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Optical Cable Acceptance Testing

(Optical Test Methods)

About this document ...

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Table of Content

1 *Scope*

This document describes optical test methods to be used for the acceptance of optical fibre cable installed in the UK Fibre Network.

2 *Safety*

Special safety precautions need to be taken when working on optical fibre systems. Directive SFY/CSP/B039 Safe Working Practices for Optical Fibre Systems defines procedures and working practices, applicable to Laser & LED optical fibre systems and optical test equipment at locations within the BT Network. The directive is MANDATORY.

3 *Optical Attenuation Measurements*

This section details the procedures to be used when measuring the end to end attenuation of an Elementary Cable Section (ECS). A combination of Light Source and Power Meter are used to provide a measurement of optical loss in a given wavelength window. Three methods are described:

(a) The cut-back method for bare fibres.

(b) The direct measurement method for connectorised fibres.

(c) The use of Optical Commissioning and Testing Kit 1A.

3.1 Attenuation by the Cut-Back Method

This method applies when the cable section has not been terminated in optical connectors. *Figure 2* illustrates the test procedure.

3.1.1 Principle of measurement

Optical power from a suitable light source is launched into the fibre under test and the power level at the far end is recorded. The fibre is cut-back at the launch end and the power reading at the cut is recorded. The difference between the two measurements equals the attenuation of the fibre under test.

3.1.2 Equipment required

Transmit Unit (Light Source Dual Wavelength).

Receive Unit (Power Meter).

Mechanical splices. e.g. Sleeve Optical 2A.

Termination Optical 8001C (pig-tail).

Test Cords (terminated in Connector Optical Fibre 8A) 2 or 3 metre.

When measurements are required to be conducted in both directions of transmission, for ease of use, two complete sets of equipment would be required. In this document, the near-end and the far-end will be respectively designated Station A and Station B.

3.1.3 Preparation of Terminating Cable

1. Cable Preparation. All traces of filling compound will be removed from cable end, tools, hands, clothing and general working area before commencing work on test fibres.
2. Collet the fibres to allow identification of individual fibres prior to testing.
3. Using the correct stripping tools, prepare a sufficient length of fibre e.g. 3 metres and store in the individual splicing trays prior to test.
4. On completion of the acceptance testing, all fibres shall be reduced to 1.5 metres in length to allow for termination.

3.1.4 Calibration Checks

For these checks, both sets should be brought to a common location in order to verify their accuracy against each other. *Figure 1* illustrates the calibration procedure.

Note: Inspect and clean, if necessary, all connectors on test cords prior to carrying out the calibration procedure.

1. Interconnect using test cords, the Transmit Unit (light Source) and Receive Unit (power meter) on both sets and allow the units to stabilise (Refer to manufacturers handbook as necessary).
2. Select a test wavelength of 1550nm (nominal) on the Transmit Units and ensure that the Receive Units are set to the correct measurement wavelength. (Refer to manufacturer’s handbook as necessary).
3. Set the Receive Unit to "ABSOLUTE (dBm)" measurement range.
4. Ensure that the readings on the two Receive Units are stable and note the two power levels (Readings 1 and 2).
5. Leaving the test cords in place on the transmit unit, interchange the two Receive Units.
6. Again ensure that the readings on the two Receive Units are stable and note the two power levels (Readings 3 and 4).
7. Verify that Readings 1, 2, 3 and 4 are within 0.3dB of each other (see Figure 1).

8. Select a test wavelength of 1310nm (nominal) on the Transmit Units and repeat steps (4) to (7) above.
9. One set should now be taken to Station A and the other to Station B.

3.1.5 Measurement Procedure

Steps (1) to (4) below cover the setting up procedure for the measurement and apply to both ends of the fibre under test (Station A and Station B).

Note: Inspect and clean, if necessary, all connectors on pig-tails prior to carrying out the measurement procedure.

1. Switch on Transmit Unit (light Source) and Receive Unit (power meter) and allow the units to stabilise.
2. Select a test wavelength of 1550nm (nominal) on the Transmit Unit. Ensure that the Receive Unit is set to the correct measurement wavelength when it receives the Transmit Unit signal. (Refer to manufacturer's handbook as necessary.)
3. Set the Receive Unit to "ABSOLUTE (dBm)" measurement range.
4. Attach a pigtail to the Transmit Unit output. The pigtail shall be left in-situ for the duration of the tests.
   Steps (5) to (10) below describe the measurement in direction Station A to Station B.
5. Prepare the Fibre Under Test in accordance with Preparation of Terminating Cable and connect to Transmit Unit (A) pigtail using a mechanical splice.
6. Attach a pigtail to the Receive Unit (B) input, cleave the far end of the fibre under test and connect to pigtail using mechanical splice. Repeat three times to confirm that a stable power level is obtained. This "MEASUREMENT 1550" shall be recorded.
7. Select a test wavelength of 1310nm (nominal) on Transmit Unit (A). Ensure that the Receive Unit (B) is set to the correct measurement wavelength, wait for the reading to settle and record this "MEASUREMENT 1310" reading.
8. Attach a pigtail to the Receive Unit (A) input. Cleave the fibre under test approximately 300mm beyond the mechanical splice adjacent to the Transmit Unit (A). Using a mechanical splice connect fibre launch side to pigtail attached to Receive Unit (A) input. Repeat three times to confirm a stable power level is obtained and record this "REFERENCE 1310" reading.
9. Switch the Transmit Unit wavelength back to 1550nm. Wait for the Receive Unit (A) reading to settle and record this "REFERENCE 1550" reading.
10. The difference between the "MEASUREMENT" and "REFERENCE" readings equals the attenuation of the fibre under test.
    MEASUREMENT 1550 - REFERENCE 1550 = ATTENUATION 1550 (dB)
    MEASUREMENT 1310 – REFERENCE 1310 = ATTENUATION 1310 (dB)

11. Repeat steps (5) to (10) in the reverse direction of transmission (from Station B to Station A).
12. Compare the results of the measurements against the requirements of Specification LW350.

3.2 Attenuation by Direct or Substitution Measurement

This method should be used when the fibre section to be measured has been already connectorised (Direct), or pigtails (Substitution) have been fitted for testing purposes. *Figure 3* illustrates the test procedure.

Note: Temporary Termination Optical 8001C pigtails may be attached to line fibres using a mechanical or fusion splice connection and the appropriate loss correction calculated.

3.2.1 Principle of Measurement

Optical power from a suitable light source is connected to the fibre under test and the power level at the far end is measured and recorded. The light source is then connected to a power meter via a connecter and its power level is measured and recorded. The difference between the two measurements equals the attenuation of the fibre under test plus the loss of the connector. The loss due to the connector or any temporary connection system should be assessed and the correction value taken away from the end to end measurement. BT Specification LW350 refers.

3.2.2 Equipment Required

Transmit Unit (Light Source Dual Wavelength).

Receive Unit (Power Meter).

Test Cords (terminated in Connector Optical Fibre 8A) 2 or 3 metre.

Coupler Optical Fibre 8A.

Termination Optical 8001C (pig-tail) – optional.

Mechanical splices. e.g. Sleeve Optical 2A – optional.

Measurements shall be conducted in both directions of transmission. For ease of use, two complete sets of equipment would be required. In this document, the near-end and the far-end will be respectively designated Station A and Station B.

Note: **If equipment has alternative optical interfaces, such as “SC” or “LC”, then the correct test cords and couplers must be used.**

3.2.3 Calibration Checks

For these checks, both Receive Units should be brought to a common location in order to verify their accuracy against one another.

Carry out the calibration checks described previously in the section **Attenuation by the Cut-back Method.**

One Unit should now be taken to Station A and the other to Station B.

3.2.4 Measurement Procedure

Steps (1) to (5) below cover the setting up procedure for the measurement and apply to both ends of the fibre under test (Station A and Station B).

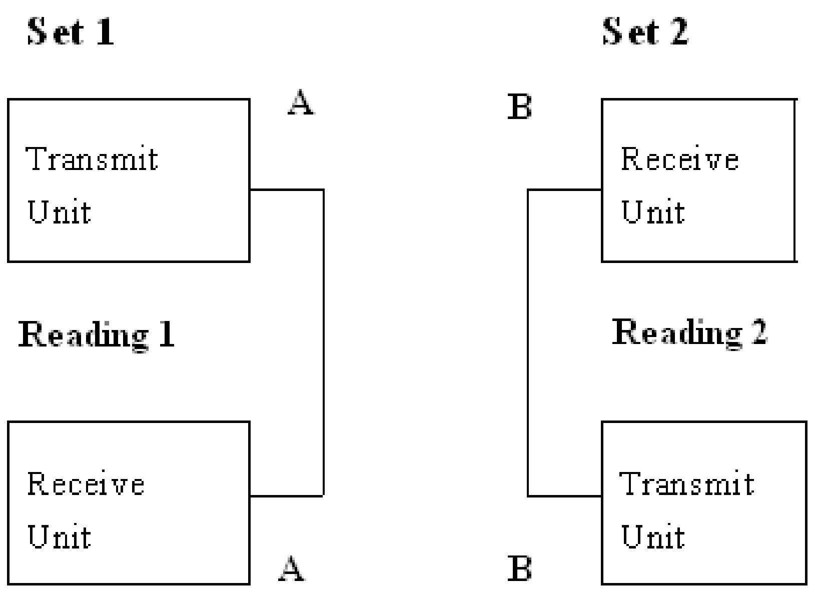
Note: Inspect and clean, if necessary, all connectors on test cords and pig tails prior to carrying out the measurement procedure.

1. Switch on Transmit Unit (light Source) and Receive Unit (power meter) and allow the units to stabilise. Laser sources require at least a 15 minute warm up period.
2. Set the Receive Units to 'ABSOLUTE' (dBm) measurement range.
3. Select a test wavelength of 1550nm (nominal) on the Transmit Units and ensure that the Receive Units are set to the correct measurement wavelength. (Refer to manufacturers handbook as necessary).
4. Connect the test cord to the Transmit Unit output. This test cord should be left in-situ for the duration of the tests.
   Steps (5) to (10) below describe the measurement in the direction Station A to Station B.
5. Connect the fibre under test to the Transmit Unit (A) test cord via a back to back Coupler Optical Fibre 8A (or SC or LC as appropriate).
6. Connect the far-end of the fibre under test DIRECTLY to Receive Unit (B). Do NOT use a test cord. Check for a stable power level and note the 'MEASUREMENT 1550' reading.
7. Switch the Transmit Unit (A) wavelength to 1310nm. Wait for the Receive Unit (B) reading to settle and record this 'MEASUREMENT 1310' reading.
8. Disconnect the test cord from the coupler and insert in Receive Unit (A). Check for a stable power level and record this 'REFERENCE 1310' reading.
9. Switch the Transmit Unit wavelength back to 1550nm. Wait for the Receive Unit (A) reading to settle and record this 'REFERENCE 1550' reading.
10. The difference between the 'MEASUREMENT' and 'REFERENCE' readings minus an allowance for the connector loss equals the attenuation of the fibre under test.
    MEASUREMENT 1550 - REFERENCE 1550 - 0.5 = ATTENUATION 1550

(dB)
MEASUREMENT 1310 - REFERENCE 1310 - 0.5 = ATTENUATION 1310 (dB)

11. Repeat Steps (5) to (10) above in the reverse direction of transmission (from Station B to Station A).
12. Apply loss correction as appropriate for temporary (Substitution) method.

    Compare the results of the measurements against the requirements of Specification LW350.



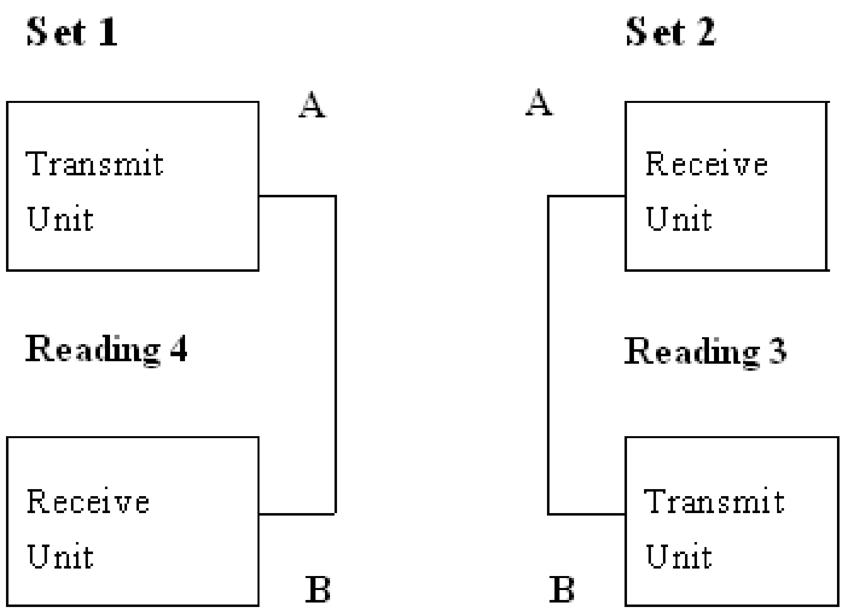
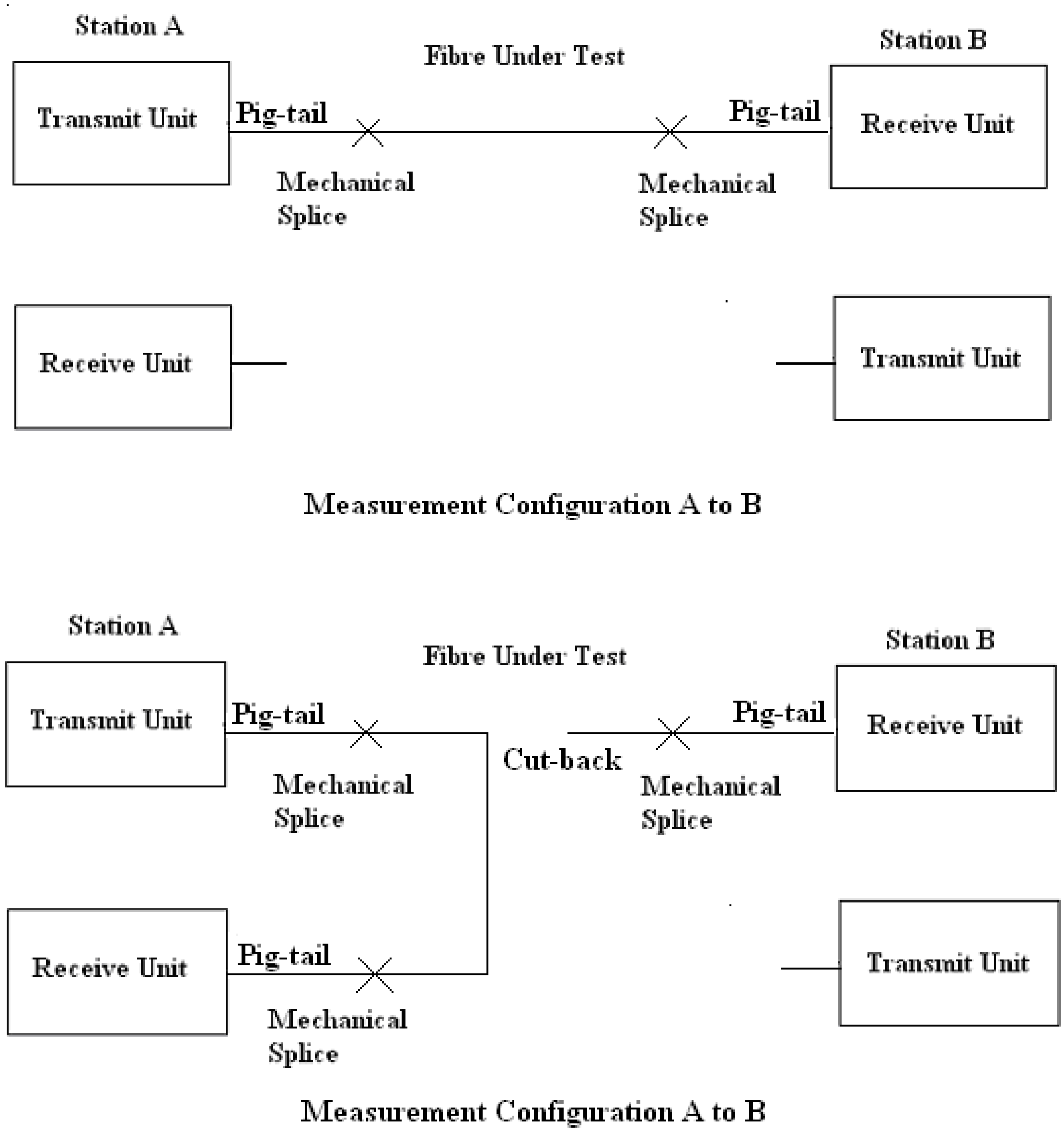
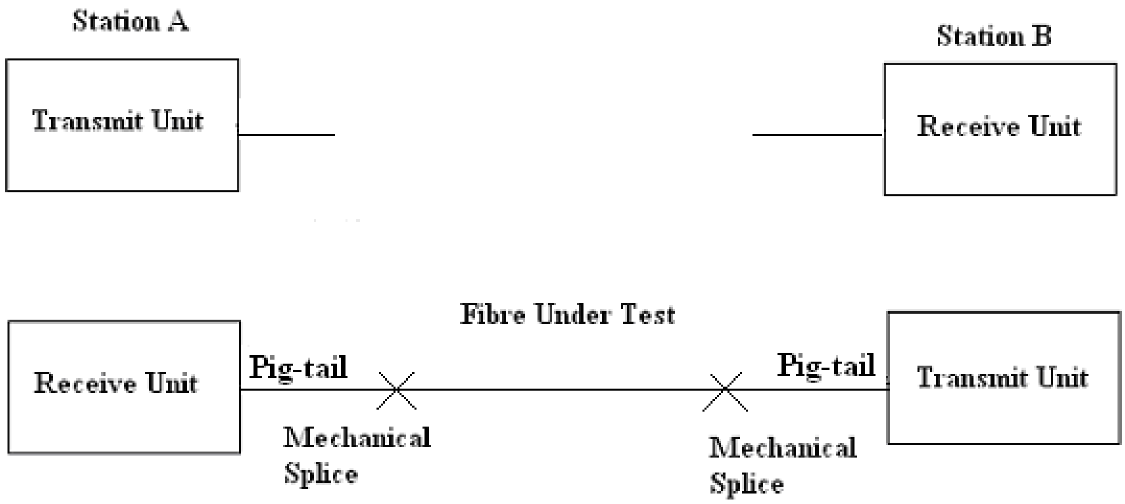
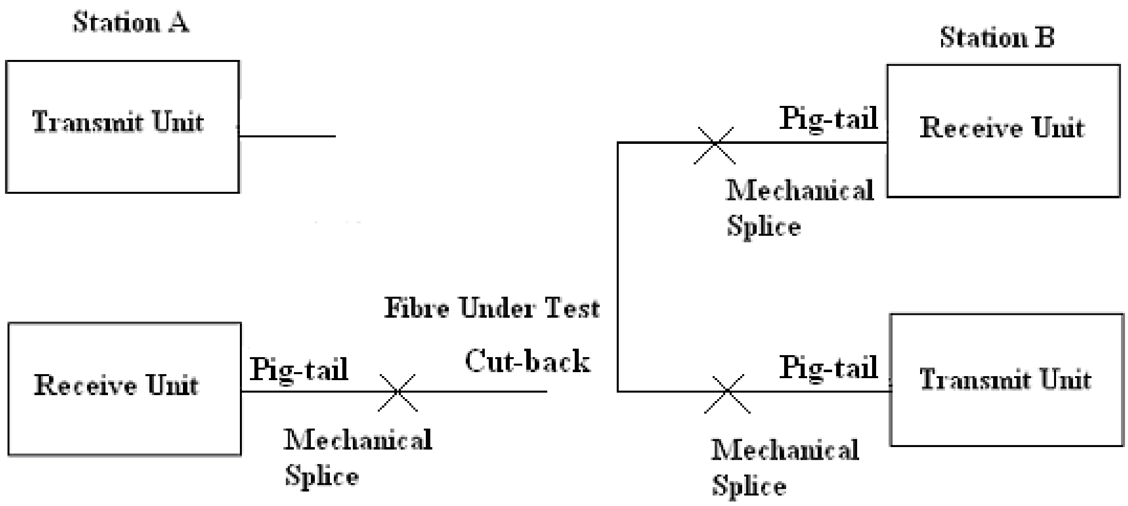


Figure 1 **Calibration Checks**



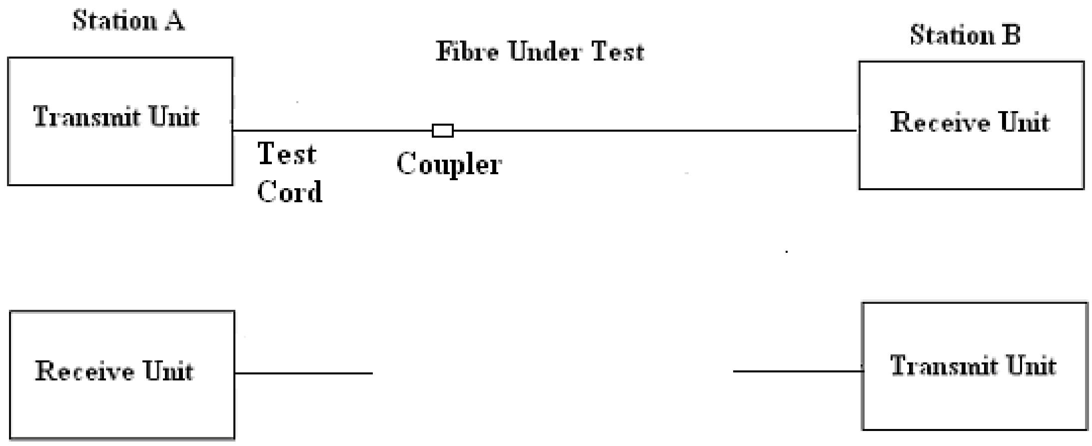


Measurement Configuration B to A

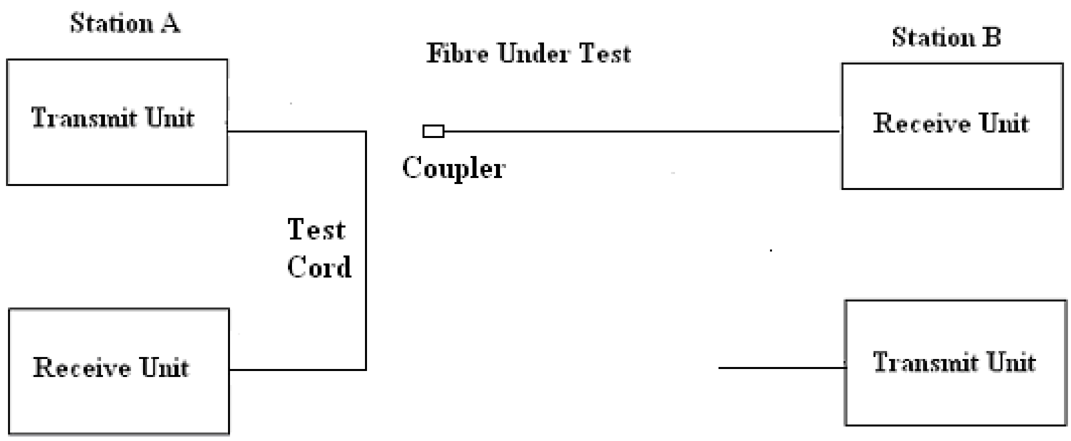


Measurement Configuration B to A

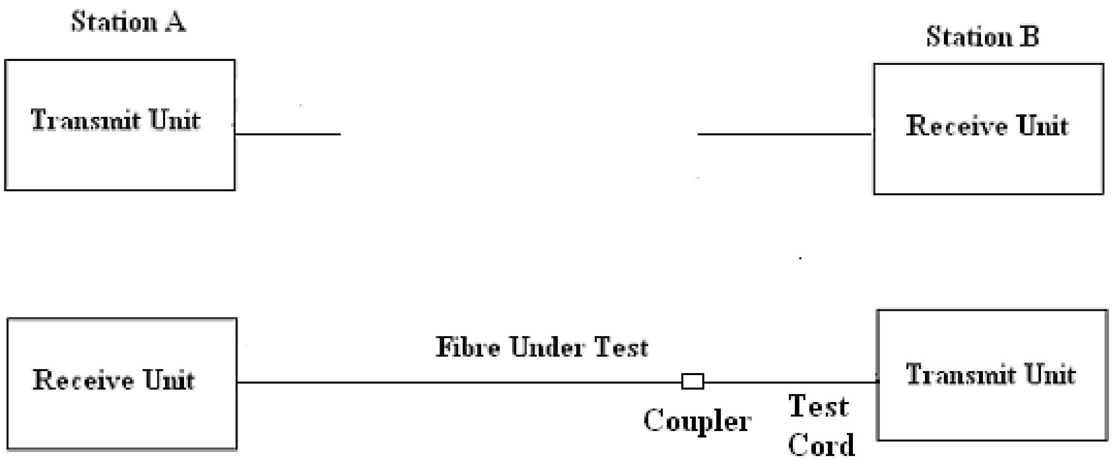
Figure 2 **Attenuation by the Cut-back Method**



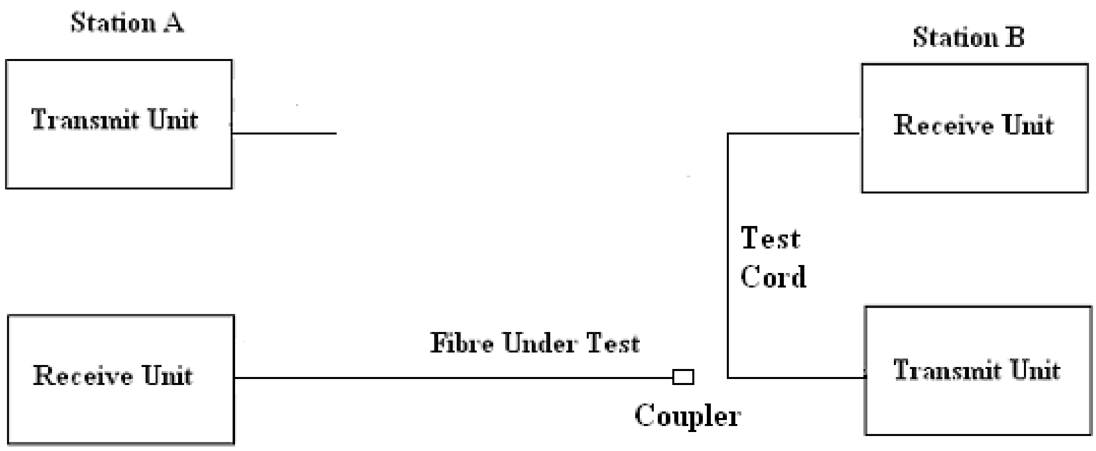
Measurement Configuration A to B



Measurement Configuration A to B



Measurement Configuration B to A



Measurement Configuration B to A

Figure 3 **Attenuation by the Direct / Substitution Measurement Method**

3.3 Optical Commisioning and Testing Kit 1A (Item Code 026459)

The method for the end to end attenuation measurement of an Elementary Cable Section (ECS) using the Optical Commissioning & Testing Kit 1A (item code number 026459) is shown in the attached document. CLICK HERE to link to document.

The Optical Commissioning & Testing Kit 1A consists of the following items:

Light Source 5C (item code number 026456).

Power Meter Optical 3C (item code number 026457).

Live Fibre Detector 1A (item code number 819272).

4 *OTDR Test Methods*

This section presents the principles and techniques to be observed when making measurements using an optical time domain reflectometer (OTDR). It describes the evaluation of section losses, splice losses and bend losses.

Within BT, the current OTDR for use in the Core and Access Fibre Network is the Reflectometer Optical No.9. This is a medium to long range unit. This OTDR is suitable for the test methods described in this section.

4.1 Principles

This section presents the principles and techniques to be observed when making measurements using an optical time domain reflectometer (OTDR). It describes the evaluation of section, splice and bend loss. The manufacturer's handbook should be referred to for performance settings and operation of the unit.

4.2 Parameters

4.2.1 Distance Range

This parameter determines the maximum length of fibre (up to 260km) that can be measured. The OTDR should be set to the shortest range available and which is greater than the length of the fibre to be tested.

4.2.2 Pulse Width

This is the parameter that determines resolution and range, typically 10ns to 10μs. The shortest pulse width gives the best resolution of distance. However, because a short pulse possesses relatively little energy, it will not travel very far along a fibre before being lost in the background noise. Therefore the distance range is severely limited when using the shortest pulse. Conversely, the longest pulse gives maximum range but at the expense of resolution.

4.2.3 Refractive Index

This setting determines the absolute value of the distance readout of the instrument. Usually a RI value of 1.47 can be assumed for typical optical fibres to BT Specification CW1505.

4.2.4 Averaging

Averaging is used to extend the distance range of an OTDR by recovering the reflected signal from the general background noise. This is achieved by sampling the signal a large number of times (e.g. 5000) and numerically averaging the samples. Because random noise is equally likely to add or subtract from the wanted signal, by taking a large number of samples and averaging, the effect of the noise can be greatly diminished. This function is normally set to a nominal time duration e.g. 60 seconds that will give a clean representation of the fibre trace.

4.2.5 Sweep Mode

Normal averaging sweep mode should be used for splice loss and section loss measurements. The OTDR also features a *Continuous* sweep mode which gives a rapidly updating real time display which is useful for observing the effects of adjustments to connectors and mechanical splices.

4.2.6 Measurement Mode

A number of different measurement modes are available for loss evaluation and the most common are 2PA (two point average) or LSA (least squared average).

2PA applies to loss measurements using two markers. In this mode, the instrument displays the directly calculated difference in loss between the two markers.

LSA mode is used to reduce the effect of noise on the trace. In this mode, the instrument calculates the best straight line fit to the measured data and uses the calculated straight line to derive the loss measurement.

4.3 Techniques

The following notes summarises various techniques that are useful for obtaining maximum information from the OTDR trace.

4.3.1 Connecting to the OTDR

In order to avoid an excessive Fresnel reflection from the front panel connector, it is essential to ensure cleanliness. It is usually sufficient to clean and inspect the patch cord or pigtail connector using a Microscope 1D; but if a large reflection is still obtained, then the front panel connector itself should be dismantled and cleaned.

If making a temporary connection to a bare fibre using a mechanical splice, adjust the connection to maximise the launch level; this is particularly important when using the smallest pulse.

4.3.2 Initial Settings

The Reflectometer 9C has an automatic setting that will optimise to the fibre under test. However, if manual settings are required, these can be adjusted within the setup menu.

Set the DISTANCE RANGE, PULSE WIDTH, REFRACTIVE INDEX, AVERAGING LIMIT, WAVELENGTH and SWEEP MODE to suit the fibre under test.

Confirm that the READY LED is on, and press the LASER key.

Press AVERAGE if the waveform is noisy.

4.3.3 Section Loss Measurement

Use the V ZOOM, H ZOOM, V SHIFT and H SHIFT keys to position the section to be measured centrally on the screen.

LSA mode is recommended for loss measurements. However, if the trace is relatively noise free then 2PA mode is also acceptable. If a splice or Fresnel reflection is present within the section to be evaluated, then 2PA mode MUST be used.

Select LOSS and accurately position the two markers at the extremes of the section to be measured.

Read off the section loss and distance directly from the screen.

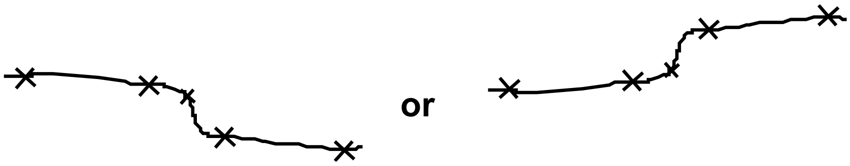
Note: Many of these parameters are produced in an automated "Table or on Screen Results" that may be read directly.

4.3.4 Splice Loss Measurement

Because the fibres on either side of a splice may have different back-scatter coefficients, it is essential to measure splice losses from both ends of the fibres and to average the two readings. A splice will normally appear on the screen as a downward step in the trace. However, when dissimilar fibres have been spliced together, the splice can sometimes appear as an upward step (i.e. as an apparent gain) or as no step at all (i.e. as a loss of 0dB).

Use the V ZOOM, H ZOOM, V SHIFT and H SHIFT keys to position the splice to be measured centrally on the screen.

Accurately position the central marker at the leading edge of the splice; and the remaining four markers on either side of the splice as shown in the diagram below. (Pressing the MARKER key toggles between the markers.)



Read off the splice loss directly from the screen.

Note: Many of these parameters are produced in an automated "Table or on Screen Results" that may be read directly.

4.3.5 Macro-Bend Losses

Macro-bends usually occur in fibre-handling enclosures where fibres can be accidentally pulled too tightly around fibre guides or otherwise incorrectly installed. The effect of a macro-bend is to allow light to escape through the fibre cladding and hence it causes excessive attenuation.

Because a macro-bend usually occurs at a fibre handling point, it is important to distinguish it from a possible adjacent 'splice' in order to avoid re-splicing fibres unnecessarily.

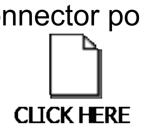
Note: The distinction can be made by observing the 'splice' loss at the two different wavelengths of 1310nm and 1550nm.

Note: The longer 1550nm wavelength light is less easily guided by the fibre and consequently, macro-bends have a greater effect at this wavelength.

Therefore, splice losses should always be evaluated at both wavelengths and the losses at the two wavelengths compared. A higher loss at 1550nm indicates the probable presence of a macro-bend.

4.3.6 Connector Return Loss

A description of the set up and Return Loss measurement of a far end optical connector point using an OTDR is shown in the attached document.



to link to document.

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