



*This document has been prepared to aid consultants or engineers in developing contractual specifications covering the certification of Category 6 Permanent Links. It is offered as a general guide. Suitability for any intended use is the responsibility of the user.*

## SECTION 27 17 00

### TESTING, IDENTIFICATION AND ADMINISTRATION OF BALANCED TWIST PAIR INFRASTRUCTURE

#### PART 1 - GENERAL

##### 1.1 WORK INCLUDED

- A. 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.
- B. 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.
- C. In addition to the tests detailed in this document, the contractor shall notify the Owner or the Owner's representative of any additional tests that are deemed necessary to guarantee a fully functional system. The contractor shall carry out and record any additional measurement results at no additional charge.

##### 1.2 SCOPE

- A. This Section includes the minimum requirements for the test certification, identification and administration of horizontal balanced twisted pair cabling.
- B. This Section includes minimum requirements for:
1. Copper cabling test instruments
  2. Copper cabling testing
  3. Identification
    - a) Labels and labelling
  4. Administration
    - a) Test results documentation
    - b) As-built drawings
- C. Testing shall be carried out in accordance with this document.
- D. Testing shall be performed on each cabling link. (100% testing)
- E. All tests shall be documented.

##### 1.3 QUALITY ASSURANCE

- A. All testing procedures and field-test instruments shall comply with applicable requirements of:
1. ANSI/TIA-1152, Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling
  2. ANSI/TIA-568-C.0, Generic Telecommunications Cabling for Customer Premises.
  3. ANSI/TIA-568-C.1, Commercial Building Telecommunications Cabling Standard

4. ANSI/TIA 568 C.2, Balanced Twisted-Pair Telecommunications Cabling and Components Standards.
5. ANSI/TIA-606-B, Administration Standard for Commercial Telecommunications Infrastructure, including the requirements specified by the customer, unless the customer specifies their own labeling requirements.

- B. Trained technicians who have successfully attended an appropriate training program 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:

1. Manufacturer of the connectors or cable.
2. Manufacturer of the test equipment used for the field certification.
3. Training organizations (e.g., BICSI, A Telecommunications Association headquarters in Tampa, Florida; ACP [Association of Cabling Professionals™] Cabling Business Institute located in Dallas, Texas)

- C. The Owner or the Owner's representative shall be invited to witness and/or review field-testing.
1. The Owner or the Owner's representative shall be notified of the start date of the testing phase five (5) business days before testing commences.
  2. The Owner or the Owner's representative will select a random sample of 5% of the installed links. The Owner or the Owner's representative shall test these randomly selected links and the results are to be stored in accordance with Part 3 of this document. The results obtained shall be compared to the data provided by the installation contractor. If more than 2% of the sample results differ in terms of the pass/fail determination, the installation contractor under supervision of the representative shall repeat 100% testing at no cost to the Owner.

##### 1.4 SUBMITTALS

- A. Manufacturers catalogue sheets and specifications for the test equipment.
- B. A schedule (list) of all balanced twisted-pair copper links to be tested.
- C. Sample test reports.



## 1.5 ACCEPTANCE OF TEST RESULTS

A. Unless otherwise specified by the Owner or the Owners representative, each cabling link shall be in tested for:

1. Wire Map
2. Length
3. Propagation Delay
4. Delay Skew
5. DC Loop Resistance – recorded for information only
6. DC Resistance Unbalance – recorded for information
7. Insertion Loss
8. NEXT (Near-End Crosstalk)
9. PS NEXT (Power Sum Near-End Crosstalk)
10. ACR-N (Attenuation to Crosstalk Ratio Near-End) – recorded for information only
11. PS ACR-N (Power Sum Attenuation to Crosstalk Ratio Near-End) – recorded for information only
12. ACR-F (Attenuation to Crosstalk Ratio Far-End)
13. PS ACR-F (Power Sum Attenuation to Crosstalk Ratio Far-End)
14. Return Loss
15. TCL (Transverse Conversion Loss) – recorded for information only
16. ELTCTL (Equal Level Transverse Conversion Transfer Loss) – recorded for information only

B. All installed cabling Permanent Links shall be field-tested and pass the test requirements and analysis as 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.

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.

## PART 2 - PRODUCTS

### 2.1 BALANCED TWISTED-PAIR CABLE TESTERS

A. The field-test instrument shall be within the calibration period recommended by the manufacturer, typically 12 months.

B. Certification tester

1. Accuracy
  - a) *Level III accuracy in accordance with ANSI/TIA-1152*
  - b) *Independent verification of accuracy*
  - c) *Acceptable manufacturers*
2. Permanent Link Adapters
  - a) *RJ45 plug must meet the requirements for NEXT, FEXT and Return Loss in accordance with ANSI/TIA-568-C.2 Annex C*
  - b) *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*

3. Results Storage

a) *Must be capable of storing > 10,000 results for all measurements found in 2.1.B.4 below*

4. Measurement capabilities

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

C. PC Software

1. Windows® based.
2. Must show when 3 dB and 4 dB rules are applied
3. Re-certification capability, where results must have their Cable IDs suffixed with (RC).
4. Built in PDF export – no additional third party software permitted.
5. Built-in statistical analysis.

### 2.2 IDENTIFICATION

A. Labels

1. Shall meet the legibility, defacement, exposure and adhesion requirements of UL 969.
2. Shall be preprinted using a mechanical means of printing (e.g., laser printer).
3. Where used for cable marking, provide vinyl substrate with a white printing area and a clear “tail” that self laminates the printed area when wrapped around the cable. If cable jacket is white, provide cable label with printing area that is any other color than white, preferably orange or yellow – so that the labels are easily distinguishable.
4. Where insert type labels are used provide clear plastic cover over label.
5. Provide plastic warning tape 6 inches wide continuously printed and bright colored 18” above all direct buried services, underground conduits and duct-banks.
6. Acceptable Manufacturers:
  - a) *Brady Corporation*
  - b) *Silver Fox*
  - c) *Brother*
  - d) *Epson*
  - e) *Dymo*



## 2.3 ADMINISTRATION

- A. Administration of the documentation shall include test results of each Permanent Link.
- B. The test result information for each link shall be recorded in the memory of the field-test instrument upon completion of the test.
- C. The test result records saved within 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.

## PART 3 – EXECUTION

### 3.1 GENERAL

- A. All 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.

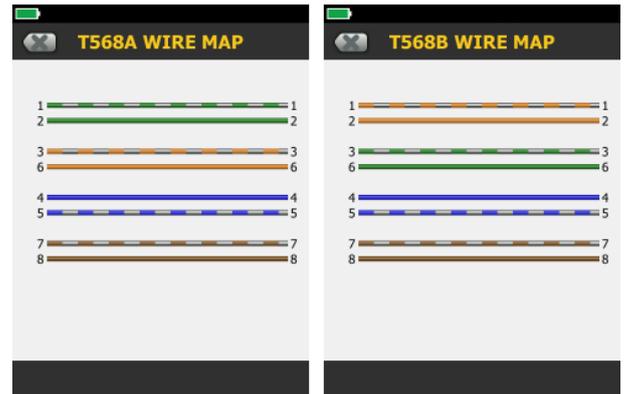
### 3.2 BALANCED TWISTED PAIR CABLE TESTING

- A. Field-test instruments shall have the latest software and firm-ware installed.
- B. Permanent Link test results including the individual frequency measurements from the tester 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.
- C. Testing shall be performed on each cabling segment (connector to connector). Sampling is not acceptable.
- D. Permanent Link adapters made from 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.
- E. The installer shall build a reference link. All components shall be anchored so it is not possible to disturb them. The technician is to conduct a Category 6 Permanent Link test each day to ensure no degradation of the tester or its Permanent Link adapters.

#### F. Wire Map Measurement

1. 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:
  - a) *Continuity to the remote end*
  - b) *Shorts between any two or more conductors*
  - c) *Reversed pairs*
  - d) *Split pairs*
  - e) *Transposed pairs*
  - f) *Distance to open on shield*
  - g) *Any other miss-wiring*

2. 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. Examples are given below:



#### G. Length Measurement

1. The length of each balanced twisted pair shall be recorded.
2. 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.
3. 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.

#### H. Propagation Delay measurement

1. Is the time it takes for a signal to reach the end of the link.
2. The measurement shall be made at 10 MHz per ANSI/TIA-1152.
3. The propagation delay of each balanced twisted pair shall be recorded.
4. Is not to exceed 498 ns per ANSI/TIA-568-C.2 Section 6.3.18.

#### I. Delay Skew measurement

1. Is the difference in propagation delay @ 10 MHz between the shortest delay and the delays of the other wire pairs.
2. The delay skew of each balanced twisted pair shall be recorded.
3. Is not to exceed 44 ns per ANSI/TIA-568-C.2 Section 6.3.19.

#### J. DC Resistance

1. Often reported as Resistance, is the loop resistance of both conductors in the pair.
2. Is not specified in ANSI/TIA-1152, but shall be recorded for all four pairs.



**K. DC Resistance Unbalance**

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

**L. Insertion Loss**

1. Is the loss of signal strength over the cabling (in dB).
2. The frequency resolution shall be:
  - a) 1 – 31.25 MHz: 150 kHz
  - b) 31.25 – 100 MHz: 250 kHz
  - c) 100 – 250 MHz: 500 kHz
3. Worst case shall be reported for all four pairs in one direction only.
4. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (\*).
5. Is not to exceed the Category 6 Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.7.

**M. NEXT (Near-End Crosstalk)**

1. Is the difference in amplitude (in dB) between a transmitted signal and the crosstalk received on other wire pairs at the same end of the cabling.
2. The frequency resolution shall be:
  - a) 1 – 31.25 MHz: 150 kHz
  - b) 31.25 – 100 MHz: 250 kHz
  - c) 100 – 250 MHz: 500 kHz
3. Shall be measured in both directions. (12 pair to pair possible combinations)
4. Both worst case and worst margins shall be reported.
5. Is not to exceed the Category 6 Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.8.
6. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (\*).
7. The Time Domain Xtalk data shall be stored for any marginal or failing NEXT results.

**N. PS NEXT (Power Sum Near-End Crosstalk)**

1. Is the difference (in dB) between the test signal and the crosstalk from the other pairs received at the same end of the cabling.
2. The frequency resolution shall be:
  - a) 1 – 31.25 MHz: 150 kHz
  - b) 31.25 – 100 MHz: 250 kHz
  - c) 100 – 250 MHz: 500 kHz
3. Shall be measured in both directions. (8 pair possible combinations)
4. Both worst case and worst margins shall be reported.
5. Is not to exceed the Category 6 Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.9.
6. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (\*).
7. The Time Domain Xtalk data shall be stored for any marginal or failing PS NEXT results.

**O. ACR-N (Attenuation Crosstalk Ratio Near-End)**

1. Is a calculation of NEXT minus Insertion Loss of the disturbed pair in dB.

2. The frequency resolution shall be:

- a) 1 – 31.25 MHz: 150 kHz
- b) 31.25 – 100 MHz: 250 kHz
- c) 100 – 250 MHz: 500 kHz

3. Shall be calculated in both directions.
4. Is not specified in ANSI/TIA-1152, but shall be recorded for all 12 possible combinations.

**P. PS ACR-N (Power Sum Attenuation Crosstalk Ratio Near-End)**

1. Is a calculation of PS NEXT minus Insertion Loss of the disturbed pair in dB.
2. The frequency resolution shall be:
  - a) 1 – 31.25 MHz: 150 kHz
  - b) 31.25 – 100 MHz: 250 kHz
  - c) 100 – 250 MHz: 500 kHz
3. Shall be calculated in both directions.
4. Is not specified in ANSI/TIA-1152, but shall be recorded for all 8 possible combinations.

**Q. ACR-F (Attenuation Crosstalk Ratio Far-End)**

1. Is a calculation of FEXT minus Insertion Loss of the disturbed pair in dB.
2. The frequency resolution shall be:
  - a) 1 – 31.25 MHz: 150 kHz
  - b) 31.25 – 100 MHz: 250 kHz
  - c) 100 – 250 MHz: 500 kHz
3. Shall be measured in both directions. (24 pair to pair possible combinations)
4. Both worst case and worst margins shall be reported.
5. Is not to exceed the Category 6 Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.11.
6. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (\*).

**R. PS ACR-F (Power Sum Attenuation Crosstalk Ratio Far-End)**

1. Is a calculation of PS FEXT minus Insertion Loss of the disturbed pair in dB.
2. The frequency resolution shall be:
  - a) 1 – 31.25 MHz: 150 kHz
  - b) 31.25 – 100 MHz: 250 kHz
  - c) 100 – 250 MHz: 500 kHz
3. Shall be measured in both directions. (8 pair possible combinations)
4. Both worst case and worst margins shall be reported.
5. Is not to exceed the Category 6 Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.13.
6. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (\*).

**S. Return Loss**

1. Is the difference (in dB) between the power of a transmitted signal and the power of the signals reflected back.
2. The frequency resolution shall be:
  - a) 1 – 31.25 MHz: 150 kHz
  - b) 31.25 – 100 MHz: 250 kHz
  - c) 100 – 250 MHz: 500 kHz



3. Shall be measured in both directions. (8 pair possible combinations)
4. Both worst case and worst margins shall be reported.
5. Shall be ignored at all frequencies where the Insertion Loss is less than 3 dB for that pair.
6. Is not to exceed the Category 6 Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.6.
7. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (\*).
8. The Time Domain Reflectometer data shall be stored for any marginal or failing Return Loss results.

T. TCL (Transverse Conversion Loss)

1. 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.
2. The frequency resolution shall be:
  - a) 1 – 31.25 MHz: 150 kHz
  - b) 31.25 – 100 MHz: 250 kHz
  - c) 100 – 250 MHz: 500 kHz
3. Shall be measured in both directions.
4. Is not specified in ANSI/TIA-1152 for a Permanent Link, but shall be recorded for all 8 possible combinations.

U. ELTCTL (Equal Level Transverse Conversion Transfer Loss)

1. 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.
2. The frequency resolution shall be:
  - a) 1 – 31.25 MHz: 150 kHz
  - b) 31.25 – 100 MHz: 250 kHz
  - c) 100 – 250 MHz: 500 kHz
3. Shall be measured in both directions.
4. Is not specified in ANSI/TIA-1152 for a Permanent Link, but shall be recorded for all 8 possible combinations.

### 3.3 ADMINISTRATION

A. Test results documentation

1. Test results saved within the field-test instrument shall be transferred into a Windows™-based database utility that allows for the maintenance, inspection and archiving of the test records. These test records shall be uploaded to the PC unaltered, i.e., “as saved in the field-test instrument”. The file format, CSV (comma separated value), does not provide adequate protection of these records and shall not be used.
2. The test results documentation shall be available for inspection by the Owner or the Owner’s representative during the installation period and shall be passed to the Owner’s representative within 5 working days of completion of tests on cabling served by a telecommunications room or of backbone cabling. The installer shall retain a copy to aid preparation of as built information.

3. The database for the complete project, including twisted-pair copper cabling links, if applicable, shall be stored and delivered on CD or DVD prior to Owner acceptance of the building. This CD or DVD shall include the software tools required to view, inspect, and print any selection of the test reports.
4. Circuit IDs reported by the test instrument should match the specified label ID (see 3.3 of this Section).
5. The detailed test results documentation data is to be provided in an electronic database for each tested balance twisted-pair and shall contain the following information

- a) *The overall Pass/Fail evaluation of the link-under-test*
- b) *The date and time the test results were saved in the memory of the tester*
- c) *The identification of the customer site as specified by the end-user*
- d) *The name of the test limit selected to execute the stored test results*
- e) *The name of the personnel performing the test*
- f) *The version of the test software and the version of the test limit database held within the test instrument*
- g) *The manufacturer, model and serial number of the field-test instrument*
- h) *The adapters used*
- i) *The factory calibration date*
- j) *Wire Map*
- k) *Propagation Delay values, for all four pairs*
- l) *Delay Skew values, for all four pairs*
- m) *DC Resistance values, for all four pairs*
- n) *DC Resistance Unbalance, values for all four pairs*
- o) *Insertion Loss, worst case values for all four pairs*
- p) *NEXT, worst case margin and worst case values, both directions*
- q) *PS NEXT, worst case margin and worst case values, both directions*
- r) *ACR-F, worst case margin and worst case values, both directions*
- s) *PS ACR-F, worst case margin and worst case values, both directions*
- t) *Return Loss, worst case margin and worst case values, both directions*
- u) *TCL, worst case values both directions*
- v) *ELTCTL, worst case values, both directions.*
- w) *Time Domain Crosstalk data if the link is marginal or fails*
- x) *Time Domain Reflectometer data if the link is marginal or fails*



B. Record copy and as-built drawings

1. Provide record copy drawings periodically through out the project as requested by the Construction Manager or Owner, and at end of the project on a CD or DVD.

Record copy drawings at the end of the project shall be in CAD format and include notations reflecting the as built conditions of any additions to or variation from the drawings provided such as, but not limited to cable paths and termination point. The as built drawings shall include, but are not limited to block diagrams, frame and cable labeling, cable termination points, equipment room layouts and frame installation details. The as built shall include all field changes made up to construction completion:

- a) *Field directed changes to pull schedule.*
- b) *Horizontal cable routing changes.*
- c) *Associated detail drawings.*