1. Introduction

The scope of this document includes the testing and integration of all new devices, reset devices, and existing devices connected to the fiber optic backbone on the North I-25 Design/Build Project (Project) within the Project limits.

Integration and testing shall be conducted for all Project elements that meet any of the following criteria:

- A new device and/or cabinet supporting the device has been installed or relocated.
- The communications path between the devices and the local cabinet has been disturbed and/or relocated.
- A new communication path to a device has been established.

1.1. Roles and Responsibilities

1.1.1 The Contractor

The Contractor shall install, configure, and test all new Intelligent Transportation System (ITS) devices and fiber communications throughout the Project corridor. The Contractor will be responsible for providing the appropriate notice to the Colorado Department of Transportation (CDOT) ITS and submitting all test results and as-built documentation. The Contractor shall include notification periods, testing periods, and burn-in time in their overall project schedule.

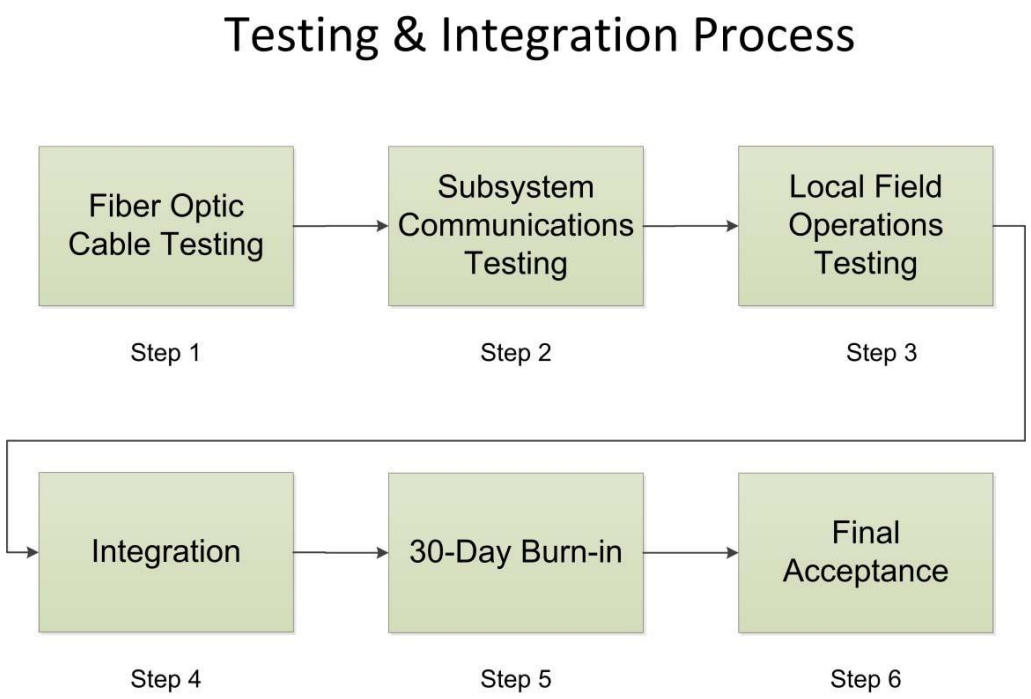
1.1.2 E-470

E-470 will install and test devices related to the Electronic Toll Collection (ETC) system per their own Testing and Integration Plan.

1.1.3 CDOT ITS

CDOT ITS will be responsible for providing Internet Protocol (IP) address ranges for all devices, configuring all switches and routers, integration efforts on the Colorado Transportation Management Center (CTMC) side, and configuration of server and software settings. Specific responsibilities for each device are included in Section 2.0 of this document. CDOT ITS or their designated representative will be responsible for witnessing and signing off on all testing.

1.2 Flow Chart



1.3 Notification Timelines

Item Requiring Notification	Required Notice Period	Notes
Fiber Splicing	Contractor shall notify the Project Engineer and CDOT ITS two weeks prior to performing the work, as well as one week advance notice of any fiber optic backbone cutover work	
Subsystem Communications Testing	Contractor shall notify the Project Engineer and CDOT ITS 7 days in advance	Performed in conjunction with CDOT ITS
Electronic Sign Commissioning	Contractor shall notify the Project Engineer and CDOT ITS two weeks in advance	Performed by manufacturer representative
Local Field Operations Testing	Contractor shall notify the Project Engineer and CDOT ITS two weeks prior to the test date for each site	Upon notification, Contractor must submit Form 1411
Integration	Contractor shall notify the Project Engineer and CDOT ITS 7 days prior to when they would like CDOT to begin integration	

2 Testing Procedures

2.1 Fiber Optic Cable Testing

Test Fiber Optic Cable shall include Optical Time Domain Reflectometer (OTDR) tests, Coarse Wave Division Multiplexor (CWDM) OTDR tests, spectrum analysis of CWDM fiber, and optical power meter tests of all installed fiber and modified existing fiber on the project.

The Contractor shall use equipment that is calibrated twice per year. A copy of the most recent certificate of calibration and all out-of-tolerance conditions shall be provided to the Project Engineer prior to the initiation of testing activities. The following equipment and information is required to perform fiber optic cable tests:

2.1.1 An OTDR (submit certification to Project Engineer)

2.1.2 A Coarse Wave Division Multiplexor OTDR (submit certification to Project Engineer)

2.1.3 An optical spectrum analyzer (submit certification to Project Engineer)

2.1.4 Optical Power Meter Equipment capable of measuring optical power in dBm (submit certification to Project Engineer)

2.1.5 A launch box (min length – 1000 feet)

2.1.6 A light source at the appropriate wavelength

2.1.7 Test jumpers shall be 3 feet to 12 feet long with connectors that are compatible with the light source and power meter and shall have the same fiber construction as the link segment being tested.

Prior to splicing and testing on the project the Contractor shall submit a detailed Method Statement to the Project Engineer describing the splicing and testing plan and schedule. Discussion of the Contractor's Device Cutover Plan and a proposed Device Cutover Schedule shall be included in the Method Statement. No fiber optic splicing shall begin until the Method Statement is submitted and approved. If at any time it is determined that work began without an approved Method Statement, or the work is not following the approved Method Statement, an immediate "stop work" order will be issued and work will not resume until the Method Statement has been submitted and approved. Once the splicing and testing begins, the Method Statement shall be updated if necessary to address any changes in the original planned and approved procedures.

The Contractor shall conduct fiber optic testing at the following stages:

(1) Pre-installation testing – bi-directional OTDR test of every fiber on every reel after delivery of the reel

(2) Post installation and pre-splicing test – bi-directional OTDR test of every fiber of every cable after fiber is installed in the ground

(3) Post-splicing tests, pre-CWDM filter splicing tests

i) Optical Power meter test from all fiber terminated in communications cabinets to a network facility for all fiber that is not used for CWDM on the project.

ii) Bi-directional OTDR test of all fiber between termination point in a network facility and cable end and between termination point in a network facility and communications cabinets for fiber that is not used for CWDM on the project
iii) Bi-directional CWDM OTDR test of all fiber between termination point in a network facility and cable end and between termination point in a network facility and communications cabinets for all fiber that is used for CWDM on the project

(4) Post-CWDM filter splicing tests

i) Spectrum analysis of all terminated fiber used for CWDM after filters have been spliced
ii) CWDM-OTDR
iii) Optical Power meter test and documented attenuator values

(5) Re-testing of all stages above if initial test fails and after corrective action is taken

The guidelines for fiber optic cable testing include:

(1) Launch box and test jumpers must be of the same fiber core size and connector type as the cable system: Single mode fiber 9.0μm (nominal) /125 μm

(2) The light source and OTDR must operate within the range of 1310±10 nm and 1550±20 nm single mode nominal wavelength for testing in accordance with Telecommunications Industry Association (TIA) TIA-526-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant.

(3) The power meter and the light source must be set to the same wavelength during testing.

(4) The OTDR and power meter must be calibrated at each of the nominal test wavelengths and traceable to the National Institute for Standards and Technology (NIST) calibration standards.

(5) The calibration of the OTDR and power meter shall conform to the requirements set forth in Telecommunications Industry Association/Electronic Industries Alliance (TIA/EIA) TIA/EIA-455-226 Calibration of Optical Time-Domain Reflectometers and TIA-455-231 Calibration of Fiber Optic Power Meters, respectively.

The Contractor shall document jacket length measurements for lateral and backbone cable at each end including splice enclosures and patch panels, and at any intermediate splice points.

The Contractor shall document bare fiber slack not accounted for in jacket length.

All system connectors, adapters and jumpers shall be cleaned per manufacturer's instructions before measurements are taken.

At locations of new lateral fiber optic cable installation and at locations that require the re-installation of existing lateral fiber optic cable, the Contractor shall conduct testing from the termination panel mounted in the communications cabinet to the splicing manhole. The bi-directional test shall be conducted from the termination panel towards the splicing manhole and from the splicing manhole to the communications cabinet termination panel.

Final splicing will not begin until such time that the Contractor submits OTDR test results to the Project Engineer and the Project Engineer reviews the results.

Final OTDR testing from the communications cabinet to the corresponding node building shall be conducted after their splicing work has been completed. All issues with communications related to Contractor installation and workmanship shall be remediated by the Contractor at no additional cost to the project.

A functional test shall be made in which it is shown that each and every part of the system functions as specified or intended herein.

(f) Optical Fiber Cable Testing with OTDR

The Contractor shall perform an OTDR test of all fibers in all tubes on the reel prior to installation of the fiber. The test results shall be supplied to the Project Engineer prior to installation of the cable.

Fiber testing shall be performed on all terminated fibers from patch panel to patch panel and unterminated fibers from end to end. Additionally, mid entry splices into mainline cables require testing of all strands in the mainline cable before and after installation. Testing shall consist of a bi-directional end-to-end OTDR trace.

Loss numbers for the installed link shall be calculated by taking the sum of the bi-directional measurements and dividing that sum by two.

The Contractor shall use an OTDR that is capable of storing traces electronically and shall save each final trace.

The Contractor shall use a test reel of minimum length identified in the Materials section of this Special Provision. The Contractor shall indicate the length of the test reel, in feet, for all test results.

If the fiber designation is not indicated on the trace itself, the Contractor shall provide a cross-reference table between the stored trace file name and the fiber designation.

The Contractor shall record the following information during the test procedure:

(1) Name and contact information of person conducting the test

(2) Type of test equipment used (manufacturer, model, serial number, calibration date and valid certification of calibration)

(3) Date test is being performed

(4) Optical source wavelength and spectral width

(5) Fiber identification

(6) Start and end point locations

(7) Test direction

(8) Launch conditions

(9) Method of calculation for the attenuation or attenuation coefficient

(10) Acceptable link attenuation

(11) Cable manufacturer stated index of refraction for cable being tested

(12) Jacket readings in and out of each splice vault and each pull box

(g) Optical Fiber Cable Testing with Optical Power Meter

The Contractor shall conduct an Optical Power Meter Test of each fiber installed.

Single mode segments shall be tested in one direction at both the 1310 nm and 1550 nm wavelength.

The following information shall be recorded during the test procedure:

(1) Names of personnel conducting the test

(2) Type of test equipment used (manufacturer, model, serial number, calibration date and a valid certification of calibration)

(3) Date test is being performed

(4) Optical source wavelength and spectral width

(5) Fiber identification

(6) Start and end point locations

(7) Test direction

(8) Reference power measurement (when not using a power meter with a Relative Power Measurement Mode)

(9) Measured attenuation of the link segment

(10) Acceptable link attenuation

(h) Acceptable Attenuation Values

The Contractor shall calculate acceptable attenuation values for each fiber tested. These values represent the maximum acceptable test values.

The general attenuation equation for all single mode link segments is as follows:

Acceptable Link Attenuation = Cable Attenuation + Connector Attenuation + Splice Attenuation.

8.3 μm (nominal) Single-mode Attenuation Coefficients:

(1) Cable Attenuation=Cable Length (km) x (0.35 dB/km at1310 nm and 0.22 dB/km at1550 nm)

(2) (No. of Mated Connections x 0.50 dB)

(3) Splice Attenuation = Splices x 0.30 dB

(i) Test Procedures

The single mode Optical Power Meter fiber test shall be conducted in accordance with TIA-526-7.

The single mode OTDR test shall be conducted in accordance with TIA-526-7.

Testing for CWDM single wavelength filters (CWDM filter) shall be conducted in the following manner to ensure that the filter Pass, Reflect and Common pigtails are spliced to proper lateral fiber strands. Testing procedures and CWDM data flow information is included on the plans. Testing shall be conducted for all CWDM wavelengths applicable to each fiber strand used for data communications. CWDM wavelengths on this project are expressed in nanometer (nm) and include 1430 nm, 1450 nm, 1470 nm, 1490 nm, 1510 nm, 1530 nm, 1570 nm, 1590 nm, and 1610 nm. Industry standard wavelengths (e.g. 1430 nm = 1431 nm) shall be observed.

After completion of fiber optic cable installation and prior to the CWDM filter splicing, all backbone cable to lateral cable splices shall be completed in the individual Ethernet switch sub-rings. Required steps shall include:

(1) The backbone end of Lateral Cable 1 shall be spliced to the fiber optic backbone cable in Splice Closure 1. Once this splice is complete no future access to Splice Closure 1 shall be made unless a re-splice is required.

(2) The opposite end of Lateral Cable 1 shall be spliced to itself in Splice Closure 2 in a manner to achieve continuity in the backbone strands from the beginning of the sub-ring (first node building) to the far end of the sub-ring (next node building).

(3) An OTDR test shall be conducted on the sub-ring from building to building to ensure proper splicing of Lateral Cable 1 in Splice Closure 1.

Once the OTDR test is complete the results shall be submitted to the Project Engineer for approval. After approval the splicing of CWDM filters in Splice Closure 2 may begin.

The Contractor shall be required to break the Lateral Cable 1 splices in Splice Closure 2 used in the continuity test and conduct the CWDM filter splicing per the project fiber splice plans. This will include splicing of Lateral Cable 1 and Lateral Cable 2 in Splice Closure 2 and the termination of Lateral Cable 2 in the communications cabinet.

After CWDM filter splicing, the Contractor may use one of the following methods to ensure the proper CWDM filter splicing.

(1) By using a fiber identifier, testing of the incoming signal from either the upstream or downstream CWDM location, the Contractor shall show the Project Engineer that proper CWDM filter pigtail splicing has been achieved.

(2) By using a spectrum analyzer to test the incoming wavelength to ensure proper splicing and wavelength of the CWDM signal.

Once all splicing of the individual sub-ring is complete the Contractor shall conduct the CWDM-OTDR and spectrum analyzer testing and submit the results to the Project Engineer. At the acceptance of these tests, the Contractor shall determine the proper optical attenuator to install in the Receive (RX) ports at both the communications termination panel and the node building termination panel. After installation one final test of optical power shall be conducted to determine if the proper signal strength is being achieved by the Ethernet switch CWDM optic.

At that point the Colorado Department of Transportation, Colorado Transportation Management Center personnel along with Ciena network engineers will configure the sub-ring into the overall CDOT ITS network. If network communications cannot be achieved, a review of the CWDM testing materials will begin.

(j) Test Acceptance

The Contractor shall demonstrate that the tests result in acceptable attenuation values.

The Contractor, solely at the Contractor's expense, shall re-splice all fusion splices and re-terminate all terminations that have test results exceeding acceptable attenuation values. The Contractor, solely at the Contractor's expense, shall retest all fiber links that have been re-spliced and shall retest all fiber links that have been re-terminated.

The Contractor, solely at the Contractor's expense, shall bring all links not meeting the requirements of this specification into compliance.

(k) Submittals

The Contractor shall submit test result documentation as both a hard copy and electronic copy.

After each reel test, the Contractor shall submit one hard copy of the OTDR trace for every fiber on the reel.

After installation, the Contractor shall submit two hard copies and one electronic copy of the following tests:

(1) Continuity OTDR trace for every spliced fiber which the CWDM optical network will utilize.

(2) OTDR trace for every fiber the high speed DWDM optical network will utilize.

(3) CWDM-OTDR trace for every fiber which the CWDM optical network will utilize.

(4) Spectrum analyzer test results for every fiber which the CWDM optical network will utilize.

(5) OTDR traces and power meter results for all "dark" unused fiber strands in the backbone fiber optic cable from node buildings.

Hard copy traces shall be organized and bound in logical order in an 8 ½ inch x 11 inch hard cover binder.

The Contractor shall submit, after approval of the hard copy traces, electronic copies of all traces (PDF and native file format) and appropriate software, if needed, to allow reading the traces.

The Contractor shall submit one copy of the complete contract Plans, including additional drawings issued as part of all change orders, with all deviations clearly marked in color. Deviations to be noted shall include at a minimum, but not be limited to, the following:

(1) Fiber Splice location

(2) Fiber Splice configuration

(3) Termination layout

After all splicing and fiber optic testing is completed the Contractor shall test the optical power of the incoming, (Receive) signal at each field Ethernet switch and existing node building location. To obtain the most accurate values of optical power, the testing equipment shall be attached to the SFP optic end of the pre-connectorized patch cable.

Once the optical power has been tested, the Contractor shall install the appropriate attenuator in the receive port to meet the receive values of the SFP optic module, including a design margin of 6 dB (to allow for degradation over the life of the system).

2.2 Subsystem Communications Testing

2.2.1 Description (CDOT performs this work)

A subsystem communication throughput test over the communication path between each field device and the node building shall be performed. The testing shall occur after all communication installation for a particular site has been completed, the communication paths between the device and the node building have been functional for at least 48 hours, and all fiber optic tests have been successfully passed.

CDOT has testing procedures for certain devices as outlined in Section 2.2 Local Field Operations Testing. For all other elements, the Contractor shall develop a test plan for conducting system and subsystem testing and submit it to CDOT for Approval. No testing shall be performed until CDOT has approved the test plan. A CDOT staff member or an authorized CDOT representative must witness and sign off on all tests.

2.2.2 Prerequisites for CDOT Testing

Prior to CDOT performing the Subsystem Communications Testing, the Contractor shall ensure that local field operations testing is complete, including network connectivity tests.

2.2.3 Scheduling Requirements

The Contractor shall notify the Project Engineer and CDOT ITS at least seven days prior to when they would like CDOT to begin testing. CDOT may adjust the proposed testing schedule by up to seven days, at no cost to CDOT, to accommodate availability of personnel. CDOT shall be provided two weeks to complete their Subsystem Communications Testing and, if CDOT completes their Subsystem Communications Testing within these timeframes, no time extensions or schedule allowances will be granted to the Contractor.

2.3 Local Field Operations Testing

Local Field Operations Testing shall be conducted to demonstrate that all hardware, cables, and

connections furnished and installed by the Contractor operate correctly and that all functions are

in accordance with the requirements described in the specifications, manufacturer's recommendations, and this document. When Local Field Operations Testing is scheduled at a specific site, all devices on an Ethernet switch at that site shall be tested simultaneously.

2.3.1 Documentation

The Contractor shall maintain their own tracking and documentation of the testing procedures on the Project. This documentation shall be maintained at a minimum on a weekly basis and the Contractor shall be able to provide CDOT with the latest version of their documentation upon request at any time once testing procedures have begun on the Project. At a minimum, the documentation shall include, by device, the date that the pretest notification was given to CDOT, the date that the device data sheets were submitted to CDOT, the date that preliminary testing of a device was complete by the Contractor, and the date that Local Field Operations Testing was complete.

The Contractor shall notify the Project Engineer and CDOT ITS at least two weeks prior to the test date for each site. This notification shall contain the Device Information Sheet and be provided to the CDOT ITS in Golden, CO. The Device Information Sheet submittal shall include photos. The Contractor shall also notify the Project Engineer and CDOT ITS upon test completion.

The Contractor shall provide device commissioning sheets from each device manufacturer, as required herein. The Contractor shall submit any additional testing documentation or requirements as required by the individual device specifications.

2.3.2 General Testing

Testing for each device shall include confirming physical location, verifying proper orientation of all devices, checking for physical access to the cabinet, voltage testing, local communication connectivity testing, grounding, proper cable management, and device-specific function testing as described in the following sections. It shall be demonstrated that all hardware, cables, and connections furnished and installed by the Contractor operate correctly and that all functions are in accordance with the requirements described in the specifications, manufacturer's recommendations, and this document. The tests shall include all items addressed in the specifications, manufacturer's recommendations, and this document. Local communication connectivity testing will ensure communication between each device and the respective local switch or modem, and a link to the nearest node building aggregation switch. Power and communications are required in order to schedule the acceptance of a site.

The Project Engineer and a CDOT ITS representative shall witness and sign off on all tests. Prior to performing local operations testing with a CDOT staff member or an authorized CDOT representative, the Contractor shall run through the local operations testing themselves. If the site is not fully configured, functional, and ready for testing when the CDOT staff member or authorized CDOT representative is there, the test date will be rescheduled with the notification periods starting over.

After completion of device specific testing and communication with the respective gateway at the CTMC is confirmed, the Contractor shall notify the Project Engineer and CDOT ITS that the device is ready for integration into the head-end control system. All modifications to the head-end control system will be performed by CDOT ITS.

2.3.3 Site Grounding

The Contractor shall verify the installation of the grounding system at each site. This test will ensure that the system has been installed per the specifications and this document. The test will also require the technician to verify that all devices are properly grounded and that all conductors have been terminated.

Testing shall be performed prior to connecting to utility ground in an effort to eliminate ground loops. When the grounding electrodes are installed, they shall be measured for their effectiveness using the three-point, fall of potential method per IEEE 81 to measure the resistance of the installed grounding electrode configuration with respect to the surrounding soil using an earth ground resistance tester. The final measurement must be performed in the presence of the Engineer or CDOT's designated representative. The Contractor shall provide documentation to the Engineer of ground grid measurement results for each ITS site location tied to a single grounding system.

Contractor shall furnish its own earth ground resistance tester including stakes, clamps, cabling, transformers, and other required accessories needed to perform the testing. A copy of the earth ground resistance tester's NIST certification shall be provided to the Engineer as verification that the unit has been calibrated using standards and instruments traceable to international standards.

See Attachment B for required Site Grounding testing form.

2.3.4 Location Specific Testing

2.2.3.1 ***2.3.4.1Cabinets***

The Contractor shall verify installation of all cabinet equipment. The power supply voltages and the functionality of the cabinet fans and heaters shall be verified.

See Attachment B for required cabinet testing forms.

2.3.4.2 Dynamic Message Signage

The Contractor shall perform a Dynamic Message Sign (DMS) acceptance test procedure for approval and acceptance by CDOT in the presence of the Engineer, a representative of the CDOT CTMC, and the manufacturer's representative. The test shall include the use of the latest version of the NTCIP Exerciser, or equivalent, to demonstrate that no proprietary protocols have been used and that the local and central software are NTCIP compliant.

All DMS shall be fully commissioned by the manufacturer. This documentation, including all manufacturers' testing and commissioning forms, shall be submitted to CDOT. The Contractor shall submit a "*DMS Commissioning Procedure*" for each type of DMS included in the project for Acceptance by CDOT. The test procedure shall be performed in the presence of CDOT and the manufacturer's representative. The Contractor shall notify the Project Engineer and CDOT ITS at least two weeks prior to the test date.

See Attachment B for required DMS testing forms.

2.3.4.3 Closed Circuit Television Camera and Lowering Device

Testing of each Closed Circuit Television (CCTV) Camera shall include checking the functionality and performance of the camera lowering pole including successfully raising and lowering the camera three times. Other devices on the camera lowering pole must not interfere with the operation of the lowering system. The tester will then need to verify that a local connection can be made through the assigned IP address. Once connected to the web Graphical User Interface (GUI), the tester will need to verify streaming video in both JPEG and H264 formats. The tester will verify the camera field of view is completely free of obstructions. Next, the tester will need to ensure the Pan/Tilt/Zoom functions in accordance with the specifications, manufacturer's recommendations, and this document.

See Attachment B for required CCTV Camera testing forms.

2.3.4.4 Ramp Meter System

The Contractor shall confirm full operation of all flashing beacons and signal heads. The Contractor shall verify communications are properly functioning for the passage, demand, and queue detection. The Contractor shall then observe traffic for each lane for a period of ten minutes to ensure each sensor is reading and communicating the traffic passing over it. The Contractor shall also monitor operation of the ramp meter for a three day period during operational time slots to ensure proper function of the RMS. Detailed documentation of all observations shall be recorded and submitted to CDOT for review.

The Contractor shall confirm communication between the controller and the Microwave Vehicle Radar Detector (MVRD) that is performing mainline detection. The Contractor shall perform MVRD testing for all RMS related MVRDs per the following Section of this document.

See Attachment B for required RMS testing forms.

2.3.4.5 Microwave Vehicle Radar Detector

The Microwave Vehicle Radar Detector (MVRD) test shall include ensuring proper alignment of the radar head to the lanes of traffic it is detecting. The Contractor shall then verify the proper cabling and termination of all cables between the radar head and all interfacing click modules. The Contractor shall then use the SSD HD V2.0.6 software to connect to the assigned IP address of the Click! 301. Within the SSD HD software, the Contractor shall verify correct setup of bin definitions and lane setup by observing traffic flow. The Contractor shall perform testing to verify the accuracy of volume, occupancy, and speed readings per the MVRD testing forms.

See Attachment B for required MVRD testing forms.

2.3.4.6 DTD ATR

For the DTD Automatic Traffic Recorders (ATR), acceptance shall be based on the testing and operation of the Wavetronix SmartSensor and Phoenix Diamond Counter (for the temporary ATR) and will be based on the testing and operation of the piezos and loops (for the permanent ATR) under actual traffic conditions, in which one week of actual data will be collected. The volume and vehicle class shall be within ±10 percent for the site compared to historical data for the test period. There shall be no more than one percent sensor misses in any one lane for the same time period.

The Contractor shall verify the correct operation of this equipment in conjunction with CDOT's Mike DelCupp to ensure proper reading of the traffic, correct configuration of the Phoenix Diamond Counter, and verify communication back to CDOT's ATR server via the existing telephone lines.

The piezo shall be tested for capacitance and dissipation factor prior to and after installation using an LCR meter. Capacitance and dissipation shall be within ±20 percent of the data sheet supplied with the piezo. Prior to acceptance of the site, the TDC will test the piezo for voltage and signal quality with live traffic. Voltage shall be no lower than 80 millivolts on the front axles of a class II vehicle (car).

Prior to sealing the loop, loop lead and feeder slots, a loop continuity test shall be performed. The test shall be performed by the TDC representative. Loop continuity shall be no higher than 1 ohm. Loop continuity higher than 1 ohm shall be cause for replacement of the loop. Replacement shall be at the Contractor's expense.

See Attachment B for required DTD ATR testing forms.

2.3.4.7 Road Weather Information Systems

The Contractor shall perform the CCTV Camera tests described herein for the RWIS camera. The vendor shall complete the commissioning process. After commissioning, the Contractor shall verify communication of the RWIS controller back to the RWIS server at the CTMC.

After completion of the equipment installation, the equipment manufacturer representative shall perform all final system checks, sensor alignments, sensor setup, RPU configuration including site communication setup, and central server configuration to provide a fully operational RWIS.

Additionally, all RWIS shall be fully commissioned by the manufacturer. This documentation, including all manufacturer's testing and commissioning forms, shall be submitted to CDOT.

See Attachment B for required RWIS testing form.

2.4 Integration

2.4.1 CTMS and CDOT's Camera Software Integration

2.4.1.1 Description

CDOT ITS will be responsible for modifying the CTMS and CDOT's camera software to integrate all local devices within the Project corridor.

2.4.1.2 Prerequisites for Integration

Once local field operations testing is complete for a device, the Contractor shall notify the Project Engineer and CDOT ITS that the device is ready for integration into the CTMS software, as well as CDOT's camera software for CCTV Cameras.

2.4.1.3 Scheduling Requirements

Once the fiber optic backbone cable has been installed, the Contractor shall contact the Project Engineer and CDOT ITS to schedule an Integration Kick-Off Meeting.

The Contractor shall notify the Project Engineer and CDOT ITS at least seven business days (excluding state holidays) prior to when they would like CDOT to begin CTMS and CDOT's camera software integration. CDOT may adjust the proposed integration schedule by up to seven days, at no cost to CDOT, to accommodate availability of personnel. CDOT shall be provided three weeks to complete their CTMS and CDOT's camera software integration and, if CDOT completes their work within these timeframes, no time extensions or schedule allowances will be granted to the Contractor.

2.4.2 Toll System Integration (E-470)

2.4.2.1 Description

A toll point is defined as a single toll collection point for one direction of travel. E-470 will be responsible for installing and integrating all ETC equipment at each toll point. E-470 will also be responsible for lane testing of the ETC equipment and final acceptance testing.

2.4.2.2 Prerequisites for E-470 Integration

Prior to E-470's work to install and integrate all ETC equipment at each tolling location, the Contractor must have performed all fiber and power testing to the toll locations, utilizing the testing procedures described herein to confirm functionality of the toll cabinets and lateral fiber. See Section 19.3 of the RFP for additional requirements.

2.4.2.3 Scheduling Requirements

See Section 19.3 of the RFP for requirements regarding scheduling and coordination with E-470.

2.5 Thirty Day Burn-in Test

2.5.1 Description of Test

After successful completion of all subsystem test procedures, the Contractor shall notify the Project Engineer and CDOT ITS that the 30-day burn-in test is ready to begin. All devices that are new, reset, or existing and connected to the fiber optic backbone within the Project corridor shall be included in the 30-day burn-in test. Each site shall be tested for proper functionality and device availability for 30 consecutive days. The test shall be performed per the specifications, manufacturer's recommendations, and this document. During the testing period, all equipment at the site that was provided, installed, or relocated by the Contractor shall operate without failures of any type. The Contractor shall coordinate with CDOT ITS for maintenance repair request tickets. Within 24 hours of notification by CDOT of a faulty component or device, the Contractor shall troubleshoot to find the exact cause of the failure and correct any fault. The cost of correcting equipment malfunctions shall be the responsibility of the Contractor. After the component malfunction has been corrected to the satisfaction of CDOT, the 30-day test period shall be start over.

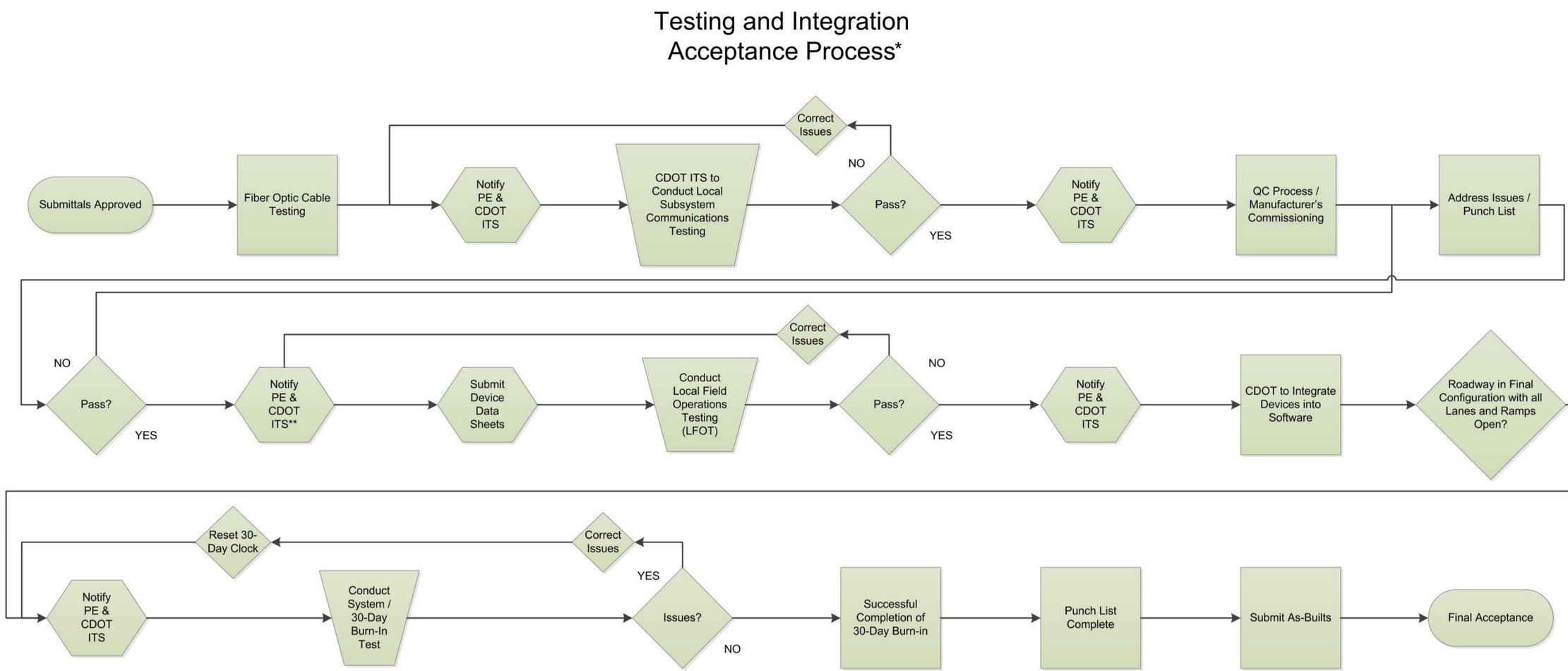
2.5.2 Acceptance Procedures

Documentation indicating successful passing of each test shall be submitted to CDOT for review prior to Project Final Acceptance.

2.5.3 Documentation

The Contractor shall maintain their own tracking and documentation for the progress of the 30-day burn-in test. This documentation shall be maintained at a minimum on a weekly basis and the Contractor shall be able to provide CDOT with the latest version of their documentation upon request at any time once the 30-day burn-in testing period has begun on the Project. At a minimum, the documentation shall include the date that the 30-day burn-in testing originally began, the date and time of any equipment malfunctions within the corridor, and the date and time that the Contractor restored functionality of any equipment that failed (marking the restart of the 30-day test period).

3 Testing and Integration Acceptance Process Flow Chart



*This flow chart applies to ITS equipment only; see Section 19.3 ETC System Coordination for information regarding ETC equipment requirements.

**Before notifying the Project Engineer and CDOT ITS that devices are ready for the LFOT to be witnessed, the Contractor shall self-perform the testing and verify everything is working.

4 Attachment A: Deliverables Checklist

Fiber Optic Cable Testing		
☐	Final OTDR test results	Date: _____
☐	Method Statement	Date: _____
☐	OTDR Trace Documentation (Prior to Installation)	Date: _____
☐	Continuity OTDR Trace (CWDM Optical Network)	Date: _____
☐	OTDR Trace (DWDM Optical Network)	Date: _____
☐	CWDM-OTDR Trace (CWDM Optical Network)	Date: _____
☐	Spectrum Analyzer Test Results (CWDM Optical Network)	Date: _____
☐	OTDR Traces and Power Meter Results (“Dark” Fiber Strands)	Date: _____
☐	Fiber Optic Cable As-Built Documentation Forms	Date: _____
Cabinets		
☐	Cabinet Testing Forms	Date: _____
Dynamic Message Signage (DMS) (VMS & VTMS Signs)		
☐	Device Information Sheet	Date: _____
☐	ITS As-Built Documentation Forms	Date: _____
☐	Device Commissioning Sheets from Manufacturer	Date: _____
☐	DMS Testing Forms	Date: _____
Closed Circuit Television (CCTV) Camera and Lowering Device		
☐	Device Information Sheet	Date: _____
☐	ITS As-Built Documentation Forms	Date: _____
☐	CCTV Testing Forms	Date: _____
Ramp Meter System (RMS)		
☐	Device Information Sheet	Date: _____
☐	ITS As-Built Documentation Forms	Date: _____
☐	RMS Testing Forms	Date: _____
Microwave Vehicle Radar Detector (MVRD)		
☐	Device Information Sheet	Date: _____

☐	ITS As-Built Documentation Forms	Date: _____
☐	MVRD Testing Forms	Date: _____
☐	MVRD Detector Accuracy Verification Test: Volume Forms	Date: _____
☐	MVRD Detector Accuracy Verification Test: Speed Forms	Date: _____
☐	MVRD Detector Accuracy Verification Test: Occupancy Forms	Date: _____
DTD Automatic Traffic Recorders (ATR)		
☐	Device Information Sheet	Date: _____
☐	ITS As-Built Documentation Forms	Date: _____
☐	DTD ATR Testing Forms	Date: _____
Road Weather Information Systems (RWIS)		
☐	Device Information Sheet	Date: _____
☐	ITS As-Built Documentation Forms	Date: _____
☐	RWIS Testing Forms	Date: _____
Site Grounding		
☐	Ground Grid Measurement Results	Date: _____
☐	Copy of Earth Ground Resistance Tester's NIST Certification	Date: _____
☐	Grounding Testing Forms	Date: _____
30-Day Burn-In		
☐	Daily Equipment Failure Reports (EFRs)	Date: _____
☐	Documentation indicating successful passing of each test submitted to CDOT	Date: _____

Attachment B: Forms

Cabinet Testing Form

4.1 General Information

Date of Testing Notification to CDOT:_____ Date of Test: _____

Commission Date:_____ Manufacturer:_____

Model #:_____ Serial #: _____

Mile Marker:_____ Nearest Interchange: _____

Direction:_____ Project Stationing: _____

Username (If Required):_____ Password (If Required): _____

Method of Communication: _____

Visual Inspection			
Requirement	**Pass**	**Fail**	**Notes**
Verify the approved cabinet type is actually installed.	☐	☐	
Verify that the cabinet location is correct.	☐	☐	
Verify that the mounting bracket is fully intact, unbent, and contains the proper amount of securely tightened bolts (when pole mounted).	☐	☐	
Verify that conduit type(s) and cabinet entries are properly sealed with watertight bushings that don't leave sharp edges that can damage cable outer jackets (when pole mounted).	☐	☐	
Verify cabinet foundation type and size.	☐	☐	
Verify cabinet foundation height above surrounding finished grade.	☐	☐	
Verify that gap between cabinet and foundation has been sealed with a CDOT-approved silicone caulk.	☐	☐	
Verify that the proper number of anchor bolts are used with washers and nuts securely fastened.	☐	☐	
Verify that cabinet door hardware is functional; verify locking system is operational and conforms to CDOT-approved cabinet key type.	☐	☐	
Verify that cabinet door hinge area is not cracked.	☐	☐	
Verify that cabinet door seals are fully intact and functional.	☐	☐	
Verify that the document holder mounted on the inside of the cabinet door contains the required documents.	☐	☐	
Verify proper cable management.	☐	☐	
Verify the cabinet is correctly oriented on the foundation.	☐	☐	

5 Cabinet Testing Form (continued)

Cabinet Interior			
Requirement	**Pass**	**Fail**	**Notes**
Verify that equipment installed within the cabinet has not been damaged.	☐	☐	
Verify that all equipment inside the cabinet is properly secured (no loose or missing screws, etc.).	☐	☐	
Verify that all required equipment is properly installed with its associated power and communication cabling terminated safely and securely at each end.	☐	☐	
Verify that power and communication cables are not pinched when cabinet door closes.	☐	☐	
Verify that power and communication cables are not nicked or damaged and are properly labeled.	☐	☐	
Verify that conduit entries with cabling are properly sealed to prevent rodent and water infiltration; unused spare conduits must also be plugged with mechanical, water tight plugs.	☐	☐	

Thermal Management			
Requirement	**Pass**	**Fail**	**Notes**
Verify installation of cabinet fan and accompanying thermostat.	☐	☐	
Verify CFM rating of cabinet fan.	☐	☐	
Verify installation of a new cabinet filter at air intake.	☐	☐	
Verify temperature setting of thermostat and test to ensure both fan and thermostat are functional.	☐	☐	

Lighting			
Requirement	**Pass**	**Fail**	**Notes**
Verify installation of cabinet lighting.	☐	☐	
Verify light source for cabinet lighting is energy efficient.	☐	☐	
Verify that light source if functioning properly with door switch activation/deactivation.	☐	☐	

6 Cabinet Testing Form (continued)

Electrical			
Requirement	**Pass**	**Fail**	**Notes**
Verify that the power distribution panel is functional and is protected by approved overcurrent breakers.	☐	☐	
Verify that breakers are properly labeled.	☐	☐	
Verify that an approved main surge protector is installed.	☐	☐	
Verify conductor sizes and types used.	☐	☐	
Verify that there are no exposed 120 VAC terminals inside cabinet.	☐	☐	
Verify voltage in all electrical outlets within the cabinet are within +/- 10% of 120 VAC using a receptacle tester and/or digital multimeter.	☐	☐	
Verify GFCI outlet functionality by using the “Test” and “Reset” buttons.	☐	☐	
Verify voltages of all devices in the cabinet powered by external power supplies.	☐	☐	
Verify proper installation of cabinet UPS and any external batteries.	☐	☐	
Verify that cabinet UPS is plugged into a non-GFCI outlet.	☐	☐	
Verify that cabinet UPS has a network management card (if not integral to unit) with Ethernet interface.	☐	☐	
Verify that cabinet UPS works properly when power is turned off at feed point.	☐	☐	
Verify installation of equipment ground and all devices are tied to equipment ground using a grounding conductor or strap.	☐	☐	

Network			
Requirement	**Pass**	**Fail**	**Notes**
Verify that network-enabled devices in the cabinet have a label showing their IP address and subnet mask and are plugged into the Ethernet switch.	☐	☐	
Verify through the Ethernet switch that all network-enabled devices within (or connected to) the cabinet can be pinged with a laptop using PuTTY and the IP address of each device.	☐	☐	
Verify through the Ethernet switch that the designated CDOT gateway can be pinged with a laptop using PuTTY.	☐	☐	

7 Dynamic Message Sign Testing Form

7.1 General Information

Date of Testing Notification to CDOT:_____ Date of Test: _____

Commission Date:_____ Manufacturer:_____

Model #:_____ Serial #: _____

Mile Marker:_____ Nearest Interchange: _____

Direction:_____ Project Stationing: _____

Username (If Required):_____ Password (If Required): _____

Method of Communication:_____ IP Address: _____

Subnet Mask:_____ Controller Serial 3: _____

Pre-Installation Requirements			
Requirement	**Pass**	**Fail**	**Notes**
Inspect exterior and interior of sign for damage.	☐	☐	
Visually inspect power terminations within sign at main lugs and power supplies. Verify that connections are tight, clean, and landed in the correct polarity.	☐	☐	
Using a safe procedure, verify voltage from the panel board main breaker input lugs to neutral and record values for L1 to Neutral.	☐	☐	
Using a safe procedure, verify voltage from the panel board main breaker input lugs to neutral and record values for L2 to Neutral.	☐	☐	
Using a safe procedure, verify voltage from the panel board main breaker input lugs to neutral and record values for Neutral to Ground.	☐	☐	
Using a safe procedure, verify DC voltage on the breaker input in the sign display; value should be 24 VDC +/- 10%.	☐	☐	
Turn on sign controller power switch and verify that the power indicator LED is illuminated.	☐	☐	
Display the “All on 100% Burn” test pattern; check that all fans turn on. Once test is complete, set test pattern to “None”.	☐	☐	

Push the vent fan override button in the service control panel, if equipped, for the ventilation fans and verify that they turn on. Release it and verify that they turn off.	☐	☐	

General Requirements			
Requirement	**Pass**	**Fail**	**Notes**
Verify that Manufacturer's Commissioning has been completed.	☐	☐	
Verify that VMS installation satisfies the minimum vertical clearance from the highest point on roadway to lowest point of VMS (or its support structure).	☐	☐	

Electrical			
Requirement	**Pass**	**Fail**	**Notes**
Verify that all power conductors are of the size and type required and properly terminated.	☐	☐	
Verify voltage at cabinet is within +/- 10% of 120 VAC or 240 VAC.	☐	☐	
Verify voltage in sign load center is within +/- 10% of 120 VAC or 240 VAC.	☐	☐	
Verify sign and cabinet are properly grounded.	☐	☐	
Verify that after power cycling all equipment turns back on properly.	☐	☐	

8 Dynamic Message Sign Testing Form (continued)

Operations Test			
Requirement	**Pass**	**Fail**	**Notes**
Verify that controller correctly identifies the address of the controller, its ID, current time, and date.	☐	☐	
Verify that controller can be connected to laptop.	☐	☐	
Verify that a new message can be created, stored in memory, and recalled for display.	☐	☐	
Verify proper display of test messages and graphics in controller memory.	☐	☐	
Verify that sign can be blanked out.	☐	☐	
Verify proper installation and aiming of display modules.	☐	☐	
Verify that display modules are properly wired by displaying a text message that identifies the module's correct row and column position.	☐	☐	
Verify operation of every pixel, including uniform brightness at all brightness levels and proper electrical current consumption.	☐	☐	
Verify that brightness can be manually adjusted from controller.	☐	☐	
Verify that brightness can be set to "Auto" in controller and test operation of photo sensor(s).	☐	☐	
Verify door switch alarm.	☐	☐	
Verify correct wiring of alarms and sensors to the controller's input.	☐	☐	
Verify that all diagnostic routines can be successfully performed.	☐	☐	
Verify operation of sign monitoring through the controller.	☐	☐	

9 CCTV Camera Testing Form

9.1 General Information

Date of Testing Notification to CDOT:_____ Date of Test: _____

Commission Date:_____ Manufacturer:_____

Model #:_____ Serial #: _____

Mile Marker:_____ Nearest Interchange: _____

Direction:_____ Project Stationing: _____

Username (If Required):_____ Password (If Required): _____

Method of Communication:_____ IP Address: _____

Camera Lowering System			
Requirement	**Pass**	**Fail**	**Notes**
Verify the camera lowering system was properly installed by lowering and raising the CCTV to the ground three full cycles.	☐	☐	
Verify that CCTV is stable and locked at the top of the CLS.	☐	☐	
Verify that network cable has proper strain relief within pole and is not being damaged by movement of pulleys and support cable.	☐	☐	

CCTV			
Requirement	**Pass**	**Fail**	**Notes**
Verify quality of video and bandwidth setting.	☐	☐	
Verify streaming video in both JPEG and H264 formats.	☐	☐	
Verify pan, tilt, and zoom functionality.	☐	☐	
Verify manual and auto focus capability.	☐	☐	
Verify iris control.	☐	☐	

10 CCTV Camera Testing Form (continued)

Installation			
Requirement	**Pass**	**Fail**	**Notes**
Verify location of CCTV installation.	☐	☐	
Verify height of pole.	☐	☐	
Verify that CDOT-approved CCTV is installed.	☐	☐	
Verify voltage to PoE injector.	☐	☐	
Verify proper grounding of PoE injector power and network cable attachment.	☐	☐	
Verify shielding requirements of network cable and cable type is appropriate for outdoor installation.	☐	☐	

11 Ramp Metering System Testing Form

11.1 General Information

Date of Testing Notification to CDOT:_____ Date of Test: _____

Commission Date:_____ Manufacturer:_____

Model #:_____ Serial #: _____

Mile Marker:_____ Nearest Interchange: _____

Direction:_____ Project Stationing: _____

Username (If Required):_____ Password (If Required): _____

Method of Communication: _____

12 Ramp Metering System Testing Form (continued)

Installation			
Requirement	**Pass**	**Fail**	**Notes**
Verify that all demand detection zones have been installed.	☐	☐	
Verify that all passage detection zones have been installed.	☐	☐	
Verify that all queue detection zones have been installed.	☐	☐	
Check for indication of broken, cut, or exposed loop or lead-in wires.	☐	☐	
Check for exposed wire or missing sealant in loop slots.	☐	☐	
Verify that all lead-in wires have been properly twisted to avoid crosstalk and properly labeled.	☐	☐	
Verify loop lead in cables are properly identified and labeled in the cabinet and pull box specials.	☐	☐	
Verify that each loop is connected to the correct terminals on the input file.	☐	☐	
Verify the sensitivity on each loop amplifier channel (default value shall be 2).	☐	☐	
Verify that all unused channels of loop amplifiers are disabled.	☐	☐	
Verify that loop amplifiers are configured for 6'x6' loops and set on presence detection rather than pulse.	☐	☐	
Verify that all detection zones properly register the appropriate calls.	☐	☐	
Verify that the right side signal assembly is properly installed and signal heads operate correctly.	☐	☐	
Verify that the left side signal assembly is properly installed and signal heads operate correctly.	☐	☐	
Verify that the mast arm signal assembly is properly installed and signal heads operate correctly.	☐	☐	
Verify that the right side advance flashing beacon assembly is properly installed and operational.	☐	☐	
Verify that the left side advance flashing beacon assembly is properly installed and operational.	☐	☐	
Verify that the tripping of 208 watchdog timer card causes the signal heads and advance flashing beacons to go into yellow flash.	☐	☐	
Verify all equipment is properly grounded.	☐	☐	

13 Ramp Metering System Testing Form (continued)

Ramp Meter Loops Input File					
Location:					
Function	**Input File Slot**	**4 Channel**	**2 Channel**	**Field Connections**	**Verified**
HOV Detector	I-2U	Channel 3		I-2D,E	☐
Queue Detector 1	I-2L	Channel 4		I-2J,K	☐
Queue Detector 2	I-3U	Channel 1		I-3D,E	☐
Queue Detector 3	I-3L	Channel 2		I-3J,K	☐
Primary Upstream Detector 1	I-8U	Channel 1		I-8D,E	☐
Secondary Upstream Detector 1	I-8L	Channel 2		I-8J,K	☐
Primary Upstream Detector 2	I-7U	Channel 3		I-7D,E	☐
Secondary Upstream Detector 2	I-7L	Channel 4		I-7J,K	☐
Primary Upstream Detector 3	I-6U	Channel 1		I-6D,E	☐
Secondary Upstream Detector 3	I-6L	Channel 2		I-6J,K	☐
Primary Upstream Detector 4	I-5U	Channel 3		I-5D,E	☐
Secondary Upstream Detector 4	I-5L	Channel 4		I-5J,K	☐
Primary Upstream Detector 5	I-4U		Channel 1	I-4D,E	☐
Secondary Upstream Detector 5	I-4L		Channel 2	I-4J,K	☐
Primary Upstream Detector 6	I-9U	Channel 3		I-9D,E	☐
Secondary Upstream Detector 6	I-9L	Channel 4		I-9J,K	☐
Primary Upstream Detector 7	I-10U	Channel 1		I-10D,E	☐
Secondary Upstream Detector 7	I-10L	Channel 2		I-10J,K	☐
Primary Upstream Detector 8	I-11U		Channel 1	I-11D,E	☐
Secondary Upstream Detector 8	I-11L		Channel 2	I-11J,K	☐
Demand Detectors 1	I-12U	Channel 3		I-12D,E	☐
Passage Detector 1	I-12L	Channel 4		I-12J,K	☐
Demand Detectors 2	I-13U	Channel 1		I-13D,E	☐
Passage Detector 2	I-13L	Channel 2		I-13J,K	☐

Ramp Metering System Testing Form (continued)

Ramp Meter Loops Output File			
Location:			
Function	**Input File Slot**	**Field**	**Verified**
Ramp on Flasher	LS1 Red	PO 7	☐
Signal Red	LS2 Red	PO 4	☐
Signal Yellow	LS2 Yel	T210	☐
Signal Green	LS2 Grn	PO 6	☐

MVRD Testing Form

13.1 General Information

Date of Testing Notification to CDOT:_____ Date of Test: _____

Commission Date:_____ Manufacturer:_____

Model #:_____ Serial #: _____

Mile Marker:_____ Nearest Interchange: _____

Direction:_____ Project Stationing: _____

Username (If Required):_____ Password (If Required): _____

Method of Communication:_____ IP Address: _____

Tested by:_____ CDOT Witness: _____

General			
Requirement	**Pass**	**Fail**	**Notes**
Verify that MVRD is installed at the correct location.	☐	☐	
Verify that the top of the MVRD cabinet is about 5' to 7' above finished grade.	☐	☐	
Verify that MVRD cabinet is oriented such that maintenance personnel will have a direct line-of-sight with oncoming traffic.	☐	☐	
Complete MVRD Detector Accuracy Verification Test for Volume.	☐	☐	
Complete MVRD Detector Accuracy Verification Test for Speed.	☐	☐	
Complete MVRD Detector Accuracy Verification Test for Occupancy.	☐	☐	

14 MVRD Testing Form (continued)

Electrical			
Requirement	**Pass**	**Fail**	**Notes**
Verify that all power connectors include a quick disconnect.	☐	☐	
Verify that MVRD AC circuit breaker is properly sized, installed on DIN rail, and connected to AC line.	☐	☐	
Verify that MVRD AC surge protector is properly installed on DIN rail and connected to circuit breaker and AC neutral.	☐	☐	
Verify that MVRD power supply is sized appropriately for the required voltage and number of MVRDs it will be powering.	☐	☐	
Verify that MVRD power supply is connected to AC surge protector on input side and to each lightning surge protector on output side.	☐	☐	
Verify DIN rail is properly grounded.	☐	☐	
Verify that the manufacturer's recommended power/communication cable is being used and is of adequate length.	☐	☐	
Verify power supply has AC to DC converter mounted to DIN rail and measure output voltage of power supply.	☐	☐	

Alignment			
Requirement	**Pass**	**Fail**	**Notes**
Verify that the lateral mounting meets the minimum and maximum allowable setbacks per the manufacturer's recommendations.	☐	☐	
Verify that MVRD mounting is in compliance with manufacturer's recommended installation method	☐	☐	
Verify the height of MVRD above finished grade and if it conforms with manufacturer's recommendations.	☐	☐	
Verify that MVRD is mounted with its cable connector down and tilted so that it is aimed in accordance with manufacturer's requirements.	☐	☐	
Verify that MVRD's view of roadway is not obstructed.	☐	☐	
Verify that contact closure card is properly installed in card rack and receiving actuations.	☐	☐	
Verify address of the contact closure card.	☐	☐	
Verify that patch cords are securely terminated between each contact closure card and lightning surge protector.	☐	☐	
Verify that sensor cable is properly terminated to each lightning surge protector.	☐	☐	

14.1 MVRD Detector Accuracy Verification Test: Volume

Site:_____

Date:_____ Time: _____

14.1.1 Objective

To verify and demonstrate the functionality and accuracy of volume for the detector locations.

14.1.2 Prerequisites

Detector and cabinet installation must be complete. Lane must be open to traffic. ATMS inspector must be present during testing.

14.1.3 Test Equipment

A stop watch and traffic count board.

14.1.4 Success Criteria

Volume obtained from each detector for each lane of traffic will be within +/- 10 percent of each sample size. Sample size will be ten minutes, or 50 vehicles, whichever comes first. Traffic will be running at typical free-flowing speed and condition.

14.1.5 Test Instructions

1. Record the observed actual hand count volume and detector counts for ten minutes, or 50 vehicles, whichever comes first.
2. Record the volume of vehicles detected by the sensor over the test period.
3. Subtract hand count volume from detector count volume and then divide by the hand count volume. Multiply by 100 to get the percent accuracy.
4. Indicate pass if result is +/- 10 percent.
5. Adjust sensitivity and repeat if percent accuracy is out of range.

14.2 MVRD Detector Accuracy Verification Test: Volume (continued)

Volume Test Results					
Lane #					
Test Duration (min:sec)					
Observed Hand Count Volume					
Detector Count Volume (from Laptop)					
% Accuracy = (100 x (detector count – hand count)/(hand count))					
Pass or Fail (Pass if accuracy is < +/- 10%					
Sensitivity Setting					
Test Completed by (Installer's Tester)					
Date					
Test Inspected by (ATMS Inspector)					

MVRD Detector Accuracy Verification Test: Speed

Site:_____

Date:_____ Time: _____

14.2.1 Objective

To verify and demonstrate the functionality and accuracy of speed for detector locations. Note that this test is applicable to Wavetronix Smart Sensor HD units that compute rolling average speed. Also note that this speed testing is not required for freeway on/off ramps, only for mainline detection.

14.2.2 Prerequisites

Detector and cabinet installation must be complete. Lane must be open to traffic. CDOT Inspector must be present during testing.

14.2.3 Test Equipment

A calibrated radar gun, a stop watch, 2-way radios, and a laptop.

14.2.4 Procedure

1. Record distance L from radar gun to detector site.
2. Record offset O from center of each lane to radar gun site.
3. Compute the resultant angle theta (= inverse tangent (O / L)), which is the angle between radar gun beam and vehicle travel direction.
4. Compute cosine theta, which is the speed correction factor for the measurement angle.
5. Ensure that Detector unit is functioning, and that rolling average speed is being recorded.
6. Set the interval on the detector unit to 3 minutes.
7. Record the individual speeds of 16 consecutive vehicles using radar gun. If measuring consecutive vehicles is not possible, measure speeds for as many vehicles in the lane as possible, for 16 vehicles or 3 minute time period, whichever comes first.
8. Simultaneously to recording the 16th vehicle, or completing the 3 minute time period, immediately record the current Detector Mean Speed as indicated at that moment by the Detector unit.
9. Compute the mean (Average) speed of the 16 vehicles, based on radar gun readings.
10. Compute the Modified Radar Gun Mean Speed (= radar gun mean speed / cosine theta), if needed, if radar gun is not shooting head-on at vehicles.
11. Compare the Modified Radar Gun Mean Speed to the Detector Mean Speed. Pass if difference < 5 mph. If test does not pass, adjust the sensitivity of the sensor and retest.

12. Repeat for each lane.

14.3 MVRD Detector Accuracy Verification Test: Speed (continued)

14.3.1 Set-up Data

Radar Unit Type, Model, and Serial #: _____

Record Distance L from Radar Site to Detector Site: _____

Record Offset O from Radar Site to Center of Lane 1: _____

Compute Theta 1:_____Compute Cosine Theta 1: _____

Record Offset from Radar Site to Center of Lane 2: _____

Compute Theta 1:_____Compute Cosine Theta 1: _____

Record Offset from Radar Site to Center of Lane 3: _____

Compute Theta 1:_____Compute Cosine Theta 1: _____

Record Offset from Radar Site to Center of Lane 4: _____

Compute Theta 1:_____Compute Cosine Theta 1: _____

Record Offset from Radar Site to Center of Lane 5: _____

14.4 MVRD Detector Accuracy Verification Test: Speed (continued)

Speed Test Results					
Lane #					
Vehicle #	Speed form Radar Gun Display (mph)	Speed from Radar Gun Display (mph)	Speed form Radar Gun Display (mph)	Speed form Radar Gun Display (mph)	Speed form Radar Gun Display (mph)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
Radar Gun Mean Speed (mph)					
Cosine Theta					
Modified Radar Gun Mean Speed (mph)					
Detector Mean Speed (mph)					
Pass or Fail (Pass if Modified Radar Gun and Detector Mean Speeds are within +/- 5 mph)					
Sensitivity Setting					
Does Controller Properly Record Occupancy?					
Test Completed by (Installer's Tester)					
Date					
Test Inspected By (ATMS Inspector)					

MVRD Detector Accuracy Verification Test: Occupancy

Site:_____

Date:_____ Time: _____

14.4.1 Objective

To verify and demonstrate the functionality and accuracy of occupancy for the detector locations.

14.4.2 Prerequisites

Detector and cabinet installation must be complete. Lane must be open to traffic. ATMS Inspector must be present during testing.

14.4.3 Test Equipment

A stop watch, a traffic count board, and a laptop.

14.4.4 Success Criteria

Occupancy obtained from each detector for each lane of traffic will be within +/- 5 percent of each sample size. Sample size will be three minutes. Traffic will be running at typical free-flowing speed and condition.

14.4.5 Test Instructions

1. Record the observed actual hand count occupancy and sensor counts for three (3) minutes.
2. Record the occupancy of vehicles detected by the sensor over the test period.
3. Subtract hand count volume from detector count volume and then divide by the hand count volume. Multiply by 100 to get the percent accuracy.
4. Indicate pass if result is +/- 5%.
5. Adjust sensitivity and repeat if % accuracy is out of range.

Occupancy Measurements	
# of Axles	Vehicle Length (Approximate)
2	20 feet
3	30 – 40 feet
>3	> 40 feet

Use the chart above to determine the number of axles by vehicle length. Choose a populated lane and monitor the occupancy of the lane for three (3) minutes. Use the chart on the next page to complete the test.

14.5 MVRD Detector Accuracy Verification Test: Occupancy (continued)

Occupancy Test Results										
Lane #	Time Duration (min:sec)	Observed Occupancy Counts			Occupancy (from Laptop)			% Accuracy	Pass/Fail	Sensitivity Setting
		2 Axle	3 Axle	>3 Axle	2 Axle	3 Axle	>3 Axle	= 100 x (laptop – observed) / (observed)	Pass if < +/- 5%	

Cabling			
Requirement	**Pass**	**Fail**	**Notes**
Verify type of conduit used to run cables and proper termination techniques on each end.	☐	☐	
Verify that conduits enter cabinets through bottom (preferred) or side (alternative)	☐	☐	
Verify that all cable entrances are sealed and waterproof.	☐	☐	
Verify that all drilled holes for installing cabling in mounting structures must be free of burrs and sharp edges.	☐	☐	
Verify that all signal cables are continuous and unspliced.	☐	☐	
Verify that each cable utilizes a unique color tape on each end that is resistant to fading due to UV exposure.	☐	☐	

15 DTD ATR Testing Form

15.1 General Information

Date of Testing Notification to CDOT:_____ Date of Test: _____

Commission Date:_____ Manufacturer:_____

Model #:_____ Serial #: _____

Mile Marker:_____ Nearest Interchange: _____

Direction:_____ Project Stationing: _____

Username (If Required):_____ Password (If Required): _____

Method of Communication: _____

Installation			
Requirement	**Pass**	**Fail**	**Notes**
Verify that all detection zones have been installed.	☐	☐	
Verify that loop sawcuts are finished and level with roadway without excess epoxy.	☐	☐	
Verify all equipment is properly grounded.	☐	☐	

Lanes			
Requirement	**Pass**	**Fail**	**Notes**
Verify that the detection works properly for each lane that loops are installed.	☐	☐	

16 DTD ATR Testing Form (continued)

Piezo Loops			
Requirement	**Pass**	**Fail**	**Notes**
Using a LCR meter, verify that the capacitance is within the tolerances specified by the manufacturer.	☐	☐	
Using a LCR meter, verify that the dissipation factor is within the tolerances specified by the manufacturer.	☐	☐	
Verify that installed piezo sensors are class II (used to collect axle classification data).	☐	☐	
Verify that sensor misses per lane shall not exceed the requirements of DTD during the test period.	☐	☐	
Verify that loop continuity must not exceed 1 ohm.	☐	☐	
Verify that voltage for a front axle of a car is not less than 80 mV.	☐	☐	

Data Retrieval			
Requirement	**Pass**	**Fail**	**Notes**
Verify that real-time vehicle viewing per selected lane can be performed.	☐	☐	
Verify that system data retrieval does not impact data collection operation.	☐	☐	
Verify that device supports collection of data for opposing lanes of traffic.	☐	☐	

Accuracy			
Requirement	**Pass**	**Fail**	**Notes**
Verify that piezos and loops were tested under actual traffic conditions.	☐	☐	
Verify that one week of data was collected.	☐	☐	
Verify that the volume count is within +/- 10 percent accuracy for the site compared to historical data.	☐	☐	
Verify that the vehicle classification type is within +/- 10 percent accuracy for the site compared to historical data.	☐	☐	
Verify that sensor misses do not exceed 1 percent in each lane during the test period.	☐	☐	

17 RWIS Testing Form

17.1 General Information

Date of Testing Notification to CDOT:_____ Date of Test: _____

Commission Date:_____ Manufacturer:_____

Model #:_____ Serial #: _____

Mile Marker:_____ Nearest Interchange: _____

Direction:_____ Project Stationing: _____

Username (If Required):_____ Password (If Required): _____

Method of Communication:_____ IP Address: _____

18 RWIS Testing Form (continued)

Installation			
Requirement	**Pass**	**Fail**	**Notes**
Verify installation location.	☐	☐	
Verify that heavy duty fold over tower was installed per CDOT requirements.	☐	☐	
Verify that base assembly was installed per CDOT requirements.	☐	☐	
Verify that concrete footing was installed per CDOT requirements.	☐	☐	
Verify that concrete pad was installed per CDOT requirements.	☐	☐	
Verify that system is properly grounded.	☐	☐	
Verify that chain link fence is 5’ to 7’ tall and installed within 6’-2” of the edge of the concrete along the perimeter.	☐	☐	
Verify that a 3’-6” or 4’-0” gate is provided in the chain link fence with locking hasps and end caps centered opposite the hinged side of the tower to allow access to fold down tower.	☐	☐	
Verify that tower is mounted in a direction that will not impede traffic when folded down.	☐	☐	
Verify that air temperature/relative humidity sensor is mounted on the tower 6’ above finished grade.	☐	☐	
Verify that the wind sensor is mounted on the tower at 30’ above finished grade.	☐	☐	
Verify that the PTZ camera is mounted on the tower at 27’ above finished grade.	☐	☐	
Verify that the non-intrusive road surface state sensor is mounted at an angle recommended by the manufacturer.	☐	☐	
Verify that data from temperature, humidity, windspeed, and road surface sensors are being collected and processed by processing unit.	☐	☐	

19 Connected Vehicle Roadside Unit Testing Form

19.1 General Information

Date of Testing Notification to CDOT:_____ Date of Test: _____

Commission Date:_____ Manufacturer:_____

Model #:_____ Serial #: _____

Mile Marker:_____ Nearest Interchange: _____

Direction (Deployment location):_____ Project Stationing: _____

Username (If Required):_____ Password (If Required): _____

Method of Communication:_____ IP Address: _____

Subnet Mask:_____ Controller Serial 3: _____

Pre-Installation Requirements			
Requirement	**Pass**	**Fail**	**Notes**
Inspect exterior and interior of RSU for damage.	☐	☐	
Visually inspect power terminations within WIM at main lugs and power supplies. Verify that connections are tight, clean, and landed in the correct polarity.	☐	☐	
Using a safe procedure, verify voltage from the panel board main breaker input lugs to neutral and record values for L1 to Neutral.	☐	☐	
Using a safe procedure, verify voltage from the panel board main breaker input lugs to neutral and record values for L2 to Neutral.	☐	☐	
Using a safe procedure, verify voltage from the panel board main breaker input lugs to neutral and record values for Neutral to Ground.	☐	☐	
Using a safe procedure, verify DC voltage on the breaker input in the sign display; value should be 24 VDC +/- 10%.	☐	☐	
Verify that the power indicator LED is illuminated.	☐	☐	

Electrical			
Requirement	**Pass**	**Fail**	**Notes**
Verify that all power conductors are of the size and type required and properly terminated.	☐	☐	
Verify voltage at cabinet is within +/- 10% of 120 VAC or 240 VAC.	☐	☐	
Verify RSU and cabinet are properly grounded.	☐	☐	
Verify that after power cycling all equipment turns back on properly.	☐	☐	

20 Weigh in Motion Unit Testing Form

20.1 General Information

Date of Testing Notification to CDOT:_____ Date of Test: _____

Commission Date:_____ Manufacturer:_____

Model #:_____ Serial #: _____

Mile Marker:_____ Nearest Interchange: _____

Direction (Deployment location):_____ Project Stationing: _____

Username (If Required):_____ Password (If Required): _____

Method of Communication:_____ IP Address: _____

Subnet Mask:_____ Controller Serial 3: _____

Pre-Installation Requirements			
Requirement	**Pass**	**Fail**	**Notes**
Inspect exterior and interior of WIM device for damage.	☐	☐	
Visually inspect power terminations within WIM at main lugs and power supplies. Verify that connections are tight, clean, and landed in the correct polarity.	☐	☐	
Using a safe procedure, verify voltage from the panel board main breaker input lugs to neutral and record values for L1 to Neutral.	☐	☐	
Using a safe procedure, verify voltage from the panel board main breaker input lugs to neutral and record values for L2 to Neutral.	☐	☐	
Using a safe procedure, verify voltage from the panel board main breaker input lugs to neutral and record values for Neutral to Ground.	☐	☐	
Using a safe procedure, verify DC voltage on the breaker input in the sign display; value should be 24 VDC +/- 10%.	☐	☐	
Verify that the power indicator LED is illuminated.	☐	☐	

Electrical			
Requirement	**Pass**	**Fail**	**Notes**
Verify that all power conductors are of the size and type required and properly terminated.	☐	☐	
Verify voltage at cabinet is within +/- 10% of 120 VAC or 240 VAC.	☐	☐	
Verify WIM and cabinet are properly grounded.	☐	☐	
Verify that after power cycling all equipment turns back on properly.	☐	☐	

21 Grounding Testing Form

21.1 General Information

Date of Testing Notification to CDOT:_____ Date of Test: _____

Mile Marker:_____ Nearest Interchange: _____

Direction:_____ Project Stationing: _____

Username (If Required):_____ Password (If Required): _____

Test Meter Manufacturer:_____ Test Meter Model No.: _____

Test Meter Serial No.:_____ Test Meter Calibration Date: _____

Test Conducted By: _____

Test Conditions

Soil Condition (Check One): ☐ Dry ☐ Moist

Temperature:_____ºF

Soil Type (Check One): ☐ Clay ☐ Granite ☐ Limestone ☐ Loam ☐ Shale ☐ Sand and Gravel ☐ Slate ☐ Sandstone ☐ Other _____

Number of Rods Used (Circle One): 1 2

Final Rod Depth:_____ feet

Effective Grounding Electrode Resistance:_____ Ω

22 Grounding Testing Form (continued)

General Requirements			
Requirement	**Pass**	**Fail**	**Notes**
Verify that ground rods are copper-clad steel not less than 0.625" diameter and a minimum of 8' length.	☐	☐	
Verify that CDOT approved other ground rod type if copper-clad steel was not used.	☐	☐	
Verify that grounding electrode conductor is not less than #6 AWG.	☐	☐	
Verify that braided ground straps consist of non-insulated tinned copper flat braid wire not less than 0.5" width and 0.07" thick (for bonding between a cabinet frame and busbar only).	☐	☐	
Verify that insulated grounding electrode conductors are Type THWN with green jacket color.	☐	☐	
Verify that grounding electrode conductor was installed in a continuous run without splices or joints.	☐	☐	
Verify that connectors are exothermic weld for below grade connections and areas exposed to moisture.	☐	☐	
Verify that connectors are UL listed compression connectors for above grade installations and where safety dictates.	☐	☐	
Verify that ground bus is copper bar stock with stainless steel stand-off brackets and mounting hardware.	☐	☐	
Measure resistance of the first installed grounding electrode and test with earth ground resistance tester (3-point fall of potential method). If results exceed 10 ohm, a second grounding electrode needs to be installed.	☐	☐	
Verify that second grounding electrode is at least one electrode length away from the first grounding electrode and connected via bonding jumper.	☐	☐	
Measure grounding electrode system resistance with earth ground resistance tester (3-point fall of potential method). CDOT will accept 25 ohm or less after two grounding electrodes have been installed.	☐	☐	
Verify that oxidation and antioxidant compound was used at connection points to ground bus.	☐	☐	
Verify that stainless steel hardware was used and torqued to a specific value based on hardware grade, material, and size.	☐	☐	
Verify that connections to ground bus utilize a flat washer and Bellville washer for each bolt.	☐	☐	
Verify that all exothermic welds have slag removed.	☐	☐	
Verify that testing is performed prior to connecting to utility ground.	☐	☐	