Verizon NEBS™ Compliance: Test Equipment Repeatability and Accuracy Validation Procedure

Verizon Technical Purchasing Requirements

VZ.TPR.9413

Issue 2, April 2008

CHANGE CONTROL RECORD:

Version	Date	Action*	Reason for Revision
1	*10/04/2007*	New	New Document
2	*4/3/2008*	Change	Changes symbols in the RL accuracy sections of the document from > to <

*** New, Add, Delete, Change, Reissue**

ISSUED BY:

Name, Title, Organization	**Date**
Vijay Jain M.Tech. M.A.Sc., PMP FOC-ITL Program Manager NEBS & Quality Assurance Verizon Technology Organization 320 St. Paul Place, Floor 14 Baltimore, MD 21202 Phone: 410-736-7947; Fax: 410-736-5144 E-mail: Vijay.x.jain@verizon.com	10/4/07

APPROVED BY:

Name, Title, Organization	**Date**
Ludwig C. Graff Director, NEBS Compliance and Quality Assurance Verizon Technology Organization Systems Integration and Testing 320 St. Paul Place, Floor 14 Baltimore, MD 21202 Phone: 410-736-5904; Fax: 410-736-5144 E-mail: Ludwig.c.graff@verizon.com	10/4/07

Table of Contents

1.0 PURPOSE

The purpose of this Verizon Technical Purchasing Requirement document is to provide FOC testing equipment reliability and accuracy requirements for Optical Product testing.

2.0 SCOPE

FOC Products

3.0 REFERENCES

GR-326-CORE	Generic Requirements for Singlemode Optical Connectors and Jumper Assemblies
Verizon PFOC Memo #13	Verizon FOC Compliance: Test Equipment Repeatability and Accuracy Validation Procedure

4.0 ACRONYMS

FOC	Fiber Optic Components
ITL	Independent Testing Laboratory
C	Celsius
F	Fahrenheit
RH	Relative Humidity
nm	Nano-meter
dB	Decibel
OTDR	Optical Time Domain Reflectometer
IL	Insertion Loss
BR	Back Reflection
RL	Return Loss
A	Attenuation Setting
Reff	Effective Reflection
Rref	Reference Reflector

5.0 TEST EQUIPMENT REPEATABILITY AND ACCURACY REQUIREMENTS

Verizon requires testing to be performed on all optical products deployed in the Verizon network. Verizon also requires certain levels of repeatability and accuracy be met with all optical monitoring equipment utilized for all of this testing. Optical monitoring/measurement equipment utilized for FOC testing must be validated in the following manor.

6.0 Procedure: Detail for Optical Monitoring System Validation

This section presents the following information:

- Ambient Lab Conditions
- Optical Monitoring Equipment Requirements
  - Bench top
  - In-Situ
  - Other
- Examples of facilities suitable for testing optical products
- Validation Methods for Optical Monitoring Equipment
  - Bench Top (w/o switch)
  - Bench Top (w/switch)
  - In-Situ: Transmission Based
  - In-Situ: OTDR Based
  - Other
- Expected Data formats

6.1 Ambient Lab Conditions

Ambient laboratory conditions during equipment validation shall be as follows.
Temperature: 23°± 2°C (73° ± 4°F)
Humidity: less than 75% RH

6.2 Optical Monitoring Equipment Requirements

An optical monitoring facility is required to measure optical loss and reflectance while optical product is subjected to the required testing.

The requirements for the optical monitoring facility are the following:

6.2.1 Bench Top Equipment Optical Requirements

6.2.1.1 Single Channel System (no switch)

- Laser: center wavelength and spectral width (Per GR-326)
  - Center wavelengths:
    - 1310nm+/-20nm
    - 1490nm+/-20nm
    - 1550nm+/-20nm
    - 1625nm+/-20nm
- Spectral Width: < 75nm
- Source Stability: 0.02dB maximum over 8 hours

- Detector: Linearity/Accuracy and range
  - Linearity/Accuracy – within manufacturer specification
  - Range: 1290nm thru 1645nm minimum
- Return loss: accuracy and range
  - Accuracy:
    - ± 1.5 dB –40 > BR ≥ -60
    - ± 2db –60 > BR ≥ –70dB
    - +/-5dB – 70 > BR
- Range: -40db thru –70db minimum

6.2.1.2 Multiple Channel System (switch)

- Laser: center wavelength and spectral width (Per GR-326)
  - Center wavelengths:
    - 1310nm+/-20nm
    - 1490nm+/-20nm
    - 1550nm+/-20nm
    - 1625nm+/-20nm
- Spectral Width: < 75nm
- Source Stability: 0.02dB maximum over 8 hours
- Detector: Linearity/Accuracy and range
  - Linearity/Accuracy – within manufacturer specification
  - Range: 1290nm thru 1645nm minimum
- Return loss: accuracy and range
  - Accuracy:
    - ± 1.5 dB –40 > BR ≥ -60
    - ± 2db –60 > BR ≥ –70dB
    - +/-5dB – 70 > BR
  - Range: -40db thru –70db minimum
- Switch: Insertion Loss repeatability/accuracy
  - Loss of +/-0.05dB
  - Measured over a 8 hours period

6.2.2 In-Situ Optical Monitoring Equipment

6.2.2.1 Transmission Based

- Laser: center wavelength and spectral width (Per GR-326)
  - Center wavelengths:
    - 1310nm+/-20nm
    - 1490nm+/-20nm
    - 1550nm+/-20nm

            - 1625nm+/-20nm
- Spectral Width: < 75nm
- Source Stability: 0.02dB maximum over 8 hours
- Detector: Linearity/Accuracy and range
    - Linearity/Accuracy – within manufacturer specification
    - Range: 1290nm thru 1645nm minimum
- Return loss: accuracy and range
    - Accuracy:
        - ± 1.5 dB –40 > BR ≥ -60
        - ± 2db –60 > BR ≥ –70dB
        - +/-5dB – 70 > BR
    - Range: -40db thru –70db minimum
- Switch: Insertion Loss repeatability/accuracy
    - Loss of +/-0.05dB
    - Measured over a 168 hours period

6.2.2.2 OTDR based

- Laser: center wavelength and spectral width (Per GR-326)
    - Center wavelengths:
        - 1310nm+/-20nm
        - 1490nm+/-20nm
        - 1550nm+/-20nm
        - 1625nm+/-20nm
- Spectral Width: < 75nm
- Source Stability: 0.02dB maximum over 8 hours
- Detector: Linearity/Accuracy and range
    - Linearity/Accuracy – within manufacturer specification
    - Range: 1290nm thru 1645nm minimum
- Return loss: accuracy and range
    - Accuracy:
        - ± 1.5 dB –40 > BR ≥ -60
        - ± 2db –60 > BR ≥ –70dB
        - +/-5dB – 70 > BR
    - Range: -40db thru –70db minimum
- Switch: Insertion Loss repeatability/accuracy
    - Loss of +/-0.05dB
    - Measured over a 168 hours period

6.2.3 Other

This group is for equipment, which does not fall into the above listed categories. The lab is required to meet all the above listed requirements in the equipment category, which most closely matches their equipment. Any deviations must be presented in writing to Verizon for acceptance before the equipment may be put into service.

6.3 Examples of facilities suitable for testing optical products

6.3.1 Transmission Measurement Facility

An example of a transmission measurement facility for measuring loss and reflectance using two multichannel switches is illustrated in Figure 1-1.

The major elements of this facility are the following:

- Four optical sources, 1310nm, 1490nm, 1550nm and 1625 nm
- A four-way optical switch for selecting the wavelength at which measurements are made
- Two multichannel optical switches for selecting the test sample under test
- An optical coupler for reflectance measurements
- An optical power meter.

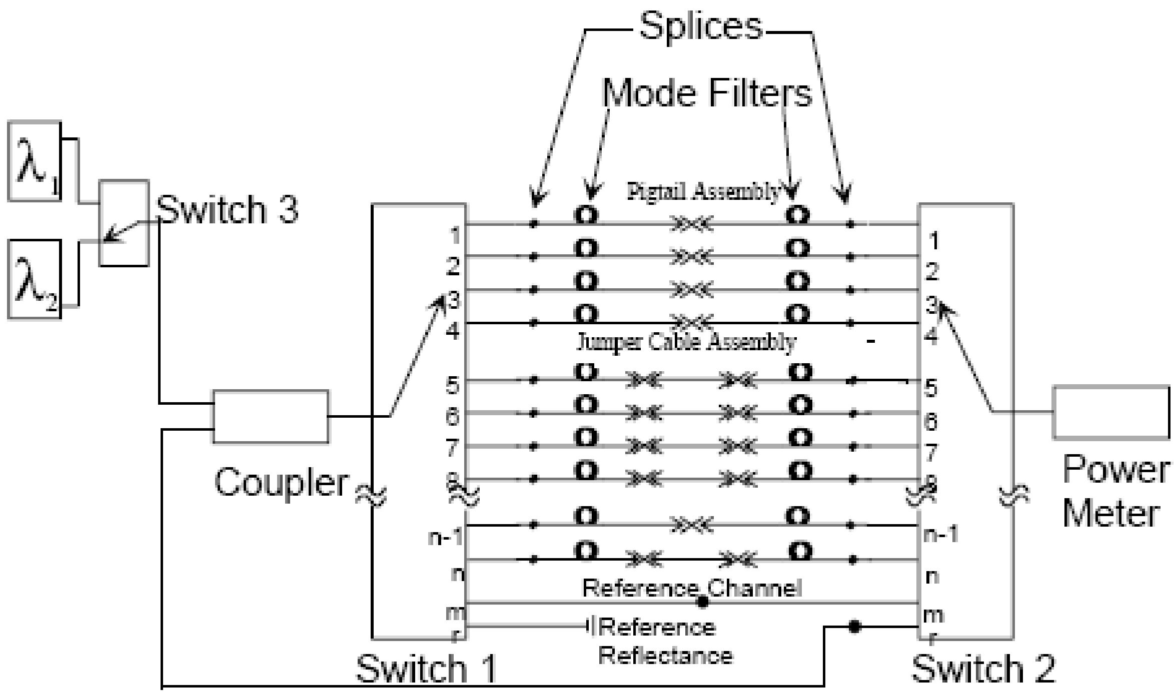


Figure 1.1- Transmission Measurement Facility

A CW type optical transmission measurement switching system may be used to provide an absolute insertion loss and/or return loss measurement. However for components with high values of return loss the accuracy of these measurements may not be assured. The optical switching system, for applications involving the measurement of high values of RL these types of measurements should be used for measuring IL and RL changes relative to initial measurements taken with some other type of acceptable method such as an appropriate benchtop measurement instrument. An optical switching system designated for FOC testing must be capable of measuring the change in IL to +/-0.05dB and the change in RL to +/-1.5dB @ 60dB and +/-2dB @ 65dB. Any individual channels of the system that do not meet these requirements must be identified and may not be used for testing.

6.3.2 OTDR Measurement Facility

An example of a measurement facility for measuring loss and reflectance that employs an OTDR is illustrated in Figure 1-2.

The major elements of this facility are

- An Optical Time Domain Reflectometer (OTDR) capable of performing measurement at 1310nm, 1490nm, 1550nm and 1625nm.

- Two multichannel optical switches for selecting the connector assembly under test.

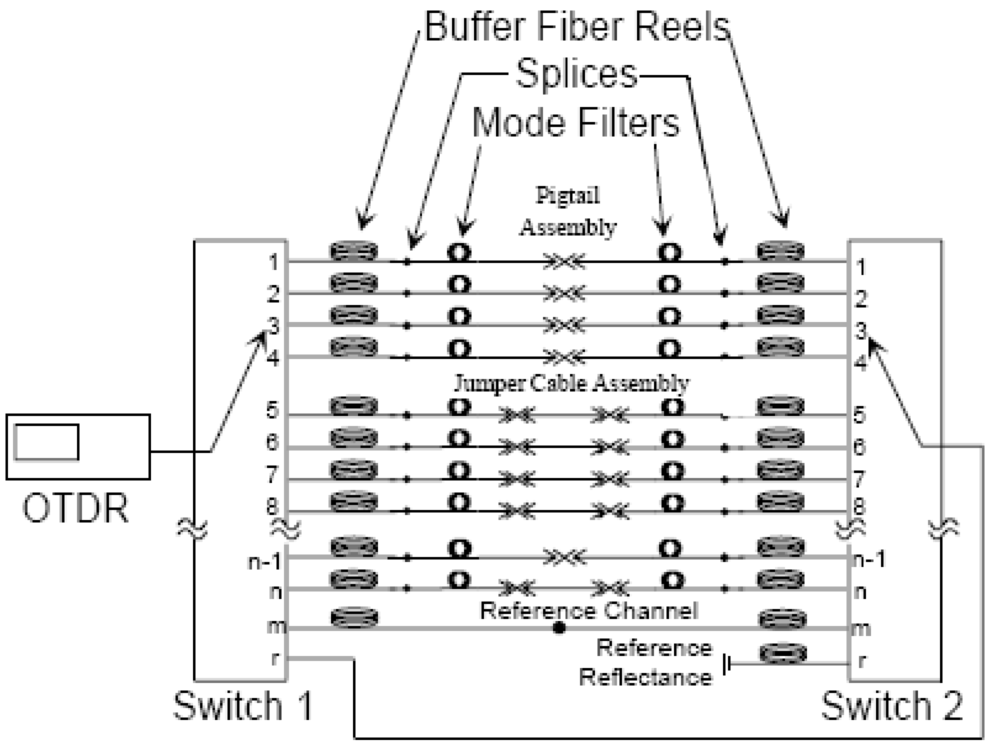


Figure 1.1- OTDR Measurement Facility

While an OTDR based systems may provide for greater RL dynamic range, up to and possibly exceeding the 80dB limit, there are concerns with the accuracy of the measurements above 70 dB. The accuracy of OTDR based RL measurements may be limited by the overall length of the DUT, the number of events, the proximity of the events to the DUT, etc. The absolute accuracy of some OTDR based switch type test system may be sufficient for all FOC testing including initial or final absolute measurements. Ultimately, it is the responsibility of the test lab to ensure that any test system used for FOC testing is capable of measuring the change in IL to +/-0.05dB and the change in RL to +/-1.5dB @ 60dB and +/-2dB @ 65dB.

6.4 Validation of Optical Monitoring Equipment

6.4.1 Validation Schedule

At least once per year, all optical monitoring equipment must be checked to verify that they meet all of the requirements specified in this document. The data is to be presented in the specified format (see specific procedural sections) and submitted, in soft and hard copy, on an annual basis (no later then January 1st) of each calendar year. The exception is when a new piece of equipment is placed in services which will required all information be presented before the new equipment can be utilized for FOC testing.

6.4.2 Validation of Single Channel Bench Top Optical Monitoring System

a. A Bench Top Optical Monitoring Instrument or system shall be calibrated by an accredited calibration house or by an approved in house calibration services using the appropriate methods and traceable equipment. The bench top optical monitoring device calibration interval shall be a minimum of 12 months. .

Calibration is to include the following at all applicable wavelengths.

a. Insertion Loss Accuracy
b. Linearity over the range of equipment
c. Return Loss Accuracy

b. Stability

Source stability is verified over an 8 hours period.

i. The Bench Top system is powered up and allowed to stabilize per the manufacturer's instructions or for a specified time per the lab's operation instructions /procedures.
ii. Measurements are taken initially and once every hour for the term of the test.
iii. The bench top instrument may be re-referenced at prescribed intervals per the lab's operation instructions/procedures.
iv. The maximum IL change per wavelength is calculated for the term of the test and must not exceed 0.02dB.
v. The data is to be collected and presented in a spreadsheet format including both raw data with statistics (Max, Min, STDEV). The IL change, as a function of time must be plotted.

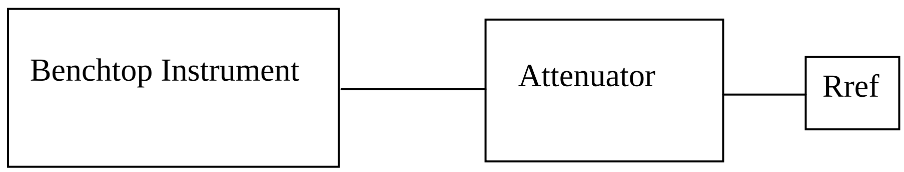
c. Return Loss Calibration/Validation

Return loss capabilities are to be validated for the range of the equipment at each wavelength. You have two different options for this process.

i. **Reference Standard Method**:
Utilize a reference standard (such as a JDS BR1) with enough range (-40 dB to –70 dB) to verify your Bench top set-up. This method will entail verifying the accuracy of the reference standard via FOTP-107 followed by performing measurements on your bench top system to verify the RL accuracy

ii. **Attenuator Method**:

Use an attenuator with a reference reflector. This method will entail splicing a known reflectance to the output of a calibrated attenuator that is connected to the bench setup being evaluated. The attenuator is adjusted to reduce the reflected power from the reference reflector to cover the required RL range.



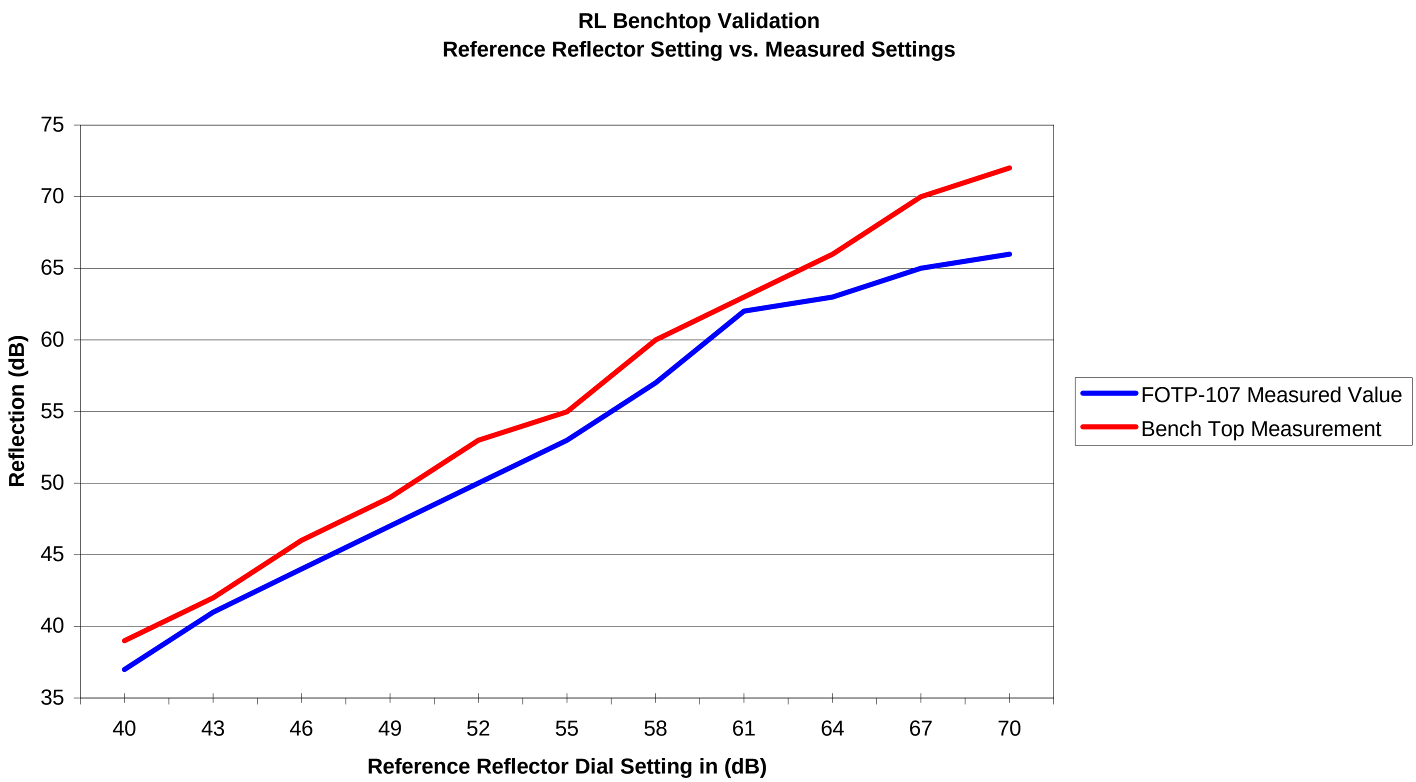
RLeff = 2x(Attenuator setting in dB) + Rref

In this example it is assumed that the inherent RL of the attenuator and fusion splices are negligible.

6.4.2.1 Reference Standard Method

1. Utilize a reference standard (such as a JDS BR1) with enough range (-40dB to –70dB) to verify your Bench top set-up.
    a. The reference standard must be calibrated with NIST traceable test equipment and the reference standard must be capable of covering the test system range to be validated.
    b. For this verification method a RL linearity curve is developed for each of the 4 measurement wavelengths.
    c. The reference standard verification range should begin at – 40 dB and extend to –70db in 3dB increments.
    d. The reference standard shall be validated using the TIA/EIA-FOTP 107 RL verification method. The FOTP-107 method will be used to measure the RL of the reference standard, e.g, to map the value from the indicator display on the reference standard to the actual measured RL values calculated from the FOTP-107 power measurements.
    e. Once validated, the reference standard is to be used to verify the measurement accuracy of the benchtop setup, by mapping the dial settings of the benchtop instrument to the instruments measured RL values.

f. The data is to be collected and presented in a spreadsheet format Present the data from FOTP 107 vs. the indicator value from the reflective standard vs. the measured value from your bench top setup. (See following example)



6.4.2.2 RL Validation with a Variable Attenuator and Reference Reflector

Utilize a reference reflector and attenuator to verify the bench setup. The reference reflector may be calibrated with a NIST traceable standard or measured per TIA/EIA-FOTP-107. A cleaved fiber or unmated polished connector could serve as the reference reflector. In addition, you will require an attenuator, adjustable in 1dB increments with a range that covers the intended RL measurement range. If the return loss of the attenuator is low, a low reflection bulk attenuator (mandrel wrapped fiber) may also be needed.

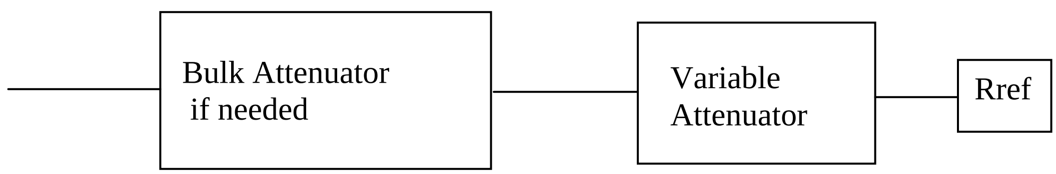
1. The reference reflector must be calibrated with a NIST traceable standard or measured using a setup per FOTP-107.
2. Prepare the bench setup per the operating instructions.
3. Connect the attenuator to the output of the bench setup.
4. Set the Variable attenuator to 0 or minimum attenuation.
5. Terminate the output fiber of the attenuator and re-reference the system reflection of the bench setup. With the added reflection, the system still needs to be capable of measuring to 70dB. If this is not possible, a non-reflective bulk attenuation, such as a mandrel wrapped fiber with a stable 10dB fixed attenuation, may be inserted between the equipment and the attenuator. If used, the RL contribution of the series combination of the bulk attenuator and variable attenuator must be included when re-referencing the system reflection.
6. Set the variable attenuator to “0” and measure the insertion loss of the variable attenuator and bulk attenuation (if used).
7. Splice the reference reflector to the output of the variable attenuator.
8. With the variable attenuator still set to 0, measure the return loss of the reference reflector at each wavelength. The value should be within ±2dB of the measured value of the reference reflector plus 2 times the insertion loss of the attenuator and bulk attenuation.
9. Repeat this measurement with the attenuator set to provide effective reflections from 40dBto 70dB in 3dB increments. The attenuator setting required to produce the required effective RL value is calculated using the following formula:

   $$A = (Reff – (Rref+(2*IL)))/2$$

   Where: A is the attenuator setting
   Reff is the effective reflection
   Rref is the measured value of the reference reflector
   IL is the insertion loss of the attenuator when set to 0 and the bulk reflection

For example, if you wanted to achieve a reflectance of 60dB. You reference reflector is 15dB and the insertion loss of the attenuator and bulk reflection is 11.5dB with the attenuator set to 0, the attenuator would need to be set to 11.0dB to obtain the desired level (where A = (60dB – (15db + (2*11.5dB)))/2.).

10. Save the file containing the return loss at each wavelength of the reference reflector. The data is to be collected and stored in a spreadsheet format. This will need to be presented per the validation schedule.



6.4.3 Validation of Multi-Channel Bench Top Optical Monitoring System

The verification in this Bench Top setup is to be preformed per section 6.4.2 (Validation of Single Channel Bench Top Optical Monitoring System) with the following additions.

6.4.3.1 Return Loss Validation

The validation is to be performed on 15 % of the channels not to exceed 5 channels.

6.4.3.2 IL Stability Verification

1. Splice each channel of the system back to back
2. Check the channel-to-channel uniformity of the throughput power to verify that there are no channels with bad fusion splices or severe fiber bends.
3. Allow the system to stabilize per the operation instructions/procedures.
4. Begin the test to measure IL change (absolute power).
5. Perform initial IL optical measurements and take measurements every 1-hour thereafter for a total of 8 hours. Re-referencing the system at prescribed intervals per the lab's operation instructions /procedures is allowed.

6. Upon completion of the test, analyze the system stability and verify the requirement accuracy of the equipment.
7. The data is to be collected and stored in a spreadsheet format both raw data with statistics and plotted. This will need to be presented per the validation schedule.

6.4.4 Validation of In-Situ: Transmission Based

Validation of an in-situ monitoring system is similar to that of bench top systems with the addition of long-term validation of stability and the validation of multiple channels for Return loss. During the Return Loss validation, the five channels with the lowest system reflectance and the five channels with the highest system reflectance will be checked for return loss accuracy. The procedures for validation of this type of system are as follows.

6.4.4.1 IL and System Reflection Stability Validation

1. Splice each channel of the input switch to its corresponding output switch channel
2. Check the channel-to-channel uniformity of the through power data to verify that there are no channels with bad fusion splice or fiber bends present. Typically, the channels should be within +/-1.0dB.
3. Allow the systems to stabilize for at least 24 hours (no trends >0.01dB over 8 hours).
4. Begin the test to measure IL change and system reflection (absolute reflected power).
5. Continue the test making optical measurements at least every 2 hours for 168 hours (1 week).
6. Upon completion of the test, analyze the IL change data. The normalized IL change for each channel during the test must be +/-0.05dB maximum relative to the start of the test.
7. Upon completion of the test, analyze the system reflection change data (from the raw reflected power file). The normalized data must be stable to +/-0.20dB maximum relative to the start of the test. (This value is still under development)
8. The data is to be collected and stored in a spreadsheet format both raw data with statistics and plotted. This will need to be presented per the validation schedule.

6.4.4.2 RL Calibration Validation

This process involves splicing a fiber with a known return loss into the optical path of the system channel to be validated. The fiber is then cut and its length reduced by steps of ½ to provide a quantifiable return loss change. The ability of the system to accurately measure a change in return loss when the reflection has been reduced to approximately the 65dB level is validated.

6.4.4.3 Sample Preparation

The fiber sample will be 10 ±0.5 meters long. This length of fiber was chosen because the return loss of 10 meters of fiber is 60dB at 1310nm and is 63dB at 1625nm. In the absence of a traceable return loss standard, the return loss of a length of fiber measured per the test method of TIA-FOTP-107 will be considered a standard for use in verifying the optical switching system return loss accuracy.

1. The return loss of each length of fiber that is to be used as a RL standard is to be measured per TIA-FOTP-107 or measured using a bench setup that has been validated per 6.4.2.1 or 6.4.2.2
2. Prepare the bench top set up for RL measurements per the operating instructions.
3. Select and splice a length of fiber greater then 12 meters to the measurement system.
4. Mark the fiber in some suitable manner, such as with a felt tipped pen, about 12" from the splice. The mark is made after the splice on the DUT side) and again at 10 meters from the 12" mark. See figure 2 below.

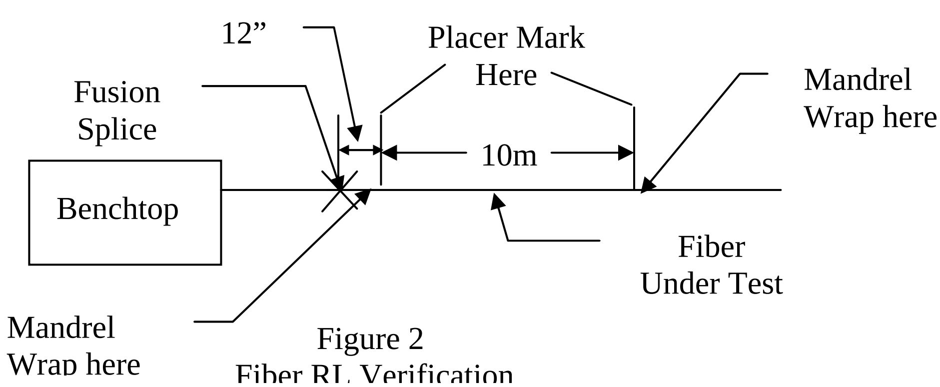


Figure 2
Fiber RL Verification

5. Mandrel wrap the fiber just in front of the 12” mark on the fiber under test and take a RL system reference. Measure the return loss of the fiber length by mandrel wrapping just behind the 10-meter marks.
6. The return loss of the fibers must be within +/-1dB of the following values.

Fiber length (m)	Return Loss (dB)			
	1310 nm	1490nm	1550 nm	1625nm
10.5	59.79	61.33	62.01	62.89

7. Cut the fiber at the 12” and 10.5-meter marks.

Fiber length (m)	Return Loss (dB)			
	1310 nm	1490nm	1550 nm	1625nm
9.5	60.22	61.76	62.44	63.32
10	60.00	61.54	62.22	63.10
10.5	59.79	61.33	62.01	62.89

8. This process will be repeated for each fiber used to verify the Optical Switching system.
9. Save the file containing the return loss at each wavelength for each fiber. The data is to be collected and stored in a spreadsheet format both raw data with statistics and plotted. This will need to be presented per the validation schedule.

6.4.4.4 Optical Switching System Return Loss Measurement

1. Review the system reflection stability data from section 6.4.4.1 and identify the 5 channels with the smallest reflections and the 5 with the greatest system reflections. These will be utilized to verify the system return loss.
2. Splice a FOTP-107 verified 10-meter length of fiber onto each of the 10 channels.
3. Using the optical switching systems software, create a project containing the channels with the fiber lengths you spliced into your systems.
4. Check the channel-to-channel uniformity of the through power data to verify that there are no channels with bad fusion splice or fiber bends present. Typically, the channels should be within +/-1.0dB.
5. Allow the systems to stabilize for at least 24 hours (no trends >0.01dB over 8 hours) before starting the verification.
6. Set up your system to take measurements at 2-hour intervals.

7. After a minimum of 24 hours, cut the 10 meter fiber just behind the receive splice, and cut the test fiber in half and set aside the free end length. Re-splice each channel to the receive end.
8. Check the change in insertion loss before and after cutting the test fiber. The change should be less than 0.1dB.
9. Continue the test with measurements to be taken at 2-hour intervals.
10. After a minimum of 24 additional hours, cut the 5 meter length of fiber just behind the receive splice. Cut the 5 meter length of fiber in half and re-splice each channel to the receive end of the measurement system.
11. Check the change in insertion loss before and after cutting the test fiber. The change should be less than 0.1dB.
12. Continue the test with measurements taken at 2-hour intervals for an additional 24 hours.
13. This data will be analyzed in the next step.

6.4.4.5 Optical Switching System Return Loss Measurement Analysis

1. Compare the change in return loss measurements taken by the optical switching system software with the expected change of 3 dB each time the fiber was cut and verify that, after each cut, the measurement was stable. The tolerance limits are shown in the following table. There is no tolerance specified for 1490nm to 1625nm with the 2.5-meter length because the absolute return loss of the fiber is beyond the 65dB limit.

Fiber Length	1310nm		1490nm		1550nm		1625nm	
	Change	Stability	Change	Stability	Change	Stability	Change	Stability
10.0M	N/A	+/-1dB	N/A	+/-1dB	N/A	+/-1dB	N/A	+/-1dB
5.0M	3+/-1.5dB	+/-1dB	3+/-2.0dB	+/-1dB	3+/-2.0dB	+/-1dB	3+/-2.0dB	+/-1dB
2.5M	6+/-2.0dB	+/-1dB	---	---	---	---	---	---

2. If any of the channels with a large system reflection (less negative) are outside of the tolerance, then they must be designated as bad channels and the next 5 largest system reflection channels must be identified and tested. Unless there is an assignable cause (bad splice, bent fiber, etc.), if any of the channels with the smallest system reflection do not meet the requirements, the entire system must be checked per this document. **You may want to verify the system setup and calibration before choosing this option. You may only have to redo this series of test rather then testing the entire system. **
3. The data is to be collected and stored in a spreadsheet format both raw data with statistics and plotted. This will need to be presented per the validation schedule.

6.4.5 Validation of In-Situ: OTDR Based

Validation of an in-situ OTDR based monitoring system is similar to that of the transmission based in-situ monitoring systems where both IL and RL will be verified for accuracy and stability with the following deviations. IL stability will require the use of SC/PC (or any connector pair) connector assemblies in-line in the test set. During the Return Loss validation, the five channels with the lowest system reflectance and the five channels with the highest system reflectance will be checked for return loss accuracy. The procedures for validation of this type of system are as follows.

6.4.5.1 IL and System Reflection Stability Validation

1. If the OTDR is used for IL measurements, you will first need to create a loss event (something consistent) that can be utilized as the DUT during this evaluation. It is recommended that a connector pair such as SC/PC connectors be chosen for this setup.
2. If the OTDR is used for IL measurements, splice the connector pairs into each channel of the input switch and its corresponding output switch channel. If the IL measurements are constant wave based, splice each channel of the input switch directly to its corresponding output switch channel.
3. Check the channel-to-channel uniformity of the through power data to verify that there are no channels with bad fusion splices or fiber bends present. Typically, the channels should be within +/-1.0dB.
4. Allow the systems to stabilize for at least 24 hours (take optical readings every 2 hours - no trends >0.01dB over 8 hours).
5. Begin the test to measure IL change.
6. Continue the test making optical measurements at least every 2 hours for 168 hours (1 week).
7. Upon completion of the test, analyze the IL change data. The normalized IL change for each channel during the test must be +/-0.05dB maximum relative to the start of the test.
8. The data is to be collected and stored in a spreadsheet format both raw data with statistics and plotted. This will need to be presented per the validation schedule.

6.4.5.2 RL Calibration Validation

This process involves the use of an attenuator placed in line between two lengths of fiber.

6.4.5.3 Sample Preparation

The intent of this sequence is to create and verify a reference reflection to be used as a calibration reference for the OTDR. The return loss of the reference reflector is to be measured per TIA/EIA-FOTP-107 or by using a bench setup that has been validated for RL per 6.4.2. A cleaved fiber or unmated polished connector could serve as the reference reflector. In addition, you will require an attenuator, adjustable in 1dB increments with an adequate range to cover the intended RL measurement range. A reference standard (such as a JDS BR1) with enough range to verify the RL requirement may be used in lieu of the reference reflector and attenuator. The reference standard must be calibrated with a NIST traceable standard or measured using a setup per FOTP-107.

1. Prepare a bench setup per the operating instructions and validate it for RL per 6.4.2 or prepare a setup per TIA/EIA-FOTP-107.
2. Connect the attenuator to the output of the test equipment.
3. Set the attenuator to 0 or minimum attenuation.
4. Select a non-reference quality pigtail that is longer than the dead zone of the switching system OTDR and splice it to the output of the attenuator.
5. Terminate the fiber just behind the reference reflector and measure the return loss of the attenuator and fiber. If the return loss is at least 15dB greater than the expected value of the reference reflector, proceed to the next step. If the return loss is too low, re-reference the system reflection with the terminated fiber.
6. With the attenuator still set to 0, measure the return loss of the reference reflector at each wavelength.
7. Increase the attenuation value by 1dB increments until you have mapped the reflectance over the desired range of the equipment (minimum of 70dB).
8. Save the file containing the return loss of the reference reflector at each wavelength. The data is to be collected and stored in a spreadsheet format. This will need to be presented per the validation schedule.

6.4.5.4 OTDR Based System Return Loss Measurement

You are actually going to perform two measures, one of the return loss accuracy and the second will be the RL stability over a period of time. This process will require the attenuator and reference reflector prepared in 6.4.5.3 or a reference standard (such as a JDS BR1) with enough range (-40dB to –70dB) to verify your OTDR Based System. The reference standard must be calibrated with a NIST traceable standard, equivalent, or measured using a setup per FOTP-107.

1. Review the system through power data from section 6.4.5.1 and identify the channel with the lowest power. This will be utilized to verify the system return loss.
2. Splice the attenuator with reference reflector to the channel on the input switch that was selected for testing. Be sure there is sufficient fiber (equivalent to that of the reference reflector) before the attenuator for the OTDR to perform a reference measurement of the fiber backscatter.
3. With the attenuator set to 0, at each wavelength, measure the reflection of the reference reflector relative to a fiber reference measurement taken just before the attenuator. The value should be within ±1.5dB of the bench measurement. Record the results.
4. Repeat this measurement with the attenuator set to provide effective reflections from 40dBto 70dB in 3dB increments. The attenuator setting is calculated using the following formula:

   A = (Reff – (Rref+(2*IL)))/2

   Where: A is the attenuator setting
   Reff is the effective reflection
   Rref is the measured value of the reference reflector
   IL is the insertion loss of the attenuator when set to 0 and the bulk reflection

   For example, if you wanted to achieve a reflectance of 60dB. You reference reflector is 15dB and the insertion loss of the attenuator and bulk reflection is 11.5dB with the attenuator set to 0, the attenuator would need to be set to 11.0dB to obtain the desired level (where A = (60dB – (15db + (2*11.5dB)))/2.).
5. Set the attenuator for an effective reflection of 65dB.
6. Set up your system to take measurements of RL at 2-hour intervals for 168 hours.
7. Save the file containing the return loss at each wavelength. The data is to be collected and stored in a spreadsheet format both raw data with statistics and plotted. This will need to be presented per the validation schedule.

6.4.6 Other

It has been recognized that the type of system you are utilizing may differ from those described or the methods given for validation will not work for your type of system. In this case, it is the labs responsibility to provide to Verizon, a complete breakdown of this system including diagrams and descriptions of the equipment along with any calibration and validations methods that would be used in place of what is defined in this document.

These circumstances will be addressed on a case-by-case base and with the decision for acceptance of the validation methods to be made by Verizon.

It will still be the labs responsibility to hold to the Validation schedule and the requirements defined within.