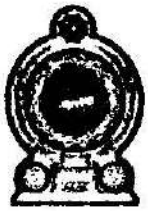

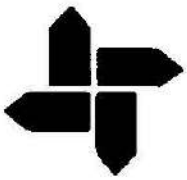

DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

MINISTRY OF PORTS & HIGHWAYS

ROAD DEVELOPMENT AUTHORITY

HAMBANTOTA HUB DEVELOPMENT PROJECT
CONSTRUCTION OF
EXTENSION OF SOUTHERN EXPRESSWAY FROM WATIYA TO ANDARAWEWA

CONTRACT AWARDED TO
CHINA STATE CONSTRUCTION ENGINEERING CORPORATION LIMITED

CIVIL WORK CONTRACT NO: RDA/RNIP/HH/01

VOLUME 3

TECHNICAL SPECIFICATION

-SECTION 3 (DIVISION 700)

AUGUST 2013

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DIVISION 700 MATERIALS

DIVISION 700 - MATERIALS

SECTION 701
CEMENT

The Contractor shall provide suitable means for storing and protecting cement against dampness. Cement which for any reason has become partially set or which contains lumps of caked cement will be rejected. Cement salvaged from discarded or used bags shall not be used.

701.1 - PORTLAND CEMENT:

Portland cement shall conform to the requirements of SLS 107..2008.

701.2 - NOT USED:

701.3 - BLENDED HYDRAULIC CEMENTS:

Blended hydraulic cement shall conform to the requirements of ASTM C 595 for Portland Blast-Furnace Slag Cement, Type IS, or Portland-Pozzolan Cement, Type IP.

701.4 - MASONRY CEMENT:

Masonry Cement shall conform to the requirements of ASTM C 91.

SECTION 702
FINE AGGREGATE

702.1 - FINE AGGREGATE FOR PORTLAND CEMENT CONCRETE:

702.1.1 - General Requirements:

Fine aggregate shall consist of crushed stone, manufactured sand, or a combination thereof, conforming to the requirements of these Specifications.

The mining of river and sea sand in the area surrounding the site of the Works is generally prohibited by local regulation. Permits for such mining have to be obtained from the Divisional Secretary. The Design Consultants investigations have indicated that such local natural sources of sand would be grossly insufficient for the requirements of the Works, and would be consequent in significant environmental impact. However, provided that the necessary permits could be obtained from the appropriate authorities (including the approval of the Central Environmental Authority) there would be no specific objection on technical grounds to the use of such sources provided that the physical characteristics of the material produced shall comply with the Specifications. Bidders shall be aware that the granting of appropriate permits by the authorities concerned is unlikely, and the Employer shall bear no responsibility for the granting or refusal (or subsequent withdrawal in the case of initial granting) of permits and approval.

The term "manufactured sand" refers to fine aggregate derived from crushing of rock conforming to the required specifications.

702.1.2 - Deleterious Substances:

The Maximum percentages of deleterious substances shall not exceed the limits below.

MATERIAL	PERCENT BY WEIGHT
Amount finer than No. 200 (75 µm) sieve for manufactured fine aggregate (AASHTO T 11 and T 27). A manufactured fine aggregate is one which has been reduced in particle size by crushing	5
Amount finer than No. 200 (75 µm) sieve for all other sands (determined by AASHTO T 11 and T 27)	3
Coal and other lightweight deleterious material (AASHTO T 113)	0
Friable particles (AASHTO T 113) 1	1

Larger percentages passing the No. 200 (75 µm) sieve in the fine aggregate fraction will be permitted if the percent passing the No. 200 (75 µm) sieve in the coarse aggregate fraction (703.4) is less than the specified maximum. In no event, however, shall the percent passing the No. 200 (75 µm) sieve in the total concrete aggregate be greater than an amount which would exist if both aggregate fractions contained their specified maximum percentage passing the No. 200 (75 µm) sieve.

702.1.3 - Soundness (Determined by AASHTO T 104):

When the fine aggregate is subjected to five alternations of the sodium sulphate soundness test, the weighted loss shall not exceed 10 percent by weight.

702.1.4 - Organic Impurities (Determined by AASHTO T21):

When the fine aggregate is subjected to the organic impurities test, the color shall not be darker than the standard. In the event a color darker than the standard is produced, the acceptability of the material will be determined as specified in 702.1.5.

702.1.5 - Mortar Strength (Determined by AASHTO T71):

Fine aggregate failing the organic impurities test shall be subjected to the test for mortar making properties. The fine aggregate shall develop a compressive strength at the age of seven days when using Type I or II cement, or at three days when using Type III cement, of not less than 90 percent of the strength developed by a mortar prepared in the same manner with the same cement and graded sand having a fineness modulus of 2.4 plus or minus 0.10.

702.1.6 - Grading:

The fine aggregate used for developing a concrete mix design shall have an A of 6.1 plus or minus 0.4.

The gradation shall be determined in accordance with AASHTO T 27 and T 11.

The determination of 'A' value is given in the second paragraph of Sub-Section 702.1.6 of Section 702 of Volume 3, Technical Specifications. However, the typographical errors in the subject paragraph are corrected as follows:

The 'A' value shall be determined by adding the cumulative percentages by weight of material passing each of U.S. Standard Sieve Nos. 37.5 mm, 19 mm, 9.5 mm, 4.75 mm, 2.36 mm, 1.18 mm, 30(600µm), 50(300µm), 100(150µm) and 200(75µm) and dividing by 100.

702.1.7 - Uniformity of Grading:

The gradation limits given in 702.1.6 represent the extreme limits which shall determine suitability of material from all sources of supply. The gradation of material from any one source, however, shall be reasonably uniform.

702.2 - MORTAR FINE AGGREGATE:

Fine manufactured aggregate shall meet the requirements of AASHTO M 45, except delete 4.1 through 4.4 and substitute the following:

Aggregate for use in masonry mortar shall be graded within the following limits:

SIEVE SIZE PERCENT PASSING

SIEVE SIZE	PERCENT PASSING
No. 4 (4.75 mm)	100
No. 8 (2.36 mm)	90-100
No. 100 (150 µm)	0-30
No. 200 (75 µm)	0-10

For joints thicker than 13 mm, sand meeting the requirements of 702.1.1 through 702.1.5 and 702.6 will be permitted.

702.3 - FINE AGGREGATE FOR ASPHALT MIXTURES:

Fine aggregate for asphalt mixtures shall meet the requirements of ASTM D 1073, except that the gradation requirements will be waived.

702.4 - MINERAL FILLER FOR ASPHALT MIXTURES:

Mineral filler for asphalt mixtures shall meet the requirements of ASTM D 242, modified as follows: Mineral filler shall be free from harmful organic impurities. Gradation requirements will be waived.

702.5 - LIGHTWEIGHT FINE AGGREGATE FOR STRUCTURAL CONCRETE:

Lightweight fine aggregate for structural concrete shall meet the requirements of ASTM C 330.

702.6 - ALTERNATE GRADING:

Fine aggregate shall be well graded from coarse to fine and shall conform to the following requirements:

SIEVE SIZE	PERCENT PASSING BY WEIGHT
d in. (9.5 mm)	100
No. 4 (4.75 mm)	95 – 100
No. 16 (1.18 mm)	45 – 80
No. 50 (300 µm)	10 – 30
No. 100 (150 µm)	2 – 10

SECTION 703
COARSE AGGREGATE

703 - GENERAL

Coarse aggregate shall consist of crushed stone, washed gravel (crushed or uncrushed), crushed slag, or any combination thereof, conforming to the requirements of these Specifications.

703.1 - CRUSHED STONE:

703.1.1 - General Requirements:

Crushed stone shall consist of particles of clean, hard, tough, durable rock free from adherent coatings.

703.1.2 - Deleterious Substances:

Deleterious substances shall not exceed the limits set forth below:

MATERIAL	% BY WEIGHT
Thin or elongated pieces (determined by METHOD OF DETERMINATION OF PERCENT OF THIN OR ELONGATED PIECES IN COARSE AGGREGATE)	5
Shale (determined by STANDARD METHOD OF TEST FOR PERCENT BY WEIGHT OF SHALE IN CRUSHED AGGREGATE)	1
Coal and other lightweight deleterious material (determined by AASHTO T 113)	0
Friable particles (determined by AASHTO T 113)	0.25

703.1.3 - Percentage of Wear (AASHTO T 96 or ASTM C 535):

Crushed stone shall have a percentage of wear not to exceed 40.

703.1.3 A – Aggregate Impact Value (BS EN 1097-2-1998)

Crushed stone shall have an Aggregate Impact Value not greater than 30%.

703.1.4 - Soundness (Determined by AASHTO T 104):

When subjected to five cycles of the sodium sulphate test, the weighted percentage of loss shall be not more than twelve.

703.2 – GRAVEL: (NOT USED)

703.3 - SLAG: NOT USED

703.4 - GRADING OF COARSE AGGREGATES:

Coarse aggregate shall be uniformly graded to conform to the requirements of Table 703.4. The gradation of coarse aggregates in the production of concrete shall be controlled by the A value as specified in 557.3 and 551.3. In addition, coarse aggregates to be used in Portland cement concrete shall have no more than one percent by weight passing the No. 200 (75 µm) sieve, except that this percentage may be increased to 1.5 in the case of crushed aggregate if the

material finer than the No. 200 (75 µm) sieve consists of the dust of fracture, essentially free from clay or shale. The gradation shall be determined in accordance with AASHTO T27 & T 11.

When the coarse aggregate is to be used in Portland cement concrete, larger percentages passing the No. 200 (75 µm) sieve in the coarse aggregate fraction will be permitted if the percent passing the No. 200 (75 µm) sieve in the fine aggregate fraction (702.1) is less than the specified maximum. In no event, however, shall the percent passing the No. 200 (75 µm) sieve in the total concrete aggregate be greater than an amount which would exist if both aggregate fractions contained their specified maximum percentage passing the No. 200 (75 µm) sieve.

Table 703.4 shows the gradations for coarse aggregates required by AASHTO M 43.

703.5 - LIGHTWEIGHT COARSE AGGREGATE FOR STRUCTURAL CONCRETE:

Lightweight coarse aggregate for structural concrete shall meet the requirements of ASTM C 330.

TABLE 703.4 - STANDARD SIZES OF COARSE AGGREGATES (AASHTO M 43)

		Amounts finer than each laboratory sieve (square openings), percentage by weight										
Size #	Nominal size square openings	100	90	75	63	50	37.5	25	19	12.5	9.5	(4.75)
1	(90 to 37.5)	100	90 to 100		25 to 60		0 to 15		0 to 5			
2				100	90 to 100	35 to 70	0 to 15		0 to 5			
24				100	90 to 100		25 to 60		0 to 10	0 to 5		
3					100	90 to 100	35 to 70	0 to 15		0 to 5		
357					100	95 to 100		35 to 70		10 to 30		0 to 5
4						100	90 to 100	20 to 55	0 to 15		0 to 5	
467						100	95 to 100		35 to 70		10 to 30	0 to 5
5							100	90 100	20 to 55	0 to 10	0 to 5	
56							100	90 to 100	40 to 85	10 to 40	0 to 15	0 to 5

Size #	Nominal size square openings	(37.5)	(25)	(19)	(12.5)	(9.5	No.4 (4.75)	No.8(2.36)	No.16 (1.18)	No.50 (300 µm)	No.100 (150 µm)
57	(25.0 to 4.75)	100	95 to 100		25 to 60		0 to 10	0 to 5			
6	(19 to 9.5)		100	90 to 100	25 to 55	0 to 15	0 to 5				

67	(19 to 4.75)		100	90 to 100		20 to 55	0 to 10	0 to 5			
68	(19 to 2.36)		100	90 to 100		30 to 65	5 to 25	0 to 10	0 to 5		
7	(12.5 to 4.75)			100	90 to 100	40 to 70	0 to 15	0 to 5			
78	(12.5 to 2.36)			100	90 to 100	40 to 75	5 to 25	0 to 10	0 to 5		
8	(9.5 to 2.3)				100	85 to 100	10 to 30	0 to 10	0 to 5		
89	(9.5 to 1.18)				100	90 to 100	20 to 55	5 to 30	0 to 10	0 to 5	
9	16 (4.75 to 1.18)					100	85 to 100	10 to 40	0 to10	0 to 5	
10	(4.75 to 0)					100	85 to 100				10 to 30

ΦIn inches (millimetres), except where otherwise indicated. Numbered sieves are those of the United States Standard Sieve Series.
@Screenings.

SECTION 704
STONE AND CRUSHED AGGREGATE

704.1 - STONE FOR MASONRY:

Stone for coursed masonry shall be tough, sound and durable, resistant to weathering action, reasonably fine grained, uniform in color, and free from seams, cracks, pyrite inclusions or other structural defects. The stone shall have a compressive strength of not less than 34.5 MPa. Stone shall be of such character that it can be truly wrought to such lines and surfaces as may be required.

704.2 - STONE FOR STONE PITHCHING:

Stone of riprap shall consist of field stone or rough unhewn quarry stone as nearly rectangular in section as is practicable. The material shall have a maximum weighted loss of 30 percent when subjected to five cycles of sodium sulphate soundness test, AASHTO T 104.

704.3 - STONE FOR GABIONS:

Material for gabions shall consist of rock, fieldstone, unhewn quarry stone or riverbed stone. The dimensions of the rock or stone fillings shall be such as to prevent loss of material through mesh openings and accomplish a mass with a minimum amount of voids. The material shall have a maximum weighted loss of 30 percent when subjected to five cycles of sodium sulphate soundless test, AASHTO T 104.

704.4 - DUMPED ROCK GUTTER:

The material for dumped rock gutter shall be rock containing a combined total of not more than 15 percent other suitable material, as determined by visual inspection.

Visual inspection shall be used to determine that the rock will conform to the following weight requirements:

Thickness of Gutter, mm	**70 Percent of the Weight of Material Shall Consist of Stones Weighing Between the Following Limits:**
300 mm	20-45 kg
450 mm	25-70 kg
600 mm	30-90 kg
750 mm	45-115 kg.668

704.5 - SPECIAL ROCK FILL:

Special rock fill may be limestone or sandstone having a maximum weighted loss of 30 percent when subjected to five cycles of sodium sulphate soundness test, AASHTO T 104. The material used for Special Rock Fill shall not be limited to limestone or sandstone. Rock of alternative geological origin will be acceptable provided it complies with the physical characteristics prescribed in the Specifications for Special Rock Fill. Metallurgical slag or broken concrete, from a source approved by the Engineer, may be furnished.

The rock shall have the dimensions in accordance with the Contract Documents.

The material used for Special Rock Fill shall not be limited to "limestone or sandstone". Rock of alternative geological origin will be acceptable provided it complies with the physical characteristics prescribed in the Specifications for Special Rock Fill.]

704.6 - AGGREGATE FOR BASE OR SUBBASE COURSE:

Aggregate for Crushed Base Course shall be Class 1 aggregate in accordance with Section 704 of the Technical Specifications.

704.6.1 - General:

Aggregate for Crushed Base Course shall be Class 1 aggregate.

The aggregate shall be crushed rock from an approved quarry and shall consist of clean hard sound durable particles of angular shape and rough surface texture. They shall be free from weathered, soft, laminated or elongated pieces, deleterious matter and shall be free from clay and excess dust.

When the Contractor elects to blend materials, each component of the blend shall meet the quality requirements of 704.6.2. Blade or road mixing will not be allowed.

When shoulders are specified, natural sand may not be used as a shoulder component.

704.6.2 - Gradation, Quality, and Crushed Particle Requirements:

When gravel is used in an unstabilized condition and in combination with other types of aggregate, it shall produce a combined material having a minimum of 80 percent one-face fracture as determined by weight of particles retained on the No. 4 (4.75 mm) sieve. When gravel is used in an unstabilized condition and alone, it shall have a minimum of 80 percent one-face fracture as determined by weight of particles retained on the No. 4 (4.75 mm) sieve.

704.6.3 - Sampling, Testing and Acceptance Procedure:

Material shall be sampled in accordance with AASHTO T 248 Aggregate Sampling procedures. Frequency of sampling and testing and plotting of gradation test data will be in accordance with established procedures.

Material failing to comply with the Specification requirements when sampled, tested, and evaluated in accordance with the above procedures shall be removed and replaced at the Contractor's expense, or, at the option of the Engineer, may be left in place with reduced payment.

TABLE 704.6.2A – GRADATION REQUIREMENTS

Gradation Amounts Finer Than Each Laboratory Sieve (Square Openings), % By Weight									
Aggregate	(200)	(63)	(50)	(37.5)	(19)	#4 (4.75)	#40 (42.5 µm)	#100 (150 µm)	#200 (75 µm)
1			100	90-95	50 – 80	25 – 40	7 – 19		5 – 12
2				100	80 – 100	35 – 75	10 – 30		
4				100	5 – 95	20 – 60	5 – 35		0 – 10
5			100			30 – 90			0 - 15
6				100	50 -100	25 – 70	10 - 45	3 – 28	0 – 25
7	90 - 100		0 - 5	With intermediate sizes between 150 mm and 100 mm represented					30
8				100	80 – 100	35 – 75	10 - 40		4 – 14
9		100		80 -95	50 – 70	20 - 40			

TABLE 704.6.2B - QUALITY REQUIREMENTS

Aggregate Class	Los Angeles Abrasion, Percent, Max.	Aggregate Impact Value Percent, Max.	Sodium Sulphate Soundness, Percent Max.	Liquid Limit Max.	Plasticity Index, Max.	Deleterious Material Percent Max.
1	50	30	12	25	6	5
2	50		12	25	6	5
4	50			25	6	5
5				25	6	5
6			30	25	6	5
7						10 (by visual observation)
8	50		12	25	6	5
9	50		12	25	6	5

704.6.4 - Test Methods:

Los Angeles Abrasion Value	AASHTO T 96, ASTM 535
Aggregate Impact Value	BS EN 1097-2-1998
Soundness (Sodium Sulphate, 5 cycles)	AASHTO T 104
Liquid Limit	AASHTO T 89
Plasticity Index	AASHTO T 90
Deleterious Materials	ASTM C 295, AASHTO T 113, AASHTO T 113, STANDARD METHOD OF TEST FOR PERCENT BY WEIGHT OF SHALE IN CRUSHED AGGREGATE
Gradation	AASHTO T 11 and T 27

704.7 - FILTER MATERIAL:

Filter material shall consist of crushed fine aggregate, other approved inert material, or a combination thereof, having hard, strong, durable particles. The material shall contain not more than a total of five percent coal, clay lumps, shale, soft fragments, organic matter, and other local deleterious substances.

The material shall conform to the following gradation:

U.S. Standard Sieve Size	Percent Passing, by Weight
50mm	100
4.75mm	65 – 100
425µm (No.40)	25 – 50
75µm (No.200)	0 - 25

704.8 - SHOT ROCK:

Shot rock shall be limestone, sandstone, or other inorganic material acceptable to the Engineer, having dimensions similar to that which exists after final blasting at the quarry site and prior to crushing. It shall contain material. that would generally be retained on a 150 mm sieve, and not larger than that which could be tailgated from a single axle 7 to 9 Mg dump truck. In addition, some 250 to 300 mm material shall be represented as an intermediate size. Shot rock shall have a maximum weighted loss of 30 percent when subjected to five cycles of the Sodium Sulphate Soundness test, AASHTO T 104.

Acceptance for gradation shall be on the basis of a letter of certification from the Producer verifying that the sizes specified are represented.

SECTION 705

ASPHALT MATERIALS

705 GENERAL

Asphalts shall be made by refining of petroleum and shall be free from tar or tar products. The respective types and grades shall meet the Specification requirements.

Asphalts shall be sampled in accordance with AASHTO T40. When asphalt material is furnished by a supplier who is not certified, the supplier shall be required to have each batch or lot of material, to be furnished to the Engineer, sampled by an Engineer-approved inspection agency, in accordance with ASTM 3666-07a and shall have the samples tested for compliance with the governing Specification in an Engineer-approved laboratory.

Measurement of the volume of asphalt materials shall be based on the volume of the materials at (15.5 °C). Volumes measured at higher or lower temperatures shall be corrected to the volumes of the material at (15.5°C) using the coefficients of expansion given below.

TEMPERATURE CONVERSION FACTORS	
Material	COEFFICIENT
Asphalt Emulsion	0.00025 (0.00045)
Asphalt Cement	0.00035 (0.00062)
Cut-back Emulsified Asphalt	0.0004 (0.0007)

Application Temperatures:

Unless otherwise indicated or directed, the ranges will be used as guide for application temperatures for the various asphalt materials. Field conditions may require temperatures outside these ranges.

TABLE 705 - APPLICATION TEMPERATURES		
Type and Grade of Material	Application Temperature Range Degrees Celsius	
Asphalt's	Spray	Mix
MC-250	36-117	36-117
RS - 1	21-60	--------
RS – 2	52-85	--------
HFRS – 2	52-85	--------
MS-1 and MS-2	22-71	22-71
HFMS-2	22-71	22-71
SS-1 and SS-1h	22-71	22-71
AEM-1	27-52	27-52
AEM-2	49-71	49-71
AEM-3	60-82	60-82
AEM-4	71-88	71-88
CRS-1	52-85	--------

CRS-2	52-85	--------
CMS-2 and CMS-2h	22-71	22-71
CSS-1 and CSS-1h	22-71	22-71
Asphalt Primer for Damproofing and Waterproofing	10-27	-------
Asphalt for Damproofing and Waterproofing	149-177	--------
Asphalt Cement		
AC – 5	141-177	121-163
AC – 10	141-177	121-163
AC – 20	145-177	121-163

705.1 - WINTER GRADE CUT-BACK ASPHALT:

This material shall conform to the requirements specified for MC-250 in AASHTO M 82 and in addition shall meet the requirements of AASHTO T 182..

TABLE 705.1 – ASPHALT EMULSION

SPECIFICATION DESIGNATION	CBAE Primer	AEM-1
Furol Viscosity at 25° C	30 - 100	40 - 250
Coating Test	Note 1	Note 2
Water Content (percent)	3 – 8	3 – 8
Residue by Distillation (percent)	45 +	50+
Residue Penetration 25° C 100 g 5 sec	50 – 200	
Residue Solubility in Trichloroethylene (percent)	97.5 +	98 +
Residue Ash Content (percent)	3.0	

Note 1: Wet Stone Coating Test. Fifty grams of a standard reference gravel washed in distilled water, having a minimum pH of 6.3, air-dried for a minimum of 24 hour, and graded to a size that 100 % passes a 9.5 mm sieve and is retained on a No. 4 (4.75 mm) sieve, shall be weighed into an eight-ounce seamless tin box and covered with distilled water for five minutes, after which the excess water shall be drained off, and four grams of primer shall be placed on the wet gravel immediately.

The mass shall be stirred vigorously for not more than five minutes, using a heavy glass rod or metal paddle. At the end of the period the aggregate shall be completely coated with asphalt.

.**Note** 2: The wet aggregate coating test of AASHTO T182 shall be met. Minimum area of aggregate coated shall be 95%.

705.2 – LIQUID ASPHALT (RAPID CURING TYPE):

Rapid curing liquid asphalt shall conform to the requirements of AASHTO M 81.

705.3 – LIQUID ASPHALT (MEDIUM CURING TYPE):

Medium curing liquid asphalt shall conform to the requirements of AASHTO M 82.

705.4 – ASPHALT EMULSION:

Asphalt emulsion in the RS, HFRS, MS, HFMS, and SS grades shall conform to the requirements of AASHTO M 140. Additional cut-back asphalt emulsion grades shall conform to the requirements of Table 705.1. The cut-back asphalt emulsions in Table 705.1 shall be tested

in accordance with the applicable methods of testing Liquid Asphalt (Rapid Curing Type), AASHTO M 81.

705.5 – PERFORMANCE GRADED BINDERS:

Performance graded binders shall conform to the requirements of AASHTO MP-1. Unless specified differently in the Contract Drawings either PG 64-22 or PG 58-28 may be used at the Contractor's option.

705.6 - PENETRATION GRADE BINDERS

Materials shall conform to the requirements of AASHTO M20-70 unless specified otherwise.

The 60/70 penetration asphaltic binder for asphalt concrete shall be in accordance with AASHTO M20-70 (1996).

705.7 - ASPHALT FOR DAMPPROOFING AND WATERPROOFING:

Materials shall conform to the requirements of ASTM – D - 41. Type B.

705.8 - PRIMER FOR USE WITH ASPHALT IN DAMPPROOFING ANDWATERPROOFING:

This primer shall conform to the requirements of ASTM – D - 41.

705.9 THROUGH 705.10 - NOT USED

705.11 - CATIONIC EMULSIFIED ASPHALT:

Cationic emulsified asphalt shall conform to the requirements of AASHTO M 208.

706 - NOT USED

SECTION 707
CONCRETE ADMIXTURES, CURING AND COATING MATERIALS

707.1 - AIR - ENTRAINING ADMIXTURES FOR CONCRETE:

707.1.1 - Acceptance Requirements for Air-Entraining Admixtures:

707.1.1.1 - In the event that the Contractor elects to use an air-entraining admixtures, evidence based on tests made in a recognized laboratory shall be submitted to show that the material conforms to the requirements of AASHTO.

707.1.1.2 - An exception to the requirements in the preceding paragraph is the case of air-entraining admixtures which are manufactured by neutralizing Vinsol resin with caustic soda (sodium hydroxide). When the Contractor proposes to use such an admixture, the Contractor shall submit a certificate concerning the admixture is of the following form:

"This is to certify that the product (trade name) as manufactured and sold by the (company) is an aqueous solution of Vinsol resin that has been neutralized with sodium hydroxide. The ratio of sodium hydroxide to Vinsol resin is one part of sodium hydroxide to (number) parts of Vinsol resin. The percentage of solids based on the residue dried at 105°C is (number). No other additive or chemical agent is present in this solution."

707.1.1.3 - When the Contractor proposes to use a air-entraining admixture which has been previously approved, the Contractor shall submit a certification stating that the admixture is the same as that previously approved. If an admixture offered for use is essentially the same (with only minor differences in concentration) as another previously approved material, a certification will be required stating that the product is essentially the same as the approved admixture and that no other admixture or chemical agent is present.

707.1.2 - Optional Acceptance Requirements for Air-Entraining Admixtures:

707.1.2.1 - The Engineer may elect to approve air-entraining admixtures as satisfactorily meeting acceptance requirements as outlined. If the Engineer chooses to exercise this option, then the acceptance requirements specified in 707.1.1 above shall be modified as noted.

707.1.2.2 - The Engineer may develop a spectroscopic standard for an air-entraining admixture if such air-entraining admixture has previously been approved by the Engineer as satisfactorily meeting all the Specification requirements as set forth in 707.1.1.

707.1.2.3 - When the Contractor proposes to use an air-entraining admixture for which a spectroscopic standard has been developed, then the air-entraining admixture may be approved without further certification being made if a special analysis made on a representative sample of the admixture proposed for use on the project compares satisfactorily with the standard related thereto.

707.1.3 - Additional Test Requirements for Air-Entraining Admixtures (Optional):

707.1.3.1 - Either prior to or at any time during construction, the Engineer may require that the admixture selected by the Contractor be further tested to determine its effect upon the strength of the concrete. When so tested, the seven-day compressive strength of concrete made with the cement and aggregates in the proportions to be used in the work and containing the admixture under test in an amount sufficient to produce from four to seven percent entrained air in the plastic concrete shall be not less than 88 percent of the strength of concrete made with the same materials and with the same cement content and consistency but without the admixture.

707.1.3.2 - The percentage reduction in strength shall be calculated from the average strength of at least five standard 150 by 300 mm cylinders of each type of concrete. Specimens shall be made and cured in the laboratory in accordance with the requirements of ASTM C 192 and shall be tested in accordance with the requirements of ASTM C 39. The percentage of entrained air shall be determined in accordance with the requirements of ASTM C 231.

707.1.3.3 - Admixtures failing to meet the above requirements will be rejected.

707.2 - WATER-REDUCING AND RETARDING ADMIXTURES FOR CONCRETE:

707.2.1 - Acceptance Requirements for Approval of Retarders:

Water reducing and retarding admixtures for concrete shall conform to the requirements of AASHTO M 194, Type D or Type G.

707.2.2 - Performance Requirements for Concrete Retarders:

707.2.2.1 - The retarding effect caused by water-reducing and retarding admixtures may vary widely with different types of cement, cement from different mills, aggregates from different sources and of different gradation, and changes in water-cement ratio. Therefore, no retarder shall be used until the concrete of the specified class, designed in accordance with the Specifications and made with the ingredients proposed for use by the Contractor, including Type D or Type G admixtures as specified or permitted under this Specification, is shown to meet the requirements of AASHTO M 194 for water reduction and compressive strength increases at ages 3, 7 and 28days.

707.2.2.2 - The mix shall contain the quantity of admixture recommended by the manufacturer at the prevailing temperature.

707.2.3 - Optional Performance Requirements for Concrete Retarders:

707.2.3.1 - The Engineer may elect to approve water-reducing and retarding admixtures as satisfactorily meeting performance requirements as outlined. If the Engineer chooses to exercise this option, then the performance tests specified in 707.2.2 will be waived.

707.2.3.2 - The Engineer's testing laboratory may design concrete mixes in which various types and grades of aggregates and various types of cements are used and in which water-reducing and retarding admixtures are used, the admixtures first having met the acceptance requirements for approval of concrete retarders as specified in 707.2.1. The water-reducing and retarding admixtures used in laboratory design mixes may be subjected to a spectral analysis, and a spectroscopic standard or a standard spectrograph may be developed if the admixture in combination with the particular type and grading of aggregate and the particular type of cement has met the performance requirements for water-reducing admixtures as specified in 707.2.2.

707.2.3.3 - When the Contractor proposes to use a water-reducing and retarding admixture with a type of grading of aggregate and a type of cement which was previously used in a laboratory design mix and for which a special standard is available, the retarder may be approved on the basis of a spectral analysis made on a representative sample of the admixture proposed for use on the project if:

i. the spectral analysis compares satisfactorily with the standard related thereto, and
ii. the admixture met performance requirements in previous tests conducted in the Engineer's laboratory as outlined in 707.2.3.2.

707.2.4 - Certification of Water-Reducing and Retarding Admixtures:

When the Contractor proposes to use an approved water-reducing and retarding admixture, the Contractor shall submit a certificate stating that the admixture is identical in composition with the

sample that was used for the acceptance tests. If the admixture varies in concentration from the acceptance sample, a certificate will be required stating that the product is essentially the same for chemical ingredients as the approved admixture, and that no other admixture or chemical has been added.

707.2.5 - Additional Test Requirements for Water-Reducing and Retarding Admixtures (Optional):

Either prior to or at any time during construction, the Engineer may require the selected admixture to be tested further to determine its effect on the strength of the concrete. When so tested the retarder shall meet the requirements specified in 707.2.2.

707.3 - WATER-REDUCING ADMIXTURES FOR CONCRETE:

707.3.1 - Acceptance Requirements for Approval of Water-Reducers:

Water-reducing admixtures for concrete shall conform to the requirements of AASHTO M 194, Type A or Type F.

707.3.2 - Performance Requirements for Concrete Water-Reducers:

707.3.2.1 - The effects of using water-reducing admixtures may vary widely with different types of cement, cement from different mills, aggregate proportions, aggregates from different sources and of different gradation, and changes in water-cement ratio. Therefore, no water-reducer shall be used until the concrete of the specified class, designed in accordance with these Specifications and made with the ingredients proposed for use by the Contractor, including Type A or Type F admixtures as specified or permitted under this Specification, is shown to meet the requirements of AASHTO M 194 for water reduction and compressive strength increases at ages 3, 7 and 28 days.

707.3.2.2 - The mix shall contain the quantity of admixture recommended by the manufacturer at the prevailing temperature.

707.3.3 - Optional Performance Requirements for Concrete Water-Reducers:

707.3.3.1 - The Engineer may elect to approve water-reducing admixtures as satisfactorily meeting performance requirements as outlined. If the Engineer chooses to exercise this option, then the performance tests specified in 707.3.2 will be waived.

707.3.3.2 - The Engineer's testing laboratory may design concrete mixes in which various types and grades of aggregates and various types of cement are used and in which water-reducing admixtures are used, the admixture first having met the acceptance requirements for approval of concrete water-reducers as specified in 707.3.1. The water-reducing admixture used in laboratory design mixes may be subjected to a special analysis, and a spectroscopic standard or a standard spectrograph may be developed if the admixture in combination with the particular type and grading of aggregate and the particular type of cement has met the performance requirements for water-reducing admixtures as specified in 707.3.2.

707.3.3.3 - When the Contractor proposes to use a water-reducing admixture with a type and grading of aggregate and a type of cement which was previously used in a laboratory design mix and for which a spectral standard is available, the water-reducer may be approved on the basis of a spectral analysis. made on a representative sample of the admixture proposed for use on the project if:

i. The spectral analysis compares satisfactorily with the standard related thereto, and

ii. The admixture met performance requirements in previous tests conducted in the Engineer's laboratory as outlined in 707.3.3.2.

707.3.4 - Certification of Water-Reducing Admixtures:

When the Contractor proposes to use an approved water-reducing admixture, the procedure set forth in 707.2.4 shall apply.

707.3.5 - Additional Test Requirements for Water-Reducing Admixtures (Optional):

Either prior to or at any time during construction, the Engineer may require the selected admixture to be tested further to determine its effect on the strength of the concrete. When so tested the water-reducer shall meet the requirements specified in 707.3.2.

707.4 - POZZOLANIC ADDITIVES FOR USE IN PORTLAND CEMENT CONCRETE:

707.4.1 - Fly ash shall conform to the following requirements when sampled and tested in accordance with the applicable Section of ASTM C311

FINENESS	Class F (ASTM C618)	Class C (ASTM C618)
Amount Retained on No. 325 (45 µm) Sieve 34	% Max.	34% Max.
Loss on Ignition:	6% Max.	6% Max.
Si02+A1203+Fe203	70% Min.	50% Min

707.4.2 - Ground granulated blast furnace slag shall conform to the requirements of AASHTO M302, Tables I and II except that slag activity index requirements of Table II do not apply.

707.4.3 - Microsilica shall conform to requirements of AASHTO M 307 except Table 2 shall not apply.

707.5 - NOT USED

707.6 - POLYETHYLENE COATED BURLAP FOR CURING.CONCRETE:

This material shall consist of burlap impregnated on one side with white opaque plastic film. The plastic film shall be securely bonded to the burlap.

The film shall be clean and free of imperfections. Acceptance will be based on visual inspection.

707.7 - BURLAP CLOTH MADE FROM JUTE OR KENAF FOR CURING CONCRETE:

The burlap cover shall be clean and free of defects. The cover shall provide a water retention blanket over the concrete. Acceptance will be based on visual inspection.

707.8 - WATERPROOF PAPER FOR CURING CONCRETE:

Waterproof paper shall consist of two sheets of craft paper cemented together with bituminous material and reinforced with fibre. The top surface shall be white. Acceptance will be based on visual inspection.

707.9 - LIQUID MEMBRANE-FORMING COMPOUNDS FOR CURING CONCRETE:

Curing compounds shall conform to the requirements of AASHTO M148, Type 2, Class A.

707.10 - WHITE POLYETHYLENE SHEETING (FILM) FOR CURING CONCRETE:

The sheeting shall be opaque white plastic film. The film shall be clean and free of imperfections. Acceptance will be based on visual inspection.

707.11 - EPOXY RESIN PROTECTIVE COATING:

The material shall conform to the requirements of ASTM C881, Type III, Grades 1 or 2, Class B or C. Pigmentation shall be required in the system so the cured coating shall conform to Federal Color Standard 595, No. 16357.

707.12 - CONCRETE SEALER:

707.12.1 – General:

The material shall be a one component, water repellent penetrating sealer, meeting the criteria for Series II and Series IV (southern climate testing procedure) tests as referenced in NCHRP 244.

The material shall be capable of meeting the criteria with a single coat and shall not alter the color of the treated surfaces.

707.12.2 – Acceptance:

When using a sealer not on the Engineer's approved list, the Contractor shall furnish certified laboratory test data showing the material approved for the use meets the NCHRP 244 criteria at the manufacturer's recommended rate of application.

SECTION 708

JOINT MATERIALS.

708.1 - PREFORMED EXPANSION JOINT FILLER FOR CONCRETE:

708.1.1 - Nonextruding and Resilient Non-bituminous Type:

The material shall conform to the requirements of AASHTO M 153. The sampling frequency shall be on the basis of one sample per each day of a manufacturer's production for each thickness.

708.1.2 - Nonextruding and Resilient Bituminous Type:

The material shall conform to the requirements of AASHTO M 213. The sampling frequency shall be on the basis of one sample per each day of a manufacturer's production for each thickness.

708.2 - PREFORMED ELASTOMERIC JOINT SEALS; LUBRICANT-ADHESIVES:

708.2.1 - Joint Seals for Concrete Pavements:

This material shall meet the requirements of AASHTO M 220. The lubricant-adhesive shall be of the type recommended by the seal manufacturer.

708.2.2 - Joint Seals for Bridges:

Multiple web design and strip seals shall meet the requirements of AASHTO M 297. The compression-deflection and recovery tests for strip seals are deleted. The lubricant-adhesive shall be of the type recommended by the seal manufacturer.

708.3 - JOINT SEALANT, HOT-POURED FOR CONCRETE AND ASPHALT PAVEMENTS:

This material shall meet the requirements of ASTM D3405.

708.4 - SILICONE JOINT SEALANT; JOINT BACK-UP MATERIAL:

708.4.1 - Silicone Joint Sealant:

708.4.1.1 - General Requirements:

Silicone sealant shall be furnished in a one part formulation. The compound shall be compatible with the surface to which it is applied. Acid cure sealants are not acceptable for use on concrete. Silicone sealants shall be of the following types:

Type I - A low modulus non-sag silicone for use in sealing horizontal and sloping joints in Portland cement concrete pavements. Tooling is required.

Type II - A very low modulus self-levelling silicone used to seal horizontal joints in Portland cement concrete pavements.

Type III - An ultra low modulus self-levelling silicone used to seal horizontal joints in Portland cement concrete pavements. It can also be used to seal joints between Portland cement concrete pavement and asphalt concrete shoulders.

708.4.1.2 - Test Requirements:

The sealant shall meet the following requirements.

TEST METHOD	TEST	TYPE I	TYPE II	TYPE III
ASTM D2202	Flow	7.6 mm Max	Self-Levelling	Self-Levelling
ASTM C679	Tack Free Time	1.5 Hours Max		
Manufacturer Note 1	Skin Over Time		2 Hours Max	2 Hours Max
ASTM D412 Die C Notes 2 & 3	Modulus @ 150% Elongation	310 kPa Max	276 kPa Max	103 kPa Max
ASTM D412 Die C Notes 2 & 3	Elongation	500% Minimum	500% Minimum	500% Minimum
ASTM D3583 Notes 2, 3, 4, 5	Adhesion To Concrete	No Failures @ 200% Elongation Minimum	No Failures @ 200% Elongation Minimum	No Failures @ 200% Elongation Minimum
ASTM C719 Note 6	Movement Capability 10 Cycles @ ± 0%	No Adhesive Or Cohesive Failures	No Adhesive Or Cohesive Failures	No Adhesive Or Cohesive Failures
ASTM C793 Notes 2 & 3	Accelerated Weathering 5,000 Hours	No Cracking	No Cracking	No Cracking

NOTE 1: The manufacturer shall verify that the sealant will have a skin-over time within the time limitations under field conditions.

NOTE 2: Cure Temperature 25 ± 2°C at 50 ± 5% Relative Humidity.

NOTE 3: Cure Time 21 Days Maximum.

NOTE 4: Specimens shall be 13 mm x 13 mm x 50 mm.

NOTE 5: Type III material shall also demonstrate adhesion to asphalt blocks.

NOTE 6: Type I material shall have movement capability 10 cycles @ +100%, -50%.

708.4.1.3 - Acceptance:

Manufacturers of silicone joint sealants shall submit certified test data during the first calendar quarter of each year. The testing shall be performed by an independent testing laboratory. The test data must demonstrate that all requirements of the Specifications are met. Only those sealants which have been evaluated and appear on the Engineer's approved list can be used on a project. Manufacturers are responsible for quality control of their product and the submission of test data in a timely manner in order to be considered for and/or continue to have their product on the approved list.

708.4.2 - Joint Back-Up Material:

Joint back-up material shall be compatible with the sealant. The material shall be the correct size to fit tightly in the joint to resist movement and to prevent the sealant from moving past the back-up material to the bottom of the joint.

708.5 - VITRIFIED CLAY PIPE JOINTS HAVING RESILIENT PROPERTIES:

This material shall conform to the requirements of ASTM C 425.

708.6 - HOT POUR MINERAL FILLED JOINT SEALER FOR SEWER AND CULVERT PIPE:

Hot pour mineral filled sealing compound shall conform to the requirements of Federal Specifications SS-S-169.

708.7 - JOINTS FOR CIRCULAR CONCRETE SEWER AND CULVERT PIPE USING FLEXIBLE WATERTIGHT GASKETS:

Joints for circular concrete sewer and culvert pipe shall conform to the requirements of AASHTO M 198.

708.8 - JOINT MORTAR:

Joint mortar shall consist of one part cement and two parts sand, with water as necessary to obtain the required consistency. Sand shall conform to the requirements of 702.2. Cement shall conform to the requirements of 701.4 for masonry construction. For other uses cement shall conform to the requirements of 701.1 or 701.3.

Mortar shall be used within 30 minutes after its preparation.

708.9 - ASPHALT PLASTIC CEMENT:

708.9.1 - General Requirement:

Asphalt plastic cement is intended for use as a joint sealer for concrete and masonry. It shall consist of an asphalt base, volatile petroleum solvents, and mineral stabilizers, mixed to a smooth, uniform consistency, suitable for trowel application.

708.9.2 - Composition:

Minimum Maximum

Non-volatile Matter, % 70

Mineral Matter (Ash), % 15 45.

708.9.3 - Physical Requirements:

Uniformity - A thoroughly stirred sample shall show no separation of solvent or setting that cannot be overcome by moderate stirring after standing for 6 hours at room temperature in a closed container.

Workability - The asphalt plastic cement shall spread readily without drawing or pulling when applied to a metal test panel and spread to a thickness of approximately 3 mm

Behaviour at 60°C - A sample cured at room temperature for one hour, and heated at 60°C in an oven for five hours shall show no blistering and not more than 6 mm sagging or slipping.

Behaviour at 0°C - After completion of the 60°C behaviour test, the sample shall be cooled to 0°C ±2°C for one hour. Immediately after this exposure, the sample shall be bent around a 25 mm diameter mandrel.

The sample shall show no cracking of the asphalt or separation of the asphalt from the panel.

708.9.4 - Test Methods:

708.10 - WATERSTOPS (ELASTOMERIC MATERIAL):

Non-volatile matter - Test in accordance with ASTM D 2822.

Ash - Transfer approximately 5 grams of the sample (weighed to the nearest 0.01g) to a crucible and heat at a low temperature (not above a dull red heat) until all carbon is consumed. Cool in a desiccator, weigh and calculate the percentage of ash.

All waterstops shall be produced by a moulded or extrusion process such that, as supplied for use, they will be dense, homogenous, and free from holes and other imperfections. The cross section of the waterstop shall be uniform along the length and shall be symmetrical transversely so that the thickness at any given distance from either edge of the waterstop will be uniform. One metre sample shall be furnished for 300 metres, or fraction thereof, of each size of waterstop material.

The waterstops shall conform to the requirements in Table 708.10.1 for the poly vinyl chloride waterstops and Table 708.10.2 for rubber waterstops.

TABLE 708.10.1 - POLYVINYLCHLORIDE WATERSTOPS

PROPERTY	VALUE	TEST METHOD
Tensile Strength, Die "C", (Mpa)	9.6 min.	ASTM D 412
Ultimate Elongation, Die "C", percent	280 min.	ASTM 412
Cold Bend Test	No Cracking	**

** The cold bend test shall be made by subjecting three full-width, one-inch long sample specimens to a temperature of -15^{0}C for two hours. The specimen shall then be bent 180° around a 13 mm (½ inch) mandrel.

TABLE 708.10.2 - RUBBER WATERSTOPS

PROPERTY	VALUE	TEST METHOD
Tensile Strength, Die "C", (Mpa)	14 min.	ASTM D 412
Ultimate Elongation, Die "C", percent	360 min.	ASTM 412
Shore Durometer Hardness, Type A	60-85	ASTM D 2240
Absorption of Water, by Weight, percent	5 max.	ASTM D 570
Weight per m	0.3 kg min.	--------

SECTION 709

METALS

709.1 - STEEL BARS FOR CONCRETE REINFORCEMENT:

All bar reinforcement, whether deformed or plain, shall meet the requirements of BS 4449.

709.1.1 - Epoxy coated reinforcing steel shall meet the requirements of Section 709.1.

709.2 - PRESTRESSING REINFORCEMENT:

Prestressing reinforcement shall be high-tensile steel wire conforming to AASHTO M 204, high-tensile wire strand conforming to AASHTO M 203, or high-tensile-strength steel bars conforming to AASHTO M 275.

709.3 - NOT USED

709.4 - WELDED WIRE FABRIC FOR CONCRETE REINFORCEMENT:

Welded wire fabric for concrete reinforcement shall conform to the requirements of AASHTO M 55, except as modified. Fabric reinforcement for pavement shall be not less than 1.5 metres in width and shall be shipped in sheets and not in rolls. Fabric for slope protection, gutters and miscellaneous items may be shipped in rolls. Sheets shall be bent in the shop as shown on the Drawings. Epoxy coated welded wire fabric for concrete reinforcement shall meet the requirements of ASTM A 884/A 884M.

709.5 - EXPANDED METAL PAVEMENT REINFORCEMENT:

Expanded metal pavement reinforcement shall be made from open-hearth mild steel plates by a cutting and drawing process to form a uniform diamond shape mesh. The strands or members shall be clean cut, straight and uniform in size. A bend test specimen cut from the furnished fabric shall withstand bending cold through 180 degrees flat upon itself without cracking on the outside of the bent portion. A tensile specimen cut from the furnished material shall have a minimum tensile strength of 380 MPa. The chemical composition of the steel shall conform to SAE Standard No. 1010.

709.6 - FABRICATED BAR OR ROD MATS FOR CONCRETE REINFORCEMENT:

Fabricated steel bar or rod mats shall conform to the requirements of AASHTO M 54.

709.7 - JOINT TIE BOLT ASSEMBLY:

The bar used shall conform to the requirements of ASTM F432, Grade 55. The tensile strength of the assembly shall be not less than 65 kN. The coupling or shank of the hook bolt shall provide a positive stop to prevent the shank of the hook bolt from being threaded beyond the centre of the coupling. The tie bolt assemblies shall be equipped with an approved fastener for installation of the assembly in the steel pavement form. The fastener shall hold the assembly in the designated position during the placing and finishing of the concrete and subsequent removal of the pavement forms without damage to the concrete or the tie bolt assembly.

709.8 - HIGH STRENGTH LOW ALLOY STRUCTURAL METAL:

High-strength structural steel for bridges shall conform to AASHTO M270, grades 50, 50W or 70W. High-strength steel for all other applications shall conform to AASHTO M222 (weathering) or AASHTO M223.

709.9 - NOT USED

709.10 - GREY IRON, MALLEABLE IRON AND DUCTILE IRON CASTINGS:

Grey iron castings shall conform to the requirements of AASHTO M 105, Class No. 30.

Malleable iron castings shall conform to the requirements of ASTM A 47, Grade 32510. Castings shall be boldly filleted at angles, and the arrises shall be sharp and perfect.

Malleable iron castings for railings posts shall be Grade No. 32510 and shall be galvanized with hot-dipped zinc coating in accordance with AASHTO M 232.

Ductile iron castings shall conform to the requirements of ASTM A-536, Grade 80-55-6, 65-45-12 or 60-40-18.

The dimension tolerance for grey iron castings is ± 5.2 mm per metre and the weight tolerance is ±5%.

All castings shall contain a manufacturer's heat number, lot number, or cast date. This identification shall be cast into the material at the time of manufacturer.

709.11 - NOT USED

709.12 - STRUCTURAL AND EYEBAR STEEL:

All structural steel for bridges shall conform to the applicable grade of AASHTO M270 that is specified in the Drawings. When no specific grade is called for, AASHTO M270, Grade 36 shall be used. Non-designated structural steel in all other sections of the Specifications shall conform to AASHTO M183.

709.13 - STEEL FORGINGS AND STEEL SHAFTING:

709.13.1 - Steel Forgings:

Steel forgings shall conform to AASHTO M 102, Class E. They shall be bored as specified in 615.4.9.2. A record of the annealing or normalizing changes shall be furnished showing the forgings in such charge, the melt or melts from which they were secured and the treatment they received.

709.13.2 - Steel Shafting:

Cold finished carbon steel shafting shall conform to AASHTO M169 Grades 1016 through 1030, inclusive, unless otherwise specified..

709.14 - STEEL CASTINGS:

Steel castings shall conform to the requirements of AASHTO M 103, except steel produced by the converter process shall not be used. All steel castings shall be grade 65-35 (450-240). Sharp un-filleted angles or corners shall not be permitted.

709.15 - COATED DOWEL BARS FOR PAVEMENT JOINT REINFORCEMENT:

Coated dowel bars shall meet the requirements of AASHTO M 254 with the following exceptions (***bold italic*** numbers refer to subsections of AASHTO M 254):

3. Materials

3.1 The core material shall meet the requirements of 709.1.

4. Dimensions

4.2 The non-abraded thickness of the Type A coating shall be a minimum of 25 mils (635 µm).

The non-abraded thickness of the Type B coating shall be a minimum of 7 mils (175 µm).

6. Sampling

ADD THE FOLLOWING

Samples for Section ***5.1*** thru ***5.4*** shall be in a basket assembly.

7. Documentation

7.3 ADD THE FOLLOWING.

The coating applicator shall be certified as set forth in AASHTO M 284AASHTO M 284.

The coated dowel manufacturer shall be certified as set forth in MP 709.15.50.

7.7 ADD THE FOLLOWING:

Regardless of general acceptance of coated dowel bars by the Engineer, when bar coatings are found to be perforated, cracked or otherwise damaged, including extensive coating damage at welds, prior to or during installation in the pavement, such bars will be rejected from use and shall be replaced with acceptable bars by the Contractor at no additional cost to the Engineer.

709.16 - NOT USED

709.17 - WELDED AND SEAMLESS STEEL PIPE:

Black and galvanized steel pipe shall meet the requirements of ASTM A 53. When used for other than pressure pipe, the hydrostatic test will be waived. Pipe for ferrous metal railing shall be galvanized after fabrication in accordance with AASHTO M 111..

709.18 - COPPER ALLOY CASTINGS FOR BEARING, EXPANSION, AND NAME PLATES FOR BRIDGES:

709.18.1 - Copper Alloy Castings for Bearing and Expansion Plates for Bridges:

The copper alloy castings for bearing and expansion plates for bridges shall be bronze conforming to the requirements of AASHTO M 107, Copper Alloy UNS Number C91100.

709.18.2 - Copper Alloy Castings for Name Plates for Bridges:

The copper alloy for name plates shall meet the requirements of ASTM B584, alloy C83600, C83450, C83800, C92200, or C92210. The mechanical requirements of the Specification are waived

709.19 - ROLLED COPPER-ALLOY BEARING AND EXPANSION PLATES FOR BRIDGES:

The rolled plates shall conform to the requirements of AASHTO M 108, Alloy C51000 or C51100.

709.20 - FLASHING FOR CONSTRUCTION AND EXPANSION JOINTS:

709.20.1 - Copper:

Copper shall conform to the requirements of AASHTO M 138. Any type cold finished, suitable for the purpose intended, may be used.

The sheet shall withstand being bent cold through180^0, flat upon itself, without fracture on the outside of the bent portion. Unless otherwise specified, thickness of the sheet shall be 550 µm (approximately 4.88 kg per square metre) with a tolerance of ±50 µm.

709.20.2 - Nickel-Copper Alloy:

Nickel-copper alloy sheeting for flashing shall conform to the requirements of ASTM B 127. It shall be cold rolled, deep drawing and spinning quality.

709.21 - PIPES FOR FLOOR DRAINS AND DOWN-SPOUTS:

Cast iron pipe for floor drains and down-spouts is to conform to the requirements of ASTM A 74.

709.22 - NOT USED

709.23 - STEEL BOLTS AND NUTS:

Material shall meet the requirements of ASTM A 307.

709.24 - HIGH-STRENGTH BOLTS FOR STRUCTURAL STEEL JOINTS, INCLUDING SUITABLE NUTS AND HARDENED WASHERS:

709.24.1 - Bolts, Nuts and Washers:

All bolts, nuts and washers shall bear the manufacturer's markings and all markings specified in the applicable AASHTO specifications.

709.24.2 - High-Strength Bolts:

High-Strength bolts, black, galvanized or zinc rich coated, shall meet the requirements of AASHTO M 164 with the following exceptions. Zinc rich coated fasteners shall also meet the requirements of 709.24.10.

709.24.2.1- Not used

709.24.2.2: Proof load tests (ASTM F606, Method #1) are required for all bolts except as excluded in Section 6.2 of AASHTO M 164. Minimum frequency of tests shall be as specified in AASHTO M 164, paragraph 9.5.1.

709.24.2.3: Wedge tests on full size bolts (ASTM F606, paragraph 3.5) are required. If bolts are to be galvanized or zinc rich coated, tests shall be performed after galvanizing or coating. Minimum frequency of tests shall be specified in AASHTO M 164, paragraph 9.5.1.

709.24.2.4: If galvanized or zinc rich coated bolts are supplied, the thickness of the zinc coating shall be measured. Measurements shall be taken on the wrench flats or top of bolt head.

709.24.3 - Nuts:

Nuts plain, galvanized or zinc rich coated shall meet the following requirements.

709.24.3.1: Nuts to be galvanized (hot-dip or mechanically galvanized), or to be zinc rich coated shall be grade DH or DH3 meeting AASHTO M291 or be grade 2H meeting AASHTO M 292.

709.24.3.2: Plain (black) nuts shall be grade C, D or C3 meeting AASHTO M 291 or shall be grade 2 meeting AASHTO M 292 and shall have a minimum Rockwell hardness of 89 HRB (or Brinell hardness 180 HB). Plain nuts may also be supplied to grades listed in paragraph 709.24.3.1 above.

709.24.3.3: Nuts that are to be galvanized shall be tapped oversize the minimum amount required for proper assembly. The amount of over tap in the nut shall be such that the nut will assemble freely on the bolt in the coated condition and shall meet the mechanical requirements of the applicable AASHTO specification listed above and shall meet the requirements of the rotational-capacity test specified (the over tapping requirements of AASHTO M 291, paragraph 7.4 shall be considered maximum values instead of. minimum, as currently shown).

709.24.3.4: Galvanized and zinc rich coated nuts shall be coated with a lubricant containing a dye of any color that contrasts with the color of the coating.

709.24.3.5: Proof load tests (ASTM F606, paragraph 4.2) are required for all nuts. Minimum frequency of tests shall be as specified in AASHTO M 291, paragraph 9.3 or AASHTO M 292, paragraph 7.1.2.1. If nuts are to be galvanized or zinc rich coated, tests shall be performed after coating, overtapping and lubricating.

709.24.3.6: If galvanized or zinc rich coated nuts are supplied, the thickness of the coating shall be measured. Measurements shall be taken on the wrench flats.

709.24.4 - Hardened Washers:

Hardened washers, plain, galvanized or zinc rich coated shall meet the requirements of AASHTO M 293 and the following:

709.24.4.1: If galvanized or zinc rich coated washers are supplied, hardness testing shall be performed after coating. (Coating shall be removed prior to taking hardness measurements).

709.24.4.2: If galvanized or zinc rich coated washers are supplied, the thickness of the coating shall be measured.

709.24.5 - Rotational Capacity Testing:

Rotational-capacity tests are required and shall be performed on all black (plain), galvanized (after galvanizing) bolt, nut and washer assemblies by the manufacturer or distributor prior to shipping. Washers are required as a part of the test. The following shall apply:

709.24.5.1: Except as modified, the rotational-capacity test shall be performed in accordance with the requirements of AASHTO M 164.

709.24.5.2: Each combination of bolt production lot, nut lot and washer lot shall be tested as an assembly.

709.24.5.3: A rotational-capacity lot number shall be assigned to each combination of lots tested.

709.24.5.4: The minimum frequency of testing shall be two assemblies per rotational-capacity lot.

709.24.5.5: The bolt, nut and washer assembly shall be assembled in a. Skidmore-Wilhelm Calibrator or an acceptable equivalent device. For short bolts which are too short to be assembled in the Skidmore-Wilhelm Calibrator see Section 709.24.5.9.

709.24.5.6: The minimum rotation, from an initial condition (10% of the specified bolt proof load) shall be 240° turn) for bolt lengths up to and including 4 diameters, 360° turn for bolt lengths over 4 diameters up to an including 8 diameters, and 480° turn for bolt lengths over 8 diameters.

709.24.5.7: The tension reached at the above rotation shall be equal to or greater than 1.15 times the required installation tension. The installation tension and the tension for the turn test are shown below:

	METRIC						
Diameter (mm)	6	20	22	24	27	30	36
Required Installation Tension (kN)	91	142	176	205	276	326	475
Turn Test Tension (kN)	105	163	202	236	317	375	546

709.24.5.8: After the required installation tension listed above has been exceeded, one reading of tension and torque shall be taken and recorded. The torque value shall conform to the following:.

Torque (T) < 0.25 PD
Where:
Torque (T) = measured torque (KNm)
P = measured bolt tension (KN)
D = bolt diameter (m)

709.24.5.9: Bolts that are too short to test in a Skidmore-Wilhelm Calibrator may be tested in a steel joint. The tension requirement of Section 709.24.5.7 need not apply. The maximum torque requirement of Section 709.24.5.8 shall be computed using a value P equal to the turn test tension shown in the Table in Section 709.24.5.7.

709.24.6 - REPORTING OF TEST RESULTS:

709.24.6.1: The results of all tests (including zinc coating thickness) required in the appropriate AASHTO specifications shall be recorded in an appropriate document.

709.24.6.2: Location where tests are performed and date of tests shall be reported on the appropriate document.

709.24.7 - WITNESSING OF TESTS:

The tests need not be witnessed by an independent inspection agency. However, the manufacturer or distributor that performs the test shall certify that the results recorded are accurate.

Independent of the above, the Engineer reserves the right to witness any and all tests as the Engineer deems necessary. The manufacturer or distributor will notify the Engineer prior to conducting any tests.

709.24.8 - DOCUMENTATION:

709.24.8.1: Mill Test Report(s) (MTR) shall be furnished for all mill steel used in the manufacture of the bolts, nuts and washers. MTR shall indicate the place where the material was melted and manufactured.

709.24.8.2: Manufacturer Certified Test Report(s) (MCTR): The manufacturer of the bolts, nuts and washers shall furnish test reports (MCTR) for the items furnished. Each MCTR shall show the relevant information required in accordance with Section 709.24.6. The manufacturer performing the rotational-capacity test shall include on the MCTR:

a. The lot number of each of the items tested.

b. The rotational-capacity lot number as required in Section 709.24.5.3.

c. The results of the tests required in Section 709.24.5.

d. The pertinent information required in Section 709.24.6.2.

e. A statement that MCTR for the items are in conformance to this specification and the appropriate AASHTO specification.

f. The location where the bolt assembly components were manufactured.

709.24.8.3 - Distributor Certified Test Report(s) (DCTR):

The DCTR shall include MCTR above for the various bolt assembly components. The rotational-capacity test may be performed by a distributor (in lieu of a manufacturer) and reported on the DCTR. The DCTR shall show the results of tests required in Section 709.24.5; shall show the pertinent information required in Section 709.24.6.2 and shall show the rotational-capacity lot number as required in Section 709.24.5.3. The DCTR shall certify that the MCTR are in conformance to this specification and the appropriate AASHTO specifications.

709.24.9 - SHIPPING:

709.24.9.1: Bolts, nuts and washers from each rotational-capacity lot shall be shipped in the same container. If there is only one production lot number for each size of nut and washer, the nuts and washers may be shipped in separate containers. Each container shall be watertight and shall be permanently marked with a shipping label on the container lid and on the side of the container. The labels shall contain, as a minimum, the following information: quantity and description of contents, manufacturer's lot number for each item and the rotational - capacity lot number.

709.24.9.2: The appropriate MTR, MCTR or DCTR shall be supplied to the Engineer or representative prior to installation of any fasteners.

709.24.10 - ZINC RICH COATED FASTENERS:

709.24.10.1: Fastener components shall be vapour degreased, blast cleaned to Steel Structures Painting Council (SSPC) condition SSPC-10 (near white) and spray coated with a high ratio water-based inorganic zinc rich primer meeting the requirements of Section 711.20.2 of the Specifications.

709.24.10.2: Dry film thickness of the zinc rich primer shall be 2 mils (50 µm) minimum and 4 mils (100 µm) maximum.

709.25 - STEEL SHELLS OR CASINGS (DRIVEN WITHOUT MANDREL) FOR CAST-IN-PLACE PILES:

Steel shells or casings shall be composed of basic open hearth steel having a tensile strength of not less than (345 MPa). The thickness of metal shall be as indicated on the Drawings. The tips (small end) shall be equipped with a steel driving point securely fastened to the shell and the entire shell shall form one integral water-tight unit. Shells shall be tapered or step-tapered from top to bottom.

Any shell proposed for use shall be approved by the Engineer before driving.

709.26 THROUGH 709.28 - NOT USED

709.29 - ZINC COATED STEEL SHEETS FOR USE IN MANUFACTURING TRAFFIC SIGNS:

The zinc coated steel sheets shall be 16 gage (USS) and shall conform to the requirements of ASTM A 525.

The sheets shall be re-squared. They shall be furnished with a galvanized coating, Class 2.00.

The surface of the sheets shall be clean, free of oil, soot, dirt, scale, and other foreign material. They shall be protected in transit and shall be suitable for painting without cleaning or processing in any manner upon receipt by the Engineer.

709.30 - CAST IRON SOIL PIPE AND FITTINGS:

Cast iron soil pipe and fittings shall conform to the requirements of ASTM A 74.

709.31 - ALUMINUM ALLOY EXTRUSIONS AND ALUMINUM ALLOY EXTRUDED TUBE:

Aluminium alloy extrusions and extruded tube shall conform to ASTM B 221, alloy 6061, temper condition T6.

709.32 - ALUMINUM ALLOY STANDARD STRUCTURAL SHAPES:

Aluminium alloy standard structural shapes, rolled or extruded, shall conform to ASTM B 308, alloy 6061, temper condition T6.

709.33 - ALUMINUM ALLOY DRAWN TUBE:

Aluminium alloy drawn tube shall conform to ASTM B 210, alloy 6061, temper condition T6.

709.34 - ALUMINUM ALLOY PIPES:

Aluminium alloy pipe shall conform to ASTM B 241, alloy 6061, temper condition T6.

709.35 - ALUMINUM ALLOY RIVETS:

Aluminium alloy rivets shall conform to Military Specifications MIL-R-5674; grade and head style shall be as specified by the Engineer.

709.36 - ALUMINUM ALLOY BOLTS, NUTS AND SET SCREWS:

Aluminum alloy bolts and set screws shall be made from rod conforming to ASTM B 211, alloy 2024, temper condition T4. The aluminium alloy nuts shall be made form rod conforming to either ASTM B 221, alloy 6061, temper. condition T6 or ASTM B 211, alloy 6061, temper condition T6. Bolt head and nuts shall conform to the American Standard Regular Hexagon, ASA Specifications B 18.2 with the following modification: the width across the flats and the width across the corners may exceed the maximum given in the specification tables by an amount no greater than 20 percent of the difference between the maximum and minimum values given in the tables.

Threads shall conform to American Standard Coarse Thread Class 2. The finished product shall be in the fully heat-treated and aged condition. Anchor bolts shall be given a clear anodic coating at least 0.0002 in (5 µm). thick. Exposed nuts and washers need not be given as anodic coating.

709.37 - ALUMINUM ALLOY WASHERS:

Aluminum alloy washers shall be made from sheet conforming to ASTM B 209, Alclad 2024, temper condition T3 or T4 depending upon the thickness supplied.

709.38 THROUGH 709.39 - NOT USED

709.40 - ALUMINUM ALLOY SHIM MATERIAL:

Aluminum alloy shims shall be made from sheet or plate conforming to ASTM B 209, alloy 1100, temper condition 0.

709.41 - ALUMINUM FILLER METAL FOR WELDING:

Aluminum filler metal for welding shall conform to ASTM B 285, alloy ER 4043.

709.42 - GALVANIZED PIPE OR TUBING FOR HORIZONTAL DRAINS:

709.42.1 - General:

Horizontal drains may be of galvanized welded or seamless steel pipe, or galvanized tubing, conforming to the requirements prescribed.

The outside diameter shall be a nominal diameter of 50 mm or greater, and the wall thickness shall be a minimum of 1 mm The material shall be perforated. Perforations shall consist of two rows of 5 mm ±1 mm diameter holes along the length of the pipe or tubing. The holes in each row shall be on 50 mm ±6 mm centres. The row shall be 110 deg apart. The material may be furnished in random or regular lengths.

709.42.2 - Galvanized Welded or Seamless Steel Pipe:

Galvanized welded or seamless steel pipe shall conform to the requirements. of ASTM A 53. The hydrostatic test will be waived.

709.42.3 - Galvanized Tubing:

Galvanized tubing shall be circular in cross section with a welded seam. The base metal shall conform to the requirements of Table 1, AASHTO M 218M. The outside surface of the weld shall be metalized.

709.43 THROUGH 709.44 - NOT USED

709.45 - GALVANIZED STEEL GUARDRAIL POSTS:

Steel guardrail posts shall be fabricated from steel meeting the requirements of AASHTO M 183 or fabricated in accordance with ASTM A 769, Grade 40.

They shall be of a section, length and weight as specified on the Drawings. The weight shall not be less than 97.5 percent of that specified.

Galvanizing shall be in accordance with AASHTO M 111, with a minimum of 600 grams per square metre.

709.46 - STEEL POSTS, POST BRACES AND GATE FRAMES FOR RIGHT-OF WAY FENCE:

End, pull, corner, gate, intermediate assembly, special length line posts, post braces and gate frames shall be either (a) galvanized steel pipe meeting the requirements of ASTM A 53, with hydrostatic pressure test requirements waived, or (b) triple-coated steel pipe meeting the requirements for Class 2 pipe in AASHTO M 181. Either type may be used unless one type is specifically called for in the Contract. Pipe members shall have the dimensions and weights called for on the Drawings. In addition, for chain link fence only, roll formed members, having the dimensions and weights called for on the Drawings and meeting the applicable requirements in 712.8 of the Specifications, may be used in lieu of pipe posts and pipe braces as shown on the Drawings.

Line posts for farm-field fence shall conform to the requirements of AASHTO M 281. Line posts for chain-link fence shall conform to the requirements shown on the Drawings. All line posts shall be galvanized. A tolerance of five percent in weight will be allowed on all fence posts.

709.47 - NOT USED

709.48 - CADMIUM COATED MATERIALS:

Cadmium coated (electrodeposited) steel articles, steel hardware, nuts, bolts, etc. shall meet the requirements of ASTM B766.

709.49 - SHEET LEAD:

Sheet lead shall conform to the requirements of ASTM B 29.

709.50 - STEEL PILE POINTS:

Steel pile points may be either ASTM A27 Grade 65/35 cast steel or ASTM A148 Grade 90/60.

SECTION 710

WOOD MATERIALS

710.1 - STRUCTURAL MATERIALS:

Timber, lumber, piles, posts, and blocks shall meet the requirements of AASHTO M168. Preservation and Treatment plants shall meet the requirements of the Book of Standards of the American Wood-Preservers' Association (AWPA).

710.2 - SPECIES AND GRADE:

710.2.1 - Structural softwood shall meet the requirements of the Southern Pine Inspection Bureau (SPIB) grading rules. All wood for structural use shall be visually or mechanically graded for the requirements shown on the Drawings or specified in the Contract.

710.2.2 - Structural hardwood shall meet the requirements of AASHTO M168. The grade and species required shall be as shown on the Drawings or specified in the Contract.

710.2.3 - Hardwood used for bridge decking shall meet the Standards of the National Hardwood Lumber Association (NHLA) for sound square edge, be rough sawn and sized by being processed through a hit or miss surfacer.

710.2.4 - All graded material may either carry the appropriate grade stamp, or be inspected by an independent inspection agency approved by the Engineer.

710.3 - PRESERVATIVE TREATMENT:

All timber products requiring preservative treatment by pressure processes shall meet the requirements of AWPA C1 in addition to the specific requirements listed below.

710.3.1 - All hardwood for highway construction shall meet the requirements of AWPA C2.

710.3.2 - All softwood for highway construction shall meet the requirements of AWPA C14.

710.3.3 - All wood products for commercial construction shall meet the requirements of AWPA C15.. The quantity of preservative shall be as required above, unless modified by the Drawings or purchase order.

710.3.4 - The preservative shall be one of the following:

710.3.4.1 - Coal tar creosote meeting AWPA P1 shall be analysed by AWPA A1.

710.3.4.2 - Waterborne meeting AWPA P5 shall be analysed by AWPA A2 and/or A9.

710.3.5 - Preservative retention shall be determined by gauge or assay.

The gauge method shall be approved by the Engineer for each treatment plant. The assay methods shall be as follows:

710.3.5.1 - Coal tar creosote by AWPA A6.

710.3.5.2 - Waterborne by AWPA A11.

710.4 - TREATMENT PLANTS:

Material treated with preservative may be purchased from certified or non-certified plants. Both type of plants shall adhere to the quality control procedures of AWPA M2.

710.4.1 - Certified Plants: The Engineer's procedure for plant certification is defined in AASHTO M 168, AASHTO M 133.

710.4.2 – Non-Certified Plants:

Material purchased from non-certified plants will be tested on a lot by lot basis. The inspection shall be performed by a Engineer approved inspection agency. The cost of the inspection will be paid by the supplier. Shipments from non-certified plants shall be documented as described in AASHTO M 168, AASHTO M 133.

710.5 - WOOD POSTS:

Wood posts shall meet the requirements of ASSHTO M168 except round posts may be used for guardrail where approved by the Engineer.

710.5.1 - Round posts for guardrail shall meet the requirements of Section 5 "Material Requirements" of ANSI 05.1. Round posts for guardrail shall be from the major or minor species of Southern Pine.

710.5.2 - Rectangular posts for guardrail shall be No. 1 major or minor species of Southern Pine as defined in Section 400 of the SPIB grading rules..

710.5.3 - Dimensions of all guardrail posts except as noted on the Plans shall be as follows:

Round Guardrail Posts :Diameter: 177 mm ±6 mm throughout the length except as noted on Drawings. Length: 1 828 mm ±13 mm

Rectangular Guardrail Posts: Size: 152 mm ±6 mm by 203 mm ±6 mm throughout the length except as noted on Drawings. Length: 1 828 mm ±13 mm

710.5.4 - Dimensions of wood posts for fence and signs shall be as shown on the Drawings.

710.6 - PLYWOOD:

710.6.1 - Plywood shall meet the requirements of Product Standard PS-1 of U.S. Department of Commerce. All plywood shall be identified with the mark of a qualified inspection and testing agency. The identification shall include:

710.6.1.1 - Species group classification, or class number, or span rating, depending on grade.

710.6.1.2 - Either interior or exterior.

710.6.1.3 - Grade name or grade of face and back veneers.

710.6.1.4 - The symbol PS-1 signifying conformance with the standard.

710.6.2 - Exterior plywood shall be bonded with exterior glue and the veneers used in manufacture cannot be less than grade C as defined in PS-1.

710.7 - COMMON LUMBER:

710.7.1 - Common lumber is untreated and suitable for general construction and utility purposes. Common lumber is from 50 mm to but not including 125 mm thick and is 50 mm or more in width. Common lumber shall be grade 2 or better when graded by the Board of Review of the American Lumber Standards Committee..

710.8 - SERVICE AND LIGHTING POLES:

710.8.1: Wood Service or lighting poles shall be ANSI Class 5, or larger, or as called for on the Contract Drawings. The poles shall be pressure-treated with copper chromium arsenate (CCA) to meet the requirements of AWPA C-14.

SECTION 711
PAINTS, COATINGS, OILS, AND INKS

711 - GENERAL

Paints shall consist of pigments and vehicles conforming to the general requirements of these Specifications, proportioned and treated to produce materials possessing the detailed composition and physical properties.

General Requirements: The finished products shall not settle excessively nor cake in the container, shall be readily mixed with a paddle to a smooth uniform paint of specified consistency and working properties. The product shall not thicken, liver, skin, or curdle. The paint shall have a storage life of at least 12 months.

All ready mixed paints shall be furnished in containers holding not more than 20 litres, unless authorized by the Engineer. Shop paints may be furnished in larger containers providing approved mechanical agitation is available.

Each container shall bear a label with the following information: Name and address of the manufacturer, trade name or trade mark, type of paint, number of litres, lot or batch number, date of manufacture, and flash point. The label of two component systems shall include mixing instructions. Sampling and testing shall be in accordance with PAINT TESTING METHODS. Quantities of 200 litres or less may be accepted on manufacturer's certification.

711.1 - NOT USED

711.2 - BOILED LINSEED OIL:

Boiled linseed oil shall conform to the requirements of ASTM D 260.

711.3 THROUGH 711.4 - NOT USED

711.5 - MINERAL SPIRITS:

Mineral spirits shall conform to the requirements of ASTM D 235.

711.6 - FIELD PRIMER:

711.6.1 - General:

Acceptance shall be based on batch testing. Initial approval of all material will be based on complete testing to assure specification compliance. This primer may be used in the shop on new steel or in the field on existing steel. The shop primer shall have a minimum slip coefficient of 0.50 (Class B) when tested in accordance with "Test Method to Determine the Slip Coefficient for Coatings used in Bolted Joints" as adapted by the Research Council on Structural Connections. The steel shall be capable of being blast cleaned to a near-white finish, SSPC-SP-10, for new steel, and to a commercial finish, SSPC-SP-6, for existing steel. This primer may be top coated in accordance with Section 711.20.1. The dry film thickness requirement for this material is three mils (75 µm) minimum unless specified otherwise.

711.6.2 - Primer shall meet the requirements of SSPC, Paint Specification Number 20, Type 2.

711.7 - FIELD OR SHOP PRIMER:

711.7.1 - General:

Acceptance shall be based on batch testing. Initial approval of all material will be based on complete testing to assure specification compliance. Subsequent approval of initially accepted

products may be based on random testing (all tests not required on each batch) at the option of the Engineer. This specification provides the requirements for a fast drying shop or field primer. This primer may be used on new steel painted in the shop or as a field primer on existing bridges. In both cases, the steel must be capable of being blast cleaned to a near white condition, SSPC-SP-10. The dry film thickness requirement for this material is 50 µm (two mils) minimum unless specified otherwise.

711.7.2 - This primer shall meet the requirements of Federal Specification TTP-664 (C) except that the minimum dry to touch time shall be deleted and the maximum increased to 10 minutes.

711.8 - FIELD PRIMER-SLOW DRYING:

711.8.1 - General:

Acceptance shall be based on batch testing. Initial approval of all material will be based on complete testing to assure specification compliance. Subsequent approval of initially accepted products may be based on random testing (all tests not required on each batch) at the option of the Engineer. This specification provides the requirements for a slow drying field primer. This primer is to be used on existing structures which are corroded to such an extent that they cannot be blast cleaned to a commercial condition, SSPC-SP-6.

The dry film thickness requirement for this material is 50 µm minimum unless specified otherwise.

711.8.2 - This primer shall meet the requirements of SSPC, Paint Specification Number 25 with the following exceptions:.

i. DELETE Tack Free Dry Time. SUBSTITUTE Set-To-Touch Time.

ii. DELETE II-R266, Type II. SUBSTITUTE TT-R266, Type I, Class A or Class B.

iii. CHANGE Maximum dry hard from 24 to 36 hours.

711.9 - NOT USED

711.10 - INTERMEDIATE FIELD COAT:

711.10.1 – General:

Acceptance shall be based on batch testing. Initial approval of all material will be based on complete testing to assure specification compliance. Subsequent approval of initially accepted products may be based on random testing (all tests not required on each batch) at the option of the Engineer. This specification provides the requirements for an intermediate field coat or coats for use in mild or average atmospheric conditions. This paint may be applied over 711.7 or 711.8 primers. It is to be top coated with a pigmented finish coat meeting 711.11. The dry film thickness requirement for this material is 50 µm minimum unless specified otherwise.

711.10.2 - This paint shall meet the following requirements:

	Minimum	Maximum
Viscosity (KU)	75	90
Fineness of Grind	4	
Drying Time (hours) Set to Touch Dry Hard		6
Gloss @ 60°C		18
Pigment, percent by weight	25	50

Color shall be light grey

Weight - The weight per litre of the paint shall be within ±225 grams of the initial qualification sample.

Adhesion - When tested in accordance with ASTM D3359 the adhesion shall not be less than 3B when the total film thickness is 125 µm or less. Thickness in excess of 125 µm require a minimum adhesion of 3A.

711.11 - PIGMENTED FINISH COAT:

711.11.1 - General:

Acceptance shall be based on batch testing. Initial approval of all material will be based on complete testing to assure specification compliance. Subsequent approval of initially accepted products may be based on random testing (all tests not required on each batch) at the option of the Engineer. This specification provides the requirements for a. pigmented finish coat or coats for use in mild or average atmospheric conditions. This finish coat is to be applied over 711.10. The field adhesion of the system primer shall be at least 90 percent when tested in accordance with PAINT TESTING METHODS. The adhesion test shall be conducted approximately 14 days after field application. The dry film thickness requirement for this material is 50 µm minimum unless specified otherwise

The colour choices permissible are from Federal Standard 595. The color difference, DE, of the acceptance samples shall not be more than five DE units from the standard listed below.

Federal Standard Number	X Coordinates	Y Coordinates	Y Coordinates
14062.	.2361	.4376	04.13
14223	.2883	.3911	20.24
17178	.3059	.3169	31.46
14241	.2915	.3382	27.75

711.11.2 - Physical Requirements:

	Minimum	Maximum
Viscosity (KU)	70	80
Fineness of Grind	6	
Drying Time (hours) Set to Touch Dry Hard		4
Gloss @ 60°C		18
Pigment, percent by Weight	25	50

Accelerated Weathering –Color change shall not exceed the five DE units after 500 hours exposure.

Weight - The weight per litre of the paint shall be within ±225 grams of the initial qualification sample.

Flexibility - There shall be no apparent failure when viewed under 8X magnification after bending around (6 mm) mandrel.

Adhesion - When tested in accordance with ASTM D3359 the adhesion shall have minimum rating of 3A.

711.12 - EPOXY MASTIC MAINTENANCE COATING:

711.12.1 - General:

This specification provides the requirements for a two components, modified epoxy coating for use as a spot primer or a one coat system for use on poorly prepared surfaces on most existing structures. All ingredients are not specified, however, the finished product shall comply with the requirements prescribed.

711.12.2 - Composition:

The pigment shall be flake metallic aluminium. The vehicle shall be modified epoxy resin and curing agent. The vehicle shall be formulated to permit trouble free application during normal humidity conditions.

711.12.3 - Physical Requirements:

i. Dry to touch @ 125 µm dry 24 Hours Maximum

ii. Dry hard @ 125 µm dry 72 Hours Maximum

iii. Weight per litre 1.42 kg Minimum

iv. Corrosion resistant steel panels meeting the requirements of PAINT TESTING METHODS, Section 5.2 shall be sandblasted to a white metal finish in accordance with SSPC-SP-5, exposed to the atmosphere for 30 days so uniform rusting occurs, and then hand cleaned with a wire brush in accordance with SSPC-SP-2. The panel shall then be spray applied with epoxy-mastic according to manufacturers' recommendations.

Fresh Water Resistance: The coated panels shall be scribed to the base metal with an X of at least 50 mm legs and shall be immersed in fresh tap water at 24°C ± 3°C. Upon examination after 30 days immersion, the panels shall be unaffected, except for discolorations of the epoxy-mastic coating. There shall be no blistering, softening, or visible rusting beyond 2 mm from the edge of the scribe mark.

Salt Water Resistance: Panels shall be scribed to the base metal with an X of at least 50 mm legs and shall be immersed in five percent sodium chloride solution at 24°C ± 3°C. The panels shall be unaffected, except for discoloration of the epoxy-mastic coating, upon inspection after 30 days. There shall be no blistering, softening or visible rusting beyond 2 mm from the centre of the scribe mark. The sodium chloride solution shall be replenished with fresh solution each week.

Weathering Resistance: Panels shall be tested in accordance with ASTM G 53. After 1,000 hours exposure the coating shall show no rusting, blistering, or loss of adhesion to the test panel.

Salt Fog Resistance: Panels shall be scribed to the base metal with an X of at least 50 mm legs. The test panels shall then be tested in accordance with ASTM B 117. After 1,000 hours of continuous exposure the coating shall show no loss of bond; nor shall it show rusting or blistering beyond 2 mm from the centre of the scribe mark.

v. Flexibility: The epoxy-mastic coating shall possess such flexibility that when applied at a 125 µm dry film thickness to a 3 mm steel panel which has been blast cleaned in accordance with SSPC-SP-5, and dried for two weeks at 20°C shall display no signs of cracking or loss of adhesion when the panel is uniformly bent 180 degrees around a 3 mm diameter mandrel.

vi. Application Properties: The paint shall be suitable for use over properly prepared zinc rich primers. The mixed paint, when thinned in accordance with manufacturer's recommendations, shall be capable of being sprayed in one coat at a 250 µm wet film thickness without runs or sags. The properly thinned paint shall be capable of brush and roller application. The manufacturer's current printed instructions for application of epoxy-mastic coating shall be submitted to the Engineer for review and approval prior to application.

711.12.4 - Packaging and Labelling:

The epoxy-mastic coating shall be packaged in two containers, labelled Part A and Part B. Each container shall bear a label on which shall be clearly shown the manufacturer and brand name of paint, the lot number, and the date of manufacture. The label on the containers shall also include complete instructions for the use of this paint. The inside of the container shall be coated, if necessary, to prevent attack by the paint components.

711.12.5 - Acceptance Procedure:

The Engineer will develop an approved list of products meeting this specification.

The list shall be based upon testing performed by the Engineer or by certified test data supplied by the manufacturer. The manufacturer shall supply the Engineer the following for each product.

i. Two one gallon (4 litre) kits of the product

ii. One gallon (4 litre) thinner

iii. Instructions for mixing, thinning and application.

iv. Materials Safety Data Sheet for both the paint and thinner

v. Company data sheet on the product

After successful testing, the Engineer will inform the manufacturer of inclusion on the approved list. Upon approval by the Engineer, further testing will not be required of the brand name of paint, unless random samples tested by the Engineer show non-compliance with any of the specification requirements. The manufacturer shall submit certified test data anytime the formulation or manufacturing process changes.

711.12.6 – Coloured epoxy-mastic to meet the above requirements with the following changes:

i. The metallic aluminium pigment shall be replaced by other pigments and colouring agent necessary to provide the specified color. The color difference, DE, of the acceptance samples shall not be more than 5 DE units from the standards listed below.

Federal Standard Number	x Coordinates	y Coordinates	Y Coordinates
14062	.2361	.4376	0413
14223	.2883	.3911	2024
14241	.2915	.3382	27.75
17178	.3059	.3169	31.46
30045	.3555	.3324	6.88

ii. Due to the fading tendencies of the coloured epoxy-mastics, all material must come from the same batch.

711.13 - INKS:

Inks for use on reflective sheeting shall be as recommended by the manufacturer of the reflective sheeting.

711.13.1 - Transparent Ink:

711.13.1.1 - Color:

The color shall meet the requirements of Table 1 and be tested in accordance with Section 7.1 of AASHTO M268.

711.13.1.2 - Black Ink:

Black Ink shall be opaque process ink made with synthetic resin.

711.13.3 - Clear Transparent Ink:

Clear transparent ink for application as a final protective coat shall be as recommended by the manufacturer of the reflective sheeting.

711.14 – OVERCOAT SYSTEMS:

711.14.1 – General:

This specification provides paint systems which may be used with minimal surface preparation.

711.14.2 – Cleaning and Painting:

Surface preparation will be limited to hand or power tool cleaning meeting SSPC-SP-2 or SSPC-SP-3. Application of the paint system shall be in accordance with the manufacturer's recommendations.

711.14.3 – Acceptance:

The Engineer will maintain an approved list of overcoat system.

711.15 THROUGH 711.19 - NOT USED

711.20 - INORGANIC ZINC RICH SYSTEM:

711.20.1 - General:

Acceptance shall be based on batch testing. Initial approval of all material will be based on complete testing to assure specification compliance. Subsequent approval of initially accepted products may be based on random testing (all tests not required on each batch) at the option of the Engineer. This specification provides the requirements for an inorganic zinc rich system. The primer is to be spray applied over a near white blasted surface, SSPC-SP-10. An intermediate coat meeting 711.20.3 may be needed to tie the primer and the top coat together. The use of an intermediate coat shall be the option of the top coat manufacturer. In either case, the field adhesion of the system shall be at least 90 percent when tested in accordance with PAINT TESTING METHODS. The adhesion test shall be conducted approximately 14 days after field application.

711.20.2 - Primer:

This primer shall meet the requirements set forth in ASTM D3925, AASHTO M300 with the following changes (***bold italic*** number refers to sub-section of AASHTO M 300):

4.2.2 Delete X-ray diffraction

4.6.8 Delete accelerated weathering

4.6.9 Delete bullet hole immersion test

4.6.10 Delete humidity test

4.7 Delete primer field performance requirement

4.8.5 Delete infrared spectrum.

4.8.6 Delete the VOC (volatile organic compound) requirement and substitute the following: The VOC shall not exceed 420 kg / m^2 for shop or field application.

The primer shall have a minimum slip coefficient of 0.50 (Class B) when tested in accordance with "Test Method to Determine the Slip Coefficient for Coatings used in Bolted Joints" as adapted by the Research Council on Structural Connections.

711.20.3 - Intermediate Field Cost:

The material shall meet the requirements set forth in ASTM D3925.

711.20.4 - Top Coat:

This top coat shall meet the manufacturer's specifications and shall meet the physical requirements of 711.20.4.1.

711.20.4.1 - Physical Requirements:

	Maximum
Drying Time (hours)	1
Set-to-touch	3
Dry for recoating	24
Dry Hard	
Flexibility (13 mm mandrel)	No Failure

Compatibility - 50 cu. cm. of the coating shall be able to be mixed with 50 cu cm of the manufacturer's thinner without curdling, livering, separating, or otherwise affecting the coating except to thin it.

Color - The color choices permissible are from Federal Standard 595.

The color difference, DE, of the acceptance samples shall not be more than five units from the Standards listed below:

Federal Standard Number	X Coordinates	Y Coordinates	Y Coordinates
14062	.2361	.4376	04.13
14223	.2883	.3911	20.24
14241	.2915	.3382	27.75
17178	.3059	.3169	31.46
30045	.3555	.3324	6.88

iv. Accelerated Weathering - After cycling 1000 hours there shall be no evidence of checking, cracking, rusting, or blistering. The degree of chalking shall not be less than No. 6 when tested according to ASTM D6549. The color difference after 1000 hours shall be no more than five DE units.

v. Chemical Resistance - The top coat shall show no visual deterioration, other than minor discolorations, after seven days exposure to:

a. Ten percent sulphuric acid solution

b. Ten percent sodium hydroxide solution

vi. Adhesion - When tested in accordance with ASTM D3359 the adhesion shall have minimum rating of 3A.

vii. Gloss - less than 25 (for color 30045 only).

711.21 - GALVANIZE REPAIR (ZINC RICH PRIMER):

Acceptance shall be based on batch testing. Initial approval of all material will be based on complete testing to assure specification compliance.

Subsequent approval of initially accepted products will be based on random testing (all tests not required on each batch) at the option of the Engineer. This primer shall meet the requirements of Military Specification MIL-P-21035, Federal Specification TTP-641, Section 711.6, or Section 711.20.2.

711.22 - INORGANIC ZINC RICH LOW VOC SYSTEM:

711.22.1 - General:

Initial approval for all material will be based on complete testing of the system for specification compliance. Subsequent approval of initially accepted products may be based on random testing (all tests not required on each batch) or from an approved list at the option of the Engineer. Each product in the system shall have a maximum Volatile Organic Compound (VOC) content. Each product in the system shall be from the same manufacturer. The primer is to be spray applied over a near white blasted surface, SSPC-SP-10. An intermediate coat meeting 711.22.3 may be needed to tie the primer and the top coat together. The use of the intermediate coat shall be at the option of the manufacturer. In either case, the field adhesion of the system shall be at least 3A when testing in accordance with PAINT TESTING METHODS.

The adhesion test shall be conducted approximately 14 days after application of the top coat.

Two low VOC systems are covered by this specification. They are as follows:

System 1 - All products are to have a VOC of maximum 336 gm per litre.

System 2 - All products are to have a VOC of 336 gm per litre maximum except the primer has no restrictions on VOC.

All fabricators/contractors will be required to use the same system formulation on a specific structure.

711.22.2 - Primer: This primer shall meet the requirements of 711.20.2.

711.22.3 - Intermediate Field Coat:

This material shall meet the manufacturer's specification and shall be compatible with the primer (711.22.2) and the top coat (711.22.4).

711.22.4 - Top Coat: This material shall meet the manufacturer's specification and shall meet the requirements of 711.22.4.1.

711.22.4.1 - Requirements:

i. Dry Hard - 24 Hours Maximum
ii. Color - Shall meet the requirements of 711.20.4.1.
iii. Gloss @ 60° - 50 Minimum

711.22.5 - The system shall be composed of a primer (711.22.2) and topcoat (711.22.4). The use of an intermediate coat is at the option of the manufacturer. The primer shall be applied at a minimum of 75 µm dry.

The total coating over the primer shall be a minimum of 100 µm dry.

711.22.5.1 - System Requirements:

i. Inter-coat Adhesion - Before and after all tests, the inter-coat adhesion shall be at least 3A when tested in accordance with PAINT TESTING METHODS.

ii. Accelerated Weathering - After cycling 1000 hours there shall be no evidence of checking, cracking, rusting, or blistering. The degree of chalking shall not be less than No. 6 when tested according to ASTM D6549. The color difference after 1000 hours shall be no more than five DE units.

iii. Salt Spray - After cycling for 1,000 hours, the inter-coat adhesion shall meet 711.22.5.1 i.

711.25 THROUGH 711.39 - NOT USED

711.40 – TEMPORARY WHITE OR YELLOW TRAFFIC PAINT:

Temporary Traffic Paint shall be any commercially available white or yellow paint designed for use on highways. The paint shall be applied at a minimum rate of 381 mm wet film thickness. The paint shall be applied with glass beads at a minimum rate of 720 grams per litre of paint. The beads shall be any glass spheres designed to be applied to the above paint. The paint shall have a minimum retro-reflective reading of 150 mc/1x/m² within three to ten days after application. During this period readings shall be performed by the Engineer. A minimum of three readings shall be taken with the LTL 2000 Retroreflectometer. Testing shall be in accordance. with ASTM E1710 with the following changes (number refers to subsection of ASTM E1710).

711.40.1 – The aperture angle of the light source as determined from the centre of the measurement area shall be a maximum of 0.33.

711.40.2 – As determined from the centre of the measurement area the aperture angle of the receiver shall be a maximum of 0.33.

Should the paint fall below 150 mc/1x/m² the Contractor shall repaint at no additional cost.

711.41 - WHITE OR YELLOW FAST-DRY TRAFFIC PAINT (TYPE II)

711.41.1 - General:

The pavement marking material shall be formulated as a medium-life pavement marking system capable of providing a minimum of one year of continuous performance. Solvent born paint, methyl methacrylate, chlorinated rubber, or other short duration products will be not approved. The composition of the paint shall be left to the discretion of the pavement marking manufacturer. The Contractor shall provide a pavement marking system to meet the following performance requirements:

COLOR: Each color installed shall match the following Federal Standards:

Yellow: No. 595A-33538

White : No. 59S A-37875

The color shall show no appreciable discoloration due to aging during the life of this pavement marking. Pavement markings shall be visually checked by the Engineer at any time during the life of this pavement marking, additionally, the Engineer may at any time during the projected life of this marking use a portable colourometer to determine if the markings have faded or darkened beyond the CIE Chromaticity Coordinate Limits.

711.41.2 - Sampling and Testing Procedures for Performance Samples:

The pavement marking system installed, shall at all times maintain a minimum reflectance value of 200 mcd/m2/lx for white pavement markings and 150 mcd/m2/lx for yellow pavement markings when measured with a LTL-2000 retroreflectometer or equal 30 metre device approved by the Engineer.

During the pavement marking life-span, the pavement marking materials furnished and installed shall show no signs of failure greater than five (5) percent loss due to blistering, excessive cracking, bleeding, staining, discoloration, smearing or spreading under heat, deterioration due to contact with oil or gasoline, chipping, spalling, poor adhesion to the pavement, damage from traffic and normal wear. Loss due to pavement failure, unless caused by the marking material, will not be considered as a material failure and will not be included in the loss calculations and/or retro-reflectivity readings.

The Engineer may conduct periodic pavement marking reviews. These reviews will occur at any time after the markings have been placed. These reviews will evaluate the pavement marking

material within the project limits for either day and night acceptability considering all requirements listed above. The following method will be used to measure the retro-reflectivity acceptance of the pavement marking material: Identified deficient areas greater than 300 metres shall be labelled as zones and these areas shall be checked for retro-reflectivity. Areas less than 300 metres shall be addressed on an individual basis concerning deficient markings. Zones of less than 1.5 km in length may have from one to three check points at the discretion of the Engineer. Check points will consist of six skip lines or of continuous marking. For each check point eighteen (18) retro-reflective readings will be taken over the six skip lines or of continuous line, with the average to be the determination of the retro-reflectivity level.

Zones 1.5 km to 5 km in length will have readings taken at a minimum of three check points within the zone. The check points shall be located at the beginning, middle and end portions of the zone in question. Zones greater than 5 km in length shall have check points at the beginning, end and at three mile intervals within the zone.

Retro-reflective readings within each check point and zone will be averaged. If any of the check point averages and/or zone averages fall below the defined minimum retro-reflective values, additional zones may be used for further evaluation of the markings to be replaced. The average zone value will be used to determine conformance to the defined minimum values.

During the life of this pavement marking if any markings greater than are found to be deficient for any reason, the Contractor will be given notification stating the locations and the type of deficiency. These notifications will be given at any time during the life of the Contract. The Contractor shall completely replace the deficient markings, as directed by the Engineer, within twenty (20) calendar days of the written notification. No direct payment shall be made for the replacement of any deficient pavement marking during the one-year warranty period as such work shall be considered as incidental to the work as paid for by the various pavement marking items in the Contract.

711.41.2.1- Submission For Approval of Equipment Personnel:

The Contractor (prior to commencement of the project) shall submit to the Engineer a detailed list of all equipment and the resumes of all personnel within the confines of this project. The Contractor shall also provide certification from the binder manufacturer that the Contractor is qualified to apply the manufacturer's material in conformance with these Specifications.

Drivers and operators with less than one year of experience shall not be used on the Works.

The Contractor will be required to fill out daily report and provide the completed forms to the Engineer. The Contractor's weekly reports shall be delivered to the Engineer the first work day of the following week.

711.41.2.2 - Application of Performance Pavement marking Materials:

The Contractor's striper shall be equipped with electrical foot counters. The counters shall individually tabulate the amount of footage applied by each striping gun whether solid or dashed. The counters shall be six digit types with a reset feature. The Contractor shall determine the accuracy of the foot counters and establish an adjustment factor as required to determine the pay item quantities. The foot counters shall be periodically checked to assure accurate measurements. No paint shall be applied without the accurate operation of the foot counters. The Contractor shall provide the Engineer with a certified document on these calibrations. The Contractor shall use an accurate dashing mechanism, capable of being adjusted to retrace existing lane or centre line markings.

The pavement marking material shall be mixed uniformly throughout and shall have a homogeneous dispersement of color and beads when applied to the pavement. The material shall have a uniformly thick cross-section through its entire length.

Pavement marking lines shall be straight or of uniform curvature and shall conform with the tangents, curves, and transitions as specified in the pavement marking standards and/or as directed by the Engineer.

The finished lines shall have well-defined edges and be free of horizontal fluctuations. The lateral deviation shall not exceed 13 mm from the proposed location alignment as specified in the Standards and/or directed by the Engineer.

When striping interchanges, material will be applied for the full length of all ramps, including all islands, gore areas, etc. The Contractor shall be responsible for completely removing all pavement marking materials spilled upon the roadway surface or adjoining area. The Contractor shall use methods acceptable to the Engineer for removing the spilled material.

SECTION 712

GUARDRAIL AND FENCE

712.1 THROUGH 712.3 - NOT USED

712.4 - GALVANIZED STEEL DEEP BEAM GUARDRAIL, FASTENERS AND ANCHOR BOLTS:

Galvanized steel deep beam guardrail, fasteners and anchor bolts shall conform to AASHTO M180, Type II, Class A.

712.5 THROUGH 712.7 - NOT USED

712.8 - CHAIN-LINK FENCE:

Chain-link fence shall conform to the requirements of AASHTO M 181. Fence height, gauge and details shall be as specified on the Drawings.

712.9 - ZINC-COATED (GALVANIZED) IRON OR STEEL FARM-FIELD AND RAILROAD RIGHT-OF-WAY WIRE FENCING:

This fencing shall meet the requirements of AASHTO M 279 and details shown on the Drawings. Either of the following styles and coating classes may be used.

1. Style 1047-6-9 with Class 1 coating
2. Style 1047-6-11 with Class 3 coating

Zinc coating for miscellaneous steel fittings an hardware shall conform to the requirements of AASHTO M 232. Zinc coating for clips used for securing fence or wire shall conform to AASHTO M 279, Class 1 coating.

712.10 - COATED STEEL BARBED WIRE:

Barbed wire shall meet the requirements of AASHTO M 280, Class 1 or AASHTO M305, Type I.

SECTION 713

METAL PIPE

713.1 - NOT USED

713.2 - METALLIC COATED CORRUGATED STEEL PIPE AND PIPE ARCH:

Metallic coated corrugated steel pipe and pipe arch shall conform to the requirements of AASHTO M 36 for Type I and Type II pipe. Special sections, such as elbows, for these conduits shall be of the same gage as the conduit to which they are jointed, and shall conform to the applicable requirements of AASHTO M 36.

713.3 - BITUMINOUS COATED CORRUGATED STEEL PIPE AND PIPE ARCH:

Bituminous coated corrugated steel pipe, pipe arches, coupling bands, elbows, and other special sections shall conform to the requirements of AASHTO M 190. Coating and invert paving shall be of the type specified.

713.4 - FULL BITUMINOUS COATED AND FULL PAVED CORRUGATED STEEL PIPE:

The pipe shall conform to the applicable requirements of AASHTO M 190 and in addition thereto, when riveted corrugated steel pipe is used, the rivets shall be placed on the outside crests of corrugations. Bituminous coating shall be in accordance with the requirements for Type A; the paving shall be in accordance with the requirements for Type B except that the pavement shall be formed on the inside for the entire circumference of the pipe. Smooth lined pipe over 750 mm diameter shall have lifting lugs attached to each section when manufactured.

713.5 - FIBER BONDED FULL BITUMINOUS COATED CORRUGATED STEEL PIPE AND PIPE ARCH:

713.5.1 - Type A, Fibre Bonded Full Bituminous Coated:

Fibre bonded full bituminous coated conduits shall comply with the requirements of AASHTO M 36 for base metal, and fabrication where applicable. The conduit shall be formed from sheets which have been coated on both sides with a layer of aramid fibres, applied in a sheet form by pressing them into a molten metallic bonding medium. Immediately after the metallic bond has solidified, the fibres shall be thoroughly saturated with a bituminous saturant. The finished sheets shall be of first class commercial quality, free from blisters and unsaturated spots. In addition, the conduit shall be coated inside and out with a bituminous material complying with the requirements of AASHTO M 190, Type A..

713.5.2 - Type C, Fibre Bonded Full Bituminous Coated and Paved Invert:

Fibre bonded full bituminous coated and paved conduits shall comply with all the requirements of 713.5.1 and shall be paved to conform with the requirements in AASHTO M 190, Type C.

713.6 - FIBER BONDED FULL BITUMINOUS COATED AND FULL PAVED CORRUGATED STEEL SEWER PIPE:

Fibre bonded full bituminous coated and full paved steel sewer pipe shall comply with the requirements of 713.5.1, where applicable, and in addition thereto, the rivets shall be placed on the outside crests of the corrugations and the inside of the pipe shall be paved so that a smooth surface will be formed filling the corrugations of the pipe with a minimum thickness of 3 mm over the crests of the corrugations. Smooth lined pipe over 750 mm in diameter shall be provided with lifting lugs for each section when manufactured.

713.7 NOT USED

713.8 - STRUCTURAL PLATE FOR PIPE, PIPE ARCH, AND ARCHES:

These conduits, and bolts and nuts for connecting plates, shall conform to the requirements of AASHTO M 167.

713.9 - FULL BITUMINOUS COATED STRUCTURAL PLATE PIPE, PIPE ARCH, AND ARCHES:

These conduits shall conform to the requirements of AASHTO M 167 and shall be coated with bituminous material conforming to the requirements of AASHTO M 190, Type A Coating.

713.10 NOT USED

713.11 - METALLIC COATED CORRUGATED STEEL UNDERDRAIN PIPE:

Metallic coated corrugated steel underdrain pipe shall conform with the requirements of AASHTO M 36 Type III.

713.12 - BITUMINOUS COATED CORRUGATED STEEL UNDERDRAIN PIPE:

This pipe shall conform to the requirements of AASHTO M 36, Type III, and shall be coated with bituminous material conforming to the requirements of AASHTO M 190, Type A coating, except that the minimum coating thickness, shall be 750 µm Coupling bands shall be fully coated. The specified minimum diameter of perforations shall apply after coating.

713.13 to 713.19 NOT USED

713.20 - END SECTIONS FOR CORRUGATED STEEL PIPE AND PIPE ARCHES:

End sections for corrugated iron or steel pipe and pipe arches shall be of the thickness recommended by the manufacturer, and they shall conform to the applicable requirements of AASHTO M 36 and the details shown on the Drawings.

713.21 to 713.24 NOT USED

SECTION 714

CONCRETE, CLAY, FIBRE AND PLASTIC PIPE

714.1 - NONREINFORCED CONCRETE PIPE:

This pipe shall conform to the requirements of AASHTO M 86 or ASTM C 14.

714.2 - REINFORCED CONCRETE CULVERT, STORM DRAIN AND SEWER PIPE:

This pipe shall conform to the requirements of AASHTO M 170 or ASTM C 76.

714.3 - REINFORCED CONCRETE ARCH CULVERT, STORM DRAIN AND SEWER PIPE:

This pipe shall conform to the requirements of AASHTO M 206 or ASTM C 506.

714.4 - REINFORCED CONCRETE ELLIPTICAL CULVERT, STORM DRAIN AND SEWER PIPE:

This pipe shall conform to the requirements of AASHTO M 207 or ASTM. C 507.

714.5 - PERFORATED CONCRETE PIPE:

This pipe shall conform to the requirements of AASHTO M 175 or ASTM C 444.

714.6 - POROUS CONCRETE PIPE:

This pipe shall conform to the requirements of AASHTO M 176.

714.7 - CONCRETE DRAIN TILE:

This pipe shall conform to the requirements of AASHTO M 178 or ASTM C 412.

714.8 T 714O CLAY DRAIN TILE:

Drain Tile shall conform to the requirements of ASTM C 4.

714.9 - VITRIFIED CLAY-LINED REINFORCED CONCRETE PIPE:

Designs for fully lined or half lined pipe of the specified strength classes shall be submitted for approval. The applicable requirements of AASHTO M 170 and AASHTO M 65 or ASTM C 479 shall govern. Liner or liner elements shall be clay of first quality, sound, thoroughly and perfectly burned, without warps, cracks, or other imperfections, and shall be fully and smoothly glazed.

714.10 - CLAY PIPE:

This pipe shall conform to the requirements of ASTM C 700. Extra strength clay pipe may be substituted for standard strength.

714.8 to 714.12 NOT USED

714.13 - PERFORATED ASBESTOS CEMENT PIPE FOR UNDERDRAINAGE:

The pipe shall conform to the requirements of ASTM C 508.

714.14 - BITUMINIZED FIBER PIPE FOR UNDERDRAINAGE:

This pipe shall conform to the requirements of ASTM D 1861 or ASTM D 1862.

714.15 - PERFORATED BITUMINIZED FIBER PIPE FOR UNDERDRAINAGE:

This pipe and fittings shall conform to the requirements of ASTM D 2311.

714.16 - FIBERGLASS-REINFORCED (FRP) PIPE:

This pipe shall conform to ASTM D 2996 or ASTM D 2997. Fittings shall be those recommended by the manufacturer.

714.17 - REINFORCED PLASTIC MORTAR (RPMP) PIPE:

This pipe shall conform to ASTM D 3262. Fittings shall be those recommended by the manufacturer.

714.18 - REINFORCED CONCRETE END SECTIONS:

Precast reinforced concrete end sections shall conform to the requirements of the cited Specifications for the conduit to the extent to which they apply and to the details shown on the Drawings.

714.19 - CORRUGATED POLYETHYLENE PIPE:

The pipe shall meet the requirements of AASHTO M 252 for nominal sizes of 75 to 250 mm and AASHTO M 294 for nominal sizes of 12 to 300 to 900 mm.

714.20 - PERFORATED PLASTIC SEMICIRCULAR PIPE:

Perforated plastic semicircular pipe shall be extruded or moulded using a high density, flexible plastic.

The pipe shall have a smooth or corrugated top and a smooth semicircular bottom, averaging 116 mm in diameter, with perforations uniformly distributed along the top of the semicircular section. The perforations shall be not less than 6 mm nor more than 10 mm in diameter, and shall provide a minimum intake area of 2100 sq. mm per m. Minimum material thickness shall be 3 mm. The top flange shall extend a minimum of 13 mm beyond the top of the semi-circular section.

714.21 - ACRYLONITRILE-BUTADIENE-STYRENE (ABS) PIPE:

This pipe and fittings shall conform to AASHTO M 264, ASTM D 2680 or ASTM D 2751.

714.22 - POLYVINYL CHLORIDE (PVC) PIPE:

This pipe and fittings shall conform to the requirements of AASHTO M278 or ASTM D 3034.

714.23 - PRECAST REINFORCED CONCRETE BOX CULVERTS:

Precast reinforced concrete box culverts shall conform to the requirements of AASHTO M259 where depth of cover is 600 mm or more and AASHTO M273 where depth of cover is less than 600 mm.

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 - NOT USED

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 AASHTO T106, T154, T 162.

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, channellizing devices, hazard warning lights, flares, and reflectors. Unless otherwise indicated such devices shall conform to the Manual on Traffic Control Devices, Part I - Traffic Signs and Road Markings (September 2000) prepared by the Sri Lanka National Road Safety Secretariat or, where not covered by that manual, the U.S. Standard, "Traffic Control for Street and Highway Construction and Maintenance Operations". The Contractor shall exhibit evidence that the warning devices furnished meet the requirements detailed.

715.9.2 - Signs:

Sign blank material shall be either 12 mm thick interior grade plywood, 2.5 mm thick aluminium, or 16 gage (1.6 mm) galvanized steel (thickness or gages shown here are nominal).

Reflectorization shall be required and shall compare favourably 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 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 minimum reflective intensity values at 0.2^0 and 0.5° divergence as shown in Table 715.9.2.1.1-I, expressed as candelas per lux per square metre of material.

TABLE 715.9.2.1.1-I

MINIMUM REFLECTIVE INTENSITY FOR TYPE I SHEETING

Diver-gence 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 10 deg. of, and centred about, a direction of 45 deg from the perpendicular to the test surface.

Viewing shall be within 15 deg. of, and centred 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 MUNSELL 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	.303	.287	.368	.353	.340	.380	.274	.316	27	--	5.OPB 7/1
White											
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

715.9.2.1.2 - Adhesive:

The reflective sheeting shall include a pre-coated 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 71°C (160°F) under a weight of 17 kPa.

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, tearing, or other damage. The sheeting shall permit cutting and color processing with compatible transparent and opaque process inks at temperatures of 15 to 30°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 0.79 mm.in 10 minutes, nor more than 3.18 mm in 24 hours in any dimension per 22.9 cm square at 20°C and 50 percent relative humidity.

Flexibility - The sheeting, applied according to the manufacturer's recommendations to a clean and etched 50.8 mm by 203 mm (2.0 inch by 8 inch) aluminium panel, conditioned a minimum of 48 hours and tested at 20°C and 50 percent relative humidity, shall be sufficiently flexible to show no cracking when bent around a 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 aluminium panel 76.2mm by 127mm (3 inch by 5 inch)

and conditioned for 24 hours at 20°C and 50 percent relative humidity, shall show no cracking when the face of the panel is subjected to an impact of a 0.9 kg weight with a 15.9mm rounded tip dropped from a 10 in.-lb. (1.13 Newton metre) 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 to 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 metres of material with a maximum of four splices per 50 metres. Length and splices shall be suitable for continuous application as supplied.

Rolls shall be packed snugly in corrugated fibreboard 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.

715.9.2.2 - Nonreflective Sheeting:

The material shall consist of a flexible, pigmented plastic film, completely pre-coated 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 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 76 µm and a maximum of 114 µm.

The material shall show not more than 400 µm shrinkage in any direction from the edge of the panel after being subjected to a temperature of 65°C for 48 hours. The material shall be heat resistant enough to retain adhesion after one week at 65°C.

715.9.2.2.2 - Adhesive:

When applied in accordance with the recommendations of the film manufacturer, the pre-coated 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:

Non reflective sheeting shall be supplied in colours; red, white, black, and yellow. The red and yellow colours shall be within the tolerance established 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 pre-coated 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 0.2^0 and 0.5° divergence as shown in Table 715.9.2.3.1-I, expressed as candelas per lux per square metre of material.

TABLE 715.9.2.3.1-I

MINIMUM REFLECTIVE INTENSITY VALUES FOR TYPE II AND IV SHEETING

Diver-gence Angle(E)	Incidence Angle(E)	Silver-White	Yellow	Red	Orange
0.2	-4	250	170	45	20
0.2	+30	150	100	25	11
0.5	-4	95	62	15	7.5
0.6	+30	65	45	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 10 deg of, and centred about, a direction of 45 deg from the perpendicular to the test surface.

Viewing shall be within 15 deg of, and centred 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 MUNSELL 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 pre-coated 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 71°C (160°F) under a weight of 17kPa.

TABLE 715.9.2.3.1-II

COLOR SPECIFICATIONS LIMITS AND REFERENCESTANDARDS FOR TYPE II & IV SHEETING

	Chromaticity Coordinates (Corner points)								Reflectance Limit y		Ref. Std. MUSELL PAPERS
	1		2		3		4				
	x	y	x	y	x	y	x	y	Mln	Max	
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	8.2R3.7 8 /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

715.9.2.3.3 - 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 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 0.79 mm in 10 minutes nor more than 3.18 mm in 24 hr in any dimension per 22.9 cm square at 22°C and 50 percent relative humidity.

Flexibility - The sheeting, with the liner removed and conditioned for 24 hours at 22°C and 50 percent relative humidity, shall be sufficiently flexible to show no cracking when slowly bent, in one second's time, around a 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 aluminium panel 76.2 mm by 127 mm and conditioned for 24 hours at 20°C and 50 percent relative humidity, shall show no cracking when the face of the panel is subjected to an impact of 0.9 kg weight with a 15.9 mm rounded tip dropped from a 10 in.-lb. (1.13 Newton-metre) 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 45 m length and splices shall be suitable for continuous application as supplied.

Rolls shall be packed in corrugated fibreboard 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, and 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 vapour. The lens shall consist

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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 moulded legibly into the face of the lens.

The specific brightness of each reflex reflector intended for use in cut-out 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 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 AASHTO T257-86, ASTM E 184, E 308.

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 retroflective system that will meet the requirements of this specification. The sheeting shall have a pre-coated 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 1.5 m under normal indoor lighting conditions. The watermark shall be spaced no more than 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°C observation angles as shown in Table 715.9.2.5.1-I expressed as average (candelas per lux per square metre) of material

TABLE 715.9.2.5.1-I

MINIMUM REFLECTIVE INTENSITY FOR TYPE III ENCLOSED LENS SHEETING

Observation Divergence Angle(E)	Entrance Incidence 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

	Chromaticity Coordinates								Reflectance Limit		Reference Standard
	1		2		3		4		y		
Colour	x	y	x	y	x	y	x	y	Min.	Max.	MUNESELL PAPERS
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 71°C under a weight of 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 22°C and conditioned for 24 hours at this temperature, shall form a durable bond that will remain effective in temperatures of –35° C to 38°C. Sheeting applied to clean, etched aluminium panels 150 mm x 150 mm and conditioned at 22°C for 48 hours, shall be subjected to 180° pullback at 300 mm per minute. Minimum pull strength shall be 78 grams per millimetre.

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 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 0.79 mm in 10 minutes or more than 3.18 mm in 24 hours in any dimension per 22.9 cm square at 22°C and 50 percent relative humidity.

Flexibility - The sheeting, applied according to the manufacturer's recommendations to a clean and etched 50.8 mm by 203 mm aluminium panel, conditioned a minimum of 48 hours and tested at 22°C and 50 percent relative humidity, shall be sufficiently flexible to show no cracking when bent around a 19.1 mm. mandrel.

Specular Gloss - The reflective sheeting shall have an 85 degree specular gloss of 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 aluminium panel 76.2 mm by 127 mm and conditioned for 24 hours at 22°C and 50 percent relative humidity shall show no cracking when the face of the panel is subjected to an impact of a 0.9 kg weight with a 15.9mm rounded tip dropped from a 10 in.-lb. (1.13 Newton-metre) 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 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 45 metres of material with a maximum of four splices per 45 metres length and splices shall be suitable for continuous application as supplied. Rolls shall be packed snugly in corrugated fibreboard 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 retro-reflective lens system having a smooth outer surface. The sheeting shall have a pre-coated 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°C and 0.5°C, divergence, as shown in Table 715.9.2.3.1-I, expressed as candelas per lux per square metre 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 centred about, a direction of 45 degrees from the perpendicular to the test surface. Viewing shall be within 15 degrees of and cantered 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 MUNSELL PAPERS designated in Table 715.9.2.3.1-II. The papers shall be recently calibrated on a spectrophotometer.

715.9.2.6.2 - Adhesive:

The reflective sheeting shall include a pre-coated 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 71°C under a weight of 17kPa.

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 0.79mm in 10 minutes nor more than 3.18 mm. In 24 hours in any dimensions per 22.9 cm. square at 22°C and 50 percent relative humidity.

Flexibility - The sheeting, with the liner removed and conditioned for 24 hours at 0°C and 50 percent relative humidity, shall be sufficiently flexible to show no cracking when slowly bent, in one second's time, around a 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 aluminium panel 76.2 mm by 127.0 mm and conditioned for 24 hours at 0°C and 50 percent relative humidity, shall show no cracking when the face of the panel is subjected to an impact of 0.9 kg. weight with a 15.9 mm rounded tip dropped from a 10 in.-lb. (1.13 Newton-metre) 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 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 45 m length and splices shall be suitable for continuous application as supplied.

Rolls shall be packed in corrugated fibreboard 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, and 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 retro-reflective sheeting is specifically designed for use on rigid substrate work zone signs to provide high visual impact under nightime 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 in Table 715.9.2.7.1-I, expressed as candelas per lux per square metre 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	2000
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-II. Daytime color and maximum spectral radiance factor (peak reflectance) of sheeting mounted on aluminium test panels shall be determined instrumentally in accordance with ASTM E 991. The values shall be determined on a Hunter Lab 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-II

Color Specification Limits ** (Daytime)

Colour	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 aluminium test panels shall be determined instrumentally in accordance with ASTM **E** 811 and calculated in the u', v' coordinate system in accordance the 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	
	u'	v'	u'	v'	u'	v'	u'	v'
Orange (New and weathered)	.416	.538	.414	.530	.414	.530	.466	.526

715.9.2.7.2 - Resistance to Accelerated Weathering:

The retro-reflective 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, 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 retro-reflection 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-II 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 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 retro-reflection shall be the average of all determinations.

715.9.2.7.3 - Impact Resistance:

The retro-reflective sheeting applied according to the sheeting manufacturer's recommendations to a test panel of alloy 6061-T6, 7.6cm by 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 0.9 kg weight with a 15.9 mm rounded tip dropped from a 10 in.-lb. (1.13 Newton-metre) setting on a variable impact tester at test temperatures of both 0^0C and 12^0C.

715.9.2.7.4 - Resistance to Heat:

The retro-reflective 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 77 +/- 3 degrees C) for 24 hours in an air circulating oven. After heat exposure the sheeting shall retain a minimum of 70% of the original coefficient of retro-reflection.

715.9.2.7.5 - Field Performance:

Retro-reflective 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 retro-reflective 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 retro-reflection 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 – Retro-reflective Sheeting for Traffic Control:

The retro-reflective 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 retro-reflective sheeting color and size shall be as specified on the Drawings.

715.9.2.8.1 – Adhesive:

General – The retro-reflective sheeting shall include a Class 1 adhesive backing.

Test Method – The test panels shall be according to AASHTO M 268. Retro-reflective 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 700 to 900 mm and a base of approximately 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 reflectorizsed.

Barricades shall be fabricated in accordance with details shown on the Drawings 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 450 mm regardless of orientation. The drum shall be 900 mm in height and orange in color.

The markings on the drum shall be horizontal, circumferential, orange and white reflectorizsed stripes 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 127 mm in height.

715.9.4 - Not used

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 220-volt, 50 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 American Society of Testing Materials.

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 -29 to 66°C) exclusive of power source.

715.9.5.2.2 - On-Time:.

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 175 mm in diameter, including a retro-reflector ring of approximately 13 mm width around a minimum of 30^0 of the periphery.

715.9.5.4.2 - Number of Lens:

Type A and Type C shall have either a bi-directional 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 tri-linear 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 swivelled through a minimum 90^0 arc in a horizontal. plane. When swivelling 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 pre-treated 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 weephole 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

715.10 - PREFABRICATED DRAINAGE SYSTEMS:

It is not envisaged that prefabricated drainage systems as described in Sub-Section 715.10 of the Technical Specifications will form part of the Works under the Contract.

715.10.1 - Prefabricated Pavement Edge Drain:

Addendum 6: Question 67A: Prefabricated Drainage System
The Spec at 715.10 describes a prefabricated drainage system for the pavement edge drain only. Please advise the Spec for the drainage system for embankments on soft foundations. The Spec advises that the height of the edge drain is shown on the drawings. Please advise which drawings. Do you intend this work being of standard materials, or is a specialist system envisaged.

Answer: It is not envisaged that prefabricated drainage systems as described in Sub-Section 715.10 of the Technical Specifications will form part of the Works under the Contract.

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 19 mm and a minimum compressive strength of 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 300 mm by 300 mm). The edge drain shall permit inflow on both sides of the drain and produce a minimum flow rate of 123 litres/minute/metre) 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 69 kPa using a closed-cell foam rubber layer on both sides. The height of the edge drain shall be as shown on the Drawings.

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 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 un-perforated 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:

'Geogrid' and 'Filter Cloth' shall comply with Sub-Section 715.11 of the Technical Specifications.

Geogrid for drainage wicks as shown in Detail B of Drawing TX0009 shall be measured under Item 212.009 of the Bills of Quantities.

Notwithstanding the 1 m Special Rock Fill thickness dimension shown in Detail B of Drawing TX0009, the actual thickness of the said layer shall be determined by the Engineer for each location at which drainage wicks shall be installed.

The bidders' attention is drawn to Item 217 of the Bills of Quantiities, under which Special Rock Fill for drainage wicks shall be measured

The bidders attention is drawn to Volume 4, Section VIII, Bill of Quantities and Dayworks, Part A: Preamble, Paragraph 9.

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 Engineer's approved list, the Contractor shall 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 Employer. 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 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 permittivity shall be a minimum of 0.2 sec^{-1} and the apparent opening size shall be no larger than No. 60 (25mm) 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 meeting 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. 11.10- Engineering Fabric for Surcharged Embankment

Tension reinforce membrane

The material to be used as a tension membrane in embankment shall be Basetex 600/50 manufactured by Tenser International or similar approved. The material shall be a high strength polyester with liner load bearing yarns. The fabric shall conform to the following material properties:

Characteristic strength –

Longitudinal :	600kN/m
Transverse:	50kN/m
Ultimate strain:	11%
Creep limited strength:	336kN/m
Max. creep strain	<1% after 10^4 hrs
Applied Load for 6% strain	294kN/m

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, Engineer II, Section 18.4.10.1.

A certified copy of test reports showing compliance with the above requirements shall be furnished to the Engineer.

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 3 mm unless modified by the Drawings.

The pads shall have a minimum tensile strength of 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.
Building Brick.....ASTM 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 Drawings.

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 Drawings.

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 min. 28-day compressive strength shall be considered to be the 20 Mpa min. 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 551.11.1 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, 9.5 mm nominal maximum 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 C88 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 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 25 mm.
iii. The maximum water content shall be 0.44 litres per kg of cement.
iv. The minimum cement factor shall be 446 kg per cubic metre 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 Drawings. Curing shall be in accordance with the applicable requirements in 551.

715.21 - NOT USED

715.22 - PRECAST CONCRETE MEDIAN BARRIERS (PERMANENT):

715.22.1 - Description:

Precast concrete median barriers shall conform to the shape and dimensions shown on the Drawings and shall meet the following requirements:

715.22.2 - Materials:

Materials shall meet the requirements specified in the following Sub-sections of these Specifications:

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
Water.....715.7

Sampling and testing of materials shall be in accordance with the minimum frequency stated in Table 2 of ASTM D3925.

715.22.3 - Proportioning:

Concrete shall be in proportion to meet the following requirements:

i. The minimum cement factor shall be 390 kg per cubic metre of concrete.

ii. The maximum water content shall be 0.44 litres 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 Drawings. Curing shall be in accordance with the applicable requirements of 551.

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 551.11.1-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 junction 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 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	(2 mm ± 100 µm)
Body Wire	(3 mm ±100 µm)
Selvedge Wire	(3.91 mm ±100 µm)

All the wire shall have a minimum tensile strength of 400 Mpa when tested in accordance with ASTM A370.

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

A section of mesh 1.83 m long, not less than 914 mm wide and including all selvedge binding shall have the ends securely clamped for 914 mm along the width. When the width of the sample under test exceeds 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 300 sq. mm located approximately in the centre 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 wire, or opening of any mesh fastening, a load of 26.7 kN. The ram head used in the test shall be circular with its edges bevelled 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 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 with 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	(3 mm ± 100 µm)
Tie Wire	(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 2.67 kN. All the wire shall have a minimum tensile strength of 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 Engineer's visual inspection of the material.

715.24.3 - Permanent Erosion Matting:

The matting shall consist of a machine produced mat of ultraviolet stabilized polumeric or other suitable fibres resistant to degradation and having a uniform weave distribution throughout. The mat shall conform to the following:

	ASTM	
Minimum Mat Thickness	D 1777	11mm
Maximum Elongation	D 4632	75%
Minimum Porosity (Calculated) *		90%
Resiliency **	D 1777	80%
Ultraviolet Stability	D 4355	80%

Type A Matting shall have the ability to prevent vegetation and soil loss at water velocities of 1.2 to 2.5 metre/sec as certified by the manufacturer.

Type B Matting shall have the ability to prevent vegetation and soil loss at water velocities of 2.5 to 4.5 metre/sec as certified by the manufacturer.

* Porosity calculation based upon unit weight, thickness and specific gravity

** Percentage of original thickness retained after three cycles of a 0.75 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 um) sieve and 100% through a No. 10 (2mm) 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. soluble potash. Fertilizer shall be furnished in standard containers with weight, name of plant nutrients and guaranteed percentages, clearly marked.

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% 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).

715. 27 MULCH MATERIAL

715.27.1 - Mulch Material for Seeding :

715.27.1.1 - Straw Mulch:

Straw mulch for seeding shall include grass cutting dried leaves. Straw mulch shall be dry and reasonably free from weeds, sticks, or other foreign material.

Acceptance shall be based on the Engineer'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 fibre. 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 fibres shall become uniformly suspended to form a homogeneous slurry. The

hydraulic sprayed slurry shall form a blotter like ground cover impregnated with grass seed. The ground cover shall permit the absorption of water and allow the rainfall or mechanically applied water to percolate to the underlying soil.

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

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

The mulch shall be delivered in packages not to exceed 45 kg.

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 fibre mulches.

715.27.2 - Materials for Landscape Plantings :

Acceptable materials for mulching shall be grass cutting, dried leaves, 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 Drawings.

715.27.3 - Seed

The varieties of grass and legume seeds to be furnished to the project shall bear a tag on each bag of species showing the lot number, the seed man's name, the percent of purity, the percent of germination and the weed seed content.

All seeds shall be free from noxious weed seeds and in no event shall the total weed content of any lot of seed or seed mixture exceed one-half percent (0.5%) by weight.

715.28 to 715.32 – NOT USED

715.33 - VINES AND GROUND COVER PLANTS :

This material shall have a healthy, well formed root system, free from disease. All plants shall be nursery grown, two years or older, and of the quality and size designated on the Drawings, and shall be subject to approval both at the nursery and on the planting site. For vines and ground cover plants, a listing by scientific names is available in Table 715.33.1

Table 715.33.1

List of Vines and Ground Cover Plant.

Ground Cover.

Scientific Name	Common Name
Desmodium	Maha Udupiyaliya
Desmodium heterophyllum	Heen Udupiyaliya
Centrella asitica	Heen Gotukola
Clitoria ternatea	Kata rolu
Cardiosterrrum halicacabum	Penal Wel
Cryptolepis buchanani	Wel Rukathana
Allocasia macrorhiza	Habarala
C\Vernonia cinerea	Monara Kudumbiya
Eclipita prostratac	Kee Kirindi
Cratara religiosa	Lunu varana
Evolylus alsinoides	Vishnukranthi
Hemidesnus	Eramusu
Dregea volubilis	Kiri Aguna
Arundina gramintfolia	Bamboo Orchid
Lycophodium cerneum	Badalwanasa
Ageratum conyzoides	Hulantala
Amorphophallus companulatum	Kidaran

List of Vines

Scientific Name	Common Name
Ipomea biloba	Mudubimtamburu
Ipomea aquatica	Kankun
Cuscuta reflexa	Agamullanathiwela
Cucumis callosus	Gonikakiri
Cocuinea grandis	Kowakka
Aristolocia indica	Sapsada
	Niyagala
Argyneia populifolia	Girithilla
Exacum tramerra	Bindara

715.34 - SEEDLING PLANTS:

This material shall have a healthy, well formed root system, free from disease.

All plants shall be nursery grown, two years or older, and of the quality and size designated on the Drawings, and shall be subject to approval both at the nursery and on the planting site.

For seedling plants, a listing of scientific names are available in Table 715.35.1.

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.

Collected plants shall be indigenous or endemic trees or shrubs growing in soils favourable 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. In the case of collected plants, ball sizes shall be at least 10% 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 trees, and shrubs, a listing by scientific names is available in Table 715.35.1.

Table 715.35.1

List of Trees and Shrubs (depending on availability coincides with list of seedling plants.)

Flora shall be when ever possible indigenous or endemic.

List of Trees

Scientific Name	Common Name
Mesua ferrea (Ceylon iron wood)	Na
Cassia fistula Indian laburnum	Ehela
Filicium decipiens	Pihimbiya
Mallotus tetracoccus	Bukenda
Peltophorum pterocapus	Yellow flams
Shorea	Beraliya
Shzygium gardeneri	Dambe
Dillinia triquetri	Diyapara
Laxacoccus rupicola	Dotalu
Macaranga peltata	Kenda
Schumacheria castaneifolia	Kekiriwara
Callophyllum inophyllum Alexandarian Laurel	Domba
Callophyllum tomentos	Keena

List of Shrubs :

Scientific Name	Common Name
Murraya Paniwlato	Atteria
Bauhinia	Koboneela
Micromelone minutum	Val Karapincha
Cassia alata	Attora
Cassia oxydentalis	Pani thora
Bauhinia tormcutosa	Kaha penath
Calotropis gigantean	Wara
Symplocus cochinnesis	Bambu
Pandanus amaryllifolieus	Rampe
Syzygium caryobhyllantum	Dhan
Phyllianthus myrtifolious	Gaga varalla
Tithonia diversifolio	Wild hibiscus
Hibiscus furcatus	Napiritta
Nepenthes distillatoria	Badura wel
Pandanus zeylanicus	
Melastoma malabathrica	Mabovitiya
Osbeckia octandra	Heenbovitiya
Osbeckia aspera	
Osbeckia buxifolia	
Clerodendran fraqrans	
Clerodeudron iufortunatum	pinna
Strachytarphela indica	balunaguta
Mussaendro frondosa	

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.

715.36 – ASPHALTUM BASE PAINT FOR TREE SURGERY

Paint for tree wounds shall be antiseptic and water proof, 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 tress.

715.37 - MISCELLANEOUS ITEMS FOR LANDSCAPE PLANTING :

715.37.1 - Tree Stakes :

Stakes used for guying or supporting newly planted trees shall be made from rough sawed timber, or other approved material, free from unsound or loose knots that impair its strength. The stakes shall be 50 mm by 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 (m)	**Stake Length (m)**
1 to 2	1.5
2 to 3	2.0
3 to 5	2.5

Larger sizes shall be guyed or supported by stakes.

715.37 - WIRE

The wire used for guying and staking plants shall be galvanized steel wire, free from bends and kinks. Trees less than 75 mm in diameter shall be guyed with No. 14 gage (1.9mm) wire, and trees 75mm 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 10 to 16 mm nominal I.D. rubber garden hose or equal. The walls of the hose shall be sufficient thickness to prevent wire damage to the plants.

715.37.4 - Twine :

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

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

715.38.1 - General:

Steps shall consist of a steel reinforcing bar encased in plastic or rubber, pressure-moulded to the steel. Steps shall have a minimum cross-sectional dimension of 25 mm. Reinforcing shall be continuous through the entire length of the legs and tread. Steps shall have a depressed tread or a 12 mm minimum height cleat at tread ends, and a top surface configuration such that it will prevent or minimize slippage during ascent or decent.

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 Engineer and appear on the Engineer'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 non-critical applications as gaskets, sealing materials, miscellaneous drainage items, etc.

The elastomeric material shall meet the following requirements:

Tensile Strength, minimum (MPa), ASTM D 412	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 these Specifications (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 - Not used

715.40.2 - Preformed Traffic Markings:

The markings described are. preformed, retro-reflective pavement markings conforming in color, size and shape to the U.S. Department of Transportation, Engineer 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 milli-candelas 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 milli-candelas 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 Employer. Upon completion of the Contract, the warranty shall be transferred to the Employer.

The material must perform successfully in the Engineer's field evaluation test.

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 276 kPa when tested according to ASTM D 638.

ii. Elongation: A sample 250 to 300 mm shall have a minimum elongation of 75 percent when tested according to ASTM D 638 using a jaw speed of 250 to 300 mm per min.

iii. Skid Resistance: The surface of the retro-reflective 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 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 milli-candelas per square metre per lux. The test distance shall be 15 m and the sample size shall be rectangle (0.61 x 0.76 m).

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

	White		Yellow	
Observation Angle	0.2 degrees	0.5 degrees	0.2 degrees	0.5 degrees
SL (mcd.ft -2 .fc -1)	550	380	410	250

* The quantity SL treats the retro-reflector 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 retro-reflective 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 – NOT USED

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 prismatic retro-reflector for reflecting light from a single or opposite direction. 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 moulded 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 un-tempered glass shall be bonded to the front surface of the prismatic retro-reflective lens faces to provide an extremely hard and durable abrasion resistant surface. color shall be as specified on the Drawings.

Using a steel wool abrasion procedure, the specific intensity of each 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 un-tempered 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 purpose of identification. Color shall be as specified on the Drawings.

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 Drawings.

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 (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 (27.6 MPa).

The color of the marker shall be uniform over the entire top surface and shall be as specified on the Drawings. The marker shall be R for reflective or NR for non-reflective as specified on the Drawings. The marker shall be nonreflective unless otherwise specified. The reflective marker shall be reflective in both directions unless specified as mono-directional 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 100 mm square and 19 mm in height when measured at the centroid. Color shall be as specified on the Drawings.

The prismatic reflective lenses shall have a minimum reflective surface of 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 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 4536 kg.

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 - NOT USED

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 Contractor shall submit to the Engineer 8 (eight) copies of the manufacturer's design (installation) drawings for the specific device. This drawing will be reviewed and, if approved, it will be stamped and one copy returned to the Contractor. Multiple devices of the same design for the same project or purchase order will require one set of drawings, not one set for each

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device. In addition, one design and one installation manual shall be shipped with each safety device.

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 0.056, 0.112, 0.196, 0.393 or 0.588 cubic metres.

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 centre 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 815 to 1,900 kg vehicles at speeds up to 100 km/hr which impacts the side of the unit at angles up to 15 degrees for the 815 kg vehicle and 25 degrees for the 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, tail-lights, turn signals and ICC bar lights. The back of the unit shall have a device attached with alternative diagonal black and reflectorizsed yellow stripes, 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 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.

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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 centre 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 815 to 1,900 kg vehicles which impact the side of the system at speeds up to 100 km/hr at angles up to 20 degrees for both right way and wrong way impacts (angles measured from systems longitudinal centreline). The unit shall be constructed so that there is no solid debris 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 Engineer.

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 Engineer 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:.

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..

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 220 volts, 50 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 –34° C and plus 50°C. Maximum inside cabinet temperature for above operation is plus 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.

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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 cam switch 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 unitised design and readily interchangeable.

All mechanisms, motors, operating coils, bearings, contacts, relays, flashers and similar components shall be sufficiently large, rugged and accessible to ensure 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 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 pre-emption.

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 220 volts, 50 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 30 amperes of tungsten lamp at 220 volts, 50 Hz AC, one half

million times without breaking physically or failing 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 pre-empt 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 1.2 metres long or of the standard length specified by the manufacturer for that controller type. The harness shall have color-coded leads of labelled sleeves or labelled 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 there from.

Seven circuits in this connector shall be capable of handling No. 12 AWG 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 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 un-fused for neutral side of power supply.

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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..

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 over-current 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 Drawings.

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.

715.42.1.2.7 - Manual Operation:

All controllers shall be designed capable of manual signal sequencing. When manual operation is specified on the Drawings it shall be accomplished with the addition of standard components.

715.42.1.2.8 - Pedestrian Actuation:

When called for on the Drawings, 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 auto-manual 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 Engineer any guarantee or warranties which are give by the manufacturer as a normal policy. The Contractor or supplier shall furnish the Engineer with three 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 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 Engineer, at no cost, engineering data, diagrams, etc. on any later changes or improvements which would increase the performance of the equipment purchased.

The Engineer 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- 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.

Actuation: 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..

Interval: Any one of the several components 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 signalisation 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.

Non-locking 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 component 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 signalisation 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.

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

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 1.2 metres 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.

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 170 to 250 volts AC. The nominal voltage shall be 220 volts AC. The controller and all associated equipment shall be designed to operate from a 220 volt, 50 Hz, AC supply (plus or minus 3.0 Hz).

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.

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 start-up 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. 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 parts 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 initialisation 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:

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 is 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

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. 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 all be resumed automatically after Manual, Flashing Pre-emption 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 pre-emption 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 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 labelled sleeves. The harness connections shall be mounted on the front of the controller unit in accordance with the following:

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

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

Connector C shall inter-mate 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 labelled.

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 arrestor 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

The Engineer 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 de-rated 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.

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 Engineer any guarantee or warranties which are given by the manufacturer as a normal policy. The Contractor or supplier shall furnish the Engineer 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.

715.42.2.3 through 715.42.2.4 - Not used

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.

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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.

715.42.3 - Not Used

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:.

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.

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 an 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 pre-empt 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.

715.42.4.2 - Not Used

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 220 VAC, 50 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 250 VAC and down to 170 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 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 de-rated 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.

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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 220 volt (plus or minus 10 percent), 50 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 aluminium 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 multi terminal, quick disconnect, plug-type connector and wiring harness. Each wiring harness shall be at least 900 mm long. The harness end opposite the connector shall have color-coded leads or labelled 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 there from.

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 Engineer 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.

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 15 m in length with up to 300 m of lead-in wire. The detector shall be capable of detecting vehicles travelling at any speed between 0 and 160 km/hr.

Individual sensor-detector assemblies shall operate satisfactorily under conditions where adjacent sensors are located within 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 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 labelled 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 220 volt AC line
2	Neutral side of 220 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 loop wire and detector feeder cable shall be as specified in 715.42.13. Loop layout and configuration shall be specified in the Drawings, 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 necessity supporting parts to be used for providing a single signal indication.

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

715.42.6.2 - Traffic Control Signal Heads:

Each signal shall be of the adjustable, coloured light, vertical type with the number and type of sections described and shown on the Drawings. 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 assemble any combination of 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 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 back plates 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 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 197 to 203 mm for a nominal 203 mm lens and 292 to 305 mm for a nominal 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 175 mm long for an 203 mm lens and at least 241 mm long for a 305 mm lens. Visors shall be described as cutaway, tunnel, or full circle. All heads shall be supplied with tunnel visors, unless otherwise noted on the Drawings or unless prior permission from the Engineer 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 Drawings.

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 Signal Sections, all brackets, trunnions 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 enamelled sections. The inside of non-metallic visors must also be painted with a permanent flat black enamel or use other means to prevent reflections.

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

The lamp holder 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 centre 60 mm in length for the 60-watt and 100-watt series and 75 mm in length for the 150-watt series. The lamp holder 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 holder 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 centre of the reflector shall occur. The metal portion of the lamp holder shall be compatible with brass or copper.

Each lamp holder shall be provided with two coded No. 18 or larger lead wires, type TEW, 600-watt, AWM fixture with 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 at minus -34° C be capable of being bent six times around a 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 aluminium 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 lamp holder 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/lamp holder 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 lamp holder 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."

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Trunnions, Brackets and Suspensions:

All trunnions, brackets and suspensions used for assembling and mounting vehicle traffic control signal 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 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 aluminium 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 Engineer 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 aluminium, steel and galvanized steel.

Backplates:

All signal head assemblies so indicated on the Drawings 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 withstand distortion in 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 125 mm border. Pedestal mounted signals shall have backplates with an 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 aluminium and aluminium 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 aluminium alloy die-castings. Visors and reflectors shall be made from sheet aluminium or die castings.

All cast metal parts shall have a tensile strength of not less than 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 aluminium parts shall be manufactured from corrosion-resistant aluminium sheet having a tensile strength of at least 138 MPa, except that reflectors shall be manufactured from the aluminium 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 1.31 mm thick. Reflectors shall be spun or drawn from aluminium not less than 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, aluminium 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 aluminium 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 450 gram weight with a spherical tip 50 mm in diameter shall be impacted into the centre section on any surface including the door with an impact of. 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 –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 fibres, 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 aluminium sheet with a tensile strength of 138 MPa and a thickness of 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 centre length (LCL) is the dimension, in mm, from the centre 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 203 or 305 mm traffic signal indications shall have a lamp rating of between 110 and 120 watts, a light centre length (LCL) of 60 mm, with a minimum initial lumen value of 1,260 and a rated life of at least 6,000 hours.

ii. All 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 centre length (LCL) of 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 l 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 coloured 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 edition.

The luminous transmission for traffic signal lenses and the limits of chromaticity for traffic signal colours 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 0.519x nor less than 0.150 plus 1.068x 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 203 mm lens shall have an outside diameter of from 211 to 213 mm. The nominal 305 mm lens shall have an outside diameter of from 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 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.

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All cast metal parts shall have tensile strength of not less than 117 Mpa. Sheet metal shall have a tensile strength of 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 aluminium 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 unitised 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 weather tight 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 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 aluminium 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 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.

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The housing door shall be finished with the best quality, oven-baked black enamel..

The housing, when properly mounted using DN40 pipe brackets, shall be able to withstand a concentrated load of 23 kg placed 150 mm from the centreline 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 weather tight 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 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 No. 18 US gage in thickness. The outside of the visor shall be of the same black 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 coloured 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 305 mm lens shall have minimum overall dimensions of 305 by 305 mm with a visible area of 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 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 aluminium and be designed for a 10 year service life.

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

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 aluminium, the thickness of the anodic coating shall be a minimum of 2.5 µm or its equivalent, spun or drawn from metal not less than 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.

The reflecting surface shall be 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 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 centre length (LCL), or the dimension, in mm, from the centre 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 305 mm pedestrian signal heads shall have a light centre length of 75 mm.

Pedestrian signal lamps shall conform to the following standards:

TWELVE-INCH PEDESTRIAN SIGNAL

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

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 centre 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 there shall be a secure fastening for the retention of the lamp in that position, but shall

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not permit any change in position of the socket with respect to the optical centre 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 0.8 mm, 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 -35° C be capable of being bent six times around a 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. 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 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 centreline through couplers and conduit. Each section shall be equipped with a sun visor.

All die-cast aluminium 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 black enamel and shall comply with Federal Specifications TT-E-489.

The signal head housing shall consist of an assembly of separate interchangeable sections, expansible 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 DN40 pipe brackets.

The optical system shall consist of a lamp, a circlet reflector, an optical limiter-diffuser combination and an objective lens. The lamp shall be nominal 150 watt, 220 volt AC, three prong, sealed beam having an integral reflector and an average rated life of 6,000 hours. A circlet 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 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 colours 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 lamp holder shall be accomplished with an interlock assembly which disconnects the lamp holder when open. Coded No. 16 lead wires shall be used of a length sufficient too 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 weather tight.

All tubular parts shall be 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 aluminium 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.

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715.42.6.7 - Lane Control Signal Heads (Single Lamp):

General Design Requirements:

Each signal head shall be of the adjustable, coloured-light type with the number and type of sections described and as shown on the Drawings. 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 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 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 0.077 sq. m for a nominal 305 mm lens and 0.185 sq. m for a nominal 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 0.077 sq. m for a nominal 305 mm lens and 0.185 sq. m for a nominal 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 254 mm long for a 305 mm lens and at least 305 mm long for an 455 mm lens. Heads shall be supplied with standard visors, unless otherwise noted on the

Drawings. All new signal heads at any one intersection shall have the same type visors supplied, unless otherwise specified on the Drawings.

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 black enamel. The door and the outside of the visor shall be finished with 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, lamp holder, 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 lamp holder 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 centre 75 mm in length for the 116-watt series and 150 mm in length for the 200-watt series. The lamp holder 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 holder 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 centre of the reflector shall occur. The metal portion of the lamp holder shall be compatible with brass or copper.

Each lamp holder shall be provided with two coded No. 18 AWG or larger lead wire, Type TEW 600-watt fixture wire 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 –34°C capable of being bent six times around a 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 aluminium 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 lamp holder 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 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/lamp holder interfaces shall be equipped with specially designed neoprene seals to completely seal the optical unit. The section must not accumulate water.

iii. If the reflector and lamp holder remain in the section when the door is open, 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 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 weather tight 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 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 aluminium 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 Engineer may be supplied. Such parts must be capable of mounting both metallic and non-metallic signal heads and must be compatible with aluminium, steel and galvanized steel.

Metallic Lane Control Signal Heads:

Each head of this type shall be constructed primarily of aluminium and aluminium 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 aluminium alloy die-castings. Visors and deflectors shall be made from sheet aluminium or die-castings.

All cast metal parts shall have a tensile strength of not less than 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 aluminium parts shall be manufactured from corrosion-resistant aluminium sheet having a tensile strength of at least 138 MPa, except that reflectors shall be manufactured from the aluminium 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 1.3 mm thick. Reflectors shall be spun or drawn from aluminium not less than 0.064 mm thick.

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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 centre length (LCL) is the dimension in mm from the centre 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	75 mm	6,000 hours	1,260
18	200	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 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 coloured 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 colours 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 0.519X nor less than 0.150 plus 1.068X 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 grey 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 220 volts, 50Hz, 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 220 volts standard service.

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 Engineer any guarantees or warranties which are given by a manufacturer.

The Engineer 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 Drawings.

The signal flasher unit shall be a motor-driven switching device for flashing beacons or traffic signal indications at signalised 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 8 amperes, 220 VAC, 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 220 VAC, 50 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 pre-timed and traffic-actuated signal controllers.

The clock motors shall be designed for synchronous operation on 220 volts, 50 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 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 - Pre-emption:

Pre-emption equipment shall be constructed and wired so as to transfer control of the signals from the controller to the pre-emption unit when actuated by the method specified and shall provide the color sequence specified. The pre-emption shall cause a clearance interval to be timed prior to the pre-emption 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 pre-emption clearance interval and shall be turned off during the pre-emption sequence, unless otherwise specified.

Installation of the pre-emption equipment shall not alter the internal wiring of the controller unit normally furnished by the manufacturer.

After release of the pre-emption, normal controller operation shall be automatically resumed at the beginning of the "green" interval specified on the Drawings 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 pre-emption 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 in pre-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 220 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 base mount NEMA type 5 ("P") cabinet or a pole mountable NEMA type 4 ("M") cabinet as called for on Drawings. The cabinet shall be UL

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listed and have a UL approval label installed on the inside of the main cabinet door. The cabinet shall also have labelling 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 centres 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 3 mm thick 5052-H32 aluminium with the following minimum exterior dimensions: (Unless otherwise shown on the Drawings)

	Base Mount	Pole Mount
Height	1370 mm	1245 mm
Width	1115 mm	760 mm
Depth	660 mm	30 mm

No cabinet shall exceed any of these dimensions by more than 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) aluminium. 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 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 centre of the door that secures the centre of the door. The strike plate shall operate two plated steel or stainless steel latch rods. The end of each rod shall be fitted with a minimum 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 25 mm by 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

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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 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 150 mm of the top of the cabinet to 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 265 mm mounted toward the rear of the cabinet shall be supplied with each cabinet. Shelves shall be aluminium and shall have sufficient strength to support the controller unit and accessory equipment. Shelves longer than 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 45 litres/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 27 to 55 degrees C.

A filtered, weatherproof opening shall be provided on the main door near the bottom, a filter 305 mm X 405 mm X 25 mm shall fit smoothly and conveniently over this opening. The filter shall be the aluminium 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 aluminium 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 aluminium 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 high 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 Drawings);
- 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 13 mm diameter hole and shall have a minimum 10 mm actuator;
- 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 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 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 aluminium, 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, pre-emption, 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 3 mm thick aluminium. 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. "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 150 mm from the floor of the base mount cabinet and no less than 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, pre-emption 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 six exceeds #18 AWG, 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 back panel 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:.

220 VAC	Black
220 VAC Neutral	White
Chassis Ground	Green
Logic Ground	Grey
+24 VDC	Red

+ 92

These colours 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 220 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 clear lexan safety cover to prevent accidental contact with the power panel components. The safety cover shall have a cut-out 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 load-switches (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 state 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 pre-emption cards. The main power lightning arrester shall be an EDCO Model SHP 300-10. No substitutes shall be allowed without prior acceptance.

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715.42.8.10 - Backpanel:

Each cabinet assembly shall be furnished with a backpanel located on the lower centre rear of the cabinet. The backpanel shall mount the load-switches, flasher, flash transfer relays and controller unit input/output terminals. A base mounted cabinet shall have a 16 position backpanel (capable of terminating 16 load-switches). A further 6 flash transfer relay bases shall be provided with terminals for flash color programming for load-switches 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 (cable of terminating 12 load-switches) 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. Phase load-switches 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, load-switch input and output groups shall be color-coded orange for red, yellow for yellow and blue for green. Load-switch 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, emergency vehicle pre-emption detectors, system communication conductors and railroad pre-emption 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 pre-emption 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 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.

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The MS D Interface Panel shall be provided with a 220 VAC relay to provide electrical isolation for a railroad pre-emption circuit. This relay shall be wired with one side of the coil connected to a continuous, 1 amp fused source of 220 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 pre-empt 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 (pre-empt 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 220 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 of 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	Pre-empt 1 Out
4	Reserved		
5	Reserved	34	Pre-empt 2 Out
6	Offset 1 Out	35	Pre-empt 3 Out
7	Offset 2 Out	36	Pre-empt 4 Out
8	Offset 3 Out	37	Railroad Pre-empt 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/Co-ord In	46	Split 3 In
18	Free/Co-ord Out	47	Split 2 Out
19	Pre-empt 1 In	48	Out
20	Pre-empt 2 In	49	Conflict Status
21	Pre-empt 3 In	50	Local Special Function 1 Out

22	Pre-empt 4 In	51	Special Function 2 Out
23	Railroad Pre-empt 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	220 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 aluminium 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 special sheet labelled 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 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:

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 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 Drawings), 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 Drawings. 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 Drawings.

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 25 mm in diameter for each 11.7 mm per m. The shaft length and diameter of the upright pole and mast arm shall be as shown on the Drawings.

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 Drawings, 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 flange bolts 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 Drawings).

Mast arms shall be connected to the upright pole at a height necessary to provide 5.25 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 Drawings. 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. requirement due to sizes or loads listed on the Drawings shall be brought to the Engineer'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 de-burred 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 aluminium pole top or aluminium 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 6.35 to 38.1 mm sizes and shall be heavy hex for sizes 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 Specifications. The places to be painted shall be thoroughly cleaned before the paint is applied.

All nuts, bolts or screws used to connect any aluminium 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 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 16 mm diameter and over, any ASTM physical and chemical qualification that is acceptable to the Engineer 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 weel before the Contractor intends to commence installation. These drawings will be reviewed by the Engineer 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 Engineer will not be considered as being just cause for delay in the completion of the 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 properly qualified operators.

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.

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 Drawings. 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 upright shaft shall be made in one continuous piece, cylindrical in cross section and shall be uniformly tapered from butt to tip approximately 25 mm in diameter for each 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 Drawings. The signal clearance will be set for a minimum of 5.25 m. The span wire will be fastened from 305 mm to 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 Drawings.

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 aluminium pole cover or aluminium 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 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 6.35 to 38.1 mm sizes and shall be heavy hex for sizes over 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 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 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 handhold cover which shall be stainless steel.

ii. For 16 mm diameter and over, any ASTM physical and chemical qualification that is acceptable to the Engineer 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 well before he intends to undertake the installation. These drawings will be reviewed by the Engineer 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 Engineer will not be considered as being just cause for delay in the completion of the 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 aluminium 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 Drawings. The signal clearance will be set for minimum of 5.25 metres). The poles shall be of sufficient length to provide the luminaire mounting height when described on the Drawings.

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 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 aluminium 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 3.18 mm wall thickness and 152 mm) diameter at the base tapering to 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 aluminium 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. 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 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 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 well before he intends to undertake the installation. These drawings will be reviewed by the Engineer 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 Engineer will not be considered as being just cause for delay in the completion of the 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 100 mm (4 inch). 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 well before he intends to undertake the installation. These drawings will be reviewed by the Engineer 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 Engineer will not be considered as being just cause for delay in the completion of the 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 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 well before he intends to undertake the installation. These drawings will be reviewed by the Engineer 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 Engineer will not be considered as being just cause for delay in the completion of the 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 Drawings, all conduits shall be 50 mm in diameter.

The Drawings will call for type of conduit to be used.

Approximate lengths of conduit are shown on the Drawings. 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.

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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 Drawings.

Junction boxes are shown on the Drawings 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 255 mm x 255 mm size or TEL-43 for the 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 75 mm of the exterior shall be formed to provide the size and shape shown on the standard drawing.

The Type H 255 x 255 mm junction box cover and frame shall have a minimum weight of 40 kg. Type H 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. by 100 x 100 x 100 mm.

The junction box and lid shall be of copper-free aluminium 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 6.35 mm.

The lid shall have a chequered 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 Drawings. 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 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 signalisation Drawing and shall be fabricated on seven steel wires, double galvanized and twisted into a single concentric strand to conform to the following:

DIAMETER mm	SIZE OF WIRE NO.	TENSILE STRENGTH kg
12.7	8	5490
11.1	9.5	4240
9.5	11	3150
7.9	12	2425
6.4	14	1430
4.7	16	860

The Contractor shall, when requested by the Engineer, 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 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 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.

Power service conductors to the breakers (fuses) 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 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. I4 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 6.5 turns per metre (two turns per foot).

All other multi-conductor detector writing, 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. I9-1 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 aluminium and aluminium 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 aluminium alloy die-casting complete with integrally cast top, bottom, and sides. All cast metal parts shall have a tensile strength of not less than 117 Mpa. All parts shall be clean, smooth and free from flaws, cracks, blowholes and other imperfections.

The die-cast aluminium 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.

The top and bottom of the signal housing shall have round openings to accommodate standard 38 mm (1½ inch) 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 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 197 to 203 mm for a nominal 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 aluminium alloy die-castings. Visors and reflections shall be made from sheet aluminium or die-castings.

Sheet aluminium parts shall be manufactured from corrosion-resistant aluminium sheet having a tensile strength of at least 138 MPa except that reflectors shall be manufactured from the aluminium 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 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 Drawings or unless prior permission from the Engineer 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 1.3 mm thick.

All mounting brackets, trunnions, and suspensions shall be finished with black enamel. The door and the outside of the visor shall also be finished with black 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, lamp holder, 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 lamp holder 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 centre 60 mm in length for the 60-watt series.

The lamp holder 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 holder 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 centre of the reflector shall occur. The metal portion of the lamp holder shall be compatible with brass or copper.

Each lamp holder shall be provided with two code No. 18 or larger lead wires, Type TEW, 600-watt, AWM fixture wire with 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 -34° C be capable of being bent six times around a 25 mm mandrel without damage to its insulating properties at rated voltage.

Reflectors shall be specular aluminium 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 lamp holder 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 aluminium not less than 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/lamp holder 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 lamp holder 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 50 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 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 weather tight.

All tubular parts shall be IPS (DN40) pipe.

The lower support or connection between signal heads in a span wire or mast arm mounted signal may be an aluminium 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 Engineer 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 aluminium, steel and galvanized steel.

715.42.14.2 - Flashing Mechanism:

The signal head shall flash at a rate of not less than 50 nor 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, 220 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.

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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 220 volts, 50 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 Drawings.

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 1.8 mm not more than 3.6 m from the edge of the travelled way or a minimum of 0.6 m and a maximum of 1.8 mm outside an un-mountable curb.

715.42.14.5.2 - Pedestal Mounted: Use the same criteria as for 715.42.14.5.1 - Post Mounted.

715.42.14.6 – Not Used

715.42.14.7 - Construction Methods:

The materials furnished and used shall be new, except as may be specified on the Drawings. All workmanship for electric work shall be in accordance with the details shown on the Drawings, 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.

715.43 - BENTONITE:

Bentonite shall meet the requirements of Section 3 of American Petroleum Institute Standard 13A and Supplements..

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SECTION 716

EMBANKMENT AND SUBGRADE MATERIAL

716.1 - GENERAL:

Material for embankment shall be suitable soil, granular material, weathered rock, hard rock, unclassified, or borrow material. The material shall have dimension limitations in accordance with the Contract documents.

The following material shall be considered unsuitable for embankment construction:-

1. Peat, organic clay and soft clays and material from swamps, marshes and bogs.

Soil or other suitable material having LL exceeding 55 and PI exceeding 25.

Material for subgrade shall be granular material free of particles larger than 75 mm.

716.1.1 - Unclassified Material:

Unclassified material shall be considered as a mixture of any or all of soil, granular material, or weathered rock as described which are permitted by the Engineer to be used in embankment. These are materials that can be incorporated in a 150 mm compacted layer.

716.1.1.1 - Soil:

Soil material shall be considered as layers or deposits of disintegrated rock, lying on or near the surface of the earth; which has resulted from natural processes, such as weathering, decay or chemical action or a combination of these processes. Material shall be considered as soil when more than 25 percent by weight of the grains or particles pass the No. 200 (75 µm) sieve.

716.1.1.2 - Granular Material:

Granular material shall be considered as natural mineral aggregate, such as broken or crushed rock, gravel or sand. Granular material shall have not more than 25 percent by weight of grains or particles passing the No. 200 (75 µm) sieve and the plasticity index shall not be more than 6. This material must be capable of being compacted to a stable condition.

716.1.1.3 – Weathered Rock:

Weathered rock shall be considered as a detrital material formed by weathering action on the indigenous rock. Material which does not break down under three complete coverages with a steel drum roller, meeting the following requirements but also does not conform with the definition for Hard Rock shall be classified as Weathered Rock.

The steel drum rollers shall provide a minimum compression of 80 KN/mm of roller drum and drum rollers with tamping feet shall provide a minimum compression of 80 KN/mm of tamping foot contact. The Contractor shall provide the roller or rollers and any other necessary equipment for this test without additional compensation.

716.1.2 – Hard Rock:

Rock is defined as in-situ material which, in the opinion of the Engineer, cannot be extracted by ripping with a tractor of at least 150 brake horsepower, with a single rear mounted heavy duty ripper. Such material will need to be removed by one or a combination of the following methods, blasting, the use of metal wedges and sledge hammers, the use of metal wedges or by blasting.

716.1.3 – Not Used

716.1.4 - Borrow Material:

The embankment material shall be free of organic matter.

716.1.5.Top Soil:

Topsoil shall consist of the uppermost layers of fertile and friable soil that contains humus material. This material varies in thickness in accordance with soil groups and usually possesses a darker color than the subsoil. The texture of the topsoil may vary within the range of natural loam, silty clay loam, and sandy loam. Acceptable topsoil shall contain organic matter in the range of 1.5 percent of 20 percent.

716.2 - TEST METHODS

Plastic Limit	AASHTO T 90 or ASTM D 4318
Grain Size Analysis	AASHTO T 88 or ASTM D 422
Sieve analysis of fine and coarse aggregate	AASHTO T 27
Amount of material finer than 200 sieve (0.075 mm) in aggregate	AASHTO T 11
Specific Gravity of Soils	AASHTO T 100 or ASTM D854
Specific Gravity and Absorption of Coarse Aggregate	AASHTO T 85 or ASTM C 127
Organic Content	AASHTO T 267
Moisture and density of soil and material having less than 40 percent of particles by weight retained on the 19 mm sieve	AASHTO T 99 method c
Moisture and density of material having 40 percent or more of the particles by weight retained on the 19 mm sieve and that are relatively uniform in gradation and can be incorporated in a 300 mm lift or less, and granular subgrade	AASHTO-T-310 (See AASHTO T 180)
Liquid Limit	AASHTO T 89 or ASTM D 4318

716.3 - MOISTURE AND DENSITY REQUIREMENTS:

716.3.1 - Embankment Moisture:

Embankment soil and material having less than 40 percent by weight of particles retained on the 19 mm sieve shall be moistened or dried to a tolerance of plus three percentage points or minus four percentage points from optimum at the time compactive effort is applied. However, soils which evidence pronounced elasticity as the result of compactive effort shall be dried to optimum moisture content, if necessary to achieve stability.

716.3.2 - Embankment and Subgrade Density:

716.3.2.1 - Soil and material having less than 40 percent by weight of particles retained on the 19 mm sieve shall be compacted within the moisture tolerance to a target percentage of dry density (Note 1) specified in Table 716.3.2.2. The maximum required dry density and the in-

place dry density of the soil layers placed and compacted shall be determined by AASHTO T 180 METHOD C.

716.3.2.2 - Soil and material having 40 percent or more by weight of particles retained on the 19 mm sieve that are relatively uniform in gradation and can be incorporated in a 225 mm lift or less, shall be compacted to the target percentage of dry density (Note 1) specified in Table 716.3.2.2. The maximum required dry density shall be determined by Part 1 of AASHTO T 180. The in-place dry density of the soil layers placed and compacted shall be determined in accordance with Part II of AASHTO T 180.

TABLE 716.3.2.2

Type of Construction	Target % of Dry Density (Note 1) of Material Having Less Than 40% by Weight Retained on Retained mm) the ¾ in. (19 mm) Sieve	Target % of Dry Density (Note 1) of Material Having 40% or More By Weight on the ¾ in.(19 Sieve and Granular Subgrade
Embankment	95	95
Subgrade	95	95

Note 1--Target percentage of density shall be the percentage of density by which the decision of acceptance is based. The percentage of dry density for each test shall be determined by comparing the in-place dry density with required maximum dry density.

716.3.2.3 - Material, as outlined in AASHTO, T 180 Table 2.2.3.1, shall be proof-rolled with a pneumatic tire roller having an effective weight of 50 tons (45.5 Mg) . Alternate proof-rollers, acceptable to the Engineer, may be used in lieu of a 50 ton (45.5 Mg) pneumatic tired roller provided the weight per tire and tire pressure is maintained so that a minimum of (9.067 KN/mm) width of tire is maintained. The roller shall be operated at a speed of not more than (8 km/hr.). The designated areas to be proof-rolled shall have two or more passes and the entire area shall be systematically covered with the proof-rolling. During the proof-rolling and after the proof-rolling is completed, the area shall be checked for unstable areas or soft spots disclosed by the operation of the proof-roller. These unstable areas or soft spots shall be corrected prior to placement of the overlying lifts of material. The Contractor may propose an alternate approach for small areas that are impractical to roll with the proof-roller.

716.4 - EMBANKMENT ORGANIC CONTENT:

The embankment material shall be free of organic matter

716.5 - ACCEPTANCE OF EMBANKMENT AND SUBGRADE:

The density of the embankment and subgrade will be accepted by the Engineer on a lot to lot basis provided the lot conforms to the Specifications. An area shall contain five approximately equal sub-areas. A sub- area shall consist of not more than 1900 cubic metres for embankment and 120 m per working width for subgrade. The Contractor's quality control testing shall include one nuclear moisture and density measurement made at a random location within each of the sub-area. Each lot shall be presented to the Engineer for acceptance. When a lot consists of more than one lift, the Contractor's quality control testing shall normally include testing on each lift. Testing for density shall be in accordance with 716.3.2.1, or 716.3.2.2, whichever is applicable. The random locations shall be determined in accordance with AASHTO T21, T 248. The Contractor's quality control testing will be evaluated for each lot and acceptance of the lot may be based either upon the Contractor's quality control testing or by independent testing

performed by the Engineer. The acceptance decision will be made as soon as practicable after the Contractor has informed the Engineer that the lot is ready for acceptance.

If the results of density tests on a lot indicate that at least 80 percent of the material, compacted to the specified target percentage of dry density, the lot will be accepted. If less than 80 percent of the material has been compacted to the specified target percentage of dry density, no additional material shall be placed on the lot until it has been reworked to meet the specified requirements.

Lots failing to meet the quality requirements shall be reworked by the Contractor at his expense and be resubmitted for acceptance. Evaluation of the reworked lots, when the testing is performed by the Engineer, shall be at the expense of the Contractor. The quality requirements of this sub-section shall apply to the reworked lots.

SECTION 717

COMPACTION CONTROL OF BASE COURSE MATERIAL

717.1 - GENERAL:

The Contractor shall notify the Engineer prior to construction of the test strips as set forth in AASHTO T 238-86. Further, the Contractor shall perform quality control compacting tests and shall record the data for all of his compaction testing on the forms as set forth in the Materials Procedures (MPs). The test data shall be available to the Engineer at the time of testing or as indicated in the Contractor's quality control Drawing.

717.2 - TEST METHODS:

717.2.1 - Moisture, maximum density, quality control density and acceptance density for Portland cement treated aggregate base course; hot-mixed, hot-laid bituminous treated aggregate base course; cold mixed bituminous treated aggregate base course; crushed aggregate base course; and aggregate subbase shall be determined in accordance with AASHTO T 238-86.

717.2.2 - Maximum density, optimum moisture, quality control moisture-density and acceptance moisture-density for soil-cement base course shall be determined in accordance with AASHTO T 180 METHOD

717.3 - MOISTURE:

717.3.1 - The amount of moisture contained in soil-cement base course after mixing with Portland cement is complete shall vary not more than three percentage points above or two percentage points below the optimum moisture content, unless otherwise agreed by the Engineer. The optimum moisture contentshall be determined as specified in 717.2.2. The moisture content shall not exceed that quantity which will cause the soil-cement mixture to become unstable during compaction and finishing. The moisture content shall be determined as specified in 717.2.2.

717.3.2 - The moisture content for crushed aggregate base course, Portland cement treated aggregate base course and aggregate subbase shall be determined in accordance with 717.2.1.

717.4 - DENSITY:

The wet density shall be determined for all base course material. The dry density shall be determined for Portland cement treated aggregate base course, crushed aggregate base course, soil-cement base course and aggregate subbase.

TABLE 717.4.4

TYPE OF CONSTRUCTION	TARGET % DRY DENSITY	TARGET % THEORITICAL MAXIMUM DENSITY
Portland Cement Treated Aggregate Base Course	98(Modified AASHTO)	
Crushed Aggregate Base Course	98 (Modified AASHTO)	
Aggregate Subbase	98 (Modified AASHTO)	
Hot-Mix, Hot-Laid Bituminous Treated Base course		92
Cold mix bituminous treated aggregate base course		92
Soil cement base course	98 (Modified AASHTO)	

NOTE 1: The target percentage (wet) (dry) density is the percentage of density used for acceptance decision. The percentage of (wet) (dry) density for each test shall be determined by comparing the in-place (wet) (dry) density with the required maximum (wet) (dry) density.

717.5 - PORTLAND CEMENT CONTENT CONTROLS:

717.5.1 - The Contractor shall perform tests to determine the cement content of cement treated base (CTB). The tests shall consist of Plant calibration procedures performed on a minimum frequency of one per each half day of production (sub-area). The test data shall be available to the Engineer at the time or as approved in the Contractor's quality control Drawing.

SECTION 718

SEWER AND WATERLINE MATERIAL

718.1 - IRON PIPE:

Ductile iron pipe for waterline applications shall conform to AWWA C151.

718.1.1: Cement lining shall conform to AWWA C104.

718.1.2: Fittings shall conform to AWWA C110 or C153.

718.1.3: Joints shall conform to AWWA C111. Flanged joints shall conform to C115.

718.2 - PLASTIC PIPE (PVC):

For pressure applications pipe shall conform to AWWA C900 and CS-256 for sizes from 100 mm to 300 mm, for pipes less than 100 mm ASTM 2241 and D1784 shall apply, for pipes from 350 mm) to 400 mm AWWA C905 shall apply.

For non-pressure application pipe shall conform to ANSI B72.2, ASTM D3033 OR D3034.

Joints for sewer line shall conform to ASTM D3212. Joints for waterline shall conform to ASTM D3139.

718.3 - PLASTIC PIPE (POLYETHYLENE):

Plastic pipe (polyethylene) shall conform to ASTM D2239 "PE3408".

Additionally, used for potable water, polyethylene pipe shall conform to CS-255 and for pipes 12.5 mm to 75 mm AWWA 901 shall apply.

718.4 - COPPER SERVICE LINE:

Copper Service Line shall conform to ASTM B88. Fittings shall be industrial quality and conform to AWWA C800.

718.5 – GATE VALVES:

Gate valves less than 75 mm shall conform to Federal Specification WW-V-58B.
Gate valves greater than 75 mm , shall conform to AWWA C500 or C509.

718.6 – VALVE BOXES:

Valve Boxes shall be as specified on the Drawings.

718.7 - CASING- PIPE (STEEL):

Casing Pipe (Steel) shall conform to the following: "ASTM A53, Grade B, ASTM A139, Grade B or ASTM A252, Graded 2 for both waterline and sewer line applications. Hydrostatic test requirements under ASTM A53 or ASTM A139 are waived."

718.8 – FIRE HYDRANTS:

Fire Hydrants shall conform to AWWA C502.

718.8 – METERS:

Meters shall conform to AWWA C700.

718.9 – MISCELLANEOUS STEEL (CLAMPS, RODS, ETC.):

Steel for miscellaneous rods, straps and clamps as required shall conform to the requirements of ASTM A 36 except that the maximum and minimum tensile strength requirements and chemical shall be waived.

718.10 – FINE AGGREGATE:

Fine Aggregate shall be crushed or uncrushed mineral aggregate with 100% passing the 9.5 mm sieve.

718.21 – BEDDING MATERIAL:

Bedding Material shall conform to Section 703 and meet gradation for size #67.

SECTION 719

ELECTRICAL EQUIPMENT AND MATERIALS SPECIFICATION

719.1 - GENERAL

719.1.1 - General

All control cabinets, cables, lighting poles including holding down bolts with nuts and washers, brackets, lanterns, flood lights, lamps, service cut outs and appurtenances will be supplied, delivered, installed, tested and commissioned by the Contractor as indicated on the Drawings and/or referred to in the Specifications.

The Contractor shall supply and install all cabling, cable protection slabs and warning tapes required for the electrical installation.

All stainless steel components shall be of Grade AISI 316.

Materials and equipment shall be suitable for use under the prevailing conditions of a harsh marine environment.

In calculating the rating of electrical cables, switchgear and all items of equipment, the necessary de-rating factors shall be determined and applied to ensure that the equipment will operate satisfactorily and meet its design criteria.

719.1.2 - Reference Standards

The installation materials and equipment shall comply with:

Regulation for electrical installation (Sixteenth Edition) the Institution of Electrical Engineers, London.

Relevant British Standards and Codes of Practice, or equivalent as approved by the Engineer. Standards and Recommendations issued by the International Electro - Technical Committee. The general requirements of the CEB.

NZS/AS 1158:1997 Road Lighting

All Standards and Codes referred to shall be the latest issue at the time of to the satisfaction of the Engineerthe Invitation for Bids.

719.1.3 - Check of Equipment Supplied by Others

The Contractor shall ensure that all equipment supplied by others forming part of his installation shall be new and in accordance with the standards required. Any defect must be reported in writing within seven days of receipt of the equipment in order to allow changes to be made or replacements instructed by the Engineer.

719.1.4 - Installation Electrical Operating Conditions

The following are the general conditions under which the cable shall operate:

Supply system shall be typically three phase, four wire.

Electrical energy is generated as three phase alternating current at a frequency of 50 Hz ± 5%.
The working voltage on any of the systems shall be nominally 230/400 volts, ± 10%
The material and equipment covered by this specification shall be suitable for operation during the varying atmospheric and climatic out-door conditions in Sri Lanka.

719.2 - CABLES

719.2.1 - General

719.2.1.1 - Operating Conditions

The cable shall be suitable for use under the installation electrical operating conditions, and shall be rated for 600/1000V, and comply with IEC Publication 502.

719.2.1.2 - Cable Identification

The oversheath shall be engraved or embossed along two lines with the following legend, complying with BS5467: 1989 or where PVC oversheath is used, embossing process must be applied.

First line: "Road Development Authority (Rated Voltage) V"

The letters and figures shall be upright block characters. The maximum size of the characters shall be 13mm and the minimum size 15% of the approximate overall diameter of the cable, or 5mm whichever is greater. The gap between the end of one legend and the beginning of the next shall not be greater than 150mm.

Second Line: "XXXX 20XX SL 4 x XXmm Cu 3955m".

This shall be equally spaced with the first line along the circumference. An identification of the manufacturer, year, country, number of cores x conductor cross section, type and metering length shall be marked at regular intervals on the sheath. This shall not affect the spacing between repetitions of the legend for the voltage designation.

719.2.1.3 - Sealing and Drumming of Cables

Before dispatch, the manufacturer shall cap the ends of all cables to form a seal to prevent the ingress of water during transportation and installation.

The cables shall be delivered to site with the manufacturer's seals, labels or other proof of origin intact. The labels and seals shall be retained for inspection by the Engineer.

Each drum length of cable shall be allotted a distinctive and separate reference number. This number shall appear on the test sheets covering the respective length of cable and shall be clearly marked on the cable drum. All cables shall be capped on the drum to prevent the ingress of water.

719.2.2 - Distribution Cables

719.2.2.1 - General

All cable accessories and materials shall be of the best quality and most suitable for local climatic conditions, and shall be such that the cable shall withstand without damage, any conditions arising from short circuits, switching operations and sudden variations of load and voltage as may be met under normal working conditions. The cable shall be suitable to be buried directly in saline soil. The Contractor shall submit for approval a sample cut piece of each type of cable and one metre length of any cable size with the required embossment or with non-erasable print. The materials are to be accompanied by manufacturers installation instructions. This specification provides for manufacturing, testing of two or four core power stranded copper conductor XLPE/SWA/MDPE cable, rated service voltage 600/1000 volts.

719.2.2.2 - Construction

719.2.2.2 (A) - Conductors

The conductors shall be stranded plain annealed copper in accordance with IEC publication 228: Conductors of Insulated Cables or BS6360: 1981.

The surface of individual strands shall be smooth and clean before insulation is applied.

The conductors shall comply with the test requirements mentioned at clause 9 of BS6360: 1981 and test certificates from independent authorities/laboratories shall be submitted.

The neutral conductor shall be full size, i.e. same wire size and cross sectional area as the phase conductors.

719.2.2.2 (B) - Insulation

The insulation shall be XLPE (GP8) complying with Table 16 of BS5467: 1989 and BS6899 in addition to IEC Publication 502:1983 Table III.

Test Certificates from independent approved bodies/authorities must to be submitted prior to delivery to site.

The insulation thickness shall comply with BS5647: 1989 Clause 6, Table 16, and IEC Publication 502.1:1983.

Core insulation colours for two core cables colours shall be Red– Black.

Core insulation colours for four core cables colours shall be Red– Yellow – Blue – Black.

The insulation shall meet the test requirements mentioned in the following standards:

Section 3 of IEC Publication 502:1983

Clause 20 of BS5467: 1989 relating to compatibility.

Clause 5 of BS 6746:1984

BS6469: 1984

BS6234: 1987

Clause 5, Table 5 of BS5467: 1989 relating to insulation.

719.2.2.2 (C) - Bedding

The inner sheath shall be black extruded PVC bedding complying with the requirements of BS: 5467:1989 and BS: 6746:1984 for type 9 compound or IEC Publication 502:1983.

719.2.2.2 (D) - Fillers and Binders

Non-hygroscopic synthetic fillers to be applied integrally with the bedding in accordance with BS: 5467: 1989 Clause 8 and IEC Publication 502:1983 to form a compact and circular cable.

Fillers and binders shall comply with Clause 20.1 of BS5467: 1989 compatibility test

719.2.2.2 (E) - Wire Armour

The armour shall consist of a single layer of galvanised steel round wires of appropriate size mentioned in Table 16 of BS5467: 1989, and IEC Publication 502:1983. The armour wires must cover the entire periphery of the inner sheath as per BS5467: 1989

719.2.2.2 (F) - Armour Tests

Samples of galvanised steel armour wires shall be tested for mechanical strength and electrical resistance in accordance with BS5467: 1989, and BS1442: 1969, respectively.

Testing requirements for zinc coatings on steel wire and for quality requirements shall comply with BS443: 1982. Test Certificates from independent approved authorities/laboratories shall be submitted prior to delivery to the Site.

719.2.2.2 (G) - Over Sheath

The over sheath shall be MDPE (Medium Density Polyethylene) type TS2 complying with BS6234: 1987.

Thickness of over sheath should comply with BS5467: 1989, table 16 or IEC publication 502:1983.

719.2.2.3 - Testing of Cables

Tests on the complete cable shall be carried out according to the schedules given in table 5 under clause 15 of BS5467: 1989. Test certificates from independent approved authorities or laboratories shall be submitted prior to delivery to the Site.

719.2.3 - Low Voltage Flexible Power Cable for Lighting Columns

719.2.3.1 - General

The following specifications are for manufacturing and testing of circular flexible copper conductor, conforming to harmonized code H05 W-F, 300/500 Volts Grade, PVC Insulated, sheathed cable rated for 70°C as per BS 6500 Table 16, which is to be used inside the lighting columns between lanterns and service cut out.

719.2.3.2 - Conductors

The conductors shall be stranded plain/tinned annealed copper in accordance with BS 6360:1981 class 5 flexible conductor.

The cross sectional area of the conductors shall be a minimum of 2.5mm2.

The conductors shall comply with the test requirements mentioned in BS6500: 1990 and test certificates from independent authorities/laboratories shall be submitted.

719.2.3.3 - Insulation

The insulation shall be PVC insulation type T12 complying with BS6500: 1990 suitable for 70°C. Test certificates from independent approved authorities/laboratories to be submitted with offer as evidence of compliance.

The insulation thickness shall comply with BS6500: 1990 Table 16. Core insulation colours of each core shall be as per table 16 of BS6500: 1990.

The insulation shall meet the test requirements mentioned in BS6500

719.2.3.4 - Sheath

Type: The sheath shall be PVC type TM2 complying with the latest edition of BS6500.
Thickness: Thickness of sheath should comply with table 16 of BS6500: 1990.

719.2.3.5 - Testing

Tests on the complete cable shall be carried out according to BS6500: 1990. Test certificates from independent approved authorities or laboratories shall be submitted with the offer as evidence.

719.2.3.6 - Cable Identification

Cable identification shall be according to BS6500: 1990

719.2.4 - Earth Cable

719.2.4.1 - General

This specification provides for manufacturing and testing of single core stranded copper conductor PVC cable (non armoured). The cable, in general, shall comply with BS6004: 1984

719.2.4.2 - Construction

CONDUCTOR

The conductors shall be stranded plain annealed copper in accordance with IEC Publication 228:Conductors of Insulation Cables or BS6360: 1981.

The conductor shall comply with the test requirements mentioned at Clause 9 of BS6360: 1981 and test certificates from independent authorities/laboratories shall be submitted prior to delivery to the Site.

INSULATION

PVC insulation shall comply with the requirements of BS6746: 1984 for type 9 compound radial thickness of insulation, and outer diameter according to table 1 of BS6004: 1990.

Compliance to the requirements shall be checked with the appropriate tests listed in table 8 of BS6004: 1990. Test certificates from independent authorities/laboratories shall be submitted prior to delivery to site.

Insulation Colour: Yellow – Green.

719.3 - SPECIFICATIONS FOR ROAD LIGHTING POLES AND BRACKETS

719.3.1 - Columns and Brackets

719.3.1.1 - General

All columns and brackets shall be tapered octagonal type as specified, made up of hot dip galvanized interchangeable sections to comply in all respects to the drawings, Bill of Quantities and Notes. They shall be manufactured to comply with BS 5649:1985. The base plate (for planted type columns), brackets arms and spigots shall be manufactured as separate units suitable for mounting or fixing into the columns.

719.3.1.2 - Design Loading

The columns shall be designed to withstand loading comprising of:

a.) Loads of wind speed up to 35m/sec.

b.) The loads due to the weight of the column and accessories, lighting lanterns and associated control gear, the bracket arms and spigots.

c.) Other applied loads.

719.3.1.3 - Fabrication

Each column section shall be mechanically formed and longitudinally welded by continuous automatic gas shielded electric arc process (M.I.G. Process) to BS 5135:1984. The sections shall be constructed to overlap each other by a minimum of 1.5 times the inside across flat diameter of the female section and to be easily assembled on site by using simple tools without employing welding. The manufacturer shall provide a mark on the finished column sections indicating this minimum overlapping position. Poles shall be assembled to the manufacturer's instructions. All damaged galvanizing shall be repaired to the satisfaction of the Engineer before being erected.

719.3.1.4 - Material

The column section shall have a minimum wall thickness of 2.5mm.
The column and accessories shall be fabricated from the following materials:

COMPONENT	MATERIAL
Column and Door	Steel to BS 4360 Grade 50, BS 4360 Grade 43. or BS 1387 as per calculation
Bracket Ann and Spigot	Steel to BS 4360 Grade 43
Base Flange	Steel to BS 4360 Grade 40
Base Plate	Steel to BS 4360 Grade 40

719.3.1.5 - Protection Against Corrosion

Individual sections of the column, base-plate, door, spigots and bracket arms shall be protected against corrosion by hot dipped galvanized, internally and externally in accordance with BS729: 1971. All welding work shall be done before galvanizing. The treatment prior to galvanizing shall include degreasing, rinsing, pickling, further rinsing and fluxing.

The minimum average weight of the zinc coating shall be 460 gm/m^2 for any individual test area. The galvanized column and spigots/bracket arms shall be of prime finish and of good uniformity, i.e. free from injurious defects, such as blister, flux and uncoated spots.

719.3.1.6 - Bracket Arms

Bracket arms shall be of suitable outreach as indicated in the Drawings and/or the Bill of Quantities. The bracket arms shall be arranged to give a 10 degree upcast angle or otherwise, as per Drawings. A tubular steel spigot of appropriate dimension for the lanterns shall be provided at the end of the bracket arms. After welding and related work, the bracket arm shall be treated as per clause "Protection Against Corrosion" before being hot-dip galvanized.

719.3.1.7 - Pipe Adaptors

Pipe adaptors shall be of suitable size as indicated in the drawing and/or the Bill of Quantities. A tubular steel tube of appropriate dimension for the lanterns shall be provided and arranged to give a 10 degree upcast angle or otherwise, as per drawings. After welding and related work, the adaptor shall be treated as per clause "Protection Against Corrosion" before being hot-dip galvanized.

719.3.1.8 - Spigots

Spigots shall be supplied and installed as in the Drawings and/or Bill of Quantities, and treated as per clause "Protection Against Corrosion".

719.3.1.9 - Doors, Door Openings and Opening for Wiring to Signs/ Lights

A hinged weatherproof flush-type door, hinged on the upper side, shall be provided complete with an anti-vandal locking device over the door opening of each column as shown in the relevant drawings. The door openings shall have internal reinforcement to compensate for the loss of stiffness of the column caused by forming the door openings.

719.3.1.10 - Earthing Terminal

Columns shall be provided with a corrosion-resistant earthing terminal having substantial contact surface for the attachment of an earthing lead. The terminal shall be provided close to the door opening inside the columns. Where a bolt is used, it shall be at least 6mm in diameter and 20mm in length and provided with two suitable washers and nuts. The bolt, nuts and washers shall be made of stainless steel.

719.3.1.11 - Service Slots

For planted type column, the service slot shall be on the same side and vertically below the service door.

719.3.1.12 - Flange and Anti-Sink Base Plate

For the flange-mounted type of column, a flange plate of substantial thickness as shown in the Drawings shall be welded onto the column. As for the planted type column, a detachable anti-sink base plate shall be supplied. The anti-sink plate, bolt and nut etc. shall be hot-dip galvanized after manufacture.

719.3.1.13 - Mounting Base, Mounting Stub and Shear Washer for Slip Base Poles

To enable slip-base assembly to be attached to a rag bolt assembly, a mounting base complete with a shear washer shall be provided complying with the form and dimensions as specified in the drawing.

To enable slip-base assembly to be directly buried, a mounting stub complete with a shear washer shall be provided complying with the form and dimensions as specified in the drawing.

719.3.2 - Tests and Test Certificates

719.3.2.1 - Tests

All sample columns and bracket arms shall be submitted to a Testing Authority for the following tests:

a.) Dimensional and Weight Measurements of pole and bracket.

b.) Galvanizing Test - the pole and bracket shall be subjected to the galvanizing thickness test as laid down in BS729: 1971.

c.) Material Test - steel material used for the manufacturing of poles and brackets shall be subjected to test for compliance with BS 4360 (Grade 43 or Grade 50). The supplier shall state the test method and the reference standards together with the bid. The test method and the reference standards shall be subjected to the approval of the Engineer.

d.) Welding Test - all welded portions of the poles and brackets shall be subjected to a relevant welding test. The reference standard shall be the latest relevant British Standard BS 5135. The reference standard and the strength of the welded joint shall also be subjected to the approval of the Engineer.

For longitudinal seam weld, minimum percentage penetration of the weld is to be stated.

The acceptable value is to be determined by the Engineer on consultation with the testing authority.

e.) Mechanical Property Test - A small piece of steel plate of adequate size shall be cut off the base of the sample pole by the Testing Authority for this test.

The tensile strength and yield of the sheet metal shall be measured. The test results shall comply with the limits specified in BS 4360 for Grade 50 or Grade 43 steel as follows:

	Grade 50	**Grade 43**
Tensile Strength (N/mm^2)	490 to 640	430 to 580
Min. Yield Strength (N/mm^2)	355	275

f.) Type Test - the type test shall satisfy deflection requirements as specified by BS 5649 Part 8: Verification of Structural Design by Testing.

719.3.2.2 - Quality Assurance Plan

The Contractor shall submit a detailed Quality Assurance Plan. As a minimum, this issue of the Quality Assurance Plan shall be sufficient to control all planned activities. The Quality Assurance Plan shall be project specific and shall include:

a) Introduction about the Company

b) Quality Assurance and Control

c) Quality System Registration

d) Certificates

e) Manufacturing and Testing Procedures

i.) Pole -Production Flow Chart

ii.) Pole -Automated Welding Processes

iii.) Hot Dip Galvanizing Processes

iv.) Procedures for Powder Coating, Inspection and Packing

v.) Tensile Testing for Raw Steel Material

vi.) Zinc Coating Thickness Measurement

If such testing facilities are not available within the manufacturer's plant, the manufacturer shall at his own expense conduct the above tests on sample columns and bracket arms to be submitted to a recognized testing/certifying authority or laboratory.

The test report for the above shall be submitted by the supplier/manufacturer together with the lot delivered. Otherwise, the lot delivered will not be accepted.

719.3.2.3 - Testing Expenses

All expenses incurred for the tests shall be borne by the supplier/manufacturer.

719.3.2.4 - Quality Assurance Scheme

The manufacturer shall propose and establish a quality control scheme for the manufacture of columns and bracket arms. This is to ensure that the final product is of high quality, good uniformity and free from all defects in manufacturing.

The scheme shall cover the assurance of quality, mechanical properties and composition of the incoming materials, dimensional tolerances, quality of weld, galvanizing standard and material thickness, etc and the final testing and inspection of finished goods. For this purpose, all materials shall be subject to inspection. The Engineer shall have free access to the factory for inspection, and to other facilities, including fabricating plant, galvanizing plant and warehouses etc. Material, which has been rejected, shall not be reused in later lots.

Columns and bracket arms, which do not comply with the Drawings and specification, shall be rejected and the manufacturer shall be required to replace them at his own expense. Galvanizing not complying with BS 729 or satisfactory galvanizing thickness or finish is sufficient cause for the rejection of the whole lot of columns and bracket arms.

In the case that the column manufacturer and the column galvaniser (hot-dip galvanizing company) do not belong to the same company, the column manufacturer must ensure that the galvaniser also observes the clauses mentioned above. The manufacturer shall have an agreement with the hot-dip galvanizing company to enable the Engineer to gain free access to the factory and fabricating plant, galvanizing plant and warehouses etc. so as to ascertain that the specifications laid down in the Contract have been fully complied with. The manufacturer must indicate by separate letter that he has obtained the agreement of the galvaniser for the quality assurance scheme. Failure to comply with this clause will adversely affect the consideration of the offer.

719.3.2.5 - Inspection

The manufacturer is responsible for carrying out such tests and measurements as necessary to ensure that the column manufactured complies with all specification requirements. These tests and measurements shall be so identified by a code used on the column that the manufacturer can produce specific reports showing these test results. Copies or reports of these tests shall be kept on file and shall be made available for inspection or submitted to the Engineer upon request.

719.3.2.6 - Batch Testing

All columns shall be subjected to inspection and sampling at the fabricating plant and warehouse or after delivery to the site of construction. The Engineer may take one section of the column and bracket arm from each 100 pieces in a lot for determination of compliance with specification requirements. If one piece fails to comply, two other pieces shall be tested. If either of these pieces fails to conform to the requirements of this Specification, the lot of columns and bracket arms represented by this sample shall be rejected and the manufacturer shall be required to replace the entire lot at his own expense.

719.4 - CONCRETE FOUNDATIONS FOR LIGHTING COLUMNS

Concrete for the foundations shall be Class 20/20 in accordance with section 551 and 557 of these specifications.

The Drawings provide typical foundation designs for poles of up to 16m. The Contractor shall verify the design, and shall provide the Engineer with shop drawings with supporting design calculations for approval prior to construction of the foundations.

A sample foundation is to be approved by the Engineer before commencement of the work and the same standard is to be maintained throughout the Contract.

Denso tape shall be placed on the exposed section of the threaded part of the holding down bolts before casting the foundations. After concreting, the bolts shall be thoroughly cleaned, greased and checked with a template to ensure accurate placement.

719.5 - LANTERNS

719.5.1 - General

Lanterns shall comply with the following general requirements, which may be superseded by the specific lanterns specification.

Lanterns shall be constructed of corrosive resistant materials to marine specifications.

Cast aluminium shall be DP 401 Grade and BS LM6 Grade.

Pressed or spun aluminium shall be 1150 Grade.

Aluminium reflectors to high purity 5557 Grade.

Stainless steel fixings shall be to BS 6105 Type 316.

Steel shall be galvanized to marine grade as BS 729.

Paint may be applied for decoration provided preparation is appropriate to ensure a reasonable life.

G.R.P. or other plastics shall not be used in areas prone to vandalism, where lanterns are ground mounted or where they may get too hot.

Polycarbonate refractors and diffusers shall be ultra violet stabilized and shall not be used on high-pressure mercury or self ballast mercury lanterns. A preference is for high impact acrylic.

Lanterns shall be water and dust resistant to I.P. 65. Any perforations or air vents shall be covered with a non-corrosive gauze to exclude insects.

Lanterns shall be securely fixed by at least two stainless steel or galvanized fastening bolts washers lock nuts.

Control gear shall be integral to lanterns.

719.5.2 - Road Lighting Lantern

H.I.D. lanterns shall be wired with heat resistant cabling, fitted with porcelain terminal blocks, configured to prevent components damaging or discolouring diffusers.

The external finish of control gear or lanterns shall not be altered without the manufacturers approval.

Adequate ventilation shall be provided for control gear.

Lanterns shall be constructed and mounted to discourage birds and vermin from bringing combustible nest material close to hot control gear or from obstructing ventilation.

The Lanterns shall have the following features:

230V Rated 250W HPS Ballast Reactor

0.9 Power Factor Corrected or better

48mm – 60mm Spigot entry

Optical and gear compartment to be separate

Access to gear compartment from above via a black plastic or aluminium cover held on by quick release latches.

Access to optical compartment via quick release latches.

Visor to be made from injection moulded high impact acrylic plastic.

Body to be high-pressure die-cast LM6 aluminium.

IP rating of optical compartment IP65 or better

IP rating of gear compartment IP34 or better

Control gear mounted on an removable plastic or aluminium gear tray.

Heat sinks in the casting near the control gear. Underneath of casting to be painted white and painted with the lamp description i.e. S250

GE239 lamp holders shall be used in the lanterns so that both European E40 and American Mogul GES39 lamps can be used when re-lamping

Optical layout designed to AS/NZS 1158.1 CAT V Standards

Lantern Body and components designed to AS3771 Electrical and Construction Standards.

719.5.3 - Underpass Lanterns

719.5.3.1 - General

Lanterns shall be constructed of corrosion resistant materials. G.R.P. and aluminium are acceptable materials for the body. High impact acrylic diffusers are preferable in higher mounted, (i.e. greater than 5m from finished floor level), less vandal-prone areas, otherwise polycarbonate shall be used.

Lantern mounting and spacing distances within the underpasses shall be as shown in the Drawings.

719.5.3.2 - Fluorescent Lantern

The lantern type shall be a 2 x 58W fluorescent fitting, complete with lamps, ballast, wiring and diffuser.

Tube holders shall be non-flammable, non-fusible, unbreakable spring loaded self-locking type with phosphor bronze contacts suitable for fluorescent tubes.

Ballasts shall be low-noise, low-loss type. They shall have copper layer wound coils and be of approved manufacture and be suitable for operation with electronic or switch start fluorescent tubes.

Lanterns shall be vandal resistant. Diffuser holding clips shall be secured in such a manner that they cannot easily be released without specialized tools.

G.R.P. gear/back plates are preferable to mild steel backplates if low loss ballasts and fuses are used. This reduces internal condensation corrosion.

Lanterns shall be I.P. 65 rated.

Zinc galvanised anti-vandal mesh shall be fitted over lanterns.

Lanterns shall be suitable for the use of 1500mm long, 38mm diameter 58W x2 fluorescent lamps.

Lanterns shall be capable of terminating Cu conductors of cross sectional area of up to $10mm^2$ (x 2) per terminal (including earth conductor connection).

7.9.3.3 - High Pressure Sodium Lantern

H.I.D. lanterns shall be wired with heat resistant cabling, fitted with porcelain terminal blocks, configured to prevent components damaging or discolouring diffusers and/or adjacent building finishes.

The external finish of control gear or lanterns shall not be altered without the manufacturer's approval.

Adequate ventilation shall be provided for control gear.

Lanterns shall be constructed and mounted so as to discourage birds and vermin from bringing combustible nest material close to hot control gear or from obstructing ventilation.

The Lanterns shall have the following features:

230V Rated 70W HPS Ballast Reactor

0.9 Power Factor Corrected or better

34mm Spigot entry

Optical and gear compartment to be separate

Access to gear compartment from above via a black plastic or aluminium cover held on by quick release latches.

Access to optical compartment via quick release latches.

Visor to be made from injection moulded toughened glass.

Body to be high-pressure die-cast LM6 aluminium.

IP rating of optical compartment minimum IP54

IP rating of gear compartment minimum IP24

Control gear mounted direct to body of lantern.

Optical Layout designed to AS/NZS 1158.1 CAT V Standards

Lantern Body and components designed to AS3771 Electrical and Construction Standards.

719.5.4 - Lamps

719.5.4.1 - General

Generic lamps shall be used which are freely available. The manufacturer's catalogue number must be clearly indicated.

719.5.4.2 - High Pressure Sodium Road Lighting Lamp

High Pressure Sodium Road Lighting lamps shall conform with the following minimum requirements:

Compliance with IEC 662

250W High Pressure Sodium

Tubular Clear

Either E40 Base or GES39

Lumen Rating (100hr) minimum 28,000 lms

Lamp must match fixture control gear and ignitor.

719.5.4.3 - Fluorescent Lamps

Fluorescent lamps shall conform with the following minimum requirements:

Regular straight fluorescent tubes shall be 38 mm diameter, colour temperature 4000k

Length 1500mm

Lumen Rating 5,200 lms

Lamps must be suitable for the controller/ballast of the fitting into which they are to be installed.

719.5.4.4 - High Pressure Sodium Underpass Lighting Lamp
High Pressure Sodium Underpass Lighting lamps shall conform with the following minimum requirements:

Compliance with IEC 662

70W High Pressure Sodium Coated External ignitor

E27 Base

Lumen Rating (100hr) minimum 5800 lms.

Lamp must match fixture control gear and ignitor.

719.6 - LIGHTING POLE SERVICE CUT-OUT

719.6.1 - Application

The lighting pole service cut-out shall be installed in each column. This is for the purpose of providing a cable termination point, and carrier for the fuse protecting the lanterns fixed at the top of the column against short circuits.

719.6.2 - Rating

The service cut-out shall be rated at 230/400v, 50 Hz operations, at 50°C ambient temperature and 95% relative humidity.

719.6.3 - Standard

The service cut-out shall conform to the provisions of BS5486 (Part 1):1997, or IEC 439.

719.6.4 - Construction

Detailed shop drawings of the service cut-out shall be submitted to the Engineer prior to manufacture. A sample shall be provided to the Engineer for approval prior to installation.

719.6.5 - Gear Plate

Fuse carriers of required numbers

4 terminal blocks, R, Y, B, N.

1 N terminal, 6-way 10mm2

1 E terminal, 6 way 10 mm2

The fuse holder shall be DIN rail mounted fully insulated and capable of accepting cylindrical H.R.C. fuses of suitable rating with fuse dimensions of 10x38mm.

719.6.6 - Terminal Assembly

4 cable terminals (3 x phase and 1 x neutral) shall be fixed to a high quality phenolic fibre board, or glass fibre reinforced insulator. The dielectric strength of the insulator shall not be less than 2kV/mm.

The flexural strength of the insulator shall be not less than 1000kg/cm^2. The insulator material shall be according to DIN 7735 type 2081 or similar approved material.

Each cable assembly shall be capable of accepting 2 Nos. sector shaped copper cables of not less than 35mm^2 cross sectional area each.

Each incoming and outgoing terminal shall be bolted to an electrolytically tinned H.C.H.D. copper bar of 40 x 5mm cross section.

Each cable terminal shall have the provision to connect and to tap off a lugged 4mm^2 phase coloured wire of not less than 10cm long.

The tap of wire shall be bolted onto the main terminal by using a M5 x 15mm slit head screw with spring washer.

1 x No lugged tap off wire in phase colour to be provided and fitted on each terminal.

All terminal parts to be made from materials not subject to corrosion when used in combination with each other.

A high quality flexible phase insulating barrier shall be provided between all terminals as well as on both sides of the end terminals. The phase barrier shall protrude sufficiently on all sides of the terminal to ensure electrical safety.

Neutral and earth bars shall be of nickel plated brass, accepting 10mm^2 cable sizes. The earth bar shall be solidly connected to the metalwork of the pole.

719.6.5 - Testing

The cut-out shall be tested as per the provisions of BS5486 Part 1 1986 and IEC 439-1:1985 Clause 8, and routine test certificates shall be submitted for the Engineer's approval.

719.7 - FEEDER PILLAR SPECIFICATION

719.7.1 - General

This section contains a description and the specifications for the lighting control pillars as indicated on the Drawings, described in the Bill of Quantities, and as specified herein:

The pillar shall consist of a single compartment cabinet with one door opening, and an equipment mounting panel at the rear of the pillar. All pillars shall be constructed fully suitable for permanent out-door installation for the control of road lighting. Each control panel shall where required have one single phase 40A MCB complying with BS3871 Part 1:1984 and connected to the outgoing side of kWh meter suitable to supply power to a traffic control panel, and where required, the relevant numbers of MCB's for controlling pedestrian underpass lighting.

The pillar shall be constructed in a way to ensure easy installation of a direct 3-phase kWh direct reading meter. All cabling for connecting the meters shall be installed by the Contractor (meters will be supplied and installed by CEB).

The feeder pillars with a capacity of 100A 3-phase and above shall be delivered ready for installation (by CEB) of a 3 phase, CT operated kWh meter. The Contractor shall provide suitably sized CTs to comply with CEB specification, and the meter shall be protected with a suitably sized circuit breaker (MCCB) and installed in the cabinet ready for operation.

All fixed components shall be labelled with traffolite labels (black text on white background) screwed to the control panel adjacent to the component/function they are describing. The minimum text height of the labelling shall be 5mm.

719.7.2 - Equipment Housing

Housing shall be to standards equivalent to BS EN60529: 1991

The enclosure shall be fabricated from high-grade aluminium sheet with a thickness not less than 3mm. The sheet aluminium enclosure shall be coated with a thermosetting powder of an epoxy resin base modified by polyester resins. The enclosure shall be provided with a smooth finish and excellent protection against corrosion for 10 years maintenance free outdoor use. It should also have excellent chemical protection properties against acid, salt, water and solvents.

All other sheet metal should be hot-dip galvanised in accordance with BS729: 1986.

The pillar enclosure shall be made suitable to withstand the dynamic stresses in the event of a short circuit. The doors shall be provided with a neoprene gasket to provide protection against the ingress of moisture and dust to degree IP55 of IEC529. The gasket shall be adequate to maintain this protection at 50 °C ambient.

The enclosure shall have 4 louvers (ears) for diagonal ventilation. Prevention of the ingress of dust through louvers shall be provided to maintain the degree of protection of IP55 of IEC529.

The colour of the enclosure shall be beige (RAL 7032).

The compartment doors shall have robust weatherproof hinges of polymid type with suitable and substantial lockable latching devices. A metal pocket for the "As-Built" information shall be provided in the enclosure door. The diagram shall not be stuck to the enclosure. The enclosure

door shall have two locks of flush non-rusting type with separate keys (two numbers) to each panel. All keys shall have the same profile and design to match all doors. Non-rusting materials shall mean stainless steel grade AISI 316 or gun metal.

An ultra violet resistant reinforced window with a suitable dimension (approximately 100x100mm) shall be supplied on the pillar door opposite to the proposed location of the kWh meter to enable the meter to be read without the necessity of opening the cabinet door.

An ultra violet resistant reinforced window with a suitable dimension (approximately 100x100mm) is to be supplied on the pillar top where required.

The door shall be designed in a manner that opening of 180° can be obtained.

An anodised aluminium label, dual colour (black background with white lettering), bearing "RDA" in the first row, and "Street Lighting Panel" in the second row, with text height being 50mm for both rows, shall be attached to the outside of the pillar, both back, and the door, in a proper location and firmly attached with rivets.

An anodised aluminium label, dual colour (black background with white lettering), bearing "Panel ##" with text height being 50mm, shall be attached to the outside of the pillar, both back, and the door, in a proper location and firmly attached with rivets. Replace ## with the appropriate number indicated in the Drawings.

Four numbers of openings in the bottom plate anchoring the feeder pillar to the concrete foundation shall be provided. Dimension, location and size of anchor bolts shall be provided. The controller housing panel shall allow building up equipment complying with IEC439 and BS5486 Part 1:1990.

Cable gland entry holes are to be factory punched and are to be the knockout type or sealed with appropriate cover. The number of cable entry holes shall not be less than six and shall be according to the cable size. The unused relative dimensions are to be specified by the Engineer.

The feeder pillar dimensions shall be within the range specified herein:

Height: 1000mm

Width: 750mm

Depth: 300mm

719.7.3 - Equipment Mounting Panel

The equipment mounting panel shall be hot dip galvanised sheet steel not less than 3mm thick, epoxy coated, or 5mm Pertinax and shall be easily installed and removed from the front of the cabinet in assembled form. All devices and equipment shall be accessible from the front of the panel. All hinges and locks are to be easily removable/replaceable.

The panel shall have full-size neutral and earth bar completely bonded to the main shell and connected to the door by a braided copper wire. Provision shall be made in the enclosure to terminate the earth bus bar with the earth electrode outside the panel. The earth bar shall be tin plated copper.

The panel shall be provided with a removable gland plate of maximum 1mm thickness near the bottom to fix compression type brass glands along with earth tag. All incoming and outgoing cables shall enter and leave the cabinet at the bottom.

719.7.3.1 - Circuit Breaker (Incoming MCCB)

There shall be one moulded case circuit breaker for the incoming feeder to each control panel. It must be rated for three phases, 400V, 50Hz to IEC157-I and BS EN60947-2: 1992 specifications, and as indicated on the Drawings.

Moulded case circuit breakers shall be suitable to accommodate auxiliaries and under voltage release. They shall be of the thermal magnetic type with a short circuit capacity withstand of not less than 25kA at 400V and shall be suitable for 60°C ambient temperature operation. Pad locking facility for the MCCB (both in the on and off positions) shall be provided. The exposed incoming terminals shall be provided with a suitable insulated cover up to the equipment mounting plate in order to allow no access to the live incoming terminals. There shall be minimum clearance of 300mm between the incoming glanded cable and input terminals of the MCCB.

The capacity of the terminal sockets for MCCB shall be 185mm^2 stranded copper/aluminium cables through suitable terminal tin-plated copper bars.

719.7.3.2 - Circuit Breaker (Outgoing MCB)

There shall be a LV system consisting of Miniature Circuit Breakers for each outgoing circuit.

Each MCB shall be rated for one or three phases, 230/400V.

Each MCB shall be rated for minimum 15kA fault current for 1 second. The continuous rating of each MCB shall be as shown on the Drawings. Any exposed terminals shall be provided with a suitable insulated cover up to the equipment mounting plate in order to allow no access to live terminals.

719.7.3.3 - Switched Power Outlet

Each feeder pillar shall have one number single phase 20A ELCB and appropriate corrosion resistant switched socket outlet (3 pin square British type with box pattress) as per BS1363: 1984 appropriately located and neatly and tightly fitted inside the enclosure.

719.7.3.4 - Wiring and Cabling

All secondary internal wiring within the control cabinet shall be heat resisting, 1000V hard grade PVC/XLPE insulated copper cables, colour coded or sleeved for easy phase identification suitable for the circuit rating, arranged neatly, and firmly attached.

All the wiring leads shall be so arranged to allow current reading with a clip on ammeter on each phase of main incoming and all outgoing circuits.

All wiring shall be housed in wiring trunking forming an integral part of the enclosure whenever possible.

Bus bars shall be provided throughout the main power circuit. All bus bars are to be colour sleeved according to phase.

Bus bars shall be of the same amperage ratings at 60°C ambient at enclosure condition as the main circuit breaker, and shall be made of tinned copper flats and round bars complying with BS159. They shall be adequately supported to withstand dynamic stresses in the event of a short circuit. Exposed bus bars shall be insulated and screened to prevent accidental contact in live condition. An earth or ground bar not less than 40mm x 4mm shall be solidly bolted with stainless steel bolts of grade AISI 316 to the main body of the control cabinet.

Sufficient vacant area (250w x 300h x 250d mm minimum) shall be left for the installation of a kWh meter by others after installation. A suitably corrosion/rot resistant back board shall be provided for the installation of the kWh meter.

All wire terminals into connectors shall have wire ends or straight lugs. All the wires selected should have the amperage rating at 50°C ambient and sufficient allowance for enclosure de-rating.

The suppliers' attention is drawn to the fact that:

All incoming cable feeders to the panel shall be armoured, copper conductors, 4 core, XLPE insulated, and PVC over-sheathed;

All outgoing cable feeders from the panel shall be armoured, stranded copper conductors, 4 core, XLPE insulated and PVC over-sheathed. The outgoing terminals shall be suitable for 2 cables of $70mm^2$, $50mm^2$, $35mm^2$ $25mm^2$ and $16mm^2$; therefore all the connectors must be suitable to receive these types of cable.

All output cables shall be connected through rugged terminals. All terminals shall be designed for sector shaped stranded copper conductors. All incoming and outgoing cables are to enter from the bottom of the enclosure and hence all the connections must be made at the bottom and not at the sides.

All cables and wires must be colour coded as per the following detail.

Red, Yellow and Blue for phases

Black for neutral

Green/Yellow for the earth wherever required.

719.7.3.5 - Cable Glands

All cable glands shall be brass compression type glands complying with BS6121 with earth tags and lock buds for XLPE/SWE/PVC/MDPE 4-core cables. All cable glands to be supplied with matching cable sleeves.

Cable glands shall be weatherproof, with inner and outer seals suitable for steel wire armour cables. The Contractor shall drill for the installation of the glands where necessary.

Glands shall be fitted with PVC shrouds filled with waterproof plastic compound and made fast to the cable with PVC tape.

Glands shall be fitted with earthing rings to allow connection of protective conductors. The Contractor shall carry out all work involved in terminating the cables, supplying weatherproof plastic compound, PVC shrouds, tape etc., all subject to the approval of the Engineer.

719.7.3.6 - Control System

The switching of the lighting lanterns shall be through an automatic control arrangement consisting of a photocell, time switch and selector switch.

719.7.3.6.1 - Photo Electric Switch

The cabinet shall be equipped with a photoelectric switch of the following specification:

The photoelectric control switch or cell for the control cabinet shall operate from a supply voltage of 230 volts and be rated for a load of 100 watts. It shall be adjustable for turning on and off within a range of 5 - 2000 lux. It shall be suitable for operation within 0°C to 50°C temperature range. It shall have a fail-safe feature so that the lighting remains energised in the event of power failure. It shall be fully electronically controlled type.

The photoelectric control switch shall be housed and mounted inside the control cabinet.

A resistor type surge protection shall be provided in parallel to the photocell switch.

The photocell is to be fitted inside the feeder cabinet behind a factory made transparent ultra violet resistant window of size 100x100mm.

Upon installation, the photoelectric switch shall be adjusted to turn on the lighting circuits 30 minutes before sunset and up to 1 hour after sunrise.

719.7.3.6.2 - Time Switch

In lieu of the photoelectric switch, a suitable time switch mechanism may be utilised to control the lighting circuit contactor. If utilised, the time switch shall conform to the following specification:

The time switch shall be an analogue dial type, which indicates the current time (utilising a 24 hour clock). The time that the switch is activated and de-activated shall be clearly marked and logical in it's operation. It shall operate from a supply voltage of 230 volts and be rated for a load of minimum 100 watts. It shall be suitable for operation within 0°C to 50°C temperature range. It shall have a fail-safe feature so that the lighting remains energised in the event of power failure.

It shall be fully electronically controlled.

The mechanism/dial shall be mounted on the feeder pillar control panel in a clear and accessible location.

Upon installation the switch shall be adjusted to turn on the lighting circuits at least 30minutes before sunset, and up to 1 hour after sunrise.

719.7.3.6.3 - Selector Switch

A selector switch for controlling the contactor shall be provided in the cabinet to perform the following functions:

Auto ON/OFF (controlled by photo electric switch)

ON (bypass photo electric switch)

OFF (turn contactor off)

The switch shall be labelled as to its function at each switch position.

The switch shall be rated at 230v 10A, and suitable for operation within 0°C to 50°C temperature range.

719.7.3.6.4 - Contactor

A contactor shall be provided to control the required number of outgoing circuits.

The remote control contactor shall be of the single coil actuated, electrically operated, suitable to carry not less than the rated current of the main circuit breaker at 50°C ambient temperature and shall be obtained without the use of latches or semi-permanent magnets.

The contactor shall comply with BS5424 Part 1:1997, and shall be for AC3 class duty. Rated insulation voltage 600V AC.

The contactor shall have minimum making and breaking capacity in accordance with utilization category AC3 of IEC158-I and shall be suitable for minimum class II intermittent duty. Ambient operation temperature shall be in the range of 0°C to 50°C.

The contactor components must be suitable for continuous duty and for repetitive load switching. The contactor selected shall be such that all current carrying and live parts shall be properly shielded and it shall not be possible to come into accidental contact with them. All contact assemblies shall be dust protected, and an arrangement for easy removal of the coil shall be provided (preferably slide in type). The coils of all contactors shall be suitable for operation at a voltage of 230V±10%, and frequency of 50Hz±5% operation. The pick up of the coil shall be from 85% to 110% of the voltage. The operation of the contactor shall be by means of a time switch or photoelectric switch.

719.7.4 - Feeder Pillar Documentation

719.7.4.1 - General

The Contractor shall submit one sample of each type of feeder pillar complete with all auxiliaries and ready for installation, for the Engineer's approval.

Note that the approval of the Engineer does not absolve the Contractor of the contractual obligations as to the performance compliance to the specification requirements.

All components, catalogues, manufacturer's ratings, cable glands, calculations and detailed drawings are to be attached with the sample submittals.

The Contractor shall submit the relevant design calculations, drawings and data for approval prior to the fabrication of any panels, which shall include but shall not be limited to:

General dimensions of the panel anchor bolts, opening locations and gland plate openings

Detailed scale drawing for the fixed components in the panel including holes for penetration of wiring through the panel, fixing details, important maintenance and operating instructions of the manufacturer

General description of the material, manufacturing, fabrication, coating and treatment of feeder pillar panel

Door hinges, locks and flaps drawings (including materials)

Internal cabinet ventilation (circulations and air flow design)

Detailed general arrangement drawing

Single line diagram

Chart showing yearly on/off times according to the latitude of Galle.

719.7.4.2 - Testing

The cabinets and internal main circuitry shall be manufactured and tested in accordance with the testing specifications of BS5486 Part 1:1990 and IEC 439-1:1985 Clause 8.

Mechanical testing including checking of all mechanical and electrical connections, locks etc shall be performed to the satisfaction of the Engineer.

Functional checks of all control circuit equipment shall be performed to the satisfaction of the Engineer.

Polarity checking of the incoming electrical supply shall be performed to the satisfaction of the Engineer.

Defects identified in testing shall be rectified at the Contractor's expense to the satisfaction of the Engineer.

The Contractor shall submit ASTA or KEMA test certificates for routine and type test from independent approved laboratories/bodies to show the compliance of his product.