SECTION 270810 - VERIFICATION TESTING OF STRUCTURED CABLING

PART 1 - GENERAL

1.1 SUBMITTALS

A. Product Data:

1. Bill of Materials (BOM):

    a. Make, Model, Serial Number.
    b. Description of the test instrument.
    c. Tests for which the instrument will be used.

2. Product Datasheets: For each test instrument to be used.
3. Product Calibration Certificate for each test instrument: Certificate shall document the date of calibration and the name of the calibration organization.

B. Closeout Submittal:

1. UTP Cable Test Result Documentation:

    a. Make, model, serial number and date of last calibration of each piece of test equipment used.
    b. Summary Test Reports: Paper copy of the summary test results shall be provided that lists the links that have been tested with the summary information as set forth in Part 3.
    c. Detailed Test Reports: Detailed test results data to be provided in the electronic database for each tested link must contain the information as set forth in Part 3.
        1) The database for the completed job as stored and delivered on CD-ROM or DVD including the software tools required to view, inspect, and print any selection of test reports.

2. Fiber Optic Test Result Documentation:

    a. Make, model, serial number and date of last calibration of each piece of test equipment used.
    b. Summary Test Reports: Paper copy of the summary test results shall be provided that lists the links that have been tested with the test summary information as set forth in Part 3.
        1) Fiber tests from the same cable between the same 2 points shall not vary over .25db from each other.

    c. Detailed Test Reports: Detailed test results data to be provided in the electronic database for each tested fiber link must contain the information as set forth in Part 3.

1) The database for the completed job as stored and delivered on CD-ROM or DVD including the software tools required to view, inspect, and print any selection of test reports.

3. Coaxial Cabling Test Result Documentation:

a. Make, model, serial number and date of last calibration of each piece of test equipment used.
b. Summary Test Reports: Paper copy of the summary test results shall be provided that list links that have been tested with the summary information as set forth in Part 3.
c. Detailed Test Reports: Detailed test results data to be provided in the electronic database for each tested link must contain the information as set forth in Part 3.
1) The database for the completed job as stored and delivered on CD-ROM or DVD including the software tools required to view, inspect, and print any selection of test reports.

1.2 REFERENCES

A. Definitions:

1. IDC: Insulation displacement connector.
2. Margin: Designates the difference between the measured value and the corresponding test limit value. For passing links, 'worst case margin' identifies the smallest margin over the entire frequency range; the point at which the measured performance is "closest" to the test limit.
3. NVP: Nominal Velocity of Propagation expresses the speed of the electrical signals along the cabling link in relation to the speed of light in a vacuum. Insulation characteristics and twist rate of the wire pair influence NVP in minor ways. Typically, an 'average' value for NVP is published for four wire-pairs in a cable.
4. OLTS: Optical loss test set.
5. OTDR: Optical time domain reflectometer.

B. Reference Standards:

1. ANSI/TIA/EIA-568-C.0, Generic Telecommunications Cabling for Customer Premises.
2. ANSI/TIA/EIA-568-C.1, Commercial Building Telecommunications Cabling Standard.
3. ANSI/TIA/EIA-568-C.2, Balanced Twisted-Pair Telecommunication Cabling and Components Standard.
4. ANSI/TIA/EIA-568-C.3, Optical Fiber Cabling Components Standard.
5. ANSI Z136.2, ANS For Safe Use Of Optical Fiber Communication Systems Utilizing Laser Diode And LED Sources.

6. ANSI/EIA/TIA-455-50B, Light Launch Conditions For Long-Length Graded-Index Optical Fiber Spectral Attenuation Measurements.
7. ANSI/TIA/EIA-455-59A, Measurement of Fiber Point Discontinuities Using an OTDR.
8. ANSI/TIA/EIA-455-60A, Measurement of Fiber or Cable Length Using an OTDR.
9. ANSI/TIA/EIA-455-61A, Measurement of Fiber or Cable Attenuation Using an OTDR.
10. ANSI/TIA/EIA-526-7, Optical Power Loss Measurements of Installed Singlemode Fiber Cable Plant.
11. ANSI/TIA/EIA-526-14-A, Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant.
12. TIA/EIA TSB-140, Additional Guidelines for Field-Testing Length, Loss and Polarity of Optical Fiber Cabling Systems.
13. The most current published edition of the "TELECOMMUNICATIONS DISTRIBUTION METHODS MANUAL" published by the Building Industry Consulting Services International (BICSI).

1.3 COORDINATION

A. The Owner or the Owner's representative shall be invited to witness and review field testing and procedures. The representative shall be notified of the start date of the testing phase a minimum of five (5) business days before testing commences.

1.4 QUALITY ASSURANCE

A. Testing shall be supervised by an individual certified by BICSI as an RCDD.

B. Individuals performing tests shall have attended and have successfully completed an appropriate training program and have obtained a certificate as proof thereof. Appropriate training programs include but are not limited to installation certification programs furnished by BICSI or the ACP (Association of Cabling Professionals).

C. Test equipment shall perform in accordance with the manufacturer's published specifications and shall have been calibrated by either the manufacturer or a recognized independent test equipment calibration organization within the 365 day period prior to its use.

1.5 SYSTEM DESCRIPTION

A. Outlets, cables, patch panels and associated components shall be fully assembled and labeled prior to field-testing. Any testing performed on incomplete systems shall be redone on completion of the work.

B. Perform testing on each cabling link (connector to connector), including copper twisted pair, fiber optic (multi-mode and single-mode) and coaxial cabling.

1. Fiber optic Intra-Building Links shall be tested as Tier 1.

2. All fiber optic links including more than one segment shall be tested as Tier 2 whether involving fusion splicing or mechanical connection.

C. Testing shall not include any active devices or passive devices within the link other than cable, connectors, and splices.

1. Link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.

D. In addition to the tests identified in this document, contractor shall notify the Owner or Owner's representative of any additional tests that are deemed necessary to guarantee a fully functional system. These tests shall be implemented with additional measurement results recorded at no additional costs.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT REQUIREMENTS

A. Subject to compliance with requirements, available test equipment manufacturers that may be used for testing include, but are not limited to the following:

1. Fluke Corporation.
2. Ideal
3. Softing
4. Viavi

B. UTP Cable Test Equipment:

1. Category 5e, 6 and 6A (Augmented Category 6) Compliance: Coordinate with the Drawings and related Sections for project requirements.

a. The test equipment (tester) shall comply with the accuracy requirements for field testers as defined in ANSI/TIA-1152. The tester, including the appropriate interface adapter, must meet the specified accuracy requirements. The accuracy requirements for the permanent link test configuration (baseline accuracy plus adapter contribution) are specified in Table 2 of ANSI/TIA-1152.
   1) Level IIe – Category 5e (100MHz)
   2) Level III – Category 6 (250 MHz)
   3) Level IV – Category 6A (500MHz)

b. The test plug shall fall within the values specified in ANSI/TIA-568-C Annex C for NEXT, FEXT and Return Loss.
c. The tester shall be within the calibration period recommended by the vendor in order to achieve the vendor-specified measurement accuracy.
d. The tester interface adapters must be of high quality and the cable shall not show any twisting or kinking resulting from coiling and storing of the tester

interface adapters. In order to deliver optimum accuracy, preference is given to a permanent link interface adapter for the tester that can be calibrated to extend the reference plane of the Return Loss measurement to the permanent link interface. The contractor shall provide proof that the interface has been calibrated within the period recommended by the vendor. To ensure that normal handling on the job does not cause measurable Return Loss change, the adapter cord cable shall not be of twisted-pair construction.

e. The Pass or Fail condition for the link-under-test is determined by the results of the required individual tests (detailed in Section 4.2.2 of ANSI/TIA-1152). Any Fail or Fail* result yields a Fail for the link-under-test. In order to achieve an overall Pass condition, the results for each individual test parameter must Pass or Pass*.

f. A Pass or Fail result for each parameter is determined by comparing the measured values with the specified test limits for that parameter. The test result of a parameter shall be marked with an asterisk (*) when the result is closer to the test limit than the accuracy of the field tester. The field tester manufacturer must provide documentation as an aid to interpret results marked with asterisks.

2. Measurement Capabilities

a. Wire Map
b. Length
c. Propagation Delay
d. Delay Skew
e. DC Loop Resistance
f. DC Resistance Unbalance within a pair
g. DC Resistance Unbalance between pairs
h. Insertion Loss
i. NEXT (Near-End Crosstalk)
j. PS NEXT (Power Sum Near-End Crosstalk)
k. ACR-N (Attenuation to Crosstalk Ratio Near-End)
l. PS ACR-N (Power Sum Attenuation to Crosstalk Ratio Near-End)
m. ACR-F (Attenuation to Crosstalk Ratio Far-End)
n. PS ACR-F (Power Sum Attenuation to Crosstalk Ratio Far-End)
o. Return Loss
p. TCL (Transverse Conversion Loss)
q. ELTCTL (Equal Level Transverse Conversion Transfer Loss)
r. Time Domain Reflectometer
s. Time Domain Xtalk Analyzer
t. PS ANEXT (Power Sum Alien Near-End Crosstalk)
u. Average PS ANEXT (Average Power Sum Alien Near-End Crosstalk)
v. PS AACR-F (Power Sum Alien Attenuation to Crosstalk Ratio Far-End)
w. Average PS AACR-F (Average Power Sum Alien Attenuation to Crosstalk Ratio Far-End)

C. Fiber Optic Cable Test Equipment:

1. The test equipment shall be within the calibration period recommended by the manufacturer.
2. Fiber optic test jumpers and adapters shall be of high quality and shall not show excessive wear.
3. Optical Loss Test Set (OLTS):

    a. An OLTS is comprised of two components: an optical light source and an optical power meter. After making a reference measurement, the source and meter are located at opposite ends of the fiber under test. A source and meter may be contained within the same package to enable bi-directional testing without swapping end test equipment.
    b. Multimode optical fiber light source:
        1) Dual LED light sources with central wavelengths of 850nm (±30nm) and 1300nm (±20nm).
        2) Output power of -20dB minimum.
        3) The light source shall meet the launch requirements of ANSI/EIA/TIA-455-50B, Method A. This launch condition can be achieved either within the field test equipment or by use of an external mandrel wrap (as described in clause E.7 of ANSI/TIA-568-C.0) with a Category 1 light source.

    c. Singlemode optical fiber light source:
        1) Dual laser light sources with central wavelengths of 1310nm (±20nm) and 1550nm (±20nm).
        2) Output power of –10dB minimum.

    d. Power Meter:
        1) 850 nm, 1300/1310 nm, and 1550 nm wavelength test capability.
        2) Power measurement uncertainty of ± 0.25 dB.
        3) Store reference power measurement.
        4) Save at least 100 results in internal memory.
        5) PC interface (serial or USB).

4. Optical Time Domain Reflectometer (OTDR):

    a. Internal non-volatile memory and removable memory device with at least 16MB capacity for results storage.
    b. Serial and USB ports to transfer data to a PC.
    c. Multimode OTDR:
        1) Wavelengths of 850nm (± 20nm) and 1300nm (± 20nm).
        2) Event deadzones of 3.7 m maximum at 850 nm and 1300 nm.
        3) Attenuation deadzones of 10m maximum at 850nm and 13m maximum at 1300nm.
        4) Distance range at least 2,000m.
        5) Dynamic range at least 10dB at 850nm and 1300nm.

d. Singlemode OTDR:
   1) Wavelengths of 1310 nm (± 20 nm) and 1550 nm (± 20 nm).
   2) Event dead zones of 3.5 m maximum at 1310 nm and 1550 nm.
   3) Attenuation dead zones of 10 m maximum at 1310 nm and 12 m maximum at 1550 nm.
   4) Distance range not less than 10,000 m.
   5) Dynamic range at least 10 dB at 1310 nm and 1550 nm

5. Fiber Microscope:

   a. Magnification of 200X or 400X for endface inspection
   b. Optional requirements:
      1) Video camera systems are preferred.
      2) Camera probe tips that permit inspection through adapters are preferred.
      3) It is preferable to use test equipment capable of saving and reporting the end face image.

6. Integrated OLTS, OTDR and fiber microscope:

   a. Test equipment that combines into one instrument an OLTS, an OTDR and a fiber microscope may be used.

D. Coaxial Cable Test Equipment:

1. Capacitance Meter:

   a. Range: 1 nanofarad to 9,999 microfarads.
   b. Accuracy: ± 1.5% or better.

2. DCR Ohms Meter:

   a. Range: .01 ohms to 40 megaohms.
   b. Resolution: ≥ .1 ohm.
   c. Accuracy: ± .4% or better.

3. Cable Loss Meter:

   a. RF Signal Generation:
      1) Range: 1-2000 megahertz.
      2) Resolution: 1 megahertz or better.
      3) Output level capability: 1dBmV to ≥20dBmV.

   b. Spectrum Analysis:
      1) Range: 1-2000 megahertz.
      2) Resolution: 1 megahertz or better.

   c. Loss Measurement Resolution:

1) .1dBmV or better.

d. Data Storage & Recall:
   1) Capable of storing test results from ≥ 100 individual cables.
   2) Serial and USB ports to transfer data to a PC.

4. Copper Time-Domain Reflectometer (TDR):

   a. Adjustable Pulse Width Settings.
   b. Programmable nominal velocity of propagation (NVOP) to match cable under test.
   c. NVOP Range: .30 to .99, in .01 increments
   d. Measurement Accuracy: 1% or better.
   e. Measurement Range: ≥ 30,000-feet @ 64% NVOP.

PART 3 - EXECUTION

3.1 UTP CABLE TESTING

A. General:

1. Field test UTP cabling upon completion of the installation.
2. Every cabling link in the installation shall be tested in accordance with the field test specifications defined in ANSI/TIA-568-C.2 “Commercial Balanced Twisted-Pair Telecommunications Cabling and Components Standard.”
3. The installed twisted-pair horizontal links shall be tested from the MDF/IDF (ER/TR) in the telecommunications room to the telecommunication wall outlet in the work area against the “Permanent Link” performance specification.
4. One hundred percent of the installed cabling links must be tested and must pass the requirements of the standards mentioned above and as further detailed in Part 3. Any failing link must be diagnosed and corrected. The corrective action shall be followed with a new test to prove that the corrected link meets the performance requirements. The final and passing result of the tests for links shall be provided in the test results documentation (below).
5. Field-test instruments shall have the latest software and firmware installed.
6. Link test results from the Test Equipment shall be recorded in the test instrument upon completion of each test for subsequent uploading to a PC in which the administrative documentation (reports) may be generated.
7. Testing shall be performed on each cabling segment (panel to panel, panel to connector or connector to connector).
8. Testing of the cabling shall be performed using high-quality test cords of the same Category and manufacturer as the cabling under test.

B. Performance Test Parameters – Category 5e, Category 6 and Category 6A (Augmented Category 6):

1. The field test specifications are defined in ANSI/TIA-568-C.2 “Commercial Balanced Twisted-Pair Telecommunications Cabling and Components Standard.”
2. The test of each link shall contain the following parameters as detailed below.

    a. Category 5e: In order to pass the test, measurements at each frequency in the range from 1 MHz through 100 MHz must meet or exceed the limit value determined in the above-mentioned standard.
    b. Category 6: In order to pass the test, measurements at each frequency in the range from 1 MHz through 250 MHz must meet or exceed the limit value determined in the above-mentioned standard.
    c. Category 6A (Augmented Category 6): In order to pass the test, measurements at each frequency in the range from 1 MHz through 500 MHz must meet or exceed the limit value determined in the above-mentioned standard.

3. Wire Map:

    a. The wire map test is intended to verify pin-to-pin termination at each end and check for installation connectivity errors. For each of the 8 conductors in the cabling, the wire map indicates:
        1) Continuity to the remote end
        2) Shorts between any two or more conductors
        3) Reversed pairs
        4) Split pairs
        5) Transposed pairs
        6) Distance to open on shield
        7) Any other miss-wiring

    b. The correct connectivity of telecommunications outlets/connectors is defined in ANSI/TIA-568-C.2. Two color schemes are permitted. The user shall define which scheme is to be used. The field tester shall document which color scheme was used.

4. Length:

    a. The length of each balanced twisted pair shall be recorded.
    b. Since physical length is determined from electrical length, the physical length of the link calculated using the pair with the shortest electrical delay shall be reported and used for making the pass or fail determination.
    c. The pass or fail criteria is based on the maximum length allowed for the Permanent Link as specified in ANSI/TIA-568-C.2 plus the nominal velocity of propagation (NVP) uncertainty of 10%. For a Permanent Link, the length measurement can be 325 ft. (99 m) before a fail is reported.

5. Propagation Delay:

    a. Is the time it takes for a signal to reach the end of the link.

b. The measurement shall be made at 10 MHz per ANSI/TIA-1152.
c. The propagation delay of each balanced twisted pair shall be recorded.
d. Is not to exceed 498 ns per ANSI/TIA-568-C.
e. This measurement is to be performed for each of the four wire pairs.
f. Minimum test results documentation (summary results): Identify the wire pair with the worst-case propagation delay. The report shall include the propagation delay value measured as well as the test limit value.

6. Delay Skew

a. Is the difference in propagation delay @ 10 MHz between the shortest delay and the delays of the other wire pairs.
b. The delay skew of each balanced twisted pair shall be recorded.
c. Is not to exceed 44 ns per ANSI/TIA-568-C.2.
d. This parameter shows the difference in propagation delay between the four wire pairs. The pair with the shortest propagation delay is the reference pair with a delay skew value of zero.
e. Minimum test results documentation (summary results): Identify the wire pair with the worst-case propagation delay (the longest propagation delay). The report shall include the delay skew value measured as well as the test limit value.

7. DC Resistance

a. Often reported as Resistance, is the loop resistance of both conductors in the pair.
b. Cat 5e and Cat 6
    1) Is not specified in ANSI/TIA-1152, but shall be recorded for all four pairs.

c. Cat 6A
    1) The DC Resistance shall be reported for all four pairs.
    2) Is not to exceed 21 Ω for all four pairs per ANSI/TIA-568-C.2.

8. DC Resistance Unbalance within a pair

a. Often reported as Resistance Unbalance, is the difference in resistance of the two wires within the pair.
b. Cat 5e and Cat 6
    1) Is not specified in ANSI/TIA-1152 for a Permanent Link, but shall be recorded for all four pairs.

c. Cat 6A
    1) The DC Resistance Unbalance within a pair shall be reported for all four pairs.
    2) Is not to exceed 200 mΩ or 3%, whichever is the greatest per ANSI/TIA-568-C.2.

9. DC Resistance Unbalance between pairs (Cat 6A)

    a. Is the difference in DC parallel resistance of the conductors of a pair compared to the DC parallel resistance of another pair, given in the formula below:

$$Resistance\_Unbalance_{Between\_pairs} = \left(\frac{|R_{P1} - R_{P2}|}{R_{P1} + R_{P2}} \right) 100\%$$

Where:

R_{P1} is the DC parallel resistance of the conductors of a pair.

1) R_{P2} is the DC parallel resistance of the conductors of another pair.

    b. The DC Resistance Unbalance shall be reported for the following pairs
        1) 1,2-3,6
        2) 1,2-4,5
        3) 1,2-7,8
        4) 3,6-4,5
        5) 3,6-7,8
        6) 4,5-7,8

    c. Is not to exceed 200 mΩ or 7.5%, whichever is the greatest.

10. Insertion Loss (Attenuation):

    a. Insertion Loss is a measure of signal loss in the permanent link or channel. The term “Attenuation” has been used to designate “Insertion Loss.” Insertion Loss shall be tested from 1 MHz through the frequency range identified above for the category-rating requirements, in maximum step size of 1 MHz. Measure insertion loss at the same frequency intervals as NEXT Loss in order to provide a more accurate calculation of the Attenuation-to-Crosstalk ratio (ACR) parameter.
    b. Minimum test results documentation (summary results): Identify the worst wire pair (1 of 4 possible). The test results for the worst wire pair must show the highest attenuation value measured (worst case), the frequency at which this worst case value occurs, and the test limit value at this frequency.

11. NEXT Loss:

    a. Pair-to-pair near-end crosstalk loss (abbreviated as NEXT Loss) shall be tested for each wire pair combination from each end of the link (a total of 12 pair combinations). This parameter is to be measured from 1 through the frequency range identified above for the category-rating requirements. NEXT Loss measures the crosstalk disturbance on a wire pair at the end from which the disturbance signal is transmitted (near-end) on the disturbing pair. The maximum step size for NEXT Loss measurements shall not exceed the maximum step size defined in the Standard as shown in Table 1.

b. Minimum test results documentation (summary results): Identify the wire pair combination that exhibits the worst case NEXT margin and the wire pair combination that exhibits the worst value of NEXT (worst case). NEXT is to be measured from each end of the link-under-test. These wire pair combinations must be identified for the tests performed from each end. Each reported case should include the frequency at which it occurs as well as the test limit value at this frequency.

c. Table 1 – Maximum frequency step size as defined in ANSI/TIA-1152

d.

Frequency Range (MHz)	Maximum Step size (MHz)
1 – 31.25	0.15
31.26 – 100	0.25
100 – 250	0.50
250 – 500	1.00

12. PS NEXT Loss:

a. Power Sum NEXT Loss shall be evaluated and reported for each wire pair from both ends of the link under-test (a total of eight results). PS NEXT Loss captures the combined near-end crosstalk effect (statistical) on a wire pair when other pairs actively transmit signals. Like NEXT this test parameter must be evaluated from 1 through the frequency range identified above for the category-rating requirements, and the step size may not exceed the maximum step size defined in the Standard as shown in Table 1.

b. Minimum test results documentation (summary results): Identify the wire pair that exhibits the worst-case margin and the wire pair that exhibits the worst value for PS NEXT. These wire pairs must be identified for the tests performed from each end. Each reported case should include the frequency at which it occurs as well as the test limit value at this frequency.

13. ACR-N Loss, pair-to-pair:

a. Attenuation Crosstalk Ratio Near-end is calculated from the pair-to-pair NEXT Loss. It shall be measured for each wire-pair combination from both ends of the link under-test. NEXT Loss measures the crosstalk disturbance on a wire pair at the close end (near-end) from which the transmitter emits the disturbing signal on the disturbing pair. NEXT is measured to compute ACR-N Loss that must be evaluated and reported in the test results. ACR-N measures the relative strength of the near-end crosstalk disturbance relative to the attenuated signal that arrives at the end of the link. This test yields 24 wire pair combinations. ACR-N is to be measured from 1 through the frequency range identified above for the category-rating requirements, and the maximum step size for NEXT Loss measurements shall not exceed the maximum step size defined in the Standard as shown in Table 1.

b. Minimum test results documentation (summary results): Identify the wire pair combination that exhibits the worst-case margin and the wire pair combination that exhibits the worst value for ACR-N. These wire pairs must be identified for the tests performed from each end. Each reported case should include the frequency at which it occurs as well as the test limit value at this frequency.

14. PS ACR-N Loss:

a. Power Sum Attenuation Crosstalk Ratio Near-end is a calculated parameter that combines the effect of the NEXT disturbance from three wire pairs on the fourth one. This test yields eight wire-pair combinations. Each wire-pair is evaluated from 1 through the frequency range identified above for the category-rating requirements, in frequency increments that do not exceed the maximum step size defined in the Standard as shown in Table 1.
b. Minimum test results documentation (summary results): Identify the wire pair that exhibits the worst pair combinations must be identified for the tests performed from each end. Each reported case should include the frequency at which it occurs as well as the test limit value at this frequency.

15. ACR-F Loss, pair-to-pair:

a. Attenuation Crosstalk Ratio Far-end is calculated from the pair-to-pair FEXT Loss. It shall be measured for each wire-pair combination from both ends of the link under-test. FEXT Loss measures the crosstalk disturbance on a wire pair at the opposite end (far-end) from which the transmitter emits the disturbing signal on the disturbing pair. FEXT is measured to compute ACR-F Loss that must be evaluated and reported in the test results. ACR-F measures the relative strength of the far-end crosstalk disturbance relative to the attenuated signal that arrives at the end of the link. This test yields 24 wire pair combinations. ACR-F is to be measured from 1 through the frequency range identified above for the category-rating requirements, and the maximum step size for FEXT Loss measurements shall not exceed the maximum step size defined in the Standard as shown in Table 1.
b. Minimum test results documentation (summary results): Identify the wire pair combination that exhibits the worst-case margin and the wire pair combination that exhibits the worst value for ACR-F. These wire pairs must be identified for the tests performed from each end. Each reported case should include the frequency at which it occurs as well as the test limit value at this frequency.

16. PS ACR-F Loss:

a. Power Sum Attenuation Crosstalk Ratio Far-end is a calculated parameter that combines the effect of the FEXT disturbance from three wire pairs on the fourth one. This test yields eight wire-pair combinations. Each wire-pair is evaluated from 1 through the frequency range identified above for the

category-rating requirements, in frequency increments that do not exceed the maximum step size defined in the Standard as shown in Table 1.

b. Minimum test results documentation (summary results): Identify the wire pair that exhibits the worst pair combinations must be identified for the tests performed from each end. Each reported case should include the frequency at which it occurs as well as the test limit value at this frequency.

17. Return Loss:

    a. Return Loss (RL) measures the total energy reflected on each wire pair. Return Loss is to be measured from both ends of the link-under-test for each wire pair. This parameter is also to be measured from 1 through the frequency range identified above for the category-rating requirements, in frequency increments that do not exceed the maximum step size defined in the Standard as shown in Table 1.
    b. Minimum test results documentation (summary results): Identify the wire pair that exhibits the worst-case margin and the wire pair that exhibits the worst value for Return Loss. These wire pairs must be identified for the tests performed from each end. Each reported case should include the frequency at which it occurs as well as the test limit value at this frequency.

18. TCL (Transverse Conversion Loss)

    a. Is the ratio (in dB) between a differential mode signal inject at the near-end and the common-mode signal measured at the near-end on the same wire pair.
    b. This parameter is also to be measured from 1 through the frequency range identified above for the category-rating requirements, in frequency increments that do not exceed the maximum step size defined in the Standard as shown in Table 1.
    c. Both worst case and worst margins shall be reported in both directions for all four pairs.
    d. Cat 5e and Cat 6
        1) Is not specified in ANSI/TIA-1152, but shall be recorded for all four pairs.

    e. Cat 6A
        1) Is not to exceed the Category 6A limits found ANSI/TIA-568-C.2.

19. ELTCTL (Equal Level Transverse Conversion Transfer Loss)

    a. Is the ratio (in dB) between a differential mode signal inject at the near-end and the common-mode signal measured at the far end on the same wire pair minus the Insertion Loss of that pair.
    b. This parameter is also to be measured from 1 through the frequency range identified above for the category-rating requirements, in frequency

increments that do not exceed the maximum step size defined in the Standard as shown in Table 1.

c. Both worst case and worst margins shall be reported in both directions for all four pairs.

d. Cat 5e and Cat 6

1) Is not specified in ANSI/TIA-1152, but shall be recorded for all four pairs.

e. Cat 6A

1) Is not to exceed the Category 6A limits found ANSI/TIA-568-C.2.

C. UTP Cable Test Result Documentation:

1. The test results/measurements shall be transferred into a database utility that allows for the maintenance, inspection and archiving of these test records. A guarantee must be made that the measurement results are transferred unaltered, i.e., "as saved in the tester" at the end of each test and that these results cannot be modified at a later time.
2. The database for the completed job shall be stored and delivered on CD-ROM or DVD including the software tools required to view, inspect, and print any selection of test reports.
3. A paper copy of the summary test results shall be provided that lists the links that have been tested with the following summary information:

a. The identification of the link in accordance with the naming convention defined in the overall system documentation.
b. The overall Pass/Fail evaluation of the link-under-test including the NEXT Headroom (overall worst case) number.
c. The date and time the test results were saved in the memory of the tester.

4. General Information to be provided in the electronic data base with the test results information for each link:

a. The identification of the customer site as specified by the end-user.
b. The identification of the link in accordance with the naming convention defined in the overall system documentation.
c. The overall Pass/Fail evaluation of the link-under-test.
d. The name of the standard selected to execute the stored test results.
e. The cable type and the value of NVP used for length calculations.
f. The date and time the test results were saved in the memory of the tester.
g. The brand name, model and serial number of the tester.
h. The identification of the tester interface.
i. The revision of the tester software and the revision of the test standards database in the tester.
j. The test results information must contain information on each of the required test parameters that are listed and detailed above.

5. In-Link (In-Channel) Test Results Data. The detailed test results data to be provided in the electronic database must contain the following information:

    a. For each of the frequency-dependent test parameters, the value measured at every frequency during the test is stored. The database program must be able to process the stored results to display and print a color graph of the measured parameters. Software must also provide a summary numeric format in which some critical information is provided numerically as defined by the summary results (minimum numeric test results documentation) as outlined above for each of the test parameters.
        1) Length: Identify the wire-pair with the shortest electrical length, the value of the length rounded to the nearest 0.1 m and the test limit value.
        2) Propagation delay: Identify the pair with the shortest propagation delay, the value measured in nanoseconds (ns) and the test limit value.
        3) Delay Skew: Identify the pair with the largest value for delay skew, the value calculated in nanoseconds (ns) and the test limit value.
        4) Insertion Loss (Attenuation): Minimum test results documentation as identified above for the worst pair.
        5) Return Loss: Minimum test results documentation as identified above for the worst pair as measured from each end of the link.
        6) NEXT, ACR-F: Minimum test results documentation as identified above for the worst pair combination as measured from each end of the link.
        7) PS NEXT and PS ACR-F: Minimum test results documentation as identified above for the worst pair as measured from each end of the link.

3.2 OPTICAL FIBER CABLE TESTING

A. General

1. Testing Tiers requirements are as described below, unless indicated otherwise or otherwise required by the Owner.
2. Every fiber optic cabling link in the installation shall be tested in accordance with the field test specifications defined in ANSI/TIA/EIA-568-C.0, Generic Telecommunications Cabling for Customer Premises.
3. One hundred percent of the installed cabling links must be tested and must pass the requirements as specified within this document. Any failing link must be diagnosed and corrected. The corrective action shall be followed with a new test to prove that the corrected link meets the performance requirements. The final and passing result of the tests for links shall be provided in the test results documentation (below).
4. The Pass or Fail condition for the link-under-test is determined by the results of the required individual tests.
5. A Pass or Fail result for each parameter is determined by comparing the measured values with the specified test limits for that parameter.

a. Loss shall not exceed calculated link loss.

6. Tests shall be documented, including OLTS dual wavelength attenuation measurements for multimode and singlemode links and channels and OTDR traces and event tables for multimode and singlemode links and channels.
7. Tests performed on optical fiber cabling that use a laser or LED in a test set shall be carried out with safety precautions in accordance with ANSI Z136.2.
8. Field-test instruments shall have the latest software and firmware installed.
9. Link and channel test results from the OLTS and OTDR shall be recorded in the test instrument upon completion of each test for subsequent uploading to a PC in which the administrative documentation (reports) may be generated.
10. Fiber end faces shall be inspected at 200X or 400X magnification. 200X magnification is suitable for inspecting multimode and singlemode fibers. 400X magnification may be used for detailed examination of singlemode fibers. Scratched, pitted or dirty connectors shall be diagnosed and corrected.

    a. End face images shall be recorded in the memory of the test instrument for subsequent uploading to a PC and reporting.

11. Testing shall be performed on each cabling segment (connector to connector).
12. Testing shall be performed on each cabling channel (equipment to equipment) that is planned for use per the owner's instructions.
13. Testing of the cabling shall be performed using high-quality test cords of the same fiber type as the cabling under test. The test cords for OLTS testing shall be between 1 m and 5 m in length. The test cords for OTDR testing shall be approximately 100 m for the launch cable and at least 25 m for the receive cable.

B. Performance Test Parameters:

1. Three tiers of certification are available that vary in thoroughness of infrastructure analysis.

    a. Tier 1: optical loss testing
    b. Tier 2: optical loss and OTDR testing
    c. Tier 3: optical loss and OTDR testing and magnified endface inspection

2. Optical loss testing (Tiers 1, 2 and 3):

    a. Backbone link:
        1) Multimode backbone links shall be tested at 850 nm and 1300 nm in accordance with ANSI/EIA/TIA-526-14A, Method B, One Reference Jumper or the equivalent method.
        2) Singlemode backbone links shall be tested at 1310 nm and 1550 nm in accordance with ANSI/TIA/EIA-526-7, Method A.1, One Reference Jumper or the equivalent method.
        3) Link attenuation does not include any active devices or passive devices other than cable, connectors, and splices, i.e. link attenuation

does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.

4) Use the One Reference Jumper Method specified by ANSI/TIA/EIA-526-14A, Method B and ANSI/TIA/EIA-526-7, Method A.1 or the equivalent method. Follow the procedures established by these standards or application notes to accurately conduct performance testing.
5) Fiber tests from the same cable between the same 2 points shall not vary over .25db from each other.

3. OTDR Testing (Tiers 2 and 3):

a. Fiber links shall be tested at the appropriate operating wavelengths for anomalies and to ensure uniformity of cable attenuation and connector insertion loss..
   1) Multimode: 850nm and 1300nm
   2) Singlemode: 1310nm and 1550nm

b. Each fiber link and channel shall be tested in both directions.
c. A launch cable shall be installed between the OTDR and the first link connection.
d. A receive cable shall be installed after the last link connection.

4. Magnified Endface Inspection (Tier 3):

a. Fibers shall be inspected at 200X or 400X magnification. 200X magnification is suitable for inspecting multimode and singlemode fibers. 400X magnification may be used for detailed examination of singlemode fibers.
b. Scratched, pitted or dirty connectors shall be diagnosed and corrected.
c. The end face images shall be saved and included in the test documentation package.

5. Length Measurement:

a. The length of each fiber shall be recorded.
b. It is preferable that the optical length be measured using an OLTS or OTDR.

6. Polarity Testing:

a. Paired duplex fibers in multi-fiber cables shall be tested to verify polarity in accordance with Clause E.5.3 of ANSI/TIA-568-C.0. The polarity of the paired duplex fibers shall be verified using an OLTS.

C. Fiber Optic Cable Test Result Documentation:

1. The OLTS and OTDR test result information for each link shall be recorded in the memory of the field tester upon completion of the test.
2. The test result records saved by the tester shall be transferred into a database utility that allows for the maintenance, inspection and archiving of these test records. A guarantee shall be made that these results are transferred to the PC unaltered (i.e., as saved in the tester at the end of each test). The popular 'csv' format (comma separated value format) does not provide adequate protection and shall not be acceptable unless specified by the end user.
3. The database for the completed job shall be stored and delivered on CD-ROM. This CD-ROM shall include the software tools required to view, inspect, and print any selection of test reports.
4. Circuit IDs reported by the test instrument shall match the specified label ID.
5. Summary Test Reports: A copy of the test results shall be provided listing links that have been tested, including the following summary information.

    a. The identification of the link in accordance with the naming convention defined in the overall system documentation.
    b. The overall Pass/Fail evaluation of the link-under-test
    c. The date and time the test results were saved in the memory of the tester.

6. General Information to be provided in the electronic data base containing the test result information for each link:

    a. The identification of the customer site as identified by the end-user.
    b. The operator responsible for testing.
    c. The overall Pass/Fail evaluation of the link-under-test.
    d. The name of the standard selected to execute the stored test results.
    e. The value of the NVP of the cable installed (used for length calculations).
    f. The date and time the test results were saved in the memory of the tester.
    g. The brand name, model and serial number of the tester.
    h. The tester software version and the revision of the test standards database in the tester.

7. Detailed Test Reports: Detailed test results data to be provided in the electronic database for each tested optical fiber must contain the following information.

    a. The identification of the link/fiber in accordance with the naming convention defined in the overall system documentation.
    b. Tier 1:
        1) The insertion loss (attenuation) measured at each wavelength, the test limit calculated for the corresponding wavelength and the margin (difference between the measured attenuation and the test limit value).
        2) The link length shall be reported for each optical fiber for which the test limit was calculated based on the formulas above.

    c. Tier 2:
        1) Tier 1 test results.

2) The overall OTDR loss (attenuation) and length.
3) The OTDR event loss at each wavelength and event location.
4) The OTDR trace at each wavelength.

d. Tier 3:
1) Tier 1 and 2 test results.
2) A picture of the magnified connector endface.
3) The pass status based upon visual inspection.

3.3 COAXIAL CABLE TESTING

A. Test every cable individually. The following tests shall be conducted and the results recorded and submitted:

1. Visual Inspections:

a. Conduct a visual inspection of the center conductor at each end of each cable. Verify that the center conductor does not have any visible nicks.

2. Mechanical retention of connectors:

a. Verify F-Connectors each can withstand at least 35 pounds of direct pulling force for 2-seconds.
b. Verify hardline connectors shall be verified to withstand at least 100 pounds of direct pulling force for 2-seconds.
c. Verify that other connector types used withstand 90% of their manufacturer rated retention strength for 2-seconds.

3. Cable measurements:

a. Length of cable. Determine length through the use of physical cable markings and through the use of a TDR calibrated for the cable under test.
b. DC Loop Resistance: Short the center conductor and shield at the station outlet end of the cable using a premade thread on 0-ohm shunt. Measure and record the loop resistance of the cable at the opposite end of the cable.
c. DC Resistance to Ground. Measure and record the DCR between each cable conductor (center and shield) and the nearest telecommunications grounding bus bar. This measurement shall occur after the telecommunications grounding system has been tested.
d. Attenuation by Frequency: Sweep the cable from 1 MHz to 1 GHz and record the attenuation results. Quantify the results in table-form in at least the following frequencies: 1, 5, 10, 50 megahertz, and 100 to 2000 megahertz in 50 megahertz increments.
e. Cable capacitance. With no load connected at one end of the cable connect a capacitance meter to the opposite end. Measure and record the total center- conductor- to-shield capacitance.

B. Conduct, coordinate and supply cable test data to parties supplying or installing products that will connect to and use the coaxial cabling. Timing is critical as these parties may need to perform calculations based on test values prior to procurement and installation of certain products.

3.4 ACCEPTANCE OF TEST RESULTS

A. A representative of the end-user may at their discretion select a random sample of five percent of the installed links. The representative (or his authorized delegate) shall test these randomly selected links, and the results shall be stored in accordance with this Section. The results obtained shall be compared to the data provided by the installation contractor. If more than two percent of the sample results differ in terms of the pass/fail determination, the installation contractor under supervision of the end-user representative shall repeat 100-percent testing at no cost to the Owner.

B. Installed cabling links and channels shall be field-tested and pass the test requirements and analysis as described in this Section. Any link or channel that fails these requirements shall be diagnosed and corrected. Any corrective action shall be documented and followed with a new test to prove that the corrected link or channel meets performance requirements. The final and passing result of the tests for links and channels shall be provided in the test results documentation in accordance with this Section.

C. Acceptance of the test results shall be given in writing after the project is fully completed and tested in accordance with Contract Documents and to the satisfaction of the Owner.

END OF SECTION 270810