

Section 1098

1 The welding of steel components, including structural details, filler metal, workmanship and
2 technique, qualification and inspection will be based on the applicable requirements of the
3 AWS Structural Welding Code, D1.1.

4 **SECTION 1098** 5 **SIGNALS AND INTELLIGENT TRANSPORTATION SYSTEM** 6 **MATERIALS**

7 **1098-1 GENERAL REQUIREMENTS**

8 **(A) Qualified Products**

9 Furnish new equipment, materials, and hardware unless otherwise required. Inscribe
10 manufacturer's name, model number, serial number and any additional information
11 needed for proper identification on each piece of equipment housed in a case or housing.

12 ITS and Signals Qualified Products List (QPL) is available on the Department's website.

13 Certain signal and communications equipment, material and hardware shall be
14 pre-approved on the QPL by the date of installation. Equipment, material and hardware
15 not pre-approved when required will not be allowed for use on the project. Consult the
16 QPL web site to obtain pre-approval procedures.

17 **(B) Submittal Requirements**

18 Furnish a Type 3 material certification in accordance with Article 106-3. When
19 requested by the Department, provide additional certifications from independent testing
20 laboratories and sufficient data to verify item meets applicable Specifications. Ensure
21 additional certification states the testing laboratory is independent of the material
22 manufacturer and neither the laboratory nor the manufacturer has a vested interest in the
23 other.

24 Identify all proprietary parts in Contractor-furnished material. The Department reserves
25 the right to reject material that uses proprietary components not commercially available
26 through electronic supply houses.

27 For Contractor-furnished material listed on the QPL, furnish submittals in the format
28 defined by the QPL.

29 For Contractor-furnished material not on the QPL, furnish 3 copies of the equipment list
30 including 3 copies of catalog cuts. Identify proposed material on catalog cuts by
31 a reproducible means (highlighter pen does not transfer to copies). Ensure material lists
32 contain material description, brand name, manufacturer's address and telephone number,
33 stock number, size, identifying trademark or symbol and other appropriate ratings.

34 Do not fabricate or order material until receipt of the Engineer's approval.

35 **(C) Observation Period**

36 Warrant workmanship and Contractor-furnished equipment for a 30-day observation
37 period under the payment and performance bond from date of acceptance.

38 If workmanship or equipment fails during the 30-day observation period, repair or
39 replace with new equipment and begin a new 30-day observation period.

40 The observation period for this work is not part of the work to be completed by the
41 project completion date.

(D) Warranties

Unless otherwise required herein, provide manufacturer's warranties on Contractor-furnished equipment for material and workmanship that are customarily issued by the equipment manufacturer and that are at least 2 years in length from successful completion of the 30-day observation period. Include unconditional coverage for all parts and labor necessary or incidental to repair of defective equipment or workmanship and malfunctions that arise during warranty period.

Ensure all contractor-furnished equipment, including pieces and components of equipment, hardware, firmware, software, middleware, internal components and subroutines, which perform any date or time data recognition function, calculation or sequencing will support a four digit year format for at least 50 years.

Upon successful completion of the 30-day observation period, transfer manufacturer's warranties with proper validation by the manufacturer to the Department or its designated maintaining agency.

(E) Firmware Licensing and Upgrades

Provide the Department with a license to duplicate all programmable devices in equipment for maintenance and software upgrades. Provide binary or hexadecimal format files for each device that may be programmed by the Department. Ensure files are provided on PC compatible compact discs or other approved media.

Ensure firmware performance upgrades that occur during the contract period are available to the Department at no additional cost.

Make firmware upgrades that are developed to correct operating characteristics available to the Department at no additional cost until the warranty period expires.

(F) Plan of Record Documentation

Before final acceptance, furnish plan of record documentation of all fieldwork. Plan of record documentation will be subject to approval before final acceptance. Store documentation in a manila envelope placed in a weatherproof holder mounted within each cabinet or housing for easy access.

Except for standard bound manuals, bind all 8 1/2" x 11" documentation, including 11" x 17" drawings folded to 8 1/2" x 11", in logical groupings in either 3-ring or plastic slide-ring loose-leaf binders. Permanently label each grouping of documentation.

Provide manual, electrical schematic diagram, and cabinet wiring diagram for each control equipment cabinet and piece of equipment in cabinet. Place manuals and prints in weatherproof holder. For wiring diagrams and electrical schematic diagrams not bound into printed manuals, provide copies at least 22" x 34".

Provide Operator's Manuals containing detailed operating instructions for each different type or model of equipment. Ensure manuals contain instructions for possible modification to equipment.

Provide maintenance procedures manuals containing detailed preventive and corrective maintenance procedures for each different type or model of equipment.

Provide detailed wiring diagrams that include interconnection of equipment with pin-out configurations, pin functions, and cable part numbers. For communications systems, camera systems, video imaging loop emulator detection systems, intelligent transportation systems, closed loop signal systems and other computerized systems, provide 2 copies of system connection diagrams showing system interconnection cables and associated terminations.

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1 (G) Wire and Cable

2 Furnish wire and cable on reels. When requested by the Department, furnish samples of
3 wire and cable to the Department at no additional cost.

4 (H) Electrical Service

5 Furnish external electrical service disconnects with single pole 50 A inverse time circuit
6 breaker with at least 10,000 RMS symmetrical amperes short circuit current rating in
7 a lockable NEMA 3R enclosure. Ensure service disconnects are listed as meeting
8 UL Standard UL-489 and marked as being suitable for use as service equipment.
9 Fabricate enclosure from galvanized steel and electrostatically apply dry powder paint
10 finish, light gray in color, to yield a minimum thickness of 2.4 mils. Provide ground bus
11 and neutral bus with at least 4 terminals with minimum wire capacity range of number 14
12 through number 4.

13 Furnish NEMA Type 3R meter base rated 100 A minimum that meets the requirements of
14 the local utility. Provide meter base with ampere rating of meter sockets based on
15 sockets being wired with insulated wire rated at least 167°F.

16 Furnish 4 terminal, 600 volt, single phase, 3 wire meter base with the following:

- 17 (1) Line, Load and Neutral Terminals accept #8 to 2/0 AWG Copper/Aluminum wire,
- 18 (2) Ringed or Ringless Type, with or without bypass,
- 19 (3) Made of galvanized steel,
- 20 (4) Listed as meeting UL Standard UL-414, and
- 21 (5) Overhead or underground service entrance as specified.

22 Ensure meter bases have electrostatically applied dry powder paint finish, light gray in
23 color, with minimum thickness of 2.4 mils.

24 Furnish 1" watertight hub for threaded rigid conduit with meter base.

25 If meter base and electrical service disconnect are supplied in the same enclosure, ensure
26 assembly is marked as being suitable for use as service equipment. Ensure combination
27 meter and disconnect mounted in a pedestal for underground service is listed as meeting
28 UL Standard 231. Otherwise, ensure combination meter and disconnect is listed as
29 meeting UL Standard 67.

30 (I) Painting

31 Where painting of signal equipment cabinets, signal heads, signal poles, and pedestals is
32 required, apply paint at the factory. No field painting will be allowed except when paint
33 has been scratched or marred. In such cases, apply 2 field coats of the same color and
34 grade enamel as the original paint to the scratched or marred portions.

35 (J) Performance of Warranty Repair and Maintenance

36 Provide authorization to the Traffic Electronics Center of the North Carolina Department
37 of Transportation (NCDOT) to perform all warranty repairs after project acceptance. The
38 decision to perform warranty work at the Traffic Electronics Center by NCDOT
39 electronics technicians or to have warranty work performed by the vendor shall be at the
40 discretion of the State. Provide any training required by the manufacturer to authorize
41 the Traffic Electronics Center to perform warranty work and ensure manufacturer will
42 furnish parts to the Traffic Electronics Center for all warranty repairs at no cost to the
43 State. In addition, ensure the manufacturer agrees to provide prompt technical support to
44 the NCDOT electronics technicians for a period of one year after the end of the warranty
45 period at no cost to the State. Defective parts replaced under warranty by the Traffic
46 Electronics Center will be returned to the vendor at the vendor's request.
47 Provide schematics, part lists, and other documentation to perform bench repair to the

1 Traffic Electronics Center within 2 weeks upon request. The Department agrees not to
 2 divulge any proprietary information in the schematics, part lists and other documentation
 3 upon request from the vendor. After project acceptance and at the request of the State,
 4 manufacturer shall perform warranty repairs to equipment which fails during the
 5 warranty period at no cost to the State including freight costs to ship repaired equipment
 6 back to the Traffic Electronics Center. Ensure all equipment is repaired and returned to
 7 the Traffic Electronics Center within 21 calendar days of receipt by the manufacturer.

8 **1098-2 BACKPLATES**

9 Comply with ITE standard *Vehicle Traffic Control Signal Heads*. Provide backplates specific
 10 to the manufacturer of the vehicle signal heads. Provide stainless steel fasteners and hardware
 11 for attachment to signal head. Provide backplates that extend at least 5" from the vehicle
 12 signal head outline. Ensure the backplate fills in the gaps between cluster-mounted vehicle
 13 signal sections (5-section vehicle signal heads). A 1/4" maximum gap between vehicle signal
 14 head and backplate, as viewed from the front, will be allowed.

15 Fabricate metallic backplates for vehicle signal heads from sheet aluminum at least
 16 0.05" thick. Provide backplates painted an alkyd urea black synthetic baking enamel with
 17 minimum gloss reflectance that meets Federal Specification MIL-E-10169, Instrument Black.

18 Provide polycarbonate or vacuum formed ABS plastic backplates that are black on both the
 19 front and back sides with a consistent color throughout the entire piece for each backplate.
 20 Provide backplates that contain UV inhibitors and stabilizers for protection against
 21 UV degradation. Provide backplates that have a minimum tensile stress at yield of 5,300 psi
 22 at 73°F and meet UL Standard 94. Ensure polycarbonate backplates have a minimum
 23 thickness of .100" with one side dull black and the other side semi-gloss black. Ensure
 24 vacuum formed ABS plastic backplates have a minimum thickness of 0.125" with a hair cell
 25 finish on the front side and a smooth finish on the back side.

26 **1098-3 MESSENGER CABLE**

27 Comply with ASTM A475 for extra high strength grade wire strand, Class A zinc coating.
 28 Fabricate messenger cable from seven steel wires twisted into a single concentric strand.

29 **1098-4 RISER SEALING DEVICES**

30 Furnish appropriately sized clamp-on aluminum weatherheads for electrical control and
 31 power cables.

32 Furnish heat shrink tubing for the installation of fiber-optic or coaxial cable in a new riser.
 33 Ensure the heat shrink tubing is made of modified polyolefin and includes a hot-melt
 34 adhesive. Provide tubing that has a length of at least 5" before heating. Ensure the heat
 35 shrink tubing will provide a watertight fit around individual cables and outer wall of the riser
 36 after heat is applied in accordance with the manufacturer's instructions.

37 Furnish heat shrink tubing retrofit kits for the installation of fiber optic cable or coaxial cables
 38 to an existing riser with existing cables. Ensure the heat shrink material is made of modified
 39 polyolefin and is supplied in a flat sheet design. Ensure the kit contains an apparatus to
 40 secure both ends of the flat sheet together to form a tube shaped cylinder. Ensure the securing
 41 apparatus is flexible to the point that it will allow the heat shrink material to conform to the
 42 shape and dimensions of the riser and cables once heat is applied and will not separate during
 43 the heating process. Provide heat shrink tubing retrofit kits with a hot-melt adhesive. Provide
 44 the flat sheet heat shrink material that has a minimum length of 5" prior to heating. Ensure
 45 the heat shrink tubing retrofit kit provides a watertight fit around individual cables and outer
 46 wall of the riser after heat is applied in accordance with the manufacturer's instructions.

47 **1098-5 JUNCTION BOXES**

48 **(A) General**

49 Comply with Article 1091-5.

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1 (B) Standard Size Junction Boxes

2 Provide standard size junction boxes and covers with minimum inside dimensions of
3 16"(l) x 10"(w) x 10"(d).

4 (C) Oversized Junction Boxes

5 Provide oversized junction boxes and covers with minimum inside dimensions
6 of 30"(l) x 15"(w) x 24"(d).

7 1098-6 POLE LINE HARDWARE

8 Provide universal grade strandvises used for extra high strength steel messenger cable.

9 Provide other pole line hardware constructed of hot-dipped galvanized steel conforming to
10 ASTM A153.

11 Provide machine bolts, eyebolts and thimble eye bolts with minimum tensile strength of
12 12,400 lb. Provide hot-dipped galvanized nuts, 3" x 3" curved square washers and
13 thimbleyelets.

14 Provide suspension clamp fabricated from hot-dipped galvanized steel with minimum length
15 of 5 3/4". Ensure clamp has a groove rated for the messenger cable size it is intended to
16 secure. Provide J-hook fabricated from 3/8" thick hot-dipped galvanized steel flat or oval
17 stock with sufficient hook radius to cradle 11/16" diameter cable. Provide two 1/2" diameter
18 hot-dipped galvanized bolts and nuts to tighten the clamp around the messenger cable.
19 Provide one 5/8" diameter hot-dipped galvanized bolt of sufficient length to attach J-hook and
20 clamp to the wood pole with a 3" x 3" curved square washer and double nuts.

21 Provide 3-bolt clamp fabricated from hot-dipped galvanized steel with minimum length
22 of 5 3/4". Ensure clamp has 2 parallel grooves rated for the messenger cable size it is
23 intended to secure. Provide three 5/8" diameter hot-dipped galvanized bolts and nuts to
24 tighten the clamp around the messenger cable.

25 Provide parallel groove clamp consisting of high strength, high conductivity non-copper
26 bearing aluminum alloy clamp halves with interlocking fingers to prevent mismatch. Ensure
27 clamp halves have molded grooves to secure #8-1/0 AWG stranded copper wires. Provide
28 clamps with grooves prefilled with antioxidant joint compound. Provide 3/8" hex head,
29 square shank, galvanized steel bolt with galvanized steel lock washer and nut.

30 Provide 1/2" and 3/4" wide, .030" thick Type 316 stainless steel straps with Type 316 stainless
31 steel buckles.

32 Provide either 0.05" x 0.30" aluminum wrapping tape or 0.06" diameter Type 316 stainless
33 steel lashing wire for lashing cables to messenger cable. Ensure aluminum wrapping tape is
34 1350 alloy, O-temper, with 12,800 psi tensile strength. Use 0.045" diameter Type 316
35 stainless steel lashing wire to lash fiber-optic communications cable to messenger cable.

36 Provide hot-dipped galvanized steel clamp with groove sized for 1/4" to 3/8" messenger cable
37 for securing lashing wire(s) to messenger cables at ends of each spiraled run. Ensure clamp
38 hardware is hot-dipped galvanized steel.

39 1098-7 GUY ASSEMBLIES

40 Furnish guy assemblies with anchor assemblies, guy cable and guy cable guard.

1 Provide anchor assemblies with all miscellaneous hardware consisting of either expanding
 2 anchor with rod and triple-eye attachment, screw anchor with extension rod and triple-eye
 3 attachment, or expanding rock anchor with triple-eye attachment. Ensure anchor assembly
 4 size is adequate for site conditions. Provide rods constructed of hot-dipped galvanized steel
 5 sized according to the soil bearing conditions in the area. Provide triple-eye guy attachments
 6 constructed of hot-dipped galvanized steel. Anchor assemblies with double-strand eyes may
 7 be used instead of those with the triple-eye feature when only one guy cable is to be attached.
 8 Ensure anchor assemblies are 7 ft minimum in length.

9 For type of anchor assembly furnished, ensure the following:

10 **(A) Expanding Anchor**

11 Provide steel construction with protective paint or heat shrink of 6 mil plastic to protect
 12 metal during shipping and storage.

13 **(B) Screw Anchor**

14 Provide hot-dipped galvanized steel construction.

15 **(C) Expanding Rock Anchors**

16 Provide malleable iron and rust-resisting paint construction.

17 Provide 3-bolt clamp to match messenger cable size.

18 Provide full round guy cable guards that are 8 ft in length and constructed of UV stabilized,
 19 high impact, bright yellow HDPE.

20 Provide guy cables consisting of messenger cable of the same size as the largest sized
 21 messenger cable to be guyed. Comply with Article 1098-3.

22 **1098-8 INDUCTIVE DETECTION LOOPS**

23 **(A) Loop Sealant**

24 Provide loop slot sealant that completely encapsulates loop wire when installed according
 25 to manufacturer's instructions. Provide loop sealant that does not generate temperatures
 26 greater than 220°F. Ensure sealant bonds with asphalt and concrete pavement saw slots
 27 so sealant and encapsulated loop wire do not come out of slot. Ensure sealant is self-
 28 leveling, but with sufficient viscosity to prevent exit from saw slot when installed along
 29 a 10% grade.

30 Provide sealant that protects loop wire by preventing the entrance of dirt, water, rocks,
 31 sticks, and other debris into saw slot, and is resistant to traffic, water, gasoline, chemical
 32 and chemical fumes, mild alkalis, oils and mild acids. Ensure sealant will not be affected
 33 by water and sealant does not chemically interact with pavement and loop wire
 34 insulation.

35 Ensure loop sealant has sufficient flexibility to permit expected pavement expansion and
 36 contraction due to weather and to permit pavement movement due to traffic without
 37 cracking for a temperature range of -40 to 160°F.

38 Provide sealant with a usable life of at least ten minutes once mixed, when the ambient
 39 temperature is 75°F. Ensure sealant dries to tack free state in less than 2 hours, and does
 40 not flow within or out of saw slot after exposed surface has become tack free. Tack free
 41 time will be determined by testing with a cotton ball until no sealant adheres to cotton
 42 ball and no cotton adheres to sealant.

43 Ensure 2 part sealant cures within 48 hours to attain 95% of published properties for the
 44 cured material.

45 Ensure one part sealant cures within 30 days to attain 95% of published properties for the
 46 cured material.

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1 (B) Loop Wire

2 Provide loop wire composed of 19-strand conductor insulated by a cross-linked
3 polyethylene compound. Ensure insulated conductors are completely encased in tubes of
4 low density polyethylene compound. Print manufacturer's name, manufacture year and
5 any applicable part number on encasing tube at intervals of 2 ft or less.

6 Provide number 14 AWG copper conductors fabricated from 19 strands that comply with
7 ASTM B3 before insulating. Ensure stranded conductors use either concentric or bunch
8 stranding and comply with circular mil area and physical requirements of ASTM B8 or
9 ASTM B174 for bunch stranding.

10 Provide insulating compound that is cross-linked thermosetting black polyethylene in
11 accordance with ASTM D2655. Ensure insulation is applied concentrically about
12 conductor. Provide insulation thickness not less than 0.026" at any point and minimum
13 average thickness of 0.030" as measured by UL Standard 62.

14 Ensure insulation of finished conductor will withstand application of a 60 Hertz or
15 3,000 Hertz, 7,500 volt (RMS) essentially sinusoidal spark test potential as specified in
16 UL Standard 83.

17 Provide insulated conductors that are factory-installed in a protective encasing tube that
18 complies with the following:

19 Encasing tube fabricated of polyethylene compound conforming to ASTM D1248 for
20 Type I, Class C, Grade E5. Provide a minimum inside diameter of 0.150". Provide
21 a wall thickness of 0.040" ± 0.010". Provide an outside diameter of 0.240" ± 0.010".

22 (C) Conduit

23 Comply with Subarticle 1091-3(C) for PVC conduit.

24 1098-9 LEAD-IN CABLE

25 Furnish lead-in cable with 2 conductors of number 14 AWG fabricated from stranded tinned
26 copper that complies with IMSA Specification 50-2 except as follows:

27 (A) Ensure conductor is twisted with a maximum lay of 2.0" resulting in at least 6 turns per
28 foot.

29 (B) Provide a ripcord to allow cable jacket to be opened without using a cutter.

30 Provide length markings in a contrasting color showing sequential feet and within 1% of
31 actual cable length. Ensure character height of the markings is approximately 0.10".

32 1098-10 FIBER-OPTIC CABLE

33 (A) SMFO Communications Cable

34 Furnish single mode fiber-optic cable manufactured into a loose buffer tube design,
35 installed around a central strength member where the cable complies with
36 RUS CFR 1755.900 and ICEA 640 requirements. Ensure the Manufacture is ISO 9001
37 and TL9000 registered and that the manufacturer's cable is RUS listed. The operating
38 temperature range of the cable shall be -40°F to +158°F.

39 Furnish individual fibers manufactured from silica and dopant materials with each fiber
40 having a color coated finish that is compatible with local injection detection (LID)
41 devices. Distinguish each fiber from others by color coding that meets EIA/TIA-598.
42 Furnish single mode fiber that does not exceed attenuation ratings of 0.25 dB/km at
43 1550 nm and 0.35 dB/km at 1310 nm and complies with ITU G.652D and
44 IEC 60793-2-50 Type B.1.3 industry standards for low water peak, single mode fiber.
45 Provide fibers that are useable and with a surface, sufficiently free of imperfections and
46 inclusions to meet optical, mechanical and environmental requirements.

1 Ensure the core central strength member is a dielectric glass reinforced rod and that the
 2 completed cable assembly has a maximum pulling rating of 600 lbf during installation
 3 (short term) and 180 lbf long term installed.

4 Construct buffer tubes (nominal size of 2.5 mm) manufactured from a polypropylene
 5 copolymer material to provide good kink resistance and allows the buffer tube to
 6 maintain flexibility in cold temperature over the expected lifetime of the cable. Ensure
 7 that buffers tubes contain no more than 12 fibers per buffer tube unless specified
 8 otherwise, and that all buffer tubes are filled with a water blocking gel or water swellable
 9 material. Construct the cable such that the buffer tubes are stranded around the central
 10 strength member in a reverse oscillating arrangement to allow for mid-span entry.
 11 Distinguish each buffer tube from others by color coding that meets EIA/TIA-598. Use
 12 filler tubes to maintain a circular cross-section of the cable. Ensure the filler tubes are the
 13 same nominal size as the buffer tubes of 2.5 mm. Apply binders (water swellable yarn,
 14 kevlar, etc.) with sufficient tension to secure buffer tubes and filler tubes to the central
 15 member without crushing the buffer tubes. Ensure that binding material is
 16 non-hygroscopic, non-wicking and dielectric with low shrinkage. Ensure the binders are
 17 of a high tensile strength that is helically stranded evenly around cable core.

18 Ensure the cable core is protected from the ingress of moisture by a water swellable
 19 material or that is filled with a water blocking compound that is non-conductive. Ensure
 20 the water swellable material (when activated) or the water blocking compound is free
 21 from dirt and foreign matter and is removable with conventional nontoxic solvents.
 22 Furnish at least one ripcord to aid in the process of removing the outer jacket. Furnish
 23 the outer jacket constructed of a medium-density polyethylene material to provide
 24 reduced friction and enhanced durability. Ensure the polyethylene material contains
 25 carbon black to provide UV protection and does not promote the growth of fungus.
 26 Ensure the cable jacket is free of slits, holes or blisters and the nominal outer jacket
 27 thickness is ≥ 0.050 ".

28 Ensure the completed cable assembly contains identification markings printed along the
 29 outside cover of the jacket every 2 ft. Ensure the character height of the markings is
 30 approximately 0.10". Provide length markings in sequential feet and within 1% of actual
 31 cable length.

32 Mark each cable with the following:

- 33 (1) Sequential length marks in feet as specified
- 34 (2) The name of the manufacturer
- 35 (3) "OPTICAL CABLE"
- 36 (4) Month/year of manufacture
- 37 (5) Number(s) of and type(s) of fibers
- 38 (6) Cable ID Number for product traceability

39 **(B) Drop Cable**

40 Furnish drop cable meeting the material requirements listed in Subarticle 1098-10(A)
 41 with the exceptions herein to provide communications links between splice enclosures
 42 and through interconnect centers. Furnish drop cable containing at least 6 individual
 43 fibers.

44 Furnish drop cable that complies with RUS-CFR 1755.900 and is RUS listed. Ensure
 45 each drop cables has the same operating characteristics as the SMFO cable it is to be
 46 coupled with.

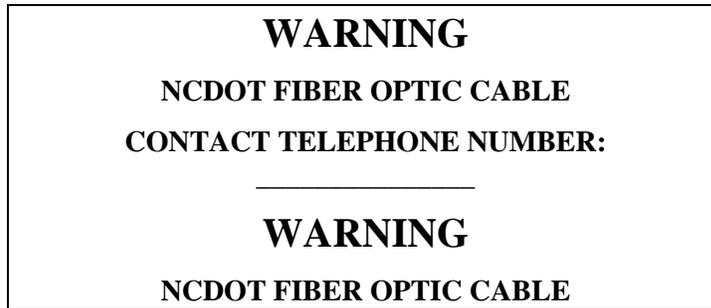
47 On one end of cable furnish six ST-PC connectors for termination on connector panel in
 48 equipment cabinet. Provide either factory assembled drop cables with ST-PC connectors
 49 or field installed connectors. No connectors are required for drop cables running from
 50 one splice enclosure directly to another splice enclosure.

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1 Ensure attenuation of drop cable at 1310 nm does not exceed 0.4 dB/km and the
2 attenuation at 1550 nm does not exceed 0.3 dB/km. Ensure attenuation loss for complete
3 drop cable assembly does not exceed a mean value of 1.5 dB.

4 (C) Communications Cable Identification Markers

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



17 **Figure 1098-1. Communication Cable Identification Marker.**

18 Overall Marker Dimensions: 7"(l) x 4"(w)

19 Lettering Height: 3/8"for WARNING, 1/4" for all other lettering

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

22 (D) Fiber-Optic Cable Storage Guides

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

30 1098-11 FIBER-OPTIC SPLICE CENTERS

31 (A) Interconnect Center

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

35 Provide splice trays that hold, protect, and organize optical fibers, and secure fibers inside
36 splice tray. Design and size splice trays to be dielectric, to accommodate all fibers
37 entering splice tray, and to provide sufficient space to prevent microbending of optical
38 fibers. Provide connector panels with ST-type connectors.

39 Furnish SMFO pigtails with each interconnect center. Provide pigtails containing
40 connector panels that are no more than 6 ft in length with a factory assembled PC-ST
41 connector on one end. Ensure SMFO pigtails meet the operating characteristics of the
42 SMFO cable with which it is to be coupled.

43 Furnish SMFO jumpers that are at least 3 ft in length with factory assembled PC-ST
44 connectors on each end. Ensure SMFO jumpers meet the operating characteristics of the
45 SMFO cable with which it is to be coupled.

(B) Splice Enclosure

Furnish splice enclosures that are re-enterable using a mechanical dome-to-base seal with a flash test valve, and are impervious to the entry of foreign material (water, dust, etc.). Ensure enclosures are manufactured so as to be suitable for aerial, pedestal, buried, junction box and manhole installation.

Provide enclosures with at least one over-sized oval port that will accept 2 cables and with at least 4 round ports (for single cables) that will accommodate all cables entering enclosure. Provide heat shrink cable shields with enclosure to ensure weather tight seal where each cable enters enclosure.

Within enclosures, provide enough hinged mountable splice trays to store the number of splices required, plus the capacity to house six additional splices. Provide a fiber containment basket for storage of loose buffer tubes expressed through the enclosure. Ensure enclosures allow sufficient space to prevent microbending of buffer tubes when coiled.

Provide splice trays that hold, protect, and organize optical fibers, and secure fibers inside splice tray. Provide splice trays that are dielectric.

1098-12 FIBER-OPTIC TRANSCEIVERS

Furnish shelf-mounted, modular, single mode fiber-optic transceivers that transmit and receive optical signals over a fiber-optic communications medium of 2 fibers and interface with equipment cabinets (signal controller, dynamic message signs, etc.). Ensure transceivers are asynchronous in operation. Ensure transceivers are capable of operating up to 5 miles without boosting signal and without distortion. Ensure transceivers are switch selectable for either local or master operation.

Do not provide transceivers internal to system equipment. Provide identical transceivers at all locations capable of being interchanged throughout system.

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

Property	Requirement
Input Power	115 VAC
Minimum Loss Budget	12 dB with corresponding receiver
Operating Wavelength	1310 or 1550 nm
Optical Connector	ST
Signal Connector	Female Plug Type DB9 or DB25
Temperature Range	0 to 150°F

Ensure modems operate in one of the following topologies:

Drop and Repeat Transceivers: Furnish transceivers that transmit and receive data in drop-and-repeat poll-response data network mode with EIA/TIA-232, EIA/TIA-422 and EIA/TIA-485 protocols.

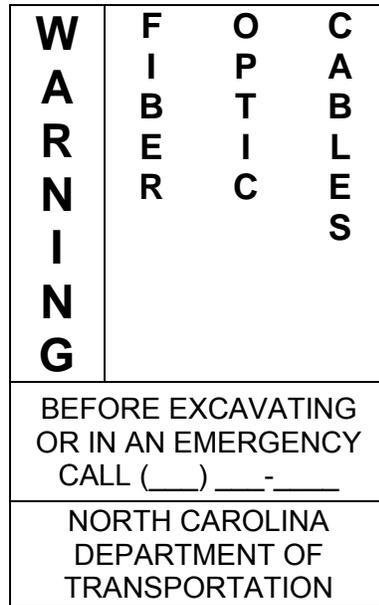
Self-Healing Ring Transceivers: Furnish transceivers that transmit and receive data in a drop-and-insert poll-response data network mode with EIA/TIA-232, EIA/TIA-422 and EIA/TIA-485 protocols. Ensure transceiver operates in a Self-Healing Ring Network Architecture.

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1 1098-13 DELINEATOR MARKERS

2 Furnish tubular delineator markers, approximately 6 ft long, and constructed of
3 Type III HDPE material. Provide delineator assemblies that are ultraviolet stabilized to help
4 prevent components from color fading, warping, absorbing water, and deterioration with
5 prolonged exposure to the elements. Provide delineators designed to self-erect after being
6 knocked down or pushed over. Provide orange delineator posts.

7 Provide text, including division contact number, hot stamped in black on a yellow reflective
8 background material that will not fade or deteriorate over time. Provide delineator markers
9 with nominal message height of 15" that contain the text in Figure 1098-2 visible from all
10 directions approaching the assembly.



11 **Figure 1098-2. Delineator Marker.**

12 **1098-14 PEDESTALS**

13 Furnish pedestal assemblies with foundations that conform to the latest edition of the
14 *AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and*
15 *Traffic Signals* in effect on the date of project advertisement. Refer to *Roadway Standard*
16 *Drawings* No. 1743 for structural design specifications for each type of pedestal.

17 **(A) Pedestal Shaft**

18 Furnish one piece pedestal shafts fabricated from either aluminum or galvanized steel
19 pipe with a uniform pipe outer diameter of 4.5" and of the lengths specified for the type
20 of pedestal shown on *Roadway Standard Drawing No. 1743*. Refer to Article 1743-2 for
21 pedestal type descriptions.

22 For Type I (pedestrian pushbutton pedestals) and Type II (normal-duty pedestals), furnish
23 shafts constructed from schedule 40 extruded aluminum pipe that conforms to Aluminum
24 Association Alloy 6063-T6 with a tensile strength of 30 KSI and a minimum wall
25 thickness of 0.237". Aluminum conduit will not develop the necessary strength required
26 and is not allowed. Thread and deburr in accordance with American National Standard
27 Pipe Threads, NPT (ANSI B2.1). Finish the exterior with a rough surface texture
28 consisting of a uniform grain pattern that is perpendicular to the axis of the pipe along the
29 full pipe length. Unless otherwise specified, do not use galvanized steel pipe for Type I
30 and Type II pedestal shafts.

1 For Type III (heavy-duty pedestals), furnish schedule 120 galvanized steel pipe that
 2 conforms to ASTM A53. Provide an 11" square by 1" thick steel base plate with
 3 minimum yield strength of 36 ksi that conforms to ASTM A36. Fabricate the base plate
 4 with four equally spaced bolt holes on an 11" bolt circle. Orient the bolt holes in the
 5 corners of the plate. Size the holes to accommodate 1" diameter machine bolts. Weld the
 6 pedestal shaft to the center of the base plate using a socket connection. Provide
 7 circumferential fillet welds at the top and bottom of the base plate. Perform all welding
 8 in accordance with the latest AWS Code. Hot-dip galvanize the pedestal shaft and base
 9 plate assembly after fabrication in accordance with ASTM A123. Unless otherwise
 10 specified, do not use aluminum pipe for Type III pedestal shafts.

11 **(B) Transformer Bases**

12 Furnish transformer bases for each type of pedestal shown on *Roadway Standard*
 13 *Drawings* No. 1743 fabricated from aluminum that meets Aluminum Association
 14 Alloy 356 or equivalent, and that are designed to break upon impact in accordance with
 15 AASHTO requirements. Submit FHWA certification for each type of transformer base
 16 that reflects compliance with NCHRP 350. For use in grounding and bonding, provide
 17 a 0.5" minimum diameter, coarse thread hole cast into transformer base located inside
 18 base and oriented for easy access.

19 Provide a minimum access opening for all transformer bases of 8" x 8" with an access
 20 door that is attached with stainless steel hinges on one side of the transformer base.
 21 Provide a 1/4" x 3/4" long stainless steel vandal proof screw to secure access door.

22 For Type I (pedestrian pushbutton pedestals) and Type II (normal-duty pedestals),
 23 provide overall base dimensions of 15" (l) x 13 3/4" (w) x 13 3/4" (d) for square bases
 24 and 14" (l) x 16 1/2" (w) x 16 1/2" (d) for octagonal bases. Provide a threaded opening at
 25 the top of the base to receive a 4" NPT pipe shaft. Fabricate the bottom of the
 26 transformer base with 4 equally spaced holes or slots for a 12" bolt circle to secure the
 27 entire assembly to the concrete foundation.

28 For Type III (heavy-duty pedestals), provide square bases with overall dimensions of
 29 17" (l) x 13" (w) x 13" (d). Fabricate the top of the transformer base with 4 equally
 30 spaced holes or slots for an 11" bolt circle to attach the pedestal shaft. Size the holes or
 31 slots to accommodate 1" diameter machine bolts. Fabricate the bottom of the transformer
 32 base with 4 equally spaced holes or slots for a 12" bolt circle to secure the entire
 33 assembly to the concrete foundation. Size the holes or slots to accommodate 1" diameter
 34 anchor bolts. Provide the following mounting hardware for heavy-duty pedestals:

35 (1) Four 1" diameter by 3 1/2" long machine bolts (ASTM F593), with heavy hex nuts
 36 (ASTM A563 Grade DH, or A 194 Grade 2H), and thick flat washers, and lock
 37 washers (ASTM F436) per pedestal assembly. Galvanize in accordance with
 38 ASTM A153.

39 (2) Three heavy hex nuts (ASTM A563 Grade DH, or A194 Grade 2H), 2 thick flat
 40 washers, and one lock washer (ASTM F436) for each anchor bolt. Galvanize in
 41 accordance with ASTM A153.

42 (3) Six minimum slotted stainless steel shims of necessary thickness for leveling per
 43 pedestal assembly.

44 **(C) Anchor Bolts**

45 For each pedestal, provide 4 anchor bolts in accordance with ASTM F1554, Grade 55, of
 46 the size and length specified in *Roadway Standard Drawings* No. 1743 each having one
 47 heavy hex nut with 2 washers at the top and 2 heavy hex nuts with one washer at the
 48 bottom. Provide anchor bolts with coarse threads at 10 threads per inch for a minimum
 49 length of 4" from each end of the bolt. All thread anchor rods may be used.

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1 Ensure anchor bolts are hot-dipped galvanized in accordance with ASTM A153 with
2 completely galvanized nuts and washers. Provide hex nuts with coarse threads. Ensure
3 hex nuts are in accordance with ASTM A563 Grade DH, ASTM A194, Grade 2H or
4 equivalent. Ensure washers are in accordance with ASTM F436 or equivalent. As a
5 minimum, provide standard size washers.

6 (D) Pedestal Cap

7 Furnish a 4 1/2" outside diameter slip fit domed pedestal top cap for each pedestal
8 assembly designed to fit over the outside of the pedestal shaft. Fabricate the cap from
9 aluminum that meets Aluminum Association Alloy 356. Ensure the cap provides
10 3 equally spaced stainless steel set screw fasteners to secure the cap to the pedestal shaft.

11 (E) Pole Flange Base for 4 1/2" Pipe

12 Furnish a flange base with cover for use with Type I (pedestrian pushbutton pedestals)
13 and Type II (normal-duty pedestals) only. Flange bases are non breakaway supports that
14 are to be used with a breakaway bolt system for AASHTO compliance for breakaway
15 structures. Provide aluminum or steel flange bases with a minimum 7.5" diameter bolt
16 circle. Ensure bases are either continuously welded to shafts or threaded to receive
17 shafts. Each base should be designed to accommodate either three or four 1/2" bolts
18 equally spaced on the bolt circle to receive breakaway anchors. Provide NPT threads on
19 the internal opening of the flange base through the full length of the flange base with
20 locking set screws at the top of the base to receive a 4" NPT pipe shaft.

21 Fabricate aluminum flange bases that meet Aluminum Association Alloy 356
22 requirements for architectural bases. Fabricate steel flange bases that meet ASTM A36.

23 Do not use flange bases for Type III pedestals.

24 (F) Breakaway Anchors

25 Furnish single or double neck omni-directional breakaway anchor bolt coupling systems
26 for use with Type I (pedestrian pushbutton pedestals) and Type II (normal-duty pedestals)
27 only. Use breakaway anchors that are FHWA certified to be compliant with NCHRP
28 Report 350 as an alternative to transformer bases. Use with non breakaway pole flange
29 bases. Use 1/2" diameter bolts for pushbutton posts and 3/4" bolts for normal-duty
30 pedestals. Fabricate from steel with a minimum yield strength of 55 KSI. Galvanize in
31 accordance with ASTM A153. Do not use breakaway anchors with Type III pedestals, or
32 in conjunction with breakaway transformer bases.

33 (G) Foundation

34 Install pedestal foundations of the type and size shown on *Roadway Standard Drawings*
35 No. 1743.04 Furnish Class A minimum concrete that conforms to Article 1000-4.

36 Provide reinforcing steel that conforms to the applicable parts of Section 1070.

37 1098-15 SIGNAL CABINET FOUNDATIONS

38 Provide foundations with a minimum pad area that extends 24" from front and back of cabinet
39 and 3" from sides of cabinet.

40 Furnish cabinet foundations with chamfered top edges. Provide minimum Class B concrete.

41 Provide preformed cabinet pad foundations with 7"(l) x 18"(w) minimum opening for the
42 entrance of conduits. For precast signal cabinet foundations, include steel reinforcement to
43 ensure structural integrity during shipment and placing of item. Include four 3/4" coil thread
44 inserts for lifting. Comply with Article 1077-16.

1098-16 CABINET BASE ADAPTER/EXTENDER

Fabricate base adapters and extenders from the same materials and with the same finish as cabinet housing. Fabricate base adapter and extender in the same manner as controller cabinets, meeting all applicable specifications called for in Section 6.7 of CALTRANS TEES. Provide base adapters and extenders a height of at least 12".

1098-17 BEACON CONTROLLER ASSEMBLIES**(A) General**

Furnish all cabinets with a solid state flasher that meets NEMA TS-2-2003. Encapsulate flasher components as necessary. Connect flasher to provide beacon operation as specified.

Submit drawings showing dimensions, location of required equipment and mechanisms, cabinet electrical diagrams, part numbers and descriptions of required equipment and accessories to the Engineer. Provide certification to the Engineer that materials used in cabinet construction meet these Specifications.

Furnish unpainted, natural, aluminum cabinet shells that comply with Section 7 of NEMA TS-2-2003. Ensure all non-aluminum hardware on cabinet is stainless steel or Department approved non-corrosive alternate. Provide roof with slope from front to back at a minimum ratio of 1" drop per 2 ft. Ensure each exterior cabinet plane surface is constructed of a single sheet of seamless aluminum. Ensure all components are arranged for easy access during servicing. When modular in construction, provide guides and positive connection devices to ensure proper pin alignment and connection.

Provide 20 mm diameter radial lead UL-recognized metal oxide varistors (MOV) between each field terminal and ground bus. Electrical performance is outlined in Table 1098-2.

**TABLE 1098-2
PROPERTIES OF SURGE PROTECTOR**

Property	Requirement
Maximum Continuous Applied Voltage at 85°C	150 VAC (RMS) 200 VDC
Maximum Peak 8x20µs Current at 85°C	6500 A
Maximum Energy Rating at 85°C	80 J
Voltage Range 1 mA DC Test at 25°C	212 - 268 V
Max. Clamping Voltage 8x20µs, 100A at 25°C	395 V
Typical Capacitance (1 MHz) at 25°C	1,600 pF

Provide beacon controller assemblies equipped with terminal blocks (strips) for termination of all field conductors and all internal wires and harness conductors. Terminate all wires at terminals. Ensure all field terminals are readily accessible without removing equipment and located conveniently to wires, cables, and harnesses to be connected. Ensure terminals are not located on under side of shelves or at other places where they are not readily visible or where they may present a hazard to personnel who might inadvertently touch them. Provide terminal blocks made of electrical grade thermoplastic or thermosetting plastic. Ensure each terminal block is of closed back design and has recessed-screw terminals with molded barriers between terminals. Ensure each terminal consists of 2 terminal screws with removable shorting bar between them. Ensure each terminal block is labeled with a block designation and each terminal is labeled with a number. Ensure all terminal functions are labeled on terminal blocks. Provide labels that are visible when terminal block is fully wired. Show labels on cabinet wiring diagrams. Ensure terminals serving similar functions are grouped together.

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1 Connect each conductor, including unused conductors, within or entering cabinet to
2 a terminal using crimped spade lugs. Place no more than 2 conductors on any single
3 terminal screw. Terminations to back panel may be soldered. Do not use quick
4 connectors or barrel connectors. Make all connections at terminals. Do not make in-line
5 splices.

6 Ensure outgoing circuits have same polarity as line side of power supply. Ensure
7 common return has same polarity as grounded conductor (neutral) of power supply.

8 Neatly package all wiring. Dress harnesses by lacing, braiding, or tying with nylon tie
9 wraps at closely spaced intervals. Attach wires, cables, or harnesses to cabinet walls for
10 support or to prevent undue wear or flexing. Use nylon tie straps or metal clamps with
11 rubber or neoprene insulators. Screw these attachment devices to cabinet. Do not use
12 stick-on clamps or straps.

13 Tag AC+, AC-, chassis ground, and flasher circuit conductors with non-fading,
14 permanent sleeve labels at conductor ends at terminals or use color-coded wire. Ensure
15 sleeve labels tightly grip conductors. Alternatively, use hot stamped labels on internal
16 conductor insulation at intervals of no greater than 4". Ensure label legends are
17 permanent.

18 Ensure all jumpers are wire conductors or metal plates. Do not use printed circuit back
19 panels or back panels using wire tracks as jumpers.

20 Lay out all equipment and components for ease of use and servicing. Ensure equipment
21 controls can be viewed and operated without moving or removing any equipment.
22 Ensure there is access to equipment or components for servicing without removing any
23 other equipment or components. Removal of equipment is acceptable to access fan or
24 thermostat. Ensure equipment can be removed using only simple hand tools. Ensure
25 layout of equipment and terminals within the various cabinets furnished is identical from
26 cabinet to cabinet, unless otherwise approved.

27 Mount equipment using harnesses with suitable multipin (or similar) connectors. Design
28 or key all equipment to make it physically impossible to connect unit to wrong connector.
29 Ensure that functionally equivalent equipment is electrically and mechanically
30 interchangeable.

31 Equip vents with standard-size, replaceable filters or, if located where they can easily be
32 cleaned, permanent filters.

33 **(B) Type F1 Cabinet**

34 Provide dual-circuit flasher and 20-amp inverse time circuit breaker with at least
35 10,000 RMS symmetrical amperes short circuit current rating. Install one insect-resistant
36 vent on bottom and one on top on opposite wall to facilitate airflow.

37 **(C) Type F2 Cabinet**

38 Provide 20" high x 16" wide x 12" deep cabinet, dual-circuit flasher, 20-amp inverse time
39 circuit breaker with at least 10,000 RMS symmetrical amperes short circuit current rating,
40 and solid state time switch. Provide filtered power to time switch. Install one insect-
41 resistant vent on each side of cabinet at the bottom to facilitate airflow.

42 **(D) Type F2 and F3 Cabinet – Surge Protection and Documentation**

43 Furnish and install a power line surge protector in the service power. Provide a 2-stage
44 power line surge protector that allows connection of the radio frequency interference
45 filter between stages of the device. Ensure device has a maximum continuous current
46 rating of at least 10 A at 120 V. Ensure device can withstand at least 20 peak surge
47 current occurrences at 20,000 A for an 8x20 microsecond waveform. Provide maximum
48 clamp voltage of 395 V at 20,000 A with a nominal series inductance of 200 μ h. Ensure
49 voltage does not exceed 395 V. Provide devices that comply with Table 1098-3.

TABLE 1098-3	
INSERTION LOSS OF SURGE PROTECTOR	
Frequency (Hz)	Minimum Insertion Loss (dB)
60	0
10,000	30
50,000	55
100,000	50
500,000	50
2,000,000	60
5,000,000	40
10,000,000	20
20,000,000	25

1 Install surge protector in circuit breaker enclosure in a manner that will permit easy
2 servicing. Ground and electrically bond surge protector to cabinet within 2" of surge
3 protector.

4 Furnish and install a suitably sized plastic envelope or container in cabinet for holding
5 cabinet wiring diagrams and equipment manuals. Locate envelope or container so it is
6 convenient for service personnel. Furnish 2 sets of non-fading cabinet wiring diagrams in
7 a paper envelope or container and place them in the plastic envelope or container.

8 **(E) Type F3 Cabinet**

9 Provide 25" high x 22" wide x 15" deep cabinet, dual-circuit flasher, fan, thermostat and
10 switch-controlled cabinet light (15 watt minimum, incandescent).

11 Install a vent or vents at or near the cabinet bottom to permit the intake of air sized for the
12 rated flow of air from the fan, but no smaller than 20 sq. in. Install fan with a minimum
13 100 CFM rating.

14 Equip cabinet with 2 inverse time circuit breakers (20A & 15A) with at least 10,000 RMS
15 symmetrical amperes short circuit current rating installed to ensure personnel servicing
16 the cabinet, including rear of back panel, cannot inadvertently be exposed to a hazard.
17 Install a terminal block that will accommodate service wire as large as number 4 AWG,
18 and connect it to the circuit breaker. Install circuit breakers in addition to any fuses that
19 are a part of the individual control equipment components. Wire switch-controlled
20 cabinet light and thermostatically-controlled fan to the 15A circuit breaker. Provide
21 thermostat with a minimum range of 90° F to 130° F and with a rating sufficient for fan
22 load.

23 Equip cabinet with a duplex receptacle that is connected to the AC out and neutral out
24 terminals of the surge protector.

25 **1098-18 SPREAD SPECTRUM WIRELESS RADIO**

26 **(A) General**

27 Furnish a spread spectrum wireless radio system with all necessary hardware and signage
28 in accordance with the plans and specifications to provide a data link between field
29 devices (i.e. Traffic Signal Controllers, Dynamic Message Signs, etc.). Provide a radio
30 system with a bi-directional, full duplex communications channel between 2 "line-of-
31 sight" antennas using license free, spread spectrum technology operating in the
32 902 - 928 MHz frequency band.

33 Furnish material conforming to the National Electrical Code (NEC), the National
34 Electrical Safety Code (NESC), Underwriter's Laboratories (UL) or a third-party listing
35 agency accredited by the North Carolina Department of Insurance, and all local safety
36 codes in effect on the date of advertisement. Comply with all regulations and codes
37 imposed by the owner of affected utility poles.

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1 (B) 900 MHz Wireless Radio

2 Furnish license free 902 - 928 MHz radio modem with antennas, coaxial cable and
3 mounting hardware, and configuration software. Design radio modem to work in “point-
4 to-point”, “point-to-multipoint”, “multipoint-to-point” and “multipoint-to-multipoint”
5 configurations. Ensure the spread spectrum wireless radio meets the following minimum
6 requirements:

- 7 (1) License free (ISM) Spread Spectrum radio band (902 - 928 MHz)
- 8 (2) Frequency Hopping Technology (Direct Sequence Spread Spectrum Technology is
9 not acceptable)
- 10 (3) Bi-Directional, Full Duplex
- 11 (4) Provide at least 3 Programmable Radio Frequency (RF) output levels ranging from
12 1mW up to 1 Watt.
- 13 (5) Provide user-selectable radio frequency channels (Min. 50) and hopping patterns
14 (Min. 50) that will allow the user to adjust operating characteristics to avoid
15 interference within the intended 902 - 928 MHz frequency range.
- 16 (6) RS-232 interface capable of operating from 1200 bps to 115.2 Kbps, with 8 or 9 bit
- 17 (7) DB9-F connector for RS-232 port
- 18 (8) Maximum of 8 mSec. end-to-end latency
- 19 (9) 16 bit Cyclic Redundancy Check (CRC) error checking with auto re-transmit
- 20 (10) Built-in store-and-forward (single radio repeater, back-to-back radio set-ups are not
21 allowed to accomplish this function)
- 22 (11) 32 Bit encryption
- 23 (12) Receiver Sensitivity of -108dBm @ 10^{-6} BER
- 24 (13) Antenna port: Threaded Connector (Nickel and/or Silver Plated Brass)
- 25 (14) Front panel LED indicators (at a minimum):
 - 26 (a) Power
 - 27 (b) Transmit Data
 - 28 (c) Receive Data
 - 29 (d) Data Port Indicators consisting of at least 3 LED's grouped together
30 representing a Low, Medium or High Signal Strength with regards to the
31 communications link with another targeted radio. Software running on a laptop
32 is not acceptable in meeting this requirement for front panel LED Data Port
33 Indicators.
- 34 (15) Operating temperature of -40 to +165°F at 0 to 95% Humidity
- 35 (16) Power supply requirements:
 - 36 (a) Wall Adapter:
 - 37 (i) Input Voltage (120 VAC UL/CSA) wall cube plug-in module
 - 38 (ii) Output Voltage (6VDC to 24VDC)
 - 39 (b) Typical current draw of no greater than 400 mA when powered with 12 VDC
40 input and transmitting one watt of RF output power
 - 41 (c) Radio Sleep mode with a maximum current draw of $<1\mu\text{A}$
- 42 (17) Shelf mounted design

1 Furnish a Radio Frequency Signal Jumper constructed of an RG-58 Coaxial Cable. On
2 one end of the cable supply a RF Threaded Connector that is compatible with the radio
3 supplied and on the other end supply a Standard N-Type Male Connector to mate with
4 the lightning arrestor. Provide the jumper in 6 ft lengths. Ensure that the cable is
5 assembled by a manufacturing facility. Contractor and/or Vendor assembled cables are
6 not acceptable.

7 Furnish an RS-232 data interface cable to be installed between the radio modem and the
8 field device's RS-232 interface. Ensure the cable is compatible with CALTRANS TEES
9 and 2070L compliant controllers. Ensure cable is at least 6 ft long. Ensure that the cable
10 is assembled by a manufacturing facility. Contractor and/or Vendor assembled cables are
11 not acceptable.

12 Ensure that installing the wireless radio system with a fully functional field device
13 (i.e. controller) does not require any field device modifications with regards to hardware
14 or software.

15 **(C) Software**

16 Furnish units with a Windows-based software program that uses a GUI (Graphical User
17 Interface) to provide "remote programming, radio configuration, remote maintenance,
18 diagnostics and spectrum analyzer" features. Ensure the software will operate on all past
19 and current Microsoft® Windows operating platforms: Windows 98®, Windows 2000®,
20 Windows NT®, Windows XP®, Windows Vista® or Windows® 7. Provide
21 configuration software that can be upgraded in the future at no additional charge.

22 Ensure the radio modem is configurable from a single location (i.e. master radio location)
23 via supplied software (no extra cost). Furnish software supplied with drivers to allow
24 easy set-up with all industry standard traffic signal controllers, including 2070 controllers
25 containing custom software written specifically for the North Carolina Department of
26 Transportation. Ensure the supplied software contains pre-written drivers for industry
27 standard radar packages and Dynamic Message Sign controllers.

28 **(D) Directional Antenna (Yagi)**

29 Furnish a directional antenna of welded construction that allows for vertical and
30 horizontal polarization. Furnish an 8.5 dBd Gain or 13 dBd Gain antenna that comply
31 with Table 1098-4.

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TABLE 1098-4 PROPERTIES OF 8.5 dBd GAIN ANTENNA	
Property	Requirement
Frequency Range	896 - 940 MHz
Nominal Gain	8.5 dBd
Front to Back Ratio	18 dB
Horizontal Beamwidth (at half power points)	65 degree
Vertical Beamwidth (at half power points)	55 degree
Power Rating, UHF Frequency	200 Watts
Lightning Protection	DC Ground
Termination	Coaxial pigtail with a Standard N-Type Female Connector
Impedance	50 ohms
Length	24"
Rated Wind Velocity	125 mph
Rated Wind Velocity (with 0.5" radial ice)	100 mph
Projected Wind Surface Area (flat plane equivalent)	0.26 sf
Number of Elements	6

TABLE 1098-5 PROPERTIES OF 13 dBd GAIN ANTENNA	
Property	Requirement
Frequency Range	902 - 928 MHz
Nominal Gain	13 dBd
Front to Back Ratio	20 dB
Horizontal Beamwidth (at half power points)	40 degree
Vertical Beamwidth (at half power points)	35 degree
Power Rating, UHF Frequency	200 Watts
Lightning Protection	DC Ground
Termination	Coaxial pigtail with a Standard N-Type Female Connector
Impedance	50 ohms
Length	53"
Rated Wind Velocity	125 mph
Rated Wind Velocity (with 0.5" radial ice)	100 mph
Projected Wind Surface Area (flat plane equivalent)	0.46 sf
Number of Elements	13

- 1 Furnish mounting hardware with the antenna that will secure the antenna to a mounting
- 2 pipe that has a 1.1/2" Nominal Pipe Size (approximately 2" OD pipe diameter), as
- 3 recommended by the manufacturer of the antenna and as approved by the Engineer.

(E) Omnidirectional Antenna

Furnish an omnidirectional antenna of a solid, single piece construction in accordance with Table 1098-6.

Property	Requirement
Frequency Range	902 - 928 MHz
Nominal Gain	Typical gains of 3 or 6 dBd (dependent upon gain needed for application)
Termination	Standard N-Type Female Connector
Impedance	50 ohms
VSWR	1.5:1
Vertical Beam Width	33 degrees (3dBd Gain), 17 degrees (6dBd Gain)
Lightning Protection	DC Ground
Power Rating, UHF Frequency	100 Watts
Length	25" (3dBd Gain), 65" (6dBd Gain)
Rated Wind Velocity	125 mph

Furnish mounting hardware with the antenna that will secure the antenna to a mounting pipe that has a 1.5" Nominal Pipe Size (approximately 2" OD pipe diameter), as recommended by the manufacturer of the antenna and as approved by the Engineer.

(F) Antenna Mounting Hardware Kit

Furnish an antenna mounting kit to support the antenna when attached to a metal pole, mast arm or wood pole.

Ensure the Antenna Mounting Hardware Kit includes at least one 96" galvanized steel cable with a stainless steel bolt, nut and lock washer assembly on each end. Ensure the pole base plate accepts a 1 1/2" NPT aluminum pipe, and provides a surface that is at least 6 3/4" long x 4 1/4" to provide contact with the pole. Ensure the pole base plate is designed to allow both ends of the 96" galvanized cables to be secured and tightened to the base plate. Provide a 90 degree elbow with internal threads on both ends to accommodate 1 1/2" NPT aluminum pipes. Provide a 1 1/2" x 18" long aluminum pipe threaded on both ends and a 1 1/2" x 24" aluminum pipe threaded on one end with an end cap.

(G) Coaxial Cable

Furnish 400 Series coaxial cable to provide a link between the antenna and the lightning arrester that meets the following minimum specifications:

Property	Requirement
Attenuation (dB/100 ft) @ 900 MHz	3.9 dB
Power Rating @ 900 Mhz	0.58 kW
Center Conductor	0.108" diameter Copper Clad Aluminum
Dielectric: Cellular PE	0.285" diameter
Shield	Aluminum Tape - 0.291" diameter Tinned Copper Braid - 0.320" diameter
Jacket	Black UV protected polyethylene
Bend Radius	1" with less than 1 ohm impedance change at bend
Impedance	50 ohms
Capacitance	23.9 pF/ft

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1 (H) Standard N-Type Male Connector

2 Furnish Standard N-Type Male Connector(s) of proper sizing to mate with the 400 series
3 coaxial cable and use a crimping method to secure the connector to the coaxial cable.
4 Furnish a connector that meets the following minimum specifications:

5 (1) Center Contact: Gold Plated Beryllium Copper (spring loaded, non-solder)

6 (2) Outer Contact: Silver Plated Brass

7 (3) Body: Silver Plated Brass

8 (4) Crimp Sleeve: Silver Plated Copper

9 (5) Dielectric: Teflon PTFE

10 (6) Water Proofing Sleeve: Adhesive Lined Polyolefin – Heat Shrink

11 (7) Attachment Size: Crimp Size 0.429" (minimum) hex

12 (8) Electrical Properties:

13 (a) Impedance: 50 ohms

14 (b) Working Voltage: 1000 Vrms (max)

15 (c) Insertion loss: $0.1 \times \sqrt{F_{GHz}}$

16 (d) VSWR: 1.25:1 (max) up to 3GHz

17 (I) Coaxial Cable Shield Grounding and Weatherproofing Kits

18 (1) Furnish a Coaxial Cable Shield Grounding Kit containing components that will
19 adequately bond and ground the cable shield to the pole ground. Ensure the
20 grounding kit complies with MIL-STD-188-124A for coaxial cable and protects the
21 cable from lightning currents of at least 200kA. Ensure each kit is supplied, as
22 a minimum, with the following:

23 (a) Preformed Strap: 24 Gauge copper strap that is at least 1 5/8" long and is sized
24 to mate with the 400 series coaxial cable

25 (b) Tensioning Hardware: Copper nuts and lock washers

26 (c) Grounding Lead Cable: #6 AWG, stranded, insulated copper wire

27 (2) Furnish a Weatherproofing Kit containing components that will protect the coaxial
28 cable shield grounding system against the ingress of moisture and prevent vibrations
29 from loosening the connections. Ensure the weatherproofing kit is supplied, as
30 a minimum, with the following:

31 (a) Butyl Mastic Tape: 3 3/4" wide by 24" long (approximately)

32 (b) Electrical Tape: 2" wide by 20" long (approximately)

33 (J) Lightning Arrestor

34 Furnish a lightning arrestor installed in line between each antenna and its designated
35 radio modem inside the equipment cabinet in accordance with Table 1098-8. Furnish
36 lightning arrestor with multistrike capability, low strike throughput energy, flange mount
37 and bulkhead mount options and a standard N-Type female connector on both the
38 surge-side and protected-side connectors.

**TABLE 1098-8
PROPERTIES OF LIGHTNING ARRESTOR**

Property	Requirement
Filter Type	DC Block (non gas tube design)
Surge	20kA, 800MHz to 2.0GHz \leq 1.1 : 1 VSWR 18kA, 800MHz to 2.3GHz \leq 1.1 : 1 VSWR 18 kA, 700MHz to 2.7GHz \leq 1.2 : 1 VSWR
Insertion Loss	\leq 0.1 dB over frequency range
Max Power	500 W @ 920MHz (750 W at 122° F)
RF Power	300 Watts
Let Through Voltage	\leq ± 3 Volts for 3kA @ 8/20 μ s Waveform
Throughput Energy	\leq 0.5 μ J for 3kA @ 8/20 μ s Waveform
Temperature	-40 to 185° F Storage/Operating
Vibration	1G at 5 Hz up to 100Hz
Unit Impedance	50 Ohm
VSWR	1.1:1
Frequency Range	800 MHz to 2200 MHz

1 **(K) Coaxial cable – Power Divider (Splitter)**

- 2 Furnish a coaxial cable power divider for repeater radio sites in accordance with
3 Table 1098-9. Ensure the power divider accommodates a single primary input RF source
4 and divides/splits the signal (power) equally between 2 output ports.

**TABLE 1098-9
PROPERTIES OF COAXIAL CABLE - POWER DIVIDER**

Property	Requirement
Power Division	2 - Way
Frequency	900 - 1100 MHz
Insertion Loss	0.22 dB
Impedance	50 Ohm
VSWR ref. to 50 Ohm (max)	1.3:1
Max. Input Power	500 Watts
Connectors	Standard N-Type Female
Dimension	2.5"W x 5"L
Weight	1.5 lb (approximately)

5 **(L) Disconnect Switch**

- 6 Furnish a double pole, single throw snap switch in a weatherproof outlet box with cover,
7 suitable for use in wet locations. Ensure outlet box and cover supports a lockout tag
8 device. Ensure outlet box includes one 1/2" diameter hole in back of box. Furnish
9 mounting hardware, sealing gaskets and lockout tag.

10 **(M) Warning Signs and Decal**

- 11 Furnish "RF Warning Sign" and "Decal" at locations called for in the plans. Furnish
12 mounting hardware to secure the sign to either metal or wood poles.