conflicting signal indications.

Cam shaft advance shall be shaded pole motor or electromagnetic coil and return by gravity assisted spring. The cam rotor mechanism shall provide ample torque to break all bus contact loads, as long as the contacts remain in operational condition. Cam shaft advance impulse shall be actuated by the timer dial unit, or when specified in the Plans by manual actuation.

All relays, coils, solenoids and motor windings shall be sufficiently large to insure reliability and minimum maintenance.

715.42.1.2.4-Electrical Connectors: All electrical connections to and from the timer unit to the controller back panel shall be made through a 47 pin MS screw-type connector and wiring harness. Each wiring harness shall be at least 48 in. (1.2 meters) long or of the standard length specified by the manufacturer for that controller type. The harness shall have color-coded leads of labeled sleeves or labeled wires. The harness connections on the controller shall be such that the timer unit may be replaced with a similar unit, without the necessity of disconnecting and reconnecting individual wires therefrom.

Seven circuits in this connector shall be capable of handling No. 12AWG wire and a maximum of 30 amperes each. Connector pins for these circuits shall be rated at 41 amperes. All other connector circuits shall be rated at 15 amperes (No. 16 AWG) with connector pins rated at 22 amperes.

715.42.1.2.5-Controller Wiring Panel: A controller panel shall be installed on the back wall of the controller cabinet on which all relays, contactors, breaker receptacles, electrically operated switching devices and other auxiliary controller equipment, not an integral part of the timer unit assembly, shall be mounted. The panel shall be easily demountable in order that the entire control system can be removed, inspected and replaced as a unit. There shall be a minimum of 3 inches (75 mm) clearance between the bottom of the panel and the bottom of the cabinet.

All terminals, except the interconnect system terminals, shall be mounted on the controller panel. Interconnect terminals shall be mounted on the side of the controller cabinet, unless otherwise specified. All panel wiring shall be neat and firm. The back panel shall contain at least the following:

- i. Terminals with circuit breakers for power supply.
- ii. Terminals unfused for neutral side of power supply.
- iii. One terminal for each outgoing signal circuit and one or more terminals for the common conductors.
- iv. A neutral bus with a minimum of six terminals to accommodate No. 10 wire.
- v. Terminals for pedestrian or any other type actuation.
- vi. Terminals for manual control of color sequence.
- vii. Terminals for red and yellow flash circuits.

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viii. Controller mode switch.

The controller mode switch shall provide for selection of timing dial and offset or system operation as a minimum. A manual sequence mode position shall be provided if manual operation is specified.

All outgoing circuit terminals shall be suitably identified and shall be of the same polarity as the line side of the power supply. The ground side of the power supply shall be grounded to the controller in an approved manner.

Power service breakers shall be provided to terminate the No. 8 AWG service conductor circuits on the controller back panel. Breaker No. 1 shall provide overcurrent protection for the controller circuits and No. 2 protection for the flasher and associated circuitry.

715.42.1.2.6-Flashing Operation: Means shall be provided for the substituting of flashing vehicular signal indications for the normal specified interval sequence. The flashing operation of the controller shall be as specified on the Plans.

Flashing of vehicular and pedestrian signal indications shall be obtained from one or more flashers, each of which is a self-contained device designed to plug into a socket mounted on the back panel of the cabinet.

Each controller shall be equipped with additional terminals which are so wired that, by an interchange of jumpers, flashing operation may be arranged to display either flashing yellow or flashing red on each of the vehicular signals.

Each controller shall be provided with a flash control switch for activating the flashing of vehicular signals. The controller shall be constructed so that the flashing operation can be obtained by operating the flash control switch even if the controller unit malfunctions or is removed from the cabinet. During flashing operation, the controller timer unit shall be de-energized.

The substitution of flashing vehicular signal indications for the normal specified interval sequence shall be obtainable by time switch as well as by the flash control switch.

The controller shall be so designed that an "open" in power service breaker No. 1 shall automatically switch the signal to flashing operation (see 715.42.1.2.5).

715.42.1.2.7-Manual Operation: All controllers shall be designed capable of manual signal sequencing. When manual operation is specified on the Plans it shall be accomplished with the addition of standard components.

715.42.1.2.8-Pedestrian Actuation: When called for on the Plans, non-concurrent, exclusive pedestrian actuated phases shall subtract the WALK interval time from the lead phase "green" interval and DON'T WALK time from the following phase "green" intervals.

Manual operation of interval timing shall provide the same interval sequence as when the controller is operating automatically. Manual interval timing shall be obtainable by means of weather-resisting manual push-button

mounted on a flexible weather proof extension cord. The transfer of manual to automatic operation, or vice versa, shall be accomplished by an automanual switch. It shall not be necessary, when switching from manual to automatic operation, or vice versa, to do so at any certain time or to make any time adjustments.

715.42.1.2.9-Signal Shutdown: Each controller shall be provided with a signal shutdown switch for turning off the signals at the intersection. This switch shall affect the power to the signals only and no other part of the controller.

715.42.1.2.10-Warranties and Guarantees: The Contractor or supplier is required to turn over to the Division any guarantee or warranties which are give by the manufacturer as a normal policy. The Contractor or supplier shall furnish the Division with three copes of complete drawings, diagrams and manufacturer's instructions for installing and maintaining the equipment and any assistance as required for timing and operation of the equipment. Any component called for by the circuit design which has special unique characteristics which would limit that component to certain manufacturers or suppliers shall be so indicated in the manufacturer's instructions.

The Contractor or supplier shall make available to the Division, at no cost, engineering data, diagrams, etc. on any later changes or improvements which would increase the performance of the equipment purchased.

The Division reserves the right to withhold any payments which may be due, should it be discovered that the equipment does not meet the Specifications.

715.42.1.3-Pre-Timed Fixed Cycle Traffic Signal Controller (Type FT-3):

The purpose of this section is to set forth specific functional specifications and design requirements for the pre-timed fixed cycle traffic signal controller (local).

The general design requirements in 715.42.1.2 shall apply, except when the specific requirements exceed those in that section.

715.42.1.3.1-Interconnection: Type FT-3 controllers shall be furnished capable of interconnection with a master controller and other local controllers in signal system. A fused, interconnect terminal panel shall be furnished for mounting on the controller cabinet side wall. As a minimum, functional terminals for offset No. 1, offset No. 2, offset No. 3, dial No. 2, dial No. 3 and flashing operation shall be provided.

715.42.1.3.2-Isolation: The FT-3 controller shall also be furnished capable of operating as an isolated controller, functionally programmed by time clocks, master controller or other command device.

715.42.1.4-Pre-Timed Cycle Traffic Signal Master Controller (Type FT-

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3M): The purpose of this section is to set forth specific functional specifications and design requirements for a pre-timed fixed cycle master traffic signal controller (master).

The general design requirements in 715.42.1.2 shall apply, except when the specific requirements herein exceed those in that section.

715.42.1.4.1-System Supervision: Type FT-3M controllers shall be furnished capable of providing system supervision for local controllers (FT-3) or local coordinating units (LCU), or both. All equipment and apparatus necessary to provide this supervision shall be furnished in the controller.

The following supervisory functions shall be furnished in the controller as a minimum:

- i. Means for automatically establishing offset time relations for a system of interconnected FT-3 or LCU units.
- ii. An offset interrupter for decreasing the disruption to interval timing caused by large offset changes.
Offset power shall be routed through an interrupter that is independent of the controller. The interruption interval shall be power on-line for 21 seconds, power off 2 seconds (23 second cycle). The interrupter shall be on breaker circuit No. 2 (flasher circuit).
- iii. Manual switch for transfer of all system controllers to flashing operation.
- iv. Manual switch for selecting dial No. 1, dial No. 2 or dial No. 3 at all interconnected FT-3 or LCU units, or both.
- v. Manual switch for selecting offset No. 1, offset No. 2 or offset No. 3 at all interconnected FT-3 or LCU units, or both.
- vi. Manual switch for transfer to emergency feature operation at all system controllers.

Back panel mode switching shall be furnished to accomplish manual operations.

The following supervisory functions shall also be controllable by the use of time clocks or other command devices:

- i. Selection of offset mode.
- ii. Selection of timing dial unit.
- iii. Selection of system flashing operation.
- iv. Selection of system emergency feature operation.

715.42.2-Solid State Traffic Actuated Signal Controllers:

715.42.2.1-Definition of Terms:

Actuated: Identifies the type of signal control which responds to calling signals generated by action of vehicle or pedestrian.

Action: The operation of any type of detector.

Auxiliary Equipment: Separate devices used to add supplementary

features to a controller assembly.

Cabinet: An outdoor enclosure for housing the controller unit and associated equipment.

Call: (Vehicle or Pedestrian) The result of a detector actuation indicating the presence of a vehicle or pedestrian requesting right-of-way.

Chassis: The traffic signal controller and housing, complete with power supply, internal wiring, harness pin connector and module bays to accommodate the number and type of phase modules specified.

Check: An outgoing circuit that indicates the existence of unanswered call.

Clearance Interval: A specific interval of time which follows after the termination of right-of-way to vehicles or pedestrians.

Controller: A complete electrical mechanism, including timer for controlling the operation of traffic signals.

Coordination: The terms applied to the interrelation between two or more intersection controllers.

Cycle: The total time required to complete one sequence of signal operation around an intersection.

Detector: An electrical device which when actuated signifies the passing or presence of a vehicle or pedestrian desiring the right-of-way.

Digital Timing: Pertaining to a method of timing that operates by counting discrete units.

Dual Max: A controller feature which provides two possible maximum time settings for cycle or right-of-way interval total time before termination.

Extension Unit: The timing interval during the extensible portion which is resettable by each detector actuation. The green right-of-way of the phase may terminate on expiration of the unit extension time.

Extension Limit: The maximum time of the extensible portion for which actuations on any traffic phase may retain the right-of-way after actuation on an opposing traffic phase.

Fail Safe: A controller feature that prevents conflicting phase indications when power or equipment malfunctions occur.

Flasher: A complete electrical mechanism for flashing a traffic signal or beacon.

Force Off: A command that will force the termination of the right-of-way.

Full Actuated: An intersection signal controller with detector input capability in all phases.

Gap Reduction: A feature where the "unit extension" or allowed time spacing between successive vehicle actuations on the phase displaying the green in the extensible portion of the interval is reduced.

Hold: A command that retains the existing right-of-way.

Initial: (Green) Minimum or guaranteed green time allotted the timing phase before which termination can begin.

Interface: A relay or electronic device(s) which isolates and matches one portion of a system to another.

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Interval: Any one of the several divisions of the time cycle during which signal indications do not change.

Interval Sequence: The order of appearance of signal indications during successive intervals of a time cycle.

Main Frame: A definitive single chassis unit within the controller cabinet that contains all signal timing and control logic. This does not include back panels, load switching devices, flashers, breakers, detectors and other peripheral equipment inside the controller cabinet.

Manual Control: A control to permit authorized personnel in the option of terminating an active phase and initiating the next sequence in the signalization cycle.

Maximum: A time limit applied to traffic actuated controls to terminate and recall the timing phase after a predetermined time.

Major Street: The roadway approach or approaches at an intersection normally carrying the major volume of vehicular traffic.

Memory: Holds as recall a momentary vehicle actuation in the phase timer until the proper signal sequence can be displayed to release the vehicle.

Minor Street: The roadway approach or approaches at an intersection normally carrying the minor volume of vehicular traffic.

Modular Design: A design concept such that functions are sectioned into plug-ins units which can be readily exchanged with similar units.

Monitor, Signal Conflict: A device used to continually check for the presence of conflicting signal indications and too provide an output **in response to conflict**.

Nonlocking Memory: A mode of actuated-controller-unit operation which does not require detector memory.

Overlap: A right-of-way indication that allows traffic movement when the right-of-way is being assigned to two or more traffic phases.

Panel: A panel within the controller cabinet upon which are mounted fuse receptacles, terminals, relays and electrically operated switches and other equipment, all suitably insulated.

Passage Period: The time allowed for a vehicle to travel at a selected speed from the detector to the nearest point of conflicting traffic.

Pedestrian-Actuated Controller: An automatic controller in which part of the intervals or groups of intervals, particularly pedestrian WALK and clearance intervals, are initiated by the actuation of a pedestrian detector.

Pedestrian Detector: A detector, usually of the push-button type installed near the roadway and capable of being operated by hand.

Pedestrian Phase: (Pedestrian Movement) A traffic phase allocated exclusively to pedestrian traffic.

Power Line Switch: A manual switch for discontinuing the operation of both traffic controller and traffic control signals.

Power Supply: As used, a fused regulated DC power source for operation of control equipment where necessary. It must be an integral part of the controller chassis.

Pre-emption: The transfer of the control of the signals from any phase or controller mode to a pre-emption timing unit to provide right-of-way for emergency vehicles or trains.

Presence: Term applied to the detection pulse produced by a passing vehicle to be used by the control for other than count purposes. True presence indicates that the pulse duration is equal to the actual time the vehicle remains in the detector field of influence.

Radio Interference Suppressor: A device inserted in the power line in the controller assembly (cabinet) that minimizes the radio interference transmitted back into the power supply line, which interference may be generated by the controller or other mechanisms in the cabinet.

Recall: A manual switch which will cause the automatic return of the right-of-way to a street, regardless of the absence of actuation on that street.

Rest: The interval portion of a phase when present timing requirements have been completed.

Semi-Actuated: A type of traffic actuated controller in which means are provided for traffic actuation on one or more, but not all, approaches to the intersection.

Sequence: The order in which signal intervals are displayed around an intersection when there are calls on all phases of an intersection.

Signal Indication: The illumination of a traffic signal lens or equivalent device, or of a combination of several lenses or equivalent devices, at the same time.

Skip Phase: A feature of actuated intersection control which omits the right-of-way signal indication for a phase or movement that does not have vehicle or pedestrian calls.

Solid State: Circuitry using semi-conductor devices exclusively in contrast to electronic (electron tubes) and electro/mechanical devices (relays, motors, etc.).

Split: The division of time within the signal cycle between adjacent phases in the sequence.

Stop Timing: Refers to the feature of a signal controller by which the application of an external signal or voltage will stop any one or all interval timers from timing further.

Terminate: Applies most frequently to the end of a timing interval. Termination of right-of-way begins in an active phase when a call is received from an inactive phase in a full-actuated control; right-of-way termination must always include adequate clearance intervals.

Time Cycle: The number of seconds required for one complete revolution of the timing dial or complete sequence of signal indications.

Traffic Adjusted: Term used in master supervisory systems where vehicle actuations and other data are fed to the master for effecting signalization changes at several intersections rather than at each intersection independently.

Uniform Manual: (MANUAL OR MUTCD) *Manual on Uniform Traffic Control Devices for Streets and Highways*, published by the Department of Transportation, Federal Highway Administration.

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Vehicle: A mobile inanimate object which legally must use roadways and is subject to traffic control by signalization.

Volume: Numerical count of vehicle traversing a roadway and passing over a detector in the roadway.

Wiring Harness: The multi-terminal (M or F) connector and associated wiring through which all electrical connections into and out of the controller chassis are made. All wiring harnesses shall be at least 48 in. (1.2 meters) long.

Yield: A command which permits the transfer of the right-of-way.

The above list of definitions may not be complete for all terms used. Final interpretation of all terms is the responsibility of the Engineer (See West Virginia Standard Specifications, Sections 101). Where applicable and as approved by the Engineer, definitions as published by the National Electrical Manufacturer's Association, Traffic Control Systems Standards may be applicable.

715.42.2.2-General Design Requirements: The following are minimum design and operating requirements for all types of solid state traffic-actuated signal controllers and associated equipment described in these Specifications.

These controllers shall be phase-modular and completely programmed for the phase and interval sequence specified for that chassis type. Phase, interval sequence and phase sequence functions and associated circuitry shall be assembled on removal plug-in modules. A separate, independent phase module shall be provided for each phase. Controller timing shall be by digital timing, utilizing power line frequency as a base, and be constant and accurate. The length of any interval, portion, period or unit extension as determined by the interval timing setting or any other programmed controller function shall not change due to power supply voltage variations between the limits of 95 to 135 volts AC. The nominal voltage shall be 120 volts AC. The controller and all associated equipment shall be designed to operate from a 120 volt, 60 Hz, AC supply (plus or minus 3.0 Hz).

Specifically, the environmental and operating limits specified in the latest Traffic Control Systems Standards Publication by the National Electrical Manufacturer's Association, designated as NEMA, must be adhered to.

A regulated fused power supply shall be an integral part of the controller chassis and it shall provide the DC voltages required for the operation of all equipment when necessary. This power supply shall provide the internal and external voltages and power requirements for normal operation of the signal equipment.

A dust resistant metal enclosure, or main frame chassis, suitable protected against corrosion shall be provided to enclose all electrical parts of the controller. The control devices, indicator lights, fuse holders, switches, input/output connectors and other components required for the operation and adjustment of the controller shall be mounted on the front panel(s). All component parts and terminals shall be readily accessible when the controller modules are removed from the enclosure for adjustments, testing or service. Circuit board extender cards or cable may be employed to facilitate testing.

The controller shall be designed for placement on a shelf. Maximum main frame sizes shall be as designated by NEMA for each controller chassis type.

The front panel(s) of the controller shall be permanently marked to indicate the module positions, and to identify the fuses, indicator lamps, switches, controls, etc. so that the operation of the controller shall be readily apparent.

The main frame chassis shall be completely equipped and wired for a full complement of modules as required for that chassis type. No additional hardware or wiring shall be required whether or not the main frame is used with the maximum possible number of modules.

All modules shall be removable from the front of the controller and those of unlike function shall be mechanically keyed or electrically inter-locked to prevent insertion into the wrong opening causing controller unit malfunction.

Modules of the same type shall be interchangeable between chassis. All modules shall be provide with controls as necessary to meet the functional requirements. In addition, all control logic for interval and startup sequence, overlap functions, coordination and all other specified controller functions must be an integral part of the main frame chassis.

Each module and associated controller bay shall be identified as to phase or function. To facilitate interchangeability, a guide or track shall be provided for each module assembly in the controller chassis. All modules shall be mechanically secured in the controller so as to retain the assemblies in their proper position under conditions of shock and vibration.

Each grouping of controller components as printed circuit assembly shall have a mean time to failure of three years. Printed circuits shall be of epoxy glass with an extra heavy (two ounces or more) copper track or a superior alternate or as otherwise specified by NEMA standards. Circuit reference symbols for all component parts shall be clearly marked on the circuit boards.

All switching functions internal to the controller shall be accomplished through the use of solid state circuitry. No electrical-mechanical devices, such as camshafts, rotary, stepping or line switches shall be used for switching functions.

All controllers shall be equipped so that they may be coordinated with other controllers or supervised by a master system. This shall be possible by the simple addition of accessory equipment external to the controller.

715.42.2.2.1-Phase Sequence Unit: The phase sequence unit must be an integral part of the controller main frame and shall establish the order and operation of the Phase Timing in accordance with vehicle and pedestrian detector calls.

In the absence of recall or detector actuation, the right-of-way shall remain on the traffic phase upon which the last actuation occurred. The actuation of any detector during the extendible portion of a traffic phase having the right-of-way shall cause the retention of right-of-way by that traffic phase for one unit extension from the time of actuation. One unit extension interval of time shall be guaranteed for each vehicle actuation registered during the extendible period. Each actuation shall cancel the remainder of the previous unit extension

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interval in effect and initiate a complete new unit extension interval, timed from the instant of actuation. The actuation of a detector on another phase shall cause the right-of-way to transfer to that phase if during the extendible portion of the timing phase there have been no actuations for more than one full unit extension interval of time.

An actuation during the clearance period for a traffic phase shall cause the right-of-way to return to that phase in the same manner. Also, when the right-of-way is transferred by operation of the extension limit, the terminated phase shall again receive the right-of-way in the above manner without further detector actuations.

The controller shall be equipped with provision for skipping any phase when there is no call for that particular phase. Exact phase sequence when there are calls on three or more traffic phases shall be as specified for each controller chassis type.

The term "Phase A" as used shall in all cases refer to the artery or mainline phase. It shall be the first phase in the sequence of phases. Other phases such as B, C etc. shall follow Phase A in alphabetical sequence with right-of-way assigned in accordance with the above, or specified sequence logic.

715.42.2.2.2-Interval Sequence Unit: The interval sequence unit must be an integral part of the main frame and shall determine the order and control of the various intervals of each phase. The rotation shall be Green, Yellow, All Red and Red for vehicle movements and Steady Walk, Flashing Don't Walk and Steady Don't Walk for pedestrian movements.

The transfer of the right-of-way from any traffic movement shall take place only after a proper clearance period.

The clearance period for each vehicular phase shall consist of a vehicle change (Yellow) and an All Red Clearance interval. Each shall be timed separately and the second clearance interval of any phase may be omitted by a simple timing adjustment.

The clearance period for a pedestrian movement shall be a Flashing Don't Walk.

715.42.2.2.3-Interval Settings and Adjustments: The controller shall provide a positive means of setting signal timing intervals. The settings for each interval shall be in seconds or divisions of a second and the controller shall provide a clear visual display of the length of each interval or period. The interval settings shall be color coded, easily identifiable and shall be made by means of dials or thumbwheels. Settings shall be provided for each phase interval and shall be mounted on the front of the associated main frame phase module. It shall not be necessary to use punched data cards, remove or change wires, pins or contacts, or to use tools of any kind in making interval adjustments. All dials shall be on the front of the controller and easily accessible.

The minimum green interval shall be equal to either initial and one unit extension, walk plus pedestrian clearance, or walk plus pedestrian clearance

plus one extension.

The timing of the extension limit shall commence with the first actuation or other registration of traffic demand for the right-of-way on any traffic phase not having the right-of-way, and should begin after the initial period has expired.

In the event the controller reverts to the start-up sequence, the signal operation shall be initiated in the Phase A green interval and at least one initial and one unit extension (or vehicle interval) period shall be timed while in that sequence. As part of the initialization routine, vehicle calls shall be placed on all phases.

All phases shall be provided with at least the following intervals and minimum range of interval settings:

i.	Initial Interval	0 to 99 Seconds
ii.	Vehicle Interval (Extension)	0 to 9 Seconds
iii.	Yellow Interval	0 to 9 Seconds
iv.	Maximum Extension	10 to 99 Seconds
v.	All Red Clearance	0 to 9 Seconds

Time spans and actuation limits specified are minimum and may be expanded.

Each phase shall be provided with recall and memory control. Capability to initiate the maximum or single unit extension recall shall be provided for each phase. In addition, phase memory of vehicle actuations during any interval shall be provided. There shall also be a "Memory Off" control for each phase to delete the memory feature when it is not required.

The controller shall be provided with a vehicle call indicator light for each phase. The indicator light shall respond to each vehicle call on its phase. The indicator light shall go off at the end or the initial portion of the green interval and indicate each actuation momentarily during the extendible portion of the green interval. Sufficient monitoring lights must be provided on the controller to visually indicate what part of the controller's timing and what function will follow. The monitoring lights shall be an integral part of the controller and must be a standard rather than an optional feature.

The front panel of the modules shall be engraved, silk screened or otherwise permanently marked to indicate module type and identify indicator lamps, switches, controls, etc. so that the functions of the module are readily apparent.

715.42.2.2.4-Flashing Operation: For use during periods of low traffic volume or emergency conditions, a flasher unit shall be provided to flash all signal indications displayed during any specified yellow-red or all-red sequence.

Upon resumption of controller operation of the signal indications, Flashing Red indications must be followed by the Steady Red or Steady Green interval

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of that sequence and Flashing Yellow must be followed by the Steady Green interval. This logic must be built into each controller main frame chassis.

The controller shall be designed such that a fuse failure (open) on the controller side of the power supply will automatically switch the signal to flashing operation.

715.42.2.2.5-Manual Control Feature: The controller shall be so designed that by wiring external to the controller, manual control of signal sequence timing may be assumed. The manual control function may be assumed with the application of the Stop Timing command. The operator may sequence the controller by applying input signals with a Manual Advance Switch.

715.42.2.2.6-Uninterrupted Timing: Normal traffic-actuated operation shall be resumed automatically after Manual, Flashing Preemption or any other special operation has been utilized.

715.42.2.2.7-Stop Timing: Means shall be provided so that on call, timing may be stopped on any one of all interval timers in the control system. This is provided for the purpose of adding extra intervals or auxiliary equipment, or both. Upon resumption of timing, the interrupted interval shall be timed in its entirety.

715.42.2.2.8-Auxiliary Equipment: The controller shall be so designed that all standard auxiliary equipment may be added without internal controller modifications. Railroad or fire station pre-emption equipment shall be constructed and wired so as to transfer control of the signals from either the controller or the flasher unit to the preemption timing unit. Installation of the pre-emption equipment shall not alter the internal wiring of the controller chassis normally furnished by the manufacturer. In addition, the controller shall be furnished capable, by the addition of standard accessories external to the controller, of the following functions:

- i. Actuated pedestrian timing associated with each phase.
- ii. Minor movements associated with each phase.
- iii. Overlaps as required.

715.42.2.2.9-Check Circuit: All controllers must be provided with a check circuit to indicate the presence or absence of an actuation on any of the phases which do not have the right-of-way so that a pedestrian interval timer may be added to any phase without additional equipment, other than the pedestrian timer.

715.42.2.2.10-Connectors and Wiring Harness: All electrical connections to and from the controller shall be made through MIL-C-26482 series pin connectors and wiring harness. Each wiring harness shall be at least 4 feet (1.2 m) long or of the standard length specified by the manufacturer for

that controller chassis type. The harness end opposite the connector shall have color-coded leads or labeled sleeves. The harness connections shall be mounted on the front of the controller unit in accordance with the following:

Connector A shall intermate with an MS3116()-22-55S.

Connector B shall intermate with an MS3116()-22-55P.

Connector C shall intermate with an MS3116()-24-61P.

The wiring harness, harness terminal functions and the MS connectors shall be identical for each connector type.

Terminals shall be provided for the signal light cable. One terminal for each signal circuit and one or more terminals for the common conductors are required. All field wiring shall be color coded and the terminals labeled.

The outgoing signal circuits shall be of the same polarity as the line side of the power supply and the common return shall be of the same polarity as the ground side of the power supply.

A double pole, low-voltage lighting arrester with mounting bracket shall be mounted on the back panel and wiring between the power supply and the fuse.

All terminals except the interconnect system shall be mounted on the controller panel. The interconnect terminals shall be mounted on the side of the controller cabinet unless otherwise specified.

715.42.2.2.11-Controller Terminal Functions Required: All controller functions shall be available at the MS connector terminals on the controller chassis. These functions shall be as specified in the latest NEMA standard-identification of input/output pin connector termination.

In addition, the controller shall be provided with all terminal functions necessary for plan phasing and to meet the specification requirements. All functions shall be standard controller features and shall be available at the external controller terminal points.

715.42.2.2.12-Per Phase Load Switching Devices: Solid-state, heavy-duty, jack mounted, per phase load switching units shall be used for opening and closing the signal light circuits. Each switching circuit shall have a minimum rating of 10 amperes for a tungsten-lamp or gas-tubing transformer load over a voltage range of 95 to 135 volts at 60 Hz. No more than one circuit shall be energized at any one time unless the combined load on the energized circuits does not exceed a 10 ampere load. This, power handling capability shall not be derated for operation over the operating ambient temperature range described in the NEMA standards.

Covers or cover plates on all switching devices shall be so designed as to be easily removed and replaced by means of set screws or similar replaceable securing devices.

All load switches shall intermate with a Cinch-Jones socket S-2412-SB, or the equivalent. Physical and electrical characteristics of the switches and load racks must conform to the latest NEMA standards.

Signal load switches for use with the controller, but for mounting external to the controller units specified, shall be used for switching signal light circuits.

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715.42.2.2.13-Fail Safe: Insofar as possible, all phase and interval sequence logic internal to the controller shall be such that conflicting signal indications are not possible even during power failures or equipment malfunction. If "failsafe" signal monitoring devices are required external to the controller, it must be clearly stated in the manufacturer's instructions.

In the same manner, combinations of signal indications expressly prohibited in the Manual on Uniform Traffic Control Devices shall not be possible.

715.42.2.2.14-Warranties and Guarantees: The Contractor or supplier is required to turn over to the Division any guarantee or warranties which are given by the manufacturer as a normal policy. The Contractor or supplier shall furnish the Division with two copies of complete drawings, diagrams and manufacturer's instructions for installing and maintaining the equipment and any assistance as required for timing and operation of the equipment. Any component called for by the circuit design which has special or unique characteristics which would limit that component to certain manufacturers or suppliers shall be so indicated in the manufacturer's instructions.

The Contractor or supplier shall make available to the Division at no cost, engineering data, diagrams, etc. on any later changes or improvements which would increase the performance of the equipment purchased.

The Division reserves the right to withhold any payments which may be due, should it be discovered that the equipment does not meet the Specifications.

All components specified shall be amply derated with regard to heat dissipating capacity and rated voltage so that, with maximum ambient temperature and maximum applied voltage, material shortening of life or shift in values shall not occur.

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715.42.2.5-Solid State Traffic-Actuated Signal Controller (Type C) (Two Through Eight-Phase NEMA-Microprocessor Based-Keyboard Entry): The purpose of this section is to set forth functional specifications for a microprocessor based, fully traffic-actuated dual-ring, functional modular controller unit capable of providing up to eight phase signal operation. Timing and per phase functions shall be programmable by main frame single keyboard entry; per-phase modular entry is not acceptable. Single entry timing mode shall be provided.

In addition to the above named, the Controller must provide a true MENU format for data entry. As a minimum, a forty (40) character by four (4) line, alpha-numeric liquid crystal data display screen must be provided on the front of the controller. The display must be easily visible in both full daylight and at night. Back lighting the display is required.

The general design requirement of 715.42.2.2, as well as the NEMA

standards, shall apply except when the specific requirements exceed those in that section of the standards.

Phase designation and sequencing shall be as outlined in 715.42.2 of these Specifications.

The Controller must be capable of storing timings and other control parameters in an internal data memory. This data must then be accessible for display and/or alteration by means of front panel keyboard control and display. Coded memory access or other approved entry control must be provided.

Power requirements and recovery from power interruption shall be as specified in current NEMA standards for solid-state signal controllers. Internal backup battery power to maintain the controller memory for up to one year in the absence of A/C power input must be provided in the controller.

Full volume density operation per phase with walk must be an integral part of the controller logic, including variable initial and gap reduction. MUTCD flash operation, overlap programming, multiple phase configurations, partial or full entry capability, last car passage per phase and extended dual ring status display must also be provided in the controller.

All inputs, outputs, interface voltage and interface common returns shall be through front panel pin connectors. These connectors shall be as specified in 715.42.2.2.10. I/O pin functions shall be in accordance with current NEMA standards.

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715.42.4-Local Coordinating Units:

715.42.4.1-General Design Requirements: The following are minimum design and operating requirements for all types of local coordinating units. The general design requirements apply to master coordinating units and secondary coordinating units; both dial, electromechanical (LCU-EM) and digital, full solid state (LCU-DS). Local coordinating units provided for an interconnected signal system shall be completely compatible with the master controller and all local controllers in that system.

The coordinating units described shall be used in conjunction with solid state traffic actuated signal controllers and traffic adjusted master controllers. The coordinators shall inhibit the internal extension limit in the local controllers and provide external maximum control. Background cycle lengths, splits, system offsets and other coordination functions as required shall be called in by a master controller or coordinator. These functions may also be called in by local or master override or time switches.

For definition purposes, traffic phases shall be considered as running in sequence, such as A-B-C-D, etc. Also, any of these phases may consist of two separate auxiliary movements which must begin simultaneously but may end at different times, as long as the following phase is the auxiliary's associated thru-phase.

All coordinating units shall be furnished capable of at least the following:

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- i. Three background time cycles.
- ii. A separate split associated with each time cycle.
- iii. Three offsets associated with each time cycle.
- iv. A variable permissive period for yielding to minor phases (B,C, etc.).
- v. External maximum limits (force offs) as required for all associated phases.
- vi. System offset interruption, unless provided for in the system master controller.
- vii. Capability of generating cycle lengths of at least 60, 70, 80, 90, 100 and 120 in association with each split and each offset.
- viii. Master-intersection control and supervision of other coordinating units as required.
- ix. Free operation when called for by the system master, time switch or manual override.
- x. A minimum of eleven independent in and out functions shall be provided per dial with associated circuitry to provide yield, force off, free operation, system sync, dial transfer, etc.

It shall be possible to set offset, splits and all synchronization functions from the front of the coordinating unit. It shall be possible to make these settings in at least one percent steps to any percentage of the associated cycle length and all such settings shall be clearly indicated.

Each coordinating unit shall be plug-connected, and it shall be possible to remove a unit and replace it with a similar unit without shutting off the power to the controller or signals. Removal of the coordinating unit and insertion of the coordinating unit harness receptacle into a shorting plug, which shall be mounted on the cabinet wall, shall cause the local controller to go to free operation.

In addition, each coordinating unit shall be provided with a switch on the front panel for selection of free or coordinated operation and at least the selection of one of three cycle lengths. Synchronization shall only be in effect in the coordinated position.

Switch indicator lights shall be provided at the local coordinating units to indicate the synchronization period in effect.

Absence or conflict of offset or cycle information on the interconnect shall place the coordinating unit in cycle number one, offset number one (average offset) or a pre-set standby cycle.

When the controller is working in coordinated operation, the internal maximum of the controller for Phase A shall be disabled. At all other times, the internal maximum of the controller shall remain operable.

Cycle change and transfer from free to coordinated operation shall take place at the first yield point (end of Phase A), unless otherwise specified.

When required in the coordinating unit, system offset interruption shall be adjustable in the range of at least 0 to 40 seconds. When the local coordinating

unit, for any reason, gets out of synchronization with the master system, the length of the dwell in any one cycle shall be limited to the time allowed by the offset interrupter. Timing shall start at the beginning of the dwell. A switch shall be provided to eliminate the offset interrupter from the interconnected system.

Any changes in the operation of traffic control signal lights caused by turning the signal lights off, or transfer to flashing or preempt operation shall not interfere with the continued in-time operation of the coordination timer. A transfer from such special operation back to normal automatic operation shall immediately establish the normal time cycle and subsequently the in-time relation.

Each coordinating unit shall be furnished with two service manuals complete with all necessary instructions and diagrams for the installation and maintenance of the equipment supplied and two complete wiring diagrams. These wiring diagrams shall identify the color code or wire tagging used in all connections.

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715.42.4.3-Time Base Coordinating Units(Type TBC): The purpose of this section is to set forth functional specifications and design requirements for signal coordinating units that do not require communications interconnect or synchronous motors to maintain a signal system time base. These units will be designated as Time Base Coordinating Units or TBC.

The general functional requirements in 715.42.4.1 for "hardwire" coordinating units shall apply to the TBC except where otherwise noted. All units shall be capable of the coordination of two (2) through eight (8) signal phases per controller.

TBC units are to be used in conjunction with solid state traffic actuated signal controllers.

The coordinating unit circuitry shall be of the latest solid state digital design. The units shall be completely self-contained and designed to be shelf mounted as auxiliary equipment in standard traffic signal controller cabinets.

The units shall operate normally on 115 VAC, 60 Hz line power and shall provide immediate standby battery power for the clock and programmable memory upon interruption of on-line power. Time base timing accuracy for normal (non-battery) operation shall be ± 1 second/month of continuous operation. Line voltage tolerance for specified operation shall be up to 135 VAC and down to 95 VAC. NEMA specified transient protection shall also be provided with each unit. Operating temperature, humidity and all other environmental tolerances specified in current NEMA standards shall be met.

Battery power for standby operation shall be of the rechargeable type and provide at least 100 consecutive hours of standby operation after 48 hours of normal operation with a minimum 3-year life. Standby clock accuracy shall be at least 0.005% in 48 hours.

The following programmable functions shall be available to the user via

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front of unit keyboard entry.

Minimum 100 time of day (TOD) program events per day of week

Four (4) cycle lengths

Three (3) offsets per cycle

Two (2) daylight savings time changes

Free operation selection

Four (4) synchronization reference times (1 per cycle)

At least eight (8) outputs associated with the above functions shall be provided. Outputs must be provided for synchronization, yield, force-off, phase omit (etc.); in addition, a minimum of three (3) auxiliary outputs shall be available to operate controller functions such as flash, MAX II, change of phase sequence, switching of detectors (etc.). The outputs shall be of the voltage required by the system configuration.

All program entries shall be available upon demand on a front panel display that is easily readable when shaded from direct sunlight. Output status shall also be available on the unit front panel display. In addition, the unit shall give positive feedback to the programmer that a keyboard entry was made and recognized. This also must be displayed on the front panel by readily discernible means.

Program transfer capability via data transfer port and cable must be provided on each unit. Standard interconnecting cable for this function must be provided with each unit.

715.42.5-Traffic Detectors:

715.42.5.1-General Design Requirements: The following are minimum design and operating requirements for all types of traffic detector units. The general design requirements apply to both the loop detectors and the magnetic probe detectors. Detector units within a traffic-actuated system shall be completely compatible with the control units in that system.

The detector units described shall be used in conjunction with pre-timed fixed cycle traffic signal controllers, solid-state traffic actuated signal controllers and traffic adjusted master system signal controllers.

The detector circuitry shall be solid state and all component parts shall be of high quality meeting the maximum acceptable standards of good engineering practices. All components shall be amply derated with regard to heat dissipating capacity and rated voltage so that, with maximum ambient temperature and maximum applied voltage, material shortening of life or shift in values shall not occur. Any component called for by the circuit design which has special or unique characteristics which would limit that component to certain manufacturers or suppliers shall be so indicated in the manufacturer's installation, operation and service instructions.

The detectors shall be capable of sensing both passage and presence of vehicles and shall not be affected by rain or other weather conditions. It shall be possible to change from passage to presence detection by a selector switch mounted on the outside of the detector unit case. The passage or presence of

a vehicle over a road sensor shall activate an output relay.

The pulse detection mode shall provide a short output signal for each vehicle entering the roadway sensor zone of detection.

The presence detection mode shall provide a vehicle presence output signal for as long as a vehicle is stopped in the roadway sensor zone or as otherwise specified.

The detectors shall be designed "fail safe." In case of power failure, the output relay shall remain in the closed position.

All detector units shall be designed to operate from a 120 volt (plus or minus 10 percent), 60 Hz, AC power line service.

The detector units shall be completely self-contained and shall include an integral, fused power supply. The detector chassis shall be enclosed in a removable, sturdy aluminum or other non-corrosive metal case. The case shall furnish the chassis protection from moisture and other ambient conditions. The detector shall be of such a size as to readily fit into a cabinet with the signal controller when so required. All electrical connections to and from the detector unit shall be made through a multiterminal, quick disconnect, plug-type connector and wiring harness. Each wiring harness shall be at least 36 in. (900 mm) long. The harness end opposite the connector shall have color-coded leads or labeled sleeves. The harness connection shall be such that the detector may be replaced with a similar unit, without the necessity of disconnecting and reconnecting individual wires leading therefrom.

If the detector is mounted in the same cabinet with signal control equipment, all harness connections except power supply and vehicle call to controller shall be made on a separate terminal strip mounted in the controller cabinet for that purpose. Power supply connection and a vehicle call to controller may be connected to terminals on the controller back-panel.

A front panel light, clearly visible under full daylight conditions, shall be provided to indicate when a vehicle is in the detection area.

An instruction manual and an internal wiring schematic drawing shall be provided with each detector to facilitate installation, operation and service of the units.

The Contractor or equipment supplier shall turn over to the Division any guarantee or warranties which are given by the equipment manufacturer as a normal policy.

NOTE: The above general design requirements do not apply to pedestrian detectors. Pedestrian push buttons are covered in 715.42.5.4.

715.42.5.2-Loop Traffic Detectors (LPS):

The purpose of this section is to set forth functional specifications and design requirements for a solid state digital, automatically tuned and completely self-contained, shelf-mounted unit for detecting the passage or presence of vehicles when connected to a wire loop embedded in the roadway surface.

The general design requirements in 715.42.5.1 and NEMA standards shall apply except when the specific requirements exceed those in 715.42.5.1 and NEMA.

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The detector shall respond only to vehicles either stopped in or passing over any portion of the roadway loop. The unit shall be capable of driving loops of various sizes and configurations within a range of 30-1,000 microhenries. It shall be capable of tuning loops of up to 50 feet (15 m) in length with up to 1,000 feet (300 m) of lead-in wire. The detector shall be capable of detecting vehicles traveling at any speed between zero and 100 mph. (0 and 160 km/hr.).

Individual sensor-detector assemblies shall operate satisfactorily under conditions where adjacent sensors are located within 6 feet (1.8 m) of each other.

The following minimum controls or equivalent shall be provided on the front panel of the detector.

- i. Frequency.....High, median and low
- ii. Sensitivity.....As specified below
- iii. Presence.....As specified below

Sensitivity - Three selections of minimum thresholds that will detect changes in total loop inductance as low as (1) 0.02%, (2) 0.08% and (3) 0.32%.

Presence - Three selections of presence time modes (1) long - 3.5 minutes (minimum), (2) medium - 20 seconds (minimum), (3) pulse – 125± 25 milliseconds pulse per vehicle.

All electrical connections to the detector shall be made through a single front-mounted, 11 pin, amphenol connector. The connection mounted on the detector shall be male-type and shall be protected and rigidly fixed.

A mating female receptacle with appropriate cable clamps and at least 4 feet (1.2 m) of connecting harness cable shall be provided with each detector. The other end of the cable shall have color-coded leads, or labeled sleeves, each of which shall be fitted with positive grip, and crimp spade terminals for field connections.

The 11 pin connector on the detector shall have the following pin assignments: (Adapter harnesses will not be acceptable.)

PIN NUMBER	CIRCUIT
1	Fused side of 120 volt AC line
2	Neutral side of 120 volt AC line
3	Not Used
4	Earth
5	Relay common contact
6	Relay, normally open, contact
7	Loop
8	Loop
9	Relay, normally closed, contact
10	Not Used
11	Not Used

Detector loopwire and detector feeder cable shall be as specified in 715.42.13. Loop layout and configuration shall be specified in the plans, or as directed by the Engineer.

Output interfacing shall be by means of relay circuitry. All components shall meet the latest requirements of the NEMA Standards.

Type LPS SD detectors shall meet all the requirements of the specifications for 715.42.5.2 - Loop Traffic Detectors (LPS), but in addition, must have separate built-in stretch and delay timers with 0 to 15, 0 to 30, and 0 to 60 seconds timing ranges.

715.42.6-Adjustable Face Signal Heads:

715.42.6.1-Definition of Terms:

Lane Control Signal Head: An assembly containing one or more signal faces having indications used to permit or prohibit the use of specific lanes of a street or highway.

Lens: That part of the optical unit which redirects the light coming directly from the lamp and its reflector.

Optically Programmed Signal Head: An assembly containing one or more signal faces which may be designated accordingly as one-way, two-way, etc., permitting the visibility zone of the indication to be determined optically.

Optical Unit: An assembly of redirecting cover glass or lens, reflector, lamp and lamp socket with the necessary supporting parts to be used for providing a single signal indication.

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Pedestrian Control Signal: A traffic control signal, manually, electrically or mechanically operated which is erected for the exclusive purpose of directing pedestrian traffic at signalized locations.

Signal Face: That part of a signal head provided for controlling traffic in a single direction. Turning indications may be included in a signal head.

Signal Head: An assembly containing one or more signal faces which may be designated accordingly as one-way, two-way etc.

Signal Indication: The illumination of a traffic signal lens or equivalent device or a combination of several lenses or equivalent devices at the same time.

Traffic Control Signal: Any device, whether manually, electrically or mechanically operated, by which traffic is alternately directed to stop and permitted to proceed.

NOTE: The above list of definitions may not be complete for all terms used. Final interpretations of all terms is the responsibility of the Engineer (see West Virginia Standard Specifications, Section 101).

715.42.6.2-Traffic Control Signal Heads: Each signal shall be of the adjustable, colored light, vertical type with the number and type of sections described and shown on the Plans. Each head shall have an indication in one direction only and shall be adjustable through 360 degrees about a vertical axis.

All new signal heads at any one intersection shall be of the same make and type.

Position of Signal Indications:

All signal indications shall be in a straight line and shall be in the following order although all indications shown need not be included in all cases. In vertical signals, Position 1 shall be at the top, the Position 8 at the bottom. In horizontal signals, Position 1 shall be at the left (facing the signal), and position 6 at the right.

POSITION		SIGNAL INDICATION
Vertical	Horizontal	
1	1	Red
2	2	Yellow
3	4	Green
4	5	Straight Thru Arrow
5	3	Left Turn Arrow
6	6	Right Turn Arrow
7		Don't Walk Symbol
8		Walk Symbol

Pedestrian signal indication shall be mounted separately below the conventional post mounted signal to allow for separate directional facing for

these indications and to obtain definition of the signal by spacing. At no time will a pedestrian signal indication be allowed to hang below an overhead-mounted signal.

Assembly:

Each head shall consist of an assembly of individual interchangeable sections securely bolted together to form a unit. There shall be no tie rods used in the assembly. The finished assembly shall present a clean, neat appearance. Each individual section shall house a complete optical unit. It shall be possible to assembly any combination of 8 in. and 12 in. (203 mm and 305 mm) heads without the use of special adapters.

The top and bottom of each section shall have an opening to accommodate standard 1½ in. (DN40) pipe brackets. The opening shall be in line vertically. The assembly shall be capable of being rotated between standard waterproof supporting brackets or trunnions and thus aimed in any direction in the horizontal plane. The portion of each section adjacent to the bracket openings and the portion used for connecting sections shall be properly reinforced to provide sufficient strength to resist shock, vibration and impact damage.

Each section shall have lugs for the mounting of at least one six-position, twelve-terminal, barrier-type terminal block.

Each section shall have lugs or pads such that backplates may be mounted without drilling or tapping the section.

The housing door shall be a one-piece square casting, having two hinge locations on the left side and at least one latch location on the right side. The hinges shall have stainless steel pins at least 3/16 inch (5 mm) in diameter. The latch shall consist (1) a latch jaw on the door and a stainless steel latch screw, wing nut, and washer securely affixed to the housing, or (2) a captive wing nut, washer, and screw assembly on the door and a captive nut in the housing. It shall be possible to open and remove the door without the use of any tools.

The door shall have a gasketed opening that shall provide a visible lens diameter of 7 ¾ to 8 in. (197 to 203 mm) for a nominal 8 in. (203 mm) lens and 11½ to 12 in. (292 to 305 mm) for a nominal 12 in. (305 mm) lens. All lenses shall be as described in 715.42.6.4.

The door shall have four equally spaced visor attachment points around the lens opening.

Visors shall be at least 7 inches (175 mm) long for an 8-inch (203 mm) lens and at least 9½ inches (241 mm) long for a 12-inch lens (305 mm). Visors shall be described as cutaway, tunnel, or full circle. All heads shall be supplied with tunnel visors, unless otherwise noted on the Plans or unless prior permission from the Division has been received. All new replacement signal heads at any one intersection shall have the same type as the existing visors supplied, unless otherwise specified on the Plans.

Visors shall be designed with a downward tilt between 3½ degrees and 5 degrees, shall eliminate the escape of light from one indication to another, and with the optical unit, shall eliminate the return of outside rays entering the unit from above the horizontal (known as sun phantom).

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The Signal Sections, all brackets, trunions and suspension devices shall be painted in accordance with ITE (INSTITUTE TRANSPORTATION ENGINEERS) Specifications. The inside of the signal section visors shall be flat black enamel to eliminate objectionable reflections. Non-Metallic signal sections must have a color impregnated finish and be the same color as the enameled sections. The inside of non-metallic visors must also be painted with a permanent flat black enamel or use other means to prevent reflections.

The optical unit shall consist of the lamp, lampholder, reflector, lens gasket and lens, and shall be so designed that all light emitted by the unit passes through the lens and so that any possibility of false indications is eliminated.

The lampholder shall be of heat resisting material designed to properly position a medium screw base traffic signal lamp, with means to accommodate a lamp having light center 2-7/16 inches (60 mm) in length for the 60-watt and 100-watt series and 3 inches (75 mm) in length for the 150-watt series. The lampholder shall be provided with a lamp grip to prevent the lamp from working loose due to vibration. Provision shall be made on either the lampholder or the reflector holder to permit rotation of the lamp so that the lead-in wires are up and the lamp shall be retained securely in that position, but no change in position of the socket with respect to the optical center of the reflector shall occur. The metal portion of the lampholder shall be compatible with brass or copper.

Each lampholder shall be provided with two coded No. 18 or larger lead wires, type TEW, 600-watt, AWM fixture with 2/64 in. (0.8 mm), 221° F (105° C) rating thermoplastic insulation, securely fastened to the socket, and with sufficient length to reach the terminal block with the holder or door fully open.

The thermoplastic insulation shall at minus 30°F (-34° C) be capable of being bent six times around a 1 in. (25 mm) mandrel without damage to its insulating properties at rated voltage. A suitable terminal block or blocks shall be provided in the second section from the top or in each section of one-section heads. The terminal block shall have at least one section for each signal head section plus at least two additional sections per block. Terminal blocks shall be standard commercially available units.

Reflectors shall be specular aluminum in accordance with the latest ITE Specifications and shall be mounted in a reflector holder. The reflector holder shall provide a rigid reflector mounting to assure proper alignment between the lens and the reflector with the door closed. The reflector shall have a lampholder opening in the back. The reflector shall have a bead or flange on the outer edge to stiffen the reflector and insure its dimensional stability. The reflecting surface shall be totally free from flaws, scratches, defacements and mechanical distortion.

The lens gasket shall be a slotted circular neoprene gasket specifically designed to exclude moisture, dust and road film. The optical unit shall be sealed to exclude moisture and dust. This may be accomplished in one of two ways:

- i. If the open door contains the complete optical unit, the reflector/door

and the reflector/lampholder interfaces shall be equipped with specially designed neoprene seals to completely seal the optical unit. The section must not accumulate water.

- ii. If the reflector and lampholder remain in the section when the door is opened, the entire section shall be made watertight and dust tight by a weatherproof neoprene gasket contained in a gasket groove in the door. The gasket shall seal against a raised bead in the section to provide the proper seal.

The lighted signal shall appear to be illuminated over the entire visible lens surface without shadows when viewed from any angle up to 30 degrees each side of the optical axis horizontally and up to 45 degrees below the optical axis vertically.

The required appearance, light distribution and candle power intensity from the complete assembled section shall meet latest revision of the ITE Specification. "A Standard for Adjustable Face Vehicle Traffic Control Signal Heads."

Trunnions, Brackets and Suspensions:

All trunnions, brackets and suspensions used for assembling and mounting vehicle traffic control signal heads shall be entirely weathertight without the use of externally applied sealants or caulking. The trunnions, brackets and suspensions shall be the same manufacturer as the signal heads.

All tubular parts shall be 1½ in. IPS (DN40) pipe. When hollow cast brackets or trunnions are used, they shall be of sufficient strength to support the maximum load imposed by the signal heads under all normal wind conditions.

The lower support or connection between signal heads in a spanwire or mast-arm mounted signal may be an aluminum casting or stamping of suitable strength.

Wire raceway areas within brackets, trunnions and suspensions shall be of adequate size to carry all necessary wires without crowding, and raceway surfaces shall be free of sharp edges or protrusions which might damage insulation on wires.

Suspensions for mast-arm or span-wire mounting shall include a device to permit adjustment for proper vertical alignment of the signal head.

Non-metallic trunnions, brackets and suspension parts previously approved by the Division may be supplied. Such parts must be capable of mounting both metallic and non-metallic signal heads and must have metallic reinforcement at points of anticipated wear.

Reinforcing metal must be compatible with aluminum, steel and galvanized steel.

Backplates:

All signal head assemblies so indicated on the Plans shall be provided with backplates designed to fit the combination of sections for each signal face.

These backplates shall be fabricated from non-ferrous metal of gage to

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withstand distortion in 60 mph. (100 km/hr) winds and shall be firmly attached to each signal face in such a manner as to withstand the above wind load and to permit the opening of any signal independent from the other doors in the signal face.

Overhead signal heads shall have backplates with a 5 inch (125 mm) border.

Pedestal mounted signals shall have backplates with an eight inch (200 mm) border.

The backplates shall be finished with the best quality, oven-baked black enamel and shall comply with Federal Specifications TT-E-489.

715.42.6.3-Metallic Signal Heads: Each head of this type shall be constructed primarily of aluminum and aluminum castings and stainless steel, and shall meet all requirements in 715.42.6.2, and shall accept lenses and lamps as described in 715.42.6.4.

The section and door shall be one-piece, corrosion-resistant aluminum alloy die castings. Visors and reflectors shall be made from sheet aluminum or die castings.

All cast metal parts shall have a tensile strength of not less than 17,000 psi. (117 MPa) All castings shall be clean, smooth and free from flaws, cracks, blowholes and other imperfections. The castings shall conform to ASTM B 85 alloys SC84A, SC84B, SG100A, SG100B, S12A or S12B.

Sheet aluminum parts shall be manufactured from corrosion-resistant aluminum sheet having a tensile strength of at least 20,000 psi (138 MPa), except that reflectors shall be manufactured from the aluminum alloy suggested by the manufacturer.

All hinge pins and latch parts shall be Type 304, stainless steel.

Miscellaneous parts and hardware shall be made of non-corrosive materials.

All parts shall have sufficient strength to show minimal damage under severe loading conditions. Visors shall be not less than 0.05 in. (1.31 mm) thick. Reflectors shall be spun or drawn from aluminum not less than 0.025 in. (0.64 mm) thick.

715.42.6.4-Non-Metallic Signal Heads: Each head of this type shall be constructed primarily of a non-metallic material, aluminum and stainless steel, shall meet all requirements of 715.42.6.2 and shall accept lenses and lamps as described below. The non-metallic material used shall be durable and resistant to marring, scratching, discoloration, weather, temperature change, shock and color change from weather or photochemical action. The thickness of the non-metallic material shall be sufficient to provide at least the strength of the cast aluminum product of the same manufacturer at any location tested.

In addition, the finished section shall pass the following test for strength: A completely wired three-section head without lamps or visors shall be securely fastened between two brackets. A one-pound(450 gram) weight with a spherical tip 2 inches (50 mm) in diameter shall be impacted into the center

section on any surface including the door with an impact of 70 ft-lb. No part of any section, except the lens, shall be dented, cracked, crazed, chipped, punctured or otherwise visibly damaged.

The test shall be conducted at 0°F, 70°F and 120°F (at -18° C, 21° C and 49° C) ambient temperatures after the head has been kept at the test temperature for 12 hours. Immediately after the test, lamps shall be installed and the head shall be shown to function normally.

The non-metallic material, resin and reinforcement fibers, where used, shall be die-cast to produce a smooth glossy surface to which water, dirt and diesel oil will not readily adhere. Colors shall be cast integrally in the material. The finished product shall be free from all visible casting defects, including color variances. All hinge pins and latch parts shall be Type 304 stainless steel.

Miscellaneous parts and hardware shall be made of a non-corrosive material.

Visors shall be at least as strong as aluminum sheet with a tensile strength of 20,000 psi (138 MPa) and a thickness of 0.05 in. (1.3 mm)

All parts shall have sufficient strength to show minimal damage under severe loading conditions.

Lamps and Lenses:

Lamps: The lamps supplied with the traffic signal heads shall have the filament adequately supported to withstand the vibration induced from truck traffic and heavy winds. The light center length (LCL) is the dimension, in inches (mm), from the center of the filament to the tip of the base. All traffic signal lamps shall have a brass, standard, medium screw base, a clear glass envelope and shall be in conformance with the following design requirements:

- i. All 8 in. or 12 in. (203 or 305 mm) traffic signal indications shall have a lamp rating of between 110 and 120 watts, a light center length (LCL) of 2-7/16 in. (60 mm), with a minimum initial lumen value of 1,260 and a rated life of at least 6,000 hours.
- ii. All 8 in. or 12 in. (203 or 305 mm) traffic signal indications, used exclusively for flashing operation shall have a lamp rating of between 60 and 70 watts, a light center length (LCL) of 2-7/16 in. (60 mm), with a minimum initial lumen value of 665 and a rated life of at least 6,000 hours.

The glass envelope of the lamps shall be etched to show the manufacturers insignia or trademark, the voltage rating, the rated wattage and the rated life hours.

Lenses: The lens shall be standard prismatic red, yellow or green and shall be durable on prolonged exposure to weather. Each lens shall be of clear colored glass or polycarbonate resin, free from bubbles and flaws and shall be annealed to relieve internal stresses. Flashed lenses will not be accepted.

Lenses shall conform to the ITE Specification, "A Standard for Adjustable Face Vehicle Traffic Control Signal Heads," and any revisions to the latest

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edition.

The luminous transmission for traffic signal lenses and the limits of chromaticity for traffic signal colors shall be as follows:

RED The minimum relative luminous transmittance shall be 0.095; the value of y shall not be greater than 0.308 nor less than 0.998 minus x

YELLOW The minimum relative luminous transmittance shall be 0.440; the value of y shall not be less than 0.411 nor less than 0.995 minus x nor greater than 0.452

GREEN The minimum relative luminous transmittance shall be 0.200; the value of y shall not be less than 0.506 minus 0.519 x nor less than 0.150 plus 1.068 x nor greater than 0.730 minus x

Each lens shall be furnished with a label which shall indicate that the lens meets the specifications of the Institute of Traffic Engineers, "A Standard for Adjustable Face Vehicle Traffic Control Signal Heads," January 2, 1966, and any revisions thereof.

All lenses, except arrows, shall have pressed on its flange the word "TOP" to indicate the proper positioning of the lens in the door for obtaining the light distribution required, together with the diameter and other designations, including the name or trademark of the manufacturer needed for proper application and help in purchasing replacements.

The nominal 8 in. (203 mm) lens shall have an outside diameter of from 8-5/16 in. to 8-3/8 in. (211 to 213 mm) The nominal 12 in. (305 mm) lens shall have an outside diameter of from 11-15/16 in. to 12-1/32 in. (303 to 306 mm) (These dimensions do not apply to the visible indication area of the optically programmed head.) Each lens shall fit into a specifically designed slotted circular neoprene lens gasket designed to fit the housing door in such a manner so as to exclude moisture, dust and road film.

Arrow Lenses:

Arrow lenses shall meet the ITE Specification, "A Standard for Adjustable Face Vehicle Traffic Control Signal Heads," January 22, 1966, and any revisions thereof, and all other specifications above. The lens shall be of approved color specified above. All lenses shall be covered, except for the arrow with the light from a 200 watt lamp placed behind it. The enamel shall be baked or fired into the lens. The enamel shall be hard and durable and shall not peel or flake when subjected to the heat of a signal lamp when the lens is in use, or when the lens is washed. The arrow shall be the only illuminated portion of the lens.

715.42.6.5-Pedestrian Control Signal Heads (Incandescent): These Specifications cover symbolic pedestrian signal assemblies to be illuminated

by incandescent lamps mounted behind two lenses (one for each symbol), having translucent symbols.

General Design Requirements:

The nominal size of the lenses shall be 12 by 12 in. (305 by 305 mm).

Housing:

The housing shall be constructed of cast or sheet corrosion resistant, non-ferrous metal or plastic, or of a combination of these materials.

All cast metal parts shall have tensile strength of not less than 17,000 psi. (117 MPa) Sheet metal shall have a tensile strength of 27,000 psi. (186 MPa)

All parts shall be clean, smooth and free from flaws, cracks, blowholes and other imperfections.

If the housing and doors of the signal heads are made of aluminum alloy, they shall have one of the following compositions:

- i. If die castings are furnished, the alloys shall be in accordance with ASTM B 85 60T or the latest revision thereof, and the physical characteristics and chemical content of the alloy used shall be within the combined limits established by allows S-12A, S-12B, SC-84A, SC-84B, SG-100A and SG-100B of the ASTM Specification.
- ii. If sand castings are furnished, the alloys shall be in accordance with ASTM B 26 60T or the latest revision thereof, and physical characteristics and chemical content of the alloy used shall be within the combined limits established by alloys S-5A and CS-72A of the ASTM Specification.
- iii. If permanent mold castings are furnished, the alloys shall be in accordance with ASTM B 108 60T or the latest revision thereof, and the physical characteristics and chemical content of the alloy used shall be within the combined limits established by alloys S-5A and CS-72A of the ASTM Specification.
- iv. If sheets are furnished, the alloys shall be in accordance with ASTM 209 58T or the latest revision thereof, and the physical characteristics and chemical content of the alloy used shall be M1A of the ASTM Specification.

When required, the successful bidder shall furnish satisfactory evidence that materials comply with the foregoing requirements.

The housing shall be of unitized sectional construction and shall consist of as many sections as there may be optical unit levels. All sections shall be rigidly and securely fastened together into one weathertight signal face assembly.

Each housing shall be arranged with round openings in the top and bottom so that it may be rotated between waterproof supporting brackets on trunnions and thus be capable of being directed at any angle to the horizontal plane. The

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openings shall be provided with a serrated ring which shall permit indexing and locking of the signal head in five-degree increments throughout the entire 360 degrees of rotation possible. The portion of the housing adjacent to the bracket shall be properly reinforced so as to have sufficient strength against breakage from shock.

The housing door of each signal section shall be a one-piece, corrosion resistant aluminum alloy die casting. Two hinge lugs shall be cast on the one side of the door and latch jaws shall be cast on the opposite side of the door.

The door shall be attached to the housing by means of two solid stainless steel hinge pins of not less than ¼ in. (6 mm) diameter.

A stainless steel latch screw, wing nut and washer on the latch jaw side of the housing shall provide for opening and closing the signal door without the use of any special tools.

A gasket groove on the inside of the door shall accommodate a weatherproof and dustproof seal.

The outer face of the door shall have tapped holes equally spaced about the perimeter of the housing to accommodate screws for securing the signal head visors.

Latch screws, hinge pins, wing nuts and washers shall be Type 304 stainless steel.

The housing door shall be finished with the best quality, oven-baked yellow enamel and shall comply with Federal Specifications TT-E-489.

The housing, when properly mounted using 1½ in. (DN40) pipe brackets, shall be able to withstand a concentrated load of 50 lbs. (23 kg) placed 6 inches (150 mm) from the centerline of the mounting brackets on either side of the opening or on both sides of the opening simultaneously. Such loading shall not produce sufficient deformation to cause the material to fail or to take a permanent set that would interfere with opening the door, rotation about the brackets, or loss of the weathertight integrity of the unit.

Visors:

Each signal head shall have a visor for each signal indication. The visor shall be designed to fit tightly against the door and shall not permit any perceptible filtration of light between door and the visor. The visor shall be 8 inches (203 mm) minimum in depth and inclined downward approximately 32 degrees with complete enclosure at the top and sides. The visor shall be of sheet construction and shall be of corrosion resistant, non-ferrous metal not less than 0.05 in. (No. 18 US gage) in thickness. The outside of the visor shall be of the same yellow enamel as the housing and door. The inside of the visors shall be painted a dull nonreflective black.

Pedestrian Signal Lenses:

Each lens shall be clear colored glass or plastic free from bubbles and flaws, and shall be annealed to relieve internal stresses. Flashed lenses will not be accepted.

Lenses shall conform to the ITE Specifications, "Adjustable Face

Pedestrian Signal Standard," and revisions thereof, where applicable.

The luminous transmission for pedestrian lenses and the limits of chromaticity for signal colors shall be as follows:

Portland Orange - Don't Walk Symbol - The luminous transmittance shall be not less than 0.300; the value of y shall not be greater than 0.390 nor less than 0.997 minus x .

Lunar White - Walk Symbol - The luminous transmittance shall not be less than 0.290; the value of x shall not be greater than 0.420 nor less than 0.329. The value of y shall not be greater than $0.510x$ plus 0.186 nor less than 0.510 plus 0.170.

Each lens shall have pressed on its flange such designation and trademark of manufacturer to facilitate proper application and to help in purchase of replacements.

The nominal 12 in. (305 mm) lens shall have minimum overall dimensions of 12 in. by 12 in. (305 by 305 mm) with a visible area of 11 in. by 11 in. (280 by 280 mm).

Message:

The Walk-Don't Walk symbols shall be according to the Standard Highway Signs Booklet, published by the Federal Highway Administration.

The surface of the lens, except for the symbol, shall be covered by opaque enamel of sufficient thickness to totally obscure the light of a 150-watt lamp when placed 12 in. (305 mm) behind the lens. The enamel shall be baked or fired into the glass and shall not peel or flake during normal use.

Reflectors:

Reflectors shall be specular Alzak finished aluminum and be designed for a 10 year service life.

Reflectors shall be mounted in a cast aluminum reflector support attached to the housing, or shall be an integral reflector and support of formed sheet aluminum.

The reflector assembly shall be pivoted to the housing and shall be designed so that it can be swung out or easily removed without the use of any tools.

The method of mounting and fastening reflectors shall be sufficiently rigid to secure proper alignment between the lens and reflector when the door is closed.

The construction of the signal head and its components shall be such that the fit between the reflector and the lens will eliminate all possibility of false indications.

Reflectors shall have an opening in the back for the lamp socket.

Pedestrian signal reflectors shall be of specular aluminum, the thickness of the anodic coating shall be a minimum of 0.0001 in. (2.5 μm) or its equivalent, spun or drawn from metal not less than 0.025 in. (0.64 mm) thick, equipped with a bead or flange on the outer edge to stiffen the reflector and insure its being held true to shape.

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The reflecting surface shall be totally free of flaws, scratches, defacements or mechanical distortion.

Light Distribution:

The lighted signal shall appear to be uniformly illuminated over the entire message surface, without shadows when viewed from usual angles encountered in service. Distribution of light through the letters shall be uniform and free from halation or other uncontrolled scattering which may reduce legibility of the message.

The pedestrian indications should attract the attention of, and be readable to, the pedestrian (both day and night) at all distances from 10 ft. (3 m) to the full width of the area to be crossed. When not illuminated, the WALK and DON'T WALK symbols shall not appear to be illuminated by external light sources when viewed from the far end of the crosswalk they control.

Lamps:

Lamps supplied with the pedestrian signal heads shall have the filament adequately supported to withstand the vibration induced from truck traffic and heavy winds. All pedestrian signal lamps shall have a brass, standard, medium screw base and clear glass envelope. The light center length (LCL), or the dimension, in inches (mm), from the center of the filament to the top of the base, shall be in conformance with the following design requirements:

All pedestrian signal lamps for use in 12 in. (305 mm) pedestrian signal heads shall have a light center length of 3 inches (75 mm).

Pedestrian signal lamps shall conform to the following standards:

TWELVE-INCH PEDESTRIAN SIGNAL

Nominal Wattage	Rated Life Hours	Min. Initial Lumens
150 watt series	6,000	1,950

The glass envelope of the lamps shall be etched to show the manufacturer's insignia or trademark, the voltage rating, the rated wattage, and the rated life hours.

Lamp Receptacle:

The lamp receptacle shall be heat resisting material designed to properly position a medium screw base pedestrian signal lamp with means to accommodate a lamp having light center 3 inches (75 mm) in length for the 150-watt series. The receptacle shall be provided with a lamp grip to prevent the lamp from working loose due to vibration. Provision shall be made on either the lamp receptacle or the reflector holder to permit rotation of the lamp

so that the lead-in wires are up, and a secure fastening for the retention of the lamp in that position, but shall not permit any change in position of the socket with respect to the optical center of the reflector. The metal portion of the lamp receptacle shall be compatible with brass or copper.

Wiring:

Each lamp receptacle shall be provided with two coded No. 18 or larger lead wires, Type TEW, 600 volt, AWM fixture wire with 1/32 in. (0.8 mm), 221° F (105° C) rating thermoplastic insulation, securely fastened to the socket, and with sufficient length to reach the terminal block with the reflector fully open. The thermoplastic insulation shall at minus 30° F (-35° C) be capable of being bent six times around a 1 in. (25 mm) mandrel without damage to its insulating properties at rated voltage. A suitable terminal block signal housing shall be provided.

Trunnions, Brackets and Suspensions:

All trunnions, brackets and suspensions used for assembling and mounting vehicle traffic control sign heads shall be entirely weather-tight without the use of externally applied sealants or caulking. The trunnions, brackets and suspensions shall be the same manufacturer as the signal heads.

All tubular parts shall be 1½ in. IPS (DN40) pipe. When hollow cast brackets or trunnions are used, they shall be of sufficient strength to support the maximum load imposed by the signal heads under all normal wind conditions.

Wire raceway areas within brackets, trunnions and suspensions shall be of adequate size to carry all necessary wires without crowding, and raceway surfaces shall be free of sharp edges or protrusions which might damage insulation on wires.

715.42.6.6-Optically Programmed Traffic Signal Heads: The purpose of this section is to set forth the minimum specifications for all optically programmed traffic signal heads and associated equipment.

Signal Heads:

All signal heads shall be the nominal 12 in. (305 mm) type and shall be adjustable through 360 degrees about a vertical axis, with each individual section being adjustable plus or minus nine degrees about a horizontal axis, maintaining a vertical centerline through couplers and conduit. Each section shall be equipped with a sun visor.

All die cast aluminum parts shall conform to the following specifications or the latest revision thereof; Die casting SC-84A, SC-84B, SG-100A, SG-100B or S-12B of ASTM Specifications B 85. All stainless steel shall be of Type 304.

All surfaces outside of the signal heads (except the underside of the visors) shall be finished with the best quality, oven-baked yellow enamel and shall comply with Federal Specifications TT-E-489.

The signal head housing shall consist of an assembly of separate

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interchangeable sections, expandable type for vertical mounting without tie rods, substantially secured together in a watertight manner to form a unit. Each section shall house an individual optical unit. The top and bottom of the signal housing shall have an opening to accommodate standard 12 in. (DN40) pipe brackets.

The optical system shall consist of a lamp, a circler reflector, an optical limiter-diffuser combination and an objective lens. The lamp shall be nominal 150 watt, 120 volt AC, three prong, sealed beam having an integral reflector and an average rated life of 6,000 hours. A circler reflector with a specular inter surface shall mate the lamp to the diffusing element. The optical limiter-diffuser combination shall provide an imaging surface, at focus on the optical axis for objects 900 to 1,200 ft. distance and permit an effective veiling system to be variously applied as determined by the desired visibility zone. The optical limiter-diffuser shall be provided with positive indexing means and composed of heat resistant glass. The objective lens shall be a high resolution planar incremental lens hermetically sealed with a flat laminate of weather-resistant acrylic. The lens shall be symmetrical in outline and may be rotated to any 90 degree orientation about the optical axis. Lens colors shall conform to the specifications of the Institute of Traffic Engineers, 1966, and any revisions thereof.

Each signal head shall be equipped with a dimming mechanism that will gradually reduce the candlepower for nighttime operation to approximately 15 percent of that for daytime operation.

The lamp fixture shall comprise a separately accessible housing and integral lamp support, ceramic socket and self-aligning, quick release lamp retainer. Electrical connection between case and lampholder shall be accomplished with an interlock assembly which disconnects the lampholder when open. Coded No. 16 lead wires shall be used of a length sufficient to permit solderless connection to line wires external to the signal.

All signal indications shall be in a straight line and shall be in the following order, although all indications shown need not be included in all cases. In vertical signals, Position 1 shall be at the top, and Position 8 at the bottom. In horizontal signals, position 1 shall be at the left (facing the signal), and Position 6 at the right.

POSITION		SIGNAL INDICATION
Vertical	Horizontal	
1	1	Red
2	2	Yellow
3	4	Green
4	5	Straight Thru Arrow
5	3	Left Turn Arrow
6	6	Right Turn Arrow
7		Don't Walk Symbol
8		Walk Symbol

Each signal head shall be equipped with a suitably designed visor. The underside of the visor shall be flat black paint.

Hardware:

All trunnions, brackets and suspensions used for assembling and mounting vehicle traffic control signal faces shall be entirely weathertight.

All tubular parts shall be 1½ in. IPS (DN40) pipe. When hollow cast brackets or trunnions are used, they shall be of sufficient strength to support the maximum load imposed by the signal heads under design wind conditions.

The lower support or connection between signal heads in multi-way span wire or mast arm mounted signals may be an aluminum casting or stamping of suitable strength.

Wire raceway areas within brackets, trunnions and suspensions shall be of adequate size to carry all necessary wires without crowding, and raceway surfaces shall be free of sharp edges or protrusions which might damage insulation on wires.

Suspensions for mast arm or span wire mounting shall include a device to permit adjustment for proper vertical alignment of the signal head.

715.42.6.7-Lane Control Signal Heads (Single Lamp):

General Design Requirements:

Each signal head shall be of the adjustable, colored-light type with the number and type of sections described and as shown on the Plans. Single indication heads shall be mounted on a vertical axis. Each head shall have an indication in one direction only and shall be adjustable through 360 degrees about a vertical axis for single indication heads, or about a horizontal axis for multi-indication heads.

All lane control signal heads at any one intersection shall be of the same make and type.

Position of Signal Indications:

All signal indications shall be in a straight horizontal line and shall be in the following order although all indications shown need not be included in all cases. Position 1 shall be at the left (facing the signal), and Position 3 at the right.

POSITION	SIGNAL INDICATION
1	Red X
2	Yellow X
3	Green Arrow

Assembly:

Each head shall consist of an assembly of individual interchangeable sections securely bolted together to form a unit. Sections shall be capable of being oriented horizontally or vertically without the use of additional parts. There shall be no tie rods used in the assembly. The finished assembly shall present a clean, neat appearance. Each individual section shall house a complete optical unit.

The ends of each section shall have an opening to accommodate standard 1½ in. (DN40) pipe brackets. The openings shall be in line. The assembly shall be capable of being rotated between standard waterproof supporting brackets or trunnions and thus aimed in any direction in the specified plane. The portion of each section adjacent to the bracket openings and the portion used for connecting sections shall be properly reinforced to provide sufficient strength to resist shock, vibration and impact damage.

Each section shall have lugs for the mounting of at least one six-position, twelve-terminal, barrier-type terminal block.

The housing door shall be a one-piece casting having two hinge locations and at least one latch location. The hinges shall have stainless steel pins at least 3/16 in. (5 mm) diameter. The latch shall consist of (1) a latch jaw on the door and a stainless steel latch screw, wing nut and washer securely affixed to the housing; or (2) a captive wing nut, washer and screw assembly on the door and a captive nut in the housing. It shall be possible to open and remove the door without the use of any tools.

The door shall have a gasketed opening that shall provide a visible lens area of 120 sq. in. (0.077 sq. m) for a nominal 12 in. (305 mm) lens and 289 sq. in. (0.185 sq. m) for a nominal 18 in. (455 mm) lens. All lenses shall be as described in 715.42.6.7.1.

The door shall have a gasketed opening that shall provide a visible lens area of 120 sq. in. (0.077 sq. m) for a nominal 12 in. (305 mm) lens and 289 sq. in. (0.185 sq. m) for a nominal 18 in. (455 mm) lens. All lenses shall be as described in 715.42.6.7.1.

The door shall have four equally spaced visor attachment points around the lens opening.

Visors shall be at least 10 in. (254 mm) long for a 12 in. (305 mm) lens and at least 12 in. (305 mm) long for an 18 in. (455 mm) lens. Heads shall be supplied with standard visors, unless otherwise noted on the Plans. All new signal heads at any one intersection shall have the same type visors supplied, unless otherwise specified on the Plans.

Visors shall be designed with a downward tilt between 3½ degrees and 5 degrees, shall eliminate the escape of light from one indication to another and, with the optical unit, shall eliminate the return of outside rays entering the unit from above the horizontal (known as sun phantom).

The section and all brackets, trunnions and suspensions shall be finished with yellow enamel. The door and the outside of the visor shall be finished with either yellow or black enamel. The inside of the visor shall be finished with a flat black enamel. All enamel shall be best quality, oven-baked meeting Federal Specifications TT-E-489.

The optical unit shall consist of the lamp, lampholder, reflector, lens gasket and lens, and shall be so designed that all light emitted by the unit passes through the lens and so that any possibility of false indications is eliminated.

The lampholder shall be of heat resisting material designed to properly position a medium screw base traffic signal lamp, with means to accommodate a lamp having light center 3 inches (75 mm) in length for the 116-watt series and 6 inches (150 mm) in length for the 200-watt series. The lampholder shall be provided with a lamp grip to prevent the lamp from working loose due to vibration. Provision shall be made on either the lampholder or the reflector holder to permit rotation of the lamp so that the lead-in wires are up, and the lamp shall be retained securely in that position, but no change in position of the socket with respect to the optical center of the reflector shall occur. The metal portion of the lampholder shall be compatible with brass or copper.

Each lampholder shall be provided with two coded No. 18AWG or larger lead wire, Type TEW 600-watt fixture wire 2/64 in. (0.8 mm), 105° C rating thermoplastic insulation, securely fastened to the socket, and with sufficient length to reach the terminal block with the holder or door fully open. The thermoplastic insulation shall be at minus 30° F (-34° C) capable of being bent six times around a 1 in. (25 mm) mandrel without damage to its insulating properties at rated voltage. A suitable terminal block or blocks shall be provided in the second section from the left or in each section of one-section heads. The terminal block shall have at least one section for each signal head section plus at least two additional sections per block. Terminal blocks shall be standard commercially available units.

Reflectors shall be specular aluminum in accordance with the latest ITE Specifications and shall be mounted in a reflector holder. The reflector holder shall provide a rigid reflector mounting to assure proper alignment between the lens and the reflector with the door closed. The reflector shall have a lampholder opening in the back. The reflector shall have a head or flange on the outer edge to stiffen the reflector and insure its dimensional stability. The

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reflecting surface shall be totally free from flaws, scratches, defacements and mechanical distortion.

The lens gasket shall be a slotted neoprene gasket specifically designed to exclude moisture, dust and road film. The optical unit shall be sealed to exclude moisture and dust. This may be accomplished in one of two ways:

- i. If the door contains the complete optical unit, the reflector/door and the reflector/lampholder interfaces shall be equipped with specially designed neoprene seals to completely seal the optical unit. The section must not accumulate water.
- ii. If the reflector and lampholder remain in the section when the door is open, the entire section shall be made watertight and dusttight by a weatherproof neoprene gasket contained in a gasket groove in the door. The gasket shall seal against a raised bead in the section to provide the proper seal.

The lighted signal shall appear to be illuminated over the entire visible lens surface without shadows when viewed from any angle up to 39 degrees each side of the optical axis horizontally and up to 45 degrees below the optical axis vertically.

The required appearance, light distribution and candlepower intensity from the complete assembled section shall meet latest revision of the specifications of the Institute of Traffic Engineers, "A Standard for Adjustable Face Vehicle Traffic Control Signal Heads."

Trunnions, Brackets and Suspensions:

All trunnions, brackets and suspensions used for pedestrian signal heads shall be entirely weathertight without the use of externally applied sealants or caulking. The trunnions, brackets and suspensions shall be of the same manufacturer as the signal heads.

All tubular parts shall be 1½ in. IPS (DN40) pipe. When hollow cast brackets or trunnions are used, they shall be of sufficient strength to support the maximum load imposed by the signal heads under all normal wind conditions.

The lower support or connection between signal heads in a span-wire or mast-arm mounted signal may be an aluminum casting or stamping of suitable strength.

Wire raceway areas within brackets, trunnions and suspensions shall be of adequate size to carry all necessary wires without crowding, and raceway surfaces shall be free of sharp edges or protrusions which might damage insulation on wires.

Suspensions for mast-arm or span-wire mounting shall include a device to permit adjustment for proper vertical alignment of the signal head.

Non-metallic trunnions, brackets and suspension parts previously approved by the Division may be supplied. Such parts must be capable of mounting both metallic and non-metallic signal heads and must be compatible with aluminum, steel and galvanized steel.

Metallic Lane Control Signal Heads:

Each head of this type shall be constructed primarily of aluminum and aluminum castings and stainless steel, shall meet all requirements of 715.42.6.7 and shall accept lenses and lamps as described in 715.41.6.7.1.

The section and door shall be one-piece, corrosion-resistant aluminum alloy die castings. Visors and deflectors shall be made from sheet aluminum or die castings.

All cast metal parts shall have a tensile strength of not less than 17,000-psi. (117 MPa). All castings shall be clean, smooth and free from flaws, cracks, blowholes and other imperfections. The castings shall conform to ASTM B 85 alloys SC-84A, SC-84B, SG-100A, SG-100B, S-12A or S-12B.

Sheet aluminum parts shall be manufactured from corrosion-resistant aluminum sheet having a tensile strength of at least 20,000 psi (138 MPa), except that reflectors shall be manufactured from the aluminum alloy suggested by the manufacturer.

All hinge pins and latch parts shall be Type 304, stainless steel.

Miscellaneous parts and hardware shall be made of non-corrosive materials.

All parts shall have sufficient strength to show minimal damage under severe loading conditions. Visors shall be not less than 0.05 in. (1.3 mm) thick. Reflectors shall be spun or drawn from aluminum not less than 0.025 in. (0.064 mm) thick.

715.42.6.7.1-Lamps and Lenses for Lane Control Signal Heads:**Lamps:**

Lamps supplied with the lane control signal heads shall have the filament adequately supported to withstand the vibration induced from truck traffic and heavy winds. The light center length (LCL), is the dimension, in inches (mm), from the center of the filament to the tip of the base. All lane control signal lamps shall have a brass, standard, medium screw base and a clear glass envelope and shall be in conformance with the following design requirements:

HEAD SIZE	WATTAGE SERIES	LCL	MINIMUM RATED LIFE	MINIMUM INITIAL LUMENS
12	116	3 in. (75 mm)	6,000 hours	1,260
18	200	6 in. (150 mm)	6,000 hours	

The glass envelope of the lamps shall be etched to show: the manufacturer's insignia or trademark, the voltage rating, the rated wattage and

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the rated life hours.

Lenses:

The lens shall be standard prismatic red, yellow or green and shall be durable on prolonged exposure to weather. Each lens shall be of clear colored glass or polycarbonate resin free from bubbles and flaws and shall be annealed to relieve internal stresses. Flashed lenses will be accepted.

Lenses shall conform to the specifications of the Institute of Traffic Engineers, "A Standard for Adjustable Face Vehicle Traffic Control Signal Heads," January 22, 1966, and any revisions thereof. The luminous transmission for traffic signal lenses and the limits of chromaticity for traffic signal colors shall be as follows:

- RED** The minimum relative luminous transmittance shall be 0.095; the value of y shall not be greater than 0.308 nor less than 0.998 minus X .
- YELLOW** The minimum relative luminous transmittance shall be 0.440; the value of y shall be not less than 0.411 nor less than 0.995 minus X nor greater than 0.452.
- GREEN** The minimum relative luminous transmittance shall be 0.200; the value of y shall not be less than 0.506 minus 0.519 X nor less than 0.150 plus 1.068 X nor greater than 0.730 minus X .

Each lens shall be furnished with a label which shall indicate that the lens meets the latest revision of the specifications of the Institute of Traffic Engineers, "A Standard for Adjustable face Vehicle Traffic Control Signal Heads."

All lenses shall have pressed on the flange the work "TOP" to indicate the proper positioning of the lens in the door for obtaining the light distribution required, together with the size and other designations, including the name or trademark of the manufacturer needed for proper application and help in purchasing replacements. Each lens shall fit the housing door in such a manner so as to exclude moisture, dust and road film. All lenses shall be covered except for the X or the arrow with a dull or dark gray enamel of thickness sufficient to totally hide the light from a 200-watt lamp placed behind it. The enamel shall be baked or fired into the lens. The enamel shall be hard and durable and shall not peel or flake when subjected to the heat of a signal lamp when the lens is in use, or when the lens is washed. The X or the arrow shall be the only illuminated portion of the lens.

715.42.7-Auxiliary Traffic Signal Equipment: The purpose of this section is to set forth the minimum design and functional requirements for all types of optional auxiliary equipment which are described in this section.

All auxiliary equipment shall operate on 120 volts, 60Hz, AC power supply. The equipment operation shall not be affected by supply voltage variations between the limits of 10 percent above and 10 percent below 120

volts standard service. Similarly, the equipment operation shall not be affected by any change in temperature between the limits of plus 122°F (plus 50°C) and minus 30°F (minus 34°C) without the necessity of any heater element.

The Contractor shall furnish manufacturer's instructions for installing, maintaining and placing into operation the auxiliary equipment, along with engineering data, diagrams, etc. or any later changes or improvements which may increase the performance of the equipment purchased.

The Contractor is required to turn over to the Division any guarantees or warranties which are given by a manufacturer.

The Division reserves the right to withhold any payment which may be due for equipment which does not meet Specifications.

Solid state flashers meeting current NEMA TS standards and capable of the above specified outputs and circuit ratings are an acceptable alternate to motor driven units.

715.42.7.1-Flasher Units: The purpose of this subsection is to set forth minimum specifications and design requirements for flasher units to perform the flashing combinations as specified on the Plans.

The signal flasher unit shall be a motor-driven switching device for flashing beacons or traffic signal indications at signalized intersections. It shall be designed for back-panel mounting in a flasher or traffic signal controller cabinet and shall be complete with jack-mounting subbase. The unit shall be capable of flashing two non-simultaneous signal circuits at a rate of not less than 50 nor more than 60 flashes per minute per circuit, with approximately 50 percent on and 50 percent off periods.

Each flashing circuit contact shall be rated at 15 amperes, 120VAC, 60 Hz under continuous make and break duty. The closing and opening of the flashing circuit contacts shall be accomplished in such a manner as to avoid undue pitting and burning. The flasher contacts shall be equipped with adequate integral radio interference filters.

The flasher motor shall be durable and provide a constant flash rate. It shall be designed for synchronous operation on 120VAC, 60 Hz and shall have lifetime lubrication.

715.42.7.2-Time Clocks: The purpose of this subsection is to describe the 24-hour electric programmable time clocks to be used in pretimed and traffic-actuated signal controllers.

The clock motors shall be designed for synchronous operation on 120 volts, 60 Hz, single phase alternating current. The clocks shall be programmable for circuit on-off operation at 15-minute intervals of the day. In addition, the clocks must be capable of skip-a-day operation. Each clock dial shall provide from one to 48 on-off operations per day minimum in 15-minute settings. Each clock shall be capable of operating in a "power-off" condition for a minimum of ten hours. Drive for the clock when electric power is off shall be provided by a reserve spring which is wound automatically during "power-on" periods. All time clocks must be easily accessible and

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demountable and fit within the controller cabinet.

715.42.7.3-Offset Interrupter: The purpose of this subsection is to set forth functional specifications and design requirements for a system offset interrupter.

The offset interrupter shall provide system offset interruption in the range of at least 0 to 40 seconds in one-second increments. No tools or additional timing gears shall be required to change the interruption interval. The interval shall be set by use of a calibrated dial on the front of the unit. The interruption period shall be of sufficient duration to release all dial or coordination units in the system, or both.

A switch shall be provided to eliminate the function of the offset interruption.

715.42.7.4-Preemption: Preemption equipment shall be constructed and wired so as to transfer control of the signals from the controller to the preemption unit when actuated by the method specified and shall provide the color sequence specified. The preemption shall cause a clearance interval to be timed prior to the preemption sequence if actuated during a "green" or "flashing yellow" interval, unless otherwise specified.

Pedestrian WALK-DON'T WALK signals shall be placed on DON'T WALK during the preemption clearance interval and shall be turned off during the preemption sequence, unless otherwise specified.

Installation of the preemption equipment shall not alter the internal wiring of the controller unit normally furnished by the manufacturer.

After release of the preemption, normal controller operation shall be automatically resumed at the beginning of the "green" interval specified on the Plans and on actuated controllers, calls shall be placed on all phase in order for the controller to complete one cycle before resuming normal actuated operation.

Two sets of complete wiring diagrams shall be provided showing the physical layout of all relays and other components of the preemption unit.

715.42.7.5-Electronic Time Switch: The purpose of this subsection is to describe the seven-day programmable time switch to be used inpre-timed and traffic-actuated signal controllers.

The time switch shall be microprocessor-based and capable of SPDT switching of at least three (3) independent five-amp loads at 120 VAC. The entire unit shall be solid state and capable of at least 15 on or off time sets per day or week. Automatic battery backup providing a minimum of 48 hours of memory protection shall also be provided. The timer shall be entirely self-contained in a unit that can be readily mounted inside a signal controller cabinet.

715.42.7.6-Electronic Time Switch (Type DST): Specification requirements for this time switch are the same as outlined in 715.42.7.5, with the exception that automatic Daylight Savings Time compensation can be

programmed into this unit for an indefinite future period.

715.42.8 - Cabinets: The following are minimum design requirements for all types of weatherproof traffic control equipment cabinets:

The terminal facilities shall be furnished in either a basemount NEMA type 5 ("P") cabinet or a pole mountable NEMA type 4 ("M") cabinet as called for on plans. The cabinet shall be UL listed and have a UL approval label installed on the inside of the main cabinet door. The cabinet shall also have labeling indicating date of manufacturer, part number, and drawing identification number. Base-mount cabinets shall be supplied with a minimum of four 1.0" (25 mm) by 2.0" (50 mm) slotted holes for anchor bolt entry on the interior of the cabinet. Anchor bolt centers shall be 40.75" (1035 mm) wide by 18.50" (470 mm) deep. Four anchor bolts shall be supplied with the cabinet. The pole-mounted cabinet shall be mounted with the standard pole mounting brackets as shown on TES Standard Detail Sheets.

The cabinet shall be constructed of 0.125 inch (3 mm) thick 5052-H32 aluminum with the following minimum exterior dimensions: (Unless otherwise shown on the Plans)

	Base Mount	Pole Mount
Height	54 inches (1370 mm)	49 inches (1245 mm)
Width	44 inches (1115 mm)	30 inches (760 mm)
Depth	26 inches (660 mm)	17 inches (30 mm)

No cabinet shall exceed any of these dimensions by a maximum of 2 inches (50 mm).

All exterior seams of the cabinet shall be continuously welded for the entire length of the seam of the interior of the cabinet. Tack welding of seams and sealing with application of silicon or other sealers are not acceptable. Unless otherwise specified, the cabinet interior and exterior shall be furnished as natural (unpainted) aluminum. All surfaces shall be clean and free of oil, weld marks, etc. No holes for mounting rails or other main cabinet interior hardware shall be drilled through the cabinet walls. The conduit entry hole in the cabinet bottom must be field drilled to fit the location and the size of conduit required. The conduit entry hole must be placed as close as possible to the cabinet back wall when drilled.

715.42.8.1 - Cabinet Doors: A stainless steel main door handle shall be supplied which is capable of being padlocked in the closed (locked) position. The cabinet handle shall operate a door strike plate assembly via a minimum 0.5" (13 mm) square (or round) solid stainless steel rod. The handle shall be oriented in such a way that it rotates inward when operated to the open position. The main door lock must be a keyed tumbler lock.

The main door shall be secured with a three-point latch assembly. The three-point latch assembly shall consist of a stainless steel strike plate located directly behind the handle in the approximate vertical center of the door that secures the center of the door. The strike plate shall operate two plated steel or

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stainless steel latch rods. The end of each rod shall be fitted with a minimum 0.75" (19 mm) diameter nylon roller complete with ball bearings to insure a smooth positive seal of the upper and lower main cabinet door. The main cabinet door shall be of essentially the same area as the front of the cabinet, and shall be provided with a #2 tumbler key lock and two keys.

The main door handle and all of its components shall be removable for replacement in the field. No parts shall be welded or permanently attached to the cabinet in any way that would restrict or prohibit replacement in the field with the use of simple tools.

The main door shall have a close cell neoprene gasket installed at its outer edge to form a watertight seal between the cabinet and main door. The gasket shall be a minimum of 1.0" (25 mm) by 0.5" (13 mm) thick and shall be secured between the edge of the door and an "L" shaped bracket welded to the inside of the door. This bracket shall extend virtually the full length of the gasket around the door. The gasket shall mate against the main door opening, which shall be formed as a double flange around the entire doorframe. The flange shall be bent in such a manner as to apply increasing pressure against the gasket as the main door handle is rotated to the locked position. An automatic doorstop shall be provided on both pole and base mount and shall be located on the bottom of the door.

The main door for base mount shall be attached by four stainless steel butt hinges and for a pole mount using only three stainless steel hinges - all which have minimum 0.25" (6 mm) diameter stainless steel pins. They shall be attached to the body of the cabinet and the door with 1/4 - 20 stainless steel carriage bolts and stainless steel nylon insert lockouts. The hinges shall be mounted in such a way that the pins are recessed and not removable with the main door closed.

715.42.8.2 - Mounting Rails: In a base mounted cabinet, four Unistrut rails shall be installed on each side of the cabinet and two on the back of the cabinet. For pole mounted cabinets, two Unistrut rails shall be installed on each side of the cabinet and two on the back of the cabinet. Each side rail shall extend from within 6" (150 mm) of the top of the cabinet to 6" (150 mm) from the bottom of the cabinet.

715.42.8.3 - Shelves: A minimum of two shelves the width of the cabinet with a minimum depth of 10.50" (265 mm) mounted toward the rear of the cabinet shall be supplied with each cabinet. Shelves shall be aluminum and shall have sufficient strength to support the controller unit and accessory equipment. Shelves longer than 36" (915 mm) shall be reinforced with an angle on the under side. Unless otherwise specified, the controller unit and conflict monitor shall be positioned on the top shelf. The shelves shall be attached with spring loaded Unistrut type nuts and stainless steel bolts.

715.42.8.4 - Ventilation: A motor-driven fan shall be mounted on a plenum in the top of the cabinet. It shall utilize roller (ball) bearings and be rated at 100 cubic feet per minute (45 liters/sec.). A finger guard shall be provided to cover the fan. The fan shall have an RC-network and V160LA20 MOV in parallel across the AC line to protect the controller unit from electrical

noise generated by the fan.

The fan shall be controlled by a variable thermostat located on the plenum in close proximity to the fan. The thermostat shall have a minimum adjustable turn and range of 80 to 130 degrees F (27 to 55 degrees C).

A filtered, weatherproof opening shall be provided on the main door near the bottom, a filter 12" x 16" x 1" (305 mm X 405 mm X 25 mm) shall fit smoothly and conveniently over this opening. The filter shall be the aluminum metal EX clean type and shall be reusable by blowing out dust particles. A positive filter retainer shall be supplied as a part of the main door assembly to firmly hold the filter against the opening. A fine mesh screen shall be provided between the filter and louvered opening to prohibit the entry of small insects. The screen shall be either aluminum or brass and fastened to the door permanently.

The exhaust for the fan shall occur above the main door under the top of the cabinet and shall be located to prevent entry of water into the cabinet. A perforated aluminum panel or screen shall be installed over the exhaust openings to prevent entry of small insects.

715.42.8.5 - Police Panel: A second hinged door (police panel), shall be located near the top of the main door for base mounted and near the bottom section of pole mounted cabinets. The police panel box shall be continuously welded to the main door. A gasket shall be provided on the inside of the police panel door for the full width of the door opening to insure a watertight seal. The police panel door shall be attached with a stainless steel hinge with a stainless steel hinge pin. The hinge shall be attached with tamper proof (one way) stainless steel screws and lockouts.

The police door shall be provided with a conventional police lock and key.

The police panel shall provide access to the following controls:

Manual Control/Auto Switch - Which shall be wired to the police panel terminal, but no switch will be provided unless called for on plans.
 Manual Control Coiled Cord and Button (only if called for on plans).
 Signal Auto/Flash Switch - On and Off (Flash transfer shall be accomplished thru de-energization of the flash transfer relays. Upon restoration to Signal Auto position from Flash, a momentary external start pulse shall be generated and applied to the controller unit to initiate the programmed start up sequence. AC power shall not be removed from the controller unit during flashing operation).

715.42.8.6 - Technicians Panel:

A technician switch panel shall be installed on the back cover of the police panel inside the controller cabinet. The following switches shall be supplied:

Detector Test Switches - Detector test push-button shall be installed in the cabinet so that calls can be placed on each vehicle and pedestrian phase. A push-button switch shall be provided and wired for each vehicle and each pedestrian phase (12 switches). Each switch shall mount in a 0.5" (13 mm) diameter hole and shall have a minimum 0.375" (10 mm) actuator.

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Controller Unit Power Switch - A switch shall be installed so that power to the controller unit and conflict monitor timer can be turned off. This switch shall not remove power from the detector rack.

Signals ON-OFF Switch - The signal on-off switch, when in the off position, shall extinguish all signal indications for normal and flashing modes without interrupting the controller unit, conflict monitor and associated equipment power.

Emergency Flash Switch - This switch shall initiate cabinet flash by de-energizing the flash transfer relays. Transfer into out of emergency flash via this switch shall be immediate and shall not restart the controller unit when returned to the normal operating position.

Wiring Diagram Holder - A 9.5" x 12" (240 mm X 25 mm) or larger plastic holder shall be mounted to the inside of the cabinet door for convenient keeping of wiring diagrams, installations layout, and timing records.

715.42.8.7 - Technician Accessories: Convenience Outlet -A duplex convenience outlet shall be mounted on the inside right sidewall of the cabinet. The outlet shall be ground fault protected and shall be connected to the load side of the 20 amp circuit breaker that protects only the outlet, lamp, and fan.

Cabinet Light - A minimum 18" (455 mm) 15 watt fluorescent cabinet light shall be mounted on the inside of the cabinet above the door opening. The cabinet light shall have an RC-network and V150LA20 MOV in parallel across the AC line to protect the controller unit from noise. The door shall activate the cabinet light switch when the door is opened.

All hardware utilized in the cabinet assembly shall be aluminum, copper, nylon, brass, nickel plated brass or stainless steel.

715.42.8.8 - Terminal Facilities: Various panels shall be installed in the cabinet to mount the necessary terminal facilities required for the controller, coordination, preemption, detectors, and signal circuits required for a full eight phase cabinet and controller unit. **A FULLY WIRED NEMA "C" CONNECTOR MUST BE PROVIDED.** All terminal facility panels shall be fabricated from minimum 0.125" (3 mm) thick aluminum. The terminals shall be provided on thermoplastic or Bakelite blocks with stainless steel or nickel-plated brass machine screws. Signal light field terminals shall utilize minimum 10-32 screws, detector terminals shall utilize minimum 8-32 screws except other terminals shall utilize minimum six 6-32 screws except as otherwise noted in this specification. All terminals including terminal stripe, sockets, and other mounting shall be made with stainless steel machine screws and nuts. No

"Pop" rivets or other non-removable fasteners shall be permitted. Every terminal shall be silk-screened with a number and, when possible, the terminal function mnemonic. Panels that utilize feed-thru connections shall be silk screened with numbers and function mnemonics on both sides. No rub-on pressure sensitive or adhesive labels shall be permitted in the cabinet assembly. Special name plates, switch or relay identifications or other labels affixed in the cabinet or on the panels shall be made of white over black plastic that is engraved with the appropriate legend. These labels shall be permanently mounted to the cabinet or panel as applicable.

Terminal facilities shall be located on the back and sides of the cabinet and below the shelves wherever possible. All terminal strips and exposed electrical connections shall be no less than 6 inches (150 mm) from the floor of the base mount cabinet and no less than 3 inches (75 mm) for a pole mount cabinet. The lower right cabinet sidewall shall contain the power panel and its related components. The lower left cabinet sidewall shall contain the detector panel with the detector terminals, preemption terminals, system communication terminals and the MS D interface panel.

All wiring within the cabinet shall utilize stranded copper conductors. Conductors shall be properly sized for the operating ampacity. Insulation shall conform to MIL standards for Type BN conductors, clear nylon jacket over color-coded PVC insulation. Where wire size exceeds #18AWG, Type TFFN or THHN insulation may be substituted for Type BN insulation.

All wiring within the cabinet shall be properly terminated at all points. Harness connections and all other connections made on the back of the backpanel shall be terminated by soldering individual wires directly to the terminal strips. Slip on or fast-on type terminals or insulation displacement methods shall not be utilized on the back of any panel for any purpose. Where terminal screws are provided, a suitable spade type terminal lug shall be attached to the end of the wire. Any crimp connection to terminals shall be made only with a controlled cycle, ratchet type tool approved for use on the specific terminal being installed. In addition, no more than three wires may be connected under any terminal screw. Connections to the field terminal blocks for the conflict monitor conductors shall be made with the use of ring type terminals which require removal of the screw in order to disconnect the terminal. Right terminals shall not be used at any other location in the cabinet. Any stranded wire connection made to a compression type terminal (ground bar, neutral bar, etc.) shall require tinning of the strands with solder before insertion into the compression lug. Connections to circular connectors shall be made by soldering or machine applied crimp connections. Hand applied crimp connectors are not acceptable.

The following color code shall be utilized throughout the cabinet:

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120 VAC	Black
120 VAC Neutral	White
Chassis Ground	Green
Logic Ground	Gray
+24 VDC	Red

These colors shall not be utilized for any purpose other than that so specified anywhere in the cabinet.

All harnesses shall be covered with "Expando" sleeving. Nylon cable ties, tape, etc. are unsuitable for use on harnesses.

All inductive loads shall be suppressed with a series R/C network consisting of a 0.1 uf 600 V capacitor and a 100 ohm 1/2 watt resistor connected in parallel with the load. In addition, a V150LA20 MOV shall be connected in parallel with the R/C network. The MOV and the R/C network shall also be provided on the duplex receptacle, fan, and fluorescent lamp. All DC inductive loads shall be suppressed with a reverse biased diode wired in parallel with the inductive load.

715.42.8.9 - Power Panel: Each cabinet shall be furnished with a power panel mounted on the lower right cabinet sidewall. This panel shall provide terminals for the incoming 120 VAC power line capable of accepting up to a #2 AWG conductors for line, neutral, and ground. In addition, the power panel shall provide mounting for circuit breakers 1 through 3, the surge arrester, line filter, mercury contactor, neutral bus bar, and ground bus bar. The circuit breakers shall be located on the panel closest to the main door opening.

All wiring on the power panel shall be properly sized for its application. Main power wiring between circuit breakers, surge arrester, line filter and mercury contactor shall be a minimum of #8 AWG conductor for line, neutral and ground functions. The power panel shall be furnished with a clearlexan safety cover to prevent accidental contact with the power panel components. The safety cover shall have a cutout area for access to the circuit breakers and shall be secured with thumbscrews for easy removal.

Three circuit breakers shall be provided for the incoming power distribution, Circuit breaker #1 shall be rated 30 amps and shall control the signal bus, detectors and control equipment. Circuit breaker #2 shall be rated 20 amps and shall power only the flasher and any related flash circuits. Circuit breaker #3 shall be rated 20 amps and shall power the fan, fluorescent lamp and duplex receptacle circuits.

A line filter shall be supplied to reduce any outgoing noise into the AC power line, minimum rating of the line filter shall be 60 amps.

A mercury relay-contactor shall be provided for control of power to the loadswitches (signal bus). This mercury shall be of a type specially designed to switch tungsten loads and shall incorporate a sealed type filled with nitrogen to eliminate "wicking" of the mercury to the electrodes under light load conditions. Minimum acceptable rating of the mercury relay for signal bus

control shall be 50 amps.

A main power lightning arrester shall be provided in the cabinet. The arrester shall consist of a primary and secondary stage. The primary stage shall be connected in parallel across the incoming AC line, neutral and ground. The line connections shall be made from the load side of circuit breaker #1. The neutral connection shall be made from the neutral power lug. The ground connection shall be made from the ground lug. Each of these connections shall be short and direct. No other connections shall be made for line, neutral or ground before the lightning arrester (except circuit breaker #1). The second stage of the lightning arrester shall be high-speed silicon protector intended to protect the controller unit, detector rack power supply, pedestrian call isolator and emergency vehicle preemption cards. The main power lightning arrester shall be an EDCO Model SHP 300-10. No substitutes shall be allowed without prior acceptance.

715.42.8.10 - Backpanel: Each cabinet assembly shall be furnished with a backpanel located on the lower center rear of the cabinet. The backpanel shall mount the loadswitches, flasher, flash transfer relays and controller unit input/output terminals. A base mounted cabinet shall have a 16 position backpanel (capable of terminating 16 loadswitches) and shall be provided. Further, 6 flash transfer relay bases shall be provided with terminals for flash color programming for loadswitches 1 through 12 (vehicle phases 1 through 8 and overlaps 1 through 4). The backpanel shall be mounted in such a way that it shall be possible to lower it for access to tall terminals on the rear with the use of simple hand tools. A pole-mounted cabinet shall have a 12 position backpanel (capable of terminating 12 loadswitches) and shall be provided. Further, 4 flash transfer relay bases shall be provided with terminals for flash color programming. Each backpanel shall be provided complete with all flash transfer relays. Per phase loadswitches shall be furnished as required for each intersection plus two spares.

Wiring on the back of the backpanel and all harnesses shall be color-coded for ease of troubleshooting. In addition, loadswitch input and output groups shall be color-coded orange for red, yellow for yellow and blue for green. Loadswitch outputs shall be wired with #16 AWG conductors. Harnesses shall be #22 AWG 19 strand and color coded* as follows:

MS A Harness	Blue
MS B Harness	Purple
MS C Harness	Pink
CM A Harness	Orange
CM B Harness	Yellow

*If The Color Coding Is Different, It Must Be Shown On The Cabinet Net Wire Diagrams.

715.42.8.11 - Detector Panel: Each cabinet shall be furnished with a detector field panel mounted on the lower left cabinet sidewall. This panel shall provide field terminals for the detector loops, pedestrian push-buttons,

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emergency vehicle preemption detectors, system communication conductors and railroad preemption circuits. The detector panel shall provide the interface between the field conductors, the detector rack, the MS D interface panel and the backpanel. In addition to the field conductors, terminals shall be provided for the 8 vehicle detector inputs, 4 pedestrian detector inputs, 8 logic level phase green outputs, (diode isolated), per channel detector rack outputs, per channel pedestrian isolation outputs and per channel emergency vehicle preemption outputs. This arrangement shall permit full programming of detector and pedestrian call phase assignments as well as phase green delay inhibit functions without having to provide additional wiring to the backpanel or soldering of additional wires on the detector rack.

715.42.8.12 - MS D Interface Panel: A panel shall be provided on the upper left sidewall to provide an interface for MS D harnesses for different brands of NEMA controller units. The panel shall mount a circular plastic connector to provide a universal interface for the MS D functions listed below. All functions from the MS D panel shall be at logic ground levels. Each controller unit furnished shall be supplied with a MS D adapter cable 3 feet (900 mm) in length. This adapter cable shall mate with the circular plastic connector on the MS D interface panel and whatever connectors are provided on the specific controller unit. If a particular model of controller unit provided requires a different logic level, coding of functions, etc., the adapter harness shall be equipped with a logic unit to perform the necessary conversions.

The MS D Interface Panel shall be provided with a 120 VAC relay to provide electrical isolation for a railroad preemption circuit. This relay shall be wired with one side of the coil connected to a continuous, 1 amp fused source of 120 VAC. The other side of the coil shall be connected to a terminal. An adjacent terminal shall be provided with AC Neutral. These terminals shall be the connection point for the railroad circuit. The relay shall be maintained in a normally energized state with no train present. When a train is detected, the railroad circuit shall open and the relay shall de-energize and initiate the preempt sequence. A test switch shall be provided to open the coil circuit of the relay. A red LED shall also be provided next to the test switch to be illuminated whenever the relay is in its de-energized (preempt active) state. A V150LA20 MOV and R/C network shall be installed across the coil of the relay.

The MS D Interface Panel shall be provided with a 120 VAC relay to provide electrical isolation for the flash sensing circuit. This relay shall be connected to the coil of the mercury contactor and shall be energized under normal signal operating conditions. This relay shall de-energize if the cabinet flash transfer relays de-energize or if the signal power is de-energized. The output of this relay shall be connected to the controller unit for reporting of flash conditions to a central monitor. A V150LA20 MOV and R/C network shall be installed across the coil of the relay.

A door switch shall be provided and connected to the MS D Interface Panel to indicate cabinet door open status. This switch shall provide a logic ground input whenever the main cabinet door is open.

The following pin connections shall be utilized for the MS D Interface Panel circular plastic connector. The connector shall be AMP part number 206438-1.

	PIN		FUNCTION
1	Offset 1 In	31	System Detector 7 In
2	Offset 2 In	32	System Detector 8 In
3	Offset 3 In	33	Preempt 1 Out
4	Reserved		
5	Reserved	34	Preempt 2 Out
6	Offset 1 Out	35	Preempt 3 Out
7	Offset 2 Out	36	Preempt 4 Out
8	Offset 3 Out	37	Railroad Preempt Out
9	Reserved	38	Cabinet Flash Monitor
10	Reserved	39	Flash Command
11	Transmit (Controller to Master)	40	Flash Out
12	Transmit (Controller to Master)	41	Dial 2 In
13	Receive (Controller to Master)	42	Dial 3 In
14	Receive (Controller to Master)	43	Dial 2 Out
15	Online	44	Dial 3 Out
16	System Enable	45	Split 2 In
17	Free/Coord In	46	Split 3 In
18	Free/Coord Out	47	Split 2 Out
19	Preempt 1 In	48	Out
20	Preempt 2 In	49	Conflict Status
21	Preempt 3 In	50	Local Special Function 1 Out
22	Preempt 4 In	51	Special Function 2 Out
23	Railroad Preempt In	52	Local Special Function 3 Out
24	Enable Dimming	53	+24 VDC
25	System Detector 1 In	54	Logic Ground
26	System Detector 2 In	55	Chassis Ground
27	System Detector 3 In	56	AC Neutral
28	System Detector 4 In	57	120 VAC
29	System Detector 5 In		
30	System Detector 6 In		

715.42.8.13 - Detector Racks: A shelf detector rack shall be furnished fully wired to the detector panel. The detector rack shall be fully wired for all functions even though some functions may not be used at the present time. This includes a call output for each vehicle, pedestrian, a delay inhibit input for each vehicle channel, a common reset input for all vehicle channels and all necessary power conductors. The detector rack shall be a sturdy aluminum frame designed to mount card guides and edge connectors for all of the cards contained in the rack. All racks must be configured as shown on the following

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special sheet labeled Dual Ring/Card Rack Mounted Detectors.

All card edge connectors shall utilize gold plated mating surfaces and shall be of the solder type. No crisp connections of any type will be allowed for attachment of loop lead-in conductors.

All loop lead-in wiring from the detector panel to the detector rack shall utilize tightly twisted conductors to eliminate coupling. Tightly twisted means a minimum of thirty-six twists per foot. Loop lead-in twisted pairs shall utilize a white/black stripe conductor for color-coding.

All cabinets must be provided with a minimum of eight (8) position NEMA racks, fully wired. Each position must be wired for two (2) channel detectors or P.C.S. as indicated. Rack Position assignments are as follows:

POSITIONS

	1	2	3	4	5	6	7	8
Channel 1	PH1	PH2	PH2	PH3	PH4	PCS	PCS	PCS
Channel 2	PH6	PH5	PH6	PH8	PH7	PH8	PCS	PCS

PH# = Phase Number

PCS = Priority Control System

NOTE: System detectors when required are to be clearly marked and placed in unused position slots. In no case should system detectors (sampling stations) be assigned to a channel with a phase detector in the same position.

715.42.8.14 - Documentation: Each cabinet assembly shall be provided with four complete and accurate wiring diagrams. The wiring diagrams shall contain an identification number which is also attached to the cabinet on an engraved nameplate. This number shall identify the prints for specific cabinet assembly. In addition to the wiring diagrams, a 3.5" disk shall be supplied with the cabinet containing the cabinet wiring diagrams in a ".DWG" format suitable for use with Autocad Version 12 (Windows version). The cabinet assembly will not be considered complete without the required documentation.

715.42.8.15 - Cabinet Submittal for Approval: One of each type of cabinet to be furnished for this project must be shipped for approval the Signal And Lighting Maintenance Shop in Charleston, West Virginia. These must be approved prior to shipping any cabinets to the project site for installation. All items covered in this subsection must be included with the representative cabinets.

715.42.9-Signal Supports: Signal supports shall be certified to be equal or exceed the requirements of "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals", including revisions, of the American Association of State Highway and Transportation Officials (AASHTO).

715.42.9.1-Mast Arm Signal Supports (Type A1, A1L, A2, A2L, B1 and B1L):

715.42.9.1.1-General Description: Mast arm supports Types A1, A2 and B1 shall consist of one two traffic signal mast arms (as designated on the Plans), an upright pole with anchor base and any other accessories or hardware as required to make a complete installation. They shall be designed to suspend traffic signals from a structural assembly similar in appearance and construction to that shown on the standard drawing which is part of the contract.

Mast arm supports Types A1L, A2L and B1L shall be identical to Types A1, A2 and B1 described above, except for the upright pole which shall be lengthened and provided with one or more street lighting luminaire arms as called for on the Plans. The upright pole length shall be governed by the mounting height specified for the luminaire and the rise provided in the luminaire arm. The luminaire arm, unless otherwise noted, shall be as similar as possible in style to that shown on the standard drawing and shall have the spread noted on the Plans.

All upright poles and all mast arms shall be made of one continuous piece, cylindrical in cross section, and they shall be uniformly tapered from butt to tip approximately 1 in. in diameter for each seven linear feet in length (0.14 in. per foot)(11.7 mm in diameter for each meter in length).

The shaft length and diameter of the upright pole and mast arm shall be as described on the Plans.

715.42.9.1.2-Mast Arm: All mast arms shall include a removable end cap, grommeted wire outlets, signal hanger assemblies of the type and quantity shown on the Plans, and a flange plate welded to the butt end to provide a rigid connection to the upright pole. The rigid connection to the upright pole shall be constructed so that it develops and transfers the full strength of the mast arm to the upright pole. The flange plate shall have four holes for the flangebolts which shall match the four tapped holes in the mounting plate on the upright pole. The entire assembly shall be constructed so that all wiring can be concealed internally. It shall be as similar, as possible in appearance and construction detail to that shown on the standard drawing. The use of guy rods of any type, or trussed-type arms, will not be permitted (except when noted for luminaire arms on the Plans).

Mast arms shall be connected to the upright pole at a height necessary to provide 17 ft-0 in. (5.2 m) clearance under the signals. The mast arm and upright pole shall be constructed so that the mast arm at any point along its length (measured from the flange plate connection), will fall within a tolerance of 0 to 5 percent of that length, above the true horizontal position, after loading as called for on the Plans. The fabricator must certify to the above and maintain results of computations or tests to document the certification for each type of mast-arm pole supplied. On Types B1 and B1L this requirement will only apply to the outboard end of the mast arm. Any deviations from this

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requirement due to sizes or loads listed on the Plans shall be brought to the Division's attention for appropriate corrective action prior to fabrication.

715.42.9.1.3-Upright Pole: Each pole shall consist of an upright shaft with a steel anchor base, a removable pole top, a J-hook wire support welded inside near the top, a handhole with reinforced frame and cover, anchor bolts and nuts, one flange plate assembly to match that welded to the butt end of each mast arm, and any other accessories or hardware as required to make a complete installation. Flange plates shall have a deburred wiring hole and four tapped holes for flange bolts. The handhole assembly shall be welded into the shaft near the base. The handhole reinforcing frame shall have a tapped hole to accommodate a grounding lug and contain a keeper chain. The keeper chain shall be secured by pop rivets or stainless steel screws. The cover shall be secured to the frame by at least two stainless steel screws. Each pole shall have a one-piece anchor base welded to the butt end. This base shall be designed to secure the pole assembly to a concrete foundation by means of four standard anchor bolts, each fitted with removable anchor bolt covers.

All construction details shall be as similar as possible to that shown on the standard drawing.

715.42.9.1.4-Materials Incorporated into the Support: The structures described above shall be fabricated from steel. The only exceptions permitted will be where the Contractor may prefer to use a cast aluminum pole top or aluminum anchor bolt covers, or both, on a galvanized steel pole.

All steel tubes for arms and poles shall be fabricated from ASTM A 595, Grade A or ASTM A 607, Grade 55, Class 2.

Miscellaneous steel materials required for fabrication of other structural components shall be of a weldable quality and shall be covered physically and chemically by an applicable ASTM Specification. This includes welding rod, plate and bar stock (for flanges, signal hangers, etc.) and casting for anchor bases.

Anchor bolts shall be fabricated from ASTM A1554 Gr. 55. Each bolt shall have the threaded end galvanized for a length sufficient to extend down through the grout and into the concrete foundation. Each bolt shall be provided with two regular nuts or heavy hex nuts that shall be hot dipped galvanized. Hex nuts shall be regular hex meeting ASTM A-563 Grade A for ¼" to 1½" (6.35 to 38.1 mm) sizes and shall be heavy hex for sizes 1½" to 4" (38.1 to 101.6 mm).

All mast-arm signal supports shall be provided with a one-piece, anchor-type base. The base shall be fabricated from material meeting ASTM A 27, Grade 65-35, or ASTM A 36 of sufficient cross section to fully develop the ultimate strength of the pole. The base shall be fastened to the pole by means of a welded connection and shall develop the full strength of the pole. The base shall be provided with four holes of sufficient size to accommodate the proper size anchor bolts that are capable of resisting at yield strength stress, the bending moment of the shaft at its yield strength stress. Four removable anchor

bolts covers shall be provided.

All steel components shall be galvanized after fabrication in accordance with ASTM A 123 or A 153. Galvanized coatings damaged for any reason shall be repaired by the application of a zinc-rich paint, conforming with 711.21 of the Standard Specifications. The places to be painted shall be thoroughly cleaned before the paint is applied.

All nuts, bolts or screws used to connect any aluminum components shall be passivated stainless steel meeting the requirements of AISI 300 series, commercial grade.

All nuts, bolts (except anchor bolts), or screws used to connect steel components shall meet the following requirements:

- i. Less than $\frac{5}{8}$ in. (16 mm) diameter shall be ASTM A 307 and plated in accordance with ASTM B 633, or stainless steel. An exception to this will be the two screws fastening the handhole cover, which shall be stainless steel in accordance with the description above.
- ii. For $\frac{5}{8}$ in. (16 mm) diameter and over, any ASTM physical and chemical qualification that is acceptable to the Division on the basis of structural design requirements and hot-dipped galvanized in accordance with ASTM A 153.

715.42.9.1.5-Drawings for Approval Purposes: Two prints of shop drawings indicating the proposed dimensions and material specifications for each of the components involved shall be submitted by the Contractor for approval purposes within three weeks after the award of the Contract. These drawings will be reviewed by the Division at the earliest possible date and one print will be returned marked "Approved," or "Returned for Revisions as Noted." Eight sets of drawings shall then be submitted for final approval. Appropriate action shall be taken by the Contractor after final approval to insure that the earliest possible erection of these items can be achieved. Resubmission of drawings to obtain final approval by the Division will not be considered as being just cause for delay in the completion of any contract.

715.42.9.1.6-Mill Test Reports and Certification: Mill test reports or certifications of conformance to specifications for materials and design will be required for all materials incorporated into the work. The following shall be supplied by the Contractor prior to acceptance of the structures:

715.42.9.1.6.1: Mill test reports (MTR) for major structural items only, as noted in the following chart, shall include both physical and chemical descriptions of the materials as supplied to the fabricator. When physical properties are altered during fabrication, the MTR covering chemical composition shall be supplemented by certified test reports indicating the physical properties of this material after fabrication.

715.42.9.1.6.2: Certification of conformance to the specifications for all remaining material not covered by MTR as noted in the following chart.

See 715.42.9.1.6.1 See 715.42.9.1.6.2

Component Materials	MTR	CERTIFICATIONS
Tubes for arms and poles	X	
Base castings	X	
Anchor bolts	X	
Pole tops, misc. fittings and hardware		X
Fabricated or cast-type arm connections	X	
Galvanizing		X
Welding rod	X	

715.42.9.1.6.3: Certification of conformance to the specifications for the design of all components not completely dimensioned and detailed on the standard drawings.

715.42.9.1.6.4: Certification that all welding was performed by operators qualified as follows: steel welders to AWS and aluminum welders to ASME.

715.42.9.2-Strain Pole Signal Supports (Types C1, C1L, C2 and C2L):

715.42.9.2.1-General Description: Each strain pole support Type C1 and C2 shall consist of an upright shaft with steel anchor base, a removable pole top, a J-hook wire support welded inside near the top, a 45 degree wire inlet near the top, a handhole with reinforced frame and cover, anchor bolts and nuts and any other accessories or hardware as required to make a complete installation. The pole and all its component parts shall be designed to support free-swinging traffic signals suspended from a span wire assembly. It shall be as similar as possible in appearance and construction detail to that shown on the standard drawing which is part of the contract.

Each strain pole support Type C1L and C2L shall be identical to the type C1 and C2 described above, except that the upright pole shall be lengthened and provided with one or more street lighting luminaire arms as called for on the Plans. The shaft length of the Type C1L and C2L pole shall be governed by the mounting height specified for the luminaire and the rise provided in the luminaire arm. The luminaire arm, unless otherwise noted, shall be as similar as possible in style to that shown on the standard drawing and shall have the spread noted on the Plans.

The upright shaft shall be made in one continuous piece, cylindrical in cross section and shall be uniformly tapered from butt to tip approximately 1

in. in diameter for each seven linear feet in length (0.14 in. per ft) (11.7 mm per m). The diameter shall be measured outside to outside of the cylinder. No horizontal joints of any type will be permitted.

The shaft length and diameter of the Type C1, C1L, C2 and C2L poles shall be as described on the Plans. The signal clearance will be set for a minimum of 17 ft. in. (5.2 m) The span wire will be fastened from 12 in. (305 mm) to 18 in. (455 mm) from the top of the pole, except for the Type C1L and C2L poles, where the span wire height shall be as specified on the Plans.

715.42.9.2.2-Materials Incorporated into the Support: The entire strain pole assembly shall be made from steel. The only exceptions permitted will be where the Contractor may prefer to use a cast aluminum pole cover or aluminum anchor bolt covers, or both, on a galvanized steel pole.

The upright shaft shall be fabricated from ASTM A 595, Grade A or ASTM A 607, Grade 55, Class 2. The minimum wall thickness shall be 0.1793 in. (7 gage) (4.55 mm).

Miscellaneous steel material required for fabrication of other structural components shall be of a weldable quality and shall be covered physically and chemically by an applicable ASTM Specification. This includes welding rod, plate or bar stock (for span wire clamps, etc.) and castings for anchor bases.

Anchor bolts shall be fabricated from ASTM A1554 Gr. 55. Each bolt shall have the threaded end galvanized for a length sufficient to extend down through the grout and into the concrete foundation. Each bolt shall be provided for two regular nuts or heavy hex nuts that shall be hot dipped galvanized. Hex nuts shall be regular hex meeting ASTM A-563 Grade A for ¼” to 1½” (6.35 to 38.1 mm) sizes and shall be heavy hex for sizes over 1½” to 4” (38.1 to 101.6 mm).

All strain pole signal supports shall be provided with a one-piece anchor type base. The base shall be fabricated from material meeting ASTM A 27, Grade 65-35 or ASTM A 36 of sufficient cross section to fully develop the ultimate strength of the pole. The base shall be fastened to the pole by means of a welded connection and shall develop the full strength of the pole. The base shall be provided with four holes of sufficient size to accommodate the proper size anchor bolts that are capable of resisting at yield strength stress, the bending movement of the shaft at its yield strength stress. Four removable anchor bolt covers shall be provided.

All steel components shall be galvanized after fabrication in accordance with ASTM A 123 or A 153. Galvanized coatings damaged for any reason shall be repaired by the application of a zinc-rich paint conforming with 711.21 of the Standard Specifications. The places to be painted shall be thoroughly cleaned before the paint is applied.

All nuts, bolts (except anchor bolts), or screws used to connect steel components shall meet the following requirements:

- i. Less than 5/8 in. (16 mm) diameter shall be ASTM A 307 and plated in accordance with ASTM B 633, or stainless steel. An exception

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to this will be the two screws fastening the handhold cover which shall be stainless steel.

- ii. For 5/8 in. (16 mm) diameter and over, any ASTM physical and chemical qualification that is acceptable to the Division on the basis of structural design requirements and hot-dipped galvanized in accordance with ASTM A 153.

715.42.9.2.3-Drawings for Approval Purposes: Two prints of shop drawings indicating the proposed dimensions and material specifications for each of the components involved shall be submitted by the Contractor for approval purposes within three weeks after the award of contract. These drawings will be reviewed by the Division at the earliest possible date and one print will be returned marked "Approved," or "Returned for Revisions as Noted." Eight sets of drawings shall then be submitted for final approval. Appropriate action shall be taken by the Contractor after final approval to insure that the earliest possible erection of these items can be achieved. Resubmission of drawings to obtain final approval by the Division will not be considered as being just cause for delay in the completion of any contract.

715.42.9.2.4-Mill Test Reports and Certification: Mill test reports or certifications of conformance to specifications for materials and design will be required for all materials incorporated into the work. The following shall be supplied by the Contractor prior to acceptance of the structures:

715.42.9.2.4.1: Mill test reports (MTR) for major structural items only, as noted in the following chart, shall include both physical and chemical descriptions of the materials s supplied to the fabricator. When physical properties are altered during fabrication, the MTR covering chemical composition shall be supplemented by certified test reports indicating the physical properties of this material after fabrication.

715.42.9.2.4.2: Certification of conformance to the specifications for all remaining material not covered by MTR as noted in the following chart.

See 715.42.9.2.4.1 See 715.42.9.2.4.2

Component Materials	MTR	CERTIFICATIONS
Tubes for upright shafts	X	
Base castings	X	
Anchor bolts	X	
Pole tops, misc. fittings and hardware		X
Galvanizing		X
Welding rod	X	

715.42.9.2.4.3: Certification of conformance to the specifications for the design of all components not completely dimensioned and detailed on the standard drawings.

715.42.9.2.4.4: Certification that all welding was performed by operators qualified as follows: steel welders to AWS and aluminum welders to ASME.

715.42.9.3-Wood Pole Signal Supports (Type D):

715.42.9.3.1-General Description: Each Type D wood pole shall consist of an upright shaft fitted with necessary hardware to make the installation complete.

The shaft length and diameter of the poles shall be as described on the Plans. The signal clearance will be set for minimum of 17 ft-0 in. (5.2 meters). The poles shall be of sufficient length to provide the luminaire mounting height when described on the Plans.

Maximum allowable span wire sag between supports is 5 percent of the pole to pole span. Maximum sag is measured at the point of the greatest offset of the span wire from a line in the plane of the support poles drawn through the span wire suspension points.

Spans supporting two signal heads or less shall not require tubular piping between the span wire mounting devices and the signal heads.

715.42.9.3.2-Material: Poles shall not have more than 180 degree twist in grain over the full length and the sweep shall be no more than 4 inches (100 mm).

715.42.9.3.3-Treatments: Poles shall be pressure treated in accordance with Section 710 of the Specifications.

715.42.9.4-Pedestal Pole Signal Supports (Types E1, E2, and E3):

715.42.9.4.1-Type E1: The pole shall consist of a cast aluminum base and tapered shaft. The shaft shall be spun from one piece of seamless tubing. Aluminum Association Alloy 6063 (ASTM B 221), having a nominal 0.125 in. (3.18 mm) wall thickness and 6 in. (152 mm) diameter at the base tapering to 42 in. (114 mm) diameter at the top which, after fabrication, shall have a mechanical strength of not less than T6 temper. The shaft shall have no longitudinal welds and no circumferential welds, except those joining the shaft to the base. A handhole shall be provided near the base.

The base shall be one-piece aluminum casting, Aluminum Association T-6 Temper (ASTM B 26). The base of adequate strength, shape, size and having a scalloped top flange, shall be secured to the lower end of the shaft by two continuous welds made by the metallic-arc-consumable-electrode-inert-gas-shielded process. The base shall telescope the shaft and one weld shall be on

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the inside of the base at the end of the shaft, while the other weld shall be on the outside at the top of the base. The two welds shall be not less than 2 inches (50 mm) apart and the welded connection shall develop the design strength of the pole assembly. The base shall be provided with four holes to receive the anchor bolts and eight tapped holes for attaching the ornamental covers. Four removable bolt covers shall be provided with each base and each cover shall attach to the upright portion of the body of the base by means of two hex-head cap screws.

Anchor bolts shall be fabricated from ASTM 1554 Gr. 55. The threaded end of each anchor bolt shall be galvanized for a length sufficient to extend down through the grout and into the concrete foundation. Four galvanized nuts and washers or clips as required shall be furnished with each pole. The anchor bolts shall be capable of resisting, at yield strength stress, the bending moment of the shaft at its yield strength stress. Bolts, nuts and washers or clips shall be galvanized to meet ASTM A 153.

The shaft shall have a uniform polished finish. Each shaft shall be tire-wrapped with a heavy water-resistant paper for protection during shipment and installation.

Two prints of shop drawings indicating the proposed dimensions and material specifications for each of the components involved shall be submitted by the Contractor for approval purposes within three weeks after the award of contract. These drawings will be reviewed by the Division at the earliest possible date and one print will be returned marked "Approved," or "Returned for Revisions as Noted." Eight sets of drawings shall then be submitted for final approval. Appropriate action shall be taken by the Contractor after final approval to insure that the earliest possible erection of these items can be achieved. Resubmission of drawings to obtain final approval by the Division will not be considered as being just cause for delay in the completion of any contract.

715.42.9.4.2-Type E2: The pole shall consist of a base with anchor bolts and nuts and pipe shaft. The shaft shall be standard 4 in. Schedule 40 (DN100) pipe conforming to the requirements of ASTM A 501 and shall be welded to the steel base. A handhole shall be provided near the base.

The base shall be a one-piece cast steel anchor base, ASTM A 27, Grade 65-35, of adequate strength, shape and size secured to the lower end of the pipe shaft by two continuous electric arc welds. The base shall telescope the shaft and the one weld shall be on the inside of the base at the end of the shaft, while the other weld shall be on the outside at the top of the base. The design shall be such that the welded connection and base shall develop the calculated yield strength of the adjacent shaft section to resist bending action.

Anchor bolts shall be fabricated from ASTM 1554 Gr. 55. The threaded end of each anchor bolt shall be galvanized for a length sufficient to extend down through the grout and into the concrete foundation. Four galvanized nuts and washers or clips, as required, shall be furnished with each pole. The anchor bolts shall be capable of resisting, at yield strength stress, the bending

moment of the shaft at its yield strength stress. Bolts, nuts and washers or clips shall be galvanized to meet ASTM A 153. Each anchor bolt shall be furnished with one cap nut (acorn).

Two prints of shop drawings indicating the proposed dimensions and material specifications for each of the components involved shall be submitted by the Contractor for approval purposes with three weeks after the award of contract. These drawings will be reviewed by the Division at the earliest possible date and one print will be returned marked "Approved," or "Returned for Revisions as Noted." Eight sets of drawings shall then be submitted for final approval. Appropriate action shall be taken by the Contractor after final approval to insure that the earliest possible erection of these items can be achieved. Resubmission of drawings to obtain final approval by the Division will not be considered as being just cause for delay in the completion of any contract.

715.42.9.4.3-Type E3: The pole shall consist of a base with anchor bolts and nuts and a tubing shaft. The shaft shall be fabricated from United States Standard 13 Ga. (0.095 in.) (2.41 mm) weldable grade commercial quality carbon steel meeting ASTM A 607 Gr. 45 after fabrication. A handhole shall be provided near the base.

The base shall be fabricated from structural quality hot-rolled carbon steel plate with a guaranteed minimum yield strength of 36,000 psi. (248 MPa) The base plate shall telescope the shaft and be circumferentially welded top and bottom. The design shall be such that the welded connection and base shall develop the calculated yield strength of the adjacent shaft section to resist bending action.

Anchor bolts shall be fabricated from ASTM 1554 Gr. 55. The threaded end of each anchor bolt shall be galvanized for a length sufficient to extend down through the grout and into the concrete foundation. Four galvanized nuts and washers or clips as required shall be furnished with each pole. The anchor bolts shall be capable of resisting, at yield strength stress, the bending moment of the shaft at its yield strength stress. Bolts, nuts and washers or clips shall be galvanized to meet ASTM A 153. Each anchor bolt shall be furnished with one cap nut (acorn).

The finish for all exposed parts shall be hot-dipped galvanizing in accordance with ASTM A 123.

Two prints of shop drawings indicating the proposed dimensions and material specifications for each of the components involved shall be submitted by the Contractor for approval purposes within three weeks after the award of the Contract. These drawings will be reviewed by the Division at the earliest possible date and one print will be returned marked "Approved," or "Returned for Revisions as Noted." Eight sets of drawings shall then be submitted for final approval. Appropriate action shall be taken by the Contractor after final approval to insure that the earliest possible erection of these items can be achieved. Resubmission of drawings to obtain final approval by the Division will not be considered as being just cause for delay in the completion of any

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contract.

715.42.9.4.4-Mill Test Reports and Certification: Mill test reports or certifications of conformance to Specifications for materials and design shall be supplied for pedestal pole signal supports (Types E1, E2 and E3) as required in 715.42.9.1.6.

715.42.10-Electrical Conduit:

Following are minimum design requirements for underground conduit housing signal control cable and other electrical wiring.

Unless otherwise specified on the Plans, all conduit shall be 2 inches (50 mm) in diameter.

The Plans will call for type of conduit to be used.

Approximate lengths of conduit are shown on the Plans. It is the responsibility of the Contractor to determine exact lengths of conduit runs in the field.

715.42.10.1-Type R (Rigid Steel Conduit): The steel conduit shall conform to American Standard Specification for rigid steel conduit, zinc-coated ASA C80-1 and current amendments.

Each length of conduit shall be furnished with one coupling.

Running threads shall not be used on conduit for connection and coupling.

All cut ends of conduit shall be reamed to remove rough edges.

Bends of rigid conduit shall be so made that the conduit will not be injured and the internal diameter of the conduit will not be effectively reduced.

715.42.10.2-Type F-(Flexible, Liquid-tight Conduit): Conduit shall be approved by Underwriters Laboratories.

Conduit shall have galvanized steel core over which is extruded a polyvinyl chloride cover.

Standard liquid-tight connectors shall be used for conduit connection.

Conduit shall protect electrical conductors from moisture, oil, grease, dirt, chemicals, corrosives, fumes, abrasion, etc.

715.42.10.3-Type P (Polyvinyl Chloride Conduit): Type P (Polyvinyl Chloride Conduit) shall be made of polyvinyl chloride plastic using polyvinyl chloride fillers where fillers are used. The conduit shall meet all requirements of EPC-40-PVC as contained in NEMA Standards Publication TC2, shall be Underwriters' Laboratories approved, and shall be suitable for direct burial.

715.42.11-Junction Boxes: Following are minimum design requirements for junction boxes for signal cable and other electrical wiring. The type will be noted on the Plans.

Junction boxes as shown on the Plans shall be installed where indicated. The Contractor may, with the approval of the Engineer and at their own expense, install additional junction boxes to facilitate the work of installing

conduit and pulling signal control cable.

715.42.11.1-Type L- (Light Duty): The box shall meet the requirements of Standard Drawing TES-50.

715.42.11.2-Type H-(Heavy Duty): The junction box shall consist of a concrete box with a cast iron frame and either a cast iron or ductile iron cover. The box shall meet the requirements of Standard Drawing TES-50 for the 10" x 10" (255 mm x 255 mm) size or TEL-43 for the 18" x 18" (460 mm x 460 mm) size.

The walls and floor of the concrete box shall be either precast or cast in place.

If cast in place in a paved area, the interior shall be formed and the exterior wall and floor may be poured directly against a smooth, well-trimmed hole in the pavement and ground.

If cast in place in other than a paved area, the interior and top 3 inches (75 mm) of the exterior shall be formed to provide the size and shape shown on the standard drawing.

The Type H (10x10) (255 x 255 mm) junction box cover and frame shall have a minimum weight of 90 pounds (40 kg). Type H (10x10) (255 x 255 mm) cover frame shall be cast integral with the concrete box.

715.42.11.3-Type M (Magnetic Probe Box): The box shall have a minimum inside dimension of 4 in. by 4 in. by 4 in. (100 x 100 x 100 mm).

The junction box and lid shall be of copper-free aluminum meeting Federal Specifications W-C-583b.

The cover shall be attached to the box by monel or stainless steel screws. The cover shall also contain a neoprene gasket of sufficient size to make it watertight.

The wall thickness on the boxes shall not be less than ¼ in. (6.35 mm).

The lid shall have a checkered non-slip surface.

715.42.11.4-Types A, B, and C: Junction boxes Types A, B, and C shall meet the dimensions and requirements as shown on the Plans. Type A and B boxes shall be fabricated from steel conforming to ASTM A 36 with galvanizing in accordance with ASTM A 123. Wall thickness shall be 3 in. (6.35 mm) for Types A and B and not less than 14 gauge for Type C.

715.42.12-Messenger Cable: The messenger cable shall be of the diameter specified on the signalization plan and shall be fabricated on seven steel wires, double galvanized and twisted into a single concentric strand to conform to the following:

DIAMETER INCHES (mm)	SIZE OF WIRE (NO.)	TENSILE STRENGTH POUNDS (kg)
½ (12.7)	8	12,100 (5490)
7/16 (11.1)	9.5	9,350 (4240)
3/8 (9.5)	11	6,950 (3150)
5/16 (7.9)	12	5,350 (2425)
¼ (6.4)	14	3,150 (1430)
3/16 (4.7)	16	1,900 (860)

The Contractor shall, when requested by the Division, furnish in suitable form a certified report of the cable to show compliance with this Specification.

715.42.13-Conductors: All conductors used for traffic signal control and external circuitry shall be solid or stranded copper wire as required, unless otherwise specified. Wire sizes shall be based on American Wire Gage (AWG). The copper wire shall conform to the requirements of ASTM B 3 and B 8, latest revision. IMSA specification numbers refer to the International Municipal Signal Associations, Inc., latest revisions on wire and cable specifications.

All single conductors shall have clear, distinctive and permanent markings on the outer surfaces throughout the entire length, showing the manufacturer's name or trademark, insulation type-letter designation, conductor size and voltage rating.

Conductors for traffic signal and supplemental flasher installations shall be rated for 600-volt operation. The insulation shall be a minimum TW Grade or as specified.

All conductors subject to flexing, such as opening and closing of the cabinet doors or on removal of equipment from the cabinet, shall be stranded. Conductors No. 14 AWG through No. 10 AWG, inclusive, shall be 19-strand and conductors No. 16 AWG shall be 26-strand.

Conductors in traffic actuated controller cabinets between the power service terminals and the "AC+" terminals on the external signal load switching devices shall have an ampacity of 20 amperes at 160° F (71° C). This ampacity shall include all switching devices and connections to switching devices in this circuit as well as signal light neutrals and interference suppressors.

Conductors in pre-timed controller cabinets between the power service terminals and the controller bus to the signal light circuits shall have an ampacity of 20 amperes at 160° F (71° C). This ampacity shall include all switching devices and connections to switching devices in this circuit as well as signal light neutrals and interference suppressors.

All other conductors in the signal light circuits (both traffic actuated and pre-timed system) shall be No. 14 AWG solid conductor cable meeting IMSA Specification No. 19-1 or 20-1. Five-conductor signal light cable shall be used as a minimum per signal conductor run (see 660.16).

Power service conductors to the breakers (fuse) in all controller cabinets shall be No. 8 AWG service wire.

Conductors between the power service terminals, the "AC+" on all flasher units and the duplex receptacle shall have ampacity of 20 amperes at 160° F (71° C). This ampacity shall include all switching devices and connections to switching devices in this circuit as well as signal light neutrals and interference suppressors.

Conductors for traffic loops shall be continuous No. 14 THWN stranded wire to the detector terminals or the feeder cable junction box or conduit.

Detector feeder cable from the loop wire terminals to the detector terminals shall be two-conductor cable, No. 14 AWG-THW, meeting IMSA Specification 19-2, 20-2 or 50-2. The two conductor pair for each feeder shall be twisted together with approximately two turns per foot (6.5 turns per meter).

All other multi-conductor detector wiring, unless otherwise specified, shall be No. 14 AWG cable meeting IMSA Specifications No. 19-1 or 20-1. Single conductor detector wiring shall be No. 14 AWG-THWN stranded, unless otherwise specified.

Interconnect cable shall be No. 14 AWG cable meeting IMSA Specification No. 19-1 or 20-1.

All conductors used in the signal controller cabinets shall be No. 22 AWG, or larger. Conductors smaller than No. 14 AWG shall conform to Military Specification: MIL-W-16878D, Type B, Vinyl-Nylon Jacket, 600-volt, 105° C. Conductors No. 14 AWG and larger shall be as specified.

715.42.14-Supplemental Flashing Beacons and Mountings:

715.42.14.1-Flashing Signal Heads: The signal head shall provide an indication in one direction only and shall be adjustable through 360 degrees about a vertical axis.

Housing:

Each head shall be constructed primarily of aluminum and aluminum castings and stainless steel, shall meet all requirements in 715.42.14.1 and shall accept lenses and lamps as described in the paragraph on Optical Unit.

The signal head housing shall be one piece, corrosion-resistant aluminum alloy die casting complete with integrally cast top, bottom, and sides. All cast metal parts shall have a tensile strength of not less than 17,000 psi. (117 MPa) All parts shall be clean, smooth and free from flaws, cracks, blowholes and other imperfections.

The die cast aluminum housing, door and cast visor of the signal heads shall comply with the following specifications or latest revision thereof: Die Castings SC-84A, SC-84B, SG-100A, SG-100B, S-12A or S-12B of ASTM B 85.

When required by the Engineer, the successful bidder shall furnish satisfactory evidence that the materials comply with the foregoing requirements.

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The top and bottom of the signal housing shall have round openings to accommodate standard 1½ in waterproof pipe brackets or trunnions. The portion of the housing adjacent to the bracket shall be properly reinforced so as to have sufficient strength to resist shock, vibration and impact damage.

Each signal head shall have lugs for the mounting of at least one six-position, twelve-terminal barrier type terminal block.

Each signal head shall have lugs or pads such that backplates may be mounted without drilling or tapping the head housing.

The housing door shall be a one-piece square casting having two hinge locations on the left side and at least one latch location on the right side. The hinges shall have stainless steel pins at least 3/16 inch (5 mm) in diameter. The latch shall consist of (1) a latch jaw on the door and a stainless steel latch screw, wing nut and washer securely affixed to the housing or (2) a captive wing nut, washer and screw assembly on the door and a captive nut in the housing. It shall be possible to open and remove the door without the use of any tools.

The door shall have a gasketed opening that shall provide a visible lens diameter of 7-¾ in. to 8 in. (197 to 203 mm) for a nominal 8 in. (203 mm) lens.

All lenses shall be as described in Optical Unit. The door shall have four equally spaced visor attachment points around the lens opening.

The section and door shall be one-piece, corrosion-resistant aluminum alloy die castings. Visors and reflections shall be made from sheet aluminum ordie castings.

Sheet aluminum parts shall be manufactured from corrosion-resistant aluminum sheet having a tensile strength of at least 20,000 psi (138 MPa) except that reflectors shall be manufactured from the aluminum alloy suggested by the manufacturer.

All hinge pins and latch parts shall be Type 304, stainless steel.

Miscellaneous parts and hardware shall be made of non-corrosive materials.

All parts shall have sufficient strength to show minimal damage under severe loading conditions.

Visors shall be at least 7 inches (178 mm) long and shall be described as standard (cut-away), tunnel, or full circle. Heads shall be supplied with standard visors unless otherwise noted on the plans or unless prior permission from the Division has been received.

Visors shall be designed with a downward tilt between 32 and 5 degrees to eliminate the return of outside rays entering the unit from above the horizontal (know as sun phantom). Visors shall be not less than 0.05 in. (1.3 mm) thick.

All mounting brackets, trunnions, and suspensions shall be finished with yellow enamel. The door and the outside of the visor shall also be finished with yellow enamel. The inside of the visor shall be finished with flat black enamel.

All enamel shall be best quality, over baked meeting Federal Specifications TT-E489.

Optical Unit:

The optical unit shall consist of the lamp, lampholder, reflector, lens gasket and lens, shall be so designed that all light emitted by the unit passes through the lens and so that any possibility of false indications is eliminated.

The lampholder shall be of heat resisting material designed to properly position a medium screw base traffic signal lamp, with means to accommodate a lamp having light center 2-7/16 in. (60 mm) in length for the 60-watt series. The lampholder shall be provided with a lamp grip to prevent the lamp from working loose due to vibration. Provision shall be made on either the lampholder or the reflector holder to permit rotation of the lamp so that lead-in wires are up, and the lamp shall be retained securely in that position, but no change in position of the socket with respect to the optical center of the reflector shall occur. The metal portion of the lampholder shall be compatible with brass or copper.

Each lampholder shall be provided with two code No. 18 or larger lead wires, Type TEW, 600-watt, AWM fixture wire with 2/64 in. (0.8 mm), 105° C rating thermoplastic insulation, securely fastened to the socket, and with sufficient length to reach the terminal block with the holder door fully open. The thermoplastic insulation shall at minus 30° F (-34° C) be capable of being bent six times around a 1 in. (25 mm) mandrel without damage to its insulating properties at rated voltage.

Reflectors shall be specular aluminum in accordance with the latest ITE specifications and shall be mounted in a reflector holder. The reflector holder shall provide a rigid reflector mounting to assure proper alignment between the lens and the reflector with the door closed. The reflector shall have a lampholder opening in the back. The reflector shall have a hood or flange on the outer edge to stiffen the reflector and insure its dimensional stability.

The reflecting surface shall be totally free from flaws, scratches, defacements and mechanical distortion. Reflectors shall be spun or drawn from aluminum not less than 0.025 in. (0.64 mm) thick.

The lens gasket shall be a slotted circular neoprene gasket specifically designed to exclude moisture, dust and road film. The optical unit shall be sealed to exclude moisture and dust. This may be accomplished in one of two ways:

- i. If the open door contains the complete optical unit, the reflector/lampholder interfaces shall be equipped with specially designed neoprene seals to completely seal the optical unit. The section must not accumulate water.
- ii. If the reflector and lampholder remain in the section when the door is opened, the entire section shall be made watertight and dusttight by a weatherproof neoprene gasket contained in a gasket groove in the door. The gasket shall seal against a raised bead in the section to provide the proper seal.

The lighted signal shall appear to be illuminated over the entire visible lens surface without shadows when viewed from any angle up to 50 degrees each

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side of the optical axis horizontally and up to 45 degrees below the optical axis vertically.

The required appearance, light distribution and candlepower intensity from the complete assembled section shall meet the latest revision of the specifications of the Institute of Traffic Engineers, "A Standard for Adjustable Face Vehicle Traffic Control Signal Heads".

Trunnions, Brackets and Suspensions:

All trunnions, brackets and suspensions used for assembling and mounting vehicle traffic control signal faces shall be entirely weathertight.

All tubular parts shall be 1½ in. IPS (DN40) pipe.

The lower support or connection between signal heads in a span wire or mast arm mounted signal may be an aluminum casting or stamping of suitable strength.

Wire raceway areas within brackets, trunnions and suspensions shall be of adequate size to carry all necessary wires without crowding and raceway surfaces shall be free of sharp edges or protrusions which might damage insulation on wires.

Suspensions for the mast arm or span wire mounting shall include a device to permit adjustment for proper vertical alignment of the signal head.

Non-metallic trunnions, brackets and suspension parts previously approved by the Division may be supplied. Such parts must be capable of mounting metallic signal heads and must have metallic reinforcement at points of anticipated wear.

All reinforcing metal must be compatible with aluminum, steel and galvanized steel.

715.42.14.2-Flashing Mechanism: The signal head shall flash at a rate of not less than 50 not more than 60 flashes per minute with each lamp being lighted 50 percent of the time. The closing and opening of the flashing contacts shall be accomplished in such a manner as to avoid undue pitting and burning at 10 amps, 115 volts, A/C, continuous make and break duty. The flasher shall be equipped with adequate radio interference filter and protected by a fuse or circuit breaker.

Solid state flashers meeting current NEMA TS Standards and capable of the above specified outputs and circuit ratings are acceptable.

715.42.14.3-Time Clocks: The clock motors shall be designed for synchronous operation on 115 volts, 60 cycle, single phase alternating current.

The clocks shall be programmable for circuit on-off operation at 15 minute intervals of the day. In addition, the clocks must be capable of skip-a-day operation. Each clock dial shall provide from one to 48 operations per day, minimum 15-minute settings.

Each clock shall be capable of operating in a "power off" condition for a minimum of 10 hours. Drive for the clock when electric power is off shall be provided by a reserve spring which is wound automatically during "power-on"

periods.

All time clocks must be easily accessible and demountable and fit within the controller cabinet.

Electronic time switches as specified under Auxiliary Traffic Signal Equipment are an acceptable alternate to the above time clock.

715.42.14.4-Flasher Cabinet: Flasher cabinets shall conform to the requirements of 715.42.8.3.

The cabinet shall be provided with the necessary opening and attachments for mounting and connecting in the manner specified by one of the following options as indicated on the plans.

715.42.14.4.1-(OPTIONAL): Mounting to wooden poles by means of lag screws.

715.42.14.4.2-(OPTIONAL): Mounting to steel poles using pole attachment clamps.

715.42.14.4.3-(OPTIONAL): The flasher mechanism may be located within one of the signal heads when the head is of special design to permit this mounting without hindering the functioning of the flasher.

715.42.14.4.4-(OPTIONAL): The timing mechanism may be located within a building and housed in a non-weatherproof cabinet.

715.42.14.5-Mounting: The mounting of the sign must conform to one of the following types:

715.42.14.5.1-Post Mounted: The post mounted sign shall be located so that the nearest edge of the sign is not less than 6 feet (1.8 m) not more than 12 feet (3.6 m) from the edge of the traveled way or a minimum of 2 feet (0.6 m) and a maximum of 6 feet (1.8 m) outside an unmountable curb.

The bottom of the sign shall be a minimum of 8 feet (2.4 m) and not more than 15 feet (4.5 m) above the pavement grade at the center of the highway.

715.42.14.5.2-Pedestal Mounted: Use the same criteria as for 715.42.14.5.1 - Post Mounted.

715.42.14.5.3-Span Wire: The sign shall be located over the center of the lane that it faces on a two-lane roadway and in the center of the lanes it faces on a multi-lane roadway.

The span wire mounting shall be such that a minimum of 17-foot (2.4 m) and a maximum of 19-foot (4.5 m) clearance is maintained from the pavement to the bottom of the sign.

The span wire shall have a maximum sag of five percent of the span.

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715.42.14.5.4-Mast Arm: The mast arm mounted sign shall be located so that the center of the sign is located over the lane or lanes to be controlled by the signs.

The mast arm mounting shall be such that a minimum of 17-foot (2.4 m) and a maximum of 19-foot (4.5 m) clearance is maintained from the pavement to the bottom of the sign.

715.42.14.6-Warranties and Guarantees: Any and all equipment shall be covered by manufacturer's written guarantee or warranty for a period of 12 months with respect to parts, workmanship and performance of product.

The department reserves the right to withhold any payments which may be due, should it be discovered that the equipment does not meet the Specifications.

The manufacturer shall make available, at no cost, engineering data, diagrams, etc., on any later changes or improvements which would increase the performance of the equipment purchased.

The manufacturer shall furnish instructions for installing and maintaining the equipment and assistance as required for timing and operation of the equipment.

715.42.14.7-Construction Methods: The materials furnished and used shall be new, except as may be specified on the Plans. All workmanship for electric work shall be in accordance with the details shown on the plans, the above Specifications, Special Provisions for 715.42 (Traffic Signals) as applicable, the Standard Drawing TES-36 and the requirements of the current National Electrical Code in addition to any local codes.

715.45-BENTONITE:

Bentonite shall meet the requirements of Section 3 of American Petroleum Institute Standard 13A and Supplements.