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## Special Specification 6183

# Intelligent Transportation System (ITS) Media Converter




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### 1. DESCRIPTION

Furnish, install, and test a media converter of the type specified in designated Intelligent Transportation System (ITS) field equipment cabinets as shown on the plans.

A Ethernet media converter is defined as a device that transmits and receives data by means of Ethernet communication and converts Ethernet RJ-45 electrical signals to single mode optical format and from single mode optical format to Ethernet RJ-45 electrical format.

A serial media converter is defined as a device that transmits and receives data by means of serial communication and converts RS-232 communication media for transport over TCP/IP through an Ethernet RJ-45 port. A serial media converter is commonly referenced in the industry as a field terminal server or port server.

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### 2. MATERIALS

Provide new corrosion resistant materials in accordance with the details shown on the plans and meet the requirements of this Item.

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### 3. EQUIPMENT

#### 3.1. Ethernet Media Converter.

**3.1.1. Functional Requirements.** Provide a Ethernet media converter that supports data transmission over Ethernet communication and operates over two single mode or multimode fibers and be full duplex. Provide a media converter with fiber ports to support the network topology as identified on the plans.

Furnish a media converter that is stable, easily configurable with minimal effort, and able to communicate with other media converters through optical modulation. The media converter must have a fail-safe design such that device failure does not cause failure of any other equipment.

Provide a media converter with diagnostic light emitting diodes (LED) for power, receive optical signals present or absent, transmit laser current/over current, and data activity levels (link/speed) for the transmitter and the receiver portion of the device.

#### 3.1.2. Electrical Requirements.

**3.1.2.1. Power Requirements.** Provide a separate power supply providing a maximum 48 VDC for each media converter, to be provided as part of this Item. Maximum power draw must be less than 10 W each.

Provide each separate power supply capable of operating at 120 VAC  $\pm$  15 VAC at 60 Hz.

**3.1.2.2. Surge Protection.** Install media converter in an environment that has protection from power surges and sags.

- 3.1.2.3. **Power Service Transients.** Supply equipment in accordance with the requirements in the National Electrical Manufacturers Association (NEMA) Standard TS-2 for Traffic Control System, Sec. 2.1.6, "Transients" or latest revision.
- 3.1.2.4. **Wiring.** Meet the requirements of the most current version of the National Electric Code (NEC). Provide wires that are cut to proper length before assembly. No splicing of cables permitted. Provide cable slacks to facilitate removal and replacement of assemblies, panels, and modules. Doubling back of any wire to take up slack is not permitted. Lace wires neatly together with nylon lacing or outdoor rated plastic straps. Secure the cables inside the cabinet with outdoor rated plastic straps.
- 3.1.3. **Ethernet Port Configuration.** Provide a media converter with one copper Ethernet RJ-45 port that has the following characteristics:
- 3.1.3.1. **Interface.** 10/100Base-TX (100 Mb) or 10/100/1000 Base-TX (Gigabit) Ethernet, automatic half/full duplex setting, and link fault pass through with a female RJ-45 connector as shown on the plans.
- 3.1.3.2. **Medium Dependent Interface.** Automatic Medium Dependent Interface (MDI) and Medium Dependent Interface-Crossed (MDI-X).
- 3.1.3.3. **Bandwidth.** Up to 328 ft. cable length at 10 Mbps on Category 3, 4, or 5 unshielded twisted-wire pair cable. Up to 328 ft. cable length at 100 Mbps on Category 5e and 6 unshielded twisted-wire pair cable.
- 3.1.3.4. **Diagnostics.** Provide port with LED link status indicator.
- 3.1.4. **Fiber Optic Port Configuration.** Provide a media converter with fiber optic interface port as required for the network topology that has the following features:
- 3.1.4.1. **Interface.** 10/100 Base-X (100 Mb) or 10/100/1000Base-X (Gigabit) Ethernet as shown on the plans.
- 3.1.4.2. **Optical Connectors.** Provide connectors of the same connector type to be compatible with the fiber interface requirements on patch panel equipment as shown on the plans or as directed.
- 3.1.4.3. **System bandwidth.** 10/100Base-X up to 2 km at 100 Mbps on multimode fiber optic cable, and up to 20 km at 100 Mbps on single mode fiber optic cable.  
  
10/100/1000Base-X up to 20 km at 1000 Mbps on single mode fiber optic cable.
- 3.1.4.4. **Media Wavelength.** Media converter must operate in the 1310 nm wavelength for single mode fiber optic cable. Media converter must operate in the 850 nm or 1310 nm wavelength for multimode fiber optic cable as shown on the plans or as directed.
- 3.1.4.5. **Link Budget/Attenuation.** Single mode and multimode fiber operates over 0 to 21 dB path attenuation.
- 3.1.5. **Protocols Supported.** Provide a media converter that supports the following protocols:
- IEEE 802.3,
  - IEEE 802.3ab 1000Base-T,
  - IEEE 802.3u 100 Base-T,
  - IEEE 802.3i 10 Base-T, and
  - IEEE 802.3x for flow control.
- 3.1.6. **Visual Indicators.** Provide a media converter that has the following visual indicators:
- power,
  - fiber link/activity
  - UTP link/activity, and
  - full/half duplex.

- 3.1.7. **Regulatory Approvals.** Provide a media converter that has been certified to the following regulatory standards.
- Product Safety: Underwriters Laboratories (UL) Standard 1950 and 60950,
  - Electromagnetic Emissions: Federal Communications Commission (FCC) Part 15, Class A, National Electrical Manufacturers Association TS2, or latest revision, and
  - Institute of Electrical and Electronic Engineers (IEEE) 802.3 compliant.
- 3.2. **Serial Media Converter.**
- 3.2.1. **Functional Requirements.** Provide a serial media converter that supports data transmission over serial and Ethernet communication. Serial data received must be full duplex and conform to all requirements of Electronic Industries Associations (EIA) Standard RS-232, RS-422, and RS-485 governed by the Electronic Components Associations (ECA). Provide a serial media converter that can integrate with existing ITS field equipment and hardware in the field.
- Furnish a serial media converter that is stable, capable of plug-and-play operation, and able to communicate with other media converters through optical modulation. The media converter must have a fail-safe design such that device failure does not cause failure of any other equipment.
- Provide a serial media converter with diagnostic LED for power, transmit and receive signals present or absent, transmit laser current/over current, and data activity levels (link/speed) for the transmitter and the receiver portion of the device.
- 3.2.2. **Electrical Requirements.** Meet the requirements specified under Section 3.1.2.
- 3.2.3. **Ethernet Port Configuration.** Provide a serial media converter meeting the requirements specified under Section 3.1.3, except as modified below:
- 3.2.3.1. **Interface.** Provide one 10/100Base-TX (100 Mb), automatic half/full duplex setting, and link fault pass through with a female RJ-45 connector as shown on the plans.
- 3.2.4. **Serial Port Configuration.** Provide a serial media converter with the number of serial ports as shown on the plans.
- 3.2.4.1. **Interface.** Serial data received must be full duplex and conform to all requirements of Electronic Industries Associations (EIA) Standard RS-232, RS-422, and RS-485 governed by the Electronic Components Associations (ECA).
- Provide EIA-232 compatible ports with a minimum of one EIA-422 and EIA-485 switch selectable port.
- Provide a RJ-45 to DB-9 crossover cable with each unit for configuration in the field.
- 3.2.4.2. **Bandwidth.** Cable length drives up to 50 ft. on minimum of 24 American Wire Gauge (AWG) cable at 115 kbps (RS-232).
- Cable length drives up to 4000 ft. on minimum of 24 AWG cable at 115 kbps (RS-422/485).
- 3.2.5. **Protocols Supported.** Provide a serial media converter that supports the following protocols:
- IEEE 802.3,
  - IEEE 802.3u 100 Base-T,
  - IEEE 802.3i 10 Base-T,
  - IEEE 802.3x for flow control,
  - Transport Control Protocol (TCP)/User Datagram Protocol (UDP) Socket Services,
  - UDP Multicast,

- Telnet (both standard and raw data transfer),
- Reverse Telnet (both standard and raw data transfer),
- Point-to-Point Protocol (PPP),
- Secure Shell (SSH) version 2,
- Secure Sockets Layer (SSL)/Transport Layer Security (TLS),
- Hyper Text Transport Protocol (HTTP), and
- Simple Network Management Protocol (SNMP) version 2.

3.2.6. **Visual Indicators.** Meet the requirements specified under Section 3.1.6.

3.2.7. **Regulatory Approvals.** Meet the requirements specified under Section 3.1.7.

3.2.8. **Additional Features.** Provide a serial media converter that has the following additional features:

- maximum of 50 ms of end-to-end forwarding delay (serial in on one serial server to serial out on the other serial server) for any character in the data stream when used for a serial over IP tunnel,
- maximum of 10 ms of Ethernet-to-serial forwarding delay (from receipt of Ethernet packet to start of serial transmission) for any character in the data stream when used for serial to IP conversion,
- each serial port is accessible using a unique TCP port and IP address combination,
- support simultaneous connections to all serial ports on the unit,
- able to use a raw connection with no Telnet negotiation or interpretation of the data stream,
- able to pass a serial data stream bi-directionally without affecting the content of the data stream, and
- performance is not affected by the content of the data stream.

3.2.9. **Management.** Provide a serial media converter that provides the following management capabilities:

- web browser/HTTP configuration and management,
- telnet configuration and management,
- serial port configuration and management, and
- allow multiple management sessions or automatically terminate existing session when a new session is requested.

3.3. **Mechanical Requirements.**

3.3.1. **Modular Design.** Provide equipment modular in design to allow for ease of component replacement in the field.

Mechanically key sockets and connectors to prevent insertion of unlike functions into the wrong socket or connector.

Clearly identify all modules and assemblies with name, model number, serial number, and any other pertinent information required to facilitate equipment maintenance, inventory, and tracking. All identifying information markings must be permanent, UV resistant and intended for harsh environments

3.3.2. **Connectors.** Make all external connections by means of connectors. Key the connectors to preclude improper hookups. Color code or appropriately mark all wires to and from the connectors. Serial data interface connections must be RS-232, 425, or 485 DB connector types as required for compatibility with the intended device communications protocol.

Plate each and every conductive contact surface or pin with a minimum of 20 microns of gold.

For all installations supply fiber optic patch cables necessary to integrate the Ethernet media converter with the communication equipment and patch panel as shown on the plans, or as directed by the Engineer at no additional cost to the Department.

- 3.3.3. **Copper Connectors.** Input and output connectors must be via pinned connectors configured in a format compatible with the interface requirements of the data communications equipment.
- 3.3.4. **Harnesses.** Provide connecting harness of appropriate length and terminated with matching connectors for interconnection with the terminal equipment shown on the plans, or as directed by the Engineer.
- 3.3.5. **Housing.** Provide standard compact serviceable modules.
- 3.4. **Environmental Design Requirements.** Ensure that equipment conforms to NEMA TS-2-2003 (R2008) and NEMA 250-2008, or most current revision, for the following categories:
- 3.4.1. **Temperature.** Provide equipment that conforms to NEMA TS-2 Section 2.1.5.1, or latest revision, and meets all the specified requirements during and after being subjected to any combination of the following conditions:
- ambient temperature range of -29°F to 165°F,
  - temperature shock not exceeding 30°F per hour,
  - relative humidity of 0 to 95%, and
  - moisture condensation on all exterior surfaces caused by temperature changes.
- 3.4.2. **Vibration.** Provide equipment that conforms to NEMA TS-2 Section 2.1.9 and Section 2.2.3, or most current version, and meets all the specified requirements during and after being subjected to a vibration of 5 to 30 Hz up to 0.5g's applied in each of 3 mutually perpendicular planes for 30 min.
- 3.4.3. **Shock.** Provide equipment that conforms to NEMA TS-2 Section 2.1.10 and Section 2.2.4, or most current version, and does not yield permanent mechanical deformation or any damage that renders the unit inoperable when subjected to a shock of 10g applied in each of three mutually perpendicular planes for 30 min.
- 3.4.4. **Corrosion.** Provide equipment that is tested to conform to NEMA 250-2003 Section 5.10, or most current version, when located in coastal Districts. Coastal Districts include Beaumont (BMT), Corpus Christi (CRP), Houston (HOU), Pharr (PHR), and Yoakum (YKM).

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## 4. CONSTRUCTION

- 4.1. **General.** Utilize the latest available techniques with a minimum number of parts, subassemblies, circuits, cards, and modules to maximize standardization and commonality.
- Design for ease of maintenance, with all component parts readily accessible for inspection and maintenance.
- Provide test points for checking essential voltages and waveforms.
- 4.2. **Mechanical Components.** Use stainless steel for all external screws, nuts, and locking washers. No self-tapping screws are allowed unless specifically approved by the Engineer.
- Provide corrosion resistant parts, such as plastic, stainless steel, anodized aluminum or brass.
- Protect all materials used in construction from fungus growth and moisture deterioration.
- Separate all dissimilar metals by an inert dielectric material.
- 4.3. **Mounting.** Provide all mounting hardware as shown on the plans, or as directed by the Engineer at no additional cost to the Department.
- 4.4. **Documentation Requirements.** Provide a minimum of 2 complete sets of operation and maintenance manuals, at least 45 days prior to testing, in hard copy format, bound, as well as an electronic version in Adobe PDF format on a CD/DVD or removable flash drive that includes the following:

- complete network configuration diagram which documents locations of installed equipment, serial and model numbers, communication protocol settings, IP address, cabling, power service connections, and fiber assignments,
- complete installation procedures,
- compliance matrix documenting conformance to this specification,
- complete parts list including names of vendors for parts not identified by universal part number such as JEDEC, RETMA, or EIA,
- operations manuals,
- warranty documentation,
- complete maintenance and trouble-shooting procedures,
- testing procedures identifying threshold values,
- recovery procedures for malfunction,
- instructions for gathering maintenance assistance from manufacturer, and
- provide the Department with certification documentation verifying conformance with environmental and testing requirements contained in this special specification. Certifications may be provided by the manufacturer or through independent certified labs.

#### 4.5. **Testing.**

4.5.1. **General.** Unless otherwise shown on the plans, perform the following tests on the applicable equipment or systems.

4.5.1.1. **Test Procedures Documentation.** Provide 5 copies of the test procedures to include tests identified in Section 4.5.1.2 through Section 4.5.1.7 inclusive and blank data forms to the Engineer for review and comment at least 45 days prior to testing for each test required on this project. Include the sequence of the tests in the procedures. The Engineer will comment, approve, or reject test procedures within 30 days after Contractor submittal of equipment for tests. Contractor to resubmit, if necessary, rejected test procedures for final approval within 10 days prior to testing. Review time is calendar days. Conduct all tests in accordance with the approved test procedures.

Record measured test data on the data forms against threshold values, as well as quantitative results. No bid item measurement or payment will be made until the Engineer has verified the test results meet the minimum requirements of the specification. The data forms for all tests, except design approval tests, must be signed by an authorized representative of the Contractor.

Provide written notice to the Engineer within 48 hr. of discovery of any testing discrepancy identified during testing by the Contractor. Furnish data forms containing the acceptable range of expected results as well as the measured values.

4.5.1.2. **Design Approval Test.** Conduct a design approval test on randomly selected units from the prototype design manufacturing run. If only 1 design prototype is manufactured, perform this test on that unit. If supplying multiple types of the equipment, provide and test a sample of each type.

Certification from an independent testing laboratory of a successfully completed design approval test is acceptable. Ensure that the testing by this laboratory is performed in accordance with the requirements of this specification. Failure of independent tests to comply with the requirements of this specification are grounds for rejection of any certification.

Provide a copy of the certification to the District in which this contract is executed. The data forms for the design approval tests must be signed by an authorized representative (company official) of the equipment manufacturer or by an authorized representative of an independent testing facility.

Notify the Engineer 10 working days before conducting this testing. The Department may witness all the tests. Perform the following tests:

- 4.5.1.2.1. **Power Service Transients.** The equipment shall meet the performance requirements in this Item when subjected to the power service transients as specified in Section 2.2.7.2, "Transient Tests (Power Service)" of the NEMA TS 2 standard, most current version.
- 4.5.1.2.2. **Temperature and Condensation.** The equipment shall meet the performance requirements specified in this Item when subjected to the following conditions in the order specified below:
- Stabilize the equipment at -30°F and test as specified in Sections 2.2.7.3, "Low-Temperature Low-Voltage Tests" and 2.2.7.4, "Low-Temperature High-Voltage Tests" of the NEMA TS 2 standard, most current version;
  - Allow the equipment to warm up to room temperature in an atmosphere having relative humidity of at least 40%. Operate the equipment for 2 hr., while wet, without degradation or failure; and
  - Stabilize the equipment at 165°F and test as specified in Sections 2.2.7.5, "High-Temperature High Voltage Tests" and 2.2.7.6, "High-Temperature Low-Voltage Tests" of the NEMA TS 2 standard, most current version.
- 4.5.1.2.3. **Relative Humidity.** The equipment shall meet the performance requirements, specified in this Item, within 30 min. of being subjected to a temperature of 165°F and a relative humidity of 18% for 48 hr.
- 4.5.1.2.4. **Vibration.** The equipment shall show no degradation of mechanical structure, soldered components, or plug-in components and shall operate in accordance with the manufacturer's equipment specifications after being subjected to the vibration tests as described in Section 2.2.8, "Vibration Test" of the NEMA TS 2 standard, most current version.
- 4.5.1.2.5. **Power Interruption.** The equipment shall meet the performance requirements specified in this Item when subjected to nominal input voltage variations as specified in Section 2.2.10 "Power Interruption Test" of the NEMA TS 2 standard, most current version.
- 4.5.1.3. **Demonstration Test.** Conduct a demonstration test on applicable equipment at an approved Contractor facility. The Contractor may submit procedures and results from previous contracts in the same District as this contract provided the materials and equipment are identical, provided results are less than 5 yr. old. Notify the Engineer 10 working days before conducting this testing. The Department may witness all the tests. Perform the following tests:
- 4.5.1.3.1. **Examination of Product.** Examine each unit carefully to verify that the materials, design, construction, markings and workmanship comply with the requirements of this Item.
- 4.5.1.3.2. **Continuity Tests.** Check the wiring to determine conformance with the requirements of the appropriate paragraphs in this Item.
- 4.5.1.3.3. **Operational Test.** Operate each unit for at least 15 min. to permit equipment temperature stabilization and an adequate number of performance characteristics to ensure compliance with the requirements of this Item.
- 4.5.1.4. **Field Acceptance (Stand-Alone) Test.** Conduct a field acceptance test for each unit after installation as required by the Engineer in order to demonstrate compliance with the functional requirements with this Item. The test shall exercise all stand-alone (non-network) functional operations. Notify the Engineer 5 working days before conducting this test. The field acceptance test may consist of the following:
- 4.5.1.4.1. **Physical Construction.** Verify physical construction is completed in accordance with the plans and specification.
- 4.5.1.4.2. **Electrical and Communication.** Verify that all connectors for grounding, surge suppression, and electrical distribution are tightened correctly. Verify all power supplies and circuits are operating under the proper voltages. Verify all power and communications cables are terminated correctly, secured inside the cabinet, and fitted with appropriate connectors.

4.5.1.4.3. **Communication Link Quality.** Conduct signal tests for each communication link, including data transmit, data receive, bandwidth, proper operation of alarm and switches, and bit error rate. Document results in a written report to the Engineer.

4.5.1.5. **System Integration Test.** Conduct a system integration test on the complete functional system. Demonstrate all control and monitor functions for each system component for 24 hr. Notify the Engineer 10 working days before conducting this testing. The Department may witness all the tests.

Provide systems integration test procedures for proper adjustment and calibration of subsystem components. Proper adjustment and calibration involves documenting settings used to meet functional requirements while providing a margin for adjustment when future conditions change. Utilize the Department's software (when available) to perform subsystem testing. At a minimum, utilize this software to verify commands and confirms, as well as, detector actuations and occupancy dwell time. The Contractor is responsible for being familiar with any existing Department equipment and software.

The failure of any one component material or equipment item in a system integration test is justification for rejecting the entire subsystem. Each subsystem component must function as a complete integrated subsystem for a minimal continuous 24 hr. period during the system integration test.

4.5.1.6. **Final Acceptance Test.** Following completion of the demonstration test, field acceptance test, and system integration test for all subsystems, provide completed data forms containing all of the data taken, including quantitative results for all tests, a set of "as built" working drawings, and a written request to begin a data communication and final acceptance test. Provide "as built" working drawings indicating the actual material, equipment, and construction of the various subsystem components.

Within 10 calendar days of the request, execute a data communications test using a Department supplied software program or Contractor supplied software approved by the Department. The data communications test may be executed by the Engineer or the Contractor with the prior approval of the Engineer. The purpose of this test is to verify that the communications plan operates with application software provided by the Department.

Perform the data communications test for a period of 72 hr. If a message error or component failure occurs anywhere in the network, resume the test once repairs are completed. All components of the communications network must operate as an integral system for the duration of the test.

A message error is defined as the occurrence of a parity error, framing error, or data error in any component of the message. The error-free message rate is defined as the ratio of the number of messages in which no message error occurs to the number of messages transmitted. The error-free message rate must exceed 99.99% for acceptable transmission quality, both for the system as a whole, and for each component of the network.

Provide all additional test results to the Engineer for review once a successful data communications test has been completed. If all the requirements of this special provision have been satisfied, contract time shall be suspended and all subsystems shall be placed into operation and operate as a complete system for a period of at least 90 calendar days.

Notify the Engineer of any defects suspected in integration or function of material or equipment. Investigate any suspected defects and correct if necessary. Provide a report of findings within 2 calendar days of notice of any suspected defects. Describe the nature of the any defects reported and any corrective action taken in the report. The integrated subsystems must operate defect free as a single complete system for at least 72 continuous hours during the 30 calendar day review period. If the number of defects or frequency of failures prevents all subsystems from operating as described above, the Engineer may reject the entire system integration test results and resume contract time. Provide any necessary corrections and resubmit system integration test results and a request to begin a final acceptance test which may include "as built" plans and a data communications test.

The project will not be accepted, notwithstanding other provisions in the Contract, until the system, inclusive of all subsystems, has operated satisfactorily for a period of 90 days and in full compliance with the plans and specifications after approval of all submitted test results and reports.

- 4.5.1.7. **Consequences of Test Failure.** If a unit fails a test, submit a report describing the nature of the failure and the actions taken to remedy the situation prior to modification or replacement of the unit. If a unit requires modification, correct the fault and then repeat the test until successfully completed. Correct minor discrepancies within 14 days of written notice to the Engineer. If a unit requires replacement, provide a new unit and then repeat the test until successfully completed. Major discrepancies that substantially delay receipt and acceptance of the unit are sufficient cause for rejection of the unit.

Failure to satisfy the requirements of any test is considered a defect and the equipment is subject to rejection by the Engineer. The rejected equipment may be offered again for retest provided all noncompliance has been corrected.

If a failure pattern develops in similar units within the system, implement corrective measures, including modification or replacement of units, to all similar units within the system as directed. Perform the corrective measures without additional cost or extension of the contract period.

- 4.5.1.7.1. **Consequences of Design Approval Test Failure.** If the equipment fails the design approval test, correct the fault within 30 days and then repeat the design approval test until successfully completed.
- 4.5.1.7.2. **Consequences of Demonstration Test Failure.** If the equipment fails the demonstration test, correct the fault within 30 days and then repeat the demonstration test until successfully completed.
- 4.5.1.7.3. **Consequences of Field Acceptance (Stand-Alone) Test Failure.** If the equipment fails the stand-alone test, correct the fault within 30 days and then repeat the stand-alone test until successfully completed.
- 4.5.1.7.4. **Consequence of System Integration Test Failure.** If the equipment fails the system integration test, correct the fault within 30 days and then repeat the systems integration test until successfully completed.
- 4.5.1.7.5. **Consequences of Final Acceptance Test Failure.** If a defect within the system is detected during the final acceptance test, document and correct the source of failure. Once corrective measures are taken, monitor the point of failure until a 30 consecutive day period free of defects is achieved.

If after completion of the initial test period, the system has not operated for 72 consecutive hours free of defects, extend the 30 day test period by an amount of time equal to 72 consecutive hours to demonstrate performance, in addition to the number of days required to complete the performance requirement of the individual point of failure.

- 4.6. **Training.** Conduct a training class (minimum of 1 hr., up to 4 hr., unless otherwise noted in the plans) for up to 10 representatives designated by the Department on procedures of installation, operations, testing, maintenance and repair of all equipment specified within this specification for each type of unit provided. Submit to the Engineer for approval, 10 copies of the training material at least 30 days before the training begins. Conduct training within the local area unless otherwise authorized by the Engineer.
- 4.7. **Warranty.** Warrant the equipment against defects or failure in design, materials, and workmanship for a minimum of 3 yr. or in accordance with the manufacturer's standard warranty if that warranty period is greater. The start date of the manufacturer's standard warranty will begin after the equipment has successfully passed all tests contained in the final acceptance test plan. Any field equipment with less than 90% of its warranty remaining after the final acceptance test is completed will not be accepted by the Department. Guarantee that equipment furnished and installed for this project performs according to the manufacturer's published specifications. Assign, to the Department, all manufacturer's normal warranties or guarantees on all electronic, electrical, and mechanical equipment, materials, technical data, and products furnished for and installed on the project

Media converters must be repaired or replaced at the Contractor's expense prior beginning the final acceptance test plan in the event of a malfunction or failure. Furnish replacement parts for all equipment within 10 days of notification of failure by the Department.

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**5. MEASUREMENT**

This Item will be measured by each ethernet media converter or serial media converter.

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**6. PAYMENT**

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price for "Ethernet Media Converter" and "Serial Media Converter" of the type specified. This price is full compensation for furnishing and installing units including all equipment, all cables and connectors, all documentation and testing; and will include the cost of furnishing all labor, materials, training, warranty, equipment, and incidentals.