SECTION 27 17 00

testing of structured cabling systems

Notes to the Specification Writer:

This Section has been written to cover most, but not all, project conditions that you will encounter. Depending on the project, you may need to add material, delete items, or modify what is currently written. Editing instructions are included throughout the document. (If this document is viewed or printed in color, these instructions appear in red specific bold italic text.)

Review this entire specification Section and edit it to meet the requirements of the specific project. Options or items where the specification writer’s input is needed are enclosed in [brackets].

Before publishing your final version of this specifications Section, remove all red bold italic instructions.

1. GENERAL

## SUMMARY

### This Section (27 17 00) includes the minimum requirements for the test certification, identification, and administration of horizontal balanced twisted pair cabling and optical fiber cabling.

### The Contractor provide all labor, materials, tools, field-test instruments and equipment required for the complete testing, identification and administration of the work called for in the Contract Documents.

### In order to conform to the overall project event schedule, the cabling Contractor shall survey the work areas and coordinate cabling testing with other applicable trades.

### In addition to the tests detailed in this document, the Contractor shall notify the Owner or the Owner’s representative of any additional tests deemed necessary to guarantee a fully functional system. The Contractor shall carry out and record any additional measurement results at no additional charge.

## SCOPE

### This Section includes the minimum requirements for:

#### Identification, including labels and labeling

#### Administration, including:

##### Test results documentation

##### As-built drawings

#### The testing of copper cabling, including:

##### Test instruments

##### Test procedures

#### The testing of fiber optic cabling, including:

##### Test instruments

##### Test procedures

### Testing shall be carried out in accordance with this document. The Contractor shall:

#### Test all installed balanced twisted pair cabling permanent links to the applicable performance level.

#### Test the attenuation and polarity of the installed optical fiber cable plant with an Optical Loss Test Set (OLTS)

#### Test the installed condition of the optical fiber cabling system and its components with an Optical Time Domain Reflectometer (OTDR)

#### Verify the condition of the fiber end faces

### The Contractor shall document all tests including:

#### OLTS dual wavelength attenuation measurements

#### OTDR traces with event tables and OTDR maps – Edit or remove this item as appropriate for the project.

#### Optical length measurements and pictures of the connector end faces

## rElated sections

#### Section 00 00 00 – Procurement and Contracting Requirements

#### Section 01 00 00 – General Requirements

#### Section 26 05 26 – Grounding and Bonding for Electrical System

#### Section 27 05 26 – Grounding and Bonding for Communication Systems

#### Section 27 05 39 – Surface Raceway for Communications Systems

#### Section 27 05 53 – Identification for Communication Systems

#### Section 27 06 28 – Pathways for Communication Systems

#### Section 27 06 36 – Cable Trays for Communication Systems

#### Section 27 11 19 – Communications Termination Blocks and Patch Panels

#### Section 27 13 23 – Communications Fiber Backbone Cabling

#### Section 27 15 13 – Communications Copper Horizontal Cabling

#### Section 27 15 43 – Communications Faceplates and Connectors

#### Section 27 16 13 – Communications Copper Custom Cable Assemblies

#### Section 27 16 13.01 – Communications Fiber Custom Cable Assemblies

#### Section 27 16 19 – Communications Patch Cords

## REFERENCES

### Requirements, Codes, and Standards

#### All testing procedures and field test instruments shall comply with the applicable requirements of the following standards including the most current revisions, addendums, and any Technical Service Bulletins (TSBs) released at the time of bid:

#### ANSI Z136.2, ANS For Safe Use of Optical Fiber Communication Systems Utilizing Laser Diode and LED Sources

#### ANSI/EIA/TIA 455 50B, Light Launch Conditions For Long-Length Graded-Index Optical Fiber Spectral Attenuation Measurements

#### ANSI/TIA/EIA-455-59A, Measurement of Fiber Point Discontinuities Using an OTDR

#### ANSI/TIA/EIA 455 60A, Measurement of Fiber or Cable Length Using an OTDR

#### ANSI/TIA/EIA 455 61A, Measurement of Fiber or Cable Attenuation Using an OTDR

#### ANSI/TIA/EIA 526 7, Optical Power Loss Measurements of Installed Single-mode Fiber Cable Plant

#### ANSI/TIA 526 14 B, Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant; IEC 61280-4-1 edition 2, Fibre-Optic Communications Subsystem Test Procedure- Part 4-1: Installed cable plant- Multimode attenuation measurement

#### TIA-TSB-4979 Practical Considerations for Implementation of Multimode Launch Conditions in the Field

#### ANSI/TIA-1152, Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling

#### ANSI/TIA-568-0. D, Generic Telecommunications Cabling for Customer Premises.

#### ANSI/TIA-568-1. D, Commercial Building Telecommunications Cabling Standard

#### ANSI/TIA 568.2-D, Balanced Twisted-Pair Telecommunications Cabling and Components Standards.

#### ANSI/TIA 568 C.3, Optical Fiber Cabling Components Standard

#### ANSI/TIA-606-C, Administration Standard for Commercial Telecommunications Infrastructure, including the requirements specified by the customer, unless the customer specifies their own labeling requirements.

### Applicability of Codes, Rules, and Regulations

#### Federal, state, and local codes, rules, regulations, and ordinances governing the work, are as fully part of the specifications as if herein repeated or hereto attached.

#### If the Contractor notes items in the drawings or the specifications, construction of which would be code violations, the Contractor should promptly call them to the attention of the Owner's representative in writing.

#### Where the requirements of other sections of the specifications are more stringent than applicable codes, rules, regulations, and ordinances, the specifications shall apply.

#### Balanced Twisted Pair Testing

##### Trained technicians, who have successfully attended an appropriate training program and have obtained a certificate as proof thereof, shall execute the tests. Acceptable certificates are ones that have been issued by any of the following organizations or an equivalent organization:

#### The manufacturer of the connectors and/or the cable

#### The manufacturer of the test equipment used for the field certification

#### Training organizations such as Building Industry Consulting Service International (BICSI), the Association of Cabling Professionals™ (ACP), the Cabling Business Institute (CBI)

### Optical Fiber Testing

#### Trained technicians who have successfully attended an appropriate training program, which includes testing with an OLTS and an OTDR and have obtained a certificate as proof thereof shall execute the tests. These certificates may have been issued by any of the following organizations or an equivalent organization:

#### The manufacturer of the connectors and/or the cable

#### The manufacturer of the test equipment used for the field certification

#### Training organizations such as Building Industry Consulting Service International (BICSI), the Association of Cabling Professionals™ (ACP), the Cabling Business Institute (CBI)

### Owner’s Participation

#### The Owner or the Owner’s representative shall be invited to witness and/or review field testing.

#### Five business days before testing commences, the Owner or the Owner’s representative shall be notified of the start date of the testing phase.

#### The Owner or the Owner’s representative shall:

##### Select a random sample of five percent of the installed links

##### Test these randomly-selected links

##### Store the results in accordance with Part 3 of this document

#### The Contractor shall compare the results obtained by the Owner to the data provided by the installation Contractor. If more than two percent of the pass/fail determinations in the sample results differ from the data provided by the installation Contractor, the Contractor, under the supervision of the Owner’s representative, shall repeat one hundred percent of the testing at no cost to the Owner.

## SUBMITTALS

### The Contractor shall submit the following:

#### The manufacturer’s catalog sheets and specifications for the test equipment

#### A schedule (list) of all links and channels to be tested

#### Sample test reports

#### The test equipment serial number

#### A graphic diagram documenting the test procedure, including all connectors, the light source (as applicable,) the origin, and the destination of each cable tested.

## TEST RESULTS

### Balanced Twisted Pair Links

#### Category 5E and Category 6 Balanced Twisted Pair

#### Unless otherwise specified by the Owner or the Owners representative, each Category 5E and Category 6 balanced twisted pair cabling link shall be tested for:

##### Wire Map

##### Length

##### Propagation Delay

##### Delay Skew

##### DC Loop Resistance

##### DC Resistance Unbalance within a pair

##### DC Resistance Unbalance between pairs

##### Insertion Loss

##### Near-End Crosstalk (NEXT)

##### Power Sum Near-End Crosstalk (PS NEXT)

##### Attenuation to Crosstalk Ratio Near-End (ACR-N)

##### Power Sum Attenuation to Crosstalk Ratio Near-End (PS ACR-N)

##### Attenuation to Crosstalk Ratio Far-End (ACR-F)

##### Power Sum Attenuation to Crosstalk Ratio Far-End (PS ACR-F)

##### Return Loss

##### Transverse Conversion Loss (TCL)

##### Equal Level Transverse Conversion Transfer Loss (ELTCTL)

#### Category 6A Balanced Twisted Pair

#### Unless otherwise specified by the Owner or the Owners representative, each Category 6A link shall be tested for all of the parameters listed above for Category 5E and Category 6 as well as the following additional parameters:

##### Power Sum Alien Near-End Crosstalk (PS ANEXT)

##### Average Power Sum Alien Near-End Crosstalk (Average PS ANEXT)

##### Power Sum Alien Attenuation to Crosstalk Ratio Far-End (PS AACR-F)

##### Average Power Sum Alien Attenuation to Crosstalk Ratio Far-End (Average PS AACR-F)

#### When a Balanced Twisted Pair Permanent Link Fails

##### All installed balanced twisted pair cabling permanent links shall be field-tested and shall pass the test requirements and analysis described in Part 3.

##### Any permanent link that fails these requirements shall be diagnosed and corrected.

##### Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected permanent link meets performance requirements.

##### The final and passing result of the tests for all permanent links shall be provided in the test results documentation, in accordance with Part 3.

### Optical Fiber Links

#### Test Limits – ANSI/TIA-568.3-E Singlemode (STD) and Multimode (STD)

#### Unless otherwise specified by the Owner or the Owners representative, each optical fiber cabling link shall comply with the following test limits:

##### Optical loss testing

##### Multi-mode and single-mode links

##### Link attenuation calculated by the formulas, as specified in ANSI/TIA‑568.3-E:

* Link Attenuation (dB)= Cable Attn (dB)+Connector Attn (dB)+Splice Attn (dB)

###### Cable Attn (dB) = Attenuation Coefficient (dB/km)\*Length (Km)

###### Connector Attn(dB)=number of connector pairs\*connector loss (dB) Maximum allowable connector loss=0.75 dB

###### Splice\_Attn (dB)=number\_of\_splices\*splice\_loss (dB) Maximum allowable splice\_loss = 0.3 dB

##### The values for the Attenuation\_Coefficient (dB/km) are listed in the table below. Where application limits are more stringent, those shall apply.

| type of optical fiber | wavelength  (nm) | attenuation  coefficient  (dB/km) | wavelength  (nm) | attenuation  coefficient  (dB/km) |
| --- | --- | --- | --- | --- |
| Multi-mode 62.5/125 µm | 850 | 3.5 | 1300 | 1.5 |
| Multi-mode 50/125 µm | 850 | 3.5 | 1300 | 1.5 |
| Single-mode (Inside plant) | 1310 | 1.0 | 1550 | 1.0 |
| Single-mode (Outside plant) | 1310 | 0.5 | 1550 | 0.5 |

#### OTDR Testing

##### Reflective events (connections) shall not exceed the following limits. Where application limits are more stringent, those shall apply.

###### 0.75 dB in optical loss when bi-directionally averaged

###### -35 dB reflectance for multi-mode connections

###### -40 dB reflectance for UPC single-mode connections

###### -55 dB reflectance for APC single-mode connections

###### Non-reflective events (splices) shall not exceed 0.3 db

#### Magnified End Face Inspection

##### Fiber connections shall be visually inspected for compliance with IEC 61300‑3‑35 Edition 1.0 for end face quality.

##### Scratched, pitted or dirty connectors shall be diagnosed and corrected.

#### When an Optical Fiber Link or Channel Fails

##### All installed optical fiber cabling links and channels shall be field-tested and pass the test requirements and analysis as described in Part 3.

##### Any link or channel that fails these requirements shall be diagnosed and corrected.

##### Any corrective action that must take place 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 all links and channels shall be provided in the test results documentation, in accordance with Part 3.

### Acceptance of Test Results

#### Once the project is fully completed and tested in accordance with the Contract Documents and to the satisfaction of the Owner, the Owner’s acceptance of the test results shall be given in writing to the Engineer.

## PROJECT CONDITIONS

### Project Environmental Requirements

#### Seismic Safety

##### Observe mechanical and electrical support means for all installed equipment as required by all applicable local building codes for this installation’s earthquake risk hazard zone and as recommended by Telcordia Specification GR-63.

##### All equipment racks should to be anchored with suitable anchors that meet safety standards.

##### Overhead devices should be mounted with appropriate safety attachments as required.

##### Where cabinets and racks are secured directly to the building, this should be done in accordance with guidance provided by the Authority Having Jurisdiction (AHJ) or a structural engineer.

##### Equipment and fixtures should have shock and vibration isolation.

#### Fiber Optic Cable Safety

##### The following warnings shall be posted on the job site:

##### WARNING: PERMANENT EYE DAMAGE CAN RESULT FROM LOOKING DIRECTLY INTO A LIGHT BEAM GENERATED BY AN LED OR LASER SOURCE OR INTO THE END OF A CABLE FIBER CONNECTED TO ONE OF THESE SOURCES.

##### CAUTION: LIGHT GENERATED BY THESE SOURCES MAY NOT BE VISIBLE YET REMAIN HAZARDOUS TO THE EYE. LOOK FOR WARNING LABELS ON SOURCE DEVICES.

##### Observe all warning signs on equipment and all written safety precautions in the equipment instruction and technical manuals.

##### Always handle cable carefully to avoid personal injury. Care should be taken with individual fibers to prevent injury to the eyes or penetration of the fibers into the skin.

#### Hazardous Materials Prohibition

##### The Contractor shall make sure that all materials used in the project are asbestos-free, unless specifically authorized in writing by the Owner.

##### Applicable products shall comply with the European directives on the Restriction of Hazardous Substances (RoHS; 2002/95/EC) and Waste Electrical and Electronic Equipment (WEEE; 2002/96/EC). – Only include this for facilities in Europe.

### Existing Conditions

#### Verify that all conditions on the project site are acceptable for the Work specified in this Section. Prior to bid opening, notify the Consulting Engineer in writing of any discrepancies, conflicts, or omissions. Otherwise, correct these issues at no additional cost to the Owner.

#### Continue to monitor the project site. If conditions develop that require a variance from the Specifications or Drawings, then immediately notify the Owner in writing. Otherwise, make recommendations, submit drawings showing how the Work may be installed, and upon approval, proceed with the necessary changes without additional cost to the Owner.

### Record Drawings

#### Keep a complete set of all telecommunications drawings in the job site office for reference of the actual installation of work under this Section.

#### Use this set of drawings for no other purpose.

#### Where any material, equipment, or system components are installed differently than what is shown on the Drawings, indicate the differences clearly and neatly using ink or indelible pencil.

#### Upon completion of the project, submit the record set of Drawings.

## USE OF THE SITE

### Where the Owner deems it necessary to place restrictions, use the site as directed by the Owner.

### When proceeding with the work, do not interfere with the ordinary use of streets, aisles, passages, exits, or operations of the Owner. During the day, set up cones and barriers in hallways and walkways. Do not string cable down the hallways during normal hours.

### Request a hazardous materials worksheet that identifies potentially-hazardous locations. Do not proceed with any work in locations where hazardous materials are known to be. Obtain instructions from the Contractor’s Project Manager on how and when to work in these areas.

### Multiple times each day, each installation contractor shall remove all trash and debris from the site.

### Before leaving the room each day:

#### The Contractor shall replace all ceiling tiles that they have removed.

#### The Contractor shall place all furniture and equipment that they have moved back into its original location.

#### The Contractor shall return any equipment that they have disconnected to working order.

#### The Contractor’s Job Foreman shall inspect all work locations to make sure that the rooms are clean and that all of the tasks described above have been done.

#### It is recommended that the Contractor inspect the site and take pictures to document the condition of the ceilings and walls.

## CONTINUITY OF SERVICES

### Take no action that will interfere with, or interrupt, existing building services unless previous arrangements have been made with the Owner’s representative. Arrange all work to minimize shutdown time.

### The Owner’s personnel shall perform shutdown of operating systems. When shutdown of systems is required, the contractor shall give three (3) days advance notice.

### Should building services be inadvertently interrupted:

#### The Job Foreman shall immediately notify the Project Manager of the accidental disruption of services, the remedy, and how long it will take to restore services.

#### The Contractor shall immediately furnish the labor, including overtime, the material, and the equipment necessary to promptly restore the interrupted service at no cost to the Owner.

# PRODUCTS

## BALANCED TWISTED-PAIR CABLE TESTERS

### The field test instrument shall be manufactured by Fluke Networks.

### The field test instrument shall have been calibrated within the last twelve months.

### There shall be independent verification that the field test instrument meets the following accuracy requirements:

#### For Category 5E, Level IIe accuracy in accordance with ANSI/TIA‑1152

#### For Category 6, Level III accuracy in accordance with ANSI/TIA‑1152

#### For Category 6A, Level IIIe accuracy in accordance with ANSI/TIA‑1152

### Permanent Link Adapters

#### The RJ45 plug must meet the requirements for NEXT, FEXT, and Return Loss in accordance with ANSI/TIA‑568.2-D.

#### Twisted pair Category 5e, 6, 6A, 7, or 7A cords are not permitted, as their performance degrades with use and can cause false Return Loss failures.

### Results Storage

#### The field test instrument shall be capable of storing more than 10,000 results for all measurements found within this section.

### Measurement Capabilities for Category 5E and Category 6 Links

#### On Category 5E and Category 6 links, the field test instrument shall be capable of testing the following parameters:

##### Wire Map

##### Length

##### Propagation Delay

##### Delay Skew

##### DC Loop Resistance

##### DC Resistance Unbalance within a pair

##### DC Resistance Unbalance between pairs

##### Insertion Loss

##### Near-End Crosstalk (NEXT)

##### Power Sum Near-End Crosstalk (PS NEXT)

##### Attenuation to Crosstalk Ratio Near-End (ACR-N)

##### Power Sum Attenuation to Crosstalk Ratio Near-End (PS ACR-N)

##### Attenuation to Crosstalk Ratio Far-End (ACR-F)

##### Power Sum Attenuation to Crosstalk Ratio Far-End (PS ACR-F)

##### Return Loss

##### Transverse Conversion Loss (TCL)

##### Equal Level Transverse Conversion Transfer Loss (ELTCTL)

##### Time Domain Reflectometer

##### Time Domain Xtalk Analyzer

### Measurement Capabilities for Category 6A

#### On Category 6A links, the field test instrument shall be capable of testing all of the parameters listed above for Category 5E and Category 6 links and all of the following parameters:

##### Power Sum Alien Near-End Crosstalk (PS ANEXT)

##### Average Power Sum Alien Near-End Crosstalk (Average PS ANEXT)

##### Power Sum Alien Attenuation to Crosstalk Ratio Far-End (PS AACR-F)

##### Average Power Sum Alien Attenuation to Crosstalk Ratio Far-End (Average PS AACR-F)

### PC Software

#### The field test instrument’s PC software shall:

##### Be Windows® based

##### Show when 3 dB and 4 dB rules are applied

##### Have re-certification capability where results have “(RC)” added to the end of the Cable IDs

##### Have a built-in PDF export capability, as no additional third party software is permitted

##### Have built-in statistical analysis

## OPTICAL FIBER CABLE TESTERS

### The field test instrument shall have been calibrated within the period recommended by the manufacturer, and a copy of the calibration certificate shall be made available.

### Optical Loss Test Set (OLTS)

#### Multi-Mode Optical Fiber Light Source

#### The multi-mode optical fiber light source shall:

##### Provide dual LED light sources with central wavelengths of 850 nm (±30 nm) and 1300 nm (±20 nm). VCSEL sources are not permitted per ANSI/TIA‑526‑14‑B.

##### Have output power of at least –20 dBm

##### Meet the Encircled Flux launch requirements of ANSI/TIA‑526‑14‑B

##### Have test reference cords that demonstrate an insertion loss of 0.15 dB when mated against each other

##### Be manufactured by Fluke Networks

#### The single-mode optical fiber light source shall:

##### Provide dual laser light sources with central wavelengths of 1310 nm (±20 nm) and 1550 nm (±20 nm).

##### Have output power of at least –10 dBm

##### Have test reference cords that demonstrate an insertion loss of 0.25 dB when mated against each other

##### Be manufactured by Fluke Networks

#### Power Meter shall:

##### Provide test capability at wavelengths of 850 nm, 1300 nm, 1310 nm, and 1550 nm

##### Have power measurement uncertainty of ±0.25 dB

##### Store reference power measurements

##### Save at least 10,000 results to internal memory

##### Have a USB PC interface

##### Be manufactured by Fluke Networks

#### Optional Length Measurement

##### An OLTS capable of measuring the optical length of the fiber using time-of-flight techniques is preferable.

##### For MPO/MTP trunk cables, length shall be calculated using cable jacket length markings.

### Optical Time Domain Reflectometer (OTDR)

#### The OTDR shall:

##### Have a color LCD display with backlight

##### Have rechargeable Li-Ion battery for 8 hours of normal operation

##### With battery and module, weigh no more than 4.5 pounds and have a volume of no more than 200 in2

##### Have internal non-volatile memory with capacity for storing at least 2,000 OTDR bi-directionally-tested fiber links

##### Have a USB port to transfer data to a PC or thumb drive/memory stick

##### Be manufactured by Fluke Networks

#### The multi-mode OTDR shall:

##### Provide test capability at wavelengths of 850 nm (±10 nm) and 1300 nm (+35 nm / -15 nm)

##### Have event dead zones that do not exceed 0.7 m at 850 nm and 1300 nm

##### Have attenuation dead zones that do not exceed 2.5 m at 850 nm and 4.5 m at 1300 nm

##### Have distance range of at least 9,000 m

##### Have a dynamic range of at least 28 dB for 850 nm and 30 dB at 1300 nm

##### Allow bi-directional testing without moving the OTDR to the far end

#### The single-mode OTDR shall:

##### Provide test capability at wavelengths of 1310 nm (±25 nm) and 1550 nm (±30 nm)

##### Have event dead zones that do not exceed 0.6 m at 1310 nm and 1550 nm

##### Have attenuation dead zones that do not exceed 3.7 m at 1310 nm and 1550 nm

##### Have distance range of at least 80 km at 1310 nm and 130 km at 1550 nm

##### Have a dynamic range of at least 32 dB for 1310 nm and 30 dB at 1550 nm

##### Allow bi-directional testing without moving the OTDR to the far end

### Fiber Microscope

#### The fiber microscope shall:

##### Have a field of view of 420 µm by 320 µm

##### Have camera probe tips that permit inspection through adapters

##### Be capable of saving and reporting the end face image to IEC 613003‑3‑35

##### Be manufactured by Fluke Networks

##### Preferably be a video camera system

### Integrated OLTS, OTDR, and Fiber Microscope

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

#### Any such system shall be manufactured by Fluke Networks.

## ADMINISTRATION

### Administration documentation shall include the test results of each permanent link.

### Upon completion of the test of each link, the test result information for that link shall be recorded in the memory of the field test instrument.

### The test result records saved in the field test instrument shall be transferred into a Windows®-based database utility that allows for the maintenance, inspection, and archiving of these test records.

### For additional information see Section 27 05 53

# EXECUTION

## GENERAL

### Prior to field-testing, all outlets, cables, patch panels, and associated components shall be fully assembled and labeled. Any testing performed on incomplete systems shall be redone after the systems are fully assembled and labeled.

### Upon completion of the work, a Registered Communications Distribution Designer (RCDD) shall submit as-built Drawings to the Owner or Owner’s representative.

### The Contractor shall input the cabling data into the cable management software.

## SYSTEM ADMINISTRATION

### Test Results Documentation

#### At the end of each working day, upload the copper cable permanent link test results, except for alien crosstalk testing, to the associated PC software for inspection by the Owner or the Owner’s representative.

#### Test results uploaded shall allow for the maintenance, inspection, and archiving of the test records.

#### Prior to the Owner accepting the project:

##### Store the database of the complete project, including, if applicable, fiber links, in the format native to the software.

##### Deliver the database to the Owner on CD, DVD, or thumb-drive.

##### To allow the Owner to inspect and print the test reports, include a working and fully-licensed copy of the software.

#### Circuit IDs reported by the test instrument should match the specified label ID. ( See “LABELS” below)

#### Provide the detailed test results documentation data, in an electronic database, for each tested optical fiber and include the following information:

##### The identification of the customer site as specified by the end-user

##### The name of the test limit selected to execute the stored test results

##### The name of the personnel performing the test

##### The date and time that the test results were saved in the memory of the tester

##### The manufacturer, model, and serial number of the field test instrument

##### The version of the test software and the version of the test limit database held in the test instrument

##### The fiber identification number

##### The length of each optical fiber

##### The index of refraction used for length calculation when using a length-capable OLTS

##### The backscatter coefficient of the fiber under test when using an OTDR

##### The OLTS attenuation link and channel measurements at the appropriate wavelengths and the margin (the difference between the measured attenuation and the test limit value)

##### The OTDR link and channel traces, event tables at the appropriate wavelengths, and a map of the link tested

##### The length of each optical fiber, as calculated by the OTDR

##### The overall pass/fail evaluation of the link-under-test for OLTS and OTDR measurements

##### A picture or image of each fiber end-face

##### A pass/fail status of the end-face using IEC 61300-3-35 Edition 1.0

#### Testing of Category 5E and Category 6 Permanent Links

##### For each Category 5E and Category 6 balance twisted-pair permanent link, provide the detailed test results documentation data in the associated PC software including:

##### The overall pass/fail evaluation of the link-under-test

##### The date and time the test results were saved in the memory of the tester

##### The identification of the customer site, as specified by the Owner

##### The name of the test limit selected to execute the stored test results

##### The name of the personnel performing the test

##### The version of the test firmware and the version of the test limit database held in the test instrument

##### The manufacturer, model, and serial number of the field test instrument

##### The adapters used

##### The factory calibration date

##### A aire map

##### Propagation delay values for all four pairs

##### Delay skew values for all four pairs

##### DC resistance values for all four pairs

##### DC resistance unbalance within a pair values for all four pairs

##### DC resistance unbalance between pairs values for all four pairs

##### Insertion loss worst case values for all four pairs

##### NEXT worst-case margin and worst-case values in both directions

##### PS NEXT worst-case margin and worst-case values in both directions

##### ACR-N worst-case margin and worst-case values in both directions

##### PS ACR-N worst-case margin and worst-case values in both directions

##### ACR-F worst-case margin and worst-case values in both directions

##### PS ACR-F worst-case margin and worst-case values in both directions

##### Return loss worst-case margin and worst-case values in both directions

##### TCL worst-case margin and worst-case values in both directions

##### ELTCTL worst-case margin and worst-case values in both directions

##### Time domain crosstalk data, if the link is marginal or fails

##### Time domain reflectometer data, if the link is marginal or fails

#### Testing of Category 6A Permanent Links

##### For each Category 6A balance twisted-pair permanent link, provide all of the same detailed test results documentation data required for Category 5E and Category 6 permanent links and also the detailed test results documentation data for alien crosstalk testing, in AxTalk Analyzer, including:

##### PS ANEXT worst-case margin for all four pairs

##### Average PS ANEXT worst-case margin

##### PS AACR-F worst-case margin for all four pairs

##### Average PS AACR-F worst-case margin

### Submit test reports within seven (7) business days of completion of testing.

## FIELD QUALITY CONTROL

### General

#### The Owner reserves the right to be present during any or all of the testing.

#### All cabling not tested in strict accordance with these specifications shall be re-tested at no additional cost to the Owner.

#### 100% of the installed cabling must be tested. All tests must meet the acceptance criteria defined in the media specific sections of this document.

#### Prior to each day’s testing, fully charge all test equipment and bring an appropriate alternate power source to the job site.

#### Throughout the testing, have a competent supervisor and supporting technical personnel, acceptable to the Owner, available on site. Changing the supervisor during the testing shall not be acceptable without prior written approval from the Owner.

#### Upon completion of the testing, it shall be the responsibility of the Contractor to perform the necessary adjustments and other controls to ensure proper system operation. The system shall be physically inspected by the Owner to assure that all equipment is installed in a neat and workmanlike manner as called for by the contract documents.

#### Verify the performance parameters of the individual systems, following established professional procedures, in addition to those specified herein. Document all acceptance testing, calibration, and correction procedures described herein, taking care to include the following information:

##### The date on which each procedure was performed

##### The reason that the procedure was performed

##### The type of and a description of the procedure

##### The parameters measured and their values, including, as applicable, the values measured prior to calibration or correction

##### The parameters associated with calibration or corrective networks, components, or devices

##### The names of the personnel conducting the procedure

##### The equipment used to conduct the procedure

### General Specifications for Testing Balanced Twisted Pair Cable

#### Use field test instruments that have the latest firmware installed.

#### Upon completion of each test, record the permanent link test results, including the individual frequency measurements from the tester, in the test instrument for subsequent uploading to the associated test equipment software in which the administrative documentation (reports) may be generated.

#### Perform permanent link testing on each cabling segment, connector to connector. Sampling is not acceptable.

#### Perform alien crosstalk testing on all Category 6A links using a sampling plan. For populations of up to 500,000 links, use an Acceptance Quality Level (AQL) of 0.4%, normal inspection, general inspection level I, as defined in ISO 2859‑1. The following table lists the sample sizes to be used.

| total number of links (N) | sample size  (No. of links to test) |
| --- | --- |
| 3 – 33 | 3 or 0.1 x N  (whichever is greatest) |
| 34 – 3,200 | 33 |
| 3,201 – 35,000 | 126 |
| 35,001 – 150,000 | 201 |
| 150,001 – 500,000 | 315 |

#### Choose an equal combination of short, medium, and long disturbed (victim) links for alien crosstalk testing.

#### Permanent link adapters made from twisted pair Category 5e, Category 6, or Category 6A cords are not permitted.

#### The installer shall build a reference Category 6A link. All components shall be anchored so that it is not possible to disturb them. Each day, the technician is to conduct a Category 6A permanent link test to ensure that there is no degradation of the tester or its permanent link adapters.

## TESTING CATEGORY 5E LINKS

### Frequency Resolution for all measurements shall be:

#### 1 – 31.25 MHz: 150 kHz

#### 31.25 – 100 MHz: 250 kHz

### Wire Map Measurement

#### The length of each balanced twisted pair shall be recorded.

### Propagation Delay

#### Record the propagation delay measurement at 10 MHz, per ANSI/TIA‑1152. Per ANSI/TIA‑568.2-D Section 6.3.18, the propagation delay of each balanced twisted pair shall not exceed 498 ns.

### Delay Skew

#### Record the delay skew measurement of each balanced twisted pair. Per ANSI/TIA‑568.2-D Section 6.3.19, the delay skew measurement Is not to exceed 44 ns.

#### DC Resistance for all four pairs:

##### Record DC resistance

##### Record DC resistance unbalance

### Insertion Loss

#### Report the worst case for all four pairs in one direction only.

#### Mark reported margins found to be within the accuracy of the field tester with an asterisk (\*).

#### Insertion loss is not to exceed the limits for Category 5e permanent links specified in ANSI/TIA‑568.2-D Section 6.3.7.

### Near-End Crosstalk (NEXT)

#### Measure NEXT in both directions for all 12 possible pair-to-pair combinations.

#### Report both worst case and worst margins.

#### NEXT is not to exceed the limits for Category 5e permanent links specified in ANSI/TIA‑568.2-D Section 6.3.8.

#### Mark reported margins found to be within the accuracy of the field tester with an asterisk (\*).

#### Store the time domain Xtalk data for any marginal or failing NEXT results.

### Power Sum Near-End Crosstalk (PS NEXT)

#### Measure PS NEXT in both directions for all 8 possible pair-to-pair combinations.

#### Report both worst case and worst margins.

#### PS NEXT is not to exceed the limits for Category 5e permanent links specified in ANSI/TIA‑568.2-D Section 6.3.9.

#### Mark reported margins found to be within the accuracy of the field tester with an asterisk (\*).

#### Store the time domain Xtalk data for any marginal or failing PS NEXT results.

### Attenuation Crosstalk Ratio Near-End (ACR-N)

#### Calculate ACR-N in both directions.

#### Record ACR-N for all 12 possible combinations.

### Power Sum Attenuation Crosstalk Ratio Near-End (PS ACR-N)

#### Calculate PS ACR-N in both directions.

#### Record PS ACR-N for all 8 possible combinations.

### Attenuation Crosstalk Ratio Far-End (ACR-F)

#### Measure ACR-F in both directions.

#### Report both worst case and worst margins.

#### ACR-F is not to exceed the limits for Category 5e permanent links specified in ANSI/TIA‑568.2-D Section 6.3.11.

#### Mark reported margins found to be within the accuracy of the field tester with an asterisk (\*).

### Power Sum Attenuation Crosstalk Ratio Far-End (PS ACR-F)

#### Measure PS ACR-F in both directions.

#### Report both worst case and worst margins.

#### PS ACR-F is not to exceed the limits for Category 5e permanent links specified in ANSI/TIA‑568.2-D Section 6.3.13.

#### Mark reported margins found to be within the accuracy of the field tester with an asterisk (\*).

### Return Loss

#### Measure return loss in both directions.

#### Report both worst case and worst margins.

#### Ignore return loss at all frequencies where the insertion loss is less than 3 dB for that pair.

#### Return loss is not to exceed the limits for Category 5e permanent links specified in ANSI/TIA‑568.2-D Section 6.3.6.

#### Mark reported margins found to be within the accuracy of the field tester with an asterisk (\*).

#### Store the Time Domain Reflectometer data for any marginal or failing return loss results.

### Transverse Conversion Loss (TCL)

#### Measure TCL in both directions.

#### Record TCL for all 8 possible combinations.

### Equal Level Transverse Conversion ELTCTL Transfer Loss (ELTCTL)

#### Measure ELTCTL in both directions.

#### Record ELTCTL for all 8 possible combinations.

## TESTING CATEGORY 6 LINKS

### Frequency Resolution for all measurements shall be:

#### 1 – 31.25 MHz: 150 kHz

#### 31.25 – 100 MHz: 250 kHz

#### 100 – 250 MHz: 500 kHz

### Wire Map Measurement

#### The length of each balanced twisted pair shall be recorded.

### Propagation Delay

#### Make the propagation delay measurement, per ANSI/TIA‑1152, at 10 MHz.

#### Record the propagation delay of each balanced twisted pair.

#### Propagation delay shall not exceed 498 ns per ANSI/TIA‑568.2-D Section 6.3.18

#### Record the delay skew measurement for each balanced twisted pair.

#### Per ANSI/TIA‑568.2-D Section 6.3.19, propagation delay is not to exceed 44 ns.

#### Record DC resistance for all four pairs.

#### Record DC resistance unbalance for all four pairs.

### Insertion Loss

#### Report the worst case for all four pairs in one direction only.

#### Mark reported margins found to be within the accuracy of the field tester with an asterisk (\*).

#### Insertion loss is not to exceed the limits for Category 6 permanent links specified in ANSI/TIA‑568.2-D Section 6.3.7.

### Near-End Crosstalk (NEXT)

#### Measure NEXT in both directions for all 12 possible pair-to-pair combinations.

#### Report both worst case and worst margins.

#### NEXT is not to exceed the limits for Category 6 permanent links specified in ANSI/TIA‑568.2-D Section 6.3.8.

#### Mark reported margins found to be within the accuracy of the field tester with an asterisk (\*).

#### Store the time domain Xtalk data for any marginal or failing NEXT results.

### Power Sum Near-End Crosstalk (PS NEXT)

#### Measure PS NEXT in both directions for all 8 possible pair combinations.

#### Report both worst case and worst margins.

#### PS NEXT is not to exceed the limits for Category 6 permanent links specified in ANSI/TIA‑568.2-D Section 6.3.9.

#### Mark reported margins found to be within the accuracy of the field tester with an asterisk (\*).

#### Store the time domain Xtalk data for any marginal or failing PS NEXT results.

### Attenuation Crosstalk Ratio Near-End (ACR-N)

#### Calculate ACR-N in both directions.

#### Record ACR-N for all 12 possible combinations.

### Power Sum Attenuation Crosstalk Ratio Near-End (PS ACR-N)

#### Calculate PS ACR-N in both directions.

#### Record PS ACR-N for all 8 possible combinations.

### Attenuation Crosstalk Ratio Far-End (ACR-F)

#### Measure ACR-F in both directions for all 24 possible pair-to-pair combinations.

#### Report both worst case and worst margins.

#### ACR-F is not to exceed the limits for Category 6 permanent links specified in ANSI/TIA‑568.2-D Section 6.3.11.

#### Mark reported margins found to be within the accuracy of the field tester with an asterisk (\*).

### Return Loss

#### Measure return loss in both directions for all 8 possible pair combinations.

#### Report worst case and worst margins.

#### Ignore return loss at all frequencies where the insertion loss is less than 3 dB for that pair.

#### Return loss is not to exceed the limits for Category 6 permanent links specified in ANSI/TIA‑568.2-D Section 6.3.6.

#### Mark reported margins found to be within the accuracy of the field tester with an asterisk (\*).

#### Store the time domain reflectometer data for any marginal or failing return loss results.

### Transverse Conversion Loss (TCL)

#### Measure TCL in both directions.

#### TCL for a permanent link is not specified in ANSI/TIA‑1152 but record it for all 8 possible combinations.

### Equal Level Transverse Conversion Transfer Loss (ELTCTL)

#### Measure ELTCTL in both directions.

#### Record ELTCTL for all 8 possible combinations.

## TESTING CATEGORY 6A LINKS

### Frequency Resolution for all measurements shall be:

#### 1 – 31.25 MHz: 150 kHz

#### 31.25 – 100 MHz: 250 kHz

#### 100 – 250 MHz: 500 kHz

#### 250 – 500 MHz: 1000 kHz

### Wire Map Measurement

#### Record the length of each balanced twisted pair.

### Propagation Delay

#### Measure the propagation delay, per ANSI/TIA-1152, at 10 MHz.

#### Record the propagation delay of each balanced twisted pair.

#### Per ANSI/TIA‑568.2-D Section 6.3.18, the propagation delay shall not exceed 498 ns.

### Delay Skew

#### Record the delay skew measurement for each balanced twisted pair.

### DC Loop Resistance

#### Report the DC loop resistance for all four pairs.

#### Per ANSI/TIA‑568.2-D Section 6.3, DC loop resistance is not to exceed 21 Ω for all four pairs.

### DC Resistance Unbalance within a Pair

#### Report DC resistance unbalance within a pair for all four pairs.

#### Per ANSI/TIA‑568.2-D Section 6.2.2, DC resistance unbalance within a pair is not to exceed 200 mΩ or 3%, whichever is the greatest.

### DC Resistance Unbalance between Pairs

#### Shall be Reported DC resistance unbalance between pairs for the following pairs:

|  |  |  |
| --- | --- | --- |
| 1,2-3,6  1,2-4,5 | 1,2-7,8  3,6-4,5 | 3,6-7,8  4,5-7,8 |

#### DC resistance unbalance between pairs is not to exceed 200 mΩ or 7.5%, whichever is the greatest.

### Insertion Loss

#### Report both worst case and worst margins, in one direction, for all four pairs.

#### Mark reported margins found to be within the accuracy of the field tester with an asterisk (\*).

#### Insertion loss is not to exceed the limits for Category 6A permanent links specified in ANSI/TIA‑568.2-D Section 6.3.7.

### Near-End Crosstalk (NEXT)

#### Report both worst case and worst margins in both directions for all pair combinations.

#### NEXT is not to exceed the limits for Category 6A permanent links specified in ANSI/TIA‑568.2-D Section 6.3.8.

#### Mark reported margins found to be within the accuracy of the field tester an asterisk (\*).

#### Store the time domain Xtalk data for any marginal or failing NEXT results.

### Power Sum Near-End Crosstalk (PS NEXT)

#### Report both worst case and worst margins in both directions for all four pairs.

#### PS NEXT is not to exceed the limits for Category 6A permanent links specified in ANSI/TIA‑568.2-D Section 6.3.9.

#### Mark reported margins found to be within the accuracy of the field tester with an asterisk (\*).

#### Store the time domain Xtalk data for any marginal or failing PS NEXT results.

### Attenuation Crosstalk Ratio Near-End (ACR-N)

#### Report both worst case and worst margins in both directions for all pair combinations.

#### Record ACR-N for all twelve possible combinations.

### Power Sum Attenuation Crosstalk Ratio Near-End (PS ACR-N)

#### Report both worst case and worst margins in both directions for all four pairs.

#### Record PS ACR-N for all eight possible combinations.

### Attenuation Crosstalk Ratio Far-End (ACR-F)

#### Report both worst case and worst margins in both directions for all 12 pair combinations.

#### ACR-F is not to exceed the limits for Category 6A permanent links specified in ANSI/TIA‑568.2-D Section 6.3.11.

#### Mark reported margins found to be within the accuracy of the field tester with an asterisk (\*).

### Power Sum Attenuation to Crosstalk Ratio Far-End (PS ACR-F)

#### Report both worst case and worst margins in both directions for all four pairs.

#### PS ACR-F is not to exceed the limits for Category 6A permanent links specified in ANSI/TIA‑568.2-D Section 6.3.13.

#### Mark reported margins found to be within the accuracy of the field tester with an asterisk (\*).

### Return Loss

#### Report both worst case and worst margins in both directions for all four pairs.

#### Ignore return loss at all frequencies where the insertion loss is less than 3 dB for that pair.

#### Return loss is not to exceed the limits for Category 6A permanent links specified in ANSI/TIA‑568.2-D Section 6.3.6.

#### Mark reported margins found to be within the accuracy of the field tester with an asterisk (\*).

#### Store the time domain reflectometer data for any marginal or failing return loss results.

### Transverse Conversion Loss (TCL)

#### Report both worst case and worst margins in both directions for all four pairs.

#### TCL is not to exceed the limits for Category 6A permanent links specified in ANSI/TIA‑568.2-D Section 6.2.14.

### Equal Level Transverse Conversion Transfer Loss (ELTCTL)

#### Report both worst case and worst margins in both directions for all four pairs.

#### ELTCTL is not to exceed the limits for Category 6A permanent links specified in ANSI/TIA‑568.2-D Section 6.2.16.

### Power Sum Alien Near-End Crosstalk (PS ANEXT)

#### The disturbed (victim) link shall have disturber links to the left and right of it and, if such links are present, above and below it.

#### Disturber cables shall include all links within the same bundle as the disturbed (victim) link and adjacent links.

#### If the link is patch-panel-to-patch-panel, then measure PS ANEXT in both directions. If the link is patch-panel-to-telecommunications-outlet, then measure PS ANEXT from the patch panel end only.

#### PS ANEXT is not to exceed the limits for Category 6A permanent links specified in ANSI/TIA‑568.2-D Section 6.3.21.

### Power Sum Alien Near-End Crosstalk (Average PS ANEXT)

#### Calculate average PS ANEXT by averaging the individual PS ANEXT loss values, in dB, for all four pairs in the disturbed (victim) link.

#### PS ANEXT is not to exceed the limits for Category 6A permanent links specified in ANSI/TIA‑568.2-D Section 6.3.22.

### Power Sum Alien Attenuation to Crosstalk Ratio Far-End (PS AACR-F)

#### PS AACR-F shall be the calculated power sum from all external pairs into the disturbed (victim) pair.

#### The disturbed (victim) link shall have disturber links to the left and right of it and, if such links are present, above and below it.

#### Disturber cables shall include all links within the same bundle as the disturbed (victim) link and adjacent links. I the link is patch-panel-to patch-panel, then measure PS AACR-F in both directions. If the link is patch-panel-to-telecommunications-outlet, then measure PS AACR-F from the patch panel end only.

#### PS AACR-F is not to exceed the limits for Category 6A permanent links specified in ANSI/TIA‑568.2-D Section 6.3.25

### Power Sum Alien Attenuation to Crosstalk Ratio Far-End (Average PS AACR-F)

#### Calculate Average PS AACR-F by averaging the individual PS AACR-F values, in dB, for all four pairs in the disturbed (victim) link.

#### The disturbed (victim) link shall have disturber links to the left and right of it and, if such links are present, above and below it.

#### Disturber cables shall include all links within the same bundle as the disturbed (victim) link and adjacent links.

#### If the link is patch-panel-to-patch-panel, measure Average PS AACR-F in both directions. If the link is patch-panel-to-telecommunications-outlet, then measure Average PS AACR-from the patch panel end only.

#### Average PS AACR-F is not to exceed the limits for Category 6A permanent links specified in ANSI/TIA‑568.2-D Section 6.3.26.

## TESTING OPTICAL FIBER CABLE

### General

#### All tests performed on optical fiber cabling that use a laser or LED in a test set shall be carried out with in accordance with the safety precautions specified in ANSI Z136.2.

#### Prior to field-testing, fully assemble and label all outlets, cables, patch panels, and associated components. Any testing performed on incomplete systems shall be redone after the systems are fully assembled and labeled.

#### Use field test instruments that have the latest software and firmware installed.

#### Upon completion of each test, record the link and channel test results from the OLTS and OTDR in the test instrument for subsequent uploading to a PC in which the administrative documentation (reports) may be generated.

#### Inspect fiber end faces using a video scope with a field of view of no less than 425 µm x 320 µm.

#### Record the end face images in the memory of the test instrument for subsequent uploading to a PC and reporting.

#### Perform testing on each cabling segment, connector to connector. Sampling is not acceptable.

#### Test the cabling using high-quality test reference cords that:

##### Are of the same core size as the cabling under test

##### Are terminated with reference grade connectors that have a loss of no more than 0.1 dB for multi-mode and 0.2 dB for single-mode

##### For OLTS testing, are between 2 m and 5 m long

##### For multi-mode OTDR testing, have launch and tail fibers that are at least 100 m (328 feet) long

##### For single-mode testing, have launch and tail fibers of lengths appropriate for the link under test, as indicated in the following table:

| maximum length of link (km) | | typical pulse  width (ns) | minimum launch  and tail cord  length (m) |
| --- | --- | --- | --- |
| 1310 nm | 1550 nm only |
| 0 to 35 | 0 to 50 | = 1,000 | 130 |
| 35 to 45 | 50 to 65 | 3,000 | 400 |
| 45 to 50 | 65 to 75 | 10,000 | 1,000 |
| = 50 | = 75 | 20,000 | 2400 |

### Optical Loss Testing for Horizontal and Backbone Links

#### Test multi-mode links in both directions at 850 nm and 1300 nm in accordance with ANSI/TIA-526-14-B, one-cord reference method, with an Encircled Flux compliant launch.

#### Single-mode backbone links shall be tested in both directions at 1310 nm and 1550 nm in accordance with ANSI/TIA/EIA‑526‑7, Method A.1 (the one-cord reference method).

### OTDR Testing – Only include this if specifically requested by the Client or Owner.

#### Test fiber links at the following wavelengths for anomalies and to ensure uniformity of cable attenuation, connector insertion loss, and reflectance:

##### For multi-mode: 850 m and 1300 nm

##### For single-mode: 1310 nm and 1550 nm

#### Test each fiber link and channel in both directions.

#### For the measurement in the opposite direction, leave the launch and tail fibers in place. Failing to do so will result in an increase in measurement uncertainty.

#### Using a loop back fiber at the far end with a tail fiber at the near end on the adjacent fiber is permitted for bi-directional testing, as long as the OTDR can split the trace automatically into two traces for the two fibers under test.

#### Install a launch cable between the OTDR and the first link connection.

#### Install a tail cable after the last link connection.

### Magnified End-Face Inspection

#### Inspect fibers using a video scope with a minimum field of view of 425 µm by 320 µm per IEC 61300-3-35 Edition 1.0.

#### Use the following test limits:

##### For multi-mode connectors, Table 6 of IEC 61300‑3‑35 Edition 1.0

##### For single-mode field polished connectors, Table 5 of IEC 61300‑3‑35 Edition 1.0

##### For single-mode factory polished connectors, Table 3 of IEC 61300‑3‑35 Edition 1.0

##### For Angled Physical Contact (APC) connectors, Table 4 of IEC 61300‑3‑35 Edition 1.0

#### Length Measurement

##### Record the length of each fiber.

##### It is preferable that the optical length be measured using an OLTS or OTDR.

#### Polarity Testing

##### Test paired duplex fibers in multi-fiber cables to verify that polarity is in accordance with Clause E.5.3 of ANSI/TIA‑568‑C.0-2

##### Verify the polarity of the paired duplex fibers using an OLTS.

### Manufacturer’s Field Service

#### At the start of the installation, periodically as the Work progresses, and after completion, furnish:

##### The services of the manufacturer’s technical representative at the job site, as needed, to advise on every phase of the Work

##### Full-time attendance at least during the first three work days and at least once every week thereafter

##### Technical assistance to the Installer as required– Edit or Remove as necessary for the intended project.

#### END OF SECTION 27 17 00