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Iowa Department of Transportation

SPECIAL PROVISIONS
FOR
TRAFFIC SIGNALS

Polk County
STP-U-0187(625)--70-77

Effective Date
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THE STANDARD SPECIFICATIONS, SERIES 2009, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

TRAFFIC SIGNAL SPECIFICATIONS –

VIDEO DETECTION SYSTEM, UNINTERRUPTIBLE POWER SUPPLY SYSTEM, EMERGENCY VEHICLE PREEMPTION SYSTEM, and FIBER OPTIC SYSTEM

Project number: STP-U-0187(625)- -70-77

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A. GENERAL

A. This part of the Special Provisions consists of the general requirements necessary when furnishing a video traffic detection system installation, uninterruptible power supply system installation, emergency vehicle preemption system, and fiber optic sytem installation complete, in place, and operative as described in the project plans and these specifications.

B. The Developmental Specifications for Traffic Signals (DS-09030) and the Standard Specifications for Highway and Bridge Construction, Series of 2009, Iowa Department of Transportation, as modified by these specifications, or other appropriate special provisions shall apply to this project. The installation of the traffic control signals and appurtenances shall be in conformance with the Manual On Uniform Traffic Control Devices for Streets and Highways, as adopted by the Department per 761 of the Iowa Administrative Code (IAC), Chapter 130.

B. VIDEO IMAGE PROCESSING SYSTEM

The City of Ankeny uses a video detection system manufactured by Traficon including the 3D.2 video detection processor card and Viewcom/E Max Communications card.

INTENT:

The intent of the following specification is to describe the minimum requirements for providing a complete Video Detection System. The system shall be capable of providing presence vehicle detection and traffic data collection at selected intersections. The video system shall be expandable without removing or replacing existing units.

OVERVIEW:

Using standard image sensor optics and in the absence of occlusion, the system shall be able to detect vehicle presence with 98% accuracy under normal conditions (days and nights), and 96% accuracy under adverse conditions (fog, rain, snow).

All items and materials furnished shall be new, unused, current production models installed and operational in a user environment and shall be items currently in distribution. The detection and data collection algorithms shall have a proven record of field use, with a minimum of three (3) years of service.

GENERAL:

These technical specifications describe the minimum physical and functional properties of a video detection system. The system shall be capable of monitoring all licensed vehicles on the roadway, providing video detection for areas outlined in the construction drawings. The entire video detection system shall consist of the following:

- Video Image Processing unit(s).
- Video system communications module.
- Video camera(s) with IR filter, enclosure and sunshield.
- Camera lens.
- Surge suppressor.
- All other necessary equipment for operation.

1.0 HARDWARE

1.0 The **V**ideo **I**mage **P**rocessor (VIP) shall be modular by design and housed in either a self-contained stand-alone unit or fit directly into NEMA TS1 & TS2 type racks as well as Type 170/179 input files. The VIP shall be interchangeable between a shelf or rack mount installation without replacing or modifying the existing VIP units.

1.1 The system shall control from 1 to 5 VIP boards allowing for 1 to 10 image sensors.

1.2 The system shall be designed to operate reliably in the adverse environment of roadside cabinets and shall meet or exceed all NEMA TS1 and TS2, as well as Type 170/179 environmental specifications.

1.3 Ambient operating temperature shall be from –35 to +75 degrees Centigrade at 0 to 95% relative humidity non-condensing.

1.4 The system shall be powered by 12-40 VDC and draw less than 2 amperes.

1.5 The system shall utilize cabinet 24 VDC for rack mount installations or external 24 VDC for stand-alone shelf installations.

1.6 Surge ratings shall be set forth in the NEMA TS1 and TS2 specifications.

1.7 Serial communications shall be through an RS232 serial port. This port can be used for communications to a modem or laptop to upload/download detector configurations, count data and software upgrades. RS485 on the rear edge connector shall facilitate communications to other VIP boards.

1.8 Each VIP board shall have 4 opto-isolated open collector outputs. Twenty (20) additional outputs shall be available via the expansion port. The VIP shall have 20 presence detection zones and 4 data detection zones per camera. Data zones shall collect and store vehicle counts, volume, speed, gap time, headway, occupancy, and classification. Data shall be time-stamped (6713 intervals) and stored onboard (non-volatile memory) in intervals from 1-60 minutes.

1.9 Data alarms are generated for: queue, inverse direction, speed drop, no video, and errors.

1.10 Must be able to provide single or double loop emulation.

1.11 Presence hold time must have parameters that range from 10 to 600 seconds.

1.12 Each VIP board shall allow for 20 digital inputs via the I/O Expansion port.

1.13 Each VIP board shall have error detection. An output contact will open if the video signal is bad or the VIP board is not functioning properly. A user defined quality level will automatically put the VIP into a recall state in cases of severe degraded visibility (i.e., fog, blizzard, etc.). Normal detection resumes when visibility improves above the user defined quality level.

1.14 Operator selectable recall shall be available via the VIP front panel. Holding the recall switch on for 5 seconds shall activate this function.

1.15 A video select button on the VIP front panel will switch between camera images of the VIP.

1.16 The VIP board shall have 2 video inputs (RS-170 NTSC or CCIR composite video) and two video outputs (one on the front panel and one on the edge connector). The video inputs shall be though the VIP board’s edge connector.

1.17 The VIP board shall have a reset button on the front panel to reset video detectors to “learn” the roadway image. During “relearn”, selectable recall can be enabled or disabled for immediate operation. Learning time of video detectors shall be less than 5 minutes.

1.18 External surge suppression, independent of the VIP board shall separate the VIP from the image sensor.

1.19 The VIP board shall have separate light emitting diodes (LEDs) that indicate:

POWER	Red to verify power supply.
I/O COMM	Red to indicate communications to expansion boards.
VIDEO 1 & 2	Red to verify the presence of video input 75 Ohm.
TX & RX	Red to indicate communications via the serial port.
OUT1- OUT4	Green if the corresponding detection group is active.

The VIP board shall also have 2 separate buttons for:

VIDEO SELECT	
RECALL	Manually places call on detectors.
RESET	Manually reset detectors to “learn” new background.

1.20 The video detection system shall be capable of being programmed locally with a handheld keypad. Keypad and monitor must be separate units. A PC mouse will not be allowed. The setup monitor is to have a 9 inch, black and white screen.

1.21 The VIP board shall have a video out female RCA style connector, DB9 female Service port and DB9 I/O Expansion port

1.22 The VIP Expansion board shall also have separate LEDs that indicate:

POWER	Red to verify power supply.
COMM	Red to indicate communications to VIP board.
I/O1- I/O4	Green if the corresponding detection group is active.

The VIP Expansion board shall have 8 dip switches that define inputs and outputs used (range: 1-12 or 13-24).

1.23 Event Log Database

The VIP module shall have an onboard database capable of time stamping and storing 500 events. The Event Log Database can be viewed or downloaded to a selected spread sheet. Erasure of the Event Log Database shall not alter programmed configurations. As a minimum, the VIP shall log and time stamp the following events;

- Firmware upgrade.
- Loss of video signal.
- Resumption of video signal.
- Configuration change.
- Bad video quality.
- Loss of power to VIP module.
- Resumption of power to VIP module.
- Speed alarm.
- Inverse direction.
- Recall activated.

Video System Communications Module

1.24 The Communication board shall be modular by design and housed in either a self-contained stand-alone unit or fit directly into NEMA TS1 & TS2 type racks as well as Type 170/2070 input files.

1.25 The Communication board shall be able to control from 1 to 6 VIP boards allowing for 1 to 12 image sensors.

1.26 The system shall be designed to operate reliably in the adverse environment of roadside cabinets and shall meet or exceed all NEMA TS1 and TS2, as well as Type 170/2070 environmental specifications.

1.27 Ambient operating temperature shall be from –34 to +74 degrees Centigrade at 0 to 95% relative humidity non-condensing.

1.28 The system shall be powered by 12-40 VDC and draw less than 2 amperes.

1.29 Serial and Ethernet (TCP/IP) communications shall be through respectively an RS232 serial port (F DB9 connector) and Ethernet port (RJ-45 connection). These ports can be used for communications to a laptop or modem to upload/download detector configurations, traffic data, technical events, send software upgrades and do remote setup of detectors. RS485 on the rear edge connector shall facilitate communications to VIP boards.

1.30 Surge ratings shall be set forth in the NEMA TS1 and TS2 specifications.

1.31 The Communication board shall have separate light emitting diodes (LEDs) that indicate:

POWER	Red LED to verify power supply.
LAN	Red LED to indicate data activity over Ethernet communication.
VIDEO OUT	Female RCA style connector.
RESET	Manual reset to re-initialize communications.
SERVICE	DB9 female Service port for setup of communication board and also used for serial/dial-up communication.

1.32 The Communications Board and equipment shall be furnished only when required in the project documentation.

2.0 FUNCTIONAL CAPABILITIES

2.1 Real Time Detection

2.2 Each VIP board shall be capable of processing two (2) separate video signals (two (2) separate cameras) per VIP board. The video signal shall be analyzed in real time (30 times per second).

2.3 The system shall be expandable up to 10 cameras that may be connected to different VIP units and programmed independently.

2.4 The system shall be capable of displaying detectors on the video image with associated outputs. Outputs/Inputs status will be indicated on the screen. Parameters will also include the ability to view raw video without any verbiage and/or detectors for surveillance purposes.

2.5 Each VIP board will detect within the view of the connected camera the presence of vehicles in user defined zones. Detectors available shall be presence, count, queue, delay, extension, or pulse mode of either arrival or departure of vehicles.

Delay and extension shall be defined between 0.1 – 99.9 seconds and pulse mode between 0 – 200msin 33ms increments if NTSC is used. Each VIP board shall also detect and collect traffic data of passing vehicles in user-defined zones within the view of the connected camera.

Collected traffic data by direction shall include:

- Volume (absolute numbers) per length class and per lane.
- Average speed (km/h or mph) per length class and per lane.
- Average gap time (1/10 sec) per length class and per lane.
- Average headway (m or feet) per lane.
- Occupancy (%) per lane
- Concentration (vehicles/km or mile) per lane.
- Average length (m or feet) per lane.
- Confidence level (0-10) per lane.

2.6 The VIP board shall be programmed without the use of a supervisor computer. A standard CCTV monitor and handheld keypad plugged into the VIP serial port will facilitate detector programming. The handheld keypad shall include the following keys and respective functionalities:

Keys	**Functionality**
Enter Key	● To enter a menu, a submenu or an item within a submenu. ● To select a value for a parameter and exit the topic.
Escape Key	● To exit the menu or submenu. ● To exit the main menu and save the settings in the current configuration.
Arrow Keys	● To scroll through a menu. ● To scroll through the values of a parameter. ● To select a submenu. ● To make a presence zone direction sensitive.
F1 Next Key	● To proceed to the next detection zone.
F2 Prev Key	● To move to the previous detection zone.
F3 Add Key	● To add a detection zone.
F4 Del Key	● To delete a detection zone.
Dir Key	● To make a data zone direction sensitive.
Help Key	● To display help text for an item.
Output Number Key	● To assign an output number to a detection zone.
Operate Key*	● To put the board in operation mode.
Edit Key	● To change settings while starting from default values for all parameters.
Modify Key*	● To change settings while starting from the last saved settings for all parameters.

* The functionality of this key is only for the video system communications modules

2.7 The VIP board shall store up to 8 detector configurations (4 per video input). It shall be possible to switch between detector configurations manually, automatically by time of day or remote input.

2.8 Via the serial port, detector configurations can be uploaded to a laptop and stored on disk.

2.9 Detectors may be linked to 24 outputs and 20 inputs using Boolean Logic features: AND, OR, NOT. It will be possible to generate conditional outputs based upon inputs from a controller.

2.10 It shall be possible to make a detector directional sensitive. Options will include an omni-directional detector or a detector that only senses movement: from right to left, left to right, up to down or down to up as you look at the monitor.

2.11 All detectors and parameters can be changed without interrupting detection. For example: when one detector is modified, all existing detectors continue to operate, including the one that is being modified. When the new position is confirmed, the new detector will enter a learning phase. Once the new detector is in function, it will take over the job of the old one. In this way, the detector is always fully operational with no interruption on any detector, even during modification. Learning phases for new detectors shall not exceed 10 seconds.

2.12 Four data detection zones per camera on a two camera VIP board may be used for collection of vehicle count, speed, classification, occupancy, density, headway, and gap time. These detectors will detect and store traffic data at user-defined intervals of 1, 2, 3, 5, 6, 10, 15, 30 & 60 minutes. It shall be possible for each VIP board to store up to 6713 intervals of data in non-volatile memory.

2.13 Six detectors per camera may be used as queue detectors. Using on screen calibration, queue detectors will detect queue delays and display the queue length in feet or meters. A queue may also generate an output alarm from the VIP board.

2.14 Associated software shall be used with a PC to download count data and export to a spreadsheet. The software shall also be used to upload/download detector configurations, traffic data, technical events and update software versions of the VIP board.

2.15 All software upgrades to associated software and VIP board software shall be provided at no cost to the city.

2.16 The VIP board shall have an internal clock with daylight savings time system, which can be enabled or disabled.

2.17 The VIP board shall provide overlaid tool tips for each individual menu- and submenu-items.

2.18 The VIP board shall have an optional password implementation. Different user-levels shall be available each having different rights. All equipment must be capable of having a minimum of 10 users that can be defined for each user-level.

2.19 The VIP board shall be able to delay or extend a detector zone output in combination with an input from the controller.

2.20 The VIP board shall detect wrong-way drivers and shall provide an alarm/event via communication board and/or output.

2.21 The VIP board shall provide an alarm and/or output when the user selected queue detection threshold of occupancy is exceeded for more than a user selected time threshold.

2.22 The VIP board shall distinguish five classes of detected vehicles based upon user selectable vehicle length thresholds.

2.23 The VIP shall be able to emulate loop emulation with user selectable loop dimensions.

2.24 The VIP shall have a Detection Hold Time function. The timing parameters shall be 10 – 600 seconds.

2.25 The VIP board shall provide advanced settings to optimize detection to avoid cross-lane traffic occlusion. Directional detectors shall be able to be programmed for Low, Medium or High depending on the severity of the occlusion.

2.26 The VIP shall be programmable for Wrong Way Suppression Delay. The timing parameters shall be 1 – 30 seconds.

2.27 The VIP board shall utilize advanced shadow rejection algorithms. It shall be possible to place detection zones over lane markings without affecting the shadow rejection accuracy from adjacent vehicle (moving) shadows.

2.28 The VIP board shall utilize an advanced Tree Shadow Suppression algorithm to suppress false detection of moving shadows (non-vehicular, i.e. trees) within a detection zone. It shall be possible to enable or disable this feature.

2.29 The VIP board shall provide integrated image quality diagnostics eliminating the need for users to manually place quality detection zones on the image. Advanced diagnostic information shall display both the quality of the video images (Qim) as well as the quality of detection (Qdet). The Qim and Qdet together will be averaged to provide an overall quality (Q). Each quality diagnostic (Qim, Qdet & Q) will be based on a 1 (poor quality) to 10 (excellent quality) scale. The Qim and the Qdet quality information for the individual camera under observation shall both be displayed simultaneously on the setup monitor equipment for quality diagnostics.

2.30 The VIP board shall provide the capability to enter a “recall” state if the quality threshold falls inside a user-defined range. The range shall be defined by the Quality Level (1-10) and a timeout range of 1 to 99 minutes. For example, if the quality drops to level 5 for 2 minutes, the VIP shall enter a “recall” mode. Once the quality rises above level 5 for 2 minutes, the VIP resumes normal operation. The VIP shall also provide a contact closure output during this condition.

VIDEO SYSTEM COMMUNICATION MODULE:

2.31 The Video System Communication board shall be able to control from 1 to 6 VIP boards allowing for 1 to 12 image sensors.

2.32 The Video System Communication board shall provide a serial or Ethernet interface and communication to provide traffic data and allow remote configuration from the Traffic Operations Center.

2.33 The LAN port shall meet IEEE 802.3 with a RJ-45 connector and meet the following specification:

- Data rates for Ethernet via LAN port: 10Mbit/s
  TCP/IP based protocol

2.34 The serial communications port shall meet EIA-232-E and meet the following specifications:

- Dial-up data rates for RS232 via Serial port: maximum 57600 bps
- Direct data rates for RS232 via Serial port: maximum 115200 bps
- Mode of operation: asynchronous, serial, 8 bit word, 1 stop bit, duplex or half-duplex
- Parity: none
- Handshake: RTS - CTS, DCD
- Configuration: DTE

2.35 The communication shall support all functions of the video detection system.

2.36 All data transmissions shall be protected by CRC (cyclic redundancy checking) or an equivalent error detection method.

2.37 The communication board shall be programmed without the use of a supervisor computer. A standard CCTV monitor and keypad plugged into the communication serial port will facilitate board programming.

2.38 The communication shall support streaming video over Ethernet and serial communication.

- Streaming video frame rate:
  - Over Ethernet: 10 frames/second
  - Over serial communication: guarantee of 1 frame every 2 seconds.

2.39 Password protected remote setup (configuration upload/download, setup of detectors and detector parameters, setup of communication board parameters, firmware updates for Communication and VIP module) and monitoring of every connected VIP module shall be possible.

2.40 Dialup shall be possible through PSTN modems.

2.41 The Communication board shall log data and events provided by the VIP module(s) and transmit data and events to the HOST computer.

2.42 RS485 communication to every VIP module shall be established via the Edge connector.

2.43 The Communication board shall be able to store on board pre-post video sequences of alarm triggered upon traffic user defined events. When connected to a HOST computer, the JPEG video sequences shall automatically be downloaded to the HOST computer.

2.44 The Communication board shall be able to accept PAL or NTSC video format.

2.45 A (via Ethernet) connection with a standard Internet browser shall be possible to communicate with the Communication board for remote set-up, monitoring and real-time data of the VIP modules.

2.46 The Communications Board and equipment shall be furnished only when required in the project documentation.

2.47 Password protection shall be provided on the Communication board for remote operations.

3.0 IMAGE SENSOR- CAMERA

3.1 The unit shall be a high resolution, 1/3" image format CCD camera, designed for professional video surveillance systems. Cameras shall be available commercially. No sole source cameras will be allowed. Incorporating the latest in CCD technology, the video camera shall provide detailed video without lag, image retention, or geometric distortion. System must also be capable of working with either a color or black and camera.

Temperature range	-20 to + 55 degrees C
Humidity	0% to 95% relative, non-condensing
Dimensions	47mm X 47mm X 83mm
Weight	7.1oz.
Camera mounting slots	1/4-20, top and bottom
Connectors	BNC for video out
Lens mount	CS Power-in / pressure screw Lens / 6-pin miniature "DIN" style
Finish	Off-white semi-gloss polyurethane
Construction	All metal housing
Rated input voltage	24 VAC, 60 Hertz
Voltage range	21 to 30 VAC
Nominal power	4 Watts
Imager	Interline transfer CCD 1/3" format
Imager spectral response	100% @ 550nm: 30% @ 400nm and 800nm
Sync system	EIA RS-170
Active picture elements	768 H X 494 V
Horizontal resolution	580 TVL

Sensitivity (2856 K)

		Usable Picture	**Full Video**
Scene Illumination	fc	0.01	0.048
	lx	0.1200	0.480
Imager Illumination	fc	0.0024	0.01
	lx	0.0024	0.10

* F 1.2 lens @ 89% highlight

Signal to noise ratio	48 dB minimum 58 dB typical
AGC	21 dB, (max)
Electronic Shutter	1/60 to 1/600000 sec. (EIA)
Aperture Correction	Horizontal and vertical symmetrical
Video out	1.0 volts peak-to-peak +/- 0.1 volt @ 75 Ohms
Programmable Controls	Video level, shutter, AGC, BLC, Auto Black

4.0 IMAGE SENSOR- LENS

4.1 The camera lens shall be a motorized vari-focal 6.5-65mm with auto iris.

• Image format	1/3 inch
• Focal length	10X zoom (6.5-65mm)
• Iris range	f 1.4 – Approx. 360 (With ND Spot Filter)
• Focus range	9.85mm (in air)
• Back focus distance	10.05mm (0.4in.) in air
• Weight	285g.
• Lens mount	CS
• Iris control	4 pin DC control
• Focus control	Motorized
• Zoom	Motorized

5.0 IMAGE SENSOR- HOUSING

5.1 The environmental housing shall be an aluminum enclosure designed for outdoor CCD camera installations.

Temperature range	-40 to +50 degrees C
Dimensions	449mm x 97mm x 112mm
Weight	1.4kg
Housing mounting	Three 1/4-20 tapped holes
Camera mounting	Removable cradle assembly
Cable entry	Three liquid-tight fittings that will accept cable diameters of: One fitting - 2 to 7 mm Two fittings - 3 to 10 mm
Finish	Off-white semi-gloss polyurethane
Construction	Extruded aluminum housing, Aluminum rear-end cap, Aluminum front cap with glass face plate, and Aluminum cradle. A sunshield shall be included
Window	3 mm thick glass that includes a Thermostatically controlled window Heater/defogger strip
Rated input voltage	115 VAC 60 Hertz
Voltage range	108 VAC to 132 VAC
Output voltage	24 VAC 60 Hertz
Nominal power	30 Watts
Enclosure protection	Waterproof and dust-tight in a NEMA-4, IP65, enclosure Type 3

6.0 SURGE PROTECTION

6.1 A video surge suppressor(s) shall be available for installation inside the traffic signal controller cabinet. The suppressor shall provide coaxial cable connection points to an EDCO CX06-BNCY (EDCO CX-06-M), or approved equal transient suppresser for each image sensor.

Peak Surge Current (8 x 20 us)	20KA
Technology	Hybrid, Solid State
Attenuation	0.1db @ 10Mhz
Response Time	<1 nanosecond

• Protection	Line to Ground
Shield to Ground	(isolated shield modules)
• Clamp Voltage	6 volts
• Connectors	BNC
• Impedance	75 Ohms
• Temperature	-40 to +85 degrees C
• Humidity	0-95% non-condensing
• Dimensions	4.5” x 1.5” x 1.25”
• UL Listed	UL 497B

7.0 IMAGE SENSOR- MOUNTING BRACKETS

7.1 Mast arm installations shall be mounted at a sufficient height to prevent occlusion from cross traffic between the stop bar and the mast arm on which the camera is installed. A 74” maximum length of internally reinforced, aluminum tube shall be attached to the mast arm bracket for camera mounting above the mast arm. Camera shall be mounted to the top of the tube with the camera manufacturers recommended bracket. Camera bracket shall provide adjustments for both vertical and horizontal positioning for the camera. Camera attachments shall be designed to securely fasten the camera to prevent the extension tube from falling into the path of vehicles and/or becoming loose. Mounting bracket must fasten to the Mast arm using a 64” or 82” aircraft cable. Miscellaneous hardware shall be stainless steel or galvanized steel. The cameras and associated pole/arm attachment unit shall be designed to withstand a wind load of 90 MPH with a 30-second gust factor.

7.2 Luminaire arm installations shall be installed on the luminaire arm, with the camera/video manufacturers recommended brackets. Camera luminaire brackets shall provide adjustments for both vertical and horizontal positioning of the camera. Camera attachments shall be designed to securely fasten the camera to the luminaire arm. Mounting bracket shall be made of aluminum. Miscellaneous hardware shall be stainless steel or galvanized steel. The cameras and associated pole/arm attachment unit shall be designed to withstand a wind load of 90 MPH with a 30-second gust factor.

8.0 IMAGE SENSOR- CABLE (COAXIAL & POWER)

8.1 Coaxial & Power cable (Siamese) shall be installed in conduits or overhead as indicated in the plans. Coaxial cable shall be suitable for exterior use and in direct sunlight. Power cable will have a minimum of five (5) conductors.

8.2 A junction box on the camera bracket arm shall provide access to video and power cable terminations. No soldering shall be required in the field. Coaxial cable will terminate with a “barrel” style BNC connector and power shall be terminated via a small terminal strip or via “wire nuts.”

8.3 Coaxial cable will be terminated in the surge suppressor before being connected to the VIP boards.

8.3 Power cable will be terminated into a fuse panel provided by the manufacturer and connected to 120 VAC in the controller cabinet.

8.4 Description of cable: Composite, 6 Conductors 2 elements: 18awg 5 conductors 7/26 bare copper, .016” polyethylene, 20awg 1 conductor, solid bare copper, 056” foam polyethylene jacket black, overall .030” PVC jacket black.

8.5

	ELEMENT 1	**ELEMENT 2**
CONDUCTORS/PAIR COUNT:	5 CONDUCTORS	1
CONDUCTOR GUAGE & STRANDING:	18AWG 7/26 BC	20AWG SOLID BC
PRIMARY INSULATION TYPE:	POLYETHYLENE	FOAM PE
INSULATION THICKNESS:	.016”	.056”
COLOR CODE:	WHITE,RED,BLUE,BLACK,BROWN.	NATURAL
SHEILD:	N/A	N/A
TAPE:	N/A	N/A
DRAIN WIRE:	N/A	N/A
BRAID:	N/A	95% BC
CAPACITANCE:	N/A	N/A
PRINT LEGEND:	N/A	N/A
JACKET TYPE:	N/A POLYETHYLENE	
JACKET COLOR:	N/A	BLACK
JACKET THICKNESS:	N/A	.035”
NOMIMAL OD:	N/A	.242”

8.6 **OVERALL ASSEMBLY OF WIRE**

JACKET THICKNESS:	.030”
JACKET COLOR:	BLACK
JACKET MATERIAL:	PVC
RIPCORD:	YES
NOMINAL OD:	.512”
VOLTAGE RATING:	600V
TEMP. RATING:	75C
UL TYPE OR STYLE:	N/A
PRINT LEGEND:	TBD
PACKAGING:	TBA
COPPER WEIGHT:	39.87 LBS/MFT
SHIPPING WEIGHT:	100 LBS/MFT

9.0 INSTALLATION

9.1 A factory certified representative from the product supplier of the video detection equipment shall be on-site during the final set up of the video detection system to supervise the final installation and final testing of the video equipment.

10.0 WARRANTY

10.1 The video detection system shall be warranted against manufacturing defects in materials and workmanship for a period of one year from the date of installation. The video detection supplier shall provide operational documentation for the VIP system.

C. UNINTERRUPTIBLE POWER SUPPLY SYSTEM

1.0 SYSTEM DESCRIPTION:

The supplier shall provide and install a microprocessor, software driven double conversion Signal Sense model SSDC-1500 UPS power system compatible with the existing city UPS central software. The Traffic UPS shall be a true on-line regenerative uninterruptable power system for traffic and ITS applications. The rated continuous output shall be 1100 watts. The system will be designed to operate continuously from any AC utility source or generator. The UPS shall be equipped with an Ethernet communication port. System shall be Ethernet ready, regardless of user readiness to deploy system Ethernet capability. The UPS is to be equipped with a programmable LCD front panel display to allow for both programming and monitoring of the UPS. The UPS shall be SNMP ready and include local and remote communication capabilities. A Power Management Module (PMM) shall be included with the UPS system to switch between utility power and battery power when required.

1.1 SYSTEM COMPONENTS

1) An “On-Line” Double Conversion UPS Module, sized as 1100 Watts – 36 volt D.C. operation.
2) The UPS system shall provide conditioned, fully regenerative, pure sine wave AC to the traffic system.
3) A PMM (Power Management Module) with a standard transfer switch that enables the system to switch between utility power and battery power.
4) A battery bank sized for the appropriate inverter – minimum of three (3) deep cycle 12 volt D.C. automobile sized car batteries.
5) A battery bank temperature sensor to regulate battery charging rate.

1.2 UPS Module Features

1) A True On Line, Double Conversion Inverter utilizing high frequency IGBT Technology.
2) Provides fully regenerative, conditioned power to the traffic system load.
3) Connections available to wire remote event monitoring and operation.
4) Standard Ethernet capability.
5) Inverter input switch-over thresholds adjustable from 85V to 135 VAC and 40 to 70 Hz.
6) Provide interchangeability with existing UPS systems in the city to include, but not be limited to, alarm status outputs, traffic signal cabinet wiring, etc. via the ethernet port/fiber optic interconnect.
7) Compatibility with the city of Ankeny existing Signal Sense CENTRAL 2010 central software UPS communications protocol and operation.

1.3 Power Management Module (PMM) Features

1) Equipped with a wrap around maintenance Bypass switch to enable removal and replacement of the UPS Module without shutting down traffic control equipment.

1.4 Battery Bank Features

1) Battery cables are equipped with Anderson type lug connectors.
2) All Battery connections are bolted utilizing stainless steel hardware.
3) System can be equipped with Valve Regulated, Absorbed Glass Mat (AGM) or Gel Batteries.
4) System is capable of utilizing any approved deep cycle “Off the Shelf” Battery.
5) System is equipped with bolt on battery temperature probe.

2.0 WARRANTY

2.1 The uninteruptible power supply system shall be warranted against manufacturing defects in materials and workmanship for a period of one year from the date of installation. The equipment supplier shall provide operational documentation for the system.

D. EMERGENCY PREEMPTION

1.0 SYSTEM DESCRIPTION:

The required priority control system will employ an Opticom brand data-encoded infrared communication to identify the presence of designated priority or probe vehicles. A record of system users, in the form of vehicle classification and identification number, will be created. In priority vehicle mode, the data-encoded communication will request the traffic signal controller to advance to and/or hold a desired traffic signal display selected from phases normally available. In probe vehicle mode, no traffic signal priority is requested--only a record of the probe vehicle's presence is generated.

The priority control system will consist of a matched system of data-encoded emitters, infrared detectors, detector cable, phase selectors and system software.

The emitter will generate an infrared, data-encoded signal. The data-encoded signal will be detected and recognized by the infrared detectors at or near the intersection over a line-of-sight path of up to 2,500 feet under clear atmospheric conditions. The phase selector will process the electrical signal from the detector to ensure that the communication (1) is a valid base frequency, (2) is correctly data encoded, and (3) is within the user-settable priority request activation range, and (4) performs priority arbitration between simultaneous users of the system. If these conditions are met, the phase selector will generate a priority control request to the traffic controller (i.e., a green light) for the approaching priority vehicles, or record the presence of approaching probe vehicles by classification and identification number.

The system will require no action from the vehicle operator other than to turn the emitter on. The system will operate on a first-come, first-served basis. High priority requests will override low priority requests. The system will interface with most traffic signal controllers and will not compromise normal operation or existing safety provisions.

2.0 MATCHED SYSTEM COMPONENTS:

The required priority control, data-encoded, infrared communications system will be comprised of five basic matched components: data-encoded emitter, infrared detector, detector cable, phase selector and system software. In addition, a card rack and an electromechanical interface card will be available if required. To ensure system integrity, operation and compatibility, all components will be from the same manufacturer. The system will offer compatibility with most signal controllers, e.g., electromechanical, NEMA (National Electrical Manufacturers Association), 170. The system can be interfaced with most globally available controllers using the RS232 interface or with the card rack using designated external inputs. Interfacing to an electromechanical controller may require the use of an interface card.

2.1 Data-Encoded Emitter. The data-encoded emitter will trigger the system. It will send the encoded infrared signal to the detector. It will be located on the priority or probe vehicle.

2.2 Infrared Detector. The detector will change the infrared signal to an electrical signal. It will be located at or near the intersection. It will send the electrical signal, via the detector cable, to the phase selector.

2.3 Detector Cable. The detector cable will carry the electrical signal from the detector to the phase selector.

2.4 Phase Selector. The phase selector will accommodate data-encoded communication and will perform priority level arbitration, validate, identify, classify and record the signal from the detector. It will be located within the controller cabinet at the intersection. It will request the controller to provide priority to the requesting vehicle and/or record presence of a probe vehicle.

2.5 System Software. The system software will be a Windows™ 98 (or greater) compliant program. It supports system configuration and gathering of operational information.

2.6 Card Rack. The card rack will provide simplified installation of a phase selector into controller cabinets that do not already have a suitable card rack.

2.7 Electromechanical Card. The electromechanical card will provide electrical interface between the phase selector and electromechanical-type traffic controllers.

3.0 SYSTEM COMPONENT SPECIFICATIONS

3.1 Data-Encoded Infrared Emitter and Programming Software

3.1.1 The required data-encoded emitter will generate the infrared signal, which serves as the trigger to the rest of the priority control system. The infrared signal generated by the data encoded emitter will be a series of intense flashes from a single light source with integral power supply. The flash signal will consist of a fixed frequency base signal and a coded overlay signal that can be used to transmit information.

3.1.2 The data-encoded emitter will be powered by the DC voltage supplied from the battery of the vehicle, 10 to 16 volts DC. The unit will be equipped with a weatherproof in-line fuse holder and a weatherproof quick-disconnect plug.

3.1.3 The unit, including all electronics, will be miniaturized to a size no greater than 5.900 inches wide by 3.800 inches high by 3.500 inches deep to accommodate standalone and internal lightbar installation.

3.1.4 The data-encoded emitter will be supplied complete with a 25 foot installation cable.

3.1.5 The flash sequence generated by the data-encoded emitter will carry three types of information: The first type will be one of three distinctly different base frequencies of either approximately 10Hz for a Low priority emitter, or approximately 14Hz for a High priority emitter, or 12Hz for Probe frequency. The second type of information generated by the data-encoded emitter will be a vehicle classification and identification code that is interleaved into the base frequency flashes. Setting the vehicle classification and identification code will be accomplished through emitter programming software. Each data-encoded emitter will be capable of setting 10 different classifications with 1,000 different identification numbers per class for a total of 10,000 codes per base frequency. The third type of information generated by the data-encoded emitter will be reserved for setting the intersection detection range. A specially equipped emitter control module with a range setting command switch will enable the traffic engineer to activate the range code from his/her vehicle. The system will accommodate setting a separate range from 200 feet

to 2,500 feet with 1200 range set points, for both High and Low priority signals.

3.1.6 The emitter will include a multi-purpose communication port compliant with the SAE J1708 communication standard. This port enables unit configuration to be set into the emitter and read from the emitter. It also allows real-time communication between the vehicle and the emitter.

3.1.7 While operating, the data-encoded emitter will conduct self-diagnostics designed to monitor data transmission integrity by checking for missing pulses. Any failures of the self-diagnostic tests will be displayed by flashing of the ON/OFF switch indicator light.

3.1.8 An ON/OFF switch (available for each data-encoded emitter) will be equipped with an indicator light providing internal diagnostics to assist in troubleshooting. The indicator light will operate as follows:

Steady on when the emitter is operating
Flash at a 0.5Hz rate when the emitter is intentionally disabled
Flash at a 2Hz rate when the emitter is inoperative

3.1.9 The data-encoded emitter will be equipped with a disable input that, when activated, will stop the emitter from flashing, thereby eliminating the possibility of inadvertent signal transmission after the priority vehicle has arrived at its destination. The disable input will be programmable to operate in either a latching or non-latching mode. Operation of the disable input will be programmable using software.

3.1.10 The data-encoded emitter will be available with an optional visible lightblocking filter.

3.1.11 The data-encoded emitter will be configured with a grating to provide precise directionality control.

3.1.12 The data-encoded emitter will have a consistent flash intensity. The energy output per flash will be 0.84 Joules.

3.1.13 The data-encoded emitter will operate over a temperature range of – 30°F (-34°C) to +165°F (+74°C).

3.1.14 The data-encoded emitter will operate over a relative humidity range of 5% to 95%.

3.1.15 Windows™ based software will be available for programming the emitter through its J1708 compatible multi-purpose port. The communication protocol will be made available upon request for creating software to implement real-time communication.

3.1.16 The emitter will provide operating modes that allow it to be powered on with the strobe active or inactive.

3.2 Infrared Detector

3.2.1 The required detector will be a lightweight, weatherproof device capable of sensing and transforming pulsed infrared energy into electrical signals for use by the phase selection equipment.

3.2.2 The infrared detector will be designed for mounting at or near an intersection on mast arms, pedestals, pipes or span wires.

3.2.3 Each infrared detector will be supplied with mounting hardware to accommodate installation on mast arms. Hardware will be available for span wire installations. Additional hardware may be needed.

3.2.4 The infrared detector design will include adjustable tubes that lock into position, to enable their reorientation for span wire mounting without disassembly of the unit.

3.2.5 The detector will accept infrared signals from one or two directions and will provide single or dual electrical output signal(s).

3.2.6 The infrared detector will be available in three configurations:
Uni-directional with one output channel.
Bi-directional with one output channel.
Bi-directional with two output channels.

3.2.7 The detector will allow aiming of the two infrared sensing inputs for skewed approaches, wide roads or slight curves.

3.2.8 The infrared detector will have a built-in, labeled terminal block to simplify wiring connections.

3.2.9 The infrared detector will receive power from the phase selector and will have internal voltage regulation to operate from 18 to 37 volts DC.

3.2.10 The infrared detector will respond to a clear lens data-encoded emitter with 0.84 (±10%) Joules of energy output per flash at a distance of 2,500 feet under clear atmospheric conditions. If the emitter is configured with a visible light filter, the detector will respond at a distance of 1800 feet under clear atmospheric conditions. The noted distances will be comparable day and night.

3.2.11 The infrared detector will deliver the necessary electrical signal to the phase selector via a detector cable up to 1,000 feet in length.

3.3 Detector Cable

3.3.1 The detector cable will deliver sufficient power from the phase selector to the infrared detector and will deliver the necessary quality signal from the detector to the phase selector over a non-spliced distance of 1,000 feet.

3.3.2 The cable will be of durable construction to satisfy the following installation methods:
Direct burial.
Conduit and mast arm pull.
Exposed overhead (supported by messenger wire).

3.3.3 The outside diameter of the detector cable will not exceed 0.3 inches.

3.3.4 The insulation rating of the detector cable will be 600 volts minimum.

3.3.5 The temperature rating of the detector cable will be +158°F (+70°C) minimum.

3.3.6 The conductors will be shielded with aluminized polyester and have an AWG #20 (7 x 28) stranded and individually tinned drain wire to provide signal integrity and transient protection.

3.3.7 The shield wrapping will have a 20% overlap to ensure shield integrity following conduit and mast arm pulls.

3.3.8 The detector cable will be comprised of three signal wires and a drain wire. Each wire will be 20 AWG (7 x 28). The capacitance will not exceed 48 pF per foot a 1 Khz. The detector cable wires will be stranded, individually tinned copper, color-coded insulation as follows:

Orange for delivery of detector power (+).
Drain wire for detector power return (-).
Yellow for detector signal #1.
Blue for detector signal #2 or ground, depending on model of detector being used.

3.4 Phase Selector

3.4.1 The phase selector, designed to be installed in the traffic controller cabinet, will accommodate data-encoded signals and is intended for use directly with numerous controllers. These include California/New York Type 170 controllers with compatible software, NEMA controllers, or other controllers along with the system card rack and suitable system interface equipment and controller software.

3.4.2 The phase selector will be a plug-in, four channel, multiple-priority device intended to be installed directly into a card rack located within the controller cabinet.

3.4.3 The phase selector will be powered from 115 volt (95 volts AC to 135 volts AC), 60Hz mains and will contain an internal, regulated power supply that supports up to twelve infrared detectors.

3.4.4 Programming the phase selector and retrieving the data stored in it will be accomplished using an IBM PC-compatible computer and the system interface software. The connection can be made either directly, via the computer's communication (COM) port, or remotely via a modem. The communication port on the phase selector will be an RS232 interface located on the front and back of the unit. The communication protocol will be made available upon request for creating software to implement other communication applications.

3.4.5 The phase selector will include the ability to directly sense the green traffic controller signal indications through the use of dedicated sensing circuits and wires connected directly to the field wire termination points in the traffic controller cabinet.

3.4.6 The phase selector will have the capability of storing up to 1000 of the most recent priority control calls, probe frequency passages, or unauthorized vehicle occurrences. When the log is full, the phase selector will drop the oldest entry to accommodate the new entry. The phase selector will store the record in non-volatile memory and will retain the record if power terminates. Each record entry will include ten points of information about the priority call, as follows:

Classification: Indicates the type of vehicle.

Identification number: Indicates the unique ID number of the vehicle.

Priority level: Indicates whether High or Low priority, or Probe frequency is requested by the vehicle.

Direction: Channel A, B, C, or D; indicates the vehicle's direction of travel.

Call duration: Indicates the total time in seconds the priority status is active.

Final greens at end of call: Indicates which phases are green at the end of the call.

Duration of the final greens: Indicates the total time final greens were active at the end of call.

Time and date call started and ended: Indicates the time a priority call started and ended; provided in seconds, minutes, hours, day, month, year.

Maximum signal intensity: Indicates the strongest signal intensity measured by the phase selector during call.

Priority output active: Indicates if the phase selector requested priority from the controller for the call.

3.4.7 The phase selector will include several control timers that will limit or modify the duration of a priority control condition, by channel, and can be programmed from an IBM PC-compatible computer. The control timers will be as follows:

MAX CALL TIME: Will set the maximum time a channel is allowed to be active. It will be settable from 60 to 65,535 seconds in one-second increments.

CALL HOLD TIME: Will set the time a call is held on a channel after the priority signal is no longer being received. It will be settable from one to 255 seconds in one-second increments. Its factory default must be six seconds.

CALL DELAY TIME: Will set the time a call must be recognized before the phase selector activates the corresponding output. It will be settable from zero to 255 seconds in one-second increments. Its factory default must be zero seconds.

3.4.8 The phase selector's default values will be re-settable by the operator using an IBM PC-compatible computer, or manually using switches located on its front.

3.4.9 The phase selector will be capable of three levels of discrimination of data-encoded infrared signals, as follows:

Verification of the presence of the base infrared signal of either High priority, Low priority or Probe frequency.

Validation of the infrared signal data-encoded pulses.

Determination of when the vehicle is within the prescribed range.

3.4.10 The phase selector's card edge connector will include primary infrared detector inputs and power outputs. Two additional detector inputs per channel will be provided on a front panel connector.

3.4.11 The phase selector will include one opto-isolated NPN output per channel that provides the following electrical signal to the appropriate pin on the card edge connector:

6.25Hz ± 0.1Hz 50% on/duty square wave in response to a Low priority call.

A steady ON in response to a High priority call.

3.4.12 The phase selector will accommodate three methods for setting intensity thresholds (emitter range) for high and low priority signals:

Using a data-encoded emitter with range-setting capability.

Using any encoded emitter by manipulating the front panel switches.

Inputting the range requirements via the communication port.

3.4.13 The intensity threshold will have 1200 set points. There will be separate intensity thresholds for the primary detector and the auxiliary detectors.

3.4.14 The phase selector will have a POWER ON LED indicator that flashes to indicate unit diagnostic mode and illuminates steadily to indicate proper operation.

3.4.15 The phase selector will have internal diagnostics to test for proper operation. If a fault is detected, the phase selector will use the front panel LED indicators to display fault information.

3.4.16 The phase selector will have a High (High) and Low (Low) LED indicator for each channel to display active calls.

3.4.17 The phase selector will have a test switch for each channel to test proper operation of High or Low priority.

3.4.18 The phase selector will properly identify a High priority call with the presence of 10 Low priority data-encoded emitter signals being received simultaneously on the same channel.

3.4.19 The phase selector will have write-on pads to allow identification of the phase and channel.

3.4.20 The phase selector will have the capability to enter unique names for each channel via the interface software.

3.4.21 The phase selector will provide one isolated confirmation light control output per channel. These outputs are user configurable through software for a variety of confirmation light sequences.

3.4.22 The NEMA model of the phase selector will have outputs for the control of NEMA controllers that lack internal preemption capability. This function will be accomplished through the use of Manual Control Enable, Interval Advance, and Phase Omit options.

3.4.23 The NEMA model will also have the option of providing separate outputs for High and Low priority calls for controllers that do not recognize a 6.25Hz pulsed Low priority request.

3.4.24 The NEMA model of the phase selector will have the capability to set Interval Advance rates as low as once every 200 mSec for Low priority calls. It will also be able to operate in the Manual Control Enable Mode for Low priority calls and activate a standard preemption output for high priority calls.

3.4.25 The phase selector will have the capability of recording the presence of a vehicle transmitting at the specified Probe frequency. The phase selector will at no time attempt to modify the intersection operation in response to the Probe frequency.

3.4.26 The phase selector will have the capability of providing Low priority in a mode where the output to the controller is gated or controlled by timing relationships within the controller cycle.

3.4.27 The phase selector will have the capability to assign a relative priority to a call request within High or Low priority. This assignment will be based on the received vehicle class.

3.4.28 The phase selector will have the capability to discriminate between individual ID codes, and allow or deny a call output to the controller based on this information.

3.4.29 The phase selector will have the capability to log call requests by unauthorized vehicles.

3.4.30 The phase selector will have the ability to command an emitter to relay a received code to the next intersection.

3.4.31 The phase selector will have the capability of functionally testing connected detector circuits and indicating via front panel LEDs nonfunctional detector circuits.

3.4.32 The phase selector will incorporate a precision real time clock synchronized to an AC power line frequency.

3.4.33 The clock will have the capability to automatically adjust itself for changes in daylight saving time. Interface software will be used to set the clock and to input the appropriate dates and times for daylight saving changes.

3.4.34 The phase selector shall have the capability to set the minimum time between Low priority calls.

3.4.35 An auxiliary interface panel will be available to facilitate interconnections between the phase selector and traffic cabinet wiring.

3.5 Card Rack

3.5.1 The required card rack will provide simplified installation of a phase selector into controller cabinets that do not already have a suitable card rack.

3.5.2 The card rack will be factory wired to one connector, located behind the card slot, and a terminal block, located next to the phase selector slot, on the front of the card rack.

3.5.3 The card rack connector on the front will provide for all connections to the traffic controller.

3.5.4 The card rack will provide labeled terminal blocks for connecting the primary infrared detectors to a phase selector.

3.6 Interface Card for Electromechanical Controllers

3.6.1 The required interface card for electromechanical controllers will provide electrical and logic interface between the phase selector and an electromechanical-type controller.

3.6.2 The inputs to the interface card for electromechanical controllers will be connected to the outputs of the phase selector.

3.6.3 The outputs of the interface card for electromechanical controllers will be connected to the Hand Control Switch or Police Panel where the dial motor and its self-generated solenoid advance pulses are disconnected from the cam/solenoid assembly and replaced by pulses generated by the action of the Hand Control Switch in the electromechanical-type controller.

3.6.4 The interface card for electromechanical controllers will decode the outputs of the phase selector(s) and advance the controller to the phase that is set for that channel by sensing the traffic controller signal indications.

3.6.5 The interface card for electromechanical controllers will have one input to disable the interface card.

3.6.6 The interface card for electromechanical controllers will include the following switches:

Channel 1 Green Time: 16-position rotary switch; Controls timing between advance pulses, in seconds, when in Phase 1 green.

Channel 2 Green Time: 16-position rotary switch; Controls timing between advance pulses, in seconds, when in Phase 2 green.

Channel 3 Green Time: 16-position rotary switch; Controls timing between advance pulses, in seconds, when in Phase 3 green.

Channel 4 Green Time: 16-position rotary switch; Controls timing between advance pulses, in seconds, when in Phase 4 green.

NON Green Time: 16-position rotary switch; Controls timing between advance pulses, in seconds, when no indications are green.

Power Switch.

3.7 Interface Software

3.7.1 The priority control interface software will be provided on a single CDROM to interface with the phase selector. The CD-ROM will include a utility to create 3.5 inch 1.44 mB diskettes to be used on computers without CD-ROM drives. It must run on most IBM-compatible computers equipped with at least 64M RAM, WindowsTM 98 and color VGA display capability.

3.7.2 The priority control interface software must accommodate:
Setting up and presenting user-determined system parameters.
Viewing and changing settings.
Viewing activity screens.
Displaying and/or downloading records of previous activity showing class, code, priority, direction, call duration, final greens at end of call, duration of final greens, time call ended in real time plus maximum signal intensity (vehicle location information). This information may be used to reconstruct the route taken by a priority (or probe) vehicle to track the vehicle.

3.7.3 The priority control interface software must accommodate operation via a mouse or via the keyboard, or in combination.

3.7.4 The priority control interface software must provide menu displays to enable:
Setting of valid vehicle ID and class codes.
Establishing signal intensity thresholds (detection ranges), modem initialization, intersection name and timing parameters.
Setting of desired green signal indications during priority control operation and upload and download capability to view.
Resetting and/or retrieving logged data and priority vehicle activity.
Addressing for each card in a multi-drop connected system.
Confirmation light configuration.
NEMA Control Parameters.

3.7.5 The interface software will provide readout of noise levels detected by the detectors. This noise level will serve as a troubleshooting tool.

3.7.6 The interface software will provide a real-time activity screen which will provide the following information:
Call intensity value even if below threshold.
Vehicle class and ID.
Emitter priority level.
Indication of detection on primary or auxiliary detector
Indication if call is being serviced or is pending.
Indication if vehicle is in range.
Readout for four separate vehicles per channel.
Detector noise level readout.
Green phase monitoring with information on the current greens.

4.0 RELIABILITY

4.1 All equipment supplied as part of the infrared priority control system intended for use in the controller cabinet will meet the following electrical and environmental specifications spelled out in the NEMA Standards Publication TS2 1992, Part 2:
1. Line voltage variations per NEMA TS2 1992, Paragraph 2.1.2.
2. Power source frequency per NEMA TS2 1992, Paragraph 2.1.3.
3. Power source noise transients per NEMA TS2 1992, Paragraph 2.1.6.1.
4. Temperature range per NEMA TS2 1992, Paragraph 2.1.5.1.
5. Humidity per NEMA TS2 1992, Paragraph 2.1.5.2.
6. Shock test per NEMA TS2 1992, Paragraph 3.13.9.
7. Vibration per NEMA TS2 1992, Paragraph 3.13.8.

4.2 Each piece of equipment supplied as part of the priority control system intended for use in or on priority vehicles will operate properly across the entire spectrum of combinations of environmental conditions (temperature range, relative humidity, vehicle battery voltage) per the individual component specifications.

5.0 INSTALLATION

5.1 A factory certified representative from the product supplier of the vehicle preemption equipment shall be on-site during the final set up of the system to supervise the final installation and final testing of the equipment.

6.0 WARRANTY

6.1 The vehicle preemption system shall be warranted against manufacturing defects in materials and workmanship for a period of one year from the date of installation. The equpiment supplier shall provide operational documentation for the system.

E. FIBER OPTIC SYSTEM

This work shall consist of furnishing and installing a fiber optic cable of the type, size and number of fibers specified.

1.0 GENERAL REQUIREMENTS

Materials and Equipment

Materials and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products. The fiber optic cable shall be manufactured by Corning conforming to the following specifications. All materials and equipment furnished shall be completely free from defects and poor quality. All fibers shall be glass and be manufactured by Corning. The cable shall be rated for gigabyte data bandwidth. All fiber shall be loose tube construction for both indoor and outdoor installation. Indoor cabling shall use plenum rated conduit to within less than 50 foot of point of termination eliminating the requirement to convert to indoor cable.

Contractor Qualifications

Trained and experienced personnel shall supervise the fiber optic cable installation. Qualified technicians shall make the cable terminations and splices. The Contractor upon request of the Engineer shall provide documentation of qualifications and experience for fiber optic equipment installations. The Engineer shall determine if the Contractor is qualified to perform this work. The Contractor shall have attended a certified fiber optic training class mandated by these specifications prior to starting work.

Codes Requirements

The fiber optic cable installation shall be in accordance with or exceed all minimal requirements of State codes, National codes, and manufacturer codes as applicable.

Miscellaneous Equipment

The Contractor shall furnish and install all necessary miscellaneous connectors and equipment to make a complete and operating installation in accordance with the plans, standard sheets, standard specifications, special provisions, and accepted good practice of the industry.

General Considerations
The cable shall meet all requirements stated within this specification.
The cable shall be new, unused, and of current design and manufacture.

Fiber Characteristics
All fibers in the cable must be usable fibers and meet required specifications.

Multi-mode Fiber
Core diameter: 62.5 +3.0um
Cladding diameter: 125.0 +2.0um
Core-to-cladding offset: <3.0um
Coating diameter 250 +15um
Graded Index
Attenuation uniformity: No point discontinuity shall be greater than 0.25 dB, except terminations or patch cords, at either 850nm or 1300nm. The coating shall be a layered UV cured acrylate applied by the fiber manufacturer. The coating shall be mechanically or chemically removable without damaging the fiber.

Factory cable rating shall be 3.5 dB/KM at 850 nM and 1.0 dB/KM at 1300 nM, or less. Installed tolerance shall be less than 3.85 dB/KM at 850 nM and less than 1.1 dB/KM at 1300 nM, testing tolerance.

All fiber cables shall be Gigabyte rated, i.e. multimode shall be 200/500 Meter for 850 and 1300 nM respectively based on a 10 dB power budget.

Single-mode Fiber
Typical core diameter: 8.3um
Cladding diameter: 125.0 +1.0um by fiber end measurement
Core-to-cladding offset: <1.0um
Coating diameter 250 +15um
Attenuation uniformity: No point discontinuity shall be greater than 0.1 dB, except terminations or patch cords, at either 1310nm or 1550nm. The coating shall be a layered UV cured acrylate applied by the fiber manufacturer. The coating shall be mechanically or chemically removable without damaging the fiber.

Factory cable rating shall be 0.35 dB/KM at 1310 nM and 0.3 dB/KM at 1550 nM. Installed tolerance shall be less than 0.44 dB/KM at 1310 nM and less than 0.33 dB/KM at 1550 nM, testing tolerance.

2.0 FIBER SPECIFICATION PARAMETERS

All fibers in the cable shall meet the requirements of this specification. The testing tolerance attenuation specification shall be a maximum attenuation for each fiber over the entire operating temperature range of the cable when installed.

The change in attenuation at extreme operational temperatures for single-mode fibers shall not be greater than 0.20 dB/km at 1550 nm, with 80 percent of the measured values no greater than 0.10 dB/km at 1550 nm.

Optical fibers shall be placed inside a loose buffer tube, minimum six (6) fibers per tube, normally twelve (12) fibers per tube. Actual number of fibers per tube shall be twelve fibers per tube unless specified differently on the Plans.

Multimode only – each buffer tube shall contain 12 or 6 fibers.
Single-mode only – each buffer tube shall contain 12 or 6 fibers.

The buffer tubes will meet EIA/TIA-598, “Color coding of fiber optic cables.”

All fiber cables shall be Gigabyte rated, i.e. multimode shall be 200/500 Meter for 850 and 1300 nM respectively and 5000 Meter for 1310 and 1550 nM.

Single-mode fibers shall be placed in the first buffer tubes. Multimode fibers shall be in the remaining buffer tubes. Fiber count, tubes of fiber, shall be as specified on the plans.

Fillers shall be included in the cable core to lend symmetry to the cable cross-section where needed.

The central anti-buckling member shall consist of a glass reinforced plastic rod. The purpose of the central member is to prevent buckling of the cable.

The cable shall use a completely dry cable design without the use of gels and filling compounds. Dry water blocking material shall be used around the buffer tubes as well as internal to the tubes. Water blocking gels shall not be acceptable on this project.

Buffer tubes shall be stranded around a central member. Acceptable techniques include the use of the reverse oscillation, or “SZ”, stranding process.

All dielectric cables (with no armoring) shall be sheathed with medium density polyethylene. The minimum nominal jacket thickness shall be 1.4 mm. Jacketing material shall be applied directly over the tensile strength members and flooding compound. Cable jacketing shall utilize the newer designs to provide maximum flexibility without loss or appreciable dB attenuation. Cable diameter shall not exceed 0.50 inch.

The jacket or sheath shall be marked with the manufacturer’s name, the words “optical cable”, the year of manufacture, number of fibers, type of fiber, and sequential feet or meter marks. The markings shall be repeated every one-meter or three feet. The actual length of the cable shall be within –0/+1% of the length marking. The marking shall be in a contrasting color to the cable jacket. The height of the marking shall be approximately 2.5 mm. A copy of the manufacturer fiber definition and shipping sheet identifying all tests, results and fiber indexes shall be provided to the Engineer on delivery of cable to the City or shall be included with a contractor’s listing of place(s) of installation when installed by a Contractor.

The maximum pulling tension shall be 600 pounds (2700 N) during installation.

Where ever possible, six (6) buffer tubes with twelve (12) fibers each, or subsets specified, shall be provided and designated as follows:

Buffer Tube/Fiber	Tube/Fiber Color
#1, 1st tube or fiber	blue
#2, 2nd tube or fiber	orange
#3, 3rd tube or fiber	green
#4, 4th tube or fiber	brown
#5, 5th tube or fiber	slate
#6, 6th tube or fiber	white
#7, 7th tube or fiber	red
#8, 8th tube or fiber	black
#9, 9th tube or fiber	yellow
#10, 10th tube or fiber	violet
#11, 11th tube or fiber	rose
#12, 12th tube or fiber	aqua

3.0 QUALITY ASSURANCE PROVISIONS

All optical fibers shall be proof tested by the fiber manufacturer at a minimum load of 100 kpsi.

All optical fibers shall be 100% attenuation tested at the manufacturer. The attenuation of each fiber shall be provided with each cable reel. The measured attenuation shall be for both 850 and 1300 frequency for multimode and 1310 or 1550 frequency for single mode. This documentation shall be provided with each spool. The Contractor shall designate on the Plans and in this documentation the location where each spool has been installed and provide this data to the Engineer.

4.0 CABLE INSTALLED IN DUCTS AND CONDUITS

A suitable cable feeder guide shall be used between the cable reel and the face of the duct and conduit to protect the cable and guide it into the duct off the reel. It shall be carefully inspected for jacket defects. If defects are noticed, the pulling operation shall be stopped immediately and the Engineer notified. Precautions shall be taken during installation to prevent the cable from being “kinked” or “crushed”. A pulling eye shall be attached to the cable and used to pull the cable through the duct and conduit system. A pulling swivel shall be used to eliminate twisting of the cable. As the cable is played off the reel into the cable feeder guide, it shall be sufficiently lubricated with a type of lubricant recommended by the cable manufacturer. Dynamometers or breakaway pulling swing shall be used to ensure that the pulling line tension does not exceed the installation tension value specified by the cable manufacturer. The mechanical stress placed on a cable during installation shall not be such that the cable is twisted or stretched. The pulling of cable shall be hand assisted at each controller cabinet. The cable shall not be crushed kinked or forced around a sharp corner. If a lubricant is used it shall be of water based type and approved by the cable manufacturer. Sufficient slack shall be left at each end of the cable to allow proper cable termination, MINIMUM OF 30 FEET. This slack shall be in addition to installation slack as

hereinafter specified. Additional slack cable shall be left in each controller cabinet, handhole, and at the top of each conduit riser. Excess slack at controller cabinets shall be re-pulled into the nearest handhole to provide a neat and orderly installation. The minimum slack amounts shall be the larger value of the amount called out on the plan set or as follows:

Controller cabinet – 30 feet
Type 1 Handhole – 20 feet
Type 2 Handhole – 100 feet

Storage of minimum slack cable in controller cabinets and additional slack at pull boxes shall be coiled. The slack coils shall be bound at a minimum of 3 points around the coil parameter and supported in their static storage positions. The binding material and installation shall not bind or kink the cable. Storage of additional slack cable adjacent to conduit risers and support poles shall be as visibly marked/tagged as "CAUTION – FIBER OPTIC CABLE". Maximum length of cable pulling tensions shall not exceed the cable manufacturer's recommendations. Along with the fiber optic cable, one (1) #10 AWG THHN, 600 volt single conductor cable (identifier conductor), orange in color, shall be pulled with ten feet (10') slack in each pull box. **All fiber cables shall be marked with a metallic, or preapproved identifier in the handhole adjacent to the traffic signal cabinet and on the cable in the traffic signal cabinet at the point of termination.** The identifier, both in the cabinet and in the handhole, shall indicate the direction the cable is going, cable contents [SM or SM/MM], and the abbreviated location for the other end destination. Fiber cabling between traffic controllers and/or hub locations shall be outdoor rated, loose tube fiber, when not linked by a direct, continuous conduit installation.

5.0 MININUM BEND RADIUS

For static storage, the cable shall not be bent at any location to less than ten times the diameter of the cable outside diameter or as recommended by the manufacturer. During installation, the cable shall not be bent at any location to less than twenty times the diameter of the cable outside diameter or as recommended by the manufacturer.

6.0 AFTER FIBER OPTIC CABLE INSTALLATION

Each section of the cable shall be tested for continuity and attenuation as a minimum. If the attenuation is found not to be within the acceptable nominal values, the Contractor shall use an optical time domain reflectometer (OTDR) to locate points of localized loss caused by bends or kinks. If this is not successful the Contractor shall replace the damaged section of cable with no additional payment. Splices will not be allowed to repair the damaged section. After all fiber cable is installed between traffic controller cabinets and fiber links between fiber distribution points (FDP) complete links, all fibers, whether terminated or non-terminated, shall be tested with an OTDR. All fibers terminated shall be tested with a power meter. The Contractor may jumper termination points at controller cabinets to minimize the number of tests and run a single OTDR test between several controller cabinets, subject to the range of the OTDR. **Links between FDP's shall be tested separately.** Each OTDR trace, for documented test result submittal, shall be displayed individually and not be combined with other fiber traces as overlays. **Multimode fiber shall be tested using 1300 nm**

and single mode fiber shall be tested at 1310 nm. The results of the OTDR test shall be provided on an electronic media (disk) and paper printout. The OTDR wave, pictorial diagram of dB loss over the length of fiber tested, shall be provided along with the measured data values. The printout shall contain the manufacturer's fiber optic Index of Refraction to the third decimal point for the fiber provided. The Contractor shall provide the Engineer with a written report showing all the values measured compared to the calculated values for length and coupler/connector losses at the completion of these tests. **Outdoor patch cords between FDP and controller units less than 151 feet do not need be OTDR tested.**

Documentation provided to the Engineer shall include a written indication of every splice, termination, patch cord, etc. for cable being measured. Power meter measurement recordings shall indicate the exact measured distance [OTDR or field measurement with cross reference for oscillation multiplier] on the sheet showing the power meter readings. Any deviations between fiber readings in the same tube shall be notated for OTDR graphs as well as deviations greater than 5% on power meter readings. Rated values for acceptable installation shall be based on the following parameters:

Patch cords/Pigtails	.60 MM & .15 SM dB each
Terminations	1.0 dB set of 2 [In and Out]
Splices	0.08 each

1 KM = 0.3077 KF where KF is 1000 feet

Data documentation shall include for each test between cabinets or between FDP sites, the length of fiber as measured by OTDR, frequency used in test on OTDR by each fiber type, distance to each splice, termination or patch cord jumper, dB loss rating by manufacture from spool documentation, index of refraction by type of fiber in section, and the dB loss of each section as measured in the final test for each fiber. A special test shall be made on all continuous spliced fiber from start to end that includes the total dB loss measured and the OTDR plot on electronic disk. Splice points shall be identified on the trace.

7.0 CABLE TERMINATION

Terminations shall be made using the method recommended by the connector manufacturer. All fibers shall utilize a fan-out kit of the size and type recommended by the manufacturer and of the number of fibers provided in each fiber tube. **Contractor shall terminate all MM fiber optic cables with ST Connectors.** All fibers terminated shall utilize a **ceramic ferrule** (outdoor connections), ST, mechanical termination, or be a wide temperature (-40 to +170 degrees Fahrenheit) epoxy. Heat cured or epoxy type connections meeting the full temperature ratings are acceptable for this Project, including factory manufactured pigtails. **The Contractor shall be required to provide proof of purchase of sufficient quantities of ceramic terminations for outdoor terminations to verify ceramic connector usage or temperature ratings on epoxy or heat cured processes prior to terminating any fibers**. **The project requires 48 ST Connectors (12 at the NE Delaware Avenue traffic signal cabinet, 12 at the I-35 NB ramp terminal traffic signal cabinet and 24 at the existing fiber optic utility cabinet).** The Contractor may terminate fibers by splicing factory pigtails to the fiber

ends and then connecting the pigtail to the fiber coupler in the fiber tray. When splicing pigtails to terminate, all splices shall be provided with the metal reinforced shrink tube protector. The contractor may terminate fibers by the use of mechanical termination connectors. **All termination ST couplers shall be rated for dual fiber application, MM and SM.**

8.0 BREAKOUT KITS

The breakout kits or termination boxes used to terminate each fiber cable in the cabinet shall provide for the separation and protection of the individual fibers with the buffer tubing and jacketing materials. Splices to pigtail fiber, where used, shall utilize fan out kit protection to the fiber, heat shrink tubing with metal bar reinforcement and 900 micron rated pigtail insulation. Splices to factory pigtails shall use pigtails that are rated for a minimum temperature range of zero degrees to +150 degrees Fahrenheit. In the absence of pigtails meeting this temperature rating, fibers shall utilize loose tube fiber in fan out kit tubes and mechanical ST connectors. These splices, fiber cable to pigtails, may be external to splice trays mounted internally to the enclosure, when shown on the wiring diagrams. All other splices, not specified to be installed external to the fiber splice tray, shall be installed in splice trays and be supported with heat shrink tubing.

9.0 ENCLOSURE

The terminations shall be installed within a wall or shelf mountable interconnect enclosure which shall provide for storing fibers, ample room for feed through cable, strain relief for multiple cables within unit, and accommodate ST compatible connectors. The units shall be either rack mountable in an EIA 19-inch rack, 21-inch rack or be wall mountable. The enclosure shall meet the requirements of ANSI/TIA/EIA-568-A and ANSI/TIA/EIA-606. Acceptable enclosures for combination termination/splice points shall be the Corning CCH-02U model. The enclosure shall be provided with four (4) ST connector panels each containing six (6) couplers designed and tested for single mode or multimode fiber installation. Acceptable connector panels shall be Corning CCH-CP06-15T for multimode fiber and Corning CCH-CP06-19T for single mode fiber applications. If not specified on the Plans or wiring diagrams, the Contractor shall coordinate with the Engineer to determine which fibers to terminate from each fiber cable entering or exiting the cabinet. All cabling that is not specified to be terminated shall neatly be tied and bundled in one of the enclosures and properly labeled as to the direction [N, E, S, or W] of entry. The All fiber pigtails shall be terminated through ST connectors on the interconnect enclosure connector panel. All terminations shall be ST type, ceramic core (outdoor connections), and plug into the provided controller unit internal fiber optic modem.

10.0 CONNECTORS

Connectors shall be mechanical ST (ceramic ferrule-outdoor connections) compatible, field installable, and self-aligning and centering or factory fabricated pigtails. Fiber optic equipment, used for terminating fibers, shall be rated for the type of connectors used.

11.0 SPLICES

The fiber cable shall be installed in continuous runs between cabinets. No splices shall be allowed, unless shown on the plans or for testing. Only mechanical splices will be allowed, when specified, such as testing of non-terminated fibers. Splices, where specified, shall be by fusion splice and shall be installed using an automatic fusion splicer. Splices between two fibers leaving the cabinet shall be supported in splice trays installed in splice enclosures. All splices shall be protected by heat shrink tubing designed for fiber optic splicing applications. Fibers being terminated in two separate termination or splice enclosures shall be supported between enclosures by the use of buffer tubing or approved equal support material or shall be pigtail patch cords. Termination / splice enclosures shall be separated by less than 12 inches unless a conduit is installed between enclosures. All splices shall be performed by an automated splicer device that verifies the final splice termination quality. All splices shall be nominally .03 to .05 dB loss but shall be less than a 0.08 dB loss.

12.0 LIGHT SOURCE

An LED light source with a wavelength that is the system wavelength, 850 and 1300 nm for multimode and 1310 and 1550 nm for single mode, shall be used. The LED shall be stable within 0.1 dB in intensity over a time period sufficiently long to perform the measurement. The output of the LED shall overfill the input end of the launch fiber/cable in both numerical apertures (NA) and core diameter. The accuracy of the combined light source and power meter shall be less than .05 dB and be temperature compensated stabilized to 0.01 dB over the operating range of the meter(s).

13.0 POWER METER

The detector in the power meter shall have an effective numerical aperture and active region that is larger than the receive reference cable and/or the fiber under test. A fiber optic source/power meter with accessories will be supplied to the city for verification testing from the beginning to completion of the project. The power meter shall have a minimum range from +3 DBMS to –40 DBMS. The power meter shall have an accuracy of +/-0.5 dB through the operating temperature and minimum resolution of 0.1 dB.

14.0 LAUNCH REFERENCE ATTENUATOR

The launch attenuator, two each for single mode and multimode fiber testing, shall be utilized for all OTDR tests such that one launch cable shall be at the beginning of the fiber being tested and the second launch cable shall be on the end of the fiber being tested past the final connector. Only one launch cable shall be required when testing non-terminated fiber. The launch attenuator(s) shall be of the same fiber core size and type as the fiber under test. The attenuator shall emulate 300 hundred foot fiber length, minimum, for multimode and 900 feet length, minimum, for single mode fiber or as specified by the OTDR manufacturer for stabilization of the pulse generation. Launch cables shall be of identical length for incoming and outgoing light during tests. ST connectors shall be utilized with each attenuator to connect the device to the test device, OTDR. One launch cable shall be installed on the start of the fiber being tested and one launch cable shall be installed on the end of each terminated to view the dB loss of the final connector.

The OTDR shall have the Threshold Loss set at a value to show each splice or termination junction of a single fiber in each tube with out showing the extraneous noise caused by handhole coils or turns into the cabinets. This level is normally a value [Threshold Loss] between 0.3 and 0.8 on the OTDR. This trace shall be provided for one fiber in each tube tested and each “event” shall be marked as to splice, jumper or patch cord. The Threshold Loss shall then be set to a value of 0.25 for multimode fiber tests and to a value of 0.10 for single mode fiber tests. The test of each fiber installed shall be conducted and any recorded events above this threshold shall be identified, such as jumper or patch cord. Events that are in excess the provided values shall be corrected prior to documentation submittal, such as terminations in excess of the rated value or bends in the fiber at the point of a splice entering of leaving the splice tray. For measured values recorded in excess of the above (0.25 MM and 0.10SM) listed values. The Engineer reserves the right to spot test fiber terminations, splices, or re-testing of all fibers in a section to insure proper quality assurance both during and after installation and testing. Deviations from Engineer testing and report documentation shall be reviewed and the Contractor shall be able to retest any or all challenged measurements to verify a valid test. Inconsistent test results, in the sole opinion of the Engineer, shall be cause for the Contractor to retest the entire fiber installation.

15.0 TESTING

General

The Contractor shall provide all personnel, equipment, instrumentation and supplies necessary to perform all testing. All testing shall be performed in an accepted manner and in accordance with the testing equipment manufacturer’s recommendations. All data shall be recorded and submitted to the Traffic Engineer as hereinbefore specified. The Contractor shall provide one copy of operating software to read and view all OTDR traces.

Attenuation

The end-to-end attenuation shall be measured for each fiber for each link after installation and termination. A patch cord jumper cable shall be connected to both the light source and the receive cable to the power meter by the use of a connector (barrel). The two reference cables shall then be connected via a termination coupler and the power meter “zeroed” to eliminate the line loss. This process results in a reading of the actual line loss (dB) of the input connector, fiber cable, exiting connector and any other splices or jumpers installed in the measured test link. The calculated “loss” shall not include the input or departing cables in the loss calculation. The calculated fiber loss measured shall list the number of terminations, including the input and departing connectors, the number of splices and the number of patch cords used to jumper the link(s) into the measured final link. The measured values for each terminated fiber in each tube shall include the Tube number, fiber number, number of feet in the link, the number of splices, the number of patch cords and the number of connectors, if any. The length of optical cable shall be as measured by the OTDR rather than the fiber cable jacket as the fiber is a reverse oscillation process resulting in a greater optical distance than the fiber cable jacket. The value for **both the OTDR length and the cable jacket shall be provided in the recorded documentation for**

each link distance. All distances shall be recorded in feet rather than meters for both recorded lengths.

Fibers that are not continuous from beginning of the link to the end of the link shall be noted in the documentation; otherwise, all fibers in a single tube may be listed with a single data entry for all required data listed above for all fibers in the tube. The fiber documentation for each fiber shall identify the fiber being tested by either fiber number or fiber coating color and be recorded by complete tube, Tube 1 through Tube 6, fiber 1 through fiber 12. The direction of the test shall be recorded for information purposes only to resolve discrepancies in replicating the test during inspections of the final installation. The power meter reading recordings shall log total dB loss over the length of the fiber measured, equivalent to a dB loss budget.

The output power levels at the network hardware transmitters and receivers shall be measured and recorded for system documentation. The power meter shall be connected to the transmitter side of the equipment with a system jumper. The transmit power level shall then be read and recorded

Each tube of a cable shall be in the same file divider where the tube cover OTDR page shows the overview of all splices, patch cords, terminations from start to end. The second section shall include all Power Meter readings and the mandated documentation to show the calculated line loss (losses). The third section shall contain all OTDR traces, one trace per screen. The fourth section shall include the spool sheet for the fiber installed on the test section. An “explanation” sheet may be included where required to clarify an unusual reading that is valid but difficult to be explained through traditional data presentation, such as a video feed fiber that is attached to a jumper to provide continuous feed from the start to end of the tube length where other fibers in the same tube are simply spliced. The above format shall be repeated for each tube of a cable.

Continuity

Continuity tests shall be used to determine whether a test or system jumper does or does not pass light. A continuity test shall also be used to assure the fibers have not been crossed over in the jumper and that the transmit fiber goes to the receiver fiber. The visible light tester shall be utilized to illuminate faulty terminations or fibers with excessive bends failing to pass light.

To perform continuity test, a high-intensity red light (Visible Fault Identifier) light source shall be aimed into the connector at one end, while an observer watches for a flicker of light at the other end. **One each 650 nm red NFL light source shall be furnished to the Engineer by the Contractor on request during the testing of the fiber by the Contractor for spot testing.** This device shall be made available during testing of continuity to the Engineer to assist in verifying fault locations and connector bleeding.

OTDR Testing

An Optical Time Domain Reflectometer (OTDR) shall be used to evaluate the quality and length of cable reels prior to their use on the project. A minimum of one fiber per tube per reel shall be tested if payment for stored goods is requested. The fiber loss in dB/km and the length of each reel shall be recorded in the documentation. The maximum attenuation of the cable shall be as hereinbefore specified. This test does not

require an electronic document; but is provided to insure that the fiber has been received in useable quality without shipment damage. The test results of the Contractor OTDR tests of received spools shall be provided to the Engineer, in a minimum of hard copy print, prior to receiving payment for stored goods.

An Optical Time Domain Reflectometer (OTDR) shall be used to evaluate the quality and length of cable installed on the project. This test shall be conducted on all fibers, terminated and not terminated, and shall be conducted after all terminations on the fibers for a link have been completed. The fiber loss in dB/km and the length of each reel shall be recorded in the documentation. The index of refraction, minimum of three decimal points, provided by the manufacturer on the spool documentation shall be used for the test on the OTDR. The maximum attenuation of the cable shall be as hereinbefore specified. A hard copy of OTDR signature traces, electronically and in printed form, for all fiber links shall be made and provided in the documentation as specified. The data provided shall be in easy to understand format and of sufficient detail to verify the results. Fiber testing shall include only one fiber trace per graph. One copy of the operating system software to view the fiber graphs shall be provided with the final documentation.

Documentation

The result of all testing shall be recorded along with date of test, name of person performing test, brand name, model number, serial number of equipment used during test, and any other pertinent information and data. The Contractor shall be responsible to provide input to the Engineer reviewing the recorded data documentation to resolve all questions or data discrepancies. A copy of the evaluation calculation equations to be used may be obtained by the Contractor by request and by supplying a floppy disk. (The evaluation FO Calculator is an EXCEL program worksheet that calculates design dB Loss based on required inputs.) Documentation shall be considered incidental to bid items and no additional compensation shall be provided.