This document has been prepared to aid consultants or engineers in developing contractual specifications covering the testing of duplex fibre optic cabling installations. 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 Fibre 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 backbone and horizontal optical fibre cabling.

B. This Section includes minimum requirements for:

1. Fibre optic test instruments
2. Fibre optic testing
3. Identification
   a) Labels and labeling
4. Administration
   a) Test results documentation
   b) As-built drawings

C. Testing shall be carried out in accordance with this document. This includes testing the attenuation and polarity of the installed cable plant with an optical loss test set (OLTS) and the installed condition of the cabling system and its components with an optical time domain reflectometer (OTDR). The condition of the fibre end faces shall also be verified.

D. Testing shall be performed on each cabling link (connector to connector).

E. Testing shall be performed on each cabling channel (equipment to equipment) that is identified by the owner.

1. Testing shall not include any active devices or passive devices within the link or channel other than cable, connectors, and splices, i.e. link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.

F. All tests shall be documented including OLTS dual wavelength attenuation measurements and OTDR traces with event tables as well as OTDR maps.

1. Optionally, documentation shall also include optical length measurements and pictures of the connector end face.

1.3 QUALITY ASSURANCE

A. All testing procedures and field-test instruments shall comply with applicable requirements of:

1. ANSI Z136.2, ANS For Safe Use Of Optical Fibre Communication Systems Utilizing Laser Diode And LED Sources
2. ANSI/TIA 526 14-C, Optical Power Loss Measurement of Installed Multimode Fibre Cable Plant with full OTDR descriptions
3. ANSI/TIA 526 7-A, Measurement of Optical Power Loss of Installed Single-Mode Fibre Cable Plant
4. TIA-TSB-4979, Practical Considerations for Implementation of Multimode Launch Conditions in the Field
5. ANSI/TIA-568-C.0, Generic Telecommunications Cabling for Customer Premises
6. ANSI/TIA-568.3-D, Optical Fibre Cabling and Components Standard
7. ANSI/TIA-606-B, Administration Standard for Commercial Telecommunications Infrastructure, including the requirements specified by the customer, unless the customer specifies their own labelling requirements

B. 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:

1. Manufacturer of the fibre optic cable and/or the fibre optic connectors.
2. Manufacturer of the test equipment used for the field certification or representative.
3. Training organization e.g. BICSI

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 catalog sheets and specifications for fibre optic field-test instruments including optical loss test sets (OLTS; power meter and source), optical time domain reflectometer (OTDR) and video microscope.

B. A schedule (list) of all optical fibres 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 compliance with the following test limits:

1. Optical loss testing

a) Multimode and Singlemode links

1) The link attenuation shall be calculated by the following formulas as specified in ANSI/TIA-568.3-D.

(i) Link Attenuation (dB) = Cable_Attn (dB) + Connector_Attn (dB) + Splice_Attn (dB)

*(ii) Cable_Attn (dB) = Attenuation_ Coefficient (dB/km) * Length (Km)*

*(iii) Connector_Attn (dB) = number_of_ connector_pairs * connector_loss (dB)*

(iv) Maximum allowable connector_loss = 0.75 dB

Check your application limits, you may need to reduce the allowable connector loss here

(v) Use of Reference Grade connectors in Test Reference Cords.

Test Reference Cords shall use Reference Grade connectors and the mated loss budget value (first and last) for these cords for Multimode shall be 0.30 dB and for Single-Mode shall be 0.50 dB.

*(vi) Splice_Attn (dB) = number_of_splices * splice_loss (dB)*

(vii) Maximum allowable splice_loss = 0.3 dB

Check your application limits, you may need to reduce the allowable connector loss here

(viii) The values for the Attenuation_ Coefficient (dB/km) are listed in the table below: Your cable may perform better than this, check the datasheet from the vendor and insert values here if desired

Type of Optical Fibre	Wavelength (nm)	Attenuation coefficient (dB/km)	Wavelength (nm)	Attenuation coefficient (dB/km)
Multimode 62.5/125 µm	850	3.5	1300	1.5
Multimode 50/125 µm	850	3.0	1300	1.5
Single-mode (Inside plant)	1310	1.0	1550	1.0
Single-mode (Outside plant)	1310	0.5	1550	0.5

2. OTDR testing

a) Reflective events (connections) shall not exceed: Check your application limits, you may need to reduce the allowable connector loss/ reflectance here

1) 0.75 dB in optical loss when bi-directionally averaged

2) -35 dB Reflectance for multimode connections

3) -40 dB reflectance for UPC singlemode connections

4) -55 dB reflectance for APC singlemode connections

b) Non-reflective events (splices) shall not exceed 0.3 dB. Check your application limits, you may need to reduce the allowable splice loss here

3. Magnified end face inspection

a) Fibre connections shall be visually inspected to IEC 61300-3-35 Edition 1.0 for end face quality.

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

B. All installed 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.

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.

Note: High Bandwidth applications such as 10GBASE-SR, FC1200, and 40GBASE-SR4 impose stringent channel loss limits. Where practical, certification should consider loss length limits that meet maximum channel (transmitter to receiver) loss. 0.75 dB per connector pair loss may not support the intended application.

D. Performance specification for multimode fibre links at 850 nm.

Fibre Type		Bandwidth	10 GBASE-SR		Fibre Channel 1200-MX-SN-1		40 GBASE-SR4	
µm		(MHz.Km)	Length (m)	Loss (dB)	Length (m)	Loss (dB)	Length (m)	Loss (dB)
OM1	62.5	200	33	2.5	33	2.4	N/A	N/A
OM2	50	500	82	2.3	82	2.2	N/A	N/A
OM3	50	2000	300	2.6	300	2.6	100	1.9
OM4	50	4700	400	2.9	N/A	N/A	150	1.5
OM5	50	4700	400	2.9	N/A	N/A	150	1.5

PART 2 - PRODUCTS

2.1 OPTICAL Fibre CABLE TESTERS

A. The field-test instrument shall be within the calibration period recommended by the manufacturer and a copy of the calibration certificate made available.

B. Optical loss test set (OLTS)

1. Multimode optical fibre light source
   a) Provide dual LED light sources with central wave lengths of 850 nm (+30 nm) and 1300 nm (+20 nm). VCSEL sources are not permitted per ANSI/TIA-526-14-C.
   b) Output power of –20 dBm minimum.
   c) The launch shall meet the Encircled Flux launch requirements of ANSI/TIA 526-14-C.
   d) The test reference cords must demonstrate an insertion loss ≤ 0.15 dB when mated against each other, and this test shall be stored and delivered with the other test results.
   e) Acceptable manufacturers
      1) Fluke Networks
2. Singlemode optical fibre light source
   a) Provide dual laser light sources with central wave lengths of 1310 nm (+20 nm) and 1550 nm (+20 nm).
   b) Output power of –10 dBm minimum.
   c) The test reference cords must demonstrate an insertion loss ≤ 0.25 dB when mated against each other, and this test shall be stored and delivered with the other test results.
   d) Acceptable manufacturers
      1) Fluke Networks
3. Power Meter
   a) Provide 850 nm, 1300 nm, 1310 nm, and 1550 nm wavelength test capability.
   b) Power measurement uncertainty of + 0.25 dB.
   c) Store reference power measurements.
   d) Save at least 10,000 results to internal memory.
   e) PC interface (USB).
   f) Acceptable manufacturers
      1) Fluke Networks
4. Optional length measurement
   a) It is preferable to use an OLTS that is capable of measuring the optical length of the fibre using time-of-flight techniques.

C. Optical Time Domain Reflectometer (OTDR)

1. Shall have a bright, color LCD display with backlight.
2. Shall have rechargeable Li-Ion battery for 8 hours of normal operation.
3. Weight with battery and module of not more than 4.5 lb and volume of not more 200 in^3.
4. Internal non-volatile memory with capacity for storing at least 2,000 OTDR bi-directionally tested fibre links.
5. USB port to transfer data to a PC or thumb drive/memory stick.
6. Multimode OTDR
   a) Wavelengths of 850 nm (+ 10 nm) and 1300 nm (+ 35 nm / - 15 nm).
   b) Event dead zones not to exceed 0.7 m at 850 nm and 1300 nm.
   c) Attenuation dead zones not to exceed 2.5 m at 850 nm and 4.5 m at 1300 nm.
   d) Distance range not less than 9,000 m.
   e) Dynamic range at least 28 dB for 850 nm and 30 dB at 1300 nm.
   f) Allow bi-directional testing without moving the OTDR to the far end.
   g) Perform on-board bi-directional averaging.
7. Singlemode OTDR
   a) Wavelengths of 1310 nm (+ 25 nm) and 1550 nm (+ 30 nm).
   b) Event dead zones not to exceed 0.6 m at 1310 nm and 1550 nm.
   c) Attenuation dead zones not to exceed 3.7 m at 1310 nm and 1550 nm.
   d) Distance range not less than 80 km at 1310 nm and 130 km at 1550 nm.
   e) Dynamic range at least 32 dB for 1310 nm and 30 dB at 1550 nm.
   f) Allow bi-directional testing without moving the OTDR to the far end.
   g) Perform on-board bi-directional averaging.
8. Acceptable manufacturers
   a) Fluke Networks

D. Fibre Microscope

1. Field of view 420 µm x 320 µm
   a) Video camera systems are preferred.
   b) Camera probe tips that permit inspection through adapters are required.
   c) Test equipment shall be capable of saving and reporting the end face image to IEC 613003-3-35.
2. Acceptable manufacturers
   a) Fluke Networks

E. Integrated OLTS, OTDR and fibre microscope
1. Test equipment that combines into one instrument an OLTS, an OTDR and a fibre microscope may be used.
2. Acceptable manufacturers
a) Fluke Networks

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) Panduit
b) Silver Fox
c) W.H. Brady
d) d-Tools
e) Brother
f) Dymo
g) Epson

2.3 ADMINISTRATION

A. Administration of the documentation shall include test results of each fibre link and channel.

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 and/or cloud-based database utility that allows for the maintenance, inspection and archiving of these test records.

PART 3 – EXECUTION

3.1 GENERAL

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

B. All outlets, cables, patch panels and associated components shall be fully assembled and labelled prior to field-testing. Any testing performed on incomplete systems shall be redone on completion of the work.

3.2 OPTICAL Fibre CABLE TESTING

A. Field-test instruments shall have the latest software and firmware installed.

B. 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 and/or a cloud-based service in which the administrative documentation (reports) may be generated.

C. Fibre end faces shall be inspected using a video scope with a field of view not less than 425 µm x 320 µm.
1. It is preferable that the end face images be recorded in the memory of the test instrument for subsequent uploading to a PC and reporting.

D. Testing shall be performed on each cabling segment (connector to connector).

E. Testing shall be performed on each cabling channel (equipment to equipment) that is planned for use per the owner's instructions.

F. Testing of the cabling shall be performed using high-quality test reference cords of the same core size as the cabling under test, terminated with reference grade connectors. Reference grade connectors are defined as having a loss not exceeding 0.1 dB for multimode and 0.2 dB for singlemode. The test reference cords for OLTS testing shall be between 2 m and 5 m in length. The length of the launch and tail fibres for multimode OTDR testing shall be at a least 100 m (328 ft.). For singlemode, the length of the launch and tail fibres will depend on the link under test. As a guide, the following table can be used for determining the length of the launch and tail fibres.

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	2,400

G. Optical loss testing
1. Horizontal/Backbone link
a) Multimode links shall be tested in one direction at 850 nm and 1300 nm in accordance with ANSI/TIA-526-14-C, one-cord reference method, with an Encircled Flux compliant launch.
b) Singlemode backbone links shall be tested in one direction at 1310 nm and 1550 nm in accordance with ANSI/TIA-526-7-A, Method A.1 (One-cord reference method).
c) 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.

H. OTDR Testing

1. Fibre links shall be tested at these wavelengths for anomalies and to ensure uniformity of cable attenuation, connector insertion loss and reflectance.
   a) Multimode: 850 nm and 1300 nm.
   b) Singlemode: 1310 nm and 1550 nm.
2. Each fibre link and channel shall be tested in both directions.
   a) The launch and tail fibres shall remain in place for the measurement in the opposite direction – failing to do so will result in an increase in measurement uncertainty.
   b) The use of a loop back fibre at the far end with a tail fibre at the near end on the adjacent fibre is permitted for bi-directional testing, so long as the OTDR is able to split the trace automatically into two traces for the two fibres under test.
3. A launch cable shall be installed between the OTDR and the first link connection.
4. A tail cable shall be installed after the last link connection.

I. Magnified End face Inspection

1. Fibres shall be inspected using a video scope with a minimum field of view 425 µm x 320 µm to IEC 61300-3-35 Edition 1.0. The following test limits shall be used:
   a) Multimode connectors; Table 6 of IEC 61300-3-35 Edition 1.0
   b) Singlemode field polished connectors; Table 5 of IEC 61300-3-35 Edition 1.0
   c) Singlemode factory polished connectors; Table 3 of IEC 61300-3-35 Edition 1.0
   d) Angled Physical Contact (APC) connectors; Table 4 of IEC 61300-3-35 Edition 1.0

J. Length Measurement

1. The length of each fibre shall be recorded.
2. It is preferable that the optical length be measured using an OLTS or OTDR.

K. Polarity Testing

1. Paired duplex fibres in multi-fibre cables shall be tested to verify polarity in accordance with Clause E.5.3 of ANSI/TIA 568.3 D. The polarity of the paired duplex fibres shall be verified using an OLTS.

3.3 IDENTIFICATION

A. Labeling

1. Labeling shall conform to the requirements specified within ANSI/TIA-606-B or to the requirements specified by the Owner or the Owner's representative.

3.4 ADMINISTRATION

A. Test results documentation

1. Test results saved within the field-test instrument shall be transferred into a Windows™-based and/or cloud-based database utility that allows for the maintenance, inspection and archiving of the test records.
   a) Portable document format (PDF)
   b) Word (.doc & .docx)
   c) Comma separated values (.csv)
   d) Excel separated values (.xls & .xlsx)
   e) Text (.txt)
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 in an electronic format or, preferably through a cloud-based service, prior to Owner acceptance of the building in the original format used by the cabling vendors' software.
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 optical fibre and shall contain the following information
   a) The identification of the customer site as specified by the end-user.
   b) The name of the test limit selected to execute the stored test results.
   c) The name of the personnel performing the test.
   d) The date and time the test results were saved in the memory of the tester.
   e) The manufacturer, model and serial number of the field-test instrument.
   f) The version of the test software and the version of the test limit database held within the test instrument.
   g) The fibre identification number.
   h) The length for each optical fibre.
   i) The index of refraction used for length calculation when using length capable OLTS.
   j) The backscatter coefficient of the fibre under test when using an OTDR.
   k) Test results to include OLTS attenuation link and channel measurements at the appropriate wave length(s) and the margin (difference between the measured attenuation and the test limit value).
   l) Test results to include OTDR link and channel traces, event tables at the appropriate wavelength(s) and a map of the link tested.
   m) The length for each optical fibre as calculated by the OTDR.
   n) The overall Pass/Fail evaluation of the link-under-test for OLTS and OTDR measurements
   o) Optional
      1) A picture or image of each fibre end-face
      2) A pass/fail status of the end-face using IEC 61300-3-35 Edition 1.0

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 CD/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. CAD drawings are to incorporate test data imported from the test instruments.

2. The as built drawings shall include, but are not limited to block diagrams, frame and cable labelling, 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) Field directed changes to cross connect and patching schedule.

c) Horizontal cable routing changes.

d) Backbone cable routing or location changes.

e) Associated detail drawings.