

**FIA**

PROJECT TEAM RGT

2010 NETCOMS 2010

# Testing Installed Optical Fibre Cabling

A report from  
**FIA** Project RGT

presented by  
David Robinson,  
Arden Photonics and Project Team Member



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# David Robinson

2010 NETCOMS 2010



**David Robinson**

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**Let us enlighten you...**



**• founded in 2001**

**Designs, manufactures and sells  
instruments and components to the optical fibre  
industry throughout the world.**



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# History

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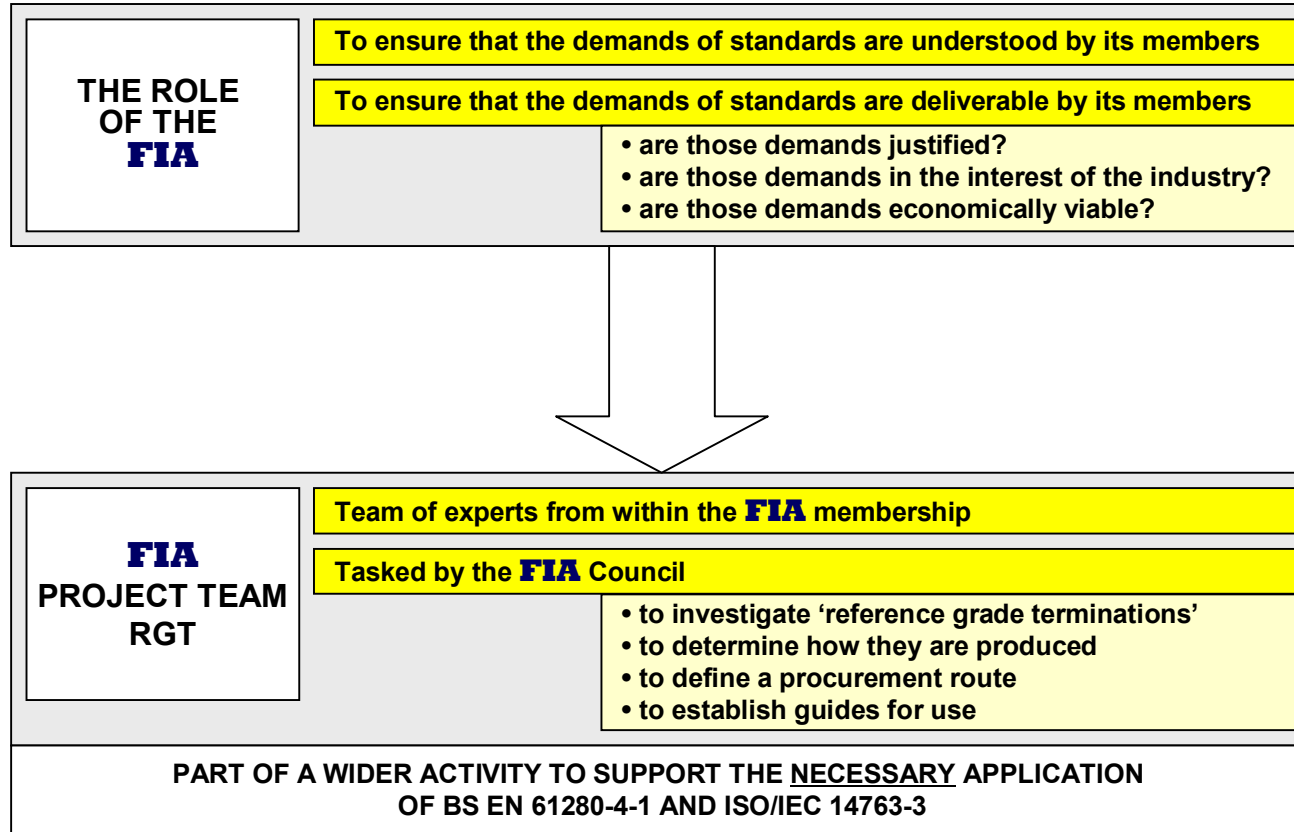
2002	<b>FIA PUBLISHES TSD-2000-4-2-1</b>
	Optical Fibre Cabling: Testing of installed cabling: LSPM
2002	<b>FIA PUBLISHES TSD-2000-4-2-2</b>
	Optical Fibre Cabling: Testing of installed cabling: OTDR
2003	<b>FIA FINDS SIGNIFICANT ERRORS IN MMF CABLING TESTS</b>
	• dependent upon launch conditions into cabling under test
<b>WORK BEGINS IN ISO/IEC TO ADDRESS THE ISSUE</b>	
2006	<b>PUBLICATION OF BS ISO/IEC 14763-3</b>
	Implementation .... of customer premises cabling - Testing of optical fibre cabling
• MMF launch conditions defined by "MPD"	
• 'cabling configuration'-independent test method	
• reference grade connectors for test cords	
2009	<b>PUBLICATION OF BS EN 61280-4-1</b>
	..... Installed cable plant - Multimode attenuation measurement
2009	<b>PUBLICATION OF ISO/IEC 14763-3 Amendment 1</b>
	• MMF launch conditions defined by "encircled flux"
• 'cabling configuration'-specific test method	
• reference grade terminations for test cords	
2010	<b>FIA INITIATES PROJECT RGT</b>



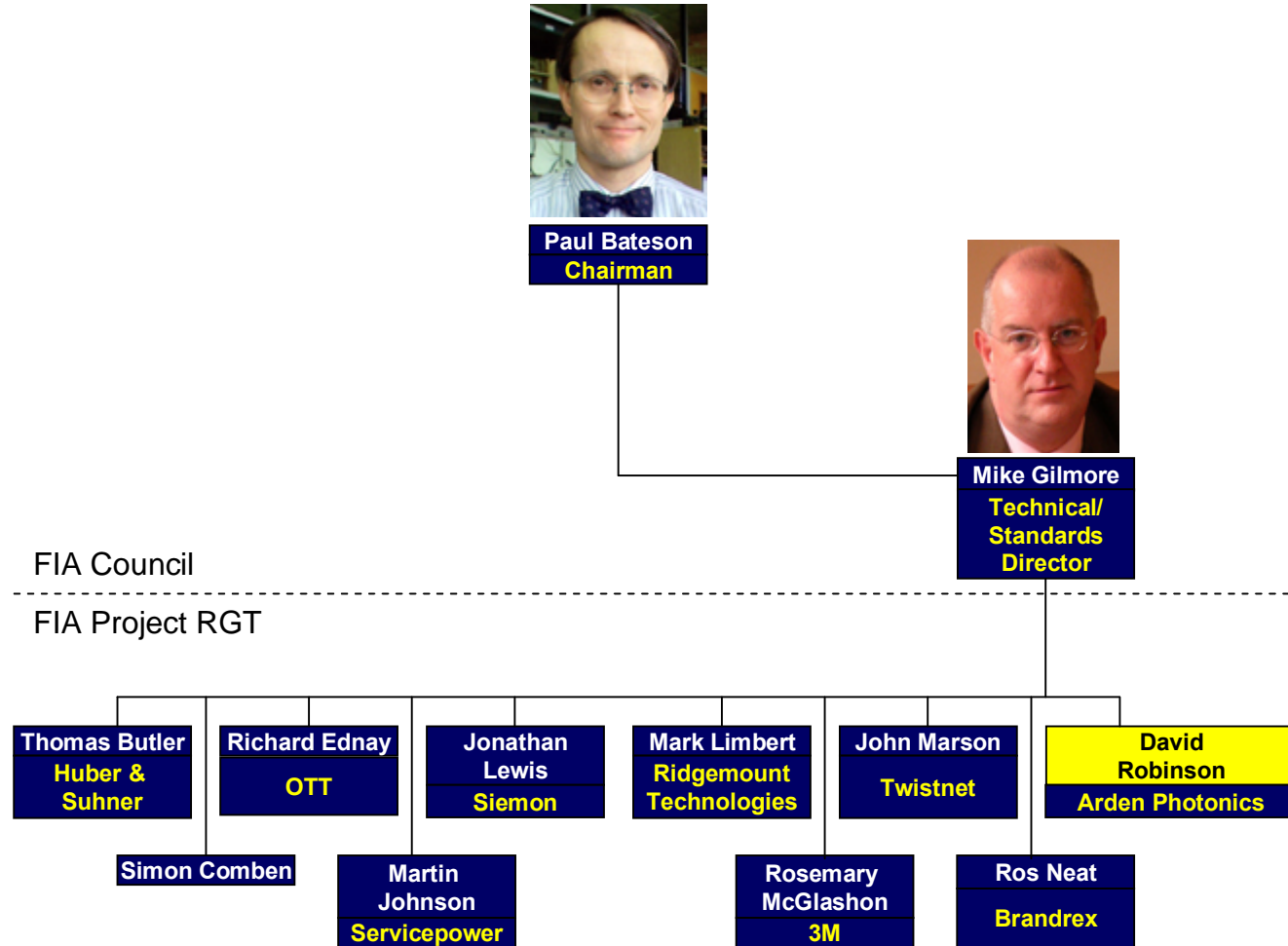
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# What is Project RGT?

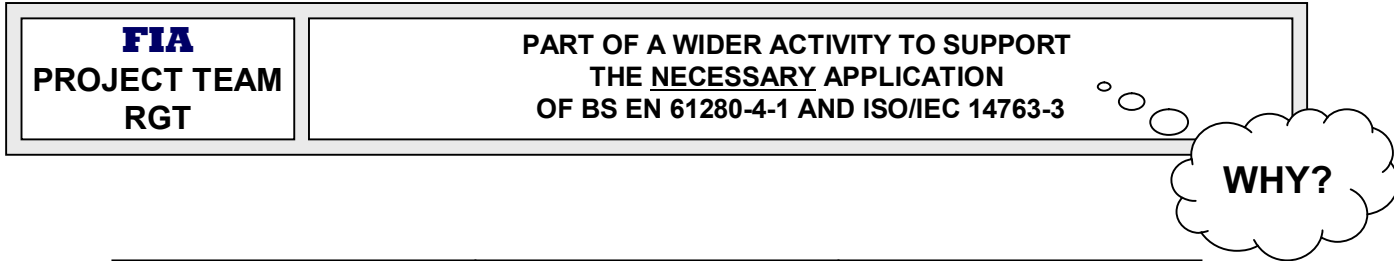


# Who is Project RGT?



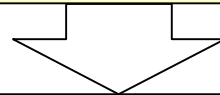
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# The Importance of RGT



MMF APPLICATION	SUPPORTED CHANNEL LENGTHS	REQUIRED CHANNEL INSERTION LOSS
10BASE-F	1514 - 2000 metres	6.8 - 12.5 dB
100BASE-F	2000 metres	11.0 dB
1000BASE-S	275 - 500 metres	2.6 - 3.6 dB
10GBASE-S	32 - 500 metres	1.6 - 2.6 dB
40/100GBASE-S	100 - 150 metres	1.5 - 1.9 dB

As data rates increase using multimode optical fibre	<ul style="list-style-type: none"> <li>• reduction in maximum CIL</li> <li>• reduction in typical channel length</li> <li>• increased risk of litigation                             <ul style="list-style-type: none"> <li>• need for accuracy</li> <li>• need for repeatability</li> </ul> </li> </ul>
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**REFERENCE GRADE TERMINATIONS PLAY A KEY ROLE IN THIS PROCESS**



# RGT - Critical to the Test System

SINGLE CORD REFERENCE METHOD	
	PREFERRED FOR PANEL-TO-PANEL CONFIGURATIONS IN BS EN 61280-4-1
	NOT USED BY ISO/IEC 14763-3
TWO CORD REFERENCE METHOD	
	USED FOR PANEL-TO-PLUG CONFIGURATIONS IN BS EN 61280-4-1
	NOT USED BY ISO/IEC 14763-3
THREE CORD REFERENCE METHOD	
	USED FOR PLUG-TO-PLUG (CHANNEL) CONFIGURATIONS IN BS EN 61280-4-1
	OPTIONAL FOR PANEL-TO-PANEL CONFIGURATIONS IN BS EN 61280-4-1
USED FOR ALL CONFIGURATIONS BY ISO/IEC 14763-3	



# RGT - Current Specification - I

**BS EN 61280-4-1**

**3.1.8**

**reference grade termination**

**connector plug** with tightened tolerances terminated onto an optical fibre with tightened tolerances such that the expected loss of a connection formed by mating two such assemblies is less than or equal to 0,1 dB

EXAMPLE: as an example, the core diameter tolerance may need to be  $\pm 0,7$  micron (ffs). Other fibre tolerances are ffs.

NOTE 1 An adapter, required to assure this performance, may be considered to be part of the reference grade termination where required by the test configuration

NOTE 2 This definition remains as a point under study. When a more complete definition is available in another document, this definition will be replaced by a reference.



# RGT - Current Specification - II

## ISO/IEC 14763-3 FOR MULTIMODE SC CONNECTORS

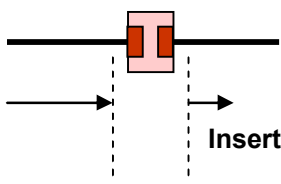
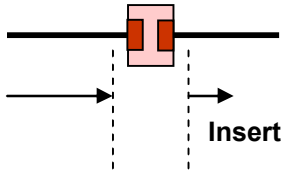
- Ferrule outer diameter is  $2,499 \text{ mm} \pm 0,0005 \text{ mm}$
- Eccentricity of the fibre core with the outer diameter of the ferrule is less than  $1 \mu\text{m}$
- Eccentricity of a spherical polished ferrule end-face is less than  $30 \mu\text{m}$
- Reference duplex adaptor shall be in accordance with IEC 60874-19-3 (MM adaptor)
- Attenuation of two plugs and a reference adaptor shall be  $< 0.1 \text{ dB}$

## ISO/IEC 14763-3 FOR OTHER CONNECTORS

	Cylindrical connector styles		Rectangular connector styles	
	MMF	SMF	MMF	SMF
Eccentricity of core centre to ferrule outer diameter	$<1 \mu\text{m}$	$<0,3 \mu\text{m}$	na	na
True position of the fibre core	na	na	$<1 \mu\text{m}$	$<0,3 \mu\text{m}$
Exit angle	$\leq 0,2^\circ$	$\leq 0,2^\circ$	$\leq 0,2^\circ$	$\leq 0,2^\circ$
Accuracy of ferrule diameter	$\pm 0,5 \mu\text{m}$	$\pm 0,5 \mu\text{m}$	na	na
Attenuation between 2 reference connectors	$\leq 0,10 \text{ dB}$	$\leq 0,20 \text{ dB}$	$\leq 0,10 \text{ dB}$	$\leq 0,20 \text{ dB}$



# The Work of Project RGT

<b>BS EN 61280-4-1</b>	
<ul style="list-style-type: none"> <li>• defines the performance</li> <li>• does not define the component mechanical tolerances</li> <li>• mentions possibility of tighter tolerance OF</li> </ul>	 <p>Insertion loss <math>\leq 0,1</math> dB</p>
<b>ISO/IEC 14763-3</b>	
<ul style="list-style-type: none"> <li>• defines the performance</li> <li>• references some specific connector standards               <ul style="list-style-type: none"> <li>• as a basis for definition</li> </ul> </li> <li>• provides a loose definition for others               <ul style="list-style-type: none"> <li>• no mention of tighter tolerance OF</li> </ul> </li> </ul>	 <p>Insertion loss <math>\leq 0,1</math> dB</p>
<p><b>FIA</b> PROJECT TEAM RGT</p>	<ul style="list-style-type: none"> <li>• the real requirements for a RGT               <ul style="list-style-type: none"> <li>• starting with MM circular ferrules</li> <li>• MM rectangular ferrules in the 'too hard' category at this time</li> <li>• SM work is partially underway elsewhere</li> </ul> </li> <li>• how to produce RGTs (if product selection is required)</li> <li>• how to procure RGTs (if complex measurement is required)</li> <li>• how to use RGTs to maintain performance</li> </ul>



# The Results of Project RGT - I

**SC CONNECTORS**

	RT01		RT02		RT03		RT04	
	RT01-A	RT01-B	RT02-A	RT02-B	RT03-A	RT03-B	RT04-A	RT04-B
Core ecc	1.0	0.8	1.3	0.8	1.9	2.0	1.1	
Bearing	177	178	105	-16	143	91	-3	
Core dia	50.3	50.2	50.1	50.3	50.6	50.4	50.3	
Ferr radius	16.27	15.47	15.19	14.84	14.63	14.23	17.81	
Spherical fibre	94.0	106.9	46.0	-19.3	-35.0	142.8	-58.5	
Apwx offset	7.6	2.6	14.6	9.9	10.8	8.4	15.2	
Ferrule bore								
Fibre rad								
Planar fibre	218.5	236.8	177.0	118.6	102.7	286.5	54.9	
Apex bearing	50.4	114.2	244.7	348.9	218.6	235.3	345.1	
Angle error	0.027	0.000	0.055	0.038	0.042	0.034	0.049	
Fibre roughness	4	4	4	4	3	5	3	
Ferrule roughness	5	4	4	7	26	6	6	

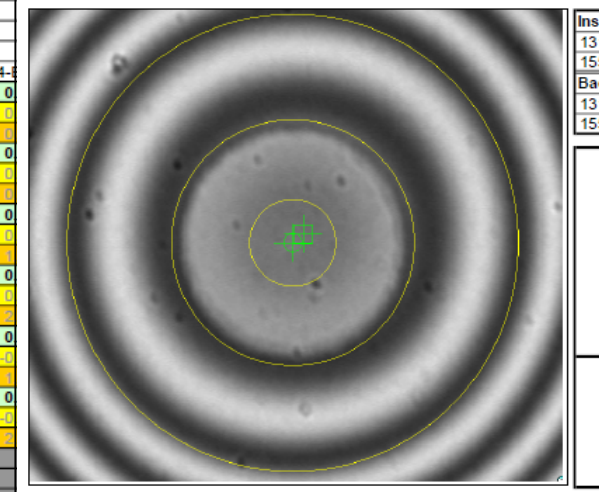
  

	RT01		RT02		RT03		RT04	
	RT01-A	RT01-B	RT02-A	RT02-B	RT03-A	RT03-B	RT04-A	RT04-B
Adaptor 1	RT01-A		0.03	0.05	0.03	0.06	0.05	0
			-0.20	0.00	0.30	0.10	0.00	0
RT01-B			1.37	1.79	1.21	2.17	2.10	0
			0.03	0.05	0.02	0.03	0.02	0
Adaptor 2	RT02-A	0.04	0.01		0.04	0.05	0.04	0
		0.20	0.10		0.50	0.30	0.20	0
RT02-B			1.37	1.20	1.19	0.80	1.95	1
			0.03	0.05	0.03	0.03	0.04	0
Adaptor 3	RT03-A	0.07	0.02	0.05	0.03		0.03	0
		-0.30	-0.40	-0.50	-0.30		-0.30	-0
RT03-B			1.21	1.45	1.19	2.86	2.88	1
			0.06	0.04	0.04	0.05	0.04	0
Adaptor 4	RT04-A	0.03	0.03	0.03	0.04	0.02	0.01	
		0.00	-0.10	-0.20	0.00	0.30	0.10	
RT04-B			2.19	2.06	0.80	2.36	2.35	2
			0.00	-0.10	-0.20	0.00	0.30	0.10
			2.19	1.75	1.95	0.37	2.88	2.35
			0.01	0	0.02	0.01	0.01	0.02
			0.00	-0.10	-0.20	0.00	0.30	0.10
			0.47	0.75	1.84	2.03	1.60	2.84

Sample name & type: SAMPLE PC-Default  
 Measurement Time & Date: 8:31:44 AM 06/23/10 ZX-1  
 Fitting Regions Used: D=260µm; E=140µm; F=50µm; A=1000µm

Measurement Parameter	Pass/Fail Limits		Measured Value
	Minimum	Maximum	
Radius of Curvature	10.00	25.00	16.27 nm
Fiber Height (Spherical Fit)	-100.0	100.0	94.0 nm
Fiber Height (Planar Fit)	-10.0	260.0	218.5 nm
Apex Offset	0.00	50.00	7.55 µm
Bearing			50.400 deg
Angle	-0.200	0.200	0.027 deg
Tilt Offset			deg
Actual Angle			deg
Key Error			deg
Fiber Roughness (Rq)	0	50	4 nm
Fiber Roughness (Ra)	0	50	3 nm
Ferrule Roughness (Rq)	0	50	5 nm
Ferrule Roughness (Ra)	0	50	4 nm
Diameter	121.0	150.0	132.1 µm

Comments  
 BLANK = NOT APPLICABLE OR NOT SELECTED

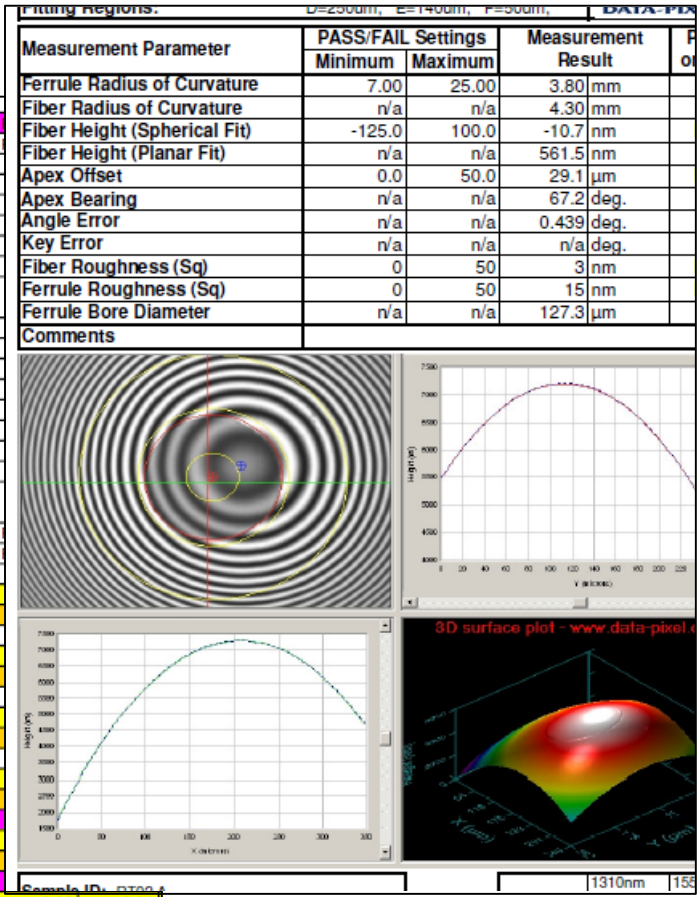


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# The Results of Project RGT - II

**LC CONNECTORS**

	RT01		RT02		RT03	
	RT01-A	RT01-B	RT02-A	RT02-B	RT03-A	RT03-B
Core ecc	0.4	0.7	2.1	0.7	1.1	0.6
Bearing	-14	17	-133	93	54	14
Core dia	53.7	53.8	52	52.1	55.1	55.8
Ferr radius	8.43	13.23	3.80	3.55	10.46	13.20
Spherical fibre	-112.0	-79.4	-10.7	39.4	-24.4	-48.8
Apwx offset	17.0	5.5	29.1	1.8	5.2	21.0
Ferrule bore	127.3	127.3	127.3	127.3	125.4	125.4
Fibre rad	29.71	17.90	4.30	4.24	11.92	15.95
Planar fibre	162.0	92.0	561.5	655.9	183.7	116.7
Apex bearing	129.2	101.2	67.2	239.5	48.7	163.8
Angle error	0.118	0.024	0.439	0.028	0.028	0.091
Fibre roughness	26	2	3	3	2	2
Ferrul roughness	9	5	15	17	7	7
	RT01	RT02	RT03			
	RT01-A	RT01-B	RT02-A	RT02-B	RT03-A	RT03-B
Adaptor 1	RT01-A		0.13	0.11	0.07	0.06
			-1.70	-1.60	1.40	2.10
			2.32	0.60	1.02	0.31
	RT01-B		0.12	0.07	0.09	0.11
			-1.80	-1.70	1.30	2.00
			2.73	0.68	0.68	0.11
Adaptor 10	RT02-A	0.08	0.15		0.01	0.08
		1.70	1.80		3.10	3.80
		2.32	2.73		3.19	2.62
	RT02-B	0.15	0.15		0.08	0.22
		1.60	1.70		3.00	3.70
		0.60	0.88		0.71	0.63
Adaptor 8	RT03-A	0.27	0.30	0.10	0.07	
		-1.40	-1.30	-3.10	-3.00	
		1.02	0.60	3.10	0.71	
	RT03-B	0.24	0.25	0.22	0.11	
		-2.10	-2.00	-3.80	-3.70	
		0.31	0.11	2.62	0.63	
Adaptor 7	RT04-A	0.22	0.24	0.15	0.22	0.02
		-1.00	-1.80	-3.60	-3.50	-0.50
		1.70	1.60	3.25	0.61	1.05
	RT04-B	0.28	0.29	0.26	0.23	0.06
		-1.80	-1.70	-3.50	-3.40	-0.40



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# The Conclusions of Project RGT

<b>REFERENCE GRADE TERMINATIONS - CIRCULAR FERRULES ON MM OPTICAL FIBRE</b>	
0,1 dB cannot be guaranteed by mechanical tolerances within the plug	
<ul style="list-style-type: none"> <li>• good results for SC             <ul style="list-style-type: none"> <li>• 3 suppliers, 4 cable types</li> </ul> </li> <li>• poor results for LC             <ul style="list-style-type: none"> <li>• 4 suppliers, 5 cable types</li> <li>• good results within supplier sample</li> <li>• poor results between supplier samples</li> </ul> </li> </ul>	
The use of single mode plugs is mandatory for MM RGTs	
No justification to control core-ferrule OD eccentricity	
No justification to control optical fibre core diameter	
The use of SM termination specification is mandatory for MM RGTs	
No justification to control end-face geometry beyond SM standard	
The use of MM or SM adaptors is supported	
The use of ceramic alignment sleeves in adaptors is considered valuable	



# Immediate Actions

REFERENCE GRADE TERMINATIONS - CIRCULAR FERRULES ON MM OPTICAL FIBRE	
2010/2011	<b>FIA COMPLETES TSD-2000-4-2-3</b>
	Optical Fibre Cabling: Testing of installed cabling: Cords
	<ul style="list-style-type: none"> <li>• manufacturing technique</li> <li>• procurement specification</li> <li>• guide to use</li> </ul>
	<b>FIA REVISES TSD-2000-4-2-1</b>
	Optical Fibre Cabling: Testing of installed cabling: LSPM
	<b>FIA REVISES TSD-2000-4-2-2</b>
	Optical Fibre Cabling: Testing of installed cabling: OTDR
	<ul style="list-style-type: none"> <li>• interpreting and supporting BS EN 61280-4-1 (MMF)</li> <li>• interpreting and supporting ISO/IEC 14763-3</li> <li>• heralding BS EN (IEC) 61280-4-2 (SMF)</li> </ul>



# The Bigger Picture

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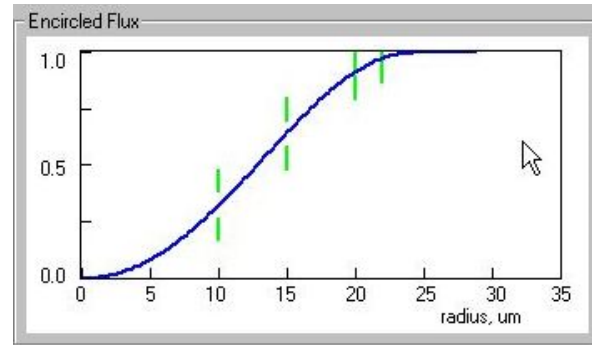
LATEST NEWS Updated August 23, 2010	HOT TOPICS
<ul style="list-style-type: none"> <li>▶ FIA Summer Seminar 2010: Presentation download</li> <li>▶ White Paper addresses OM3 and OM4 bandwidth</li> <li>▶ BS 6701:2010 is published</li> <li>▶ HSE Consultation on the AS</li> <li>▶ BS 8492</li> </ul>	<p><b>TESTING INSTALLED CABLING</b></p> <ul style="list-style-type: none"> <li>▶ Standards-compliant test equipment suppliers</li> <li>▶ Mode Controller Cord (MCC) suppliers</li> <li>▶ Standards-compliant test cord suppliers</li> </ul>

**Listing for test equipment which provides the correct launch conditions**

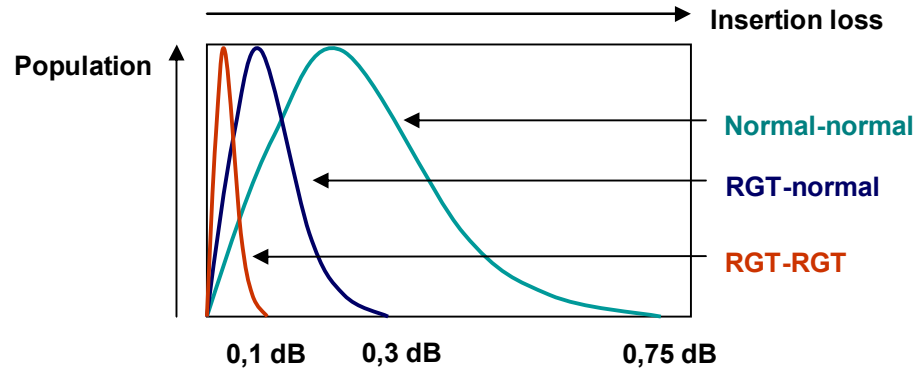
**ModCon Mode Controller from Arden Photonics**

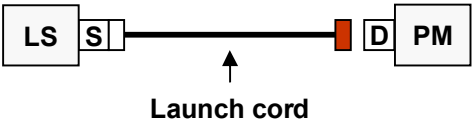
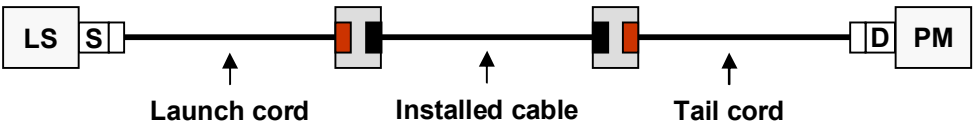


**Example plot of Encircled Flux condition required by IEC 61280-4-1**



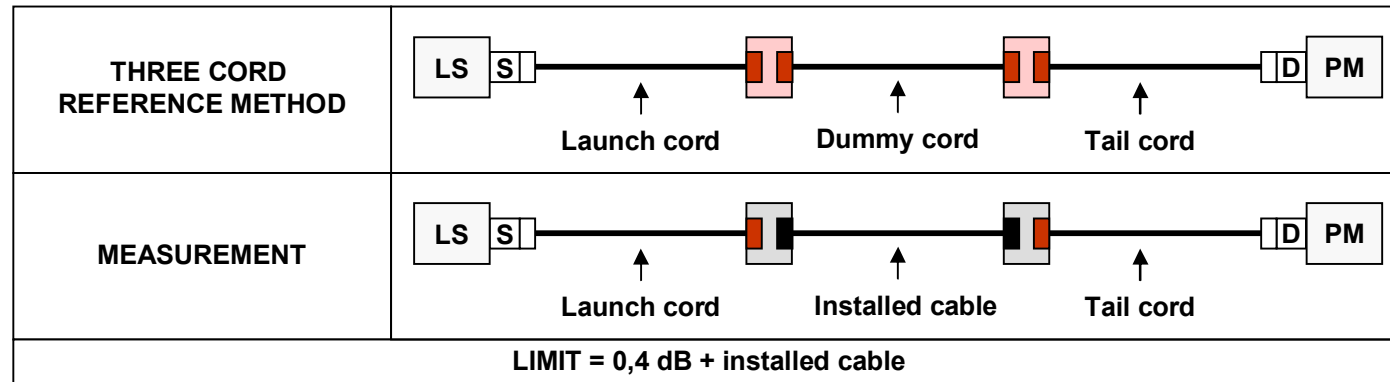
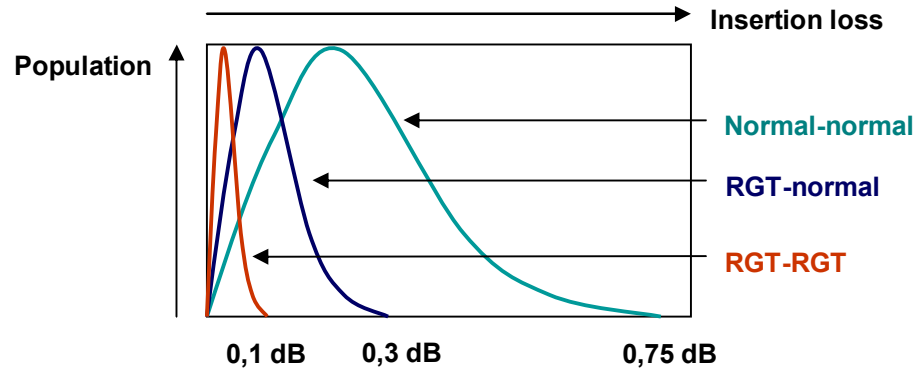
# MMF Test Limits: 1-Cord Reference



<p><b>SINGLE CORD REFERENCE METHOD</b></p>	 <p>LS S Launch cord D PM</p>
<p><b>MEASUREMENT</b></p>	 <p>LS S Launch cord Installed cable Tail cord D PM</p>
<p><b>LIMIT = 0,6 dB + installed cable</b></p>	
<p><b>PREFERRED FOR PANEL-TO-PANEL CONFIGURATIONS IN BS EN 61280-4-1</b></p>	
<p><b>NOT USED BY ISO/IEC 14763-3</b></p>	



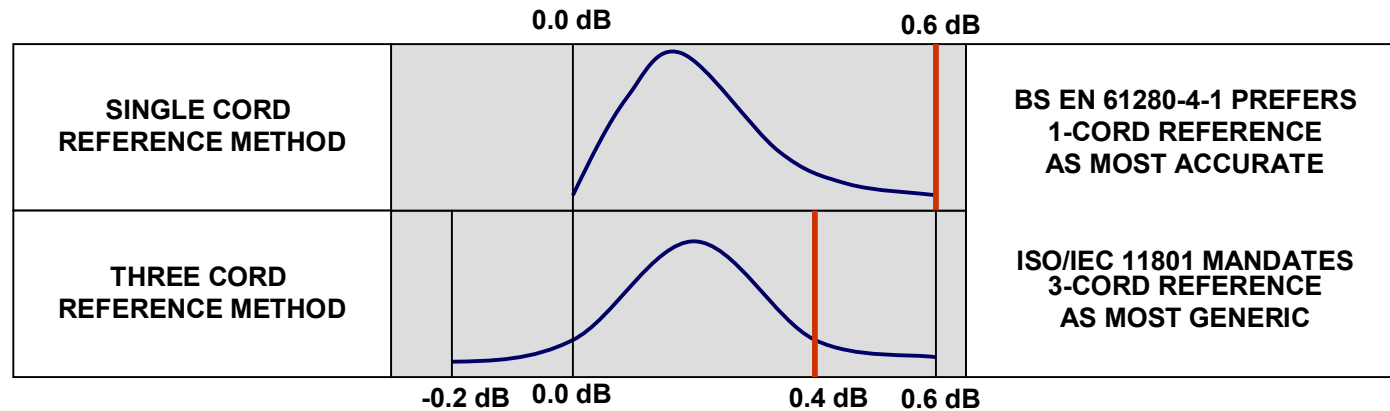
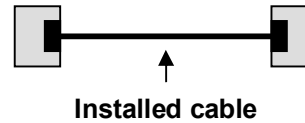
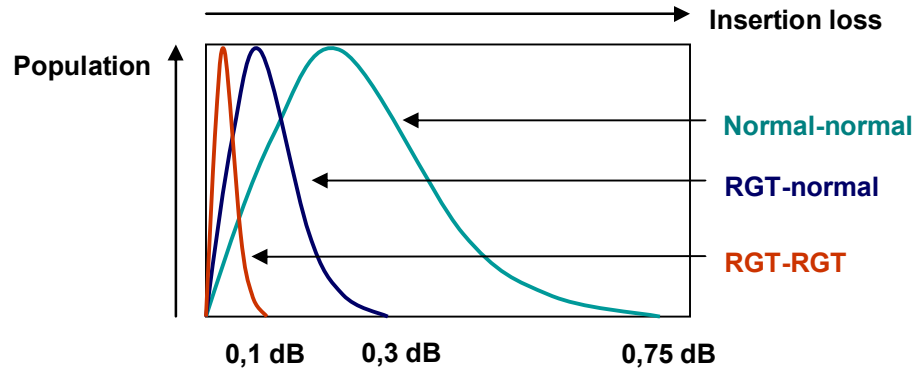
# MMF Test Limits: 3-Cord Reference



USED FOR PLUG-TO-PLUG (CHANNEL) CONFIGURATIONS IN BS EN 61280-4-1
OPTIONAL FOR PANEL-TO-PANEL CONFIGURATIONS IN BS EN 61280-4-1
USED FOR ALL CONFIGURATIONS BY ISO/IEC 14763-3



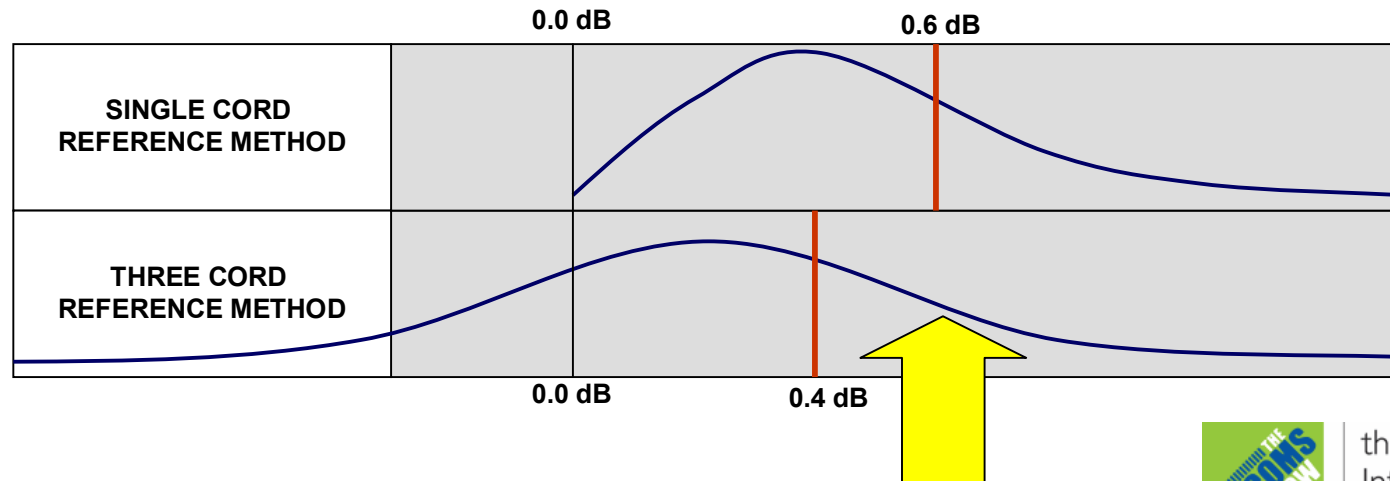
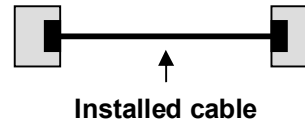
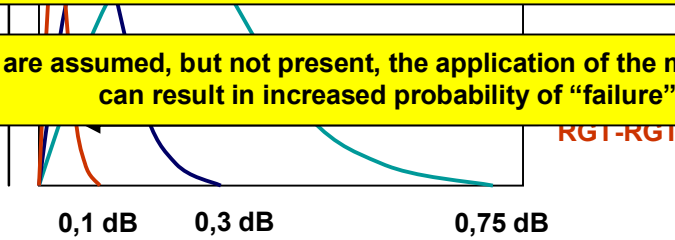
# MMF Test Results



# RGT Failure

THE USE OF REFERENCE GRADE TERMINATIONS FORCES THE MODIFICATION OF THE NORMAL TEST LIMITS

If RGT are assumed, but not present, the application of the modified limits can result in increased probability of "failure"



# Issues

## ARRAY FERRULES ARE A MAJOR CONCERN

Concerns exist regarding rectangular ferrules containing multiple optical fibres  
(if we cannot even control insertion loss for circular ferrules)

This may have implications for testing of installed MPOs  
in panel-panel configurations

## SM RGTS ARE FOR FURTHER STUDY



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