B & C Grade Tuned Connectors

White paper

Introduction

Modern systems are exponentially increasing the amounts of data being transmitted, requiring ultrahigh transportation speeds while also transmitting over long distances. With the advances in fibre-optic technology and transmission systems, reliable cabling systems are becoming even more important.

Active optical equipment, often worth hundreds of thousands of dollars, is connected into the network via the humble fibre-optic patch cord or patch lead. Substandard patch cords will affect the performance and reliability of the network and are often the most common source of failure within a network. The risk of network downtime due to unreliable cabling should be avoided. The networks transporting data over require high-performance connectivity capable of handling high input optical power, low return loss and low insertion connection loss in order to operate efficiently and ensure reliable transmission over long distances. If the quality of the connectors is not of a high standard, ie, the end face has small blemishes and specks of dust and is connected to a high-power laser output, the connector and the fibre can be badly burnt.

It is imperative that telecom companies upgrade their connector specifications in order to step up to the long-distance, super high data transportation speeds across the country. Therefore, these types of networks along with many other data centre and high-speed commercial networks require reliable cabling infrastructure in order to maximise performance and to ensure long-term reliability

This white paper gives a complete overview of Datatronix fibre optic tuned graded connectors.

Fibre-optic connector grades

Fibre optic transmission involves the transmission of an optical signal to long distances. In every fibre optic line, individual sections of fibre optic cables are connected with each other using fibre optic connections (connectors).

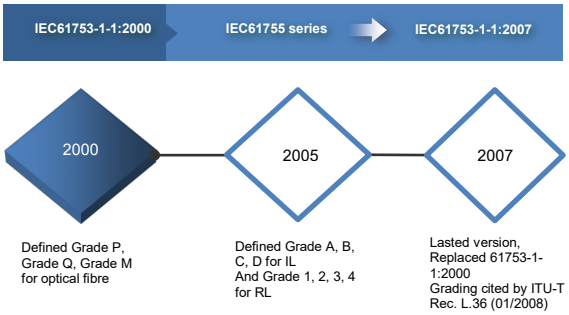
Every such connector-connector link introduces an additional undesirable loss of optical signal, referred to as insertion loss. This loss depends mostly on the quality of execution (geometrical parameters) of the fibre optic ferrule, located in every optical connection, which is defined by a parameter called concentricity of ferrule.

The better the concentricity of ferrule, the smaller the losses (lower insertion loss), which in turn results in a better quality of the optical signal transmission.

International Connector Standards

IEC standards dictate the connector performance requirement for each grade of fibre-optic patch cord connector.

These standards guide end users and manufacturers in ensuring compliance to best practices in optical fibre technology.



Optical fibre connecting hardware performance specifications are defined in international connector Standards including IEC 61753 (performance), IEC 61755 (optical), IEC 61754 (mechanical) and IEC 61300 (test and measurement).

International Standard IEC 61753-1-1:2007 has been prepared by subcommittee 86B: Fibre optic interconnecting devices and passive components, of IEC technical committee 86: Fibre optics.

This first edition of IEC 61753-1 cancels and replaces Edition 1 of IEC 61753-1-1 published in 2000. It constitutes a technical revision.

Specific technical changes ref. IEC 61753-1-1:2000 include that this new edition covers all passive fibre optic products, including connectors, passive optical components, fibre management systems and closures.

Grading criteria from IEC 61753-1

The IEC standard 61753 has not been ratified but guidelines that refer to the connector performance on the fibre-optic patch cord have been provided.

IEC 61753-1 defines optical fibre connectivity performance grades for single mode and multi-mode for controlled environments.
IEC 61753-1 specifies the insertion loss and return loss limits for single-mode connecting hardware.

Every fibre connection has two values:

- Attenuation or insertion loss
- Reflection or return loss.

Measurements of these parameters are now defined in IEC standard 61753-1. The standard gives five grades for insertion loss from A (best) to D (worst), and M for multimode. The other parameter is return loss, with grades from 1 (best) to 5 (worst).

Attenuation Grade	Attenuation random mated IEC 61300-3-34	
Grade A*	≤ 0.07 dB mean	≤ 0.15 dB max. for >97% of samples
Grade B	≤ 0.12 dB mean	≤ 0.25 dB max. for >97% of samples
Grade C	≤ 0.25 dB mean	≤ 0.50 dB max. for >97% of samples
Grade D	≤ 0.50 dB mean	≤ 1.00 dB max. for >97% of samples
Return Loss Grade	**Return Loss Random mated IEC 61300-3-6**	
Grade 1	≥ 60 dB (mated) and ≥ 55 dB (unmated)	
Grade 2	≥ 45 dB	
Grade 3	≥ 35 dB	
Grade 4	≥ 26 dB	

Specification	Each-to-each values	Budget for 10 connections
0.1 dB connector	approx. 0.2 dB (possibly higher if different manufacturers are combined or unadjusted connectors are used)	approx. 2 dB, unclear range of tolerance
Grade C	Mean ≤0.25 dB, Max ≤0.50 dB	≤2.5 dB
Grade B	Mean ≤0.12 dB, Max ≤0.25 dB	≤1.2 dB
Grade A*	Mean ≤0.07 dB, Max ≤0.12 dB	≤0.70 dB

According to IEC 61753 and IEC 61300-3-34 Attenuation Random Testing Method, ‘C’ Grade connectors have the following performance characteristics: attenuation: ≤0.25 dB mean, ≤0.50 dB max, for >97% of samples; return loss: ≥35 dB.

According to IEC, ‘B’ Grade connectors have the following performance characteristics: attenuation: ≤0.12 dB mean, ≤0.25 dB max, for >97% of samples; return loss: ≥45 dB.

The ‘A’ Grade connector (that is yet to be officially ratified by IEC) has the following performance characteristics: average insertion loss of 0.07 dB (randomly mated IEC Standard 61300-3-34) and a maximum insertion loss of 0.15 dB max, for >97% of

samples. While the return loss using IEC 61300-3-6 Random Mated Method is >55 dB (unmated - only angled connectors) and >60 dB (mated), this performance level is generally available for LC, A/SC, SC and E2000 interfaces.

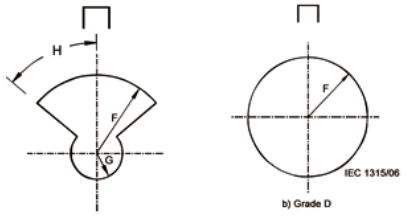
A specialised process of tuning of connections allows to obtain a lower loss and repeatability of the IL value in comparison to standard connections. At a low cost, we obtain very good parameters of connections – in line with IEC 61753 Grade B.

Tuning of connection - setting the position of ferrule - eliminates the effect of random core positioning in the connection and allows to obtain a good match of the connections in adaptors.

IEC 61755（2005）Fibre optic connector optical interfaces

The IEC 61755 testing method defines an estimation of insertion loss in respect to concentricity and fibre angular alignment in respect to fibre core and ferrule diameter. Random insertion connection loss is reduced by further tuning the fibre position in the connector ferrule, relative to the fibre optic connector keyway.

The insertion loss correlation between the two testing methods (random mated, using high stability test equipment, and concentricity measurements) is high.



IEC 61755 (2005) Fibre optic connector optical interfaces

Ref	Units	Grade A				Grade B				Grade C				GradeD			
		PC		APC		PC		APC		PC		PAC		PC		APC	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
F	um	0	0.6	0	0.6	0	1.2	0	1.0	0	1.5	0	1.4	0	1.6	0	1.5
G	um	0	0.1	0	0.1	0	0.3	0	0.2	0	0.3	0	0.3	NA	NA	NA	NA
H	Degrees	0	50	0	50	0	50	0	50	0	50	0	50	NA	NA	NA	NA

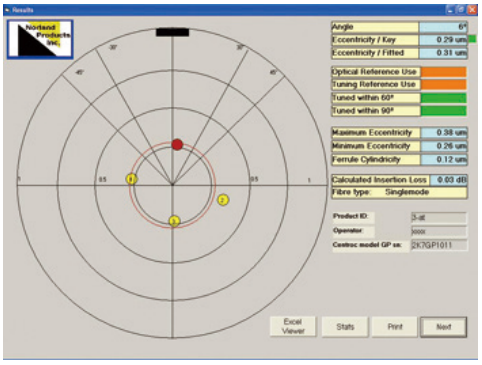
Experience & Advantages

Datatronix produces high quality IL&RL master cord, graded patchcord and customised high-spec patchcord. We are also capable of mass production of master cords and graded patch cords.

Datatronix is the chief drafter of national standard of graded ferrules for patchcord fabrication and will be released soon.

Below are the relevant product characteristics:

- They are in accordance with IEC61753, 61755, 61300, 61754 standards
- Good random mating IL performance & High return loss
- Excellent end face geometry parameter
- Fibre Core Eccentricity Test & Tuning Process
- Varieties of connectors FC, SC, ST, MU, LC
- Special specification available upon custom request



Certification

Datatronix LC/SM/PC Grade B patchcords have passed the third-party certification.

Summary

Measurement / test	Samples	Results		
		Statistics	Insertion loss, random mated [dB] at 1310 nm	at 1550 nm
Insertion loss, random mated, according to paragraph 5.1	LC PC SM, 21 samples	Mean value	0.06	0.05
		97% value	0.17	0.16
		Maximum	0.23	0.23
		Minimum	0.00	0.00

Table 2: Summary of the results of the performed measurements and tests.

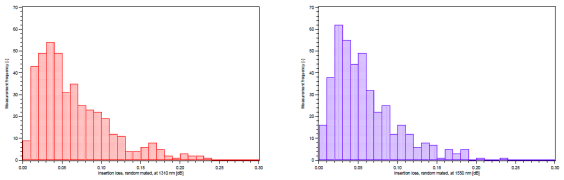


Diagram 1a/b: Measurement frequency of the insertion loss at 1310 nm (left) and 1550 nm (right) of random mated LC PC SM connectors. The measurement frequency refers to the values given in table 4 respectively table 5.

Production Capacity

Grade B Capacity:

Our regular patch cord capacity to be 1.5 million per month.

Current production line is compatible with Grade B production, and can be switched to Grade B patchcord production at any time.

Right now, 13 sets eccentricity tuning equipment. Capacity 200K Grade B/C terminators per month.

Conclusion

It is important to understand the benefits of using reliable, good quality optic fibre patch cords and connectivity. A reliable and high-performing connector ensures link integrity over the long term. Good quality connectors with low insertion loss will meet large bandwidth and high-speed requirements of the latest active optical equipment, allowing large streams of data to be transmitted reliably over long distances. Good quality connectivity begins with an excellent manufacturing, testing and inspection process.

Connector tuning ensures very low insertion loss for random-mated connections within the relevant grade. It should be noted that the couplers (adaptors) must also be of the same or better grade as the connector pairs being mated. Even with the best quality connectors, performance will be compromised unless the end-faces are clean and protected from damage.

Quality is all about consistency. A quality process ensures consistency, where every patch cord meets the high standards set. To consistently achieve graded performance, high accuracy testing using state of the art test equipment as well as constantly assessing testing methods are all required. In fact, every fibre optic patch cord manufactured by Datatronix is individually tested and inspected prior to despatch and the test result of every patch cord is kept on a database. Analysing and ensuring mechanical end face limits and that parameters are within range, ensures that graded connectivity is achieved.

It is plain to see the advantages of grading the patch cord. Graded patch cords has already been widely used in European market, and also found increasing demand in other areas in recent 2 years. We believe that it is a global trend to use graded patch cords in FTTH deployment.

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This white paper has been produced by Khushbu Solanki, on behalf of Datatronix