The Fibreoptic Industry Association

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TECHNICAL SUPPORT DOCUMENT

FIA-TSD-2000-4-2-2

OPTICAL FIBRE CABLING

-

TESTING OF INSTALLED CABLING

-

OPTICAL TIME DOMAIN REFLECTOMETER (OTDR)

Price: £150 (free to FIA members)

The Fibreoptic Industry Association

www.fibreoptic.org.uk

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The Fibreoptic Industry Association
-
An introduction for the new millennium

The past decade has been a time in which there has been a vast increase in the use of optical fibre - primarily driven by the need to provide a quality, high-speed transmission media for digital trunk telephony services. The specifications for these systems have typically been produced by large national telecommunications service providers. This has resulted in clear standards and specifications exist to which all suppliers to the WAN telecommunications industry must adhere.

In parallel there has been a significant growth in optical fibre systems being installed in private data, entertainment and telecommunications networks which are separate from the national telephony and data carrier systems. This part of the industry is characterised by having a large number of relatively small company participants albeit supplying large corporate customers with products and services. The use of optical fibres in private, local area data and sensor networks has increased rapidly throughout the 1990's. In order to support this rate of growth, an organizational focus is required for both suppliers and users in the industry in order to ensure the quality and reliability of network design, installation practice and methods of training.

The **Fibreoptic Industry Association** provides such a focus as a Trade Association to which companies, organizations and individuals involved with, or planning an involvement with, fibre optics can subscribe. In addition, by means of seminars, publications, newsletters, press promotion and similar activities, the **Fibreoptic Industry Association** is dedicated to raising the profile of the industry and highlighting its many benefits in order to increase its growth and thus provide direct benefits for members.

Our overall aims can be summarised as follows:

- to promote an awareness of the benefits and applications of fibre optic technology as an adjunct to - or as a replacement for - conventional copper communications technology;
- to promote an awareness of the existence of a professional fibre optics industry fully capable of meeting the needs of users or, so benefiting both suppliers and their customers;
- to promote and adopt standards to which professional participants within the fibre optic industry should be expected to adhere;
- to provide a central source for information on wide ranging aspects of the fibre optic industry;
- to provide a single voice to promote and represent the interests of the industry obtained by consensus and debate amongst FIA members;
- to develop and promote codes of practice within the industry - both operational and ethical - to which members will be expected to adhere and thus offer an assurance that the highest quality of service will be provided.

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FIA TECHNICAL SUPPORT DOCUMENTS

This document is one a series of FIA Technical Support Documents. During the year 2000 all the existing FIA documents will be re-written or re-published in the format used throughout this document.

More importantly, the way in which these Technical Support Documents is published has also changed.

These documents are now **free** to **FIA members** via downloads from the FIA web-site (www.fibreoptic.org.uk). Non-members are also able to purchase these documents either by contacting the Secretariat (address shown below) or by on-line purchase.

Members and non-members unable to benefit from this service may receive the documents in hard-copy or diskette/CD ROM by contacting the FIA Secretariat (contact details are shown at the bottom of each text page in this document). However, the rapidly changing nature of our technology means that web-based documents can be amended and revised easily and it is the responsibility of the reader to ensure that the latest issue of a document is used.

The FIA web-site will indicate the issue status of each document and will have links to previous issues in order that changes made will be clear to readers.

The complete list of FIA Technical Support Documents is shown in the Table below.

TOPIC	FIA-TSD-	TITLE
DESIGN	2000-1-1	OPTICAL FIBRE CABLING: LAN APPLICATION SUPPORT GUIDE
COMPONENT SELECTION	2000-2-1	OPTICAL FIBRE CABLING: CABLE SELECTION GUIDE
OPERATION	2000-3-3	OPTICAL FIBRE CABLING: POLARITY MAINTENANCE
INSTALLATION	2000-4-1-1	OPTICAL FIBRE CABLING: INSTALLATION PRACTICE: SPLICING
	2000-4-2-1	OPTICAL FIBRE CABLING: TESTING OF INSTALLED CABLING LSPM equipment
	2000-4-2-2	OPTICAL FIBRE CABLING: TESTING OF INSTALLED CABLING OTDR equipment
	2000-4-2-3	OPTICAL FIBRE CABLING: TESTING OF INSTALLED CABLING Specification, procurement and use of test cords
SAFETY	2000-5-1	OPTICAL POWER: SAFETY LEVELS
	2000-5-2	OPTICAL FIBRE: HANDLING OF PROCESSING CHEMICALS
	2000-5-3	OPTICAL FIBRE: DISPOSAL OF WASTE

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FOREWORD AND EXECUTIVE SUMMARY

The past ten years have seen a reduction in the lengths in which optical fibre has been installed. In the early days of commercial applications for optical fibre the channels were long either in the form of singlemode telecommunications systems or campus-wide interconnection of buildings. As the data rates within local area networks have increased so has the use of multimode optical fibre within buildings as backbone distribution systems and data centres.

This reduction in link lengths has highlighted the problem of measurement error when undertaking testing of installed cabling attenuation. For this reason, the FIA has produced this document which focuses on the correct method, equipment and cords to be used.

The impact of measurement error becomes manifest as the link lengths fall.

Substantial standardisation effort has been applied to delivering which reinforce existing methods but with improved test systems and conditions. The FIA are pleased to provide this Technical Support Document in order to clarify our recommended approaches following this work.

In certain cases it is still possible to obtain misleading results, as is explained in this document, and we attempt to indicate the likely outcome of measurements in advance of the testing scheme being initiated. Where deviant test results are predicted, appropriate quality assurance practices are necessary in addition to simply supplying test results to customers.

Failure to follow the procedures recommended by this Technical Support Document will increases the probability of installers and their customers becoming embroiled in disputes which could have financial impact.

By Paul Bateson, Chairman of the FIA

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INTRODUCTION

There are a number of international, European and British standards that define the correct test procedures to be used to measure the attenuation of the different link configurations and channels. In addition there are United States standards that cover the same topics.

At the time of publication of Issue 4.00 of this document, the IEC published IEC standards are more advanced than those in the United States. This situation will stabilise in coming months.

The first document to address the testing of installed cabling was the FIA/CCP/1/91 (completed by BSI in 1989 and first published by the FIA in 1991. This document was subsequently published by BSI as BS 7718 (1995).

NOTE: BS 7718 was withdrawn following the publication of BS 6701 in 2004 - although this decision was not related to testing.

The methods described in this document were followed within IEC in their publications of:

- IEC 61280-4-2 (for singlemode optical fibre) published as a British standard [BS EN] 61280-4-2 in 2000;
- IEC 61280-4-1 (for multimode optical fibre) published as a British standard [BS EN] 61280-4-1 in 2004.

Another standard, ISO/IEC 14763-3, was published as a British Standard [BS] ISO/IEC 14763-3 in 2006. The international standards for generic cabling design refer to this standard. Similarly, the general testing document in Europe, [BS] EN 50346 also refers to the ISO/IEC 14763-3 for all fibre optic cabling.

ISO/IEC 14763-3 initiated fundamental changes to testing practices - the test cords are different, the launch conditions (at least for multimode) are specified very carefully and the test limits have had to be modified accordingly.

Since the initial publication of ISO/IEC 14763-3 in 2006, the original international standard IEC 61280-4-1 for multimode cabling has been updated (published as [BS EN] 61280-4-1- in 2009). This provides maintains its wider set of test procedures, applicable to different installed cabling configurations, while incorporating the basic improvements of ISO/IEC 14763-3. In 2012, IEC is also expected to update IEC 61280-4-2 for singlemode cabling using the same philosophy.

Because the UK is not able to publish two British Standards covering the same territory (and because Euronorms take precedence), the BS endorsement of [BS] ISO/IEC 14763-3 was removed in 2010. This is a procedural matter and does not reflect any undermining of the ISO/IEC standard which will still be referenced in this document.

In summary, the procedures for attenuation testing of installed fibre optic cabling have been updated and tightened to provide more accurate results - largely as a result of the issues raised in early issue of this document. However, the outcome is a little confusing due to the proliferation of apparently standards.

Issue 4.00 and onwards of this document seeks to clarify the FIA recommendations for testing by making direct reference to the latest standards - rather than by redefining them.

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1 SCOPE

Unlike earlier issues of this Technical Support Document, this issue does not contain detailed test methods. Instead, this document clarifies which standards shall be applied to provide the best practical testing solution to be applied to particular optical fibre cabling configurations in order to measure component, event, link and channel attenuation using optical time domain reflectometer (OTDR) equipment.

This document has to be considered in conjunction with TSD-2000-4-2-3: OPTICAL FIBRE CABLING: TESTING OF INSTALLED CABLING: Specification, procurement and use of test cords.

Clause 6 outlines the commonalities and differences between the approaches taken by the two primary referenced standards and why the FIA has decided to only promote the use of one of them in this Technical Support Document.

Clause 7 provides information of the inspection and cleaning of test system connecting hardware and the interfaces to the cabling under test.

Clause 8 discusses management of test results.

Clause 9 provides a reminder of the need to produce appropriate quality plans which indicate the likely outcome of testing based upon the test methods to be applied.

2 CONFORMANCE

This Technical Support Document provides additional information enabling the more viable implementation of the requirements of published British, European and international standards in specific. Conformance to this Technical Support Document requires the application of those standards supported by the guidance provided in this document.

NOTE: Cabling system suppliers may choose to adopt other testing regimes than those outlined in this document. They are obviously free to do so and are free to ask the installer to use these regimes providing the customer accepts that approach. However, any audit work undertaken by the FIA Technical Directorate will apply the preferred methods and limits defined in this document.

In addition the testing shall be undertaken in accordance with the generic or installation-specific Quality Plan (see clause 9) produced by the installer and agreed with the customer as meeting the needs of the installation Specification. Readers are referred to [BS] EN 50174-1 for the requirements and contents of both Installation Specifications and Quality Plans.

3 RELATIONSHIP WITH PREVIOUS EDITIONS OF TSD-2000-4-2-2

From Issue 1 to Issue 1.02 of this Technical Support Document, all changes between one issue and the next were logged within a downloadable .pdf file from the FIA web-site.

With the publication of Issue 2.00 the changes are so substantial that the entire structure of the document has been changed and Issues 2.00 and above bear no direct relationship with Issue 1.02.

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4 REFERENCES

4.1 Primary references

This document will primarily refer to five standards:

[BS EN] IEC 61280-4-1:2009	Fibre optic communication subsystem test procedures - Installed cable plant - Multimode attenuation measurement
[BS EN] IEC 61280-4-2:2000	Fibre optic communication subsystem basic test procedures - Part 4-2: Fibre optic cable plant - Single-mode fibre optic cable plant attenuation
[BS EN] IEC 61300-3-35	Fibre optic interconnecting devices and passive components. Basic test and measurement procedures. Examinations and measurements. Fibre optic connector endface visual and automated inspection
[BS PD] IEC TR 62627-01	Fibre optic interconnecting devices and passive components. Fibre optic connector cleaning methods
ISO/IEC 14763-3 Ed.1.1:2011 including Technical Corrigendum 1	Information technology - Implementation and operation of customer premises cabling - Testing of optical fibre cabling

The following standard is currently being revised and is expected to have a modified title as follows:

[BS EN] IEC 61280-4-2: 2012	Fibre-optic communication subsystem test procedures - Part 4-2: Installed cable plant - Single-mode attenuation and optical return loss measurement

4.2 Other testing references

[BS] EN 50174-1	Information technology - Cabling installation - Part 1: Installation specification and quality assurance
[BS] EN 50346:2002 + A2:2009	Information Technology - Testing of installed cabling
FIA-CCP-1/91	Code of Practice for the installation of fibre optic cabling (withdrawn when BS 7718 was published)

4.3 Other general references

BS 6701:2010	Telecommunications equipment and telecommunications cabling - Specification for installation, operation and maintenance
BS 7718:1996	Code of Practice for the installation of fibre optic cabling (withdrawn when BS 6701:2004 published)
[BS] EN 50173-1	Information technology - Generic cabling systems - Part 1: General requirements
[BS] EN 50173-2	Information technology - Generic cabling systems - Part 2: Office premises
[BS] EN 50173-3	Information technology - Generic cabling systems - Part 3: Industrial premises
[BS] EN 50173-5	Information technology - Generic cabling systems - Part 5: Data centres
ISO/IEC 11801	Information technology - Generic cabling for customer premises
ISO/IEC 24702	Information technology - Generic cabling - Industrial premises
ISO/IEC 24764	Information technology - Generic cabling - Data centres

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4.4 Sourcing the primary standards

In order to understand the recommendations of this TSD, it is required that readers will have access to the published versions of the following documents. These are available as follows:

[BS EN] IEC 61280-4-1:2009	From the BSI link via the FIA web-site home page (www.fia-online.co.uk) Cost to BSI members: £86.00 Cost to non-BSI members: £172.00
[BS EN] IEC 61280-4-2:2000	From the BSI link via the FIA web-site home page (www.fia-online.co.uk) Cost to BSI members: £46.00 Cost to non-BSI members: £92.00
[BS EN] IEC 61300-3-35:2010	From the BSI link via the FIA web-site home page (www.fia-online.co.uk) Cost to BSI members: £65.00 Cost to non-BSI members: £130.00
[BS PD] IEC TR 62627-01:2010	From the BSI link via the FIA web-site home page (www.fia-online.co.uk) Cost to BSI members: £43.00 Cost to non-BSI members: £86.00

In order to understand the recommendations of this TSD, it is recommended that readers will have access to the published versions of the following documents. These are available as follows:

ISO/IEC 14763-3 Ed.1.1: 2011 including Technical Corrigendum 1	http://webstore.iec.ch/ Cost: CHF324

5 DEFINITIONS AND ABBREVIATIONS

5.1 Definitions

For the purpose of this Technical Support Document the following definitions apply:

Application	system, with its associated transmission method that is supported by telecommunications cabling ([BS] EN 50173-1)
Channel	any transmission path comprising passive cabling components between application-specific equipment ... ([BS] EN 50173-1)
Channel insertion loss	the maximum channel attenuation defined by an application standard e.g. 1000BASE-SX. This is not necessarily the same as optical power budget of the transmission equipment (see FIA-TSD-2000-2-1)
Connection	mated device or combination of devices including terminations used to connect cables or cable elements to other cables, cable elements or application specific equipment ([BS] EN 50173-1)
Equipment cord	A cord connecting a link to application-specific equipment
Installed cable	cabling between two test interfaces which can comprise cable, splices (mechanical or fusion) and/or other connections deemed to be “permanent” for the purposes of the test being carried out
Link	transmission path that excludes work area cords, equipment cords, patch cords and jumpers but includes the connection at each end. It can include a CP link
Patch cord	a cord connecting a link to a link
Test cord	a cord that is part of the test system

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5.2 Abbreviations

For the purpose of this Technical Support Document the following definitions apply:

MMF	Multimode optical Fibre
SMF	Singlemode optical fibre
LS	Light Source
PM	Power Meter

5.3 Conventions

Within this Technical Support Document the term “attenuation” is used widely as a global replacement for other terms such as “insertion loss”.

Within this Technical Support Document:

- IEC standards that are published, essentially unchanged, as European Norms (and then as British Standards) are designated [BS EN] IEC but are published by IEC as IEC xxxxx or by BSI as BS EN xxxxx;
- ISO/IEC standards that are published, essentially unchanged, as British Standards are shown as [BS] ISO/IEC but are published by IEC as ISO/IEC xxxxx or by BSI as BS ISO/IEC xxxxx;
- ISO/IEC standards that are published, essentially unchanged, as British Standards are shown as [BS] ISO/IEC but are published by IEC as ISO/IEC xxxxx or by BSI as BS ISO/IEC xxxxx;
- European Norms that are published, essentially unchanged, as British Standards are designated [BS] EN].

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6 OBJECTIVES OF THE STANDARDS

6.1 The common features of the primary referenced standards

The main objectives of ISO/IEC 14763-3 in relation to OTDR testing were to define:
- a launch condition to be use when undertaking the testing of multimode optical fibre cabling;
- the appropriate use of reference grade connectors on test cords to reduce measurement spread - together with an associated amendment of test limits.

For the testing of multimode optical fibre cabling, BS EN] IEC 61280-4-1 adopts the same launch conditions based on encircled flux and supports the use of reference grade terminations where they can be provided. [BS EN] IEC 61280-4-1 does, to some extent, take on board these changes but provides much greater flexibility.

6.2 The differences between the primary referenced standards

The main differences are that ISO/IEC 14763-3:
- is written specifically to support both multimode and singlemode optical fibre generic cabling as detailed in 6.1;
- mandates the use of reference grade connectors on test cords.

For multimode optical fibre cabling, [BS EN] IEC 61280-4-1:
- is written specifically to support all 50/125 or 62,5/125 μm multimode optical fibre cabling (a maximum length of 2000 m is quoted but is not specifically relevant);
  NOTE: the methods are applicable to other multimode optical fibres but launch conditions are not specified
- allows the use of either normal or reference grade terminations on test cords.

For singlemode optical fibre cabling, [BS EN] IEC 61280-4-2 supports the use of normal terminations on test cords.
NOTE: the revision of this document is likely to allow the use of either normal or reference grade terminations on test cords

ISO/IEC 14763-3 uses the term “reference grade connector” whereas the [BS EN] IEC 61280-4-1 uses the term “reference grade termination”. The objective of the use of test cords with either reference grade connectors or terminations (in conjunction with reference grade adapters as appropriate to the test method) is to produce mated “connections” with reduces attenuation as a mean of reducing the measurement uncertainty and resulting spread of results obtained. An FIA Project Team has investigated the viability of obtaining such reduced attenuation connection systems (irrelevant of the actual terminology applied by the standards) and the outcome of their work is detailed in FIA-TSD-2000-4-2-3.

6.3 The FIA preference for the application of the standards

The FIA does not support the direct application of ISO/IEC 14763-3 for the following reasons:
- **the work of the FIA Project Team investigating the specification and procurement of reference grade terminations found that there was no straightforward method by which test cords with reference grade terminations could be purchased that could be universally applied to all connector styles (this is documented in FIA-TSD-2000-4-2-3);**
  NOTE: for example, SC connectors had few problems but LC connectors did not lend themselves to the same approach
- **its handling of LSPM testing is insufficiently flexible and its methods increases the risk of negative attenuation results.**

These issues are detailed in TSD-2000-4-2-1 (Issue 4). These two specific technical issues are considered of major importance because they can directly lead to an installer obtaining sets of test results which become a source of technical debate and ultimately commercial conflict with their customers.

It is not in the interest of the FIA to encourage installers or their customers to act in a way that risks the reputation of the FIA or the installer and it is certainly not in the interests of the FIA to encourage practices that could result in financial penalty for any of those involved.

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In order to streamline the overall testing process, the FIA prefer to reference a consistent set of standards and i**n view of all the above factors, the FIA can only support the use of the following standards for OTDR testing of installer optical fibre cabling:**

- **[BS EN] IEC 61280-4-1 for multimode optical fibre cabling;**
- **[BS EN] IEC 61280-4-2 for singlemode optical fibre cabling.**

7 INSPECTION AND DE-CONTAMINATION OF CONNECTING HARDWARE

There is no value in undertaking any form of testing unless the optical fibre end-faces and any adapter components have not been inspected for contamination and cleaning, if contamination is found to be present.

A separate FIA Technical Support Document is planned to address this topic but the following provides some basic information.

An end-face inspection standard now exists in the form of [BS EN] IEC 61300-3-35. This allows automated inspection of end-faces using CCD microscopes of appropriate quality and with associated software-based assessment. These devices will become indispensible to installers and users alike.

[BS PD] IEC TR 62627-01 provides further information of end-face cleaning of connecting hardware.

Contamination on end-faces and within other connecting hardware components such as adapters can both cause permanent damage to mated components and can be passed via those components on to other end-faces. This is obviously a concern during testing and, if test cords are not maintained in a "de-contaminated" state, can potentially introduce a trend of worsening results as testing proceeds. This is particularly important if reference grade terminations are used on test cords since a failure to maintain their low attenuation characteristics will affect the results obtained on a systematic level.

In view of all the above factors, the FIA takes this opportunity to highlight that "**without inspection and cleaning, if necessary, of test cord end-faces and the end-faces of the cabling under test, there is no point in testing any cabling whatsoever.**"

8 TEST RESULT MANAGEMENT

8.1 Refractive index (IOR)

The use of the correct refractive index is important for the accurate measurement of length ONLY. It has no other impact. Where the refractive index is known it shall be used. Where no information is available the values shown in Table 1 shall be used.

	Wavelength			
	850 nm	**1300 nm**	**1310 nm**	**1550 nm**
SMF	-	-	1.460	1.460
MMF (50/125)	1.480	1.480	-	-
MMF (62.5/125)	1.490	1.490	-	-

Table 1 - Default IOR values

8.2 Administration

The test results shall be identified with the port ID of the local interface. In the case of duplex interfaces, the suffix A and B shall be added to the test result identifier.

A database/spreadsheet shall contain a hyperlinked direct reference from the identifier of the port under test to the file containing the OTDR characterization. Each characterization shall have the link length recorded.

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9 QUALITY ASSURANCE

9.1 General

Testing is a means of verification that the performance of installed cabling channels and links (see **Error! Reference source not found.**) meet the requirements of the relevant Installation Specification. Testing of installed cabling is not a substitute for the:

- proper inspection of installed cabling against the requirements recognised installation standards e.g. BS 6701 and the [BS] EN 50174 series;
- proper inspection of optical interfaces against the requirement of [BS EN] IEC 61300-3-35.

9.2 Quality Plan

It should be clear from the preceding clauses that:

- it is important to use the correct test method that is both matched to the configuration of the cabling under test and is appropriate to the Grade of test equipment used;
- even if the correct method is used there is a measurement error that cannot be reduced or ignored;
- on short links the impact of the measurement error is likely to produce results that lie both above and below the expected values.

In view of these factors the installer shall produce a Quality Plan in accordance with the BS EN 50174 series of standards. This may be in the form of a generic method statement.

The Quality Plan details the:

- test procedures to be used
- actions to be taken in the event of marginal results (i.e. results that lie within the measurement accuracy but outside the expected values.

Specifically the Quality Plan shall contain information about the following:

- the test equipment and test cords to be used;
- the need for bi-directional testing:
  - this may be a specific customer requirement but there is no need for bi-directional testing provided that the correct methods and cords are used;
- transmission wavelength:
  - the Installation Specification defines the wavelength(s) at which the cabling is to be tested. If the Installation Specification refers to external standards such as ISO/IEC 11801, EN 50173-1 or ANSI/TIA/EIA-568-C then these standards shall be consulted to determine their requirements;
    NOTE: all these standards define limits at both 850 nm and 1300 nm for MMF and both 1310 nm and 1550 nm for SMF but this does not means that testing is required at all wavelengths
- the administration of the test;
  - detailing how each test is to be referenced/identified;
  - detailing how the test configuration is to be recorded;
- the treatment of marginal results;
- proposals for re-testing with different test leads and the use of a statistical approach.

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