National Radio Astronomy Observatory
Socorro, NM 87801

ELVA Memorandum 40

Fiber Optic Cable Acceptance Tests

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Summary

Optical cable must be tested throughout the procurement and installation process to ensure that NRAO receives a fiber transmission system without defects or added cost. Defects can be attributed to the cable manufacturing process, shipping, the cable installation, or the system buildup. These defects must be detected at the earliest possible time so that the defects can be corrected in the most effective manner, and so similar mistakes can be prevented in the future.

Acceptance test documentation forms the basis for future troubleshooting, emergency restoration, and quality assurance.

The following three acceptance tests are required.

Cable Reel Acceptance Test: conducted upon receipt of cable from a shipper.
Cable Installation Acceptance Test: conducted after cable burial.
Final Acceptance Test: conducted after all splices and connectors are installed.

All tests must be preformed at 1310 nm and 1550 nm. The differences in operating characteristics at these two wavelengths indicate whether the fiber has any particular anomalies. These tests are designed to find fiber anomalies.

Acceptance Test Documentation

Documentation of all tests is a high priority. The data accumulated from these tests will be an invaluable resource in the future. Before the EVLA project is completed, about 9000 fiber tests will be conducted for the underground cables alone. Therefore, a well-organized documentation system is a necessity. The recommended acceptance test forms are attached and are available in MS Excel format. The recommended organization of the documentation is as follows.

1. A three ring binder should be created to contain all Reel Acceptance tests, and should be organized by Reel ID.
2. A three ring binder should be created to contain all Installation Acceptance tests, and should be organized by Cable ID.
3. A three ring binder should be created to contain all Final Acceptance tests, and should be organized by Antenna Pad ID.
4. The binders should be kept and maintained in the Fiber Optic Field Lab at the VLA.

OTDR Trace File Names

Every OTDR trace associated with an acceptance test must be saved on computer disk and archived. These computer files are useful for future reference, and could also become a legal document. This means a very large number of files will accumulate; we will have more than 9000 files. Therefore, it is important that we have a file system that is well organized and easy to use. The following organization is recommended.

1. All acceptance test sub-folders should be kept in a folder named 'Cable_Acceptance'.
2. Reel acceptance test OTDR files should be kept in a sub-folder named after the Reel ID.
3. Installation acceptance test OTDR files should be kept in a sub-folder named after the Cable ID.
4. Final acceptance test OTDR files, and future troubleshooting test files, should be kept in a sub-folder named after the antenna pad that the fiber serves.
5. Files names should have a logical and consistent format such as follows.

Date code
Test location
Tube color, Fiber color

XXX-XXXX-XXXX-XXX-mmddyy

RAT - Reel ID = Reel Test
IAT - Cable ID = Installation Test
FAT - Pad ID = Final Test

6. The color code for fiber and tubes is shown below. A yellow fiber in an orange tube would have the color code ORYW.

    1. blue = BU
    2. orange = OR
    3. green = GR
    4. brown = BN
    5. slate = SL
    6. white = WT
    7. red = RD
    8. black = BK
    9. yellow = YW
    10. violet = VL
    11. rose = RS
    12. aqua = AQ

7. Test Location should be a location code such as ASP (Array Splice Panel), DW7 (Manhole at DW7), etc.
8. All files and folders should be backed up onto CD daily, and should be kept and maintained in the Fiber Optic Field Lab at the VLA.

Cable Reel Acceptance Test

The Cable Reel Acceptance Test (Reel Test) is a preliminary test to be preformed when NRAO receives cable from the shipper. This test should be performed as soon as possible after receipt of the shipment. The Reel Test only requires one end of the cable (normally the inside end), and does not require connectors on the fiber. This test is intended to verify that the fiber is received from the shipper in sound condition and without manufacturing defects. Any anomalies must be reported immediately to the shipper and manufacturer. Cable should not be used until it passes this test.

An MS Excel form has been created to log the following information. The Reel Acceptance Form can be found here: FO_Reel_AcceptForm 051402.xls

Tools Required

1. Knife
2. Armor Stripper
3. Kevlar Shears
4. Alcohol and wipes
5. Fiber Stripper
6. Fiber Cleaver
7. Bare Fiber Adapter, glass adapter, or mechanical splice
8. OTDR
9. Floppy Disk
10. Heat Shrink and Cable Ties
11. Reel Acceptance Test data sheet

Procedure

1. Record the following information.
    a. Cable ID
    b. Cable type
    c. Number of fibers
    d. Cable length as shown on reel
    e. Maximum specified loss at 1550 nm
    f. Maximum specified loss at 1310 nm
    g. Date
    h. Test Crew
    i. OTDR model and s/n
2. Inspect the cable and record any visible signs of defects.
3. Strip at least two feet of the cable end. Clean and strip the fibers.
4. Use a bare fiber adapter and an OTDR to take the following measurements from one end of the cable.
    a. Total loss at 1550 nm
    b. Attenuation per kilometer at 1550 nm
    c. Total loss at 1310 nm
    d. Attenuation per kilometer at 1310 nm
    e. Total length as indicated by ODTR
    f. Note any anomalies (rescale for clarity and record)

5. Print and record the OTDR traces on disk. Indicate direction of measurement, and loose tube and fiber color.
6. Note differences between the 1550nm trace and the 1310nm trace.
   a. Slightly greater attenuation over a length of fiber at the shorter wavelength is normal.
   b. Uncut cable should have no reflections or attenuation steps.
   c. Larger attenuation steps at the longer wavelength may indicate macrobending.
   d. Attenuation steps or gains at both wavelengths indicate spliced, broken or damaged fiber.
   e. Reflections indicate broken fiber.
7. Compare the test results to the manufacturer's specifications.
8. Remove bare fiber adapter and cut off excess fiber from the cable end.
9. Install heat shrink or other protective covering to the cable end to prevent the entry of moisture or other contaminants.

Cable Installation Acceptance Test

The Cable Installation Acceptance Test (Installation Test) is similar to the Cable Reel Acceptance Test except the Installation Test is conducted from both ends of the fiber. The Installation Test is performed immediately after the cable is buried, and before splices or connectors are added.

An MS Excel form has been created to log the following information. The Installation Acceptance Form can be found here: FO_Inst_AcceptForm 051402.xls

Tools Required

1. Knife
2. Armor Stripper
3. Kevlar Shears
4. Alcohol and wipes
5. Fiber Stripper
6. Fiber Cleaver
7. Bare Fiber Adapter, glass adapter, or mechanical splice
8. OTDR
9. Floppy Disk
10. Heat Shrink and Cable Ties
11. Installation Acceptance Test data sheet

Procedure

1. Record the following information.
   a. Cable ID
   b. Cable type
   c. Number of fibers
   d. Cable length as shown on reel
   e. Maximum specified loss at 1550 nm
   f. Maximum specified loss at 1310 nm
   g. Date

    h. Test Crew
    i. OTDR model and s/n
2. Inspect the cable and record any visible signs of defects.
3. Strip at least two feet of the cable end. Clean and strip the fibers.
4. Use a bare fiber adapter and an OTDR to take the following measurements from one end of the cable.
    a. Total loss at 1550 nm
    b. Attenuation per kilometer at 1550 nm
    c. Total loss at 1310 nm
    d. Attenuation per kilometer at 1310 nm
    e. Total length as indicated by ODTR
    f. Note any anomalies (rescale for clarity and record)
5. Print and record the OTDR traces on disk. Indicate direction of measurement, and record tube and fiber color.
6. Note differences between the 1550nm trace and the 1310nm trace.
    a. Slightly greater attenuation over a length of fiber at the shorter wavelength is normal.
    b. Uncut cable should have no reflections or attenuation steps.
    c. Larger attenuation steps at the longer wavelength may indicate macrobending.
    d. Attenuation steps or gains at both wavelengths indicate spliced, broken or damaged fiber.
    e. Reflections indicate broken fiber.
7. Compare the test results to the manufacturer's specifications.
8. Remove bare fiber adapter and cut off excess fiber from the cable end.
9. Install heat shrink or other protective covering to the cable end to prevent the entry of moisture or other contaminants.
10. Repeat steps 2 to 9 from the opposite end of the cable.
11. Note differences in measurements taken from opposite directions.
    a. Traces should be similar in both directions.
    b. Reflections in one direction and attenuation steps in the other direction indicate a poor splice or fiber mismatch.

Final Acceptance Test

The Final Acceptance Test (Final Test) is conducted from both ends of the fiber after all splices have been installed. It is an end-to-end test, and the last test to be done before the fiber is used for transmission. This test can also be used for troubleshooting purposes whenever the integrity of the fiber is in question. Like the Installation Test, the Final Test is conducted from both ends of the fiber, but also includes return loss measurements. This test is conducted with connectors installed on the ends of the fiber, if possible.

An MS Excel form has been created to log the following information. The Final Acceptance Form can be found here: FO_FinalAcceptForm 052802.xls

Tools Required

1. Appropriate patch cords and adapters
2. OTDR
3. Floppy Disk
4. Return Loss Meter

5. Final Acceptance Test data sheet

Procedure

1. Record the following information.
    a. Pad ID
    b. Maximum specified loss at 1550 nm
    c. Maximum specified loss at 1310 nm
    d. Date
    e. Test Crew
    f. OTDR model and s/n
    g. RM model and s/n
    h. PM model and s/n
    i. Source model and s/n
2. Inspect the fiber and record any visible signs of defects.
3. Use the OTDR to take the following measurements from one end of the fiber.
    a. Total loss at 1550 nm
    b. Attenuation per kilometer at 1550 nm
    c. Total loss at 1310 nm
    d. Attenuation per kilometer at 1310 nm
    e. Total length as indicated by ODTR
    f. Note any anomalies (rescale for clarity and record)
4. Print and record the OTDR traces on disk. Indicate direction of measurement, and record tube and fiber color.
5. Note differences between the 1550nm trace and the 1310nm trace.
    a. Slightly greater attenuation over a length of fiber at the shorter wavelength is normal.
    b. Uncut cable should have no reflections or attenuation steps
    c. Connectors may have no more than 0.3 dB attenuation and low return loss (greater than 65 dB for APC Connectors).
    d. Fusion splices may have no more than 0.1 dB attenuation and no return loss.
    e. Mechanical splices may have no more than 0.3 dB attenuation and greater than 65 dB return loss.
    f. Larger attenuation steps at the longer wavelength may indicate macrobending.
    g. Attenuation steps or gains at both wavelengths indicate spliced, broken or damaged fiber.
    h. Reflections where no connectors or splices are expected indicate broken fiber.
6. Compare the test results to the manufacturer’s specifications.
7. Use the RM to measure return loss. Save the measurement in an appropriate file.
8. Repeat steps 2 to 7 from the opposite end of the cable.
9. Note differences in measurements taken from opposite directions.
    a. Traces should be similar in both directions.
    b. Reflections in one direction and attenuation steps in the other direction indicate a poor splice or fiber mismatch.

Conclusion

The purpose of acceptance testing is to limit installation errors. Acceptance testing ensures that defects are found and corrected before the fibers are needed for transmission, and helps to prevent future errors of the same type. Acceptance testing must be conducted at various stages of construction to be effective.

Acceptance test documentation also forms the basis for future troubleshooting, emergency restoration, and quality control. An efficient documentation system is essential because of the large quantity of data that will be accumulated throughout the life of the project. A documentation system was outlined in this memo.