White Paper
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Fibre Cleaning
essential best practice : part 1

Nexans

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Connectors are found in all fibre optic networks. Connector interface contamination will lead to lower bandwidth, lower transmission rates and possible damage with costly and time consuming maintenance. All too often, we see that fibre ferrule end faces and adapters aren't properly cleaned of dust and dirt. When it comes to design, maintenance and cleaning, it is essential that all procedures be followed correctly.

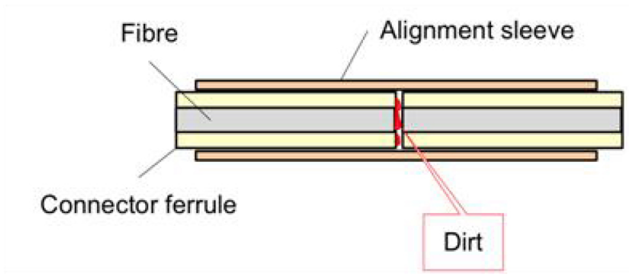


Fig 1: Typical dirt distribution

Why stay clean?

Technical staff who have been working in the industry for years sometimes admit that when it comes to fibre cleaning, their most important goal is simply to connect equipment and, for commissioning engineers, to obtain a 'pass'. However, it is vital to take fundamental steps to improve network operation and longevity as changes in technology have driven the escalating importance for correct fibre cleaning.

As bandwidth demand has increased in recent years, optical budgets have become much tighter. Today, we face the challenge of testing and certifying optical links against very low loss budgets. Fig. 2 shows the direct link between optical power and attenuation. Any increase in attenuation immediately results in reduced optical power. Just half a dB difference can result in an 11% power loss.

Attenuation (dB)	Remaining (%)	Lost Power (%)
0,05	98,8	1,1
0,1	98	2
0,2	95	5
0,3	93	7
0,4	91	9
0,5	89	11
0,75	84	16
1	79	21
2	63	37
3	50	50
5	32	68
6	25	75
7	20	80
10	10	90
15	3,2	96,8
20	1	99
30	0,1	99,9

Fig. 2: The relationship between attenuation and power loss

	Year	Application	Data Rate	Standard	Loss Budget (dB)
	1982	Ethernet	10 Mbps	IEEE 802.3	12.5
	1991	Fast Ethernet	100 Mbps	IEEE 802.3	11.0
13 years	1998	Short Wavelenght Fast Ethernet	10/100 Mbps	TIA/EIA-785	4.0
	2000	1G Ethernet	1000 Mbps	IEEE 802.3z	3.56
	2004	8&10G FC &10G Ethernet	10,000 Mbps	IEEE 802.3ae	2.60
6 years	2010	16G FC & 40G Ethernet	40,000 Mbps	IEEE 802.3ba	1.9
	2010	100G Ethernet	100,000 Mbps	IEEE 802.3ba	1.5

Fig. 3: Changing technology leads to tighter loss budgets

Fibre technology has changed dramatically over the years. If we compare fast Ethernet from the 1990's to 10G Ethernet around 2004, (Fig. 3) we're now looking at a loss budget of only 2.6dB, compared with 11dB. Anything from poor termination to sub-standard product quality or a bad patchcord will further eat into that already limited budget. Today's 100G networks have an even lower budget of 1.5 dB, so it really is vital to ensure losses are as low as possible.

Limiting maximum attenuation values is also extremely important, as this allows us to attain longer distances and a higher number of connections within the channel as seen in Fig. 5.

Cable	ISO 11801 Limit	NCS max loss
Max. MM fibre loss per km (@ 850nm)	3.5dB	< 3.0dB
Max. MM fibre loss per km (@ 1300nm)	1.5dB	< 3.0dB
Max. SM fibre loss per km (@ 1310nm)	1.0dB	< 0.4dB
Max. SM fibre loss per km (@ 1550nm)	1.0dB	< 0.28dB

Connections	ISO 11801 Limit	NCS max loss
Max. adapter (Connection) loss	0.75dB	< 0.3dB
Typical Splice loss	0.3dB	< 0.1dB

Fig. 4: Limiting maximum attenuation values for more distance and connections.

When we look at the limits as specified by manufacturers, we see that these are tighter than those specified by ISO 11801(see fig.4 & 5). You can use the Nexans warranty modules on our website to look at this in detail. By calculating carefully, you can work out the exact number of connections in a system by distance and application. Where statements might simply say 'OM3 equals 330 metres' or OM4 equals 550 metres', the actual connections in a system (distributed in or between buildings on a campus) need to be counted and the corresponding loss taken into account. This has a reduction effect on the fibre distance that can be utilised (see fig.6).

Example 1

		ISO 11801		NCS	
Link component	Quantity	Limit	Loss	Limit	Loss
Fibre (850nm)	100m	3.5dB/km	0.35dB	3.0db/km	0.30dB
Fibre end connections	2 pieces	0.75dB	1.5dBdB	0.3dB	0.6dB
Total loss			1.85dB		0.90dB

Example 2

		ISO 11801		NCS (Low loss)	
Link component	Quantity	Limit	Loss	Limit	Loss
Fibre (850nm)	100m	3.5dB/km	0.35dB	3.0db/km	0.30dB
Fibre end connections	2 pieces	0.75dB	1.5dB	0.20dB	0.4dB
MPO connections	2 pieces	0.75dB	1.5dB	0.30dB	0.6dB
Total loss			3.35dB		1.3dB

Fig. 5: Two connectors contribute to 70%-80% of the total link loss. Limits calculated from manufacturer warranted losses are tighter than those from ISO11801.

- **Applications and distance support**
  Nexans LANmark-OF OM4 Fibre systems are warranted to support any current or future application designed to be supported by fibres according to IEC 60793-2-10 A1a.3. Guaranteed distances vary depending on termination method used.

Ethernet distances								
Applications	Pre-Terminated ST/SC/LC Assemblies				Direct termination or splicing with ST/SC/LC			
# Connections	2	4	6	8	2	4	6	8
1GBase-SX	970m	960m	940m	930m	930m	880m	820m	780m
10GBase-SR	550m	540m	530m	520m	520m	490m	460m	440m
25GBase-SR	120m	115m	110m	105m	105m	90m	70m	50m
40G BiDi	155m	150m	145m	140m	145m	140m	125m	115m

Fibre Channel Distances								
Applications	Pre-Terminated ST/SC/LC Assemblies				Direct termination or splicing with ST/SC/LC			
# Connections	2	4	6	8	2	4	6	8
1GFC (PI-4 100-M5F-SN-I)	1250m	1230m	1200m	1150m	1140m	1000m	800m	700m
2GFC (PI-4 200-M5F-SN-I)	750m	740m	720m	680m	680m	560m	460m	360m
4GFC (PI-5 400-M5F-SN-I)	500m	490m	480m	470m	470m	420m	370m	330m
8GFC (PI-5 800-M5F-SN-I)	250m	245m	225m	220m	220m	190m	160m	130m
16GFC (PI-5 1600-M5F-SN-I)	165m	160m	155m	150m	150m	125m	95m	50m
32GFC (PI-6 3200-5MF-SN-I)	120m	115m	110m	100m	100m	90m	70m	50m
10GFC (10GFC 1200-M5F-SN-I)	550m	540m	530m	520m	520m	490m	460m	440m

Applications are only warranted if LANmark-OF OM4 patch cords and pigtails or connectors are used.

Fig. 6 Application guarantee: critical for system design.

Impact of contamination

If we look at an illustration of a data centre layout (Fig. 7) we see various locations where contamination at patching zones could contribute to increased loss.

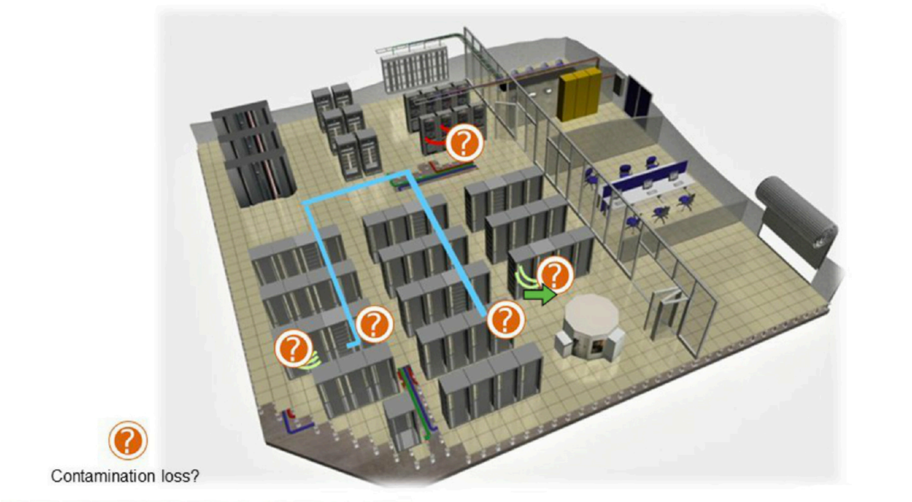


Fig.7 Impact of contamination on multiple fibre connectors.

Therefore, a maintenance philosophy and practice is required, as stipulated by the Standards bodies (e.g. 50174-1 and IEC 62627). It is fairly easy to examine single fibre connectors and check whether they're clean. By using scopes and other tools, you can rapidly determine whether there's any contamination on an interface.

SINGLE FIBRE CONNECTOR MULTI-FIBRE CONNECTOR

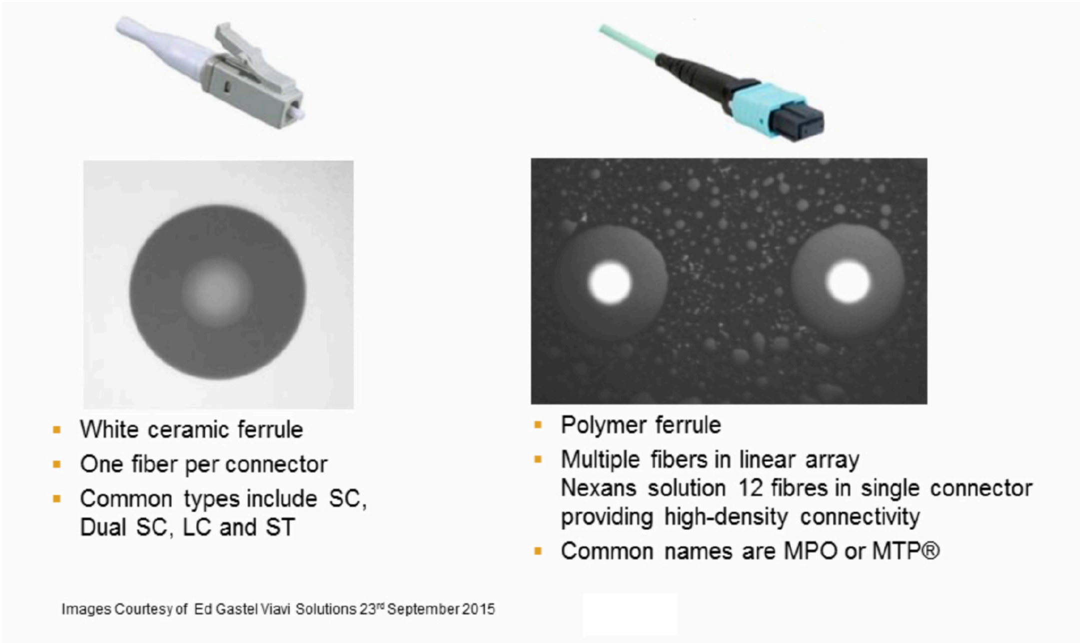


Fig.8: Connector Types

However, when we look at multi-fibre connectors (MPO/MTP), (fig.8) we see a dozen fibres packed closely together, and each of these faces, plus the connector flat face need to be kept perfectly clean to ensure ongoing operation. This requires a specific cleaning process to be used. (Fig. 9)The Nexans process consists of several discrete inspection steps that gradually lead you to a point where the connector is suitable for mating.

The equipment most typically used today is a high magnification scope, and camera systems and video microscopes are available from a variety of manufacturers. We recently reviewed some of these tools in a seminar and the results were very good. If you had determined an MPO/MTP connector was clean and wiped it on your shirt, you'd see even the slightest dirt if you inspected it again using these tools.

Inspection and cleaning process

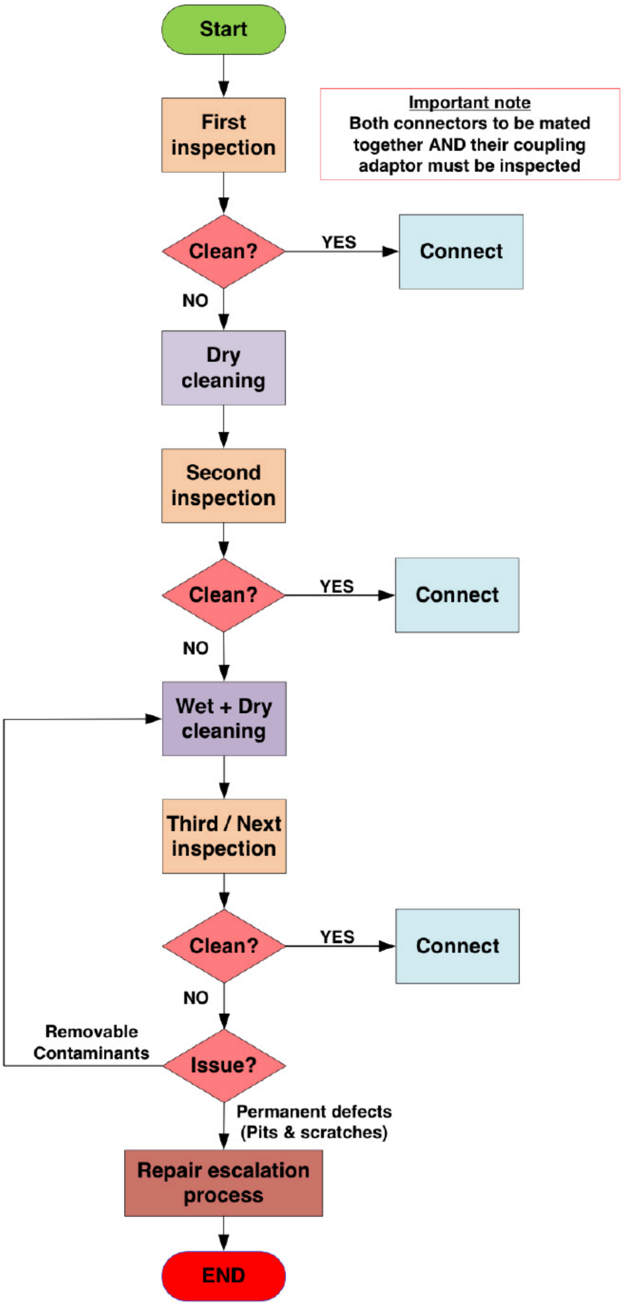


Fig 9: Inspection and cleaning process

When inspecting a fibre, you first need to determine exactly what you're looking at. There are three zones (Fig. 10) that each need to be carefully inspected: the core zone, cladding zone and ferrule zone. This applies to SC, LC and ST connectors, as well as to MPO connectors. It's important to understand the function of these three zones. The core zone is where the light travels and keeping this completely clean and free of damage is vital to operation. The cladding zone, which reflects light back into the core is less critical, but also needs to be kept clean and protected to a high standard. The ferrule zone is vital to the connector physical operation.

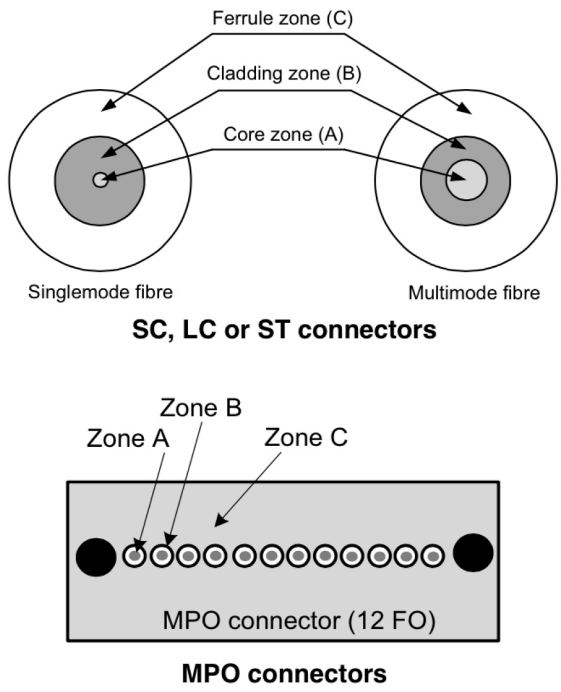
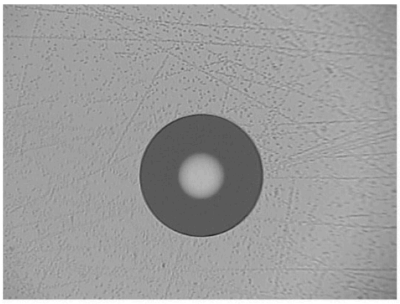
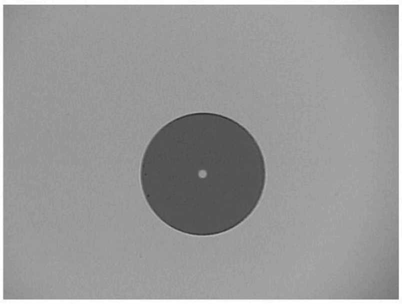


Fig 10: The three zones

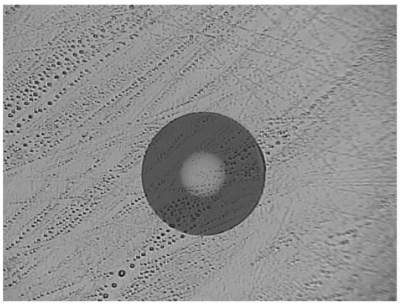
Dust, alcohol, finger grease or mineral oil, plastic or metallic particles are loose contaminants and can all be removed using the proper cleaning procedure. Scratches, cracks, pits or fixed contamination such as embedded particles resulting from the mating of dirty connectors are regarded as permanent damage. Cleaning them will not remove any permanent damage and the connector will need to be replaced.

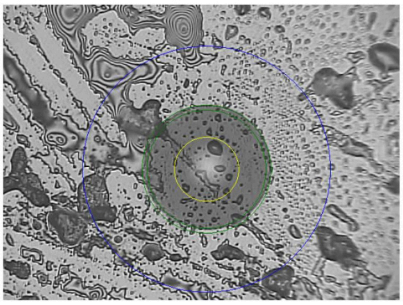
Dirt present on one connector face will also be transferred to one it has been mated to. This dirt can also permanently damage the polished end-faces of the mating connector face. For this reason, disconnected patch cords should always be cleaned and correctly stored. In the illustration below, (fig.11 & 12) we can see different types of contaminations on different types of connector, some of which spread across different zones, causing problems specifically in the critical core areas.



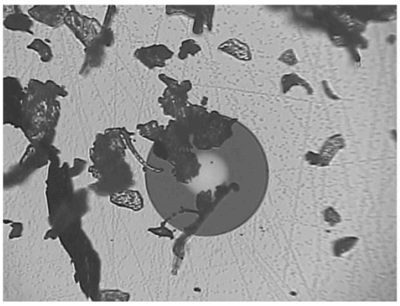


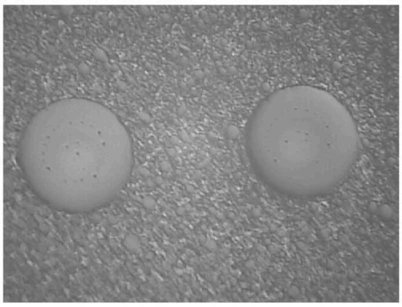
Perfect Multimode fibre | **Perfect Singlemode fibre**



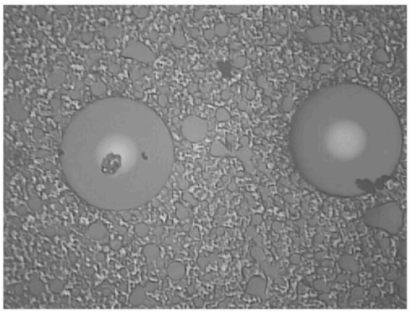


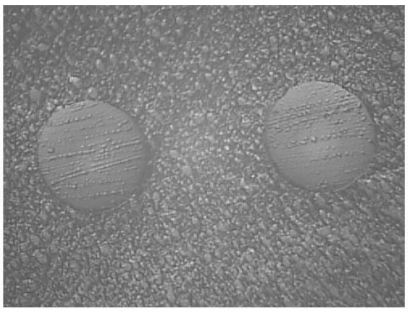
Alcohol residue contamination | **Liquid contamination**





Dust contamination | **Dust ring from mating contamination on MPO connector**





Dust contamination (MPO connector) | **Alcohol residue (MPO connector)**

Fig.11: Example FO end Faces with various contamination types

Below, we see permanent defects that can't be removed by cleaning.

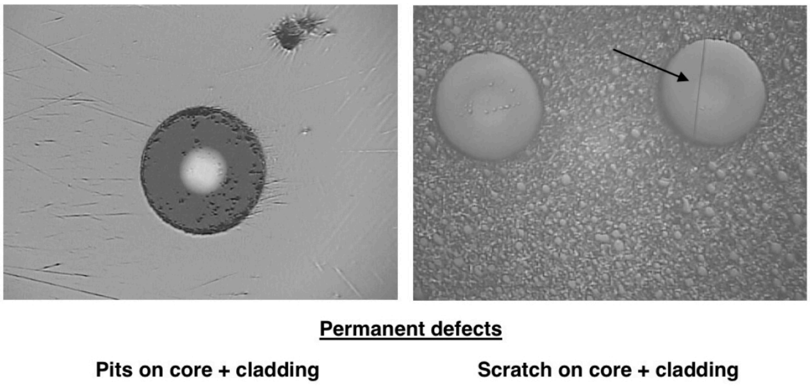


Fig.12: Example FO end Faces with permanent defects

Watch our for INSTALMENT 2 of this series, in which we'll be sharing practical guidelines and recommendations...

Resources

Fibre inspection and cleaning Webinar

http://lansystems.nexans.com/LP=187

OF connector Inspection, Cleaning & Testing General Guidelines

http://www.nexans.co.uk/eservice/UK-en_GB/fileLibrary/Download_540194193/UK/files/FO%20inspection%20and%20cleaning_%20V%202_11.pdf

Fibre field testing procedures

http://www.nexans.co.uk/eservice/UK-en_GB/fileLibrary/Download_540260094/UK/files/FO%20installation%20guide.pdf

Fibre_Testing and Cleaning:_New_Procedures_and Tools

http://www.nexans.co.uk/eservice/UK-en_GB/fileLibrary/Download_540157134/UK/files/Of%20field%20testing%20procedure%204_1.pdf

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