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 labour, 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 labelling
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 for multimode and singlemode links and channels and OTDR traces and event tables for multimode and singlemode links and channels.

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. ISO/IEC 14763-3 Information technology - Implementation and operation of customer premises cabling - Part 3: Testing of optical fibre cabling
2. IEC 60825-2, Safety of laser products – Part 2: Safety of optical fibre communication systems (OFCS)
3. IEC 61280-1-4, Fibre optic communication subsystem test procedures – Part 1-4: General communication sub systems – Light source encircled flux measurement method

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.
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 fibre optic field-test instruments including optical loss test sets (OLTS; power meter and source), optical time domain reflectometer (OTDR) and inspection scope.

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 ISO/IEC 14763-3
      (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 for connections embedded into link and 0.50/0.75 dB (MM/SM) for the first and last connector of the link. This budget includes the loss of splice if pigtails are used.
      *(v) Splice_Attn (dB) = number_of_splices * splice_loss (dB)*
      (vi) Maximum allowable splice_loss = 0.30 dB
      (vii) The values for the Attenuation_ Coefficient (dB/km) are listed in the table below:

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	3.5	1300	1.5
Single-mode (Inside plant)	1310	1.4	1550	1.0
Single-mode (Outside plant)	1310	1.0	1550	0.4

2. OTDR testing
   a) Reflective events (connections) shall not exceed 0.75 dB for connections embedded into the link and 0.50/0.65 dB (MM/SM) for the first and last connector of the link
   b) Non-reflective events (splices) shall not exceed 0.30 dB.
3. Magnified end face inspection
   a) Fibre connections shall be visually inspected 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 1000BASE-SX, 10GBASE-SR, and FC1200 impose stringent channel loss limits. Where practical, certification should consider loss length limits that meet maximum channel (transmitter to receiver) loss.

Fibre Type		Bandwidth	1000BASE-SX	
µm		(MHz.Km)	Length (m)	Loss (dB)
OM1	62.5	200	275	2.38
OM2	50	500	550	3.56
OM3	50	2000	N/A	N/A
OM4	50	4700	N/A	N/A

Fibre Type		10GBASE-SR		FibreChannel 1200-MX-SN-I	
µm		Length (m)	Loss (dB)	Length (m)	Loss (dB)
OM1	62.5	33	2.5	33	2.4
OM2	50	82	2.3	82	2.2
OM3	50	300	2.6	300	2.6
OM4	50	400	2.9	N/A	N/A

PART 2 - PRODUCTS

2.1 OPTICAL FIBRE CABLE TESTERS

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

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)
   b) Output power of –20 dBm minimum.
   c) The light source shall meet the Encircled Flux launch requirements of IEC 61280-1-4.

d) The test reference cords must demonstrate an insertion loss ≤ 0.15 dB when mated against each other. This performance needs to be verified after setting the reference and then again every time 300 links had been tested. The results from verifying the test reference cords shall be stored alongside link 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. This performance needs to be verified after setting the reference and then again every time 300 links had been tested. The results from verifying the test reference cords shall be stored alongside link results.

d) Acceptable manufacturers

1) Fluke Networks

3. Power Meter

a) Provide 850 nm, 1300, 1310 nm and 1550 nm wave length test capability.

b) Power measurement uncertainty of ± 0.25 dB.

c) Store reference power measurement.

d) Save at least 10,000 results in internal memory.

e) PC interface (USB, RJ45 or cloud connectivity).

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, colour transmissive LCD display with back-light.
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 for results storage.
5. USB ports to transfer data to a PC or internet connectivity to transfer results to a cloud storage
6. Multimode OTDR

a) Wavelengths of 850 nm (± 20 nm) and 1300 nm (± 20 nm).

b) Event dead zones of 1.0 m maximum at 850 nm and 1300 nm.

c) Attenuation dead zones of 2.5 m maximum at 850 nm and 4.5 m maximum at 1300 nm.

d) Distance range not less than 9,000 m.

e) Dynamic range at least 28 dB at 850 nm and 30 dB at 1300 nm.

7. Singlemode OTDR

a) Wavelengths of 1310 nm (± 20 nm) and 1550 nm (± 20 nm).

b) Event dead zones of 1 m maximum at 1310 nm and 1550 nm.

c) Attenuation dead zones of 3.6 m maximum at 1310 nm and 3.7 m maximum at 1550 nm.

d) Distance range not less than 130,000 m @ 1550 nm.

e) Dynamic range at least 30 dB at 1310 nm and 1550 nm

8. Acceptable manufacturers

a) Fluke Networks

D. Fibre Microscope

1. View of field min. 320 x 320 µm. Minimum detectable particle size 0.5 µm
2. Acceptable manufacturers

a) Fluke Networks

3. Optional requirements

a) Video camera systems are preferred.

b) Camera probe tips that permit inspection through adapters are preferred.

c) Use test equipment capable of saving and reporting the end face image.

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

F. 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 colour 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 coloured 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) Brothers

2.2 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 database utility that allows for the maintenance, inspection and archiving of these test records. Alternatively the result records maybe uploaded to a cloud service for intermediate access.

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 or Cloud account in which the administrative documentation (reports) may be generated.

C. Fibre end faces shall be inspected with a minimum view of field of 320 x 320 µm and minimum detectable particle size 0.5 µm. This is suitable for inspecting multimode and singlemode fibres. Scratched, pitted or dirty connectors shall be diagnosed and corrected.

1. End faces shall be inspected for compliance with IEC 61300-3-35 Ed.1
2. It is preferable that the end face images be recorded in the memory of the test instrument for subsequent up loading 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 cords of the same fibre type as the cabling under test. The test cords for OLTS testing shall be between 1 m and 5 m in length. The test cords for OTDR testing shall be approximately 100 m for the launch cable and at least 25 m for the receive cable.

G. Optical loss testing

1. Horizontal/Backbone link

a) Multimode links shall be tested at 850 nm and 1300 nm in accordance with ISO/IEC 14763-3 One Jumper Reference Method

b) Singlemode backbone links shall be tested at 1310 nm and 1550 nm in accordance with ISO/IEC 14763-3 One Jumper 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 the appropriate operating wavelengths for anomalies and to ensure uniformity of cable attenuation and connector insertion loss.

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. The calculated bi-directional average for each connector or splice loss shall be used to pass or fail the link.
3. A launch fibre shall be installed between the OTDR and the first link connection.
4. A tail fibre shall be installed after the last link connection
5. When testing from the opposite direction (End2) the fibre which functioned as a tail fibre when testing from (End1) will no function as a launch fibre.
6. It is recommended for improved efficiency and in order to reduce the number of matings between launch/tail-fibres and the link under test that, to use a loop fibre with length similar to launch/fail-fibre to test the A and B fibre of a duplex link at the same time

a) Phase 1: Configuration

[OTDR] > [L/T-Fibre#1] > [Fibre A] > [Loop-Fibre] > [Fibre B] > [L/T-Fibre#2]

b) Phase 2: Configuration

[OTDR] > [L/T-Fibre#2] > [Fibre B] > [Loop-Fibre] > [Fibre A] > [L/T-Fibre#1]

c) Test Results:

The results stored shall include all the details as if the following four individual test were performed

1) From End 1: Fibre A

2) From End 2: Fibre A

3) From End 1: Fibre B

4) From End 2: Fibre B

d) From the above four results the bi-directional averages for all connectors in Fibre A and B are calculated. These results are used to pass or fail the link

I. Magnified End face Inspection

1. Fibre end faces shall be inspected with a minimum view of field of 320 x 320µm and minimum detectable particle size 0.5 µm. This is suitable for inspecting multimode and singlemode fibres.

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 ISO/IEC 14763-3 Part 11.2 The polarity of the paired duplex fibres shall be verified using an OLTS.

3.3 IDENTIFICATION

A. Labelling

1. Labelling 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 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-ROM/DVD prior to Owner acceptance of the building. This CD-ROM/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 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
1) The index of refraction used for length calculation when using a length capable OLTS
i) 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).
j) Test results to include OTDR link and channel traces and event tables at the appropriate wavelength(s).
k) The length for each optical fibre as calculated by the OTDR.
l) The overall Pass/Fail evaluation of the link-under-test for OLTS and OTDR measurements
m) Optional
1) A picture or image of each fibre end-face
2) A pass/fail status of the end-face based upon IEC 61300-3-35.

B. Record copy and as-built drawings

1. Provide record copy drawings periodically throughout the project as requested by the Construction Manager or Owner, and at end of the project on CD-ROM/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 builds 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.