

SECTION 27 08 21  
COMMUNICATIONS FIBER OPTIC TESTING  
Construction Specification

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes: Testing of Telecommunications Backbone Fiber Optic Cabling.
- B. Related Sections
  - 1. Comply with the Related Sections paragraph of Section 270000.
  - 2. Section 271323 - Communication Backbone ISP Fiber Optic Cabling
  - 3. Section 271324 - Communication Backbone OSP Fiber Optic Cabling

1.2 REFERENCES

- A. Comply with the References requirements of Section 270000.
- B. In addition, the following standards are referenced to this Section:
  - 1. TIA/EIA-526-14A (OFSTP-14), "Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant"
  - 2. TIA/EIA-526-7 (OFSTP-7), "Measurement of Optical Power Loss of Installed Singlemode Fiber Cable Plant"
  - 3. EIA/TIA-455-77 (FOTP-77), "Procedures To Qualify A Higher-Order Mode Filter For Measurements On Singlemode Fibers"
  - 4. EIA/TIA-455-78A (FOTP-78), "Spectral-Attenuation Cutback Measurement for Singlemode Optical Fibers"
  - 5. EIA-455-95 (FOTP-95), "Absolute Optical Power Test for Optical Fibers and Cables"
  - 6. EIA-455-171 (FOTP-171), "Attenuation By Substitution Measurement – For Short-Length Multimode Graded-Index And Single-Mode Optical Fiber Cable Assemblies"
  - 7. American National Standards Institute (ANSI) Z136.2, "American National Standard for the safe use of optical fiber communication systems utilizing laser diode and LED sources"
  - 8. BICSI Telecommunication Distribution Methods Manual (TDMM)

1.3 DEFINITIONS

- A. Refer to Definitions of Section 270000, Section 271323, and Section 271324.

- B. In addition to those Definitions of Section 270000, the following list of terms as used in this specification defined as follows:
1. "Adapter" (associated with fiber connectivity): Shall mean a connecting device that joins 2 fiber connectors, either like or unlike
  2. "Connect": Shall mean install all required test cords, patch cords, system cords, etc. to complete an optical circuit
  3. "CPR": Coupled Power Ratio (according to TIA/EIA-526-14A Annex A
  4. "Cord": Shall mean a length of cordage having connectors at each end; the term "Cord" is synonymous with the term "Jumper"
  5. "Jumper": See "Cord"
  6. "OTDR": Shall mean Optical Time Domain Reflectometer
  7. "Passive Link Segment": Shall mean the cable, connectors, couplings, and splices between two fiber optic termination units
  8. "System Cord": Shall mean the cord used in the operating electrical or optical circuit.
  9. "Test Cord": Shall mean the cord certified for use in testing, as described in this section

1.4 SYSTEM DESCRIPTION

- A. Refer to Section 270000, Section 271323, and Section 271324 for addition system description information.
- B. Work Provided Under Other Sections
  1. Backbone fiber optic cabling
- C. Base Bid Work
  1. Submittals: pre-testing and post-testing
  2. Testing of completed fiber optic passive link segment(s) per the following table:

**Table 270821-1.1: Tests For Fiber Optic Cabling**

Subsystem	Type	Test	Direction	Wavelength
Backbone	Multimode	Optical Power Loss	Both	850nm and 1300nm
Backbone	Singlemode	Optical Power Loss	Both	1310nm and 1550nm
Backbone	Multimode	Characterization	Both	850nm and 1300nm
Backbone	Singlemode	Characterization	Both	1310nm and 1550nm

3. Record Documents, including test results

## 1.5 SUBMITTALS

- A. Comply with the Submittal requirements of Section 270000.
- B. Submittal Requirements at Start Of Construction:
  - 1. Testing Procedures Submittal: Describe step-by-step procedures used by the field technicians.
  - 2. Pre-Testing Loss Calculations Submittal: Calculate the loss of each segment. The cable length may be based on the footage markings printed on the cable jacket. Include a brief description of each segment.
  - 3. Product Submittal, including cut sheets of testing equipment and the following information (*this data must match the test reports*):
    - a. Manufacturer and model number
    - b. Serial number
    - c. Date of last factory calibration
    - d. Software/ firmware versions (as applicable)
  - 4. Schedule Submittal, consisting of proposed schedule of work (this schedule may be combined with the schedule developed for Division 27)
- C. Submittal Requirements at Closeout:
  - 1. Submit test results and reports in a format acceptable to the Owner, or Owner's Representative, or Engineer before system acceptance.
  - 2. Submit one soft copy of test reports, including all tested parameters. This may be combined with the reports of Section 270811.
  - 3. Submit one hard copy of warranty certificate from the manufacturer and the Contractor
  - 4. Each test report (per strand per cable link) shall include the following information:
    - a. Project/Client name, and project address
    - b. Date of test
    - c. Contractor (Company) and Technician's name
    - d. Test equipment, including Serial Numbers (*must match pre-testing submittal*)
    - e. Test procedure (e.g., OFSTP-14A) and method (e.g., Method B)
    - f. Light source's launch category (including CPR) and spectral width
    - g. Wavelength
    - h. Cable identifier, fiber number, and fiber type (e.g., "multimode")
    - i. Measurement direction, including end locations
    - j. Optical loss measurement

5. Cable and fiber identifiers of the test reports shall match the identifiers as labeled in the field – i.e., the ID stored with the test result shall be the same ID as on the cable label/fiber port label.
6. Format – Soft Copy:
  - a. Provide test report files as native data format (for example, an \*.FLW file from a Fluke tester). If not possible to submit in native format, then issue test results as an exported Microsoft Excel compatible format.
  - b. Clearly indicate the results with the following information:
    1. Client Name
    2. Project Name and Address
    3. Date of Submittal – date format: <month> <day>, <year> (e.g., “January 1, 2023”)
    4. Contractor Name

## 1.6 QUALITY ASSURANCE

- A. Comply with the Quality Assurance requirements of Section 270000.
- B. Testing equipment shall be fully functional and in proper working order. Testing equipment shall be factory calibrated within the manufacturer's published calibration period. Testing equipment must have loaded the latest firmware / operating software.
- C. Under no circumstances shall any cable's and/or optical conductor's test results be substituted for another's. If an instance of falsification is confirmed, the Contractor will be liable for a complete retest of the cabling system at no additional cost to the Owner. This includes the retaining the services of a neutral party to observe all retesting.

## 1.7 WARRANTY

- A. Warrant the validity of the test results. Issue such warranty in writing.

## PART 2 PRODUCTS

### 2.1 FIBER OPTIC LIGHT SOURCE

- A. Light source used for testing multimode fibers shall confirm to TIA/EIA-526-14A, 3.1. Light source used for testing singlemode fibers shall confirm to TIA-526-7, 3.1.1.
- B. Light source's modal launch condition shall be Category 1.
- C. Light source's connection interfaces shall be factory installed. Field-configurable connection interface will not be allowed.
- D. Light source's output wavelength and power shall be constant/unchanged after setting.
- E. Light source shall be factory calibrated (date of last factory calibration must be documented).

F. Equipment:

1. Fluke Networks
  - a. #Versiv 2 – or bundled kit
  - b. #Certifiber Pro Fiber Module, for Multimode/Singlemode Fiber
2. Or equal

2.2 FIBER OPTIC POWER METER

- A. Power meters used for testing multimode fibers shall conform to TIA/EIA-526-14A, 3.2. Power meters used for testing singlemode fibers shall conform to TIA/EIA-526-7, 3.1.2.
- B. Power meter shall be capable of measuring both relative and absolute power, and shall feature data storage (of measurements).
- C. Power meter used shall have the following performance:
  1. Dynamic range of 0dBm to -50dBm, minimum
  2. Accuracy of  $\pm 0.2$ dB
- D. Power meter shall be factory calibrated (date of last factory calibration must be documented).
- E. Equipment:
  1. Fluke Networks
    - a. #Versiv 2 – or bundled kit
    - b. #Certifiber Pro Fiber Module, for Multimode/Singlemode Fiber
  2. Or equal

2.3 FIBER OPTIC MANDREL

- A. For 50/125  $\mu$ m fiber: 22 mm mandrel diameter for jacketed (3.0 mm) fiber.
- B. Equipment:
  1. Fluke Networks
    - a. #NF-MANDREL-50; red mandrel for jacketed 50/125  $\mu$ m fiber

2.4 FIBER OPTIC OTDR

A. Multimode Source Module:

Wavelength	Dynamic Range	Attenuation Deadzone	Reflective Deadzone	Loss Resolution	Distance Accuracy
850nm	24dB	6.5mt	3.0mt	0.001dB	0.1mt
1300nm	27dB	7.0mt	3.0mt	0.001dB	0.1mt

B. Singlemode Source Module:

Wavelength	Dynamic Range	Attenuation Deadzone	Reflective Deadzone	Loss Resolution	Distance Accuracy
1310nm	40dB	6.0mt	3.5mt	0.001dB	0.1mt
1550nm	28dB	12.0mt	3.5mt	0.001dB	0.1mt

C. Equipment:

1. Corning Cable Systems

- a. #OV-1000; OTDR 'mainframe'
- b. #400-MD26; multimode module for OV-1000 OTDR
- c. #400-SD34; singlemode module for OV-1000 OTDR
- d. #2001HR; for multimode & singlemode systems (legacy product series)
- e. #340 OTDR Plus Multitester II (legacy product series)
- f. #MiniOTDR+; for multimode & singlemode systems (legacy product series)

2. Exfo

- a. #FTB-500 platform OTDR
- b. #FTB-200 platform compact OTDR

3. Fluke Networks

- a. #OF-500; "OptiFiber" OTDR mainframe – or bundled kit
- b. #OFTM-5610B; Multimode module for OptiFiber OTDR
- c. #OFTM-5730; Singlemode module for OptiFiber OTDR
- d. #OFTM-5610B; Multimode module for OptiFiber OTDR

4. Or equal

D. Reader Software: Windows-based software capable of reading stored traces and is fully functional with the testing equipment.

2.5 FIBER OPTIC TEST CORDS

A. Multimode Fiber Optic Test Cord

- 1. Multimode test cords shall conform to TIA-526-14A, 3.3.
- 2. The fiber of the multimode test cord(s) shall have the core diameter to that of the multimode fiber optic passive link under test.
- 3. Connectors of the test cords shall be compatible with (the same type as) the connector types of the light source and the power meter, and with the cabling plant.

4. The connectors shall exhibit  $\leq 0.5\text{dB}$  loss per connection @ both 850nm and 1300nm, as measured per FOTP-171 D2.
  5. Test cord length for Optical Power Loss testing: 1m - 5m.
- B. Singlemode Fiber Optic Test Cord
1. Singlemode test cords shall comply to 526-14A, 3.1.3.
  2. The fiber of the singlemode test cord(s) shall have the mode field diameter nominally equal to that of the singlemode fiber optic passive link.
  3. Connectors of the test cords shall be compatible (the same type) with the connector types of the light source and the power meter, and with the cabling plant.
  4. The connectors shall exhibit  $\leq 0.5\text{dB}$  loss per connection @ both 1310nm and 1550nm, as measured per FOTP-171 D3. The connectors shall inhibit Fresnel reflections (i.e., have a "PC" finish).
  5. Test cord length for Optical Power Loss testing: 1m - 5m.

### PART 3 EXECUTION

#### 3.1 FIELD QUALITY CONTROL

- A. Prior to the start of testing, set up a meeting with the Engineer to witness testing procedures. The Engineer will, at their discretion, come to the site and witness the technician's actual testing procedures. The Engineer may give verbal comments to correct the technician's procedures to meet these requirements, followed up with a written observation report.
- B. Calibrate test sets and associated equipment per the manufacturers printed instructions at the beginning of each day's testing and after each battery charge. Fully charge the test sets prior to each day's testing to ensure proper operation.
- C. Use undamaged test equipment and test cords. Clean connectors and adapters (with a lint-free wipe and 90% (or higher) isopropyl alcohol) prior to and during testing activities. Per the Engineer's discretion, halt testing activity and clean testing equipment, test cords, and related apparatus.
- D. Permanently record test results.

#### 3.2 OPTICAL POWER LOSS TESTING REQUIREMENTS AND PROCEDURES

- A. Safety: Use test equipment containing a laser or LED in accordance with ANSI Z136.2.
- B. Test fiber optic passive links per "Base Bid Work" under System Description in Part 1 of this Section. Follow the procedures in the following order.
- C. Precautions
  1. Adhere to the precautions described in TIA-526-14A, 5.1.
  2. Adhere to the equipment manufacturer's instructions during all testing.

3. Prior to any testing activity or any measurements taken:
  - a. Ensure test equipment is at room temperature – approximately 72 degrees F (if necessary, bring the test equipment in from outdoors and let it set until the test equipment reaches room temp).
  - b. Power on the light source and power meter for at least 5 minutes prior to obtaining measurements.
  - c. Clean connectors and adapters with a lint-free wipe and 90% (or higher) isopropyl alcohol.
4. Do not power off the light source or the power meter during testing activity.
5. Do not remove Test Cord #1 from the light source at any time (unless the testing is complete or the equipment is being put away for the evening).
6. Do not bend the test cords smaller than 20 times the cord diameter (this may induce loss into the cord reducing the accuracy of the measurement).

D. Test Cord Performance Verification

1. Connect Test Cord #1 to the light source and to the power meter.
2. Set this value into the power meter as the reference power ( $P_{ref}$ ).
3. Disconnect Test Cord #1 from the power meter. Do not disconnect Test Cord #1 from the light source.
4. Connect the 'open' end of Test Cord #1 to an adapter (of matching connector type). Connect one end of Test Cord #2 to that adapter and the other end of Test Cord #2 to the power meter.
5. The value displayed on the power meter represents the test cord #2 connection loss.
6. Flip the ends of Test Cord #2 so that the end connected to the power meter is now connected to the adapter (attached to test cord #1), and the end connected to the adapter is now connected to the power meter.
7. The value displayed on the power meter represents the test cord #2 connection loss on the opposite end.
8. Both connection loss measurements must be less than or equal to the value found in Table 270812-3.1 (below). Replace cord if measure losses exceed table values.

**Table 270821-3.1: Acceptable Test Cord Connection Attenuation**

	LC Connector	Other Mini-Connector
Multimode (OM4)	.20 dB Max	0.20 dB Max
Singlemode	.30 dB Max	0.30 dB Max

9. Repeat this test procedure from the beginning reversing the test cords in order to verify the performance of test cord #1.



- E. Test Equipment Set Up
  - 1. Follow the test equipment manufacturer's initial adjustment and set up instructions.
  - 2. Set the power meter to Relative Power Measurement Mode
  - 3. Set the meter to display power levels in dBm.
  - 4. Set the light source and power meter to the same wavelength.
- F. Multimode Passive Link Insertion Loss Testing Procedures
  - 1. Only use a light source that exhibits a Category 1 modal launch condition. Confirm the light source's modal launch condition following the procedures described in TIA-526-14A, Annex A.
  - 2. Test Method:
    - a. For 'permanent' links, perform the optical power loss testing of multimode fibers according to TIA-526-14A test method B "One Jumper Reference".
    - b. For 'channel' links, perform optical power loss testing of multimode fibers according to TIA-526-14A test method C "Three Jumper Reference" and include the system cords as part of the cable plant.
- G. Singlemode Passive Link Insertion Loss Testing Procedures
  - 1. Only use test jumpers that comply with the requirements TIA-526-7, 3.1.3.
  - 2. Test Method:
    - a. For 'permanent' links, perform the optical power loss testing of singlemode fibers according to TIA-526-7 test method A.1 "One Jumper-Cable Measurement".
    - b. For 'channel' links, perform optical power loss testing of singlemode fibers according to TIA-526-7 test method A.3 "Three Jumper-Cable Measurement" and include the system cords as part of the cable plant.
- H. Acceptable Measurement Values
  - 1. The measured loss shall not exceed the calculated loss of the pre-testing submittals.
- I. Record Test Measurements:
  - 1. Permanently record all test data per strand, including the following (minimum):
    - a. Project name
    - b. Cable identifier, fiber number, and fiber type (e.g., "multimode")
    - c. Testing company name
    - d. Testing technician's name
    - e. Date measurements were obtained

- f. Measurement direction
  - g. Wavelength
  - h. Loss measurement
  - i. Test equipment model and serial number(s)
2. If the test set (light source and power meter) does not have data storage capability, then utilize the forms provided in Part 4 of this Section (or similar) as test reports.
  3. Measurements shall carry a precision through one significant decimal place, minimum.

### 3.3 CHARACTERIZATION TESTING REQUIREMENTS AND PROCEDURES

- A. Safety: Use test equipment containing a laser or LED in accordance with ANSI Z136.2.
- B. Test fiber optic passive links per "Base Bid Work" in Part 1 of this Section.
- C. Precautions
  1. Adhere to the equipment manufacturer's instructions during testing.
  2. Prior to testing activity or measurements taken, complete the following activities:
    - a. Ensure the test equipment is at room temperature – approximately 70 degrees F (e.g., if necessary, bring the test equipment in from outdoors and let it set for about 15 minutes or for however long it takes to bring the test equipment to reach room temp).
    - b. Turn the light source and power meter power on for at least 5 minutes.
    - c. Clean test/launch cords' and system cords' connectors and the cabling system adapters with a lint-free wipe and 90% (or higher) isopropyl alcohol.
  3. Do not power off OTDR's light source during testing activity.
  4. Do not remove launch cord from the OTDR's light source at any time (unless the testing is complete or the equipment is being put away for the evening, or during trouble shooting).
  5. Do not bend the launch cord smaller than 20 times the cord diameter during testing activities (this may induce loss into the cord reducing the accuracy of the measurement).

D. Characterization Testing Procedures

1. Equipment settings / measurement parameters:

a. Index of Refraction: match cable-under-test fiber parameters; default settings as follows:

Multimode	CommScope 50/125	1.483 @ 850nm	1.478 @ 1300nm
	Corning 50/125 Infinicor	1.481 @ 850nm	1.476 @ 1300nm
Singlemode	CommScope TeraSPEED	1.466 @ 1310nm	1.467 @ 1550nm
	Corning SMF-28e+	1.4670 @ 1310nm	1.4677 @ 1550nm

b. Pulse Width: multimode: 20ns; singlemode: 50 ns

Multimode 50/125 4 ns for cable lengths up to 300 meters

20 ns for cable lengths between 300 meters and 2,000 meters

Singlemode 10 ns for cable lengths up to 2,000 meters

50 ns for cable lengths between 2,000 meters and 10,000 meters

c. Backscatter: multimode: -67dB @ 850nm, -74dB @ 1300nm; singlemode: -74dB @ 1310nm and 1550nm

d. Event Threshold: 0.05dB.

e. Reflection Threshold: multimode: -45dB, singlemode: -60dB.

f. Fiber Break/End-Of-Fiber: 3dB

2. Set the distance units (i.e., the “X” axis of the graph) to feet.

3. Waveform: The waveform shall be real-time and normal density.

4. Obtain measurements using a ‘launch’ cord connected to the test instrument and the cable-under-test.

a. The fiber of the launch cord shall match the fiber of the cable-under-test in physical and performance parameters (such as type, core/cladding size, index of refraction, refractive profile). The fiber of the launch cord should match the fiber of the cable-under-test in manufacturer and product.

b. The launch cord length shall be between 25 and 100 meters.

E. Record Test Measurements:

1. Permanently record all test data per strand, including the following (minimum):

a. Project name

b. Contractor name

- c. Testing technician's name
  - d. Date measurements were obtained
  - e. Cable identifier, strand number, and fiber type (e.g., "multimode")
  - f. Wavelength
  - g. Measurement direction
  - h. Full data set
  - i. Curve
  - j. Test equipment model and serial number(s)
2. Measurements shall carry a precision through one significant decimal place, minimum.

### 3.4 TESTING FORMS

#### A. SUMMARY OF FORMS

1. Fiber Optic Test Instrument Data Sheet
2. Fiber Optic Reference Power Measurement Method Form
3. Fiber Optic Relative Power Measurement Method Form

END OF SECTION

**Fiber Optic Test Instrument Data Sheet**

<b>LIGHT SOURCE</b>			
Manufacturer: _____	Serial Number: _____		
Model: _____	Last Calibration: _____		
Spectral Width: _____	Coupled Power Ratio (Category): _____		
850-nm: _____	850-nm: _____		
1300-nm: _____	1300-nm: _____		
1310-nm: _____	1310-nm: _____	N/A	
1550-nm: _____	1550-nm: _____	N/A	
<b>POWER METER</b>			
Manufacturer: _____	Serial Number: _____		
Model: _____	Last Calibration: _____		

Note: Submit a separate data sheet for each test set being used.

**Fiber Optic Reference Power Measurement Method Form**

<b>TEST SUMMARY INFORMATION</b>	
Test Personnel: _____	Date: _____
Light Source Location: _____	Power Meter Location: _____
Wavelength: _____	Reference Power Measurement ( $P_{ref}$ ): _____
Method: _____	
Page _____ of _____	

<b>TEST RESULTS</b>										
Strand #	Cable ID	Power ( $P_{sum}$ ) (dB)	Link Seg Attn (dB)	Accep Attn (dB)		Strand #	Cable ID	Power ( $P_{sum}$ ) (dB)	Link Seg Attn (dB)	Accep Attn (dB)
1						25				
2						26				
3						27				
4						28				
5						29				
6						30				
7						31				
8						32				
9						33				
10						34				
11						35				
12						36				
13						37				
14						38				
15						39				
16						40				
17						41				
18						42				
19						43				
20						44				
21						45				
22						46				
23						47				

24				
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48				
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**Fiber Optic Relative Power Measurement Method Form**

**TEST SUMMARY INFORMATION**

Test Personnel: \_\_\_\_\_ Date: \_\_\_\_\_  
 Light Source Location: \_\_\_\_\_ Power Meter Location: \_\_\_\_\_  
 Wavelength: \_\_\_\_\_  
 Method: \_\_\_\_\_  
 Page \_\_\_\_\_ of \_\_\_\_\_

**TEST RESULTS**

Strand #	Cable ID	Link Seg Attn (dB)	Accept Attn (dB)	Strand #	Cable ID	Link Seg Attn (dB)	Accept Attn (dB)
1				25			
2				26			
3				27			
4				28			
5				29			
6				30			
7				31			
8				32			
9				33			
10				34			
11				35			
12				36			
13				37			
14				38			
15				39			
16				40			
17				41			
18				42			
19				43			
20				44			
21				45			
22				46			
23				47			
24				48			



