10-3. SYSTEM TESTING AND DOCUMENTATION

System testing and documentation must cover pre-installation testing, sub-system testing, fiber optic cable testing, video link testing, data link testing, acceptance testing, physical inspection, functional testing, performance testing, final acceptance and system documentation required to validate the operational performance of communications systems as described elsewhere in these special provisions.

TEST PLAN

You must submit 5 copies of an installation and test plan that details methods of installation, material, equipment, and cable testing, and a working day schedule to the Engineer within 14 working days. The Engineer will review the test plan and approve or disapprove it within 10 working days. If the Engineer rejects the test plan, submit a revised test plan within 20 working days for review and approval by the Engineer. No testing must be performed until the Engineer has approved your test plan. Material and equipment must meet the requirements of these special provisions. Test results, including results of failed tests or re-tests, must be submitted to the Engineer and a copy placed with the equipment at the site. You must supply test equipment.

You must notify the Engineer of intent to proceed with functional and sub-system testing 48 hours prior to commencement of tests. Full environmental conditions must be tested as part of the functional tests for field equipment. Sub-system testing and inspections must include visual inspection for damage in correct installation, adjustments and alignment, and measurement of parameters and operating conditions.

Pre-Installation Testing

Documentation for testing conducted at the manufacturer’s premises must be submitted to the Engineer when the equipment is delivered to the site.

Active equipment must be connected to normal operating power, energized and subjected to normal operating conditions in the laboratory of not less than 48 continuous hours.

Functional testing must be performed by the manufacturer on material after delivery to the site. Functional tests must be performed in accordance with an approved test plan. Material or equipment which fails to meet requirements must be repaired or replaced and tests must be repeated until satisfactory. Functional test results, including results of failed tests or re-tests, must be submitted and delivered with material and equipment delivered to the site.

Full performance tests must be performed by the manufacturer’s representative or by you on not less than 5 percent or at least one unit of material selected at random from the normal production run. Full performance tests must be performed in accordance with a test plan developed by you and approved by the Engineer.

Sub-system Testing

Sub-system testing must encompass testing of material, equipment and cables after installation, but prior to acceptance tests. Tests must be in accordance with the performance testing for individual items.

Materials, equipment and cables must be tested after installation at the site. Sub-system testing and inspections must include visual inspection for damaged or incorrect installation, adjustments and alignment, and measurement of parameters and operating conditions. Notify the Engineer of intent to proceed with sub-system testing 48 hours prior to commencement of individual tests.
Installation documentation and test results must be provided for materials, equipment and cables prior to commencement of acceptance tests. Installation documentation must include the following as appropriate:

1. Model, part number and serial number for material and equipment.
2. Test equipment model number, serial number, settings, and date of last calibration.
4. Record of adjustments and levels.
5. Alignment measurements.
7. Factory and site test results.

**Fiber Optic Cable Testing**

Attention is directed to "Fiber Optic Testing" of these special provisions.

**Video Link Testing**

Video link testing must be conducted after you submit a test plan and receives approval from the Engineer. A video link must be established from Los Angeles Regional Transportation Management Center (LARTMC) and Video Node T1046 to CCTV camera locations for testing and verification. Measurements must be made from the baseband-in to baseband-out connections.

Video links in communications systems must be tested with a video test signal at the video transmitter input. You must perform level adjustments and alignments required on video links. If a video link fails to meet performance requirements, you must restore failed links to the required performance.

Video links in communications systems must be tested for qualitative performance with associated cameras turned on and connected to BNC connectors of video transmitters. Measure, record, and tabulate video receiver’s dynamic range at the optical connector of the new single fiber optic video receivers at LARTMC and at the new fiber optic video transmitters in the new Video Node T1046 under test using a 90 percent APL (average picture level) flat field input to the existing single video transmitter.

The output video signal must be connected to a video display monitor. The observed picture on the video display monitor must be assessed for qualitative performance. Qualitative comments must be recorded for individual cameras. The Engineer will approve the video test set. Measure, record and demonstrate that the performance meets or exceed the specified EIA RS-250 requirements listed below:

1. Differential gains.
2. Differential phases.
3. Chrominance to luminance delays inequality.
4. Amplitude vs. frequency characteristics.
5. Frequency response characteristic.
6. Signal to noise ratio.
7. Signal to low frequency noise.
8. Signal to periodic noise.
9. Output signal levels.

**Data link testing**
Data link testing for the alignment and testing of data systems must be conducted after you submit a test plan and receive approval from the Engineer. The activities must include verification of data circuits in the low speed data links, high speed data ring network and in the integrated data system. Adjust levels required for the data system to operate.

Data link tests must be conducted between LARTMC and the communication system routing equipment in the controller cabinets, including CCTV cameras and Model 2070 controllers.

Records of tests must be delivered to the Engineer. Circuits must be fully tested to the channel card using a transmission impairment measuring set (TIMS). Bit error rate (BER) tests must be conducted using Model 400 modems (or equivalent) at 1200 bps from LARTMC to the circuit terminus. BERTS must be used in a 3-hour test for each circuit.

The bit error rate in both directions must be less than $1 \times 10^{-6}$ at 9600 bps for all circuits.

**Data link performance**

Data link performance tests must consist of functional tests conducted between the existing Data multiplexer in the LARTMC and from the new data node TI046 to various field element locations, such as closed circuit television (CCTV) cameras, video node and cable nodes, weigh-in-motion stations, and ramp metering systems that are connected to the existing and new trunk line fiber optic cables, as shown on the plans and as directed by the Engineer. The audio channel must be verified in both directions using telephone instruments. The signaling system must be verified in both directions. In addition to circuits using 4 WTO channel cards for modems, bit error rate (BER) tests must be conducted using appropriate Model 400, 1200 BPS modem or ITU compatible high speed modem, and a bit error rate test set (BERTS) must be used to verify error free transmission for 5 minutes at the bit rate to be employed in the system.

Records of tests must be delivered to the Engineer. Circuits must be tested to the channel card manufacturer's specifications. End-to-end bit error rate tests (BERTS) must be conducted using the type modem to be employed on the link at the bit rate to be employed. The BERTS must be with the modem at the equipment sites configured in a loop back and with the test setup at the node. The BERTS must be a minimum of 3 hours for each circuit, including required bridges.

**Acceptance Testing**

Acceptance testing must be conducted in accordance with the approved test plan. Acceptance testing must include acceptance tests and subsequent retests, and documentation of test results.

Final acceptance tests must be conducted after site and sub-system test results have been reviewed and accepted by the Engineer. These tests include the complete system in normal operations. The test plan must address full testing requirements of these special provisions. The test plan must detail tests to be performed, expected test results, and test schedules. The acceptance test plan must include the following test and acceptance categories:

1. Physical inspection.
2. Functional tests.
3. Performance tests.

Test communications systems, according to the approved acceptance test plan, must provide test equipment, labor and ancillary items required to perform testing. Test equipment must be certified to be calibrated to manufacturer's specifications. The model, part numbers, and date of last calibration of test equipment must be included with test results.
Acceptance testing must not commence until materials required by these special provisions and plans are delivered, installed, and aligned and the Engineer has approved production test and site test documentation and results.

Acceptance test results must be documented and documentation provided to the Engineer as a condition of acceptance.

**Physical Inspection**

You must provide documentation to prove delivery of material, equipment, cable and documentation. If material or documentation is outstanding or has been replaced under pre-acceptance warranty, physical inspection and documentation must be provided. Physical inspection must consist of inspecting installed material to ensure workmanship.

**Functional Tests**

Circuits (video, data, and voice), cameras, camera control and equipment must satisfy functional requirements.

Testing must include testing of camera images and verification of camera controls from camera control receivers. Connectivity of data channels must be demonstrated. Document functional test results. If an aspect of functional tests is determined by the Engineer to have failed, you must cease acceptance testing, determine the cause of the failure, and repair materials to the satisfaction of the Engineer. Acceptance testing must, at the discretion of the Engineer, be repeated beginning from the start of functional tests.

**Performance Tests**

Conduct operational performance tests on the following:

1. The video links from the LARTMC building and from the new Video node TI046 to new CCTV camera locations that are connected to the existing and new trunk line fiber optic cables.
2. Data links from the D4 channel banks (multiplexes) at the LARTMC building and the new data node TI046 to various field element locations, such as CCTV cameras, video node and cable nodes, weigh-in-motion stations, and ramp metering systems that are connected to the existing and new trunk line fiber optic cables, as shown on the plans and as directed by the Engineer.

Video tests must satisfy the end-to-end performance requirements under normal operating conditions. Video tests must be measured with camera video output transmitting a video signal at the input of video display monitors. You must test the video sub-system and record the results.

Video signal to noise must be measured according to EIA-250. Video signal to noise ratio must be measured and recorded with cameras providing video-input reference and with suitable video test equipment providing video reference signals. When the source is test equipment, the video signal to noise ratio must be greater than 47 dB.

Adjustments must be calculated to account for deviation in output level of cameras resulting from variable light conditions, the automatic iris and associated automatic gain controls. The resulting video signal to noise ratio must be recorded.

Video signal to low frequency noise ratios must be measured according to EIA-250. The resulting video signal to low frequency noise ratios must be greater than 39 dB. If an AGC
circuit does not allow measurement as per EIA-250, you must submit an alternative test plan for approval.

Video signal to periodic noise ratios must be measured according to EIA-250. The resulting video signal to periodic noise ratio must be greater than 52 dB.

Data tests must be performed on operational and data circuits using appropriate test equipment for the measurement of the following parameters:

Run end-to-end bit error rate tests from the data nodes and cable node to individual remote drop of individual data Circuit A data test set must be used at cable nodes and remote modems to insert an asynchronous pseudo-random pattern using 8 data bits, 1 start bit, 1 stop bit and even parity. The data test set at remote modems must hold RTS high for the duration of the data test. The data rate of the test sets must be set to rate as employed in the system.

A 15-minute test on individual drop of multipoint circuits must be error free in both directions. One drop of individual circuit as chosen by the Engineer must be tested for 72 hours.

The round-trip propagation delay for Model 2070-based controller circuits must be measured by using a loop back connector on the slave modem furthest from the master. Loop back connectors must connect pin 2 to 3, 8 to 4, and 6 to 20 of the DB-25 connector. A data test set capable of measuring delay must be used at the data node. Tests must be repeated 3 times and the average value calculated.

Pulse-width distortion is the difference between the data pulse width into a data channel port at the communications building port and the pulse width out of the EIA-232C port of an interconnected drop modem.

Distortion must be tested between cable nodes and the field modem for data circuits. Signals must not have a gross span-stop distortion greater than 20 percent at a data interface measured as per EIA-404-A.

If a circuit or element fails to satisfy the specified performance requirements, determine the cause and correct the failure to the satisfaction of the Engineer. Full performance tests must be repeated under operating conditions as determined by the Engineer.

SYSTEM DOCUMENTATION

Submit a draft copy of documentation for review and approval prior to production of documentation. The Engineer will review and approve or reject the draft documentation within 4 weeks of receipt.

Modify documentation if required and submit provisional documentation. The Engineer will approve or reject the provisional documentation within 3 weeks of receipt. Arrange for re-submission in a timely manner to meet the schedule if the documents are rejected.

Submit draft documentation 8 weeks prior to the start of installation. Draft documentation must show the general approach in preparing final manuals.

Upon approval of draft documentation, provisional documentation must be supplied 3 weeks prior to starting site testing. Provisional documentation must be the same format as final manuals but with temporary insertion for items which cannot be finalized until the system is completely tested and accepted.

Final documentation must be submitted no later than 4 weeks after completion of the acceptance tests and must incorporate comments made during approval stages. You are responsible for delay caused by non-compliance to requirements.

Final documentation must be approved prior to its production. Ten copies of final documents must be delivered. The copies must be 8.5 inch x 11 inch paper and bound in 3-ring hard-covered binders with dividers.
System documentation must be arranged in an operation and maintenance (O & M) manual format providing information necessary to operate, maintain and repair equipment and cables to the lowest module or component level.

Operations and maintenance manuals must as a minimum consist of the following sub-sections:

1. Master Items Index, This must be the first section of the O & M manual. The section must describe the purpose of individual manual and brief description to the directory of the manual. It must reference equipment manuals as required for additional and support material.
2. System Description and Technical Data, This section must contain an overall description of the system and associated equipment and cables with illustrative block diagrams. This section must identify equipment and cables in the system stating the exact module and option number that are employed in the system. Technical data specification and settings for every type of equipment or cable must be provided. Modifications to equipment must be clearly described.
3. Theory of Operation, The manual must contain a functional description of elements of the system, explaining how an individual function is achieved separately and how elements work together to form the complete system.
4. Operations, The manual must describe how to operate the system and a particular type of equipment. Equipment layout, layout of controls, displays, and other information required to correctly operate the system and each functional unit must be provided. Procedures must be provided for initial tune-up of the system and adjustment and checkout required to ensure that the system is functioning within the performance requirements. Warning of special procedures must be given. The functions and setting of parameters must be explained.
5. Corrective Maintenance procedures.
7. Parts List, The manual must include a list of replaceable parts with exact parts description.

Test Results, This section must include a copy of the results for the tests that have been conducted for the contract.

Manuals

Twelve complete sets of operation and maintenance manuals must be provided. The manuals must, as a minimum, include the following:

1. Accurate Block Diagrams.
2. Installation and turn-on procedures.
3. Performance specifications (functional, electrical, mechanical, and environmental) identified by a universal part number such as JEDEC, RETMA, or EIA.
4. Stage-by-stage explanation and trouble-shooting procedures.
5. Stage-by-stage explanation of operation.

Provide system schematic drawings to identify the type of equipment at individual location. Drawings must show how systems are interconnected. A list of cabling and wiring must be provided to identify the interconnection and labeling of equipment in the field.
FINAL ACCEPTANCE

Final acceptance of systems will not occur until the following conditions have been met:

1. Physical, functional and full performance acceptance tests have been completed and the Engineer approves the results.
2. Documentation has been completed and submitted to the Engineer.
3. Connections that were changed to perform acceptance tests are restored and tested.

PAYMENT

The contract lump sum price paid for system testing and documentation includes full compensation for furnishing all labor, materials, tools, equipment and incidentals for performing all the work involved in system testing and documentation, as specified in the standard specifications and these special provisions and as directed by the Engineer.