

Project Special Provisions (Version 02.16b) Signals and Intelligent Transportation Systems

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1. 2002 STANDARD SPECIFICATIONS FOR ROADS & STRUCTURES – SECTION 1098 REVISIONS

The 2002 Standard Specifications are revised as follows:

1.1. General Requirements (1098-1)

Page 10-220, Subarticle 1098-1(A)

In the last paragraph, sentence 1, revise “by the date of advertisement of the project” to “by the date of materials installation.”

Pages 10-222,3 Subarticle 1098-1(H)

Replace paragraphs 2, 3, and 4 with the following paragraphs:

Except for grounding conductors, provide signal cable conductors of size Number 16 AWG that are fabricated from stranded copper. **Number 16 AWG cable can only be used with an all LED traffic signal intersection.** Repairs to a non-LED traffic signal intersection must use Number 14 AWG cable.

Provide either 0.05 x 0.30 inch (1.3 x 7.6 mm) aluminum wrapping tape or 0.06 inch (1.5 mm) stainless steel lashing wire for the purpose of lashing cables, except fiber-optic communications cables, to a messenger cable. Use 0.045-inch (1.14-mm) stainless steel lashing wire for the aerial installation of fiber-optic communications cable to messenger cable.

1.2. Signal Heads (1098-2)

Page 10-223, Subarticle 1098-2(A)

In paragraph 5, sentence 4, revise “1 3/8 inch (32 mm) vertical conduit entrance hubs” to “1 1/4 inch (32 mm) vertical conduit entrance hubs” and revise “1 5/8 inch (40 mm) horizontal hubs” to “1 1/2 inch (40 mm) horizontal hubs.”

In the last paragraph, sentence 3, revise “2/5 x 3/4 inch (9.5 mm x 19.1 mm) square head bolts” to “3/8 x 3/4 inch (9.5 mm x 19.1 mm) square head bolts.”

Page 10-225, Subarticle 1098-2(C)

Replace paragraphs 2 and 3 with the following paragraphs:

Unless otherwise required by the plans, provide single-section countdown pedestrian heads with 6 inch (150 mm) minimum deep traditional visors that prevent the sun phantom illumination of the indication.

Where required by the plans, provide two-section pedestrian signal heads with traditional three-sided, rectangular visors 12 inches (300 mm) long.

Replace the last paragraph with the following:

Provide lead-in cable that complies with the loop lead-in cable section of these project special provisions.

Pages 10-225-227, Subarticle 1098-2(E) [**Light Emitting Diode (LED) Sections**]

Replace the entire subarticle with the following two subarticles:

(1) Vehicular

Provide light emitting diode (LED) traffic signal modules (hereafter referred to as modules) that consist of an assembly that uses LEDs as the light source in lieu of an incandescent lamp for use in traffic signal sections. Use LEDs that are aluminum indium gallium phosphorus (AlInGaP) technology for red and yellow indications and indium gallium nitride (InGaN) for green indications. Install the ultra bright type LEDs that are rated for 100,000 hours of

continuous operation from -40°C to +74°C (-40°F to +165°F). Design modules to have a minimum useful life of 60 months, and to meet all parameters of this specification during this period of useful life.

Ensure, unless otherwise stated in these specifications, that each module meets or exceeds the requirements of the Interim Purchase Specification of the ITE VTCSH part 2 (Light Emitting Diode (LED) Vehicular Traffic Signal Modules (hereafter referred to as VTCSH-2). Ensure arrow displays meet or exceed the electrical and environmental operating requirements of VTCSH-2 sections 3 and 5, chromaticity requirements of section 4.2, and the requirements of sections 6.3 (except 6.3.2) and 6.4 (except 6.4.2).

Provide modules that meet the requirements of Table 1098-1. Design the modules to operate from a 60 ±3 HZ AC line voltage ranging from 80 volts to 135 volts. Ensure that fluctuations of line voltage have no visible effect on the luminous intensity of the indications. Design the module to have a normal operating voltage of 120 VAC, and measure all parameters at this voltage.

**Table 1098-1
Maximum Power Consumption (in Watts) at 25°C (77°F)**

	Red	Yellow	Green
300 mm circular	17	34	24
200 mm circular	10	16	12
300 mm arrow	9	10	11

Certify that the module has a power factor of 0.90 or greater, and that total harmonic distortion (THD) (current and voltage) induced into an AC power line by the module does not exceed 20 percent for modules with power ratings above 15W, and 40 percent for modules with power ratings of 15W or less. Design the module’s onboard circuitry to include voltage surge protection to withstand high repetition noise transients as stated in Section 2.1.6 of NEMA Standard TS-2, 1992. Ensure all wiring meets the requirements of Section 13.02 of the ITE Publication: Equipment and Material Standards, VTCSH-2. Provide spade terminals appropriate to the lead wires and sized for a #10 screw connection to the existing terminal block in a standard signal head.

Ensure that the module is compatible with signal load switches and conflict monitors. Design the module to provide sufficient current draw to ensure proper load switch operation while the voltage is varied from a regulated 80 Vrms to 135 Vrms. Design off-state for green and yellow modules to be 30Vrms or greater, and on-state to be 40 Vrms or greater. Design the voltage decay to 10 Vrms or less to be 100 milliseconds or less for green and yellow modules. Ensure that the control circuitry prevents current flow through the LEDs in the off state to avoid a false indication.

Design all modules to meet existing NCDOT monitor specifications for each of the following types of signal monitors: NEMA TS-1 conflict monitors (including so-called NEMA plus features such as dual indication detection and short yellow time detection); NEMA TS-2 Malfunction Management Units (MMU); and 170 cabinet Type 210ECL and 2010ECL conflict monitors (including red monitoring and so-called plus features such as dual indication detection and short yellow time detection).

Ensure that the modules and associated onboard circuitry meet Class A emission limits referred to in Federal Communications Commission (FCC) Title 47, Subpart B, Section 15 regulations concerning the emission of electronic noise.



Provide modules that meet the requirements of Tables 1098-2, 3, and 4. Test all ball modules for luminous intensity at 25°C (77°F) to meet 115% of values in tables 1098-2 and 4. Design and certify the modules to meet or exceed the maintained minimum luminous intensity values throughout the warranty period based on normal use in a traffic signal operation over the operating temperature range. Test the Red and Green modules for maintained luminous intensity (Tables 1098-2, 3, and 4) at 74°C (165°F) (ITE 6.4.2.2). Use LEDs that conform to the chromaticity requirements of VTCSH-2, Section 8.04 throughout the warranty period over the operating temperature range. Make chromaticity coordinate compliance measurements at 25°C (77°F).

Table 1098-2
Specification for 12 inch (300 mm) Extended View Signals

Minimum Luminous Intensity Values (In Candelas)				
Expanded View Vertical Angle	Horizontal Angle (Left/Right)	RED	YELLOW	GREEN
+/-2.5	2.5	339	678	678
	7.5	251	501	501
	12.5	141	283	283
	17.5	77	154	154
+/-7.5	2.5	226	452	452
	7.5	202	404	404
	12.5	145	291	291
	17.5	89	178	178
	22.5	38	77	77
	27.5	16	32	32
+/-12.5	2.5	50	101	101
	7.5	48	97	97
	12.5	44	89	89
	17.5	34	69	69
	22.5	22	44	44
	27.5	16	32	32
+/-17.5	2.5	22	44	44
	7.5	22	44	44
	12.5	22	44	44
	17.5	22	44	44
	(Not Extended View) 22.5	20	41	41
	(Not Extended View) 27.5	16	32	32
+/-22.5	2.5	20	40	40
	17.5	20	40	40

Notes

1. Design signal modules to meet these requirements as a minimum throughout the warranty period.
2. Design signal modules to have a minimum initial intensity equal to 115% of Table 2 at 25°C.
3. Independent laboratory test reports are required to validate the initial intensity.



Table 1098-3

Minimum Initial and maintained Intensities for Arrow Indications (in cd/m²)

	Red	Yellow	Green
Arrow Indication	5,500	11,000	11,000

Table 1098-4

Specification for 8 inch (200 mm) Extended View Signals

Minimum Luminous Intensity Values (In Candelas) for circular indications				
Expanded View Vertical Angle	Horizontal Angle (Left/Right)	RED	YELLOW	GREEN
+/-2.5	2.5	133	267	267
	7.5	97	194	194
	12.5	57	113	113
	17.5	25	48	48
+/-7.5	2.5	101	202	202
	7.5	89	178	178
	12.5	65	129	129
	17.5	41	81	81
	22.5	18	37	37
	27.5	10	20	20
+/-12.5	2.5	37	73	73
	7.5	32	65	65
	12.5	28	57	57
	17.5	20	41	41
	22.5	12	25	25
	27.5	9	16	16
+/-17.5	2.5	16	32	32
	7.5	14	28	28
	12.5	10	20	20
	17.5	9	16	16
	(Not Extended View) 22.5	6	12	12
	(Not Extended View) 27.5	4	9	9

Notes

- Design signal modules to meet these requirements as a minimum throughout the warranty period.
- Design signal modules to have a minimum initial intensity equal to 115% of Table 4 at 25°C.
- Independent laboratory test reports are required to validate the initial intensity.

Table 1098-5

Chromaticity Standards (CIE Chart)

Red	Y: not greater than 0.308, or less than 0.998 - x
Yellow	Y: not less than 0.411, nor less than 0.995 - x, nor less than 0.452
Green	Y: Not less than 0.506 - .519x, nor less than 0.150 + 1.068x, nor more than 0.730 - x

Design the modules as retrofit replacements for installation into standard incandescent traffic sections that do not contain the incandescent lens, reflector assembly, lamp socket and lens gasket. Ensure that installation does not require special tools or physical modification for the

existing fixture other than the removal of the incandescent lens, reflector assembly, lamp socket, and lens gasket.

Provide modules that are rated for use in the operating temperature range of -40°C (-40°F) to $+74^{\circ}\text{C}$ ($+165^{\circ}\text{F}$). Ensure that the modules (except yellow) meet all specifications throughout this range. Fabricate the module to protect the onboard circuitry against dust and moisture intrusion per the requirements of NEMA Standard 250-1991 for Type 4 enclosures to protect all internal components.

Design the module to be a single, self-contained device with the circuit board and power supply for the module inside and integral to the unit.

Design the assembly and manufacturing process for the module to ensure all internal components are adequately supported to withstand mechanical shock and vibration from high winds and other sources. Wire the individual LEDs such that a catastrophic loss or the failure of one LED will result in the loss of not more than 20 percent of the signal module light output. Solder the LEDs to the circuit board.

Fabricate the lens and signal module from material that conforms to ASTM specifications. Ensure enclosures containing either the power supply or electronic components of the module are made of UL94VO flame retardant materials. The lens of the signal module is excluded from this requirement.

Permanently mark the manufacturer's name, trademark, model number, serial number, date of manufacture (month & year), and lot number as identification on the back of the module.

Permanently mark the following operating characteristics on the back of the module: rated voltage and rated power in watts and volt-amperes.

If a specific mounting orientation is required, provide permanent markings consisting of an up arrow, or the word "UP" or "TOP" for correct indexing and orientation within the signal housing.

Provide a lens that is integral to the unit with a smooth outer surface and UV stabilized to withstand ultraviolet exposure for a minimum period of 60 months without exhibiting evidence of deterioration. Coat the front of a polycarbonate lens to make it more abrasion resistant. Seal the lens to the module to prevent moisture and dust from entering the module.

Tint the red and yellow lens to match the wavelength (chromaticity) of the LED. Provide a green lens that is either colorless or tinted to match the wavelength (chromaticity) of the LED.

For 12-inch (300-mm) arrow modules, ensure that the module meets specifications stated in Section 9.01 of the ITE VTCSH for arrow indications. Design arrow displays to be solid LEDs (spread evenly across the illuminated portion of the arrow or other designs), not outlines.

Determine the luminous intensity using the CALTRANS 606 method or similar procedure.

Provide test results for ball modules from an independent testing laboratory showing wattage and compliance with ITE VTCSH-2 specifications 6.4.2, 6.4.4.1, 6.4.4.2, 6.4.4.3, 6.4.5, and 6.4.6.1 as a minimum. Ensure the 6.4.2.1 test meets the requirements of Tables 1098-2 and 4 of this specification. The 6.4.2.2 test is for Red and Green only. Ensure that the LED signal modules tested are typical, average production units.

Burn In - Energize the sample module(s) (a sample of one module minimum) for a minimum of 24 hours, at 100 percent on-time duty cycle, at a temperature of $+74^{\circ}\text{C}$ ($+165^{\circ}\text{F}$) before performing any qualification testing. Any failure of the module, which renders the unit non-

compliant with the specification after burn-in, is cause for rejection. All specifications will be measured including, but not limited to:

- (a) **Photometric (Rated Initial Luminous Intensity)** - Measure at +25°C (+77°F). Measure luminous intensity for red and green modules upon the completion of a 30 minute 100 percent on-time duty cycle at the rated voltage. **Measure luminous intensity for yellow modules immediately upon energizing at the rated voltage.**
- (b) **Chromaticity (Color)** - Measure at +25°C (+77°F). Measure chromaticity for red and green modules upon the completion of a 30 minute 100 percent on-time duty cycle at the rated voltage. Measure chromaticity for yellow modules immediately upon energizing at the rated voltage.
- (c) **Electrical** - Measure all specified parameters for quality comparison of production quality assurance on production modules. (rated power, etc)

Equipment Compatibility - In addition to the 6.4.4.5 test of modules for compatibility with controllers, conflict monitors, and load switches, perform the following test, and certify the results. Connect each signal module to the output of a standard load switch connected to a variable AC voltage supply (95 to 135 VAC). With the load switch "off," vary the AC voltage from 95 Vrms to 135 Vrms, and measure the drop across the module. Readings greater than 15 Vrms are unacceptable.

NCDOT evaluates and approves all LED Traffic Signal modules for the QPL by a standard visual inspection and blind operational survey, a compatibility test, current flow, and other random tests, in addition to reviewing the lab reports and documentation from the manufacturer. The tests are conducted at the Traffic Electronics Center in Raleigh. Ensure each 12-inch (300-mm) ball module is visible at 450 feet (135 meters) during sway conditions (extended view) until obscured by the visor. Ensure each 8-inch ball (200-mm) and 12-inch (300-mm) arrow modules are visible at 300 feet (90 meters) during sway conditions (extended view) until obscured by the visor. Sufficient luminance during the extended views will be determined during this blind survey evaluation.

In addition to meeting the performance requirements for the minimum period of 60 months, provide a written warranty against defects in materials and workmanship for the modules for a period of 60 months after shipment acceptance of the modules. Provide replacement modules within 30 days of receipt of modules that have failed at no cost to the State. Provide warranty documentation to the Department before QPL acceptance. Provide luminous intensity testing at an independent lab, to determine degradation, for two modules of each color provided by NCDOT at the end of two and four years of operation.

Provide testing at an independent laboratory for a designated module to be tested for maintained luminous intensity at 25°C (77°F) once each year during the five year warranty period.

(2) Pedestrian

Design the LED pedestrian traffic signal modules for installation into standard pedestrian traffic signal sections that do not contain the incandescent signal section reflector, lens, eggcrate visor, gasket, or socket. Provide a clear 0.25-inch (6.4-mm), non-glare, mat finish lens with a smooth outer surface and UV stabilized to withstand ultraviolet exposure for a minimum period of 60 months without exhibiting evidence of deterioration. Coat the front surface of a polycarbonate lens to make it more abrasion resistant. Ensure that the lens has light transmission properties equal to or greater than 80%.

Ensure installation of all modules requires no physical modification of the existing fixture other than the removal of the incandescent signal section reflector, lens, eggcrate visor and socket where applicable.

Design the countdown display as a double row of LEDs, and ensure the countdown display blanks-out during the initial cycle while it records the countdown time. Ensure that the countdown display is operational only during the flashing don't walk, clearance interval. Blank-out the countdown indication after it reaches zero until the beginning of the next don't walk indication, and design the controlling circuitry to prevent the timer from being triggered during the solid hand indication.

Design the man and hand to be a solid display, which meets the minimum requirements of "The Equipment and Materials Standards" of the Institute of Transportation Engineers (ITE) Chapter 3, Table 1 *Symbol Message*. Wire the LEDs such that a catastrophic loss or failure of one or more LEDs will result in the loss of not more than five percent of the signal module light output.

Ensure that the power consumption for the modules is equal to or less than the following in watts, and that the modules have EPA Energy Star compliance ratings, if applicable to that shape, size and color.

	77°F (25°C)	165°F (74°C)
Temperature		
Hand	10	12
Man	9	12
Countdown	9	12

Provide 16-inch (400-mm) displays, where required by plan or bid document, that have the hand/man overlay on the left and the countdown on the right. Ensure the hand/man meets the dimension requirements cited in Chapter 3, Table 1 *Symbol Message* for Class 3 displays. Ensure that the countdown number display is at least 7 inches high by 6 inches wide. Configure the signal head with a sufficient number of LEDs to provide an average luminous intensity of at least 342 candela per square foot (3750 candela per square meter) of lighting surface for the "RAISED HAND" and "COUNTDOWN", and 483 candela per square foot (5300 candela per square meter) of lighting surface for the "WALKING PERSON". Ensure they meet this average luminous intensity throughout the warranty period over the operating temperature range.

Provide 12 inch (300 mm) displays, where required by plan or bid document, that meet the dimension requirements cited in Chapter 3, Table 1 *Symbol Message* for Class 2 displays. Furnish three types of modules, the solid hand/man module as an overlay, the solid hand module, and the solid man module. Configure the signal head with a sufficient number of LEDs to provide an average luminous intensity of at least 342 candela per square foot (3750 candela per square meter) of lighting surface for the "RAISED HAND" and "COUNTDOWN", and 483 candela per square foot (5300 candela per square meter) of lighting surface for the "WALKING PERSON". Ensure they meet this average luminous intensity throughout the warranty period over the operating temperature range.

Design all modules to operate using a standard 3 - wire field installation. Provide lead wires that are eighteen gauge (18AWG) minimum copper conductors with 221 degree F (105 degree C) insulation. Ensure that lead wires are a minimum of 30 inches (760 mm) long with NEMA "spade" terminals that are appropriate to the lead wires and sized for a #10 screw connection to the existing terminal block in the signal head. Solder the LEDs to the circuit board.

Ensure that modules are compatible with signal load switches and conflict monitors. Design the module to provide sufficient current draw to ensure proper load switch operation while the voltage is varied from a regulated 80Vrms to 135Vrms. Provide control circuitry to prevent current flow through the LEDs in the off state to avoid a false indication. Design all modules to meet existing NCDOT monitor specifications for each of the following types of signal monitors: NEMA TS-1 conflict monitors (including so-called NEMA plus features such as dual indication detection and short yellow time detection); NEMA TS-2 Malfunction Management Units; and 170 cabinet 210ECL and 2010ECL conflict monitors (including red monitoring and so-called plus features such as dual indication detection and short yellow time detection).

Comply with the following sections: 3.3, 3.5, 3.6, 5.2, 5.3, 5.7, 6.1, 6.3.1, 6.3.3, 6.3.4, 6.3.5, 6.4.4, 6.4.5, and 6.4.6 of "The Equipment and Material Standards" of the Institute of Transportation Engineers "Vehicular Traffic Control Signal Heads" (VTCSH) Part 2, Chapter 2A.

Furnish Portland Orange LEDs for the hand and countdown that are the latest AlInGaP technology or higher, and Lunar White LEDs for the man that are the latest InGaN technology or higher.

Provide certification with the signal modules when offered for evaluation that your product complies with the sections of the ITE specification identified in paragraph 1.12 above and this specification. Provide test results showing that the signal modules meet or exceed the luminous intensity requirements of sections 1.8 and 1.9 of this specification.

Ship each module as a complete kit designed for retrofitting existing pedestrian signal sections with an LED display module. Provide modules that include, but are not limited to the following items: lens, LED display mounted on a circuit board, wire leads with strain relief, rigid housing, electronics including a power supply integral to the LED module which is protected by the housing, and a neoprene one piece gasket. Ensure that the module is compatible with standard, existing, pedestrian head mounting hardware.

Warrant performance for a period of 60 months from the date of installation and include repair or replacement of an LED signal module that exhibits light output degradation, which in the judgment of the Department, cannot be easily seen at 150 feet (45 meters) in bright sunlight with a visor on the housing or which drops below the luminous intensity output requirements. Warrant failure due to workmanship, materials, and manufacturing defects during the first 60 months after the date of installation. Repair or replace any failed modules within 30 calendar days of notification at no cost to the Department.

Page 10-227, Subarticle 1098-2(F)

Replace the first sentence in the paragraph with the following:

Furnish 16-4 and 16-7 signal cable that complies with IMSA specification 20-1 except provide the following conductor insulation colors:

- For 16-4 cable: white, yellow, red, and green
- For 16-7 cable: white, yellow, red, green, yellow with black stripe tracer, red with black stripe tracer, and green with black stripe tracer. Apply continuous stripe tracer on conductor insulation with a longitudinal or spiral pattern.

Provide a ripcord to allow the cable jacket to be opened without using a cutter. IMSA specification 19-1 will not be acceptable.

1.3. Wood Poles (1098-6)

Page 10-228, Article 1098-6

Replace the entire article with the following:

Provide poles of treated southern pine or treated Douglas fir that meet the requirements of ANSI 05.1. Provide Class 3 or better wood poles that are a minimum length of 40 feet (12.2 meters) unless otherwise shown on the plans and are of a sufficient length to maintain minimum required distances above the roadway, obstructions and affected railroad tracks. Mark each pole in accordance with ANSI 05.01. First roof and bore poles and then give them a full-length preservative treatment.

Provide poles with pentachlorophenol or chromated copper arsenate (CCA) preservative, in accordance with AWWA Standard C4-99. Ensure the retention of preservative is a minimum of 0.45 lb. per cubic foot (7.2 kg per cubic meter) for pentachlorophenol and 0.6 lb. per cubic foot (9.6 kg per cubic meter) for CCA.

1.4. Guy Assemblies (1098-7)

Page 10-228, Article 1098-7

Add the following to paragraph two:

Anchor assemblies with double-strand eyes may be used in lieu of those with the tripeye feature when only one guy cable is to be attached. Ensure anchor assemblies are 7 feet (2.13 meters) minimum in length.

1.5. Loop Lead-In Cable (1098-9)

Page 10-230, Article 1098-9

Replace the entire article with the following:

Furnish lead-in cable with conductors of size 18 AWG that are fabricated from stranded copper, and that complies with IMSA Specification 50-2 except as follows:

- Provide the following two pair (4 conductor) conductor insulation pair colors: clear-brown and blue-pink.
- Provide the following four pair (8 conductor) conductor insulation pair colors: clear-brown, blue-pink, clear with black stripe tracer-brown with black stripe tracer, and blue with black stripe tracer-pink with black stripe tracer. Apply continuous stripe tracer on conductor insulation with a longitudinal or spiral pattern.
- Ensure one spirally-wrapped Aluminum Mylar tape is applied with the aluminum side out to completely cover the conductor assembly.
- Provide cable jacket formed from black polyethylene. Ensure the finished jacket provides environmental stress resistance, outdoor weatherability, toughness, low temperature performance, and ultraviolet resistance.
- Provide a ripcord to allow the cable jacket to be opened without using a cutter.

1.6. Fiber-optic Cable (1098-11)

Page 10-233, Subarticle 1098-11(A)

In paragraph 3, sentence 5, delete "Construct buffer tubes with an inner layer made of polycarbonate and an outer layer made of polyester."

1.7. Pedestals (1098-17)

Page 10-239, Article 1098-17



In paragraph 5, last sentence, revise “1/2 inch (2 mm) minimum diameter” to “1/2 inch (12.5 mm) minimum diameter.”

Page 10-240, Article 1098-17

In paragraph 1, revise “18 inch (455 mm)” to “36 inches (900 mm)”.

1.8. Type 170E Controllers (1098-18)

Page 10-240, Article 1098-18

Delete the second paragraph.

1.9. Type 170E Cabinets (1098-19)

Page 10-241, Subarticle 1098-19(B)

Add the following paragraphs:

If additional surge protected power outlets are needed to accommodate fiber transceivers, modems, etc.; install a UL listed, industrial, heavy-duty type power outlet strip with a maximum rating of 15 A / 125 VAC, 60 Hz. Provide a strip that has a minimum of 3 grounded outlets. Ensure the power outlet strip plugs into one of the controller unit receptacles located on the rear of the PDA. Ensure power outlet strip is mounted securely; provide strain relief if necessary.

Connect detector call switches for cabinets as follows:

336S Cabinet		332A Cabinet	
Detector Call Switches	Terminals	Detector Call Switches	Terminals
Phase 1	I1-F	Phase 1	I1-W
Phase 2	I2-F	Phase 2	I4-W
Phase 3	I3-F	Phase 3	I5-W
Phase 4	I4-F	Phase 4	I8-W
Phase 5	I5-F	Phase 5	J1-W
Phase 6	I6-F	Phase 6	J4-W
Phase 7	I7-F	Phase 7	J5-W
Phase 8	I8-F	Phase 8	J8-W

Pages 10-245-247, Subarticle 1098-19 (D) (**Model 2010 Enhanced Conflict Monitor**)

Replace Subarticle (D) with the following:

Furnish Model 2010 Enhanced Conflict Monitors with 16 channels. In addition to CALTRANS requirements, ensure that the conflict monitor monitors for the absence of a valid voltage level on at least one channel output of each load switch. Ensure that the absence of the programming card will cause the conflict monitor to trigger, and remain in the triggered state until reset.

Provide a conflict monitor that recognizes the faults specified by CALTRANS and the following additional per channel faults that apply for monitor inputs to each channel:

- consider a Red input greater than 70 Vrms as an “on” condition;
- consider a Red input less than 50 Vrms as an “off” condition (no valid signal);
- consider a Red input between 50 Vrms and 70 Vrms to be undefined by these specifications;
- consider a Yellow or Green input greater than 25 Vrms as an “on” condition;

- consider a Green or Yellow input less than 15 Vrms as an “off” condition; and
- consider a Green or Yellow input between 15 Vrms and 25 Vrms to be undefined by these specifications.

Ensure that the monitor will trigger upon detection of a fault and will remain in the triggered (failure detected) state until the unit is reset at the front panel or through the remote reset input for the following failures:

1. **Red Monitoring or Absence of Any Indication (Red Failure):** A condition in which no valid voltage signal is detected on any of the green, yellow, or red inputs to a given monitor channel. If a signal is not detected on at least one input (R, Y, or G) of a conflict monitor channel for a period greater than 1000 ms when used with a 170 controller and 1500 ms when used with a 2070L controller, ensure that the monitor will trigger and put the intersection into flash. If the absence of any indication condition lasts less than 750 ms when used with a 170 controller and 1200 ms when used with a 2070L controller, ensure that the conflict monitor will not trigger. Have red monitoring occur when the P20 Connector is installed and both of the following input conditions are in effect: a) the Red Enable input to monitor is active (Red Enable voltages are “on” at greater than 70 Vrms, off at less than 50 Vrms, undefined between 50 Vrms and 70 Vrms), and b) and neither Special Function 1 nor Special Function 2 inputs are active.
2. **Yellow Indication Sequence Error:** Yellow indication following a green is missing or shorter than 2.7 seconds (with ± 0.1 -second accuracy). If a channel fails to detect an “on” signal at the Yellow input following the detection of an “on” signal at a Green input for that channel, ensure that the monitor triggers and generates a sequence error fault indication.
3. **Dual Indications on the Same Channel:** In this condition, more than one indication (R,Y,G) is detected as “on” at the same time on the same channel. If dual indications are detected for a period greater than 500 ms, ensure that the conflict monitor triggers and displays the proper failure indication (Dual Ind fault). If this condition is detected for less than 250 ms, ensure that the monitor does not trigger.

Enable the monitor function for short/missing yellows and for dual indications on a per channel basis.

Provide Special Function 1 and Special Function 2 that comply with the Los Angeles City DOT Traffic Signal Specification DOT 170 ATSAC Universal and Related Equipment #54-053-02 to eliminate red failure monitoring while allowing other additional enhanced fault monitoring functions to continue.

Ensure that the removal of the P-20 ribbon cable will cause the monitor to recognize a latching fault condition and place the cabinet into flashing operation.

Ensure that when the Conflict Monitor is triggered due to a fault, it provides an LED indication identifying the type of failure detected by the monitor except for the P20 ribbon cable removal fault. Ensure that the monitor indicates which channels were active during a conflict condition and which channels experienced a failure for all other per channel fault conditions detected, and that these indications and the status of each channel are retained until the Conflict Monitor is reset.

Ensure that the conflict monitor will store at least nine of the most recent malfunctions detected by the monitor in EEPROM memory. For each malfunction, record at a minimum the time, date, type of malfunction, relevant field signal indications, and specific channels involved with the malfunction.

Provide communications from the monitor to the 170/2070L controller via an RS-232C/D port on the monitor in order to upload all event log information from the monitor to the controller or to a Department-furnished system computer via the controller. Ensure that the controller can receive the data through a controller Asynchronous Communications Interface Adapter (Type 170E) or Async Serial Comm Module (2070L) determined by the controller software. Provide software capable of communicating directly through the same monitor RS-232C/D to retrieve all event log information to a Department-furnished laptop computer.

In addition to the connectors required by the CALTRANS Specifications, provide the conflict monitor with a connector mounted on the front of the monitor (3M-3428-5302 with two polarizing keys or equal) which mates with a 20 pin ribbon cable connector that conducts the signals from the P20 connector on the cabinet assembly. Provide a P20 connector and terminal assembly that complies with the Los Angeles City DOT "Traffic Signal Specification DOT 170 ATSAC Universal and Related Equipment #54-053-02" in effect on the date of advertisement. Provide connector pins on the monitor with the following functions:

Pin #	Function	Pin #	Function
1	Channel 15 Red	11	Channel 9 Red
2	Channel 16 Red	12	Channel 8 Red
3	Channel 14 Red	13	Channel 7 Red
4	Chassis Ground	14	Channel 6 Red
5	Channel 13 Red	15	Channel 5 Red
6	Special Function 2	16	Channel 4 Red
7	Channel 12 Red	17	Channel 3 Red
8	Special Function 1	18	Channel 2 Red
9	Channel 10 Red	19	Channel 1 Red
10	Channel 11 Red	20	Red Enable

Provide a DB-9 female connector for the purpose of data communication with the controller. Electrically isolate the port interface electronics from all monitor electronics, excluding Chassis Ground. Furnish a communications connecting cable with pin connections as follows:

170		Conflict Monitor DB-9
RX pin L	Connect to	TX pin 2
TX pin K	Connect to	RX pin 3
+5 pin D	Connect to	DTR pin 4
GND pin N	Connect to	GND pin 5

2070L		Conflict Monitor DB-9
DCD pin 1	Connect to	DCD pin 1
RX pin 2	Connect to	TX pin 2
TX pin 3	Connect to	RX pin 3
GND pin 5	Connect to	GND pin 5
RTS pin 7	Connect to	CTS pin 7
CTS pin 8	Connect to	RTS pin 8

Pages 10-247, Subarticle 1098-19(E)

Replace Subarticle (E) with the following:

Furnish external electrical service disconnects with a single pole 50 ampere circuit breaker with a minimum of 10,000 RMS symmetrical amperes short circuit current rating in a lockable NEMA 3R enclosure. Ensure service disconnects are UL listed and marked as being suitable for use as service equipment. Fabricate enclosure from galvanized steel and electrostatically apply dry powder paint finish, light gray in color, to yield a minimum thickness of 2.4 mils (60 μm). Provide ground bus and neutral bus with a minimum of four terminals with a minimum wire capacity range of number 14 through number 4.

Furnish a NEMA Type 3R outdoor enclosure, 100 Ampere rated meter base. Furnish a 4 terminal, 600 volt, single phase, 3 wire meter base that complies with the following:

- Line, Load, and Neutral Terminals accept #8 to 2/0 AWG Copper/Aluminum wire
- Ringless Type without bypass
- Made of galvanized steel
- Meet the UL-414 standard
- Overhead and underground service entrance

Provide meter bases in which the ampere rating of the meter sockets are based on the meter sockets being wired with a minimum of 167 degrees F (75 degrees C) insulated wire. Ensure that the meter bases have an electrostatically applied dry powder paint finish, light gray in color, with a minimum thickness of 2.4 mils (60 μm).

Furnish 1-inch (25-mm) watertight hub for threaded rigid conduit with meter base.

If meter base and electrical service disconnect are supplied in the same enclosure, ensure assembly is UL listed and marked as being suitable for use as service equipment.

2. 2002 STANDARD SPECIFICATIONS FOR ROADS & STRUCTURES – SECTION 1700 REVISIONS

The 2002 Standard Specifications are revised as follows:

2.1. General Requirements (1700)

Page 17-1, Subarticle 1700-3 (C), replace the 3rd paragraph with the following paragraph:

The Department will be responsible for direct payment of monthly utility company usage charges. The Contractor will be responsible for all expenses associated with utility installation costs, hookups, etc.

Page 17-2, Subarticle 1700-3 (D), add the following paragraph:

Except for damages and malfunctions caused by the contractor's work activities, the contractor will not be held responsible for pre-existing conditions that were reported to the Engineer before starting traffic signal work at the specific intersection. The contractor will assume responsibility for all maintenance and emergency services necessary once traffic signal work has begun at the specific intersection, and for all damages and malfunctions caused either directly or indirectly by the contractor's work activities.

In the event the contractor fails to perform in accordance with the plans and specifications within the time frame specified, the Department reserves the right to perform the maintenance and emergency service necessary to assure continuous traffic signal operation. Further, all expenses incurred by the Department in implementing this option will be deducted from the payment due the contractor, plus a \$2,500 liquidated damage per occasion, per day, or any portion thereof, until corrected. The liquidated damages are due to increased public hazard resulting from the malfunction.

Page 17-2, Subarticle 1700-3 (F)

In paragraph 2, sentence 2, delete “type 1.”

Page 17-3, Subarticle 1700-3 (J)

In paragraph 2, sentence 2, revise “detectable metallic burial tape” to “marker tape.”

Page 17-3, Article 1700-3, add Subarticle (K) to read as follows:

(K) Electrical Bonding

Using an approved termination means, connect a Number 14 AWG min. 19-strand copper conductor (Type THW) with green insulation to serve as an equipment grounding conductor to metal poles with mast arm supports, vehicular and pedestrian signal pedestals, and other metallic components which are not otherwise bonded through means approved by the Engineer.

2.2. Messenger Cable (1710)

Page 17-6, Article 1710-3

In paragraph 5, revise “provide a minimum of 30 feet (9.1 m)” to “provide a minimum of 27 feet (8.2 m)”.

2.3. Underground Conduit (1715)

Page 17-8, Subarticle 1715-3(A)

Add the following paragraph:

Install metallic conduit at all locations where conduits traverse railroad tracks or as shown on the plans. For all other locations, install nonmetallic conduit unless otherwise shown on the plans. Backfill with excavated material and compact to 95% of its original density. Remove any rock and debris from backfill material.

Page 17-8, Subarticle 1715-3(C)

Delete the first paragraph.

Page 17-8, Subarticle 1715-3(D)

Replace reference to Article 342-3 with reference to Article 1540-3 (A&B).

Page 17-8, Subarticle 1715-3(E)

Revise the last sentence to:

Label all tracer wires. Terminate tracer wire to equipment ground bus as specified in the plans.

2.4. Wood Poles (1720)

Page 17-10, Article 1720-3

Replace the fourth paragraph with the following paragraph:

On joint use poles and NCDOT owned poles, at signal and intelligent transportation systems equipment installations (i.e. controller cabinets, CCTV cabinets, DMS cabinets, etc.), bond the messenger cable to the existing pole ground using burndy clamps at each end and at 1300-foot intervals. On multiple messenger cable arrangements, connect all messenger cable ends with #6 solid bare copper wire and bond with split bolt connectors or burndy clamps (UCG25RS) or equivalent. On joint use and NCDOT owned poles, if an existing pole ground does not exist, install a grounding system consisting of a #6 AWG bare copper wire that is exothermically welded to a ground rod.

In the last paragraph, last sentence, revise “5/8 inch x 8 foot (16 mm x 2.4 m) ground rod” to “5/8 inch x 10 foot (16 mm x 3.0 m) ground rod.”

2.5. Riser Assemblies (1722)

Page 17-12, Article 1722-3

In paragraph 4 add the following after the last sentence:

Install conduit on all risers for lead-in cable.

2.6. Inductive Detection Loops (1725)

Page 17-13, Article 1725-3

Add the following paragraph before paragraph 1:

All work performed in this section must be done in the presence of the Engineer.

Replace paragraph 6 with the following:

Before sealing loop conductors, test that impedance from the loop wire to ground is at least 100 megohms. For each location with inductive loops, submit a completed “Inductive Detection Loop & Grounding Test Results” form and place copy in controller cabinet. Ensure all loops are included on form. The form is located on the Department’s website at:

<http://www.ncdot.org/doh/preconstruct/traffic/tmssu/ws/default.htm>

2.7. Loop Lead-In Cable (1726)

Page 17-14, Article 1726-3

Replace paragraph 1 with the following:

Install lead-in cable.

Delete paragraph 3.

In paragraph 4, delete “type 1.”

In paragraph 6, revise “less than 0.0036 ohms per foot (0.012 ohms per meter)” to “less than 0.00885 ohms per foot (0.0295 ohms per meter).”

Page 17-15, Article 1726-4

Replace the last sentence with the following:

No measurement will be made between 2-pair and 4-pair lead-in cable as this will be considered incidental to furnishing and installing lead-in cable.

2.8. Signal Pedestals (1743)

Page 17-25, Article 1743-3

Delete paragraph 10.

2.9. Controllers with Cabinets (1751)

Page 17-34, Subarticle 1751-3(A)

In paragraph 3, replace sentence 2 with the following:

For all other installations, do not program the controller for late night flashing operation unless otherwise directed.

Page 17-34, Subarticle 1751-3(B)

Add the following paragraph after the first paragraph:

Program telemetry command sequences and enable devices necessary for testing of communication between local controllers and field master controllers, and between field master controllers and the Department-furnished central computer.

Page 17-34, Article 1751-4

Replace paragraph 2 with the following:

Actual number of each type of detector cards (2-channels) furnished, installed, and accepted. If 4-channel detector cards are used in order to fulfill the requirements of the plans, payment will be allowed for two detector cards for each 4-channel detector card.

In paragraph 3, revise "No measurement will be made..." to include "modems and meter bases."

Page 17-35, Article 1751-5

Replace paragraph 2 with the following:

The quantity of detector cards, measured as provided above, will be paid for at the contract unit price each for "Detector Card (____)."

In paragraph 3, revise "Detector Channel" to "Detector Card."

3. GENERAL REQUIREMENTS

Comply with the requirements of Division 17 of the 2002 Standard Specifications for Roads and Structures.

4. ELECTRICAL REQUIREMENTS

Ensure that an IMSA certified, or equivalent, Level II traffic qualified signal technician is standing by to provide emergency maintenance services whenever work is being performed on traffic signal controller cabinets and traffic signal controller cabinet foundations. Stand by status is defined as being able to arrive, fully equipped, at the work site within 30 minutes ready to provide maintenance services.

5. SIGNAL HEAD SPECIAL FEATURES

5.1. DESCRIPTION

Furnish and install signal head hardware in accordance with the plans and specifications.

5.2. MATERIALS

A. Optically-Programmed Vehicle Signal Sections:

Material, equipment, and hardware furnished under this section must be pre-approved on the Department's QPL by the date of installation.

Design the programmable signal sections to tilt in two degree increments for a maximum of ten degrees above and ten degrees below horizontal, while still maintaining a common vertical axis.

Design the programmable signal sections to mount to standard signal sections to form a signal head. Ensure that the programmable signal sections have a mounting system compatible with the standard 1.5-inch (41-mm) traffic signal fittings.

Provide an optical system consisting of a lamp, a diffuser, an optical limiter, and an objective lens. Ensure that all programming is accomplished optically with no hoods or louvers necessary to accomplish the programming. Provide optical masking tape with each section.

Provide a 150-Watt, 115 VAC lamp with integral reflector and rated output of 1750 lumens. Ensure that the average rated life is at least 6000 hours.

Provide a high resolution, annular, incremental lens. Ensure that the lens and door are sealed to provide a moisture and dust proof seal. Provide a red, yellow, or green ball or arrow indication as specified by the bid list, plans, or purchase order.

5.3. CONSTRUCTION METHODS

A. Optically-Programmed Vehicle Signal Sections:

Install vehicle signal heads with optically programmed vehicle signal sections so that movement of the vehicle signals head is restricted. Tightly tether vehicle signal heads at the top and bottom when installed on messenger cable. Attach vehicle signal heads using a mounting-bracket assembly that locks the vehicle signal head into position from the back and restricts movement when installed on mast arms.

5.4. MEASUREMENT AND PAYMENT

Actual number of vehicle signal heads with a single optically programmed section furnished, installed, and accepted.

Payment will be made under:

Vehicle Signal Head with Single Optically-Programmed SectionEach

6. DIRECTIONAL DRILLING

6.1. DESCRIPTION

Furnish and install conduit and all necessary hardware by using the horizontal directional drilling method in accordance with the plans and specifications.

6.2. MATERIALS

A. General:

Provide conduit that is suitable for underground use in an ambient temperature range of -30 to 130 degrees F (-35 to 55 degrees C) without degradation of material properties.

Provide conduit that is resistant to benzene, calcium chloride, ethyl alcohol, fuel oil, gasoline, lubricating oil, potassium chloride, sodium chloride, sodium nitrate, and transformer oil, and is protected against degradation due to oxidation and general corrosion.

Provide conduit with an outer diameter to minimum wall thickness ratio that complies with ASTM-D3035, Standard Dimension Ratio (SDR) 13.5.

Provide conduit that meets or exceeds the following:

ASTM-D638	Tensile Strength - 3,000 psi (20 Mpa), minimum
	Elongation - 400 percent, minimum
ASTM-D1238	Melt Index - 0.4 maximum
ASTM-D1505	Density - (0941-0955 g/cc)
ASTM-D1693	Condition B - 20 percent failure, maximum
ASTM-D2444	Impact - NEMA Standards Publication Number TC7
ASTM-D3350	Cell classification - 334420 or 344420

Furnish conduits with a coefficient of friction of 0.09 or less in accordance with Belcore GR-356.

Dependent upon the number of conduits required, furnish conduits in black, orange, blue and white colors. Provide conduits that are factory extruded with the appropriate colors.

Furnish ½-inch (12.7-mm), prelubricated, woven polyester tape, pull line with a minimum rated tensile strength of 2,500 lb (11 kN).

B. Polyethylene Conduit:

Furnish factory lubricated, low friction, coilable conduit constructed of virgin high-density polyethylene (HDPE). Furnish conduits with inside diameter as required by the plans. Provide conduit with a smooth outer wall and ribbed inner wall and ensure the conduit is capable of being coiled on reels in continuous lengths, transported, stored outdoors, and subsequently uncoiled for installation without affecting its properties or performance.

Furnish duct plugs that provide a watertight barrier when installed in an unused conduit. Furnish duct plugs sized in accordance with the conduit furnished. Provide duct plugs that are removable.

Furnish mechanical sealing devices that provide a watertight barrier between the conduit and communications cable. Furnish mechanical sealing devices sized in accordance with the conduit furnished and with appropriately sized holes for the communications cable. Provide mechanical sealing devices that are removable.

6.3. CONSTRUCTION METHODS

A. Pre-Approvals and Minimum Depth Requirements:

Obtain the Engineer's approval before beginning drilling operations.

At all points where the proposed conduit will traverse under city streets, state roads, driveways, sidewalks, and/or "Controlled Access Areas" including entrance/exit ramps, ensure the conduit maintains a minimum depth of 4 feet (1.2 meters) or 8 times the back reamer's diameter, whichever is deeper. For an installation that runs parallel to a controlled access area or entrance and exit ramps ensure the conduit maintains a minimum depth of 30 inches (760 mm) below grade. Maintain a minimum clearance of 30 inches (760 mm) below grade when crossing ditch lines. For the following man-made structures, the minimum clearance requirements are shown in the table below:

Man-made Structure	Minimum Clearance Requirement
Bridge foundation	5' (1.5 m) horizontal & 4' (1.2 m) vertical (clearances greater than minimum horizontal should continue to use the 4V:5H ratio, i.e., 10' horizontal should be no deeper than 8')
Drainage pipes less than 60"	1' (0.3 m) above or below [while maintaining a minimum depth of 30" (760 mm) below grade]
Drainage pipes greater than 60"	1' (0.3 m) above or 4' (1.2 m) below [while maintaining a minimum depth of 30" (760 mm) below grade]
Box Culverts	1' (0.3 m) above or 4' (1.2 m) below [while maintaining a minimum depth of 30" (760 mm) below grade]
Slope protection	2' (0.6 m) below
Slope protection foundation footing	5' (1.5 m) below

Guarantee the drill rig operator and digital walkover locating system operator are factory-trained to operate the make and model of the equipment provided and have a minimum of one year's experience operating the make and model of drill rig. Submit written documentation of the operators' training and experience for review by the Engineer at least two weeks before beginning directional drilling operations.

Provide a means of collecting and containing drilling fluid/slurry that returns to the surface such as a slurry pit. Provide measures to prevent drilling fluids from entering drainage ditches and storm

sewer systems. Prevent drilling fluid/slurry from accumulating on or flowing onto sidewalks, other pedestrian walkways, driveways or streets. Immediately remove any drilling fluids/slurry that is accidentally spilled.

B. Directional Drill Operations:

Provide grounding for the drill rig in accordance with the manufacturer's recommendations.

Place excavated material near the top of the working pit and dispose of as required. Backfill pits or trenches excavated to facilitate drilling operations immediately after the drilling has been completed.

Use a drill head suitable for the type of material being drilled and sized no more than 2 inches (50 mm) larger than the outer diameter of the conduit to be installed. Direct the drill head as needed to obtain the proper depth and desired destination. Pressure grout with an approved bentonite/polymer slurry mixture to fill any voids. Do not jet alone or wet bore with water.

During each drilling operation, locate the drill head every 10 feet (3 meters) along the drill path and before traversing any underground utility or structure. Use the digital walkover locating system to track the drill head during the directional drilling operation. Ensure the locating system is capable of determining the pitch, roll, heading, depth and horizontal position of the drill head at any point. Unless otherwise approved, do not deviate from the proposed line and grade by more than two percent.

Once the drill head has reached its final location, remove the head, and install a reamer of appropriate size (no more than 2 inches (50 mm) larger than the outer diameter of the ducts) to simultaneously facilitate back drilling of the drill hole and installation of the conduit. The reamer is sized larger than the actual conduits to ensure the conduits are not subjected to extraneous deviations caused by the original drill operation and are as straight as possible in their final position.

The intent of these specifications is to limit the diameter of the actual drill shaft/hole such that it is no more than 2 inches (50 mm) larger than the conduit outer diameter. The 2-inch (50-mm) larger diameter can be accomplished during the original bore or during the back reaming/conduit installation process.

Once the physical installation of the conduit has started, continue performing the installation without interruption to prevent the conduit from becoming firmly set. Ensure the bentonite/polymer slurry mixture is applied as the conduit installation process is occurring.

Upon completion of the conduit installation perform a mandrel test on the conduit system to ensure that no conduit has been damaged. Furnish a non-metallic mandrel having a diameter of approximately 50% of the inside diameter of the conduit in which it is to be pulled through. If damage has occurred, replace the entire length of conduit.

Extend the ends of the conduit such that upon completion of the installation the conduit will extend a minimum of 2 inches (50 mm) above concrete surfaces and 4 inches (100 mm) above crushed stone bases.

C. Drilling Fluids:

Furnish and use lubrication for subsequent removal of material and immediate installation of the pipe. The use of water and other fluids in connection with the directional drilling operation will be permitted only to the extent necessary to lubricate cuttings. Do not jet alone or wet bore with water. Use a drilling fluid/slurry consisting of at least 10 percent high-grade bentonite to consolidate excavated material and seal the walls of the drill hole.

Transport waste drilling fluid/slurry from the site and dispose of such slurry in a method that complies with Local, State and Federal laws and regulations.

D. Splicing of the Conduit:

Do not splice or join sections of conduit. Upon approval, a junction box may be installed at locations where splicing or coupling of the conduit is necessary due to problems encountered with the installation.

E. Duct Plugs and Mechanical Sealing Devices:

Following the installation of the conduit where the communications cable is not immediately installed use a duct plug to seal the ends of the conduit. Secure the pull line to the duct plug in such a manner that it will not interfere with the installation of the duct plug and provide a watertight seal.

In conduits containing communications cable, seal the conduit with an approved mechanical sealing device. Ensure the installation provides a watertight seal.

F. Plan of Record Drawings:

Upon completion of the drilling operation and conduit installation furnish the Engineer with a plan of record profile drawing and a plan drawing for the drilled conduit showing the horizontal and vertical locations of the installed conduit.

6.4. MEASUREMENT AND PAYMENT

Measured horizontal linear feet (meters) of directionally drilled polyethylene conduit furnished, installed and accepted. Measurement of the drill path will be from point-to-point horizontally along the approximate centerline.

As examples, an installation of a single 1.25” HDPE conduit would be paid as:

Directional Drill Polyethylene Conduit, (1.25”)(1)Linear Foot (Meter)

An installation of two 1.25” and four 2” HDPE conduits would be paid as:

Directional Drill Polyethylene Conduit, (1.25”)(2)&(2”)(4)Linear Foot (Meter)

No additional payment will be made for vertical and horizontal sweeps, excavation of drill pits, backfill, site restoration, seeding and mulching, removal of excess material, duct organizers, mechanical sealing devices, duct plugs, pulling lubricants, mandrel test, and plan of record drawings, as these will be considered incidental to the directional drill and/or conduit installation.

Payment will be made under:

Directional Drill Polyethylene Conduit, (Size)(Qty)Linear Foot (Meter)

7. UNDERGROUND POLYETHYLENE CONDUIT

7.1. DESCRIPTION

Furnish and install underground polyethylene conduit systems with all necessary hardware in accordance with the plans and specifications.

7.2. MATERIALS

Furnish factory lubricated, low friction, coilable, conduit constructed of virgin high-density polyethylene (HDPE). Furnish conduits with nominal diameter as required by the plans. Provide individual conduits with smooth outer walls and ribbed inner walls and ensure the conduit is capable of being coiled on reels in continuous lengths, transported, stored outdoors, and subsequently uncoiled for installation without affecting its properties or performance.

Provide conduit that is suitable for underground use in an ambient temperature range of – 30 to 130 degrees F (-35 to 55 degrees C) without degradation of material properties.

Provide conduit that is resistant to benzene, calcium chloride, ethyl alcohol, fuel oil, gasoline, lubricating oil, potassium chloride, sodium chloride, sodium nitrate, and transformer oil, and is protected against degradation due to oxidation and general corrosion.

Provide conduit with an outer diameter to minimum wall thickness ratio that complies with ASTM-D3035, Standard Dimension Ratio (SDR) 13.5.

Provide conduit that meets or exceeds the following:

ASTM-D638	Tensile Strength - 3,000 psi (20 Mpa), minimum Elongation - 400 percent, minimum
ASTM-D1238	Melt Index - 0.4 maximum
ASTM-D1505	Density - (0941-0955 g/cc)
ASTM-D1693	Condition B - 20 percent failure, maximum
ASTM-D2444	Impact - NEMA Standards Publication Number TC7
ASTM-D3350	Cell classification - 334420 or 344420

Furnish conduits with a coefficient of friction of 0.09 or less in accordance with Belcore GR-356.

Dependent upon the number of conduits required, furnish conduits in black, orange, blue and white colors. Provide conduits that are factory extruded with the appropriate colors.

Furnish conduit organizers at all points where multiple conduits enter and exit a junction box or cabinet. Furnish conduit organizers that are appropriately sized with regards to the conduits. Provide conduit organizers that are removable.

Furnish duct plugs that provide a watertight barrier when installed in an unused conduit. Furnish duct plugs sized in accordance with the conduit furnished. Provide duct plugs that are removable.

Furnish mechanical sealing devices that provide a watertight barrier between the conduit and communications cable. Furnish mechanical sealing devices sized in accordance with the conduit furnished and with appropriately sized penetration holes for the communications cable. Provide mechanical sealing devices that are removable.

Furnish conduit spacers to bind the individual conduits together when installed in a common trench. Furnish conduit spacers that are appropriately sized with regards to the conduits.

Furnish ½-inch (12.7-mm), prelubricated, woven polyester tape, pull line with a minimum rated tensile strength of 2,500 lb (11 kN) in all conduit.

Furnish non-detectable underground marker tape with the wording "WARNING -- Fiber Optic Cable" in all trenches.

7.3. CONSTRUCTION METHODS

A. General:

Pull the tracer wire simultaneously with the fiber-optic communications cable in a continuous length. When multiple pulls of fiber-optic cable are required, only one tracer wire is required. Where tracer wire is spliced, provide waterproof butt splices. Splicing is allowed only in cabinets and junction boxes. Label all tracer wires. Terminate tracer wire to equipment ground bus as specified in the plans.

In non-used/spare conduits, seal each end of the conduit with a duct plug. Secure each end of the pull line to the duct plug before installing the duct plug. Ensure that the placement of the pull line does not interfere with the installation of the duct plug and provides a watertight seal.

In conduits containing communications cable, seal the conduit with an approved mechanical sealing device. Ensure the installation provides a watertight seal.

For underground polyethylene conduit installations (trenched or plowed), backfill in accordance with Article 300-7 of the Standard Specifications.

B. Underground Polyethylene Conduit Installation in Trench:

Install underground polyethylene conduit system along the route of the trench. Install conduit organizers at points where multiple conduits enter or exit the junction box or cabinet, etc.

Maintain a minimum trench depth of 30 inches (760 mm) below finished grade or 6 inches (150 mm) below roadway subgrade, whichever is deeper.

Install longitudinal runs of conduit at a minimum of 1 foot (300 mm) from the back of curb or 6 feet (1.8 m) from the edge of pavement in the absence of curb.

Use one common trench with approved conduit spacers to bind the individual conduits together at no more than every 50 feet (15 meters). Install the non-detectable marker tape approximately 15 inches (380 mm) below the finished grade.

Extend the ends of the conduits such that upon completion of the installation the conduits will extend a minimum of 2 inches (50 mm) above concrete surfaces and 4 inches (100 mm) above crushed stone bases.

Remove all rock and debris from backfill material. Remove excess material from the site and compact the excavation according to Article 300-7 of the Standard Specifications.

Finish unpaved areas flush with the surrounding natural ground. Restore damaged grassed areas. Seed and mulch within 7 days after the occurrence of the damage.

Finish paved areas with materials matching the damaged area within 7 days of the occurrence of the damage. Cut neatly and replace only the width of the trench for damages caused by trenching. Place graded stone material to temporarily maintain traffic where repairs cannot be performed immediately. Comply with Section 545 of the Standard Specifications.

Backfill the trench at locations along the trench path where non-movable objects, such as rocks and boulders, cannot be avoided, thus causing a deviation in the elevation height of the underground polyethylene conduit system. The purpose of the backfill is to provide a gradual change in the elevation of the trench, from the bottom elevation to the highest point of the obstruction such that excessive bending and stress will not be transferred to the conduits once the underground polyethylene conduit system is installed.

After the installation of the conduits and upon completion of the tamping and backfill process, perform a mandrel test on each individual conduit to ensure that no conduit has been damaged. Furnish a non-metallic mandrel having a diameter of approximately 50% of the inside diameter of the conduit in which it is to be pulled through. If damage has occurred replace the entire length of conduit.

C. Underground Polyethylene Conduit Installation by Plowing:

Direct plow the number of HDPE ducts called for in the plans simultaneously using chute plow method. Direct plow ducts at a minimum depth such that the top of the highest duct is 30 inches (760 mm) deep unless otherwise approved by the Engineer.

Use equipment that is of a sufficient size and horsepower to accommodate the chute plowing of up to 4 reels of duct to the depth called for in these Project Special Provisions. Do not exceed reel dimensions, burial depths, and weight limits called for by the equipment manufacturer. Follow all procedures required or recommended by the equipment manufacturer.

Provide sufficient personnel to feed chute, operate prime mover and equipment carrying reels (if separate equipment is used), observe chute feeding, observe plowing, and observe reel payout. Use chute with adequate dimensions to allow for passage of duct and cable without damage to either.

During the plow operation, continuously check the chute opening and path to be sure there are no obstructions and monitor the payout reels to be sure that the reels are turning at a steady rate.

D. Splicing of Underground Polyethylene Conduits:

Splicing or joining of underground polyethylene conduits is prohibited. With the Engineer's approval, install a junction box at all locations where splicing or coupling of the underground polyethylene conduits is necessary due to problems encountered with the installation method.

E. Plan of Record Drawings:

Upon completion of the underground polyethylene conduit system installation, furnish the Engineer with a plan of record profile drawing and plan drawing showing the horizontal and vertical locations of the installed conduit system.

7.4. MEASUREMENT AND PAYMENT

Measured horizontal linear feet (meters) of each HDPE system (containing the individual conduit called for in the plans) that is furnished, installed underground (via plowed and/or trench and backfill), and accepted. Measurement of the HDPE conduit system will be from point-to-point horizontally along the approximate centerline.

As examples, an installation of a single 2" HDPE conduit would be paid as:

Underground Polyethylene Conduit, (2")(1)Linear Foot (Meter)

An installation of three 1.25" and two 2" HDPE conduits would be paid as:

Underground Polyethylene Conduit, (1.25")(3)&(2")(2)Linear Foot (Meter)

Vertical segments will not be paid for as these will be considered incidental to the installation of the conduit system.

No additional payment will be made for trenching (paved or unpaved), seeding and mulching, removal of excess material, furnishing and placing incidental stone, furnishing and placing paved material, marker tape, pull lines, mechanical sealing devices, duct plugs, pulling lubricants, conduit organizers, mandrel test, and plan of record drawings, as they will be considered incidental.

Payment will be made under:

Underground Polyethylene Conduit, (Size)(Qty)Linear Foot (Meter)

8. FIBER-OPTIC SYSTEM SUPPORT EQUIPMENT

8.1. DESCRIPTION

Furnish fiber optic system support equipment with all necessary hardware in accordance with the plans and specifications. Comply with the provisions of section 1700.

8.2. MATERIALS

A. MMFO Transceiver (For Emergency Restoration):

Furnish MMFO transceivers identical to the type installed in the traffic signal controller cabinets to be used for emergency restoration of the system and the fiber optic communications system.

8.3. METHOD OF MEASUREMENT

Actual number of fiber optic transceivers furnished and accepted.

8.4. BASIS OF PAYMENT

The quantity of MMFO transceivers, measured as provided above, will be paid for at the contract unit price each for "Furnish Fiber Optic Transceiver."

Payment will be made under:

Furnish MMFO TransceiverEach

9. REMOVE EXISTING COMMUNICATIONS CABLE

9.1. DESCRIPTION

Remove existing communications cable.

9.2. CONSTRUCTION METHODS

Removal of existing aerial communications cable also includes proper disposal of the communications cable, messenger cable and mounting hardware, including abandoned risers.

Removal of existing underground communications cable includes proper disposal of the communications cable and junction boxes, if required. Removal of junction boxes will be noted on the plans.

Do not reuse any removed communications cable, messenger cable, junction boxes, pole attachment hardware or abandoned risers on the project, unless otherwise identified by the plans. In the event that any of the removed communications cable, junction boxes or pole attachment hardware is to be returned to the Engineer, it will be so noted on the plans.

9.3. METHOD OF MEASUREMENT

Measured horizontal linear feet (meters) of existing communications cable removed and accepted. Sag, vertical segments, or spare segments of communications cable will not be paid for as these distances will be considered incidental to the removal of the existing communications cable.

No additional measurement will be made for multiple cables being removed from the same conduit or same pole. Where multiple adjacent conduits exist (each containing multiple cables), each conduit will be considered separately for purposes of payment. No payment will be made for cable that cannot be removed and is abandoned in place.

No measurement will be made of the removal of messenger cable, pole attachment hardware, and junction boxes, as these will be considered incidental to removing existing communications hardware.

9.4. BASIS OF PAYMENT

The quantity of removed existing communications cable, measured as provided above, will be paid for at the contract unit price per linear foot (meter) for "Remove Existing Communications Cable."

Payment will be made under:

Remove Existing Communications CableLinear Feet (Meters)

10. METAL TRAFFIC SIGNAL SUPPORTS

10.1. METAL TRAFFIC SIGNAL SUPPORTS – ALL POLES

A. General:

Furnish and install metal poles with mast arms, grounding systems, and all necessary hardware. The work covered by this special provision includes requirements for the design, fabrication, and installation of both standard and custom/site specifically designed metal traffic signal supports and associated foundations.

Provide metal traffic signal support systems that contain no guy assemblies, struts, rods, stay braces, clamps or U-bolts, except where noted otherwise. Provide designs of completed assemblies with hardware that equals or exceeds AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals 4th Edition, 2001 (hereafter called 4th Edition AASHTO), including the latest interim specifications. Provide assemblies with a round or near-round cross-sectional design consisting of no less than six sides. The sides may be straight, convex, or concave.

Comply with Subarticle 1098-1B “General Requirements” of the Standard Specifications for submittal requirements. Furnish shop drawings for approval. Provide triplicate copies of detailed shop drawings for each type of structure. Ensure that shop drawings show materials specifications for each component and identifies welds by type and size. Do not release structures for fabrication until structural drawings have been approved.

If plans call for Standard Metal Signal Supports, comply with Subarticle 1098-1A “General Requirements” for QPL submittals.

B. Materials:

Fabricate shafts of the tapered tubular type and steel conforming to ASTM A-595 Grade A or an approved equivalent.

Galvanize in accordance with ASTM A-123, including field-drilled holes.

Use the submerged arc process to continuously weld shafts for the entire length. Ground or roll smooth exposed welds until flush with the base metal. Ensure shafts have no circumferential welds except at the lower end joining the shaft to the base. Provide welding that conforms to Article 1072-20 of the Standard Specifications, except that no field welding on any part of the pole will be permitted.

Fabricate anchor bases from plate steel meeting the requirements of ASTM A 36M or cast steel meeting the requirements of ASTM A 27M Grade 485-250 or an approved equivalent.

Ensure hardware is galvanized steel or stainless steel.

Ensure material used in steel anchor bolts conforms to AASHTO M 314, and yield strength does not exceed 55,000 psi. Provide anchor bolts with a circular anchor bolt lock plate at the embedded end secured with a washer and nut.

Ensure cap is cast aluminum conforming to Aluminum Association Alloy 356.0F.

C. Construction Methods:

Connect poles to grounding electrodes and the intersection grounding systems.

For holes in the poles used to accommodate cables, install grommets before wiring pole or arm. Do not cut or split grommets.

Attach the terminal compartment cover to the pole by a sturdy chain or cable. Ensure the chain or cable is long enough to permit the cover to hang clear of the compartment opening when the cover is

removed, and is strong enough to prevent vandals from being able to disconnect the cover from the pole. Ensure the chain or cable will not interfere with service to the cables in the pole base.

Attach cap to pole with a sturdy chain or cable. Ensure the chain or cable is long enough to permit the cap to hang clear of the opening when the cap is removed.

Perform repair of damaged galvanizing that complies with the Standard Specifications, Article 1076-6 "Repair of Galvanizing."

Anchor Nut Tightening Procedure

Compute the required projection of the anchor bolt above the foundation top. Compute the total projection based on the following:

- Provide between 3 and 5 threads of anchor bolt projection above the top nut after tightening is complete. Avoid any additional projection, or a normal depth socket torque wrench can not be used on top nuts.
- Include the sum of the thickness of top nut, top nut flat washer or top nut beveled washer, base plate, leveling nut flat washer or leveling nut beveled washer, and leveling nut.
- Set the maximum distance between the bottom of the leveling nut and the foundation top to one nut height to avoid excessive bending stresses in the anchor bolt under service conditions.
- Do not use lock washers.

Installation Procedure:

1. Place a leveling nut and washer on each anchor bolt and install a template on top of the leveling nuts to verify that the nuts are level and uniformly contact the template. Use beveled washers if the leveling nuts cannot be brought into firm contact with the template. Verify that the distance between the bottom of the leveling nuts and the top of the concrete is no more than one nut height.
2. Install the structural element on the anchor bolts, and tighten nuts in compliance with steps 3, 4, and 5 below. Do not attach cantilever arms or overhead truss components to the vertical post until all of the top nuts and leveling nuts have been properly tightened on the anchor bolts.
3. Install top nuts and washers. Install flat washers under the top and leveling nuts. Use beveled washers if the nuts cannot be brought into firm contact with the base plate. Lubricate threads of the anchor bolts, nuts, and bearing surface of the nuts and tighten to a snug-tight condition with a spud wrench following a star pattern (using at least two increments). Snug-tight condition is defined as 20% to 30% of the verification torque (600 ft-lbs.). Lubricant shall be beeswax, stick paraffin, or other approved lubricant.
4. After the top nuts have been snug tightened, snug tighten the bottom nuts up to the base plate using the same procedure as described above. The base-plate must be in firm contact with both the top and bottom nuts to achieve the proper pretension in the anchor bolts.
5. Before further turning of the nuts, mark the reference position of the top nut in the snug-tight condition by match marking each nut, bolt shank, and base plate. Use ink or paint that is not water-soluble.
6. Turn the top nuts in increments using the star pattern (using at least two full tightening cycles) to 1/6 of a turn. Use a torque wrench to verify that at least 600 ft-lbs. is required to further tighten the top nuts. At least 48 hours after the entire structure and any attachments are erected, use a torque wrench again to verify that at least 600 ft-lbs. is still required to tighten the top nuts. Verify that the leveling nuts remain in firm contact with the base plate.

7. Do not place non-shrink grout between the base plate and foundation. This will allow for future inspection of leveling nuts and for adequate drainage of moisture.

10.2. METAL POLE WITH MAST ARM

A. Materials:

Fabricate arms from standard weight black steel pipe conforming to ASTM A 53-90a, Type E or Type S, Grade B or an approved equivalent.

After all fabricating, cutting, punching, and welding is completed, hot-dip galvanize the structure in accordance with the 4th Edition AASHTO M111.

B. Construction Methods:

Install horizontal-type arms within 2 degrees of horizontal when loaded with signal heads and signs.

Attach cap to the mast arm with a sturdy chain or cable. Ensure that the chain or cable is long enough to permit the cap to hang clear of the arm opening when the cap is removed.

10.3. CUSTOM DESIGN OF TRAFFIC SIGNAL SUPPORTS

A. General:

Design traffic signal supports with foundations consisting of metal poles with mast arms.

The lengths of the metal signal poles shown on the plans are estimated from available data for bid purposes. Determine the actual length of each pole from field measurements and adjusted cross-sections. Furnish the revised pole heights to the Engineer. Use all other dimensional requirements shown on the plans.

Design all traffic signal support structures using the following 4th Edition AASHTO specifications:

- Use the wind pressure map developed from 3-second gust speeds, as provided in Article 3.8.
- Ensure signal support structures include natural wind gust loading and truck-induced gust loading in the fatigue design, as provided for in Articles 11.7.3 and 11.7.4, respectively. Designs need not consider periodic galloping forces.
- Assume the natural wind gust speed in North Carolina is 11.2 mph.
- Design for Category II fatigue, as provided for in Article 11.6, unless otherwise specified.
- Calculate combined stresses to determine combined stress ratio (CSR) using applicable equations from Section 5. Maximum allowable CSR for all signal supports is 0.9.
- Conform to article 10.4.2 and 11.8 for all deflection requirements. North Carolina's 3% vertical dead load tip deflection criteria for mast arms is no longer required.

Ensure that the design permits cables to be installed inside poles and mast arms.

The computed surface area for ice load on signal heads is:

- 3-section, 12-inch (300-mm), Surface area: 26.0 ft² (2.4 m²)
- 4-section, 12-inch (300-mm), Surface area: 32.0 ft² (3.0 m²)
- 5-section, 12-inch (300-mm), Surface area: 42.0 ft² (3.9 m²)

Assume the combined minimum weight of a messenger cable bundle (including messenger cable, signal cable and detector lead-in cables) is 1.3 lbs/ft (1.94 kg/m). Assume the combined minimum diameter of this cable bundle is 1.3 inches (33 mm).

Ensure that designs provide a removable pole cap with stainless steel attachment screws for each pole top and mast arm end.

B. Metal Poles:

Submit design drawings for approval showing all the necessary details and calculations for the metal poles including the foundation and connections. Include signal inventory number on design drawings. Include as part of the design calculations the ASTM specification numbers for the materials to be used. Provide the types and sizes of welds on the design drawings. Include a Bill of Materials on design drawings. Ensure design drawings and calculations are signed, dated, and sealed by the responsible Professional Engineer licensed in the State of North Carolina. Immediately bring to the attention of the Engineer any structural deficiency that becomes apparent in any assembly or member of any assembly as a result of the design requirements imposed by these Specifications, the plans, or the typical drawings. Said Professional Engineer is wholly responsible for the design of all poles and arms and review and acceptance of these designs by the Department does not relieve said Professional Engineer of this responsibility. Do not fabricate the assemblies until receipt of the Department's approval of the design drawings.

For mast arm poles, provide designs with provisions for pole plates and associated gussets and fittings mast arm attachment. As part of each mast arm attachment, provide a grommeted cable passage hole in the pole to allow passage of the signal cables from the pole to the arm.

Design tapers for all pole shafts that begin at the base with diameters that decrease uniformly at the rate of 0.14 inch per foot (11.7 millimeters per meter) of length.

Design for a base plate on each pole. The minimum base plate thickness for all poles is determined by the following criteria:

Case 1 Circular or rectangular solid base plate with the upright pole welded to the top surface of base plate with full penetration butt weld, and where no stiffeners are provided. A base plate with a small center hole, which is less than 1/3 of the upright diameter, and located concentrically with the upright pole, may be considered as a solid base plate.

The magnitude of bending moment in the base plate, induced by the anchoring force of each anchor bolt is $M = (P \times D_1) / 2$,

where M = bending moment at the critical section of the base plate induced by one anchor bolt

P = anchoring force of each anchor bolt

D_1 = horizontal distance between the anchor bolt center and the outer face of the upright, or the difference between the bolt circle radius and the outside radius of the upright

Locate the critical section at the face of the anchor bolt and perpendicular to the bolt circle radius. The overlapped part of two adjacent critical sections is considered ineffective.

Case 2 Circular or rectangular base plate with the upright pole socketed into and attached to the base plate with two lines of fillet weld, and where no stiffeners are provided, or any base plate with a center hole that is larger in diameter than 1/3 of the upright diameter.

The magnitude of bending moment induced by the anchoring force of each anchor bolt is $M = P \times D_2$,

where P = anchoring force of each anchor bolt

D_2 = horizontal distance between the face of the upright and the face of the anchor bolt nut

Locate the critical section at the face of the anchor bolt top nut and perpendicular to the radius of the bolt circle. The overlapped part of two adjacent critical sections is considered ineffective.

If the base plate thickness calculated for Case 2 is less than Case 1, use the thickness calculated for Case 1.

Ensure that designs have anchor bolt holes with a diameter 1/4 inch (7 mm) larger than the anchor bolt diameters in the base plate.

Ensure that the anchor bolts have the required diameters, lengths, and positions, and will develop strengths comparable to their respective poles.

Provide designs with a 6 x 12 inch (150 x 300 mm) hand hole with a reinforcing frame for each pole.

Provide designs with a terminal compartment with cover and screws in each pole that encompasses the hand hole and contains provisions for a 12-terminal barrier type terminal block.

For each pole, provide designs with provisions for a 1/2 inch (12 mm) minimum thread diameter, coarse thread stud and nut for grounding which will accommodate a Number 6 AWG ground wire. Ensure the lug is electrically bonded to the pole and is conveniently located inside the pole at the hand hole.

Where required, design couplings on the pole for mounting pedestrian pushbuttons at a height of 42 inches (1070 mm) above the bottom of the base. Provide mounting points consisting of 1-1/2 inch (40 mm) internally threaded half-couplings that comply with the NEC that are mounted within the poles. Ensure the couplings are essentially flush with the outside surfaces of the poles and are installed before any required galvanizing. Provide a threaded plug in each mounting point. Ensure that the surface of the plug is essentially flush with the outer end of the mounting point when installed and has a recessed hole to accommodate a standard wrench.

C. Mast Arms:

Design all arm plates and necessary attachment hardware, including bolts and brackets.

Design for grommeted holes on the arms to accommodate the cables for the signals.

Design arms with weatherproof connections for attaching to the shaft of the pole.

10.4. DRILLED PIER FOUNDATIONS FOR METAL TRAFFIC SIGNAL POLES

A. Description:

Perform a soil test at each proposed metal pole location. Furnish and install foundations for NCDOT metal poles with all necessary hardware in accordance with the plans and specifications.

Metal Pole Standards have been developed and implemented by NCDOT for use at signalized intersections in North Carolina. If the plans call for a standard pole, then a standard foundation may be selected from the plans. However, the Contractor is not required to use a standard foundation. If the Contractor chooses to design a non-standard site-specific foundation for a standard pole or if the plans call for a non-standard site-specific pole, design the foundation to conform to the applicable provisions in the NCDOT Metal Pole Standards and Section B4 (Non-Standard Foundation Design) below.

If the Contractor chooses to design a non-standard foundation for a standard pole and the soil test results indicate a standard foundation is feasible for the site, the Contractor will be paid the cost of the standard foundation (drilled pier and wing wall, if applicable). Any additional costs associated with a non-standard site-specific foundation including additional materials, labor and equipment will be considered incidental to the cost of the standard foundation. All costs for the non-standard foundation design will also be considered incidental to the cost of the standard foundation.

B. Soil Test and Foundation Determination:

1. General:

Drilled piers are reinforced concrete sections, cast-in-place against in situ, undisturbed material. Drilled piers are of straight shaft type and vertical.

Some standard drilled piers for supporting poles with mast arms may require wing walls to resist torsional rotation. Based upon this provision and the results of the required soil test, a drilled pier length and wing wall requirement may be determined and constructed in accordance with the plans.

For non-standard site-specific poles, the contractor-selected pole fabricator will determine if the addition of wing walls is necessary for the supporting foundations.

2. Soil Test:

Perform a soil test at each signal location. Complete all required fill placement and excavation at each signal pole location to finished grade before drilling each boring. Drill one boring to a depth of 26 feet (7.9 meters).

Perform standard penetration tests (SPT) in accordance with ASTM D 1586 at depths of 1, 2.5, 5, 7.5, 10, 15, 20 and 26 feet (0.3, 0.8, 1.5, 2.3, 3.0, 4.6, 6.1 and 7.9 meters). Discontinue the boring if one of the following occurs:

- A total of 100 blows have been applied in any 2 consecutive 6-in. (0.15-m) intervals.
- A total of 50 blows have been applied with < 3-in. (.08-m) penetration.

Describe each intersection as the “Intersection of (Route or SR #), (Street Name) and (Route or SR #), (Street Name), _____ County, Signal Inventory No. _____”. Label borings with “B- N, S, E, W, NE, NW, SE or SW” corresponding to the quadrant location within the intersection. For each boring, submit a legible (hand written or typed) boring log signed and sealed by a licensed geologist or professional engineer registered in North Carolina. Include on each boring the SPT blow counts and N-values at each depth, depth of the boring, and a general description of the soil types encountered.

3. Standard Foundation Determination:

Use the following method for determining the Design N-value:

$$N_{AVG} = \frac{(N@1' + N@2.5' + \dots + N@Deepest\ Boring\ Depth)}{\text{Total Number of N-values}}$$

$$Y = (N@1')^2 + (N@2.5')^2 + \dots + (N@Deepest\ Boring\ Depth)^2$$

$$Z = (N@1' + N@2.5' + \dots + N@Deepest\ Boring\ Depth)$$

$$N_{STD\ DEV} = \left[\frac{(\text{Total Number of N-values} \times Y) - Z^2}{(\text{Total Number of N-values}) \times (\text{Total Number of N-values} - 1)} \right]^{0.5}$$

Design N-value equals lesser of the following two conditions:

$$N_{AVG} - (N_{STD\ DEV} \times 0.45)$$

Or

$$\text{Average of First Four N-Values} = \frac{(N@1' + N@2.5' + N@5' + N@7.5')}{4}$$

Note: If less than 4 N-values are obtained because of criteria listed in Section 2 above, use average of N-values collected for second condition. Do not include the N-value at the deepest boring depth for above calculations if the boring is discontinued at or before

the required boring depth because of criteria listed in Section 2 above. Use N-value of zero for weight of hammer or weight of rod. If N-value is greater than 50, reduce N-value to 50 for calculations.

If standard NCDOT poles are shown on the plans and the Contractor chooses to use standard foundations, determine a drilled pier length, "L," for each signal pole from the Standard Foundations Chart (sheet M 7) based on the Design N-value and the predominant soil type. For each standard pole location, submit a completed "Metal Pole Standard Foundation Selection Form" signed by the contractor's representative. Include the Design N-value calculation and resulting drilled pier length, "L," on each form.

If non-standard site-specific poles are shown on the plans, submit completed boring logs collected in accordance with Section 2 (Soil Test) above along with pole loading diagrams from the plans to the contractor-selected pole fabricator to assist in the pole and foundation design.

If one of the following occurs, the Standard Foundations Chart shown on the plans may not be used and a non-standard foundation may be required. In such case, contact the Engineer.

- The Design N-value is less than 4.
- The drilled pier length, "L", determined from the Standard Foundations Chart, is greater than the depth of the corresponding boring.

In the case where a standard foundation cannot be used, the Department will be responsible for the additional cost of the non-standard foundation.

The Standard Foundations Chart is based on level ground around the traffic signal pole. If the distance between the edge of the drilled pier and the top of a slope steeper than 2:1 (H:V) is less than 10 feet (3 meters) or the grade within 10 feet is steeper than 2:1 (H:V), contact the Engineer.

The "Metal Pole Standard Foundation Selection Form" may be found as follows:

- 1) Go to www.NCDOT.org/business/.
- 2) Click on "Geotechnical Engineering Unit-Forms."
- 3) Click on "Metal Pole Standard Foundation Selection Form."

If assistance is needed with the required calculations, contact the Signals and Geometrics Structural Engineer at (919) 733-3915. However, in no case will the failure or inability to contact the Signals and Geometrics Structural Engineer be cause for any claims or requests for additional compensation.

4. Non-Standard Foundation Design:

Design non-standard foundations based upon site-specific soil test information collected in accordance with Section 2 (Soil Test) above. Provide a drilled pier foundation for each pole with a length and diameter that results in a horizontal lateral movement of less than 1 inch (25 mm) at the top of the pier and a horizontal rotational movement of less than 1 inch (25 mm) at the edge of the pier. Contact the Engineer for pole loading diagrams for standard poles to be used for non-standard foundation designs. Submit any non-standard foundation designs including plans, calculations, and soil boring logs to the Engineer for review and approval before construction. A professional engineer registered in the state of North Carolina must seal all plans and calculations.

C. Drilled Pier Construction:

1. Excavation:

Perform excavations for drilled piers to the required dimensions and lengths including all miscellaneous grading and excavation necessary to install the drilled pier. Depending on the

subsurface conditions encountered, excavation in weathered rock or removal of boulders may be required.

Dispose of drilling spoils as directed and in accordance with Section 802 of the Standard Specifications. Drilling spoils consist of all material excavated including water or slurry removed from the excavation either by pumping or with augers.

Construct all drilled piers such that the piers are cast against undisturbed soil. If a larger casing and drilled pier are required as a result of unstable or caving material during drilling, backfill the excavation before removing the casing to be replaced. No additional payment will be made for substituting a larger diameter drilled pier in order to construct a drilled pier cast against undisturbed soil.

Construct drilled piers within the tolerances specified herein. If tolerances are exceeded, provide additional construction as approved by the Engineer to bring the piers within the tolerances specified. Construct drilled piers such that the axis at the top of the piers is no more than 3 inches (75 mm) in any direction from the specified position. Build drilled piers within 1% of the plumb deviation for the total length of the piers. Construct the finished top of pier elevation between 5 inches (125 mm) above and 2 inches (50 mm) above the finished grade elevation. Form the top of the pier such that the concrete is smooth and level.

If unstable, caving, or sloughing soils are anticipated or encountered, stabilize drilled pier excavations with either steel casing or polymer slurry. Steel casing may be either the sectional type or one continuous corrugated or non-corrugated piece. Ensure all steel casings consist of clean watertight steel of ample strength to withstand handling and driving stresses and the pressures imposed by concrete, earth or backfill. Use steel casings with an outside diameter equal to the specified pier size and a minimum wall thickness of 1/4 inches (7 mm). Extract all temporary casings during concrete placement in accordance with this special provision unless the Contractor chooses to leave the casing in place in accordance with the requirements below.

Any temporary steel casing that becomes bound or fouled during pier construction and cannot be practically removed may constitute a defect in the drilled pier. Improve such defective piers to the satisfaction of the Engineer by removing the concrete and enlarging the drilled pier, providing a replacement pier or other approved means. All corrective measures including redesign as a result of defective piers will not be cause for any claims or requests for additional compensation.

Any steel casing left in place will be considered permanent casing. Permanent steel casings are only allowed for strain poles. When installing permanent casing, do not drill or excavate below the tip of the permanent casing at any time such that the permanent casing is against undisturbed soil. The Contractor may excavate a hole smaller than the specified pier size to facilitate permanent casing installation. Ensure the sides of the excavation do not slough during drilling. Ensure the hole diameter does not become larger than the inside diameter of the casing. No additional compensation will be paid for permanent casing.

If polymer slurry is chosen to stabilize the excavation, use one of the following polymers listed in the table below:

PRODUCT	MANUFACTURER
SlurryPro EXL	KB Technologies Ltd 3648 FM 1960 West, Suite 107 Houston, TX 77068 (800) 525-5237
Super Mud	PDS Company 105 West Sharp Street El Dorado, AR 71730 (800) 243-7455
Shore Pac GCV	CETCO Drilling Products Group 1500 West Shure Drive Arlington Heights, IL 60004 (800) 527-9948

Use slurry in accordance with the manufacturer's guidelines and recommendations unless approved otherwise by the Engineer. The Contractor should be aware that polymer slurry may not be appropriate for a given site. Polymer slurry should not be used for excavations in soft or loose soils as determined by the Engineer.

In wet pour conditions, advise and gain approval from the Engineer as to the planned construction method intended for the complete installation of the drilled pier before excavating.

2. Reinforcing Steel:

Completely assemble a cage of reinforcing steel consisting of longitudinal and spiral bars and place cage in the drilled pier excavation as a unit immediately upon completion of drilling unless the excavation is entirely cased. If the drilled pier excavation is entirely cased down to the tip, immediate placement of the reinforcing steel is not required.

Lift the cage so racking and cage distortion does not occur. Keep the cage plumb during concrete operations and casing extraction. Check the position of the cage before and after placing the concrete.

Securely cross-tie the vertical and spiral reinforcement at each intersection with double wire. Support or hold down the cage so that the vertical displacement during concrete placement and casing extraction does not exceed 2 inches (50 mm).

Do not set the cage on the bottom of the drilled pier excavation. Place plastic bolsters under each vertical reinforcing bar that are tall enough to raise the rebar cage off the bottom of the drilled pier excavation a minimum of 3 inches (75 mm).

In order to ensure a minimum of 3 inches (75 mm) of concrete cover and achieve concentric spacing of the cage within the pier, tie plastic spacer wheels at five points around the cage perimeter. Use spacer wheels that provide a minimum of 3 inches (75 mm) "blocking" from the outside face of the spiral bars to the outermost surface of the drilled pier. Tie spacer wheels that snap together with wire and allow them to rotate. Use spacer wheels that span at least two adjacent vertical bars. Start placing spacer wheels at the bottom of the cage and continue up along its length at maximum 10-foot (3-m) intervals. Supply additional peripheral spacer wheels at closer intervals as necessary or as directed by the Engineer.

3. Concrete:

Begin concrete placement immediately after inserting reinforcing steel into the drilled pier excavation. If the drilled pier excavation is entirely cased down to the tip, immediately placement of the concrete is not required.

a) Concrete Mix

Provide the mix design for drilled pier concrete for approval and, except as modified herein, meeting the requirements of Section 1000 of the Standard Specifications.

Designate the concrete as Drilled Pier Concrete with a minimum compressive strength of 4500 psi (31.0 MPa) at 28 days. The foundation will be considered acceptable for loading when the concrete reaches a minimum compressive strength of 3000 psi (20.7 Mpa). This provision is intended to allow the structure to be installed on the foundation in a shorter time frame, and does not constitute full acceptance of the drilled pier. Full acceptance will be determined when the concrete meets its full strength at 28 days. The Contractor may use a high early strength mix. Make certain the cementitious material content complies with one of the following options:

- Provide a minimum cement content of 640 lbs/yd³ (380 kg/m³) and a maximum cement content of 800 lbs/yd³ (475 kg/m³); however, if the alkali content of the cement exceeds 0.4%, reduce the cement content by 20% and replace it with fly ash at the rate of 1.2 lb (1.2 kg) of fly ash per lb (kg) of cement removed.
- If Type IP blended cement is used, use a minimum of 665 lbs/yd³ (395 kg/m³) Type IP blended cement and a maximum of 833 lbs/yd³ (494 kg/m³) Type IP blended cement in the mix.

Limit the water-cementitious material ratio to a maximum of 0.45. Do not air-entrain drilled pier concrete.

Produce a workable mix so that vibrating or prodding is not required to consolidate the concrete. When placing the concrete, make certain the slump is between 5 and 7 inches (125 and 175 mm) for dry placement of concrete or 7 and 9 inches (175 and 225 mm) for wet placement of concrete.

Use Type I or Type II cement or Type IP blended cement and either No. 67 or No. 78M coarse aggregate in the mix. Use an approved water-reducer, water-reducing retarder, high-range water-reducer or high-range water-reducing retarder to facilitate placement of the concrete if necessary. Do not use a stabilizing admixture as a retarder in Drilled Pier Concrete without approval of the Engineer. Use admixtures that satisfy AASHTO M194 and add admixtures at the concrete plant when the mixing water is introduced into the concrete. Redosing of admixtures is not permitted.

Place the concrete within 2 hours after introducing the mixing water. Ensure that the concrete temperature at the time of placement is 90°F (32°C) or less.

b) Concrete Placement

Place concrete such that the drilled pier is a monolithic structure. Temporary casing may be completely removed and concrete placement may be temporarily stopped when the concrete level is within 42 to 48 inches (1067 to 1220 mm) of the ground elevation to allow for placement of anchor bolts and conduit. Do not pause concrete placement if unstable casing soils are present at the ground surface. Remove any water or slurry above the concrete and clean the concrete surface of all scum and sediment to expose clean, uncontaminated concrete before inserting the anchor bolts and conduit. Resume concrete pouring within 2 hours.

Do not dewater any drilled pier excavations unless the excavation is entirely cased down to tip. Do not begin to remove the temporary casing until the level of concrete within the casing is in excess

of 10 feet (3 m) above the bottom of the casing being removed. Maintain the concrete level at least 10 feet (3 m) above the bottom of casing throughout the entire casing extraction operation except when concrete is near the top of the drilled pier elevation. Maintain a sufficient head of concrete above the bottom of casing to overcome outside soil and water pressure. As the temporary casing is withdrawn, exercise care in maintaining an adequate level of concrete within the casing so that fluid trapped behind the casing is displaced upward and discharged at the ground surface without contaminating or displacing the drilled pier concrete. Exerting downward pressure, hammering, or vibrating the temporary casing is permitted to facilitate extraction.

Keep a record of the volume of concrete placed in each drilled pier excavation and make it available to the Engineer.

After all the pumps have been removed from the excavation, the water inflow rate determines the concrete placement procedure. If the inflow rate is less than 6 inches (150 mm) per half hour, the concrete placement is considered dry. If the water inflow rate is greater than 6 inches (150 mm) per half hour, the concrete placement is considered wet.

- **Dry Placement:** Before placing concrete, make certain the drilled pier excavation is dry so the flow of concrete completely around the reinforcing steel can be certified by visual inspection. Place the concrete by free fall with a central drop method where the concrete is chuted directly down the center of the excavation.
- **Wet Placement:** Maintain a static water or slurry level in the excavation before placing concrete. Place concrete with a tremie or a pump in accordance with the applicable parts of Sections 420-6 and 420-8 of the Standard Specifications. Use a tremie tube or pump pipe made of steel with watertight joints. Passing concrete through a hopper at the tube end or through side openings as the tremie is retrieved during concrete placement is permitted. Use a discharge control to prevent concrete contamination when the tremie tube or pump pipe is initially placed in the excavation. Extend the tremie tube or pump pipe into the concrete a minimum of 5 feet (1.5 m) at all times except when the concrete is initially introduced into the pier excavation. If the tremie tube or pump pipe pulls out of the concrete for any reason after the initial concrete is placed, restart concrete placement with a steel capped tremie tube or pump pipe.

Once the concrete in the excavation reaches the same elevation as the static water level, placing concrete with the dry method is permitted. Before changing to the dry method of concrete placement, remove any water or slurry above the concrete and clean the concrete surface of all scum and sediment to expose clean, uncontaminated concrete.

Vibration is only permitted, if needed, in the top 10 feet (3 m) of the drilled pier or as approved by the Engineer. Remove any contaminated concrete from the top of the drilled pier and wasted concrete from the area surrounding the drilled pier upon completion.

Permanently mark the top of each foundation with a stamp or embedded plate to identify the depth of the foundation.

4. Concrete Placement Time:

Place concrete within the time frames specified in Table 1000-2 of the Standard Specifications for Class AA concrete except as noted herein. Do not place concrete so fast as to trap air, water, fluids, soil or any other deleterious materials in the vicinity of the reinforcing steel and the annular zone between the rebar cage and the excavation walls. Should a delay occur because of concrete delivery or other factors, reduce the placement rate to maintain some movement of the concrete. No more than 45 minutes is allowed between placements.

5. Scheduling and Restrictions:

During the first 16 hours after a drilled pier has achieved its initial concrete set as determined by the Engineer, do not drill adjacent piers, install adjacent piles, or allow any heavy construction equipment loads or “excessive” vibrations to occur at any point within a 20 foot (6 m) radius of the drilled pier.

In the event that the procedures described herein are performed unsatisfactorily, the Engineer reserves the right to shut down the construction operations or reject the drilled piers. If the integrity of a drilled pier is in question, use core drilling, sonic or other approved methods at no additional cost to the Department and under the direction of the Engineer. Dewater and backfill core drill holes with an approved high strength grout with a minimum compressive strength of 4500 psi (31.0 Mpa). Propose remedial measures for any defective drilled piers and obtain approval of all proposals from the Engineer before implementation. No additional compensation will be paid for losses or damage due to remedial work or any investigation of drilled piers found defective or not in accordance with these special provision or the plans.

10.5. MEASUREMENT AND PAYMENT

Actual number of metal poles with single mast arms furnished, installed, and accepted.

Actual number of designs for mast arms with metal poles furnished and accepted.

No measurement will be made of foundation designs prepared with metal pole designs, as these will be considered incidental to designing signal support structures.

Actual number of soil tests with SPT borings drilled furnished and accepted.

Actual volume of concrete poured in cubic yards (cubic meters) of drilled pier foundation furnished, installed and accepted.

Payment will be made under:

Metal Pole with Single Mast Arm	Each
Mast Arm with Metal Pole Design	Each
Soil Test	Each
Drilled Pier Foundation.....	Cubic Yard (Cubic Meter)

11. CABINET BASE EXTENDER

11.1. DESCRIPTION

Furnish and install cabinet base extenders in accordance with the plans and specifications.

11.2. MATERIALS

Fabricate base extenders out of the same materials and with the same finish as the cabinet housing. Fabricate the base extenders in the same manner as the controller cabinets, meeting all applicable specifications called for in Section 6.2.2 of the CALTRANS Traffic Signal Control Equipment Specifications (TSCES). Provide base extenders that are a minimum height of 12 inches (300 mm).

11.3. CONSTRUCTION METHODS

Install a cabinet base **extender** at every location requiring a new Model 332A cabinet on a new foundation or an existing Model 332A cabinet that does not have a cabinet base extender.

Use a permanent, flexible waterproof sealing material to:

146
300

- Seal between the base of the cabinet and the cabinet base extender,
- Seal the seams of a two-piece cabinet base extender, and
- Seal the space between the cabinet base extender and the foundation.

11.4. MEASUREMENT AND PAYMENT

Actual number of cabinet base extender furnished, installed, and accepted.

Payment will be made under:

Cabinet Base Extender.....Each

12. SPLICE CABINET (FIBER OPTICS)

12.1. DESCRIPTION

Furnish and install splice cabinets and all necessary hardware in accordance with the plans and specifications for the purpose of splicing and terminating fiber-optic cable(s). Comply with the provisions of Section 1700 of the 2002 Standard Specifications for Roads and Structures.

12.2. MATERIALS

Furnish NEMA Type 4 splice cabinets of sufficient size to accommodate the fiber-optic interconnect center. Provide sufficient size so that the equipment installed will not occupy more than 60 percent of the total cabinet volume.

12.3. CONSTRUCTION METHODS

A. General:

Locate cabinets so as not to obstruct sight distance of vehicles turning on red.

B. Base Mounted:

Install base mounted cabinets as shown on the plans and as approved by the Engineer. Refer to Section 1750 - Signal Cabinet Foundations of the 2002 Standard Specifications for Roads and Structures for installation requirements for the foundations. The following exceptions are made:

- Install only the required number of conduits as shown on the plans plus one additional spare stub out conduit.
- Do not provide a 24-inch (600-mm) working area on the backside of the cabinet. Provide only a 24 inch (600 mm) working area measured form the front of the cabinet and 3 inch (75 mm) lip measured from the sides and back of the cabinet.
- All other requirements apply.

12.4. METHOD OF MEASUREMENT

Actual number of fiber-optic splice cabinets (base mounted) furnished, installed, and accepted.

No measurement will be made for the cabinet foundation as it will be covered under Section 1750 – Signal Cabinet Foundations of the 2002 Standard Specifications for Roads and Structures.

12.5. BASIS OF PAYMENT

The quantity of fiber-optic splice cabinets, measured as provided above, will be paid for at the contract unit price each for “Fiber-optic Splice Cabinet (_____).”

Payment will be made under:

Fiber-optic Splice Cabinet (_____).....Each

13. FIBER-OPTIC CABLE

13.1. DESCRIPTION:

Furnish and install multi-mode (MMFO) fiber-optic communications cable and all necessary hardware in accordance with the plans and specifications.

13.2. MATERIALS:

A. General:

Furnish MMFO communications cable with grounding systems, fiber-optic cable storage guides (snowshoes), communications cable identification markers, lashing wire, and all necessary hardware.

B. MMFO Communications Cable:

Furnish loose tube fiber-optic cable with required fiber count that complies with RUS CFR 1755.900, multi-mode, 12 fiber with a dielectric central member. Use multi-mode fiber in the cable that does not exceed 3.5 dB/km @ 850 nm and 1.0 dB/km @ 1300nm. Provide fiber optic cable with all fibers that are useable and with a surface sufficiently free of imperfections and inclusions to meet the optical, mechanical, and environmental requirements. Provide fiber optic cable with operating temperature of at least -40 degrees C to +70 degrees C.

Use a dual layered, UV cured acrylate fiber coating applied by the by the fiber optic cable manufacturer that may be stripped mechanically or chemically without damaging the fiber.

Provide fibers inside a loose buffer tube. Use a doped silica core surrounded by a concentric silica cladding for each fiber. Distinguish each fiber and buffer tube from others by means of color coding meeting the requirements of EIA/TIA-598, "Color Coding of Fiber Optic Cables. In buffer tubes containing multiple fibers, ensure that the colors are stable during temperature cycling and not subject to fading, sticking, or smearing into each other or into the gel filling material. Construct buffer tubes with an inner layer made of polycarbonate and an outer layer made of polyester. Use fillers in cable core if necessary to provide a symmetrical cross-section of cable. Fill buffer tubes with non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogenous gel. Ensure gel is free from dirt and foreign matter, and is removable with conventional nontoxic solvents.

Provide a central member consisting of a dielectric glass reinforced plastic rod. Apply binders with sufficient tension to secure buffer tubes and binders to the central member without crushing buffer tubes. Ensure binders are non-hygroscopic, non-wicking (or rendered so by the flooding compound), and dielectric with low shrinkage.

Provide cable that has cable core interstices filled with super-absorbent, water-blocking compound that is non-conductive and homogenous. Ensure compound is free from dirt and foreign matter, and is removable with conventional nontoxic solvents.

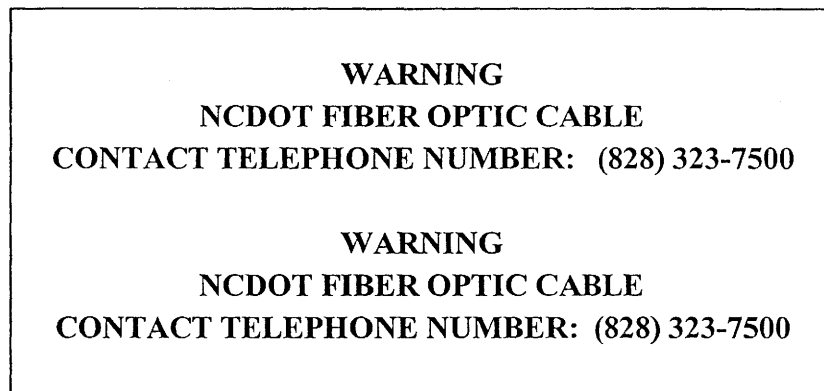
Provide cable with high tensile strength aramid yarns or fiberglass yarns that are helically stranded evenly around the cable core.

Provide cable jacket of consistent thickness that is free of holes, splits, and blisters, and containing no metal elements. Provide outer jacket of medium density polyethylene with minimum nominal sheath thickness of 0.050 inch (1.25 mm). Ensure polyethylene contains carbon black for ultraviolet light protection and does not promote the growth of fungus.

Provide length markings in sequential feet and within one percent of actual cable length. Ensure character height of the markings is approximately 0.10 inch (2.5 mm).

C. Communications Cable Identification Markers:

Furnish yellow communications cable identification markers that are resistant to fading when exposed to UV sources and changes in weather. Use markers designed to coil around fiber-optic cable, and that do not slide or move along the surface of the cable once installed. Ensure exposure to UV light and weather does not affect the markers natural coiling effect or deteriorate performance. Provide communications cable wraps that permit writing with an indelible marking pen and that contain the following text in black:



Overall Marker Dimensions: 7(l) x 4 (w) inches (175 mm(l) x 100 mm(w))

Lettering Height: 3/8 inch (9.5 mm) for "WARNING"

1/4 inch (6.5 mm) for all other lettering

Submit a sample of the proposed communications cable identification markers to the Engineer for approval before installation.

D. Fiber Optic Cable Storage Guides:

Furnish fiber-optic storage guides (snowshoes) that are non-conductive and resistant to fading when exposed to UV sources and changes in weather. Ensure snowshoes have a captive design such that fiber-optic cable will be supported when installed in the rack and fiber-optic cable's minimum bending radius will not be violated. Provide stainless steel attachment hardware for securing snowshoes to messenger cable and black UV resistant tie-wraps for securing fiber-optic cable to snowshoe. Ensure snowshoes are stackable so that multiple cable configurations are possible.

13.3. CONSTRUCTION METHODS:

A. General:

Provide cable manufacturer's attenuation and Optical Time Domain Reflectometer (OTDR) testing data for each reel of cable.

Install single mode and multi-mode fiber-optic communications cable with grounding systems, snow shoes, communications cable identification markers, lashing wire, and all necessary hardware.

Comply with NESC and manufacturer's recommendations. Install communications cable on signal poles, utility poles, on messenger cable, and in conduits as required to bring the fiber-optic cable into and, if necessary, out of each splice enclosure.

Take all precautions necessary to ensure cable is not damaged during storage, handling, and installation. Do not violate the minimum bending radius of 20 times the radius of the cable diameter or the manufacturer's recommendation, whichever is greater. Do not step on cable nor run over cable with vehicles or equipment. Do not pull cable over or around obstructions, or along the ground.

Determine lengths of cable necessary to reach from termination-point to termination-point. Install cable in continuous lengths between approved splicing facilities. Additionally, provide a sufficient amount of slack cable to allow for an additional 20 feet (6.2 meters) of cable to be present after removal of the outer sheath for termination. Measure slack cable by extending cable straight out of the cabinet door.

Keep cable ends sealed at all times during installation to effectively prevent the ingress of moisture. Use approved heat shrink cable end cap. Do not use tape to seal cable ends.

Before installing cable, provide three copies of the cable manufacturer's recommended and maximum pulling tension. Do not exceed the manufacturer's recommended pulling tension. Use pulling grips containing a rotating swivel. Coil cable in a "figure-8" configuration whenever cable is unreeled for subsequent pulling.

Install fiber-optic cable in separate 2-inch (50-mm) risers with heat shrink tubing. Do not share risers with other type cable.

B. Aerial Installation:

Double lash fiber-optic cable to messenger cable with one 360-degree spiral per foot (304 mm).

Use pole attachment hardware and roller guides with safety clips to install aerial run cable.

Maintain tension during the pulling process for aerial run cable by using an approved mechanical clutch (dynamometer) device. Do not allow cable to contact the ground or other obstructions between poles during installation. Do not use a motorized vehicle to generate cable-pulling forces.

Use a cable suspension clamp when attaching cable tangent to a pole. Select and place cable blocks and corner blocks so as not to exceed the cable's minimum bending radius. Do not pull cable across J-hooks.

Store 100 feet (30 meters) of slack fiber-optic cable over-head on all cable runs that are continuous without splices and are greater than 2,500 feet (762 meters). Obtain approval for spare cable storage locations. Store spare fiber-optic cable on fiber-optic cable storage guides (snowshoes). Locate spare cable storage in the middle of spans between termination points. Do not store spare fiber-optic cable over the roadway or driveways.

Install one communications cable identification marker within 36 inches (1 meter) of pole attachment points and at locations where more than one cable originates or terminates.

Maintain electrical continuity of messenger cable at all poles.

C. Underground Installation:

Install fiber-optic cable underground in conduit using cable-pulling lubricants approved by the fiber-optic cable manufacturer and the Engineer.

Obtain approval of cable pulling lubricant and method of pulling before installing underground fiber-optic cable.

Use a dynamometer (clutch device) so as not to exceed the maximum allowable pulling tension if the cable is pulled by mechanical means. Do not use a motorized vehicle to generate cable-pulling forces.

Keep tension on the cable reel and pulling line at the start of each pull. Do not release tension if the pulling operation is halted. Restart the pulling operation by gradually increasing tension until the cable is in motion.

For pulling cable through manholes, junction boxes, and vaults, place the cable reel using a method approved by the manufacturer. Feed cable by manually rotating the reel. Do not pull cable through intermediate junction boxes, handholds, or openings in conduit unless otherwise approved.

13.4. METHOD OF MEASUREMENT:

Actual linear feet (meters) of MMFO fiber-optic cable of each fiber count furnished, installed, and accepted. Measurement will be made by calculating the difference in length markings located on the outer jacket of the fiber-optic cable from the start of the fiber run to the end of the fiber run for each fiber run. All fibers shall be terminated before determining the length of the cable run.

No measurement will be made for terminating, splicing, and testing of the fiber optic cable, for communications cable identifications markers, or for fiber optic storage racks, grounding of messenger cable, as this will be considered incidental to the installation of the fiber optic cable.

13.5. BASIS OF PAYMENT:

The quantity of MMFO fiber-optic cable, measured as provided above, will be paid for at the contract unit price per linear foot (meter) for “MMFO Communications Cable (___-Fiber).”

Payment will be made under:

MMFO Communications Cable (___-Fiber).....Linear Foot (Meter)

14. FIBER-OPTIC TRANSCEIVERS

14.1. DESCRIPTION:

Furnish and install fiber-optic transceivers with all necessary hardware in accordance with the plans and specifications.

14.2. MATERIALS:

Furnish card mounted MMFO transceivers for installation in the local controllers. To ensure compatibility with the City of Hickory’s existing system, provide OPTELECOM Model 4170-S-ST (Card Mount) transceivers or an approved equivalent. Provide identical transceivers at all locations and that are capable of being interchanged throughout the system.

Furnish transceivers that transmit and receive RS-232/optical pulse signals to and from the master controller and to each remote field cabinet. Ensure transceivers are capable of operating at distances up to 5 miles (8 kilometers) without the need to boost the signal and without distortion of the signal.

Provide LED's on the front panel of transceivers for power, and transmitting and receiving indications. Comply with the following:

- Input Power: 115 VAC
- Minimum Loss Budget: 12 dB with corresponding receiver
- Operating Wavelength: 850nm to 1300nm
- Optical Connector: ST
- Signal Connector: Female Plug Type
- Temperature Range: 0 to 150 degrees F (-17 to 65 degrees C)

14.3. CONSTRUCTION METHODS:

Install fiber-optic transceivers in each field cabinet and comply with the manufacturer’s installation instructions.

14.4. METHOD OF MEASUREMENT:

Actual number of MMFO transceivers for local cabinet communications furnished, installed and accepted.

14.5. BASIS OF PAYMENT:

The quantity of MMFO transceivers, measured as provided above, will be paid for at the contract unit price each for "MMFO Transceiver."

Payment will be made under:

MMFO Transceiver.....Each

15. MULTI-MODE FIBER-OPTIC INTERCONNECT CENTERS

15.1. DESCRIPTION:

Furnish and install MMFO Interconnect Centers and all necessary hardware in accordance with the plans and specifications.

15.2. MATERIALS:

A. Interconnect Center:

Furnish compact, modular interconnect centers designed to mount inside equipment cabinets. Design and size interconnect centers to accommodate all fibers entering equipment cabinets.

Provide splice trays that hold, protect, and organize optical fibers, and that secure fibers inside the splice tray. Design and size splice trays to be dielectric, to accommodate all fibers entering the splice tray, and to provide sufficient space to prevent macrobending of optical fibers.

Provide connector panels with ST-type connectors.

Furnish MMFO pigtails with each interconnect center. Provide pigtails that are a minimum of 6 feet (1.8 meters) in length with a factory assembled PC-ST connector on one end. Ensure the MMFO pigtails meet the operating characteristics of the cable in which it is to be coupled.

Furnish MMFO jumpers that are a minimum of 3 feet (0.9 meters) in length with factory assembled PC-ST connectors on each end. Ensure the MMFO jumpers meet the operating characteristics of the cable in which it is to be coupled. Longer lengths may be required.

15.3. CONSTRUCTION METHODS:

A. General:

Install MMFO interconnect centers with connector panels, splice trays, storage for slack cable or fibers, mounting and strain relief hardware, and all necessary hardware.

Fusion splice and secure the cable in splice trays inside the splice enclosure.

Do not exceed .1 dB of attenuation per splice for multi-mode cable.

Furnish strain relief so that no tensile force is on the cable when it is held within the interconnect center or aerial splice enclosure.

B. Termination and Splicing within Interconnect Center:

Terminate and splice all fibers including unused fibers.

Label all fiber-optic connectors, whether on jumpers, connector panels, or other equipment, to prevent improper connection. Obtain approval of the fiber-optic connectors labeling method.

Ensure that all buffer tubes are contained within the splice tray so that no bare fibers are outside the tray.

For all fibers designated for termination to a connector panel within the interconnect center, fusion splice the fibers to the pigtails.

For all cut fibers designated to be expressed through the interconnect center, fusion splice the fibers.

For all buffer tubes designated to be expressed through the interconnect center, neatly coil the excess tubing inside the interconnect center. Do not damage the cable or violate the minimum-bending radius of the cable.

C. Testing:

Provide written notification a minimum of ten days before beginning fiber-optic cable testing.

After completion of splicing, perform the two-patch cable test procedure and the OTDR test on each fiber, including unused fibers, to ensure the following:

- fusion splice loss shall not exceed 0.1 dB, for multi-mode cable
- terminations and connections have a loss of 0.1 dB or less, for multi-mode cable
- and reflection loss is 40 dB or greater for each connector.

If exceeded, remake splices until the loss falls below 0.1 dB for multi-mode cable.

Furnish durable labeled plots of test results for each fiber including engineering calculations demonstrating that OTDR test results meet or exceed the attenuation requirements and that optical properties of the cable have not been impaired. Provide engineering calculations and tests for fiber-optic cable that demonstrates the loss budget where the fiber originates and the point where the fiber meets an electronic device.

If any fiber exceeds the maximum allowable attenuation or if the fiber-optic properties of the cable have been impaired, take approved corrective action including replacement of complete segments of fiber-optic cable if required. Corrective action will be at no additional cost to the Department.

15.4. METHOD OF MEASUREMENT:

Actual number of MMFO interconnect centers furnished, installed and accepted.

No measurement will be made of splice trays, pigtails, jumpers and connector panels and testing as this will be considered incidental to furnishing and installing fiber optic interconnect centers.

15.5. BASIS OF PAYMENT:

The quantity of MMFO Interconnect Centers, measured as provided above, will be paid for at the contract unit price each for "Interconnect Center."

Payment will be made under:

MMFO Interconnect Center.....Each